Asia Pacific Network Information Centre

APNIC

Welcome!
APNIC Members Training Course

Internet Resource Management II

22 March 2004, Kathmandu, Nepal

Sponsored by Nepal Internet Exchange (NPIX)

Introduction

- Presenters
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<training@apnic.net>

Assumptions & Objectives

Assumptions

- Are current APNIC members
- Have submitted resource requests
- Are familiar with policies
- Are familiar with procedures

Objectives

- Teach members about specific APNIC guidelines and more advanced concepts
- Keep membership up-to-date with latest policies
- Liaise with members
  - ✂☺ Faces behind the e-mails

Schedule

- APNIC Role in the Asia Pacific
- Policy Guidelines

TEA BREAK
(10:30 – 11:00)

- APNIC Database – advanced topics
- ASN

LUNCH (12:30 – 13:30)

- Internet Routing Registry
- Reverse DNS

TEA BREAK
(15:30 – 16:00)

- IPv6
- Summary

APNIC's role in the Asia Pacific

Asia Pacific Network Information Centre

Overview

- What is APNIC?
  - Regional Internet Registry
  - APNIC structure
- What Does APNIC do ?
  - APNIC Membership services
- Why APNIC ?
  - APNIC resources
  - APNIC environment
  - APNIC responsibilities

What is APNIC?

- RIR for the Asia Pacific
  - Regional Internet Registry
  - Regional authority for Internet Resource distribution
  - IPv4 & IPv6 addresses, ASNs, reverse dns delegation
- Industry self-regulatory body
  - Non-profit, neutral and independent
- Open membership-based structure

APNIC is not…

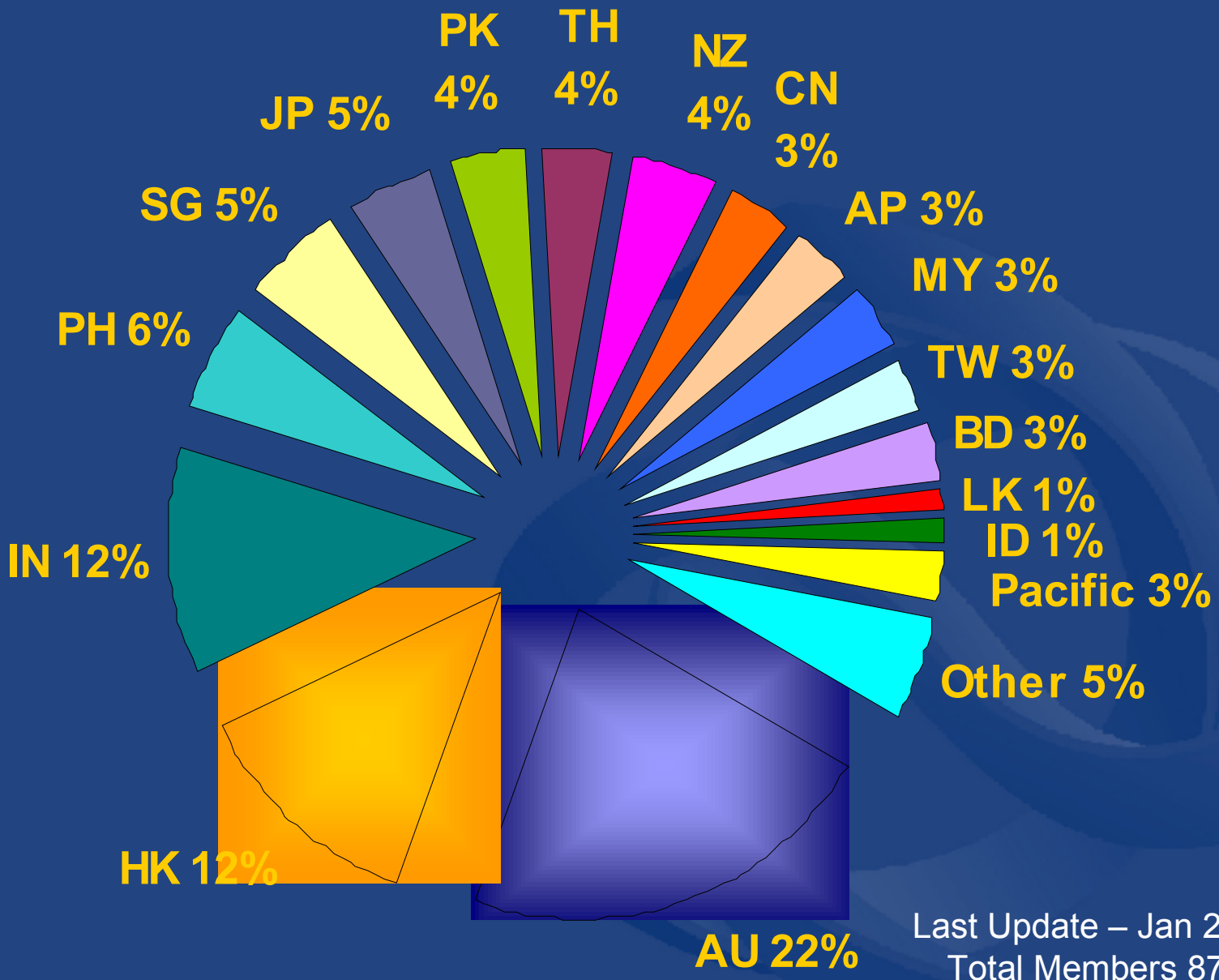
- Not a network operator
  - Does not provide networking services
    - Works closely with APRICOT forum
- Not a standards body
  - Does not develop technical standards
    - Works within IETF in relevant areas (IPv6 etc)
- Not a domain name registry or registrar
    - Will refer queries to relevant parties

APNIC structure

- Industry self-regulatory structure
  - Participation by those who use Internet resources
  - Consensus-based decision making
    - Eg. Policy changes, db requirements etc
  - Open and transparent
- Meetings and mailing lists
  - Open to anyone

APNIC region

APNIC Membership



Last Update – Jan 2004
Total Members 879

APNIC Services & Activities

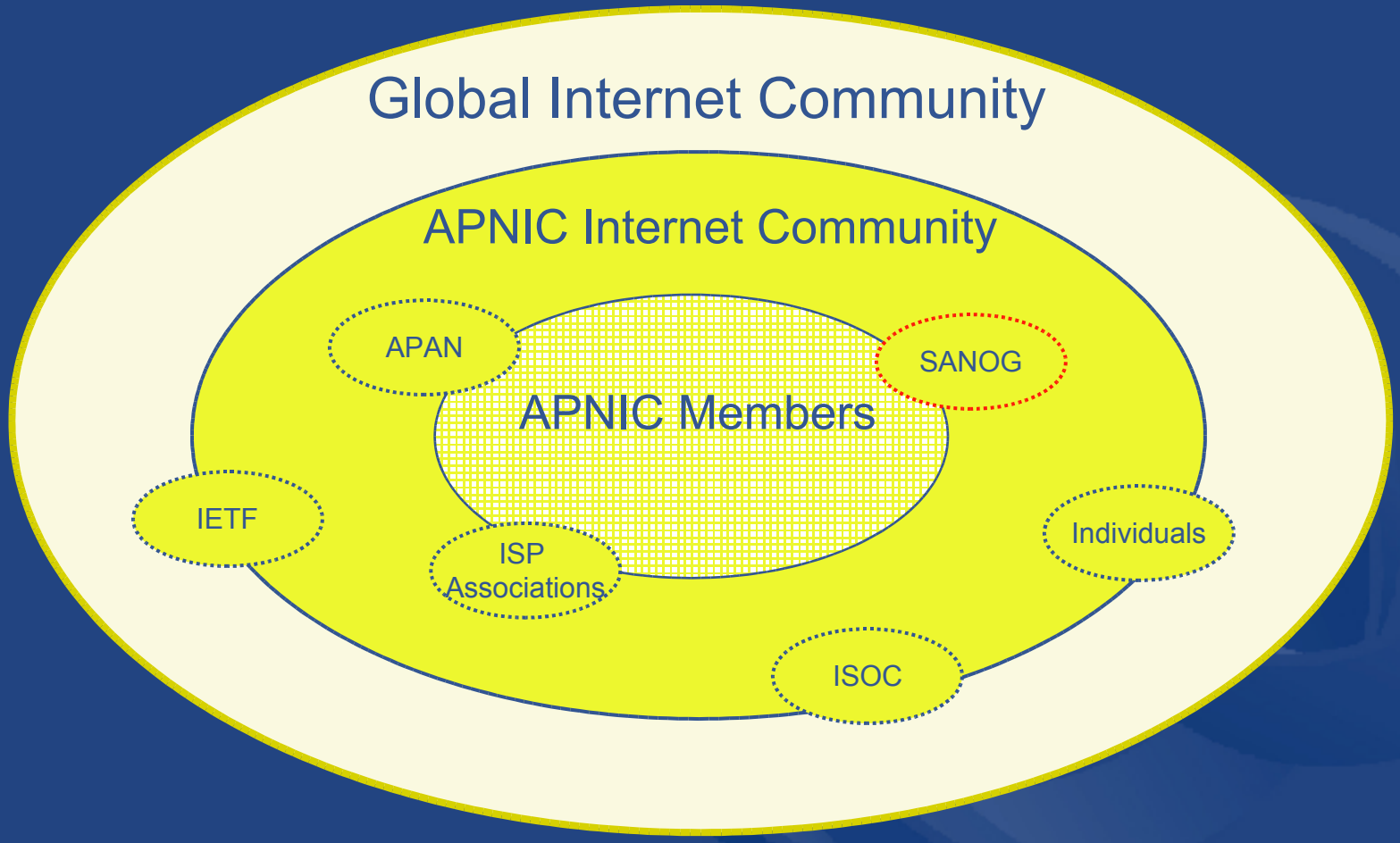
Resources Services

- IPv4, IPv6, ASN, reverse DNS
- Policy development
  - Approved and implemented by membership
- APNIC whois db
  - whois.apnic.net
  - Registration of resources

Information dissemination

- APNIC meetings
- Web and ftp site
- Mailing lists
  - Open for anyone!
- Training Courses
  - Subsidised for members
- Co-ordination & liaison
  - With membership, other RIRs & other Internet Orgs.

Definition – “Internet Community”



Questions ?

Policy guidelines

Additional guidelines, tips, recommendations and recap

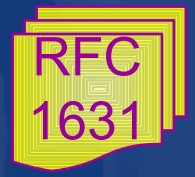
RIR Policy objectives – *Recap!*

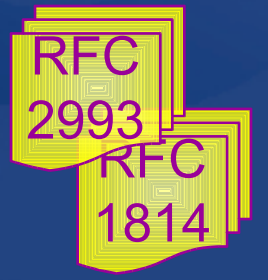
- Conservation
  - *Ensuring efficient use and conservation of resources*
- Aggregation
  - *Limiting growth of routable prefixes*
- Registration
  - *Registering the Internet resources in a public db*
- Uniqueness
  - *Global visibility*
- Fairness and consistency
  - *Equal consideration irrespective of external factors*

Private address space & NAT

- Private address space
  - Not necessary to request from the RIRs
    - Strongly recommended when no Internet connectivity
      - 10/8, 172.16/12, 192.168/16

- Network Address Translation (NAT)
  - Use entirely up to individual organisation
    - Considerations:
      - breaks end-to-end model, increases complexity, makes troubleshooting more difficult, introduces single point of failure





General assignment guidelines

- Static & Dynamic
  - Transient connections (dial-up)
    - dynamic recommended
  - Permanent connections
    - static assignments ok (1:1 contention ratio)
      - (dynamic encouraged)
- IP unnumbered
  - Encouraged when possible
    - Helps conserving IP addresses
      - statically routed, single-homed customer connections (no BGP)

http://www.apnic.net/info/faq/ip_unnumb.html

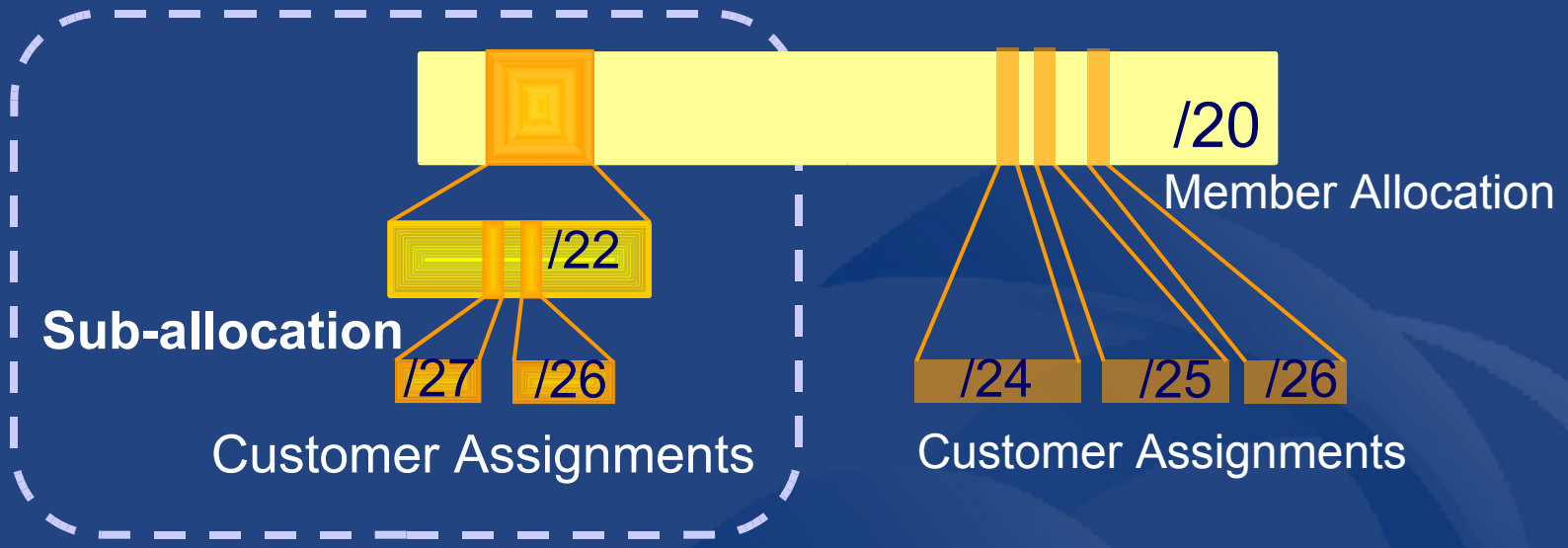
Cable/DSL guidelines

- Bootstrap criteria
  - Simplified, optional criteria
  - Assumption of /24 per CMTS
- Subsequent allocation
    - CMTS devices per headend
    - 3 month subscriber projection
    - Average growth per month
      - option: MRTG to support growth rate evaluation
    - equipment purchase receipts

Virtual web hosting

- Name based hosting
  - '*Strongly recommended*'
    - Use 'infrastructure' field to describe web servers
- IP based hosting
  - Permitted on technical grounds
    - SSL, virtual ftp..
    - Use 'infrastructure' field to describe web servers
  - Special verification for IP based
    - If more than /22 used for this purpose
    - Requestor must send list of URLs of virtual domain and corresponding IP address

Sub-allocations



- No max or min size
  - Max 1 year requirement
- Assignment Window & 2nd Opinion applies
  - to both sub-allocation & assignments
    - Sub-allocation holders don't need to send in 2nd opinions

Sub-allocation guidelines

- Sub-allocate cautiously
  - Seek APNIC advice if in doubt
  - If customer requirements meet min allocation criteria:
    - Customers should approach APNIC for portable allocation
- Efficient assignments
  - LIRs responsible for overall utilisation
    - Sub-allocation holders need to make efficient assignments
- Database registration
  - Sub-allocations & assignments to be registered in the db

GPRS guidelines

- Infrastructure
  - Agreed to use public addresses to support roaming and use private addresses where possible
  - Business as usual for RIRs
- Mobile phones
  - Draft document prepared by GSM Association
  - Recommends using private addresses where possible

http://www.gsmworld.com/technology/gprs/guidelines.shtml

Portable critical infrastructure assignments

- What is Critical Internet Infrastructure?
  - Domain registry infrastructure
    - Root DNS operators,
    - gTLD operators
    - ccTLD operators
  - Address Registry Infrastructure
    - RIRs & NIRs
    - IANA
- Why a specific policy ?
    - Protect stability of core Internet function
- Assignment sizes:
  - IPv4: /24
  - IPv6: /32

APNIC16 policy update

16th APNIC Open Policy meeting took place the 19th – 22nd August, Seoul, Korea

consensus

- Policy development proposal
  - Revised policy development process
    - Text proposal on ML 1 month before meeting
    - 'Comment period' on ML 2 months after meeting

consensus

- IPv4 policy proposal
  - Historical resource transfers
    - Allows transfers from 'historical' to 'current' status
    - Recipient must be an APNIC member
    - Address space subject to current policy framework

APNIC16 policy update

- IPv4/IPv6 policy proposal
  - Revised IXP assignment policy — consensus
    - Definition amended, restriction on routing lifted
    - Further discussion required for remainder of proposal
- IPv6 informational proposal — consensus
  - Create a guidelines document to explain existing IPv6 policy

APNIC17 policy update

- *17th APNIC Open Policy meeting took place the 25th – 27nd February 2004, Kuala Lumpur, Malaysia*

- IPv4 minimum allocation size

consensus

  - Consensus to lower the minimum allocation to /21 with lower eligibility criteria:
  - immediate need of /23 and
  - a detailed plan for /22 in a year

APNIC17 policy update

- IPv6 allocation to closed network
  - To allow IPv6 allocations to closed networks, if the other eligibility criteria are met

consensus

- IPv6 allocations to v4 networks
  - To allow IPv4 infrastructure to be explicitly considered during IPv6 request process
  - The proposal was amended slightly to add a requirement for LIRs to have plan to move some of their customers from IPv4 to within two years

consensus

APNIC17 policy update

- Recovery of address space
  - To recover unused historical IPv4 addresses in the AP region.

consensus

consensus

- IPv6 Guidelines document
  - An informational document to assist with understanding the IPv6 request process. The APNIC Secretariat will edit the document and publish it on the sig-policy mailing list for comments

APNIC17 policy update

consensus

- Protecting historical resource records in the APNIC Whois Database
  - To protect historical resource objects (inetnum and aut-num) in the APNIC Whois Database, in order to prevent unverified transfer of resources.
  - Existing custodians that wish to maintain records should sign a formal agreement with APNIC and pay service fees (capped at US$100)

APNIC17 policy update

consensus

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Questions ?

