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# IPv4 to IPv6 Shift: Major Challenges

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***Abstract:-Today, the Internet Assigned Numbers Authority (IANA), The Regional Internet Registries (RIRs) have become depleted of IPv4 addresses. The ever-increasing popularity of internet and its simultaneous users has forced to the need of IPv6 addresses (with much larger address space) & its urgent usage & implementations. But the implementation .deployment and shifting to IPv6 is rather difficult than expected as it suffers from the various technical challenges that needs to be resolved. This paper focuses on the various IPV6 challenges that the users & organizations have to consider & needs to be sorted out before migrating to IPv6 from IPv4. It includes a detailed study of challenges for migrating to IPV6,and an in-depth look of the probable solutions available today.***

***Index Terms*— DNS (Domain Name Server), IPv4, IPv6, Routing.**

## I. INTRODUCTION

Based on the best available forecasts [1] the last IPv4 blocks have already been allocated by IANA to the RIRs. Thus we are already exhausted all the pool of IPV4 addresses. Thus we are having the problem of running out of IP addresses and this is going to become worse over time. In the future, the numbers and types of devices connecting to the Internet will increase. Devices like PDAs, pagers, telephones, automobiles, and many other when starts connecting to network, will require Internet connectivity. This will dramatically fuel demand for even more IP addresses. Thus we are in constant need of a much larger pool of internet addresses. IPv6 is the solution with 128 bit address space as compare to 32 bits of IPv4.

But today's concern is whether we are or will be able to migrate to IPv6.No,not for the next few years, at least The technical bottlenecks & deployment issues related to IPv6 has been a constant worry for all Internet communities & researchers. Whether it would be addressing methods, or uneven address hierarchies IPv6 has been a setback. Issues as simple as DNS (Domain Name Server) need to be re-evaluated for it. Application specific modifications just added few worries to the list. Route table unexpected growth due to Multihoming for which the original IPv6 has been proposed ;still remained a matter to be resolved Most importantly the time span that actually be need in real scenarios so that to minimize the deployment cost is one of the major concern too. This single reason laid the basis for gradual shifting to IPv6.

## II. IPv6: CHALLENGES & ISSUES

The addresses in the IPv6 are allocated according to the following hierarchy.

