Is the IPv6 Address Space Too Small?

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BT exact TECHNOLOGIES

Introduction

- The current organisation of IPv6's 128 bit address space will not support emerging Next Generation Network applications such as ubiquitous computing.
- Division of address space is extremely wasteful, but required for commercial and political reasons
- On this basis it is likely that over 160 bits of address space is required for ubiquitous computing applications.
- IPv6 Network Operators will experience political, technical and commercial constraints similar to those caused by IPv4 address exhaustion, within a decade.
- Some future apps will probably not use IP

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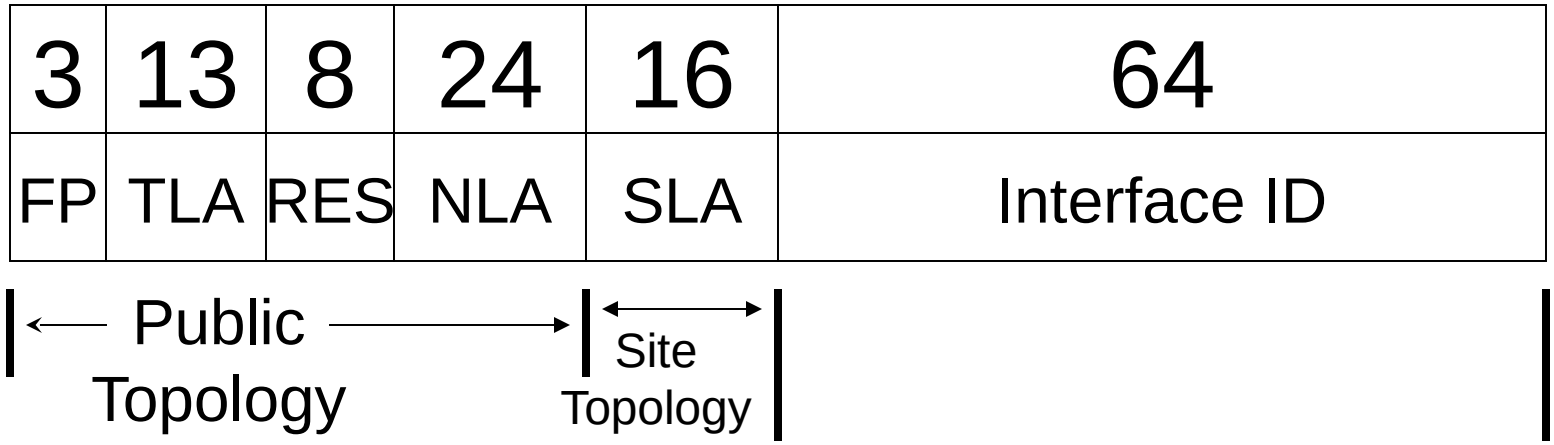
A typical “NGN” application objective.

- For Heinz to ask a tin of baked beans if its been opened.

“Have you been opened?” asked Heinz.

The IPv6 Address Format

- Specified in RFC2374.



FP	Format Prefix (001)
TLA ID	Top-Level Aggregation Identifier
RES	Reserved for future use
NLA ID	Next-Level Aggregation Identifier
SLA ID	Site-Level Aggregation Identifier
INTERFACE ID	Interface Identifier

The EUI-64

- The Interface ID, the last 64 bits of an IPv6 address, can be an EUI-64 or a random number.
- The IEEE defined 64-bit global identifier (EUI-64) is assigned by a manufacturer that has been assigned a company_id value by the IEEE Registration Authority.
- The IEEE administers the assignment of 24-bit company_id values.
- See http://standards.ieee.org/regauth/oui/tutorials/EUI64.html
- The EUI-64 is used as a name in LANs to switch traffic to the right device.

The EUI-64. Continued.

- LAN switches have a “routing” entry per attached device.
- As such LAN switching has limited scalability. It works today because they are attached to routers that route on addresses.
- The EUI-64 identifies the manufacturer of an object but not the user or type of the object.
- Note the old EUI-48 (MAC address) is being superseded by the EUI-64 because of MAC space address exhaustion.

Comparison with product bar codes

- Universal Product Codes, as seen on bar codes, are 12 digit numbers, the last digit is a check digit.
- 11 digits are required to identify the product (10 billion products with up to 10 versions.)
- this is equivalent to 37 bits.
- See http://www.howstuffworks.com/upc.htm
- Heinz sold 650 million bottles of ketchup in 2000.
- It is reasonable to assume we need at least 1 Billion unique numbers per product per year to cater for many products.
- Assume a number life time of 100 years.
- This requires 40 bits to give a unique number to each unique product.

Comparison with product bar codes, continued.