Advanced Database

Advanced queries, role objects & PGP protection

Basic database query – *Recap!*

- Unix
  - whois –h whois.apnic.net <lookup key>
    - Example:

      whois –h whois.apnic.net HM20-AP

      whois –h whois.apnic.net 202.12.29/24

- Web interface
  - http://www.apnic.net/apnic-bin/whois2.pl
    - Also capable of performing advanced queries

Advanced database queries

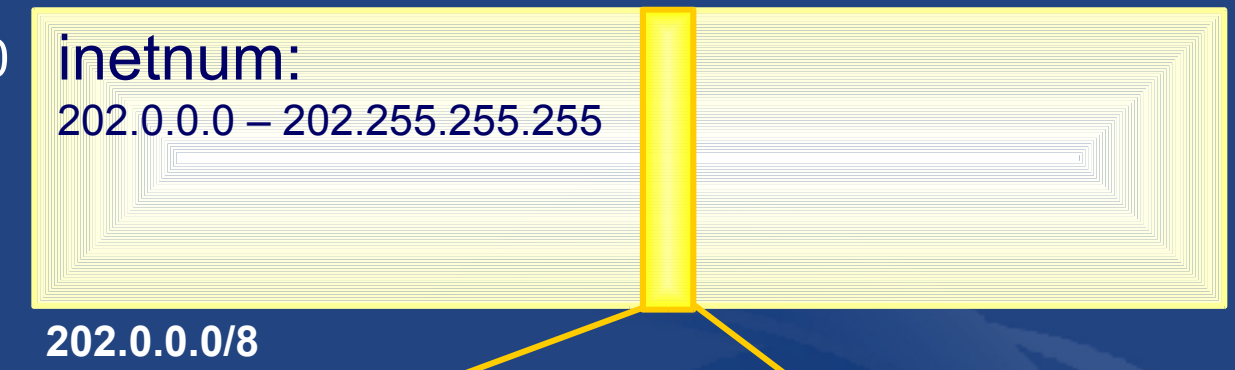
– Flags used for inetnum queries

None find exact match
- l find one level less specific matches
- L find all less specific matches
- m find first level more specific matches
- M find all More specific matches
- x find exact match (if no match, nothing)
- d enables use of flags for reverse domains
- r turn off recursive lookups

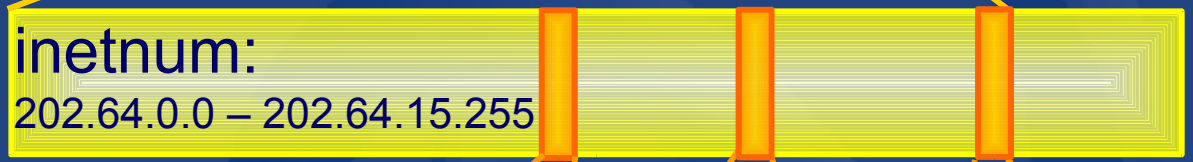
Database query - inetnum

whois -L 202.64.0.0 /20

Less specific →
(= bigger block)



whois 202.64.0.0 /20



whois –m 202.64.0.0 /20

More specific →
(= smaller blocks)

Database query - inetnum

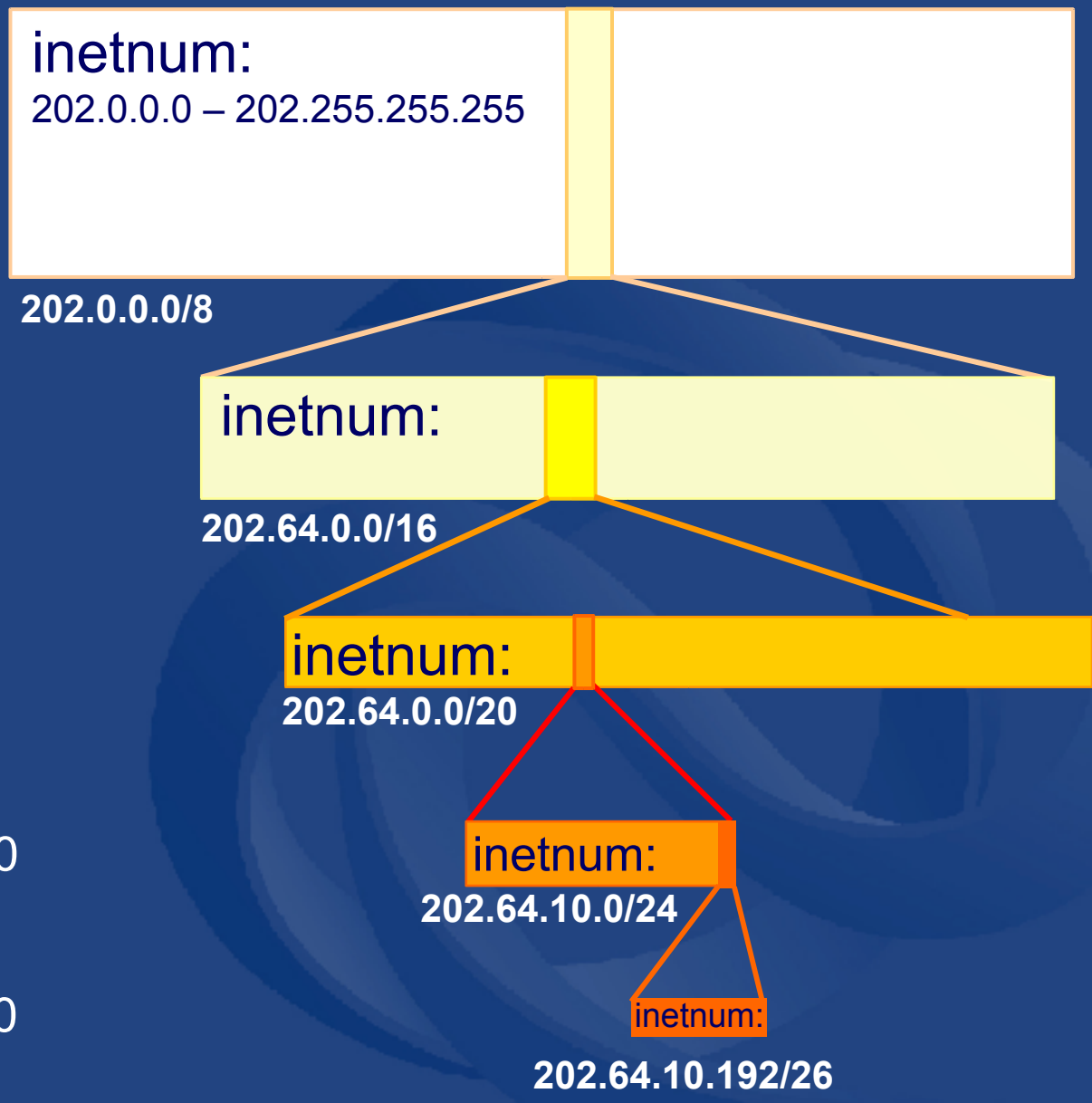
whois -L 202.64.0.0 /20
(all less specific)

whois -l 202.64.0.0 /20
(1 level less specific)

whois 202.64.0.0 /20

whois –m 202.64.0.0 /20
(1 level more specific)

whois –M 202.64.0.0 /20
(all more specific)



Database query - inetnum

'-M' will find all assignments in a range in the database

```
% whois -M 202.64.0.0/20
```

```
inetnum:     202.64.10.0 - 202.64.10.255
netname:     SILNET-AP
descr:       Satyam Infoway Pvt.Ltd.,
.....
inetnum:     202.64.12.128 - 202.64.12.255
netname:     SOFTCOMNET
descr:       SOFTCOM LAN (Internet)IP.
.....
inetnum:     202.64.15.192 - 202.64.15.255
descr:       SILNET
descr:       Satyam Infoway's Chennai LAN
.....
```

IP address queries

- -x<ip-lookup>
  - Only an exact match on a prefix
    - If no exact match is found, no objects are returned
    - whois -x [IP range]

- -d <ip-lookup>
  - Enables use of the "-m", "-M", "-l" and “-L" flags for lookups on reverse delegation domains.

Recursive lookups

- whois 202.12.29.0

recursion enabled by default

  - whois -r 202.12.29.0

recursion turned off

  - whois -T inetnum 202.12.29.0

'type' of object specified

  - whois -r -T inetnum 202.12.29.0

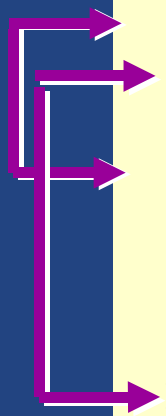
'type' of object specified & recursion turned off

Database query - recursion

Recursion is enabled by default

```
% whois 203.113.0.0/19

inetnum:      203.113.0.0 - 203.113.31.255
netname:      TOTNET-AP
descr:        Telephone Organization of THAILAND(TOT)
descr:        Telephone and IP Network Service Provider
descr:        State Enterprise Thailand Government
country:      TH
admin-c:      NM18-AP
tech-c:       RC80-AP
   ..... .
person:       Nopparat Maythaveekulchai
address:      YTEL-1234 Office
address:      Telephone Organization of THAILAND(TOT)
   ..... .
person:       Rungsun Channarukul
address:      YTEL-1234 OfficeP
address:      Telephone Organization of THAILAND(TOT)
```



Database query – no recursion

Turn off recursion '-r' no nic-handle lookup

```
% whois -r  203.113.0.0/19
```

```
inetnum:      203.113.0.0 - 203.113.31.255
netname:      TOTNET-AP
descr:        Telephone Organization of THAILAND(TOT)
descr:        Telephone and IP Network Service Provider
descr:        State Enterprise Thailand Government
country:      TH
admin-c:      NM18-AP
tech-c:       RC80-AP
mnt-by:       APNIC-HM
mnt-lower:    MAINT-TH-SS163-AP
changed:      hostmaster@apnic.net 19990922
source:       APNIC
```

Inverse queries

- Inverse queries are performed on inverse keys
  - *See object template (whois –t)*
- Returns all objects that reference the object with the key specified as a query argument
  - Practical when searching for objects in which a particular value is referenced, such as your nic-hdl
- Syntax: whois -i <attribute> <value>

Inverse queries - examples

- *What objects are referencing my nic-hdl?*
  - whois -ipn KX17-AP
- *In what objects am I registered as tech-c?*
  - whois –i tech-c KX17-AP
- *Return all domain objects where I am registered as admin-c, tech-c or zone-c*
  - whois -i admin-c,tech-c,zone-c -T domain KX17-AP

- *What objects are protected by my maintainer?*
  - whois -i mnt-by MAINT-WF-EX

Database query - inverse

Inverse lookup with '-i '

```
% whois -i person DK26-AP
```

```
inetnum:      202.101.128.0 - 202.101.159.255
netname:      CHINANET-FJ
descr:        chinanet fujian province network
country:      CN
admin-c:      DK26-AP
……
domain:       128.103.202.in-addr.arpa
descr:        in-addr.arpa zone for 128.103.202.in-addr.arpa
admin-c:      DK26-AP
…….
aut-num:      AS4811
as-name:      CHINANET-CORE-WAN-EAST
descr:        CHINANET core WAN EAST
descr:        connect to AT&T,OPTUS
country:      CN
admin-c:      DK26-AP
……
person:       Dongmei Kou
address:      A12,Xin-Jie-Kou-Wai Street,
address:      Beijing,100088
country:      CN
phone:        +86-10-62370437
nic-hdl:      DK26-AP
```

Database query - options

- Summary of other flags:
  - -i inverse lookup on given attribute
  - -t give template for given type
  - -v verbose information for given type
  - -h specify database server site
- For more information try...
  - whois -h whois.apnic.net HELP

Role object

- Represents a *group* of contact persons for an organisation
  - Eases administration
  - Can be referenced in other objects instead of the person objects for individuals
- Also has a nic-hdl
  - Eg. HM20-AP

http://www.apnic.net/db/role.html

Role object - example

- Contains contact info for several contacts

Attributes	Values
role:	OPTUS IP ADMINISTRATORS
address:	101 Miller Street North Sydney
country:	AU
phone:	+61-2-93427681
phone:	+61-2-93420813
fax-no:	+61-2-9342-0998
fax-no:	+61-2-9342-6122
e-mail:	noc@optus.net.au
admin-c:	NC8-AP
tech-c:	NC8-AP
tech-c:	SC120-AP
nic-hdl:	OA3-AP
mnt-by:	MAINT-OPTUSCOM-AP
source:	APNIC

Creating a role object

- Email
  - Whois –t role
    - Gives role object template
  - Complete all fields
    - With the nic-hdls of all contacts in your organisation
  - Send to

<auto-dbm@apnic.net>

Replacing contacts in the db
- using person objects

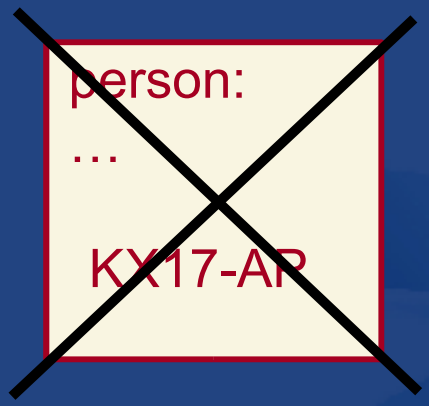
K. Xander is leaving my organisation. Z. Ulrich is replacing him.

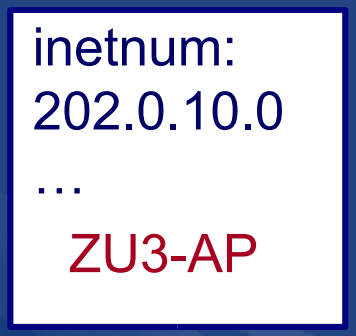
1. Create a person object for new contact (Z. Ulrich).

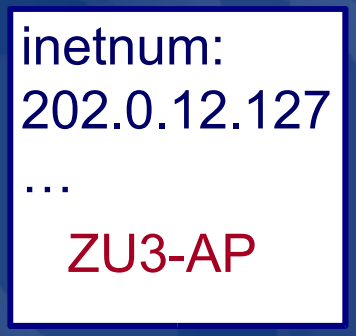
2. Find all objects containing old contact (K. Xander).

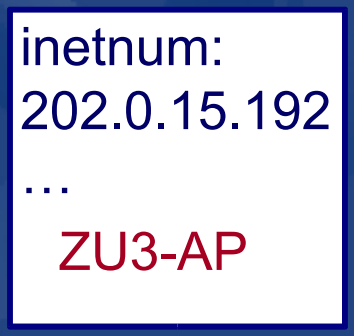
3. Update all objects, replacing old contact (KX17-AP) with new contact (ZU3-AP).

4. Delete old contact's (KX17-AP) person object.









Replacing contacts in the db
– *using a role object*

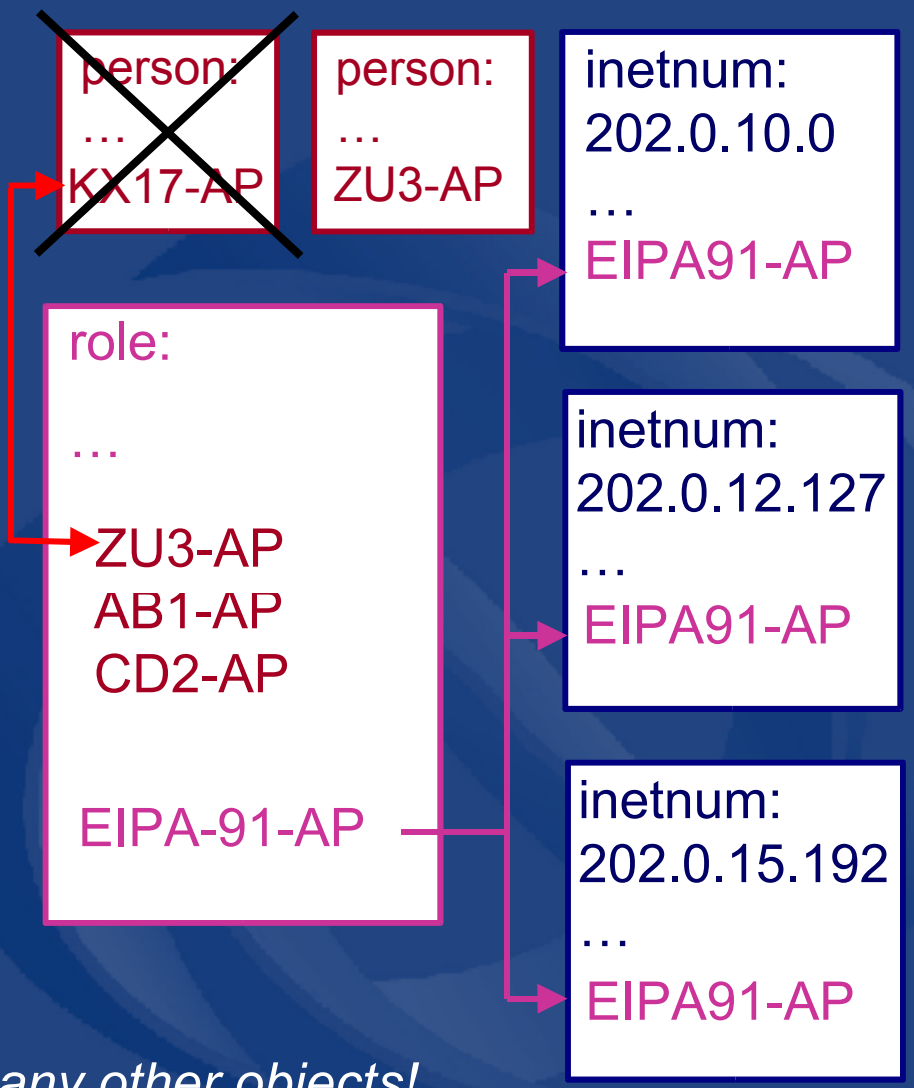
K. Xander is leaving my organisation. Z. Ulrich is replacing him.

I am using a role object containing all contact persons, which is referenced in all my objects.

1. Create a person object for new contact (Z. Ulrich).

2. Replace old contact (KX17-AP) with new contact (ZU3-AP) in role object

3. Delete old contact's person object.



No need to update any other objects!