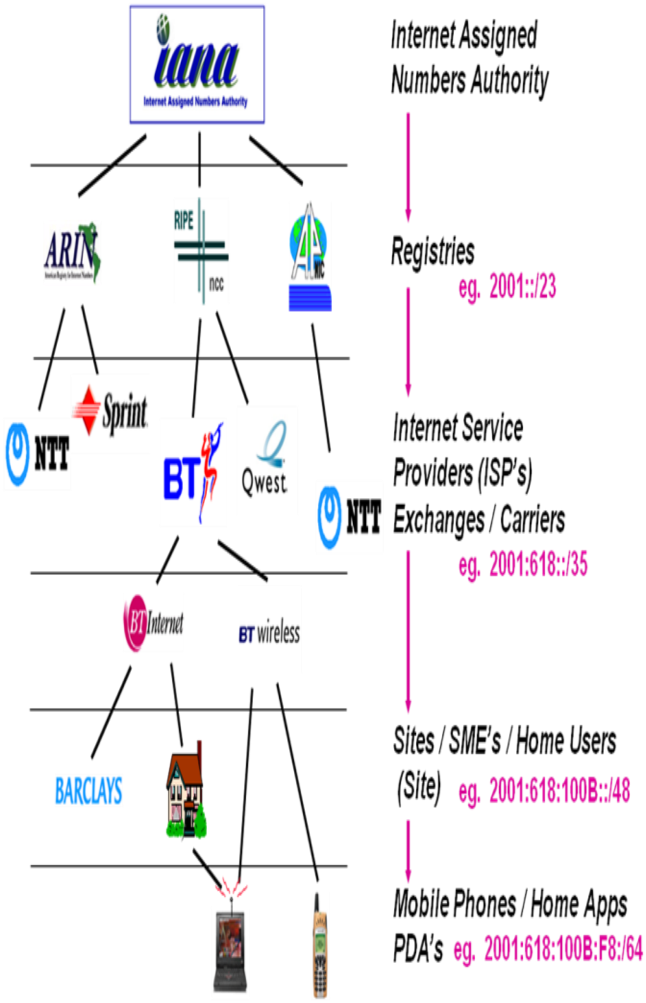


**Fig 1. Address Hierarchy in IPv6**

### A. *IPv6 Addressing Complexities*

**a) <u>Network Addressing Schemes</u>**

**Table 1 Network Addressing Scheme 1**

| **Hierarchical Level** | **Size** | **No of bits** |
|---|---|---|
| Continent | 7 | 3 |
| Country | 221 | 8 |
| State | 64 | 6 |
| Town | 128 | 7 |
| Line/Site | 102 4 | 10 |
| | | **Tot. bits 34** |

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Showing network address scheme according to geographical area.

**Table 2 Network Addressing Scheme 2**

| Hierarchical Level | Size | No of bits |
|---|---|---|
| International backbone | 10pops | 4 |
| Continental | 20 pops | 5 |
| Country backbone | 1000 pops | 10 |
| Lines to customers | 1024 lines | 10 |
| | | **Tot. 29 bits** |

Showing network address scheme according to backbone network.

**Current NLA size = 24 bits + 8 more reserved bits**

These different schemes led to the confusion which scheme to select. Huitema – Durand calculations [2] may prove beneficial for selecting one of them and deciding the no of bits in NLA. According to Huitema-Durand method & related calculations [2] it has been theoretically found that 31 bits are sufficient for 30 million homes. Thus it has been sufficient to represent NLAs by 34 bits.

**b) <u>IPv6 Address Hierarchies: NLA's & sTLA's</u>**

Four different hierarchies that are used are as follows:

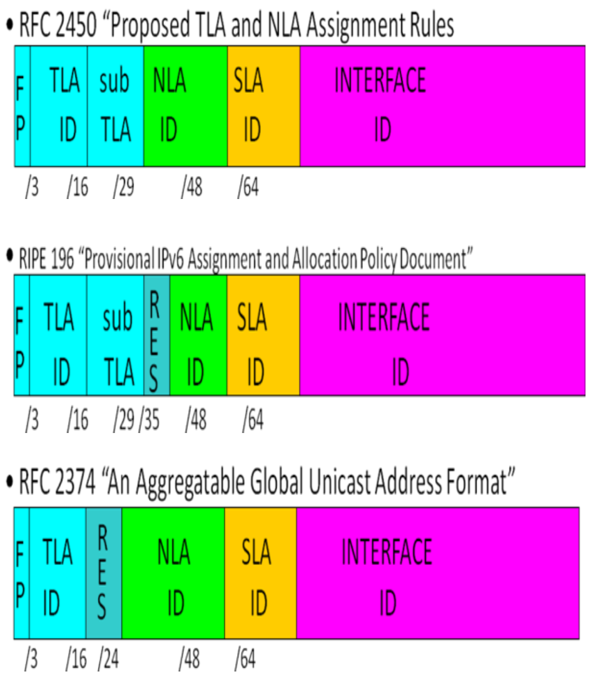


**Fig 2. Showing three different address hierarchies.**

All these hierarchies suffer from the facts that sub TLA's are very small. Not only this NLA's are also small and more unfortunately they vary in no of bits. Address utilization targets if set too high cause a flattening of network hierarchy which leads to higher engineering costs. Therefore a TLA/NLA/SLA [3] structuring & address assignment rule drives a commercial model of customers dependent on Tier 2 ISPs dependent on Tier 1 ISPs. **This is not the way 3G works!!**

**Possible alternatives**

An IPv6 Provider-Independent Global Unicast Address Format. [4] .The users IPv6 address is derived from their latitude and longitude. Increase the number of bits in the global routing prefix by reducing the number in the interface id. Then allow any ISP unqualified addresses space. The ideal situation is that every ISP has enough address space to address everyone.