- To uniquely identify every product produced over the next 100 years requires 37 bits to identify the product type and 40 bits to enumerate the product = **77 bits**.
- Even for existing network apps 10 billion people owning average 5 network devices each, with 4 addresses (fixed, mobile, anycast, multicast) per device on average, will require >40 bits

The IPv6 Address Format

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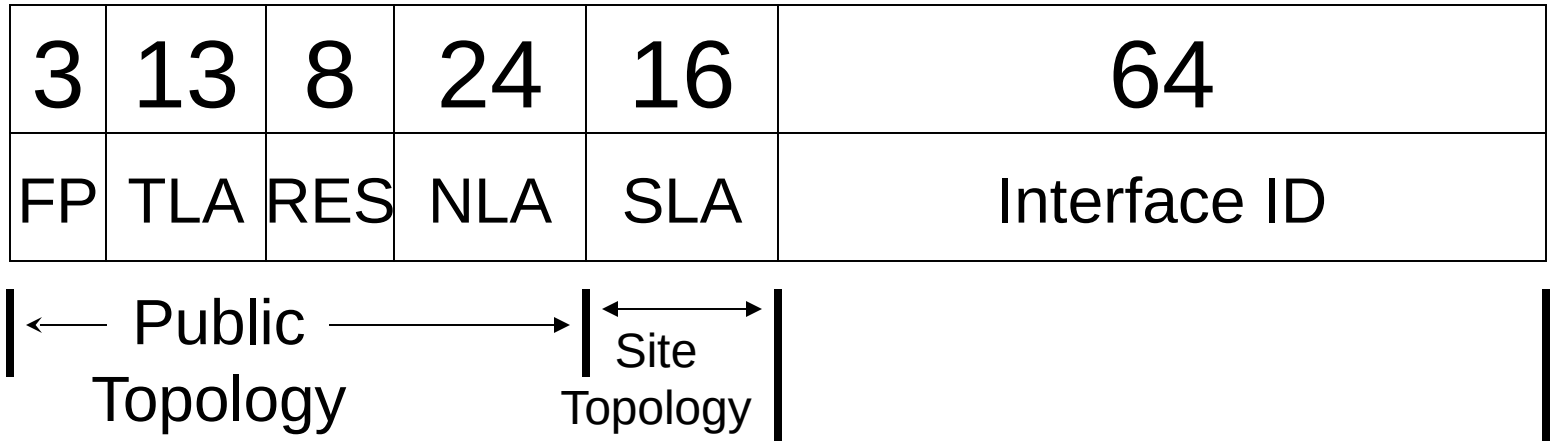

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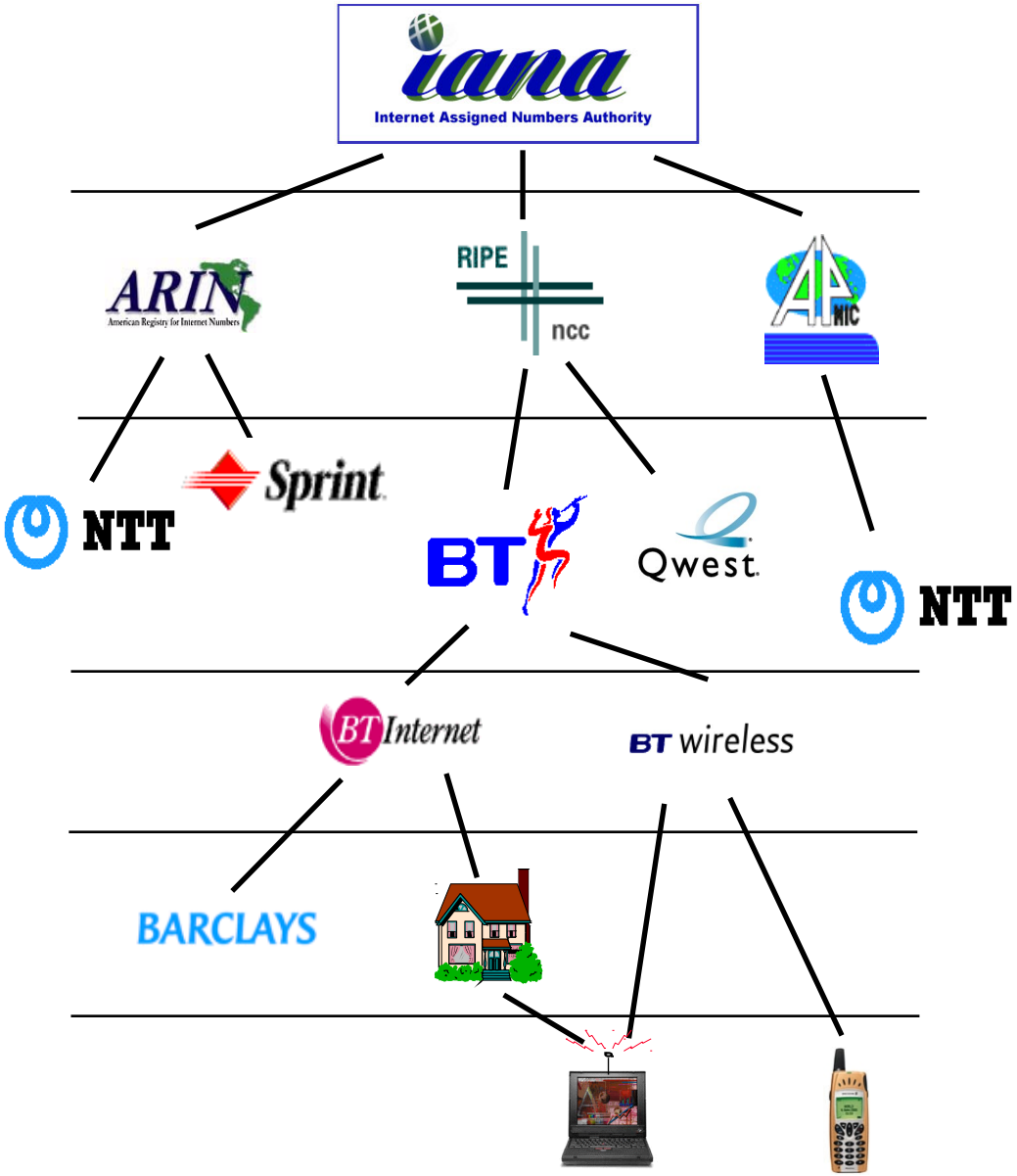
What network operators use address space for.