Tip – Choosing your nic-hdl

- Automatic generation of nic-hdls

```
person:  Ky Xander
...
nic-hdl: KX17-AP
```

- Specifying initials in your nic-hdl

```
role:    SparkyNet Staff
...
nic-hdl: SN123-AP
```

Database authentication

PGP, CRYPT-PW and MD5

Authentication methods

- CRYPT-PW
  - Can be cracked, simple to use
- PGP
  - Considered secure
- MD5 (soon available)
  - Considered secure and very simple to use
- (None)
  - Offers no protection
    - *Should not be used as auth method!*

CRYPT-PW

- Use webform

Maintainer using CRYPT-PW

mntner:	MAINT-WF-SPARKYNET
descr:	Sparkynet ISP
auth:	CRYPT-PW aptHONzHrLHzQ
admin-c:	KX17-ap
tech-c:	ZU3-AP
country:	WF
mnt-nfy:	kxander@sparkynet.com
changed:	kxander@sparkynet.com 20030701
mnt-by:	MAINT-WF-SPARKYNET
referral-by:	APNIC-HM
source:	APNIC

Using PGP in the APNIC DB

1. Create a PGP key
2. Register public key in Database
   - Create key-cert object
3. Insert name of PGP key object in mntner ‘auth’ attribute

Outlook GnuPG plugin

- Download from
  - http://www3.gdata.de/gpg/download.html
- Install and follow the instructions

1. Public key created

-----BEGIN PGP PUBLIC KEY BLOCK-----
Version: GnuPG v1.0.4e (MingW32)
Comment: For info see http://www.gnupg.org

mQGiBD5BwbgRBACxLMukZVrtyLrso3EZ1nPWSUPilfn9aVWoJqDjRUoLaJ0gZ1tk
k+DjEvuBE3tSmoCDhypvBQl886dRwtpCm45e90iwYfyalJ51e5ymmUfTa7w4OqSg
D9YYO7/TDurQA3ezksBsyV5HWBoliamjLtT+mPFNYZTz+fZlii3JMD69nwCg+IzI
UhTDj5lh8SKJLo3yaeU5yPMD/1H9dP3bicXq53FSuOCQhRDkgFZaf86k0UQImWnq
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ms2M7gvSdkIH5OiE26tLpSvwmi/U/GSOfG6YtJqn7RbHWrO/pbQkQXJ0aCBQYXVs
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1r5TniR1y/xOmOZ6CQk5eNPHvlwi0Ohnqm9Sgl2o4mHq32vikVOvrhZq5IfLGMhG
UQMO9nDeA3DjLVtS1laStUkC6UoizbQxsdrUQDgm3Oha6FhfGCYZ9cxPkIU+ZLXo
pifMEohGBBgRAgAGBQI+QcG7AAoJEEV94S9UIjYiyl8AoKSLnWlwZhXjWtgJlX4I
Gpurqs3tAKDLH27XqiFdnswcd4HILPCr4eTb4g==
=rUbp
-----END PGP PUBLIC KEY BLOCK-----

2. Register public key

key-cert:	[mandatory] - 8 digit PGP key ID without "0x" prefix
method:	[generated] - System generated
owner:	[generated] - System generated
fingerpr:	[generated] - System generated
certif:	[mandatory] - exported public key in armored ASCII
remarks:	[optional] - same meaning with other object
notify:	[optional] - same meaning with other object
mnt-by:	[mandatory] - same meaning with other object
changed:	[mandatory] - same meaning with other object
source:	[mandatory] - same meaning with other object

Putting it all together

```
Key-cert:       PGPKEY-54223622
certif:         -----BEGIN PGP PUBLIC KEY BLOCK-----
certif:         Version: GnuPG v1.0.4e (MingW32)
certif:         Comment: For info see http://www.gnupg.org
certif:
certif:         mQGiBD5BwbgRBACxLMukZVrtyLrso3EZ1nPWSUPilfn9aVWoJqDjRUoLaJ0gZ1tk
certif:         k+DjEvuBE3tSmoCDhypvBQl886dRwtpCm45e90iwYfyalJ51e5ymmUfTa7w4OqSg
certif:         D9YYO7/TDurQA3ezksBsyV5HWBoliamjLtT+mPFNYZTz+fZlii3JMD69nwCg+lzl
certif:         UhTDj5lh8SKJLo3yaeU5yPMD/1H9dP3bicXq53FSuOCQhRDkgFZaf86k0UQImWnq
certif:         pJIh4tKhecAvCaomU3zmTtpMECBIR3bJOvMQl2BsStNE/nt7A/2HYX9ek4ztBJj0
certif:         F2/NPyyf0I2dmiVhdJaZilM7qS4hWEsjPxFJd1IV61eVJch14gWb61cp0yALlFtz
certif:         QHPlqfPqzrZp9u82OPH/PnHUvDsmyS/TEzVzmAPF4LbJxSFYH/Rt4XVwZCSpAbDu
certif:         a661fLUuTiBN5fcwPIDSQYr3Lwh8YRkK23wEyxYpyoqjZQyJJaWaOMPnDpM3BeON
certif:         dMmRSlWtHdfDjTlwdaCnAAMFA/0c59wwF9FuVSs6oARYbdyE6Aum1ITXG12UsDUv
certif:         Gpurqs3tAKDLH27XqiFdnswcd4HILPCr4eTb4g==
certif:         =rUbp
certif:         -----END PGP PUBLIC KEY BLOCK-----
remarks:        Mydigital ID
notify:         Arth@apnic.net
mnt-by:         MAINT-AU-BLUETOOTH
changed:        arth@apnic.net 20030206
source:         APNIC
Password:       my-crypt-password
```

Send template to <auto-dbm@apnic.net>

Key-cert object in APNIC DB

```
key-cert:   PGPKEY-FEB0C9ED
Method:     PGP
owner:      Ky Xander <kxander@sparkynet.com>
fingerpr:   A0C2 4EFC 5983 8606 A8AC  0C39 CC44 BEDB FEB0 C9ED
certif:      -----BEGIN PGP PUBLIC KEY BLOCK-----
certif:      PGPfreeware 7.0.3  <http://www.pgp.com>
certif:     …
certif:     kRBADZ32LpvNQenzoNdttqJyrVOcA1qYjr/2/inm1Cp2DEF
certif:     dsZ/pLA23lqGSgsi5dfbvF5ktZSWUmTxcNqTeaushAHNtlk
certif:     …
certif:     -----END PGP PUBLIC KEY BLOCK-----
remarks:    Mydigital ID
notify:     kxander@sparkynet.com
mnt-by:     MAINT-WF-SPARKYNET
changed:    kxander@sparkynet.com 20030701
source:     APNIC
```

3. Updating the maintainer object

mntner:	MAINT-WF-SPARKYNET
descr:	Sparkynet ISP
auth:	PGPKEY-54223622
admin-c:	KX17-ap
tech-c:	ZU3-AP
country:	WF
mnt-nfy:	kxander@sparkynet.com
changed:	kxander@sparkynet.com 20030701
mnt-by:	MAINT-WF-SPARKYNET
referral-by:	APNIC-HM
source:	APNIC

Send template to <auto-dbm@apnic.net>

MD5 (Soon available)

- Will be the recommended auth method
- Based on the MD5 hash algorithm
- Stronger protection than CRYPT-PW
  - *But just as easy to use!*

Questions ?

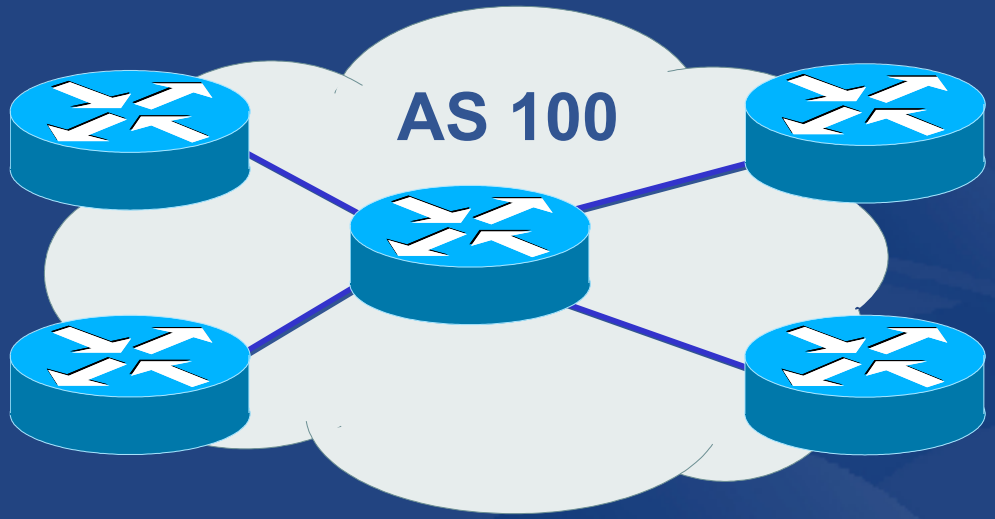
Autonomous System Numbers

Procedures

Overview

- What is an AS?
- Guidelines and procedures
- Application form (documentation)
- Policy expression

What is an Autonomous System?



- Collection of networks with same routing policy
- Usually under single ownership, trust and administrative control

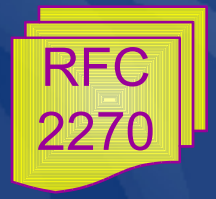
When do I need an ASN?

- When do I need an AS?
  - Multi-homed network to different providers and
  - Routing policy different to external peers

- Recommended reading!
  - RFC1930: Guidelines for creation, selection and registration of an Autonomous System

When don't I need an ASN?

- Factors that don't count
  - Transition and 'future proofing'
  - Multi-homing to the same upstream
    - RFC2270: A dedicated AS for sites homed to a single provider
  - Service differentiation
    - RFC1997: BGP Communities attribute



Requesting an ASN

- Complete the request form
  - web form available:
    - http://www.apnic.net/db/aut-num.html
- Request form is parsed - real time
  - Must include routing policy
    - multiple import and export lines
  - Is checked for syntactical accuracy
    - based on RPSL (rfc2622)
  - Peers verified by querying routing table
  - [NO-PARSE] will not send request to parser

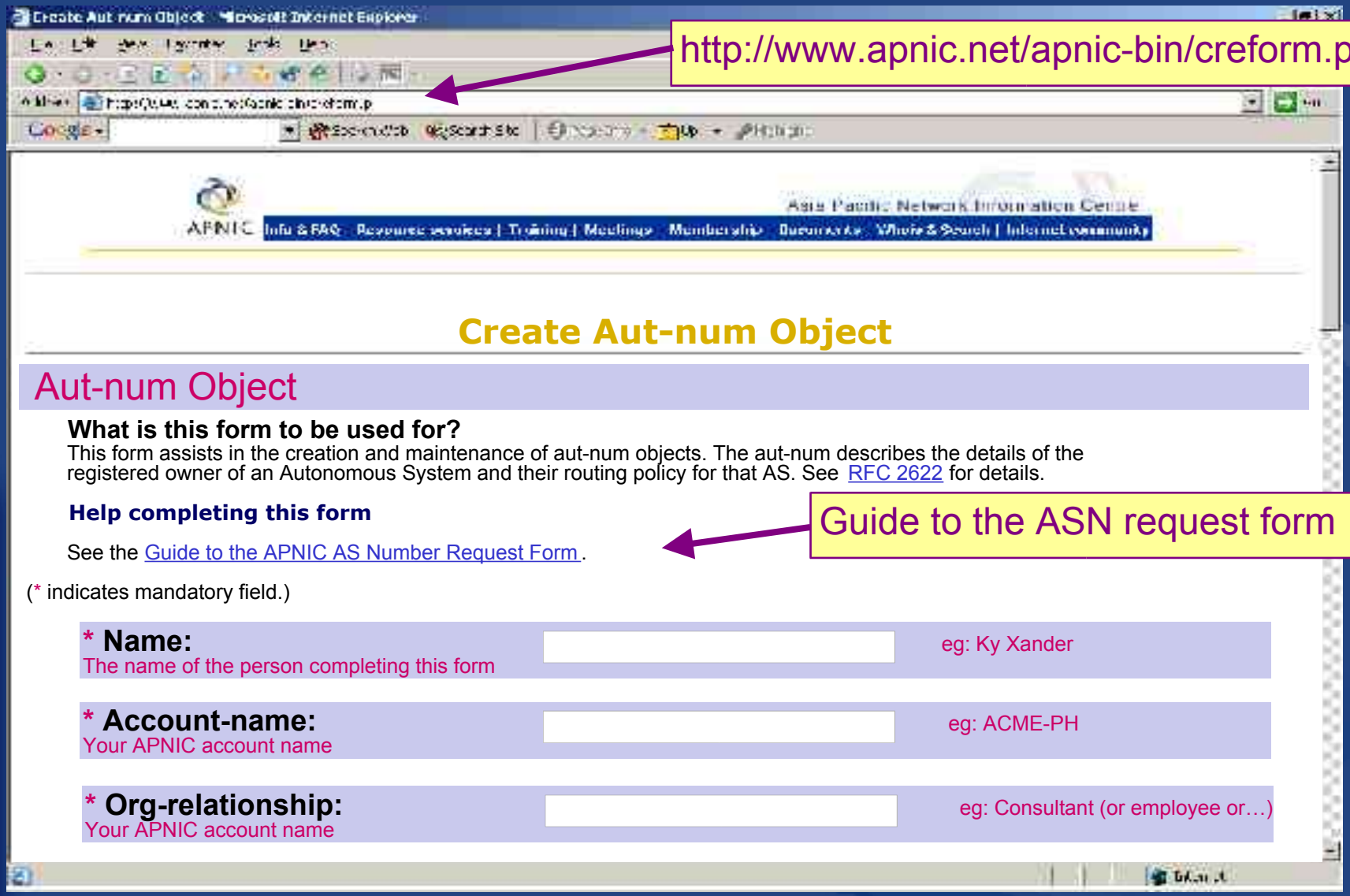
Requesting an ASN - Customers

1. Requested directly from APNIC
   - AS number is “portable”
2. Requested via member
   - ASN is “non-portable”
   - ASN returned if customer changes provider

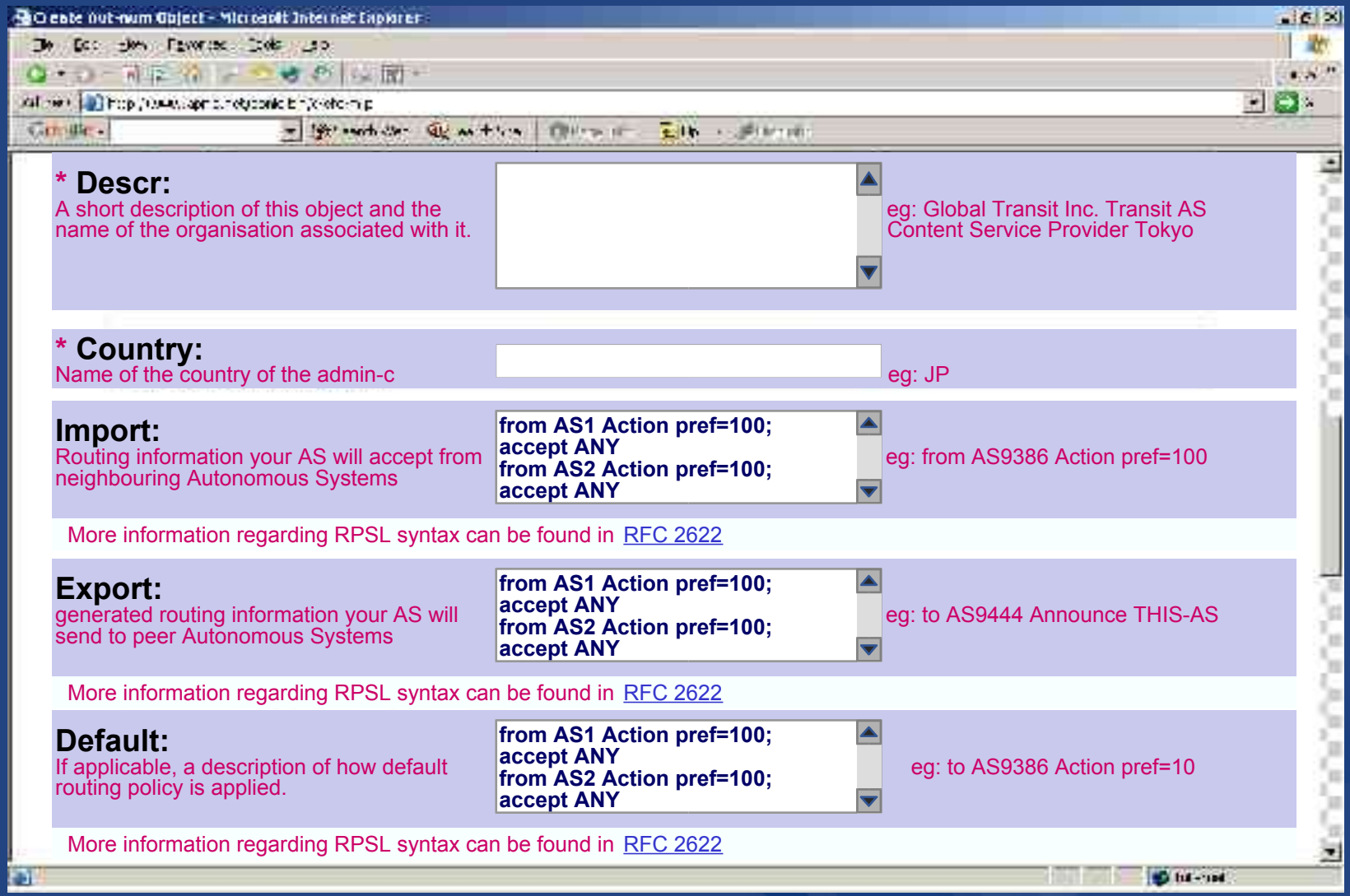
New policy as of Nov-02

- Transfers of ASNs
  - Need legal documentation (mergers etc)
  - Should be returned if no longer required

ASN request form



Request form – routing policy



*** Descr:**
A short description of this object and the name of the organisation associated with it.

eg: Global Transit Inc. Transit AS
Content Service Provider Tokyo

*** Country:**
Name of the country of the admin-c

eg: JP

Import:
Routing information your AS will accept from neighbouring Autonomous Systems

```
from AS1 Action pref=100;
accept ANY
from AS2 Action pref=100;
accept ANY
```

eg: from AS9386 Action pref=100

More information regarding RPSL syntax can be found in RFC 2622

Export:
generated routing information your AS will send to peer Autonomous Systems

```
from AS1 Action pref=100;
accept ANY
from AS2 Action pref=100;
accept ANY
```

eg: to AS9444 Announce THIS-AS

More information regarding RPSL syntax can be found in RFC 2622

Default:
If applicable, a description of how default routing policy is applied.

```
from AS1 Action pref=100;
accept ANY
from AS2 Action pref=100;
accept ANY
```

eg: to AS9386 Action pref=10

More information regarding RPSL syntax can be found in RFC 2622

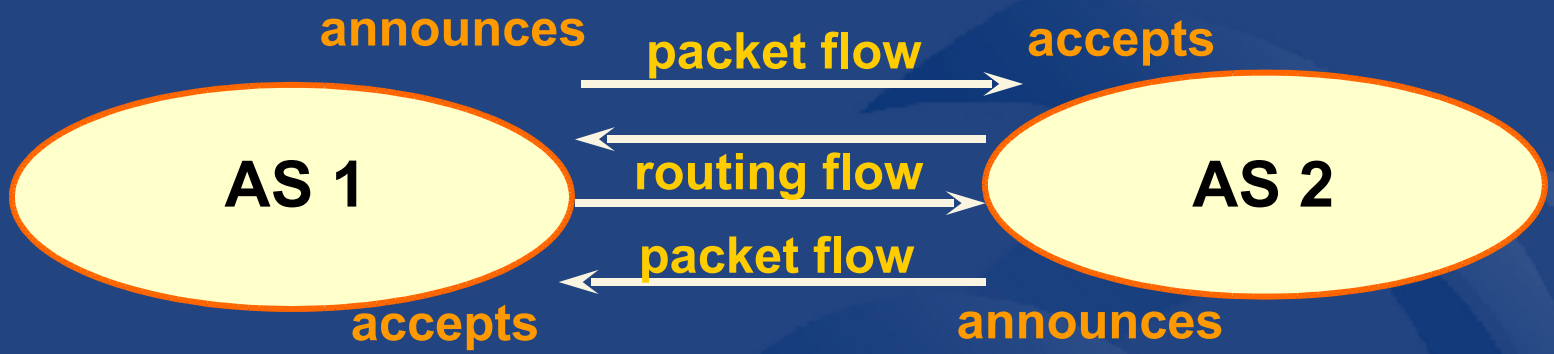
Aut-num object example

aut-num:	AS4777
as-name:	APNIC-NSPIXP2-AS
descr:	Asia Pacific Network Information Centre
descr:	AS for NSPIXP2, remote facilities site
import:	**from AS2500 action pref=100; accept ANY**
import:	**rom AS2524 action pref=100; accept ANY**
import:	**from AS2514 action pref=100; accept ANY**
export:	**to AS2500 announce AS4777**
export:	**to AS2524 announce AS4777**
export:	**to AS2514 announce AS4777**
default:	**to AS2500 action pref=100; networks ANY**
admin-c:	PW35-AP
tech-c:	NO4-AP
remarks:	Filtering prefixes longer than /24
mnt-by:	MAINT-APNIC-AP
changed:	paulg@apnic.net 19981028
source:	APNIC