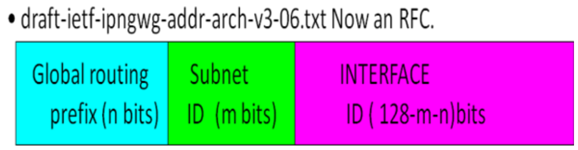


**Fig 3. Provider-Independent Global Unicast Address Format.**

***B. DNS Mania***

**Firstly**, IPv4 uses "A" records for translation whereas IPv6 "AAAA" records for translation a more difficult and lengthy one. **Secondly**, all web browsers have default DNS support for IPv4 while this is not the case with IPv6.

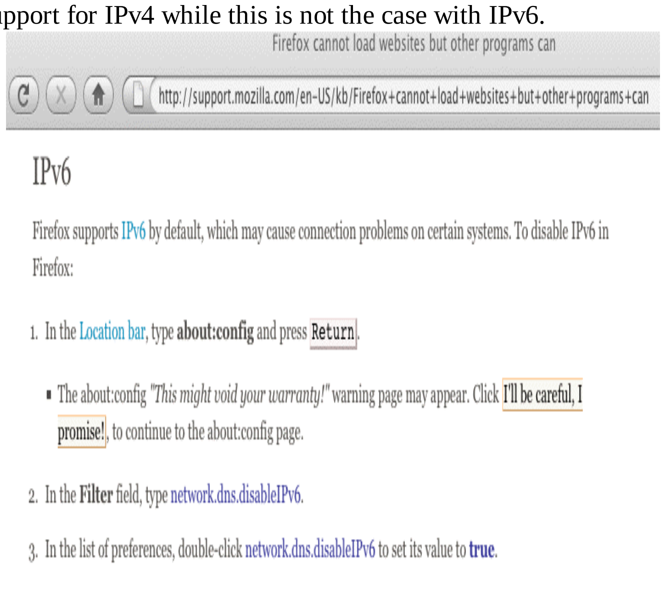


**Fig 4. Browser support for IPv6**

If a fully qualified domain name (such as network-services.uoregon.edu) is bound to both IPv4 and IPv6 addresses, which one should gets used? Which one should be "preferred" The IPv6 one or the IPv4 one? This may be determined by the application (e.g., it may ask for both, and then use its own internal precedence information to determine which it will use), or by the DNS server [6] (hypothetically it might just give you an IPv6 address for a host and then stop).Also this would be a problem if you advertise an IPv6 address for a host but then don't actually offer IPv6 connectivity for that AAAA, or if the user asks for an IPv6 address but doesn't actually have IPv6 connectivity

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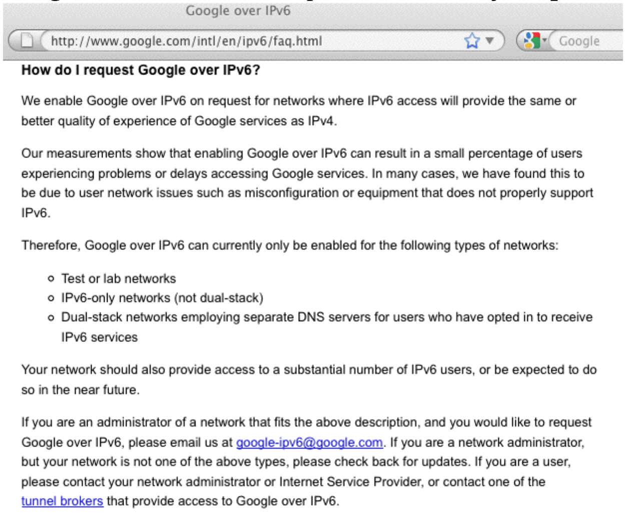
after all. **Example: Google (Enabling IPv6 DNS for by Default v/s by Request)**

**In default case**, for all users (IPV6 as well as IPV4) IPv6 connectivity gets tried first (only to fail). It takes time (20+ seconds –a major issue) for those failures to occur. After each failure, IPv4 connectivity gets tried as a fall-back plan, but users quickly get grumpy if their browsing experience is repeatedly slowed by one failed IPv6 connection attempt after another.

