Transition to IPv6
Drivers and Challenges

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Workshop on the IPv6 development in Saudi Arabia
8 February 2009; Riyadh - KSA
The ICT sector is developing rapidly - new services, and new modes of service delivery.

The Internet will be the primary medium for all services.

One of the major challenges: Internet ability to connect billions of people and devices.

IPv6 is the next generation protocol for the Internet. It's advantages: more suitable to NGI – Addressing and control.

IPv6 – innovation, scalability, security, interoperability and allow more competition.

Transitioning to IPv6 represents a fundamental change in the Internet Protocol layer – Growth and more completion.
MAIN POINTS

- The take-up in the use of IPv6 has been very slow - because of a lack of applications, content, awareness, and clear benefits.
- The Co-Operation of all is needed to enable the timely and smooth transition to IPv6.
- All stakeholders have a role to play in the deployment of IPv6. The creation of The IPv6 Task Force will assist in:
  - Developing clear strategy, setting action plans and drawing a clear road map.
  - Increase awareness of IPv6 role for the future of the Internet.
  - Increase IPv6 training and expertise, including in the area of security.
- All stakeholders should draw lessons from successes and barriers identified in IPv6 implementations so far.
The objective of this presentation is to raise awareness among all stakeholders of:

- The capacity and limitations of the IPv4.
- The drivers behind the need for transition to IPv6.
- The need for all stakeholders to play a part in IPv6 deployment.

This Presentation will cover:

- An overview of the major initiatives that have taken place in Internet addressing to-date.
- An overview of the drivers and challenges for transitioning to IPv6.
- Public policy considerations and recommendations to all stakeholders and in particular the government.
AN OVERVIEW OF INTERNET ADDRESSING

- IP addresses identify Roles: *(who)* - participating devices on the network; *(where)* – destination; *(how)* – Routing packets destination.

- The IPv4 address space is a **32-bit** address scheme – about 4 billion possible unique addresses.

- IPv6 address space is a **128-bit** address scheme – about **340 billion**, billion, billion, billion unique IPv6 addresses.

- **200 millions** IPv4 addresses used in **2008**, The US the biggest user, but China is catching up.

- The total IPv6 address space in use is just **0.027%**.

- IPv4, is expected to run out by **2011**, only **13%** remains unallocated today.
AN OVERVIEW OF INTERNET ADDRESSING

- The situation is critical for the future of the Internet economy: all will be affected by the availability IPv4 addresses.
- The IETF developed several short-term solutions to the lack of IPv4 address space:
  - The "Classless" address architecture; The Network Address Translation (NAT).
- IPv6 adoption is being driven by providing additional address space, and by:
  - The rapid growth of broadband, of Internet mobile and sensor networks, as well as the development of new services.
  - The public sector procurement mandates;
  - The deployment of innovative products and services.
  - The decreased network complexity.
### Worldwide IP Address Ownership by Country 2008

<table>
<thead>
<tr>
<th>ISO Country Code</th>
<th>Country Name</th>
<th>Percentage</th>
<th>2008 Banking</th>
<th>2007 Banking</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>UNITED STATES</td>
<td>37.1654%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>UK</td>
<td>UNITED KINGDOM</td>
<td>11.3728%</td>
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<td>2</td>
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<tr>
<td>CN</td>
<td>CHINA</td>
<td>7.0814%</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>JP</td>
<td>JAPAN</td>
<td>6.9465%</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>DE</td>
<td>GERMANY</td>
<td>4.0077%</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>FR</td>
<td>FRANCE</td>
<td>1.7521%</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>KR</td>
<td>KOREA REPUBLIC OF</td>
<td>2.9127%</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>CA</td>
<td>CANADA</td>
<td>2.6635%</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>NL</td>
<td>NETHERLANDS</td>
<td>1.0068%</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>IT</td>
<td>ITALY</td>
<td>1.7678%</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>SA</td>
<td>SAUDI ARABIA</td>
<td>0.0979%</td>
<td>50</td>
<td>53</td>
</tr>
</tbody>
</table>

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IPv4 ADDRESS SPACE

IPv4 ADDRESS SPACE ISSUED
(RIRs TO CUSTOMERS)