POLICY RPSL

Representation of routing policy

- Routing and packet flows

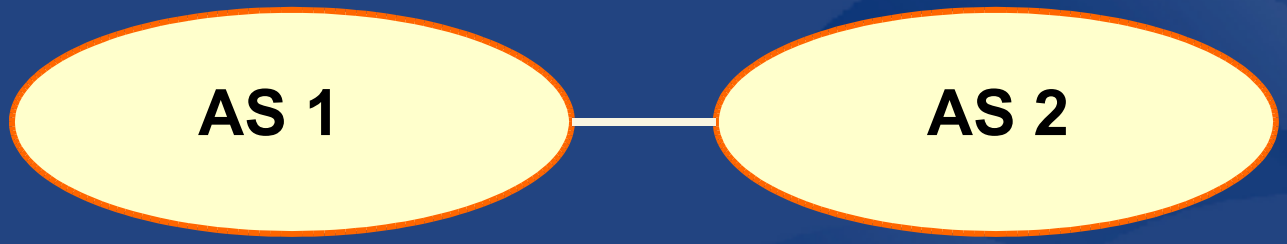


For AS1 and AS2 networks to communicate

- AS1 must announce to AS2
- AS2 must accept from AS1
- AS2 must announce to AS1
- AS1 must accept from AS2

Representation of routing policy

Basic concept

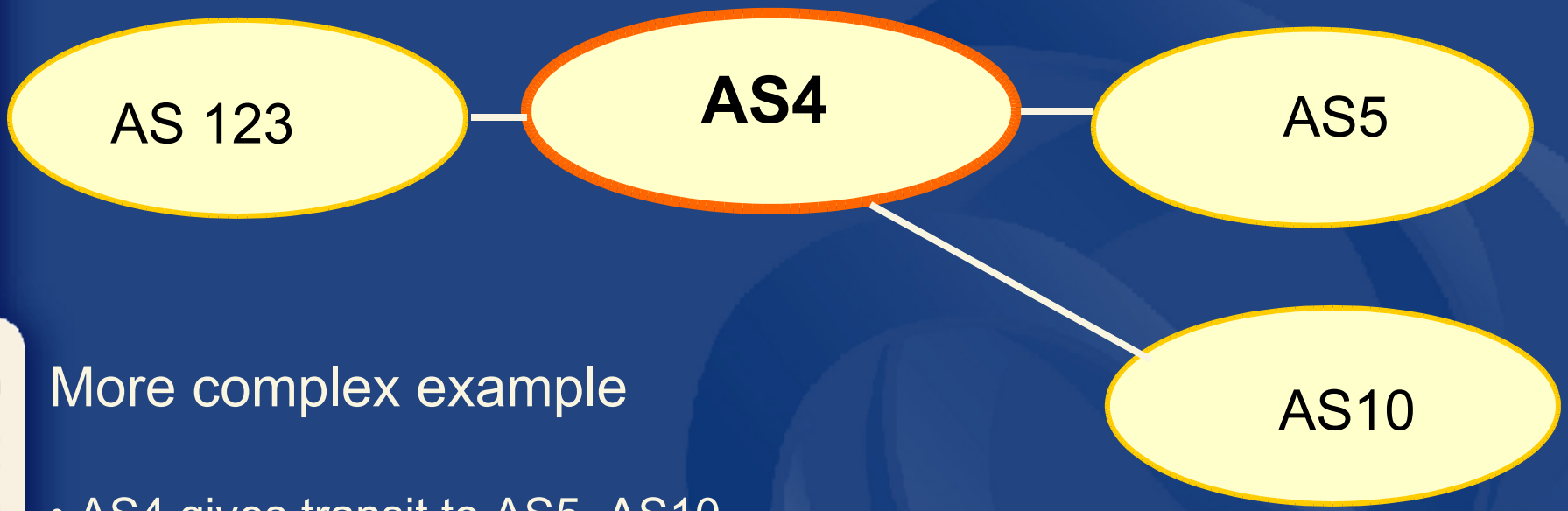


"action pref" - the lower the value, the preferred the route

aut-num: AS1
...
import: from AS2
action pref=100;
accept AS2
export: to AS2 announce AS1

aut-num: AS2
...
import: from AS1
action pref=100;
accept AS1
export: to AS1 announce AS2

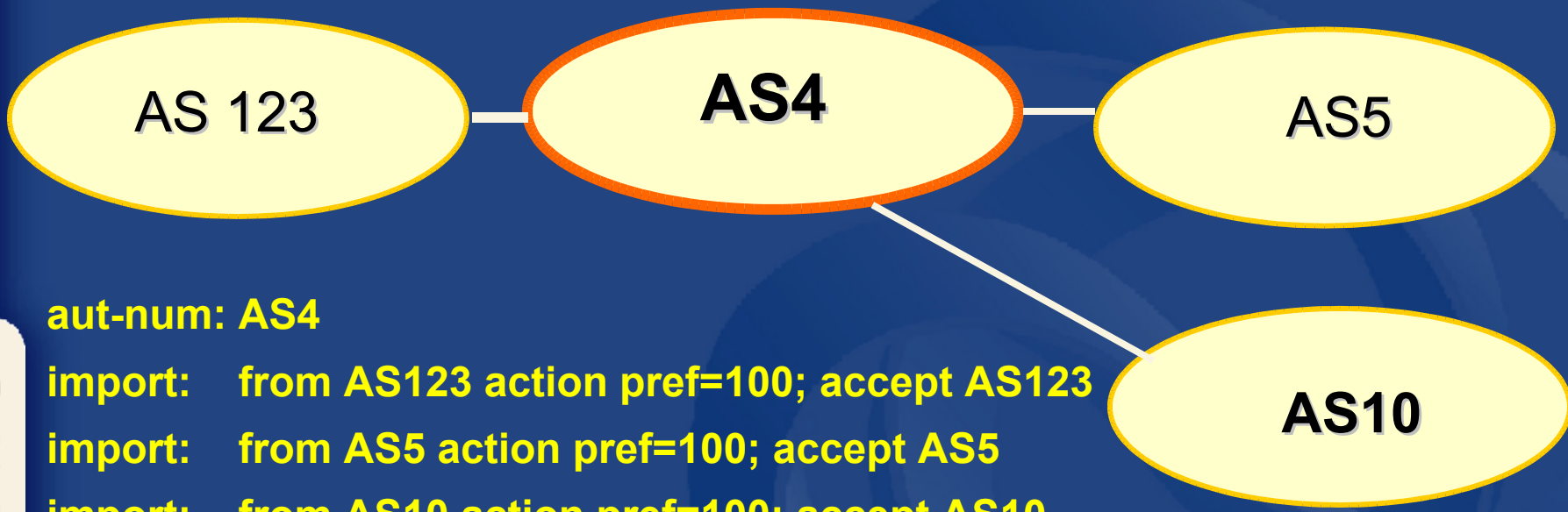
Representation of routing policy



More complex example

- AS4 gives transit to AS5, AS10
- AS4 gives local routes to AS123

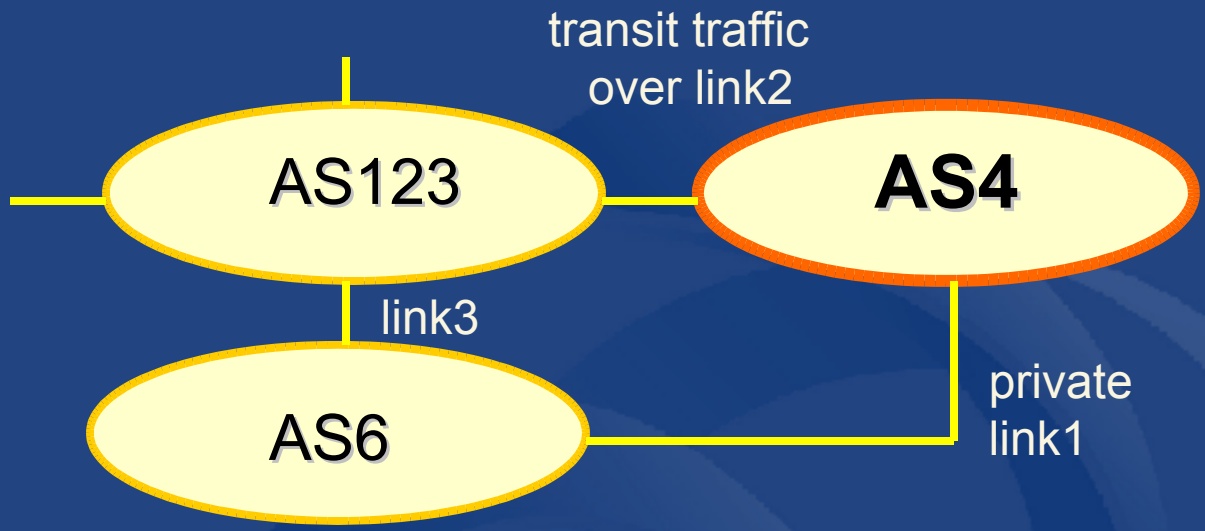
Representation of routing policy




```
aut-num: AS4
import:   from AS123 action pref=100; accept AS123
import:   from AS5 action pref=100; accept AS5
import:   from AS10 action pref=100; accept AS10
export:   to AS123  announce  AS4
export:   to AS5 announce AS4 AS10
export:   to AS10 announce AS4 AS5
```

Not a path

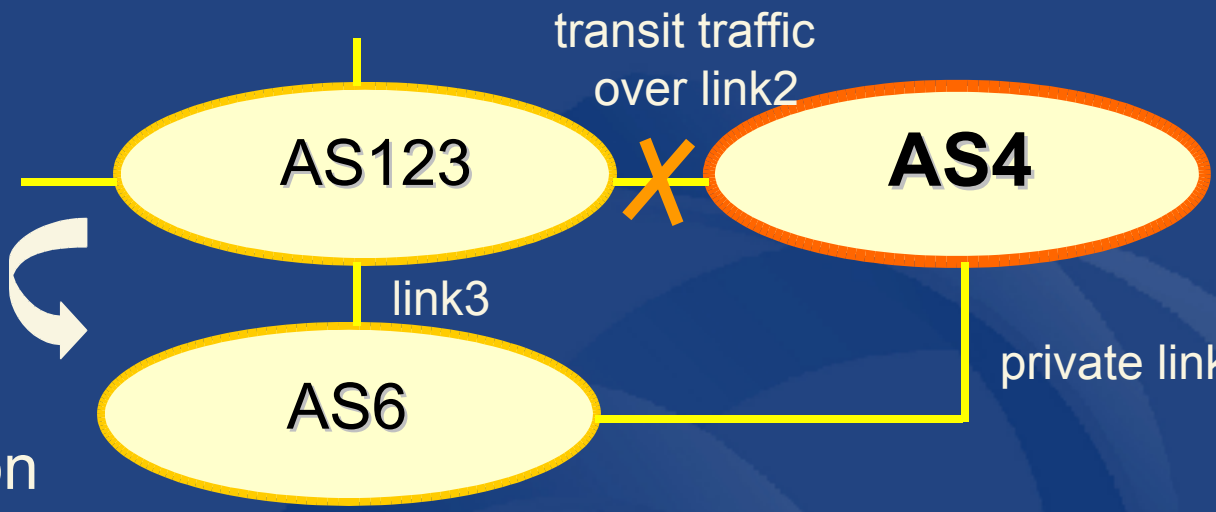
Representation of routing policy



More complex example

- AS4 and AS6 private link1
- AS4 and AS123 main transit link2
- backup all traffic over link1 and link3 in event of link2 failure

Representation of routing policy



AS representation

```
aut-num:    AS4
import:  from AS123 action pref=100; accept  ANY
import:  from AS6     action pref=50; accept AS6
import:  from AS6     action pref=200; accept  ANY
export:  to     AS6     announce   AS4
export:  to     AS123  announce   AS4
```

full routing received

higher cost for backup route

Routing Policy Specification Language

- RPSL
  - Derived from RIPE-181
  - Introduced with v3 Database
    - 20 August 2002
  - “New” object specification language
    - more expressive syntax
    - advanced aut-num and routing policy options
  - Especially useful in an Internet Routing Registry

Questions ?

Asia Pacific Network Information Centre

APNIC

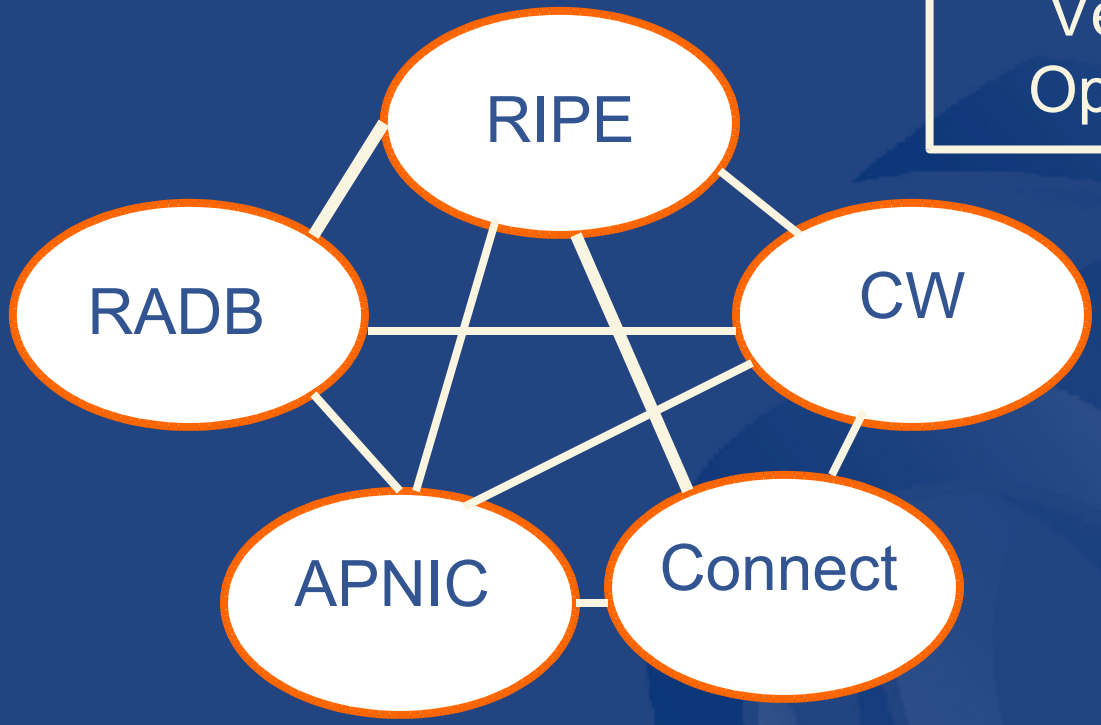
APNIC
Internet Routing Registry

What is an IRR?

- Global Internet Routing Registry database
  - http://www.irr.net/
    - Uses RPSL
  - Established in 1995
- Stability and consistency of routing
  - network operators share information
- Both public and private databases
  - These databases are independent
    - but some exchange data
    - only register your data in one database

Internet Routing Registries

ARIN, ArcStar, FGC, Verio, Bconnex, Optus, Telstra, ...



IRR = APNIC RR + RIPE DB + RADB + C&W + ARIN + …

Why use an IRR?

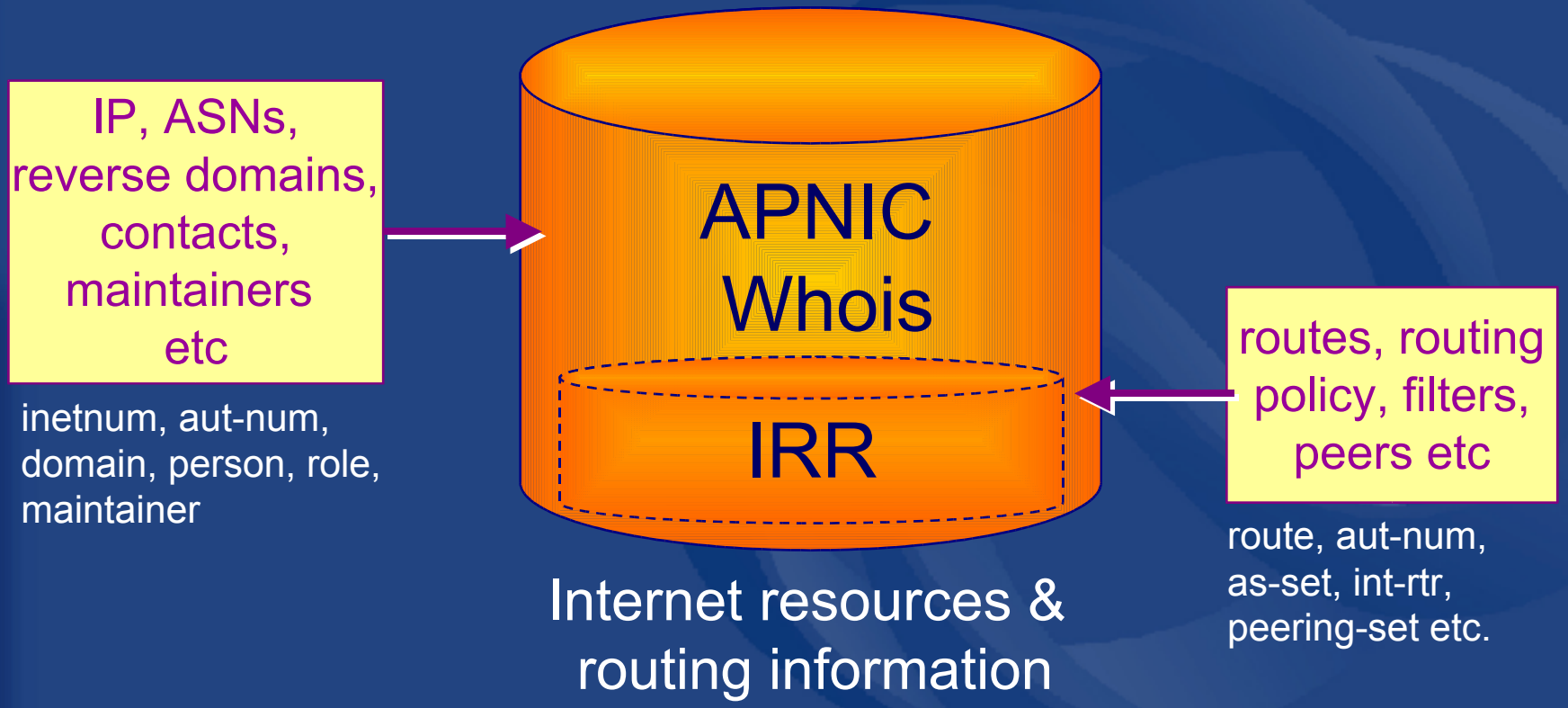
- Route filtering
  - Peering networks
  - A provider and its customer
- Network troubleshooting
  - Easier to locate routing problems outside your network
- Router configuration
  - By using IRRToolSet
    - ftp.ripe.net/tools/IRRToolSet
- Global view of routing
  - A global view of routing policy improves the integrity of Internet's routing as a whole.