Therefore Google only enables automatic IPv6 resolution of Google websites for IPv6-capable networks **by Request**.


Google over IPv6
http://www.google.com/intl/en/ipv6/faq.html

**How do I request Google over IPv6?**

We enable Google over IPv6 on request for networks where IPv6 access will provide the same or better quality of experience of Google services as IPv4.

Our measurements show that enabling Google over IPv6 can result in a small percentage of users experiencing problems or delays accessing Google services. In many cases, we have found this to be due to user network issues such as misconfiguration or equipment that does not properly support IPv6.

Therefore, Google over IPv6 can currently only be enabled for the following types of networks:

- Test or lab networks
- IPv6-only networks (not dual-stack)
- Dual-stack networks employing separate DNS servers for users who have opted in to receive IPv6 services

Your network should also provide access to a substantial number of IPv6 users, or be expected to do so in the near future.

If you are an administrator of a network that fits the above description, and you would like to request Google over IPv6, please email us at google-ipv6@google.com. If you are a network administrator, but your network is not one of the above types, please check back for updates. If you are a user, please contact your network administrator or Internet Service Provider, or contact one of the tunnel brokers that provide access to Google over IPv6.

**Fig 5. Enabling IPv6 in Google BY REQUEST**

**Thirdly** and most importantly it is nearly impossible to handle inverse address records ("PTR") records for IPv6 addresses assigned via SLAAC or DHCPv6We can create static inverse address records for static IPv6 addresses assigned to servers that are not a problem. Unfortunately, there's isn't community consensus around how to handle inverse address records ("PTR") records for IPv6 addresses assigned via SLAAC or DHCPv6.No one wants to create 18,446,744,073,709,551,616 inverse address records, one for each IP in each /64 It would take forever, and wouldn't make any sense (most of those PTRs would never even be queried) **Probable solution** for this includes such as dynamic DNS as well as wildcarding, as well as creating inverse address records on the fly. This is yet another unsolved IPv6 challenge [5].

### *C. Route Table Bloating Problem [7]*

**a) <u>Most Little Sites (No Impact on Table Size)</u>**

If you're a small and simple site with just a single upstream provider, your upstream ISP may aggregate the network addresses you use with other customers it also services. Thus, the global routing table might have just a single table entry servicing many customers. Once inbound network traffic hits the ISP, the ISP can then figure out how to deliver traffic for customer A, B, etc. The ISP handles that & the Internet doesn't need to know the "gory" local details. Similarly, outbound, if you're a small site with just a single upstream provider, your choice of where to send your outbound traffic is pretty simple: you've only got one place you can send it. This allows you to set a "default route," sending any non-local traffic out to your ISP for eventual delivery wherever it needs to go.

**b) <u>Sites with Their Own IP Address Space</u>**

Sometimes, however, sites have their own address space. For example, UO has the prefix 128.223.0.0/16,the IPv4 addresses 128.223.0.0--128.223.255.255.That address block is not part of any ISP's existing address space. If UO wants to receive traffic intended for those addresses, it needs to announce (or "advertise") that network address block to the world. When UO's route gets announced, each router worldwide adds that route to its routers' routing tables, and thus knows how to direct any traffic it may see that's destined for UO, to UO. Without that route, our address space would be unreachable.

**c) <u>Sites Having Multiple Prefixes</u>**

Sometimes sites have more than one chunk of network address space. For example, Indiana University has 129.79.0.0/16, 134.68.0.0/16, 140.182.0.0/16, 149.159.0.0/16 149.160.0.0/14, 149.165.0.0/17, 149.166.0.0/16, 156.56.0.0/16, and 198.49.177.0/24, and thus IU has nine slots in the global routing table associated with those prefixes. Other sites may have a range of addresses which could be consolidated and announced as a single route, but some sites might intentionally "de-aggregate" that space, perhaps announcing a separate route for each /24 they use.