Source: www.nro.net
IPv6 ADDRESS SPACE

IPv6 Allocations RIRs to LIRs/ISPs

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IPv6 DEPLOYMENT
IPv6 DEPLOYMENT

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GENERAL BENEFITS AND APPLICATION AREAS FOR IPv6

- The IPv6 can help Internet to **support the next generation wireless**, **high-bandwidth**, **multimedia** applications, and the **overall number of users**.
- IPv6 deployment drivers focus on the **performance**, and **operational cost savings** through using simpler network models, and on **enabling new product and service innovation**.
- **Increasing mobility** of internet users.
- **Need for more than one IP address per session**.
- **Establishment of more home networks**.
- **Always on** services and applications
- **Convergence** of applications over the IP based infrastructure
IPv6 DRIVERS
Demand for IP Addresses

- Escalating demand for IP addresses is a main driver for IPv6 adoption.
  - Convergence and the development of new IP networks and IP-based services.
  - The limited IPv4 address space is unable to satisfy the increased numbers of users, applications, services, networks, and distributed computing or gaming.
  - Always-on environments further increases the address requirements.
- IPv6 quadruples the number of network address bits from 32 to 128 bits, which simplifies the reachability of these devices.
- The increasing number of cases in which networks “outgrow” IPv4 private space - COMCAST is an example.
- Mobile operators could consume large amounts of IP addresses.

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IPv6 DRIVERS
Public Procurement Mandates

- In some cases, aggressive IPv6 adoption policies by government bodies have provided incentives for industry.
- In many cases, public sector mandates have caused vendors to develop IPv6 solutions, which then accelerate IPv6 deployment.
  - In 2003, the US Department of Defense mandated the integration of IPv6 to be ready by 2008.
  - The Korean Ministry of Information and Communication set a target to convert Internet equipment in public institutions to IPv6 by 2010.
  - The Australian Government Information Management Office has released its Strategy for the Transition to IPv6 for Government agencies, to last from January 2008 to December 2015.

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IPv6 DRIVERS
Innovative Applications

- A key driver for IPv6 is to make possible new business and services, such as networked sensors for industrial or home automation services - directly deployed over IPv6 infrastructures, (or dual-stack).
- Trends in the Internet include more capable consumer devices: Personal digital assistants, videogame consoles, audio-visual equipment, including home servers, set-top boxes, digital TV sets, networked home appliances, car navigation systems, wireless sensor networks, and intelligent transport systems and servers in trains, ships and airplanes.
- IPv6 feature to support devices at any given time, combined with mobility, make it a logical candidate for some of these new uses.
- Sensor networks can benefit from the plug-and-play capabilities of IPv6.
- Home security and health care emerging applications.

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IPv6 DRIVERS
Less Expensive Network Administration

- IPv6 simplifies some functions in network administration, through a simplified routing efficiency, auto configuration, easier renumbering, ready-to-use, and multicast support.
- Actors will deploy IPv6 when the cost/benefit ratio is acceptable.
  - Large address consumers, are likely to accelerate deployment plans for IPv6 for their internal infrastructure where possible,
  - It’s more difficult and expensive to obtain new IPv4 address space.
  - The cost and complexity associated with keeping track of and managing remaining IPv4 address space will also increase.
- Adoption decisions will be taken by many and various stakeholders based on the costs and benefits they see for their activity.
- ISPs may implement IPv6 in their internal networks if the benefits outweigh maintaining IPv4 and increasing NATs.

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IPv6 DRIVERS
Better Mobility Support

- More mobile phones, and PDAs, will increasingly require Internet access and IP addressing.
- IPv6 offers improved support for mobility, and public addresses can be assigned to mobile nodes.
- Mobile phone players see handsets as “always-on”, this architecture has developed into 3GPP IP Multimedia Subsystem.
- Many smart phone operating systems support IPv6, a challenge is the availability of billing and authentication applications.
- Mobile IPv6 is deemed to offer route optimization between any-to-any node. But overhead cost, to make the mobile transmissions secure.
- Although there are plans to deploy MIPv6 in the future releases of 3GPP, WiMAX, there are currently no commercial deployments.
IPv6 CHALLENGES
IPv6-Related Deployment Strategies, Associated Costs and Skills