- With the 24 bits of the NLA the network operator needs to describe their network topology.
- An enterprise will only have 16 bits of the SLA to describe their network topology.
- How many bits does a global network operator need to describe their network topology?

IPv6 – Addressing Issues - Today's Problem



Internet Assignned Numbers Authority

Registries
eg. 2001::/23

Internet Service Providers (ISP's) Exchanges / Carriers
eg. 2001:618::/35

Sites / SME's / Home Users (Site) **eg. 2001:618:100B::/48**

Mobile Phones / Home Apps PDA's **eg. 2001:618:100B:F8::/64**

Global Network Addressing Scheme1

Hierarchical Level	Size	Number of bits
Continent	7	3
Country	221	8
State/County	64	6
Town	128	7
Line/Site	1024	10

Total = 34 bits

Remember current NLA size = 24 bits

Global Network Addressing Scheme2

Hierarchical Level	Size	Number of bits
International backbone	10 PoPs	4
Continental backbone	20 PoPs	5
Country backbone	1000 PoPs	10
Lines to customers	1024 lines	10

Total = 29 bits

Remember current NLA size = 24 bits

Global Network Addressing Scheme3 and NLA Size Conclusion

- Assume very efficient address allocation without any network hierarchy (not a recommended design!)then how many lines to customers could we have with a 24 bit NLA?
- 2^24 = 16 Million.
- Therefore 1 TLA would not be big enough for a UK wide operator with the potential to go to every home in the UK
- More than 1 TLA per operator has implications on the number of TLAs required.
- Simply a NLA of 24 bits is not big enough for a global network operator nor big enough for a UK operator aiming to reach every home.
- **A 34 bit NLA should be sufficient**.

SLA Size

- Largest enterprises own millions of lines
- It is reasonable to assume large Enterprises will require a similar network hierarchy to global network operators.
- Therefore the SLA should be the same size as the current NLA.
- **A 24 bit SLA could be sufficient.**

How many network operators?

- 13 bits of TLA = 8192 network operators
- It is assumed there will be less that 8192 network operators (note some network operators may require more than 1 TLA because of the lack of space in the NLA field).
- However, the number of ASes in operational use today is 8457.
- If the multi-homing problem can not be fixed then each AS will need its own TLA. Commercial realities may also dictate this.
- So today the 13 bit TLA is not big enough.

How many network operators? Continued.

- The trend is for all servers to become multi-homed for reliability reasons.
- There are proposals to increase the AS from 16 bits to 32 bits to cope with the growth in the number of ASes.
- It is estimated there is in the order of 15,000 ISPs in the World (14 bits)
- It is therefore reasonable to assume the minimum size of TLA should be 16 bits.
- **A 24 bit TLA should be sufficient**.
- Smaller TLAs might work if the multi-homing problem is fixed and network operators agree to the commercial model.

So how many bits do we need?

- 3 bits format prefix.
- 24 bits to identify the server/network operator
- 34 bits to describe the network operators topology.
- 24 bits to describe the enterprise topology.
- 77 bits to uniquely identify the object
- **162 bits total**
- Alternatively stay with IPv6's 128 bits but do not overload the interface-id functionality with an attempt to name the object. Use a 25 bit random number instead.

What are the implications of IPv6 address space being too small?

- Either IPv6 addresses are restructured so we have an IPv6.1 that decreases the number of bits used for the Interface ID.
- Or IPv6 network operators will be faced with similar political, commercial and technical constraints obtaining and using IPv6 addresses as current network operators experience with IPv4.
- IPv6 on its own does not enable “sci-fi” Next Generation Network applications.

Crystal Ball Gazing

- IPv6 address structure will be reworked into IPv6.1.
- The EUI-64 will be dropped and a smaller randomly generated number will be used instead.
- IPv6.1 will probably require upgrades to end-users operating systems (e.g Windows) and network infrastructure.
- IPv6.1 should be interoperable with IPv6.0 without needing translation.

The result.

“*Have you been opened?” asked Heinz.*

“Unable to locate that tin,” was the response.