**d) <u>Route Table & Routing</u>**

Each route in the global routing table needs to be carried by routers at every provider in the world. Each route in the route table consumes part of a finite pool of memory in each of those routers. When routers run out of memory, "Bad Things" tend to happen. Some routers even have relatively small fixed limits to the maximum size routing table they can handle Each route in the route table will potentially change whenever routes are introduced or withdrawn, or links go up or down. The larger the route table gets, the longer it takes for the route table to re-converge following these changes, and the more CPU the router requires handling that route processing in a timely way. Thus in any case Route table (IPv4) continues to grow

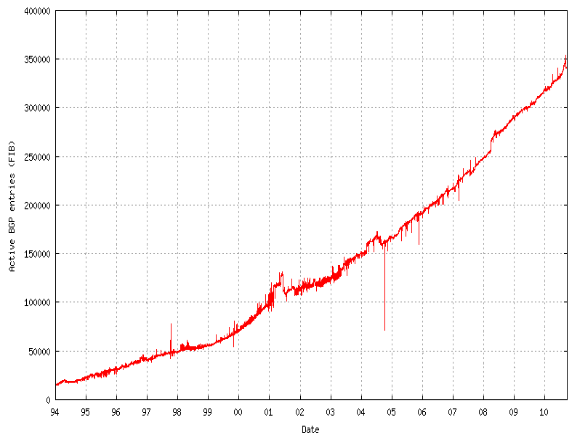



**Fig 6. IPv4 Route Table [8]**

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**e) Multihoming**

When IPv6 was designed, address assignment was supposed to be hierarchical. That is, ISPs would be given large blocks of IPv6 address space, and they'd then use chunks of that space for each downstream customer, and only a single entry in the IPv6 routing table would be needed to cover ALL the space used by any given ISP and ALL their downstream customers. But now, let's pretend that my Internet connectivity is important to me, so I don't want to rely on just a single ISP -- I want to connect via multiple ISPs so that if one provider has problems, the other ISPs can still carry traffic for my site. This connection to multiple sites is known as "Multihoming."Now the problem starts. When I get connectivity from sites (let say A, B and C), whose address space would I announce. Neither of the sites wants other sites' address to b announced. I need to either assign each host multiple addresses (e.g., one address from A, one from B, and one from C),or I need to get my own independent address space which I can use for all three ISPs, but which will then take up a slot in the global routing table.

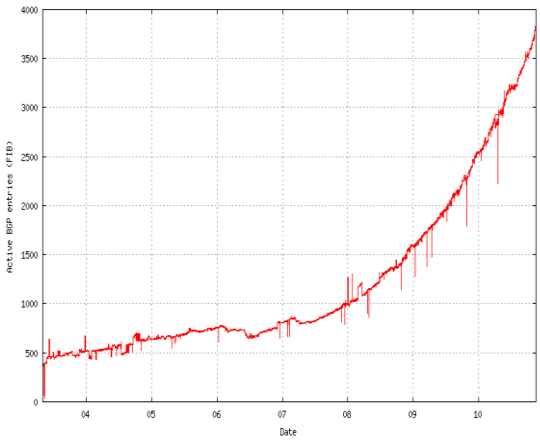


**Fig 7. IPv6 Route Table [8]**

**The IPv6 was supposed to be the answer to this issue, but that proved only up to a par and that too theoretically.**

But if I assign multiple IPs to each host, one for each upstream ISP I connect to, how do I know which of those IP addresses I should use for outbound traffic generated by each host? Do I arbitrarily assign the address from A to some traffic? The address from B to other traffic? What about the address from C? (Hosts shouldn't need to act like routers). And which of those addresses do I map to my web site or other servers via DNS? Do I use just A's address? Just B's? Just C's? All three of those addresses? What if one of my providers goes down? Will traffic failover to just the other two providers quickly enough? All these questions need to be answered before further IPv6 deployment.IPv6 Multihoming without use of provider dependent address space is one of the unsolved/open issues in the IPv6 world today. Operationally, in the real world, ISP customers who need to multihome request their own provider independent IPv6 address space, and use that, even if it adds an entry to the global routing table.