APNIC Database & the IRR

- APNIC whois Database
  - Two databases in one
- Public Network Management Database
  - “whois” info about networks & contact persons
    - IP addresses, AS numbers etc
- Routing Registry
  - contains routing information
    - routing policy, routes, filters, peers etc.
  - APNIC RR is part of the global IRR

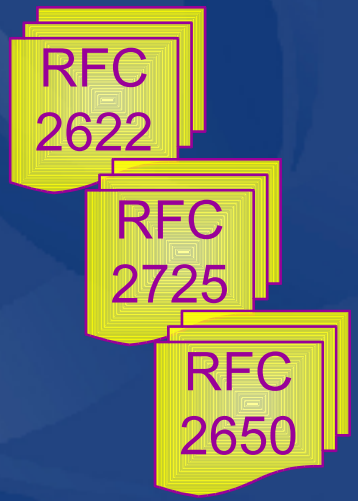
Integration of Whois and IRR

- Integrated APNIC Whois Database & Internet Routing Registry



RPSL

- Routing Policy Specification Language
  - Object oriented language
    - Based on RIPE-181
  - Structured whois objects
- Higher level of abstraction than access lists
- Describes things interesting to routing policy:
  - Routes, AS Numbers …
  - Relationships between BGP peers
  - Management responsibility
- Relevant RFCs
  - Routing Policy Specification Language
  - Routing Policy System Security
  - Using RPSL in Practice

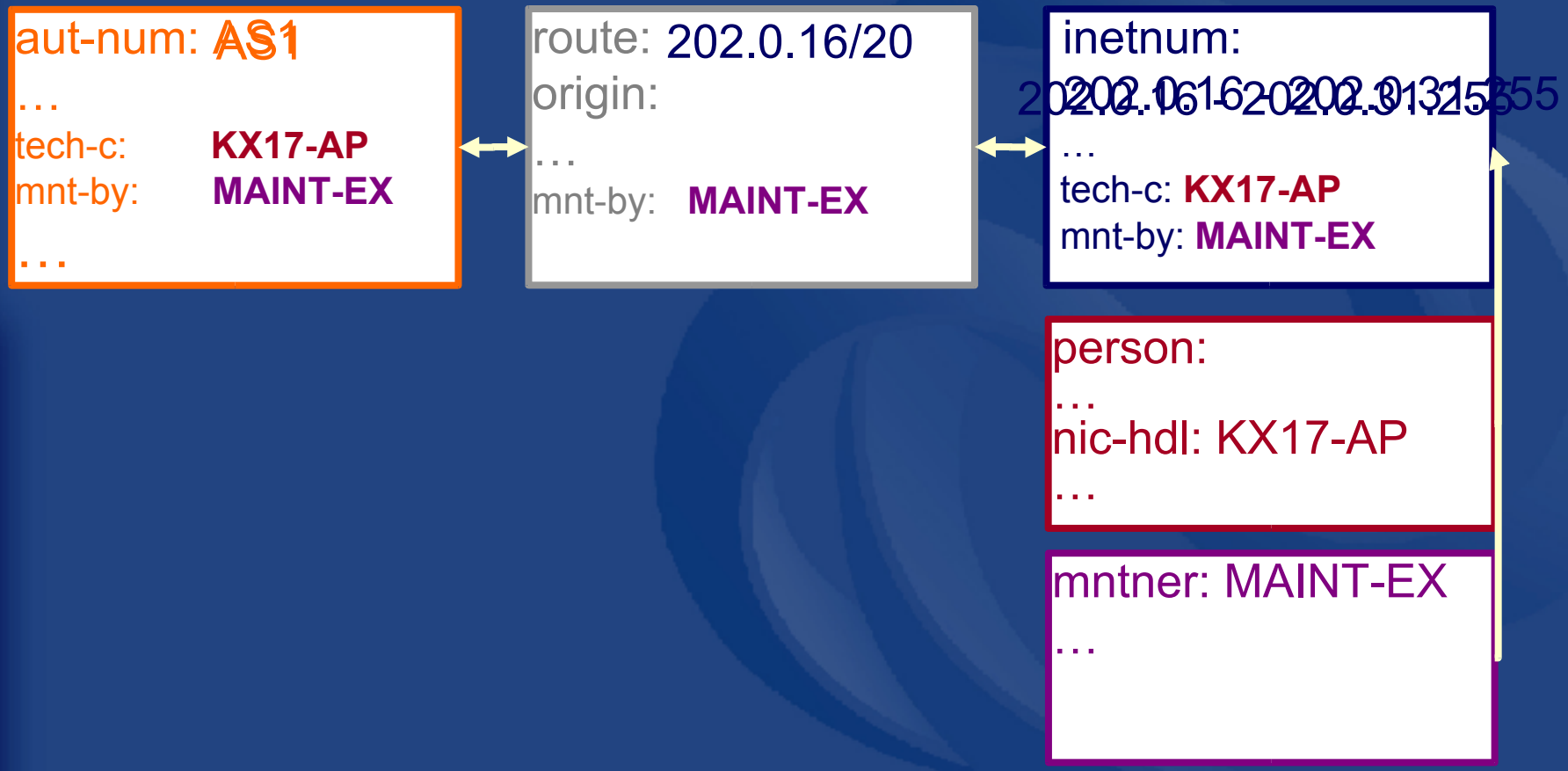


IRR objects

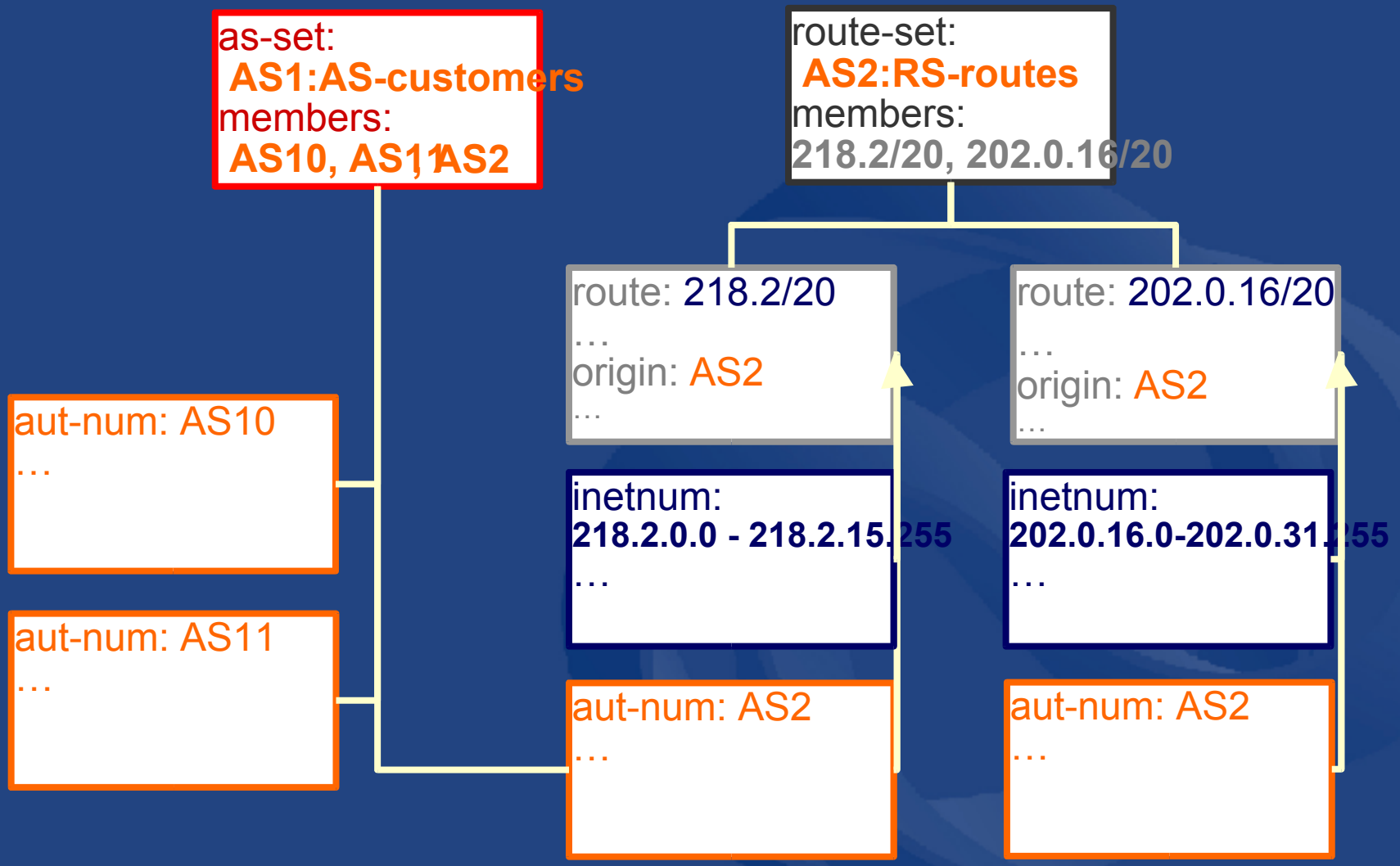
- route
  - Specifies interAS routes
- aut-num
  - Represents an AS. Used to describe external routing policy
- inet-rtr
  - Represents a router
- peering-set
  - Defines a set of peerings
- route-set
  - Defines a set of routes
- as-set
  - Defines a set of **aut-num** objects
- rtr-set
  - Defines a set of routers
- filter-set
  - Defines a set of routes that are matched by its filter

www.apnic.net/db/ref/db-objects.html

Inter-related IRR objects



Inter-related IRR objects

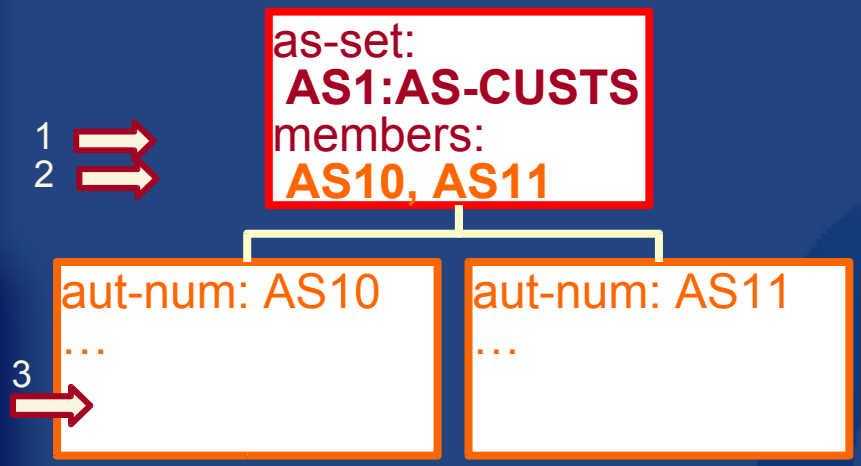


‘Set-’ objects and their members

- Two ways of referencing members

members

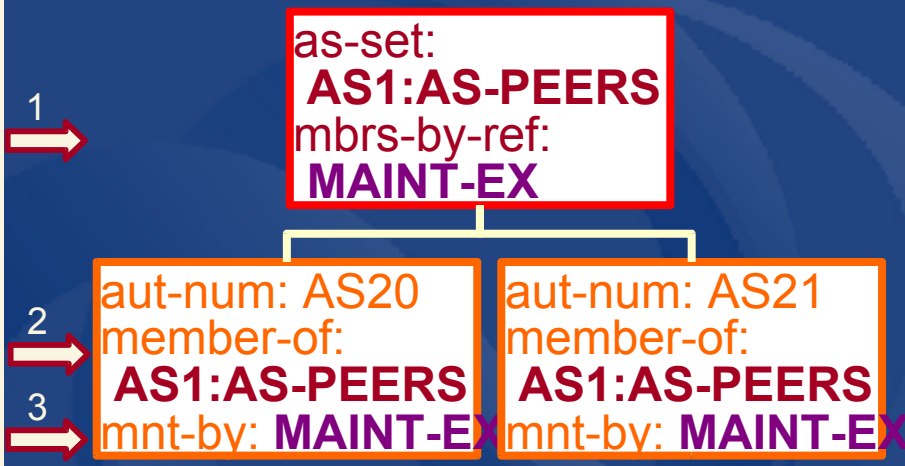
- members specified in the ‘set-’ object



1. ‘members’ specifies members of the set
2. Members added in the ‘set-’ object
3. No need to modify the member object when adding members

mbrs-by-ref

- ‘set’ specified in the member objects



1. ‘mbrs-by-ref’ specifies the maintainer of the members.
2. Members reference the ‘set-’ object in the ‘member-of’ attribute
3. Members are maintained by the maintainer specified in the ‘set-’

Hierarchical authorisation

- **mnt-routes**
  - authenticates ***creation*** of route objects
    - creation of route objects must pass authentication of mntner referenced in the mnt-routes attribute
  - Format:
    - `mnt-routes:  <mntner>`

In:

`inetnum` , `aut-num` and `route` objects

Authorisation mechanism

```
inetnum:      202.137.181.0 - 202.137.185.255
netname:      SPARKYNET-WF
descr:        SparkyNet Service Provider
…
mnt-by:       MAINT-APNIC-AP
mnt-lower:    MAINT-SPARKYNET
mnt-routes:   MAINT-SPARKYNET-WF
```

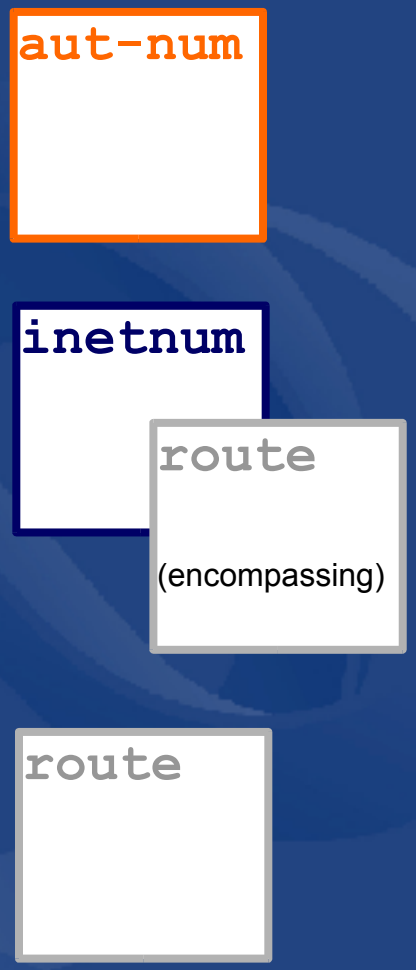
This object can only be modified by APNIC

Creation of more specific objects (assignments) within this range has to pass the authentication of MAINT-SPARKYNET

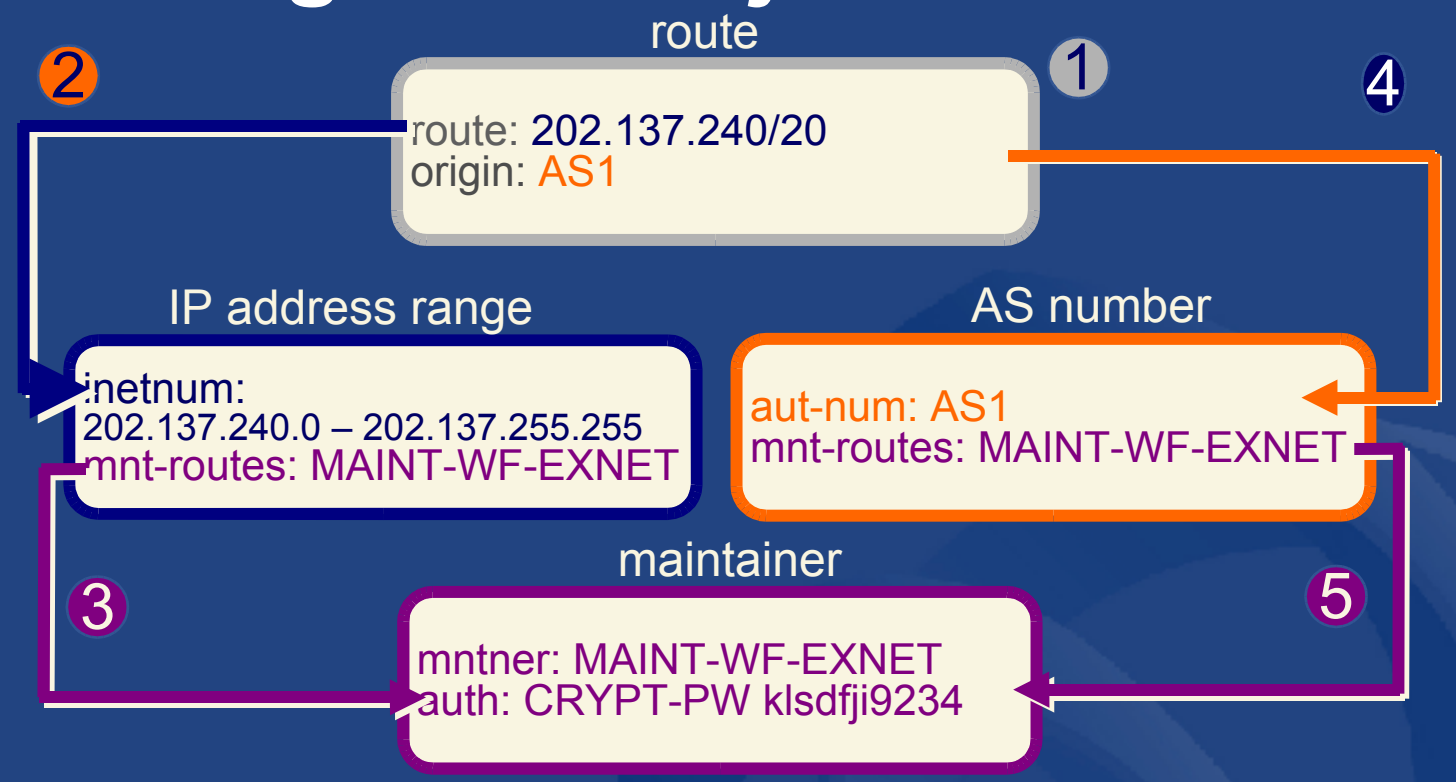
Creation of route objects matching/within this range has to pass the authentication of MAINT-SPARKYNET-WF

Creating route objects

- Multiple authentication checks:
  - Originating ASN
    - mntner in the mnt-routes is checked
    - If no mnt-routes, mnt-lower is checked
    - If no mnt-lower, mnt-by is checked
  - AND the address space
    - Exact match & less specific route
      - mnt-routes etc
    - Exact match & less specific inetnum
      - mnt-routes etc
  - AND the route object mntner itself
    - The mntner in the mnt-by attribute



Creating route objects



1. Create route object and submit to APNIC RR database
2. Db checks inetnum obj matching/encompassing IP range in route obj
3. Route obj creation must pass auth of mntner specified in inetnum *mnt-routes* attribute.
4. Db checks aut-num obj corresponding to the ASN in route obj
5. Route obj creation must pass auth of mntner specified in aut-num *mnt-routes* attribute.