- **Immediate costs** are associated with deployment of IPv6.
- The **cost of IPv6 deployment** vary according to network needs and business. User cost differences depend on:
  - Network infrastructure; type of services; future needs of an organization's network; level of security required during the transition.
- Deploying IPv6 only involves **training**, **configuration**, **testing**, **management costs**, **cost of software and hardware upgrades**.
- For many organizations, operational costs, including **staff training** constitute the **majority of the cost** of upgrading to IPv6.
- Organizations that run **in-house customized software** will experience **additional costs** to upgrade these programs to IPv6.
- A major barrier to IPv6 deployment is that of **expertise: education, training and awareness**, in particular for IPv6 **security**.

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IPv6 CHALLENGES
Co-Existence

- IPv6 deployment is not backwards compatible with IPv4:
  - Both protocols must be deployed, or sophisticated “tunneling” and translation systems set-up.
- Co-existence of IPv4 and IPv6, is a major challenge for IPv6, because the two protocols are not “interoperable”.
  - IPv4 will need to be supported alongside IPv6 for a substantial period of time.
- IPv6 deployment requires long term planning and co-ordination
  - Managing more than one network and maintaining interoperability with many existing IPv4 implementations during the transition.

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IPv6 CHALLENGES
Security Considerations

The transition from a pure IPv4 to IPv4/IPv6 network brings security considerations that need to be taken into account when deploying IPv6 and operating the dual-protocol.

IPv4 → IPv6

IPv6 Specific Protocol

IPv6 Deployment

Transition Mechanisms

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IPv6 CHALLENGES
Dual-Stack Approach

- The dual-stack approach implies that all devices interoperate with IPv4 devices using IPv4 packets, and with IPv6 devices using IPv6 packets.
- Most IPv6 implementations today are dual-stack.
- In the early phases of IPv6 deployment, the IPv6 component of dual-stack hosts and network deployments will be isolated “islands”.
- This implies a need for support of automated IPv6 tunneling, to connect isolated IPv6 islands.
IPv6 SOLUTION to CHALLENGES

Tunneling Mechanisms

- Tunneling provides a way for the existing IPv4 routing infrastructure to remain functional, and also carry IPv6 traffic.
- Data is carried through an IPv4 tunnel - IPv6 packet is carried inside an IPv4 packet.
From an end user's perspective, the key issue with transitioning to IPv6 is likely to be content rather than cost.

There is currently little Internet content available via IPv6.

Latency is the time needed for a packet to get from one point to another. Dual-stack environment might slow connection time.

Content providers consider latency to be a major obstacle for making their content and services available through IPv6.

Lack of IPv6 peering agreements and Internet eXchange Points (IXPs) supporting IPv6 can increase latency because traffic may have to travel further to reach its destination.

The latency issue with IPv6 will disappear once a critical number of service providers have enabled native IPv6.

Several content providers seem to have provisioned IPv6 address space, which may signal change – Google, Microsoft and Cisco are examples.
The primary reason behind not investing in IPv6 deployment was dissatisfaction with the way IPv6 supports “multi-homed” users, i.e. users with traffic exchange with two or more independent networks.

Multi-homed users add entries corresponding to their routes to the global routing tables, which increases the size of the tables.

Technical solutions for site multi homing with IPv6 and their adoption as standards by the IETF are viewed as very important for IPv6 adoption.

Scalability of the routing system is seen as a major issue for the future of the Internet.

Addressing and routing are interdependent and there are economic benefits in devising solutions to scalable routing systems.
PUBLIC POLICY CONSIDERATIONS AND RECOMMENDATIONS

1. Governments should consider working with the private sector to increase education and awareness and reduce bottlenecks

- IPv6 adoption is a long, complex integration process.
- Maintaining operations and interoperability at the application level will be critical during the long co-existence period.
- The need for awareness and co-operation among all players during the transition period is of high importance as each player is capable of addressing only part of the issue.

Governments should

- Raise awareness.
- Establish co-operation mechanisms to guide the transition to IPv6.
- Develop and communicate educational materials on IPv6.
- Target decision-makers in awareness efforts on IPv6 deployment.
- Support registries and industry groups to facilitate the management of IPv4 and adoption of IPv6, and make specific efforts to ease bottlenecks.