***D. IPv6 Is More Secure Than IPv4 (A theoretical myth more than a fact)***

IPSec is mandatory in IPv6and thus it is considered more secure than IPv4. Deployed under three architectures (gateway to gateway, node to node, and node to gateway) and supporting various encryption modes (md5 & various key exchanges) operating in two modes (tunnel mode & transport mode); IPSec **(IP Secure protocol)** ensures authentication, confidentiality, integrity, and replay protection. **But only if is used. That is support for IPSEC may be mandatory, but that doesn't mean it is getting used.** IPv6 can be brought up without IPSec getting enabled, and in fact this is routinely the case.

**Some IPv6 Traffic Statistics From a Mac OS X Host: No ipsec6 Traffic**

```
# netstat -s -finet6
[snip]

ip6:
    124188 total packets received
    [snip]
    84577 packets sent from this host
    [snip]

    ipsec6:
    0 inbound packets processed successfully
    0 inbound packets violated process security policy
    [snip]
    0 outbound packets processed successfully
      0 outbound packets violated process security policy
    [snip]
```

**Fig 8. Showing IPSec traffic on MAC host**

More broadly, if people are doing cryptographically secured protocols of any sort, they inevitably run into problems -- crypto stuff just tends to be inherently tricky and hard to learn to use. This would be reason why IPSec (Even on IPv4!) isn't getting much use.

**Protocol Distribution From One of CAIDA's Passive Monitors** (showing not much IPv4 IPSec traffic)

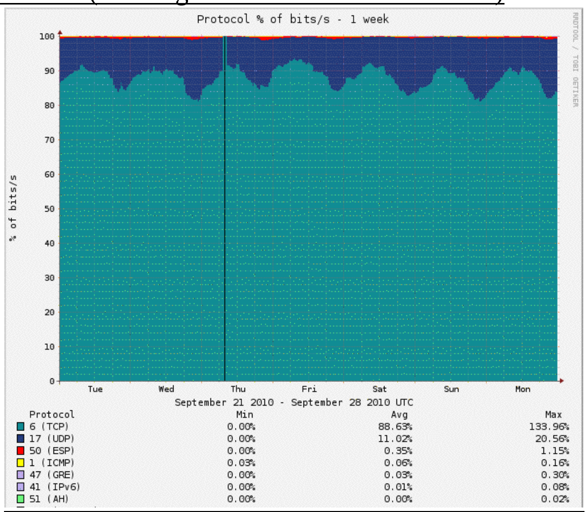


**Fig 9. Almost negligible IPv4 IPSec Traffic [9]**

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Sites are not deploying IPSec because IPSec is not yet completely baked or still too-much under development. It's too complex & hard to deploy at significant scale causing it perfectly interoperable. It also causes firewall issues and congestion insensitiveness that adds complications in maintaining/& debugging the network, etc., etc., etc. Regardless of whether these perceptions are correct (some may be, some may **not** be), IPSec adoption hasn't happened much to date.

***E. IPv6 Deployment Issues: Cost Modeling of IPv6 Migration***

Attempting to include all costs, including new software, memory, hardware, OSS and desktop upgrades. Extra maintenance costs assume the extra costs of running IPv6 on an existing IPv4 network. That is assuming a **Dual-Stack** Scenario. Once IPv4 is phased out then extra-maintenance costs no longer apply.