Useful IRR queries

- *What routes are originating from my AS?*
  - whois -i origin <ASN>
    - route objects with matching origin
- *What routers does my AS operate?*
  - whois -i local-as <ASN>
    - inet-rtr objects with a matching local-as
- *What objects are protecting "route space" with my maintainer?*
  - whois -i mnt-routes <mntner>
    - aut-num, inetnum & route objects with matching mnt-routes

(always specify host. e.g. 'whois –h whois.apnic.net')

Useful IRR queries (cont'd)

- *What '-set objects' are the objects protected by this maintainer a member of?*
  - whois -i mbrs-by-ref <mntner>
    - set objects (as-set, route-set and rtr-set) with matching mbrs-by-ref
- *What other objects are members of this '-set object'?*
  - whois -i member-of <set name>
    - Objects with a matching member-of
      - provided the membership claim is validated by the mbrs-by-ref of the set.

Using the Routing Registry

Routing policy, the IRRToolSet &
APNIC RR Benefits

IRRToolSet

- Set of tools developed for using the Internet Routing Registry
  - Started as RAToolSet
- Now maintained by RIPE NCC:
  - http://www.ripe.net/db/irrtoolset/
  - Download: ftp://ftp.ripe.net/tools/IRRToolSet/
    - Installation needs: lex, yacc and C++ compiler

Use of RPSL - RtConfig

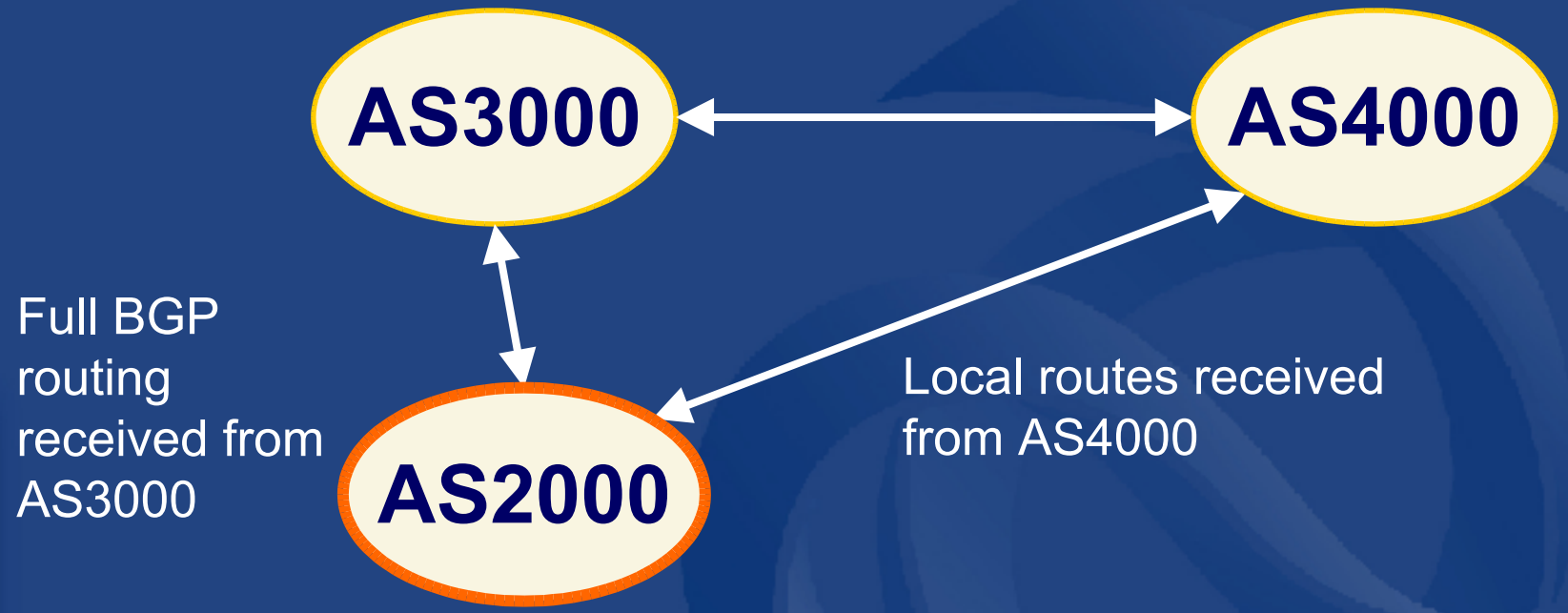
- RtConfig v4
  - part of IRRToolSet
- Reads policy from IRR (aut-num, route & -set objects) and generates router configuration
  - vendor specific:
    - Cisco, Bay's BCC, Juniper's Junos and Gated/RSd
  - Creates route-map and AS path filters
  - Can also create ingress / egress filters
    - (documentation says Cisco only)

Why use IRR and RTConfig?

- Benefits of RTConfig
  - Avoid filter errors (typos)
  - Expertise encoded in the tools that generate the policy rather than engineer configuring peering session
  - Filters consistent with documented policy
    - (need to get policy correct though)
  - Engineers don't need to understand filter rules
    - it just works :-)

Using RTConfig - Case scenario

Not fully multi-homing



10.20.0.0/24 *(range received from upstream)*

10.187.65.0/24 *(portable address range)*

Using RTconfig – IRR objects

```
aut-num: AS2000
import:  from AS3000 accept ANY
export:  to AS3000 announce AS2000
import:  from AS4000 accept AS4000
export:  to AS4000 announce AS2000
[…]
```

full BGP routing

local routes

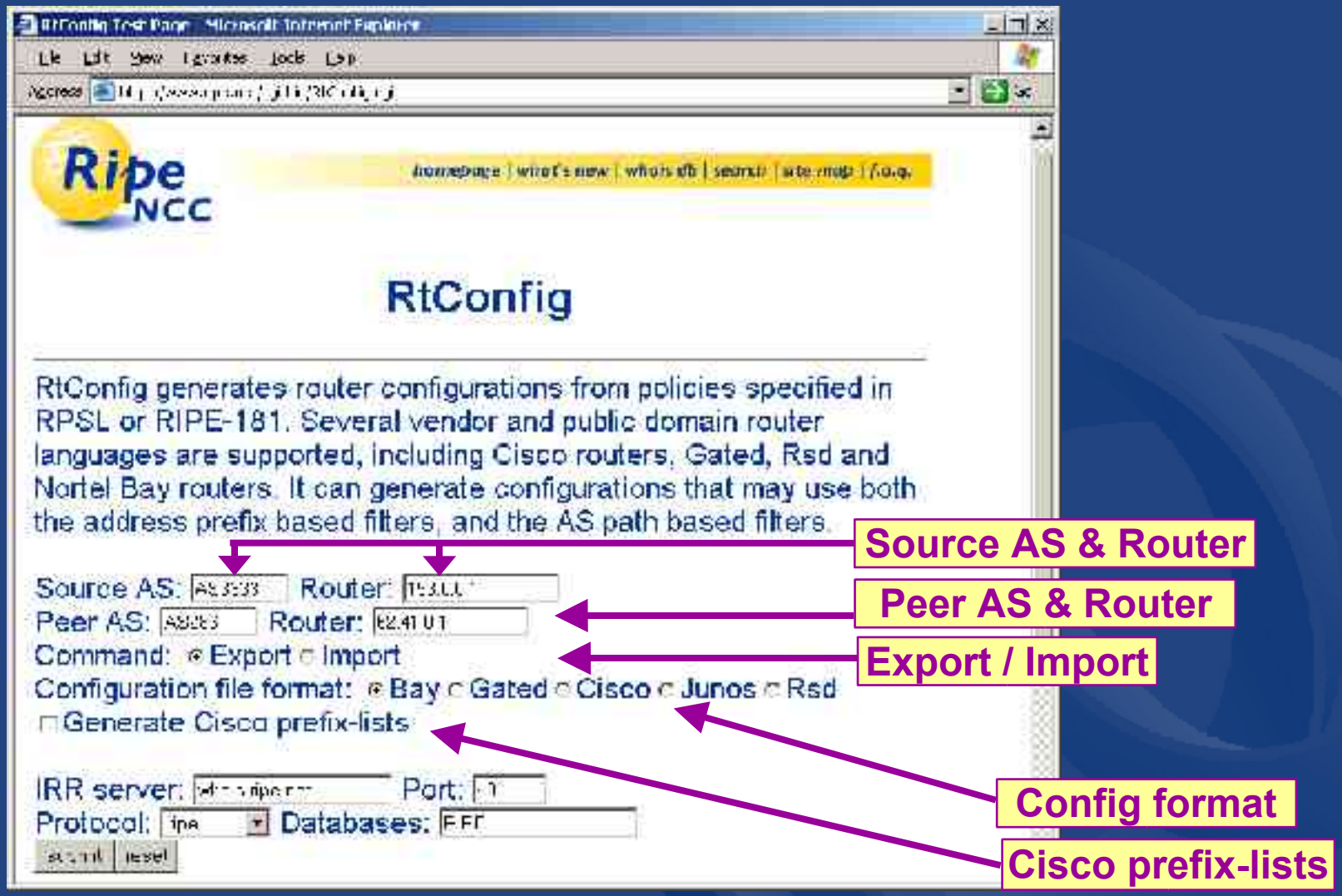
```
route: 10.20.0.0/24
origin: AS2000
[…]
```

```
route: 10.187.65.0/24
origin: AS2000
[…]
```

RtConfig commands

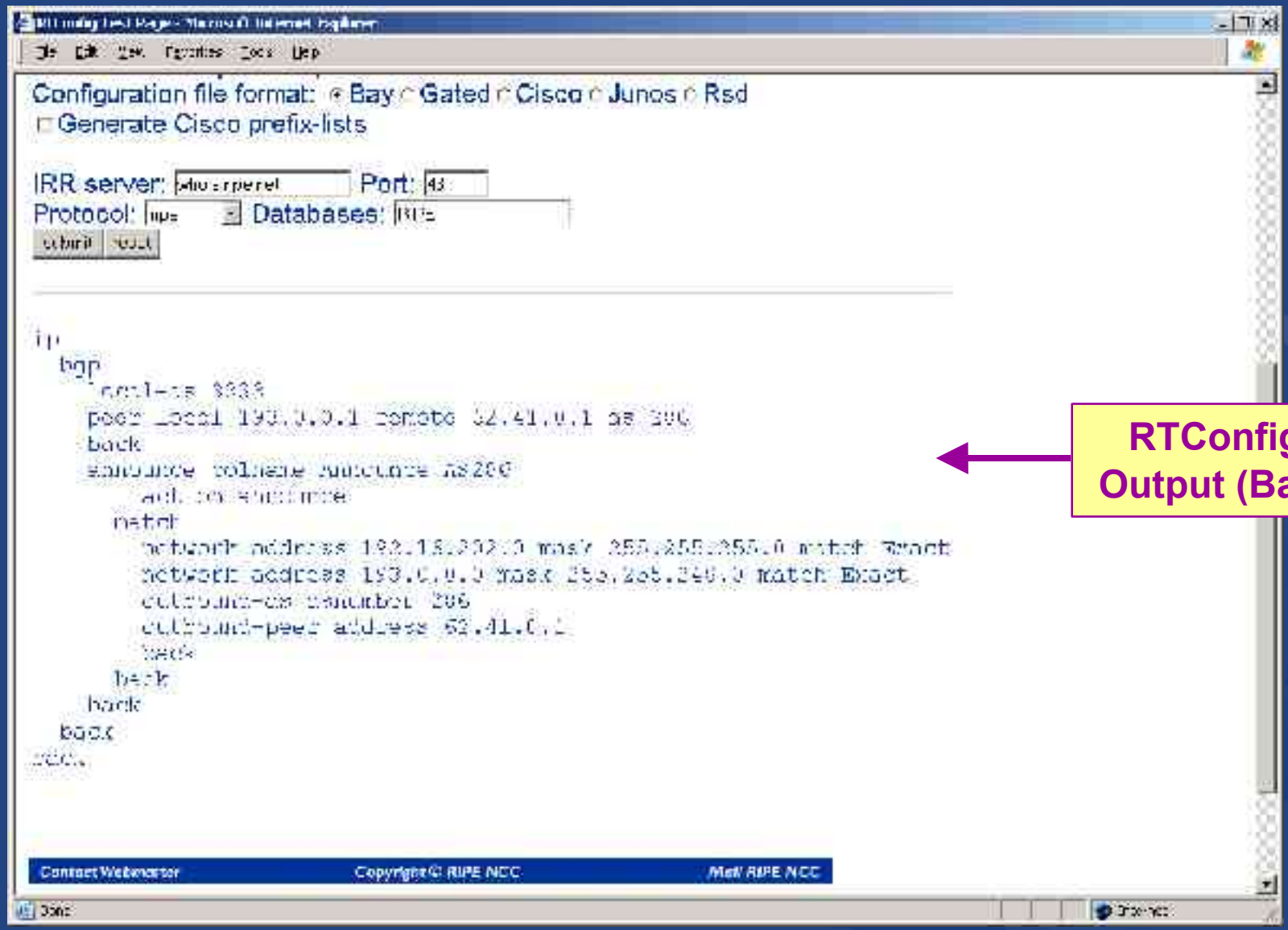
```
@RtConfig set cisco_map_name = "AS%d-IMPORT"
@RtConfig import AS2000_10.20.0.3 AS3000 10.3.15.2
!
@RtConfig set cisco_map_name = "AS%d-IMPORT"
@RtConfig import AS2000_10.20.0.4 AS4000 10.4.192.2
!
```

RtConfig – web prototype



http://www.ripe.net/cgi-bin/RtConfig.cgi

RTConfig – web output



RTConfig Output (Bay)

Using the Routing Registry

Disadvantages

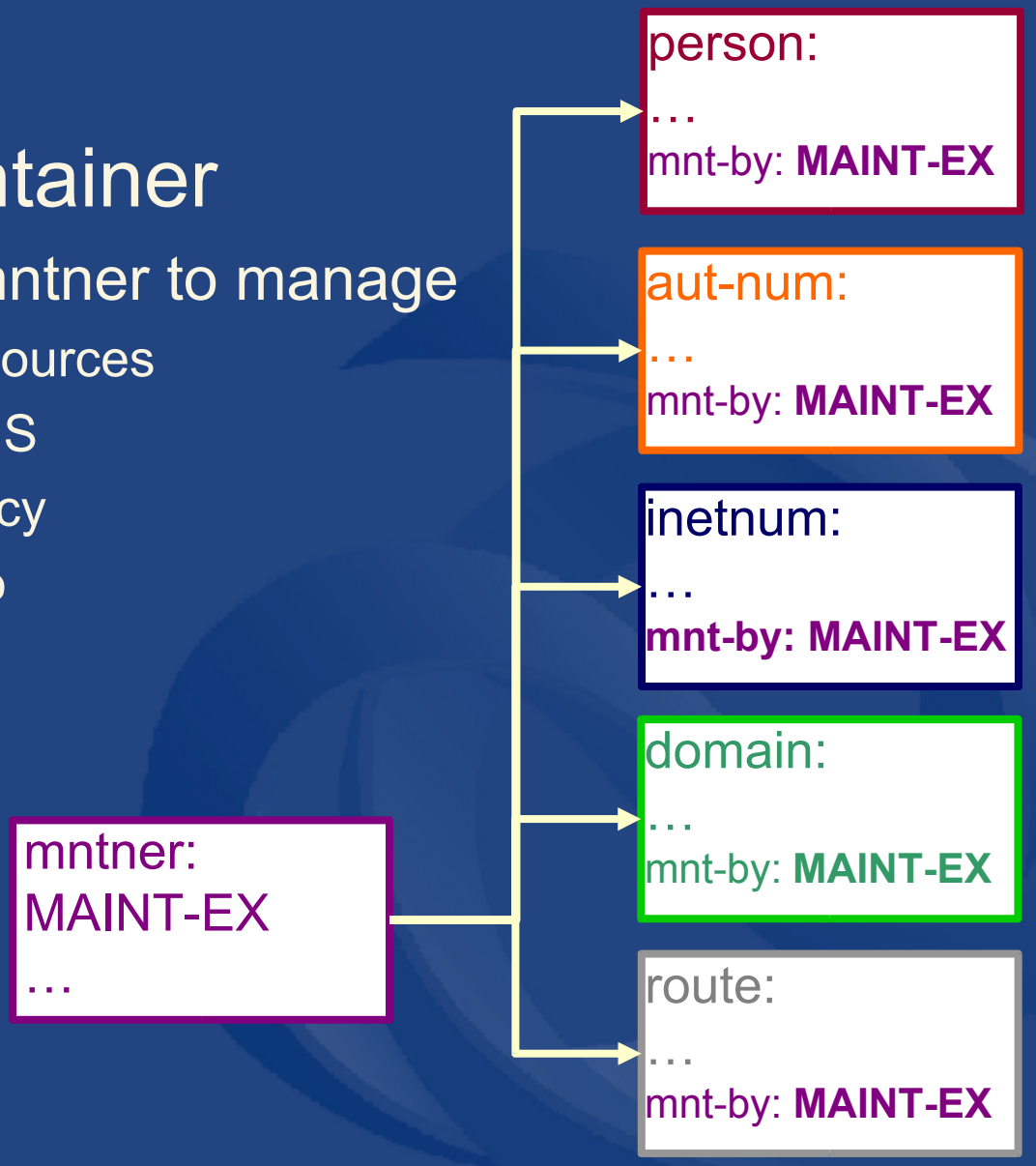
- Requires some initial planning
- Takes some time to define & register policy
- Need to maintain data in RR

Advantages

- You have a clear idea of your routing policy
- Consistent config over the whole network
- Less manual maintenance in the long run

Benefits of APNIC RR

- Single maintainer
  - Use same mntner to manage
    - internet resources
    - reverse DNS
    - routing policy
    - contact info
    - etc



(Single person object can also be used)

Benefits of APNIC RR

– APNIC able to assert resources for a registered route within APNIC ranges.

```
inetnum:     221.0.0.0 - 221.3.127.255
netname:     CNCGROUP-SD
descr:       CNCGROUP Shandong province network
country:     CN
admin-c:     CH455-AP
tech-c:      XZ14-AP
mnt-by:      APNIC-HM
mnt-lower:   MAINT-CNCGROUP-SD
changed:     hm-chnaged@apnic.net 20021224
status:      ALLOCATED PORTABLE
source:      APNIC
```

Allocation objects maintained by APNIC

```
mntner:      APNIC-HM
descr:       APNIC Hostmaster - Maintainer
...
```

APNIC RR service scope

- Routing Queries
  - Regular whois clients
  - APNIC whois web interface
  - Special purpose programs such as IRRToolSet
    - ftp://ftp.ripe.net/tools/IRRToolSet
- Routing Registration and Maintenance
  - Similar to registration of Internet resources

APNIC RR service scope

- Support
  - APNIC Helpdesk support

<helpdesk@apnic.net>

- Training
  - IRR workshop under development
- Mirroring
  - APNIC mirrors IRRs within Asia Pacific and major IRRs outside of the region.