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PUBLIC POLICY CONSIDERATIONS AND RECOMMENDATIONS

2. **Government** should demonstrate its **commitment to adoption** of IPv6

- **Adopt clear policy objectives** to guide the transition effort to IPv6.
- **Plan for the adoption of IPv6 for governments internal use** and for public services.
- **Set up a steering group “Task Force”** to provide strategic guidance on achieving IPv6 implementation objectives.
- Ensure that all new programs involving the Internet and ICT, consider the relevancy of IPv6.
- Ensure that all relevant **government security entities fully integrate** the new dimension that IPv6 brings to security.
- Take pro-active initiatives to include IPv6 training in education cycles.

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PUBLIC POLICY CONSIDERATIONS AND RECOMMENDATIONS

3. **Government** should consider Pursuing **international co-operation** and monitoring IPv6 deployment

- Awareness is a key element in support of informed policy making.
- Benchmarking at the international level is essential.
- **Government should**:
  - Engage in co-operation at regional and global levels, to share knowledge and experience on developing policies for coordination with private actors on IPv6 deployment.
  - Consider the specific difficulties and seek for assistance in the capacity building and in developing IPv6 infrastructure.
  - Encourage the participation of all stakeholders in the development of public policies for IPv6 allocation.
  - Encourage all parties to gather data to track the deployment of IPv6.
  - Monitor IPv6 readiness and penetration in domestic markets.

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THANK YOU

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### GENERAL BENEFITS AND APPLICATION AREAS FOR IPv6

<table>
<thead>
<tr>
<th>Impact Metric</th>
<th>Application / Market</th>
<th>General Description: Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost reductions resulting from increased efficiency</td>
<td>NAT removal</td>
<td>enterprise and application vendors’ spending on NAT workarounds accounts for up to 30% of IT related expenditures.</td>
</tr>
<tr>
<td>Value of remote access to existing products/services</td>
<td>Increased life expectancy of products</td>
<td>Automobile64 and appliance owners65 could increase the functionality and life expectancy of their products through the use of remote monitoring and support services.</td>
</tr>
<tr>
<td>Service costs</td>
<td></td>
<td>Automotive and appliance owners could decrease service costs through the use of remote monitoring and support services.</td>
</tr>
<tr>
<td>Innovation in communications and online products/services</td>
<td>New mobile data services</td>
<td>• Wireless companies could sell new features through expanded network capabilities.  &lt;br&gt;• Wireless companies need IPv6 to increase address capacity for peer to peer (P2P) applications.</td>
</tr>
<tr>
<td>Online gaming</td>
<td></td>
<td>Gaming and game console makers could see expanded functionality and thus opportunities for innovative new products</td>
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<table>
<thead>
<tr>
<th>PRIORITY IPv6 DEPLOYMENT CHALLENGES</th>
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<tbody>
<tr>
<td><strong>“HIGH” priority challenges</strong></td>
<td>Address Allocation Policies</td>
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<tr>
<td></td>
<td>Site Multi-Homing</td>
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<td>Quality of Service</td>
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<td>Security</td>
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<td></td>
<td>Interoperability Between IPv4 &amp; IPv6</td>
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<td></td>
<td>Network Address Translators (NATs)</td>
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<td>Impacts on Network Traffic &amp; Routing</td>
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<tr>
<td><strong>“MEDIUM” priority challenges</strong></td>
<td>Impacts on Privacy/Legal Issues</td>
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<td>Management Tools (Dual-stack &amp; IPv6 Networks)</td>
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<td>Impacts on Infrastructure Reliability</td>
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<tr>
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<td>Network Renumbering (Portability)</td>
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<td>Peering Evolution (Impacts on Settlements)</td>
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<td>Impacts on Access Networks</td>
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<td><strong>“LOW” priority challenges</strong></td>
<td>Separation of Locator &amp; Identifier</td>
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<td>Vendor Availability</td>
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<td>Dual-Stack with Domain Name System (DNS)</td>
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<td>Relationships with other Numbering Systems</td>
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<td>Cost</td>
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