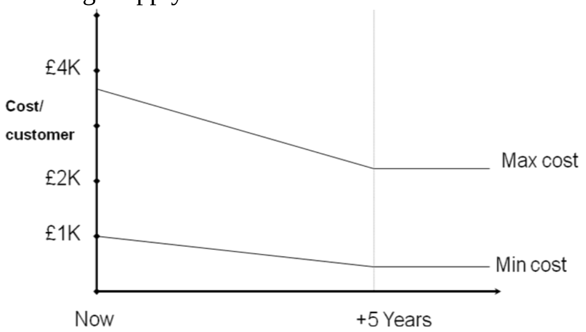


**Fig .10. Big ISP Migration Costs Big ISP equivalent to a Tier 1 ISP**

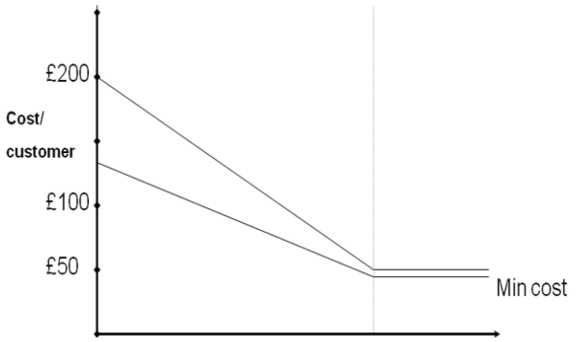


**Fig 11. Big ISP Extra Maintenance Costs Big ISP equivalent to a Tier 1 ISP**

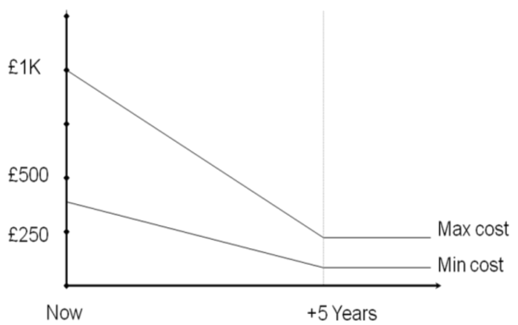


**Fig 12. Big Enterprise Migration Costs 100,000 Desktops**

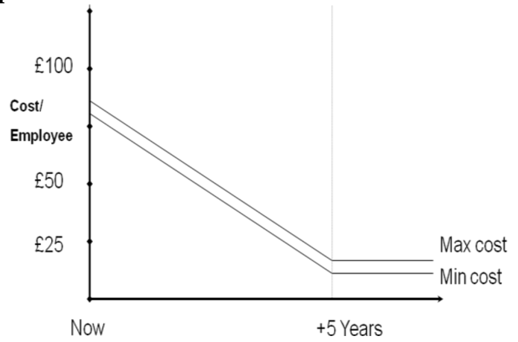


**Fig 13. Big Enterprise Extra Maintenance Costs 100,000 Desktops**

All the above statistics shows that for migration to IPv6 from IPv4 the time period must be large (minimum 5 year span) so as to reduce the overall cost. This gradual migration is a major limitation as we cannot switch over to IPv6 as soon as possible.

***F. Other Legitimate Potential Obstacles To Deploying IPv6 (At Some Sites)***

**a)** **<u>Native IPv6 Connectivity</u>**

Suppose our site needs IPv6 connectivity. For this Native IPv6 connectivity is strongly preferred. **Native IPv6 connectivity** is the IPv6 analog of normal IPv4 connectivity, and would ideally come from our current network service provider. Unfortunately, some sites may currently be getting their IPv4 Internet transit from network service providers who may not yet be offering native IPv6 transit. In those cases, we can add IPv6 by adding a second provider: If necessary, we can use one network service provider for your IPv4 Internet connectivity, and add another provider for our IPv6 Internet connectivity. For that we can either go for **IPv6 Transit Providers** or **Manually Configured IPv6 Tunnels**.

**<u>IPv6 Transit Providers</u>**

There are many major network service providers which do offer IPv6 connectivity; see the list [11].