Summary

- APNIC RR integrated in APNIC Whois DB
  - whois.apnic.net
  - <auto-dbm@apnic.net>
- IRR benefits
  - Facilitates network troubleshooting
  - Generation of router configuration
  - Provides global view of routing
- APNIC RR benefits
  - Single maintainer (& person obj) for all objects
  - APNIC asserts resources for a registered route
  - Part of the APNIC member service!

Questions ?

Reverse DNS

Overview

- Principles
- Creating reverse zones
- Setting up nameservers
- Reverse delegation procedures
- IPv6 reverse delegations
- Current status

What is ‘Reverse DNS’?

- ‘Forward DNS’ maps names to numbers
  - svc00.apnic.net -> 202.12.28.131
- ‘Reverse DNS’ maps numbers to names
  - 202.12.28.131 -> svc00.apnic.net

Reverse DNS - why bother?

- Service denial
  - That only allow access when fully reverse delegated eg. anonymous ftp
- Diagnostics
  - Assisting in trace routes etc
- Registration
  - Responsibility as a member and Local IR

In-addr.arpa

- Hierarchy of IP addresses
  - Uses ‘in-addr.arpa’ domain
    - INverse ADDRess
- IP addresses:
  - Less specific to More specific
    - 210.56.14.1
- Domain names:
  - More specific to Less specific
    - delhi.vsnl.net.in
  - Reversed in in-addr.arpa hierarchy
    - 14.56.210.in-addr.arpa

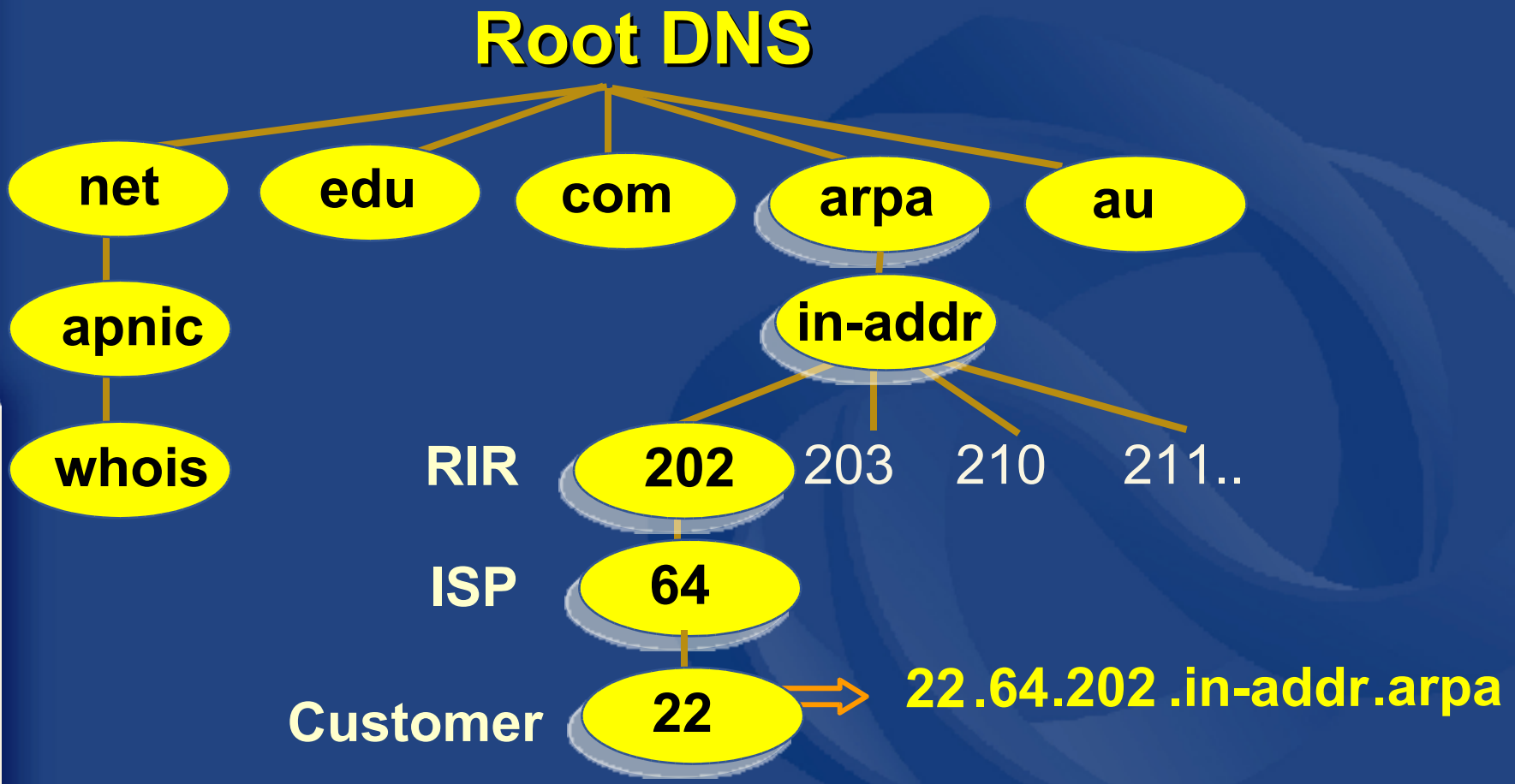
Principles

- Delegate maintenance of the reverse DNS to the custodian of the address block

- Address allocation is hierarchical
  - LIRs/ISPs -> Customers -> End users

Principles – DNS tree

- Mapping numbers to names - 'reverse DNS'



Creating reverse zones

- Same as creating a forward zone file
  - SOA and initial NS records are the same as normal zone
  - Main difference
    - need to create additional PTR records
- Can use BIND or other DNS software to create and manage reverse zones
  - Details can be different

Creating reverse zones - contd

- Files involved
  - Zone files
    - Forward zone file
      - e.g. db.domain.net
    - Reverse zone file
      - e.g. db.192.168.254
  - Config files
    - <named.conf>
  - Other
    - Hints files etc.
      - Root.hints

Start of Authority (SOA) record

admin.test-domain.net

ns.test-domain.net.

```
<domain.name.>          CLASS   SOA     <hostname.domain.name.>
   <mailbox.domain.name> (
                                        <serial-number>
                                        <refresh>
                                        <retry>
                                        <expire>
                                        <negati -caching> )
```

253.253.192.in-addr.arpa.

IN

(<2003033101>
<10800>
<3600>
<604800>
<10800>)

Nameserver (NS) records

- Declares the nameservers that serve a given zone

```
<domain.name.> IN NS <hostname.domain.name.>
```

ns.apnic.net.

Pointer (PTR) records

- Create pointer (PTR) records for each IP address

```
131.28.12.202.in-addr.arpa. IN PTR svc00.apnic.net.
```

or

```
131                 IN      PTR             svc00.apnic.net.
```

A reverse zone example

```
$ORIGIN 1.168.192.in-addr.arpa.
@       3600   IN SOA test.company.org. (
                      sys\.admin.company.org.
                      2002021301     ; serial
                      1h             ; refresh
                      30M            ; retry
                      1W             ; expiry
                      3600 )         ; neg. answ. ttl

        NS     ns.company.org.
        NS     ns2.company.org.

1       PTR    gw.company.org.
               router.company.org.

2       PTR    ns.company.org.
;auto generate:  65 PTR host65.company.org
$GENERATE 65-127 $ PTR host$.company.org.
```

What we covered so far

- Why Reverse DNS ?
- The DNS tree ?
- Files involved
- Essential Resource Records
- How to create reverse zones

Setting up the primary nameserver

- Add an entry specifying the primary server to the ***named.conf*** file

```
zone "<domain-name>" in {
type master;
file "<path-name>"; };
```

- <domain-name>
  - Ex: 28.12.202.in-addr.arpa.
- <type master>
  - Define the name server as the primary
- <path-name>
  - location of the file that contains the zone records

Setting up the secondary nameserver

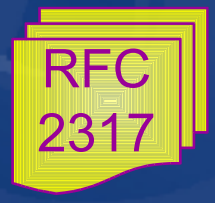
- Add an entry specifying the primary server to the ***named.conf*** file

```
zone "<domain-name>" in {
type slave;
file "<path-name>";
Masters { <IP address> ; }; };
```

- <type slave> defines the name server as the secondary
- <ip address> is the IP address of the primary name server
- <domain-name> is same as before
- <path-name> is where the back-up file is

Reverse delegation requirements

- /24 Delegations
  - Address blocks should be assigned/allocated
  - At least two name servers
- /16 Delegations
  - Same as /24 delegations
  - APNIC delegates entire zone to member
  - Recommend APNIC secondary zone
- < /24 Delegations
  - Read “classless in-addr.arpa delegation”



APNIC & ISPs responsibilities

- APNIC
  - Manage reverse delegations of address block distributed by APNIC
  - Process members requests for reverse delegations of network allocations
- ISPs
  - Be familiar with APNIC procedures
  - Ensure that addresses are reverse-mapped
  - Maintain nameservers for allocations
    - Minimise pollution of DNS

Subdomains of in-addr.arpa domain

- Subnetting on an Octet Boundary
  - Similar to delegating subdomains of forward-mapping domains
- Mapping problems
  - In IPv4 the mapping is done on 8 bit boundaries (class full), address allocation is classless
  - Zone administration does not always overlap address administration

Subdomains of in-addr.arpa domain

- Example: an organisation given a /16
  - 192.168.0.0/16 (one zone file and further delegations to downstreams)
  - 168.192.in-addr.arpa zone file should have:

```
0.168.192.in-addr.arpa.    NS ns1.organisation0.com.
0.168.192.in-addr.arpa.    NS ns2.organisation0.com.
1.168.192.in-addr.arpa.    NS ns1.organisation1.com.
1.168.192.in-addr.arpa.    NS ns2.organisation1.com.
2.168.192.in-addr.arpa.    NS ns1.organisation2.com.
2.168.192.in-addr.arpa.    NS ns2.organisation2.com.
        :
        :
```

Subdomains of in-addr.arpa domain

- Example: an organisation given a /20
  - 192.168.0.0/20 (a lot of zone files!) – have to do it per /24)
  - Zone files

0.168.192.in-addr.arpa.
1.168.192.in-addr.arpa.
2.168.192.in-addr.arpa.
:
:
15.168.192.in-addr.arpa.

Subdomains of in-addr.arpa domain

- Example: case of a /24 subnetted with the mask 255.255.255.192
  - In-addr zone – 254.253.192.in-addr.arpa
  - Subnets
    - 192.253.254.0/26
    - 192.253.254.64/26
    - 192.253.254.128/26
    - 192.253.254.192/26
  - If different organisations has to manage the reverse-mapping for each subnet
    - Solution to follow…

Classless in-addr for 192.253.254/24

- CNAME records for each of the domain names in the zone
  - Pointing to domain names in the new subdomains

```
$ORIGIN 254.253.192.in-addr.arpa.

0-63        NS      ns1.organisation1.com.
0-63        NS      ns2.organisation1.com.

1           CNAME   1.0-63
2           CNAME   2.0-63

64-127      NS      ns1.organisation2.com.
64-127      NS      ns2.organisation2.com.

65          CNAME   65.64-127
66          CNAME   66.64-127
```

Classless in-addr for 192.253.254/24

- Using $GENERATE (db.192.253.254 file)

```
$ORIGIN 254.253.192.in-addr.arpa.

0-63                    NS      ns1.organisation1.com.
0-63                    NS      ns2.organisation1.com.

$GENERATE 1-63$         CNAME   $.0-63

64-127                  NS      ns1.organisation2.com.
64-127                  NS      ns2.organisation2.com.

$GENERATE 65-127$       CNAME   $.64-127
```

Classless in-addr for 192.253.254.0/26

- Now, the zone data file for 0-63.254.253.192.in-addr.arpa can contain just PTR records for IP addresses 192.253.254.1 through 192.253.154.63

```
$ORIGIN 0-63.254.253.192.in-addr.arpa.
$TTL 1d
@    SOA  ns1.organisation1.com. Root.ns1.organisation1.com. (
                                  1        ; Serial
                                  3h       ; Refresh
                                  1h       ; Retry
                                  1w       ; Expire
                                  1h )     ; Negative caching TTL
                NS      ns1.organisation1.com.
                NS      ns2.organisation1.com.

        1       PTR     org1-name1.organisation1.com.
        2       PTR     org1-name2.organisation1.com.
        3       PTR     org1-name3.organisation1.com.
```

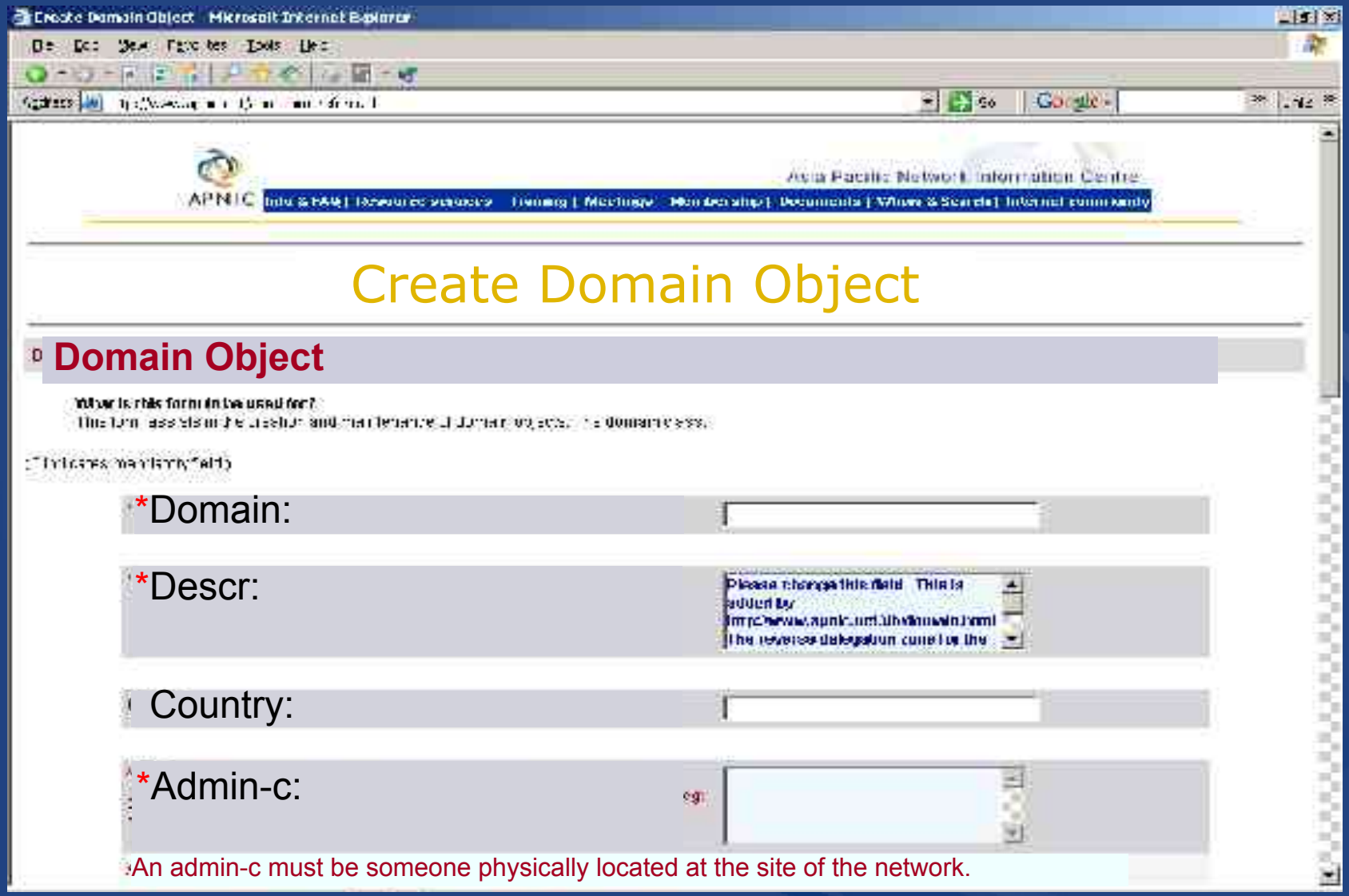
APNIC reverse delegation procedures

- Upon allocation, member is asked if they want /24 place holder domain objects with member maintainer
  - Gives member direct control
- Standard APNIC database object,
  - can be updated through online form or via email.
- Nameserver/domain set up verified before being submitted to the database.
- Protection by maintainer object
  - (current auths: CRYPT-PW, PGP).
- Zone file updated 2-hourly

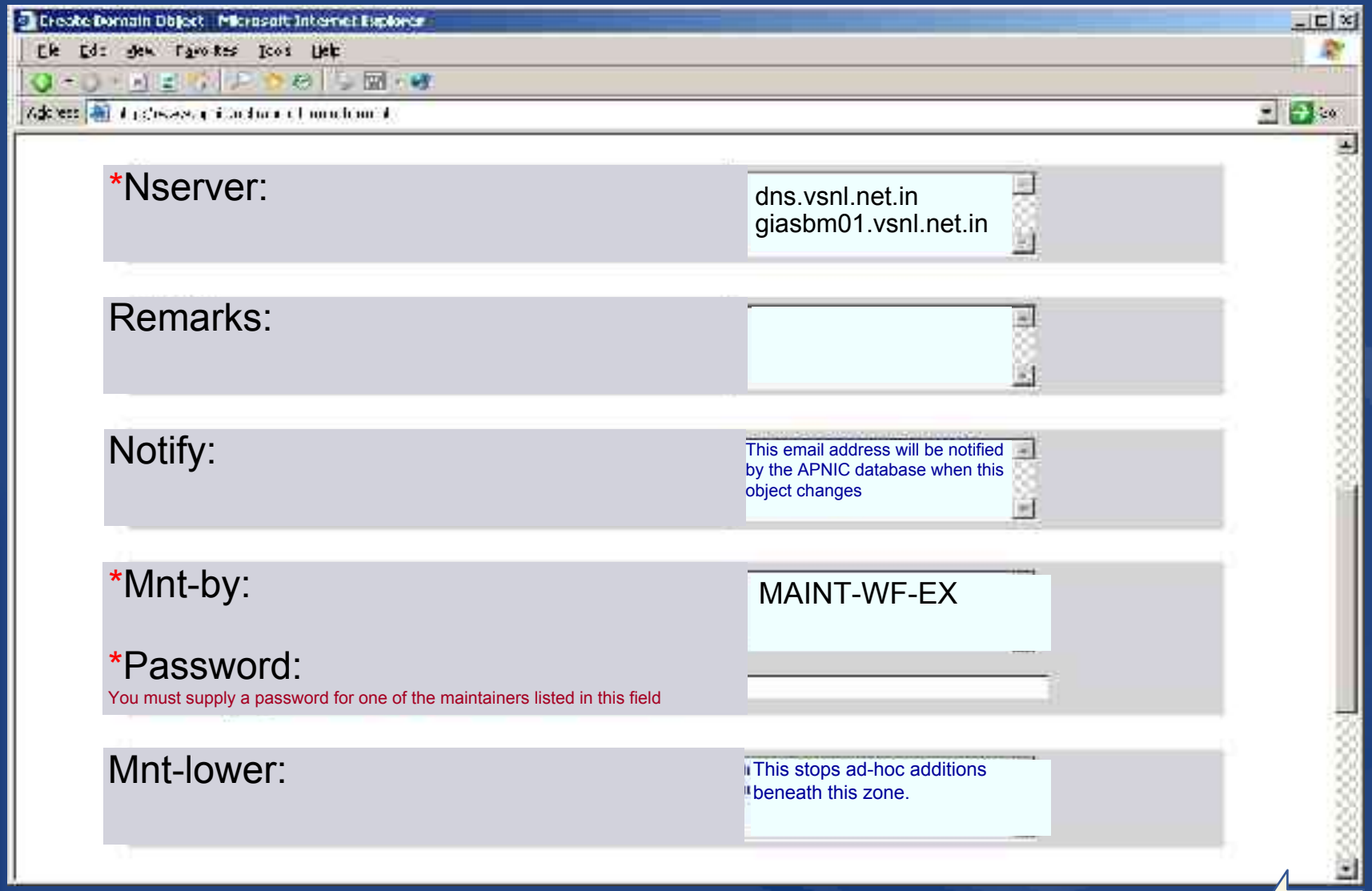
APNIC reverse delegation procedures

- Complete the documentation
  - http://www.apnic.net/db/domain.html
- On-line form interface
  - Real time feedback
  - Gives errors, warnings in zone configuration
    - serial number of zone consistent across nameservers
    - nameservers listed in zone consistent
  - Uses database ‘domain’ object

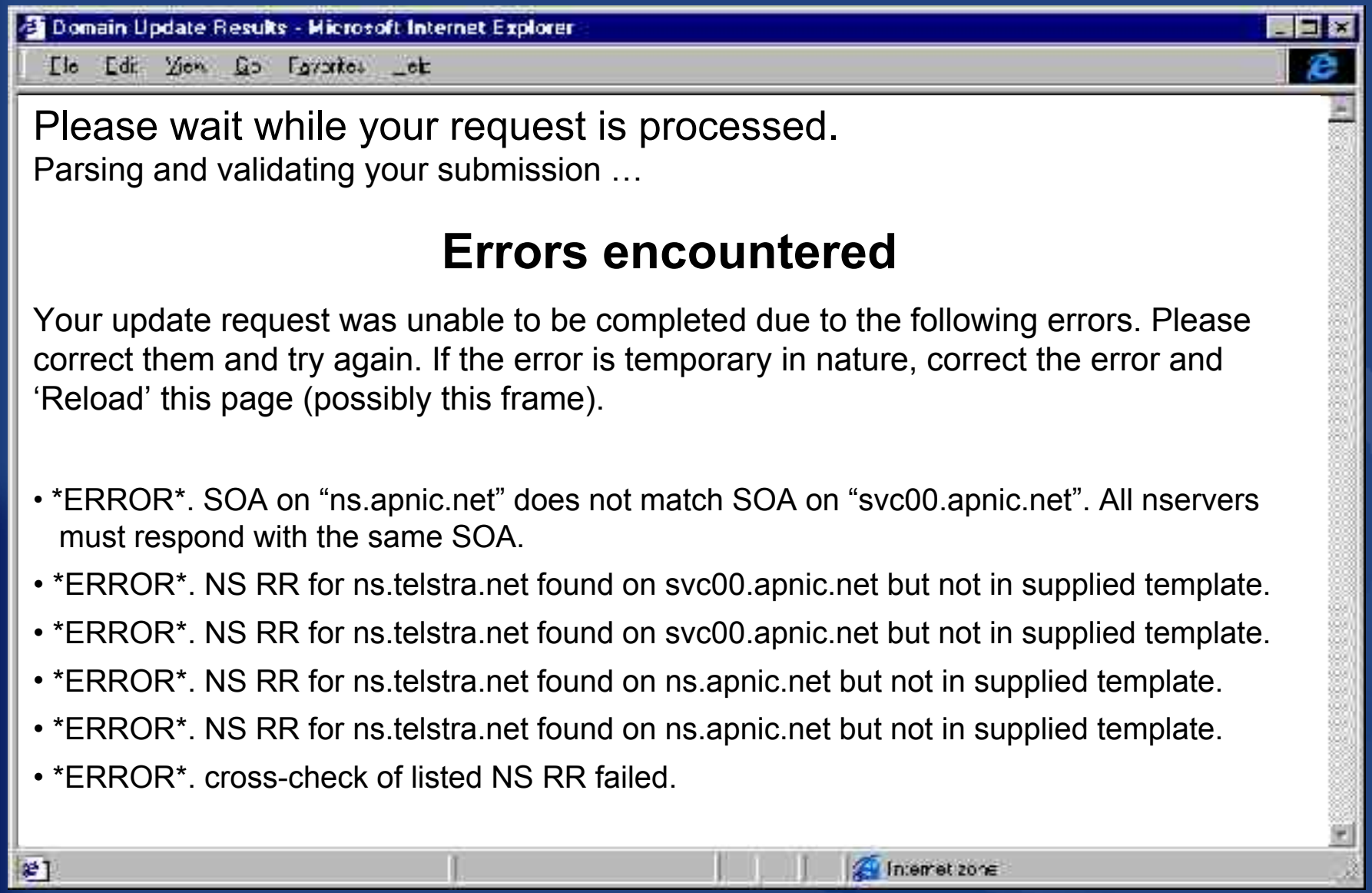
Reverse delegation request form



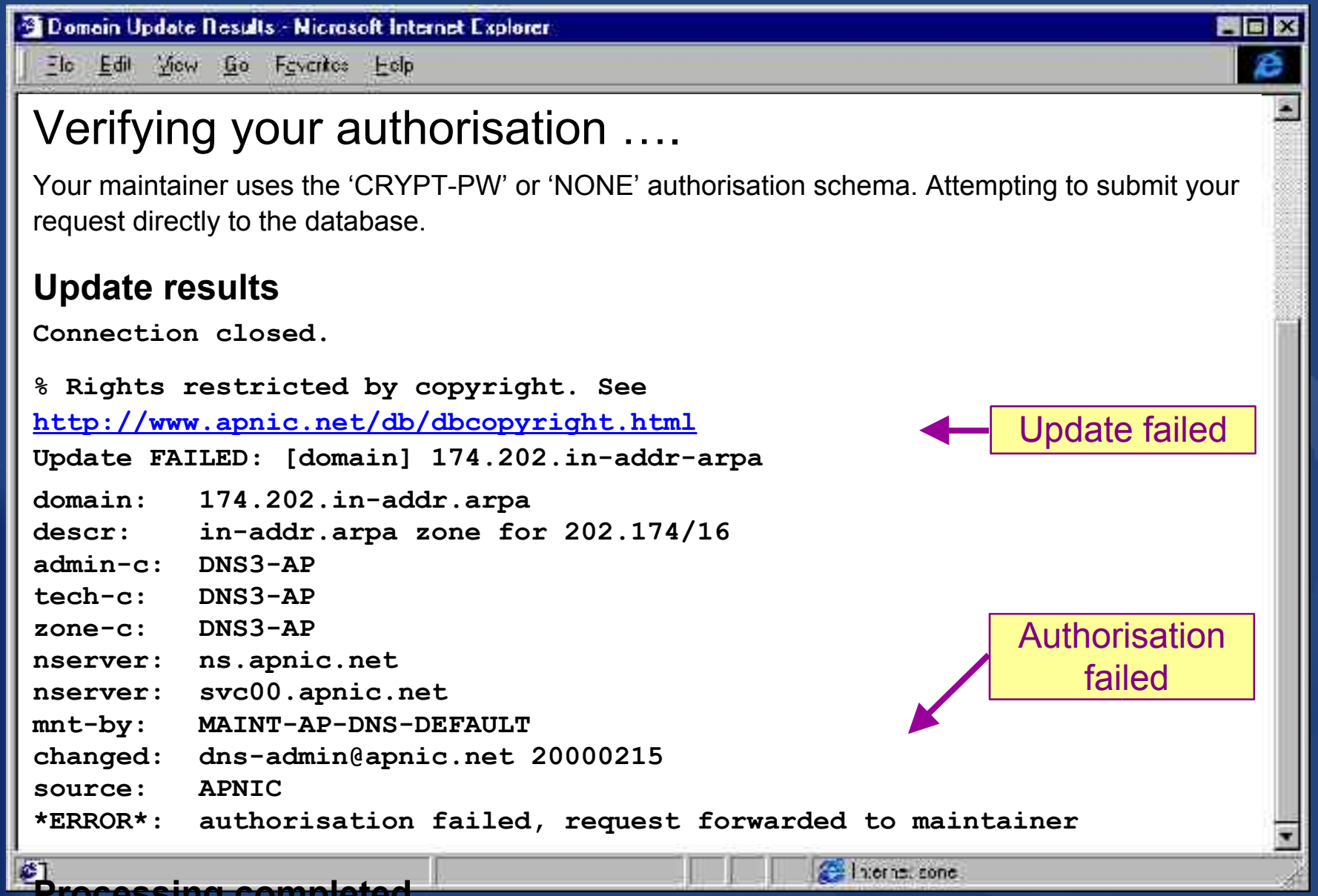
Reverse delegation request form



Online errors (also via email)



Request submission error



Processing completed

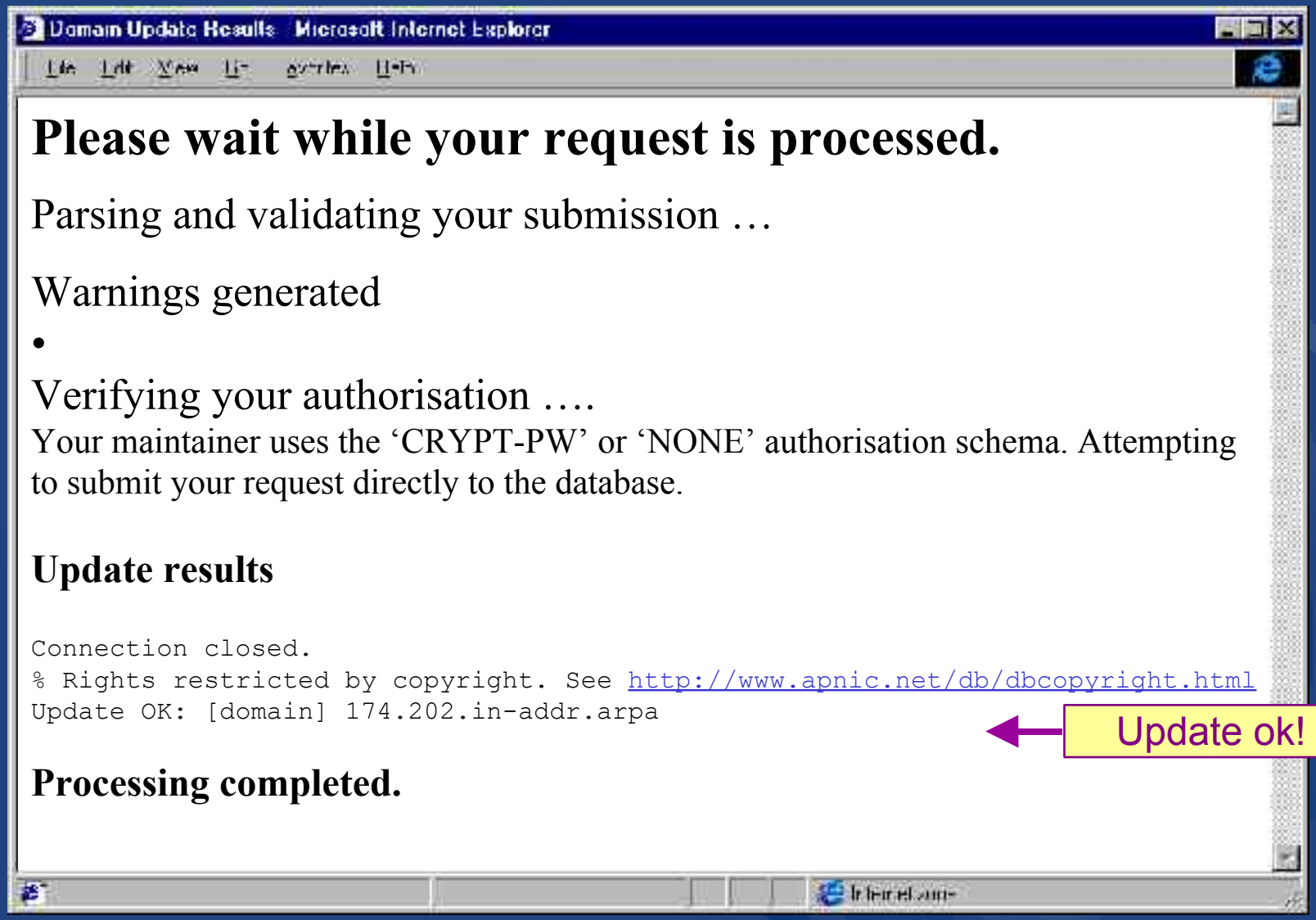
APNIC reverse delegation procedures - Evaluation

- Parser checks for
  - 'whois' database
    - IP address range is assigned or allocated
    - Must be in APNIC database
  - Maintainer object
    - Mandatory field of domain object
  - Nic-handles
    - zone-c, tech-c, admin-c

APNIC reverse delegation procedures - Evaluation

- Nameserver checks
  - Minimum 2 nameservers required
  - Check serial versions of zone files are the same
  - Check NS records in zones are the same as listed on form
  - Nameserver can resolve itself, forward and reverse

Successful update



Whois domain object

```
domain:       28.12.202.in-addr.arpa
descr:        in-addr.arpa zone for 28.12.202.in-addr.arpa
admin-c:      DNS3-AP
tech-c:       DNS3-AP
zone-c:       DNS3-AP
nserver:      ns.telstra.net
nserver:      rs.arin.net
nserver:      ns.myapnic.net
nserver:      svc00.apnic.net
nserver:      ns.apnic.net
mnt-by:       MAINT-APNIC-AP
mnt-lower:    MAINT-DNS-AP
changed:      inaddr@apnic.net 19990810
source:       APNIC
```

Reverse Zone

Contacts

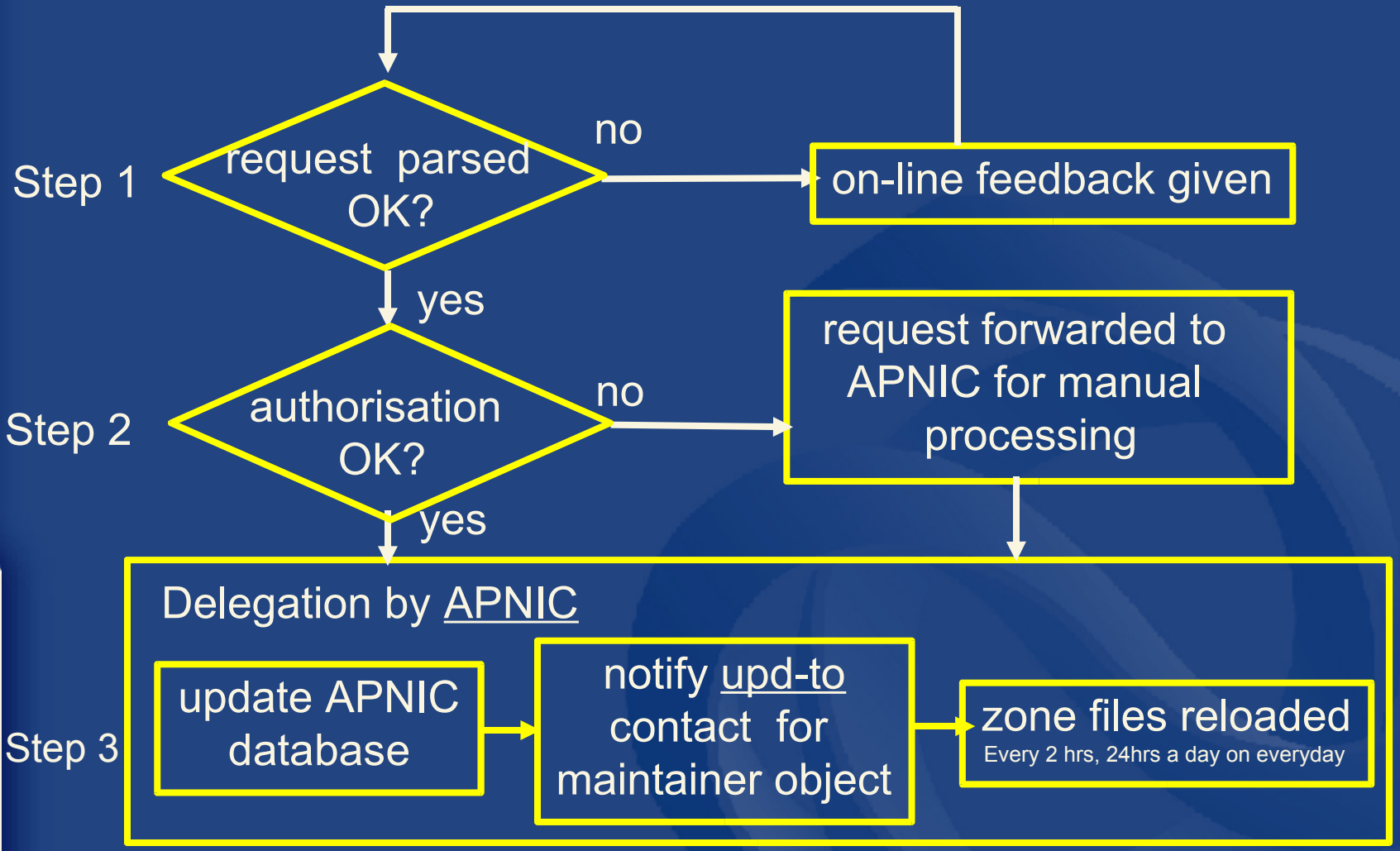
Name Servers

Maintainers (protection)

Use of maintainer object

- Domain objects protected by maintainers
  - hierarchical protection using “mnt-lower”
- Bootstrap period
  - ‘MAINT-AP-DNS-DEFAULT’ for all objects imported by APNIC from existing zone files
    - Changing delegations requires valid maintainer
    - Maintainer creation & authorisation is manual
      - Turnaround time 2 days
  - /24 place holder objects created upon allocation gives members direct control
    - No need to contact APNIC when changing nservers

Delegation process summary



Reverse DNS Troubleshooting Guide:
http://www.apnic.net/services/help/rd/troubleshooting.html

What we covered so far

- Why Reverse DNS ?
- The DNS tree
- Files involved
- Essential Resource Records
- How to create reverse zones

- Setting up nameservers – config