**<u>Manually Configured IPv6 Tunnels</u>**

Another alternative might be to arrange for a manually configured IPv6 tunnel from an IPv6 tunnel broker (although you'd **really** be better off adding native IPv6 connectivity from a second network service provider).Free tunneled IPv6 connectivity is available from a variety of providers [11] When establishing a manually configured IPv6 tunnel, beware of tunneling to a very distant tunnel endpoint -- all your traffic will have to make that long trip and that will add (potentially substantial) latency Therefore tunnels should be kept as short as possible.

**b)** **<u>Non-IPv6 Content Delivery Networks (CDNs) and Outsourcing of E-mails & Cloud based Spam filtering services[12] [13]</u>**

A growing number of sites also outsource their email operations. Unfortunately some email-as-a-service and some cloud-based spam filtering services don't support IPv6, thereby limiting the ability of their customers to integrate IPv6 into their existing IPv4-based services. CDNs and

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outsourced email and spam filtering services aren't the only reason why IPv6 adoption has been slow at some major Internet sites, but it is certainly an important stumbling block that will need to get resolved.

### *G. IPv6 Hardware and Software Issues*

**NETWORK MIDDLEBOXES** such as firewalls or network traffic load balancers. Sometimes those devices simply do not understand IPv6 at all. Other times they may have a primitive or incomplete implementation of IPv6, or require users to license an expensive "enhanced" software image to support IPv4 and IPv6.In general, will recommend moving firewalls as close to the resources they're protecting as possible (e.g., down to a subnet border, or even down to the individual Ethernet port level), assuming you can't get rid of them altogether. Some Broadband Customer Premises Equipment (CPE) also does NOT support IPv6. [14] This proves to be a major ISP stumbling block.

## III. PROMOTERS OF IPv6

Google leads the race here. Comcast has also started doing trails for IPv6 implementations Some Comcast ipv6 Trials Are Native IPv6; others are testing a Couple of Transition Mode Technologies. The U.S. Defence Research and Engineering Network(DREN) is widely using IPv6 .Not only this it is also using its services wiz-a-wiz dual stack to recursive DNS to RADIUS to security stack like IDS, IPS. Many Internet 2 sites are also IPv6 enabled [15]. To the surprise, at present Hurricane Electric is already Serving 44,383 IPv6 Tunnels Worldwide [16]. IPv6 also forms the base for Wireless 3G Mobile networking [17].

## IV. A MAJOR QUESTION

Also a major question that may arise that while during this process of IPv4 to IPv6 shift, how one can access IPv4-Only content once we run out of Globally Routable IPv4 Addresses?? Deployment of so called "Dual stack" configuration won't work in that case. One solution would be to give those customers only an IPv6 address, and then use an "IPv6-to-IPv4 GATEWAY" device to bridge IPv4-only content to IPv6-only users. An example for this can be seen at [18] Another option would be to give customers an IPv6 address and a private (RFC1918) IPv4 address that communicates with the world of globally routable IPv4 addresses via "Large Scale ("Carrier Grade") NAT. NAT also makes it possible for multiple workstations to all use a single shared globally routable IPv4 address, and many home users can connect a home network to their broadband provider via one of those little Linksys wireless access points. This solution too suffers from some of issues like applications specific, losing of transparency, difficulty in tracking down of abusive complaints etc. It may prove good for simple needs but for exotic needs like video conferencing etc., NAT will not going to work.

## V. CONCLUSION

IPv6 has got so many technical challenges and thus the shifting from IPv4 seems to a bit difficult, for the time being. Also it is really needed to pay attention on the fact that we we're getting really close to running out of IPv4 addresses. Therefore we should start the deployment process for the gradual shift, now. Also we should adopt techniques to remove the concerned pitfalls and try to learn more and more about IPv6 [10]. With 3G already been introduced and 4g is on the way the shift seems to be the only way. Apart from these technical issues involved we have also to take measures for internet traffic control improvements, QoS both for fixed/mobile environments, and most importantly for the security or protection of the architecture & infrastructure. (Deployment of IPv6 networks required to satisfy evolving network/service architecture models)European research networks [19] have by far proved successful and thus can act as base for further implementations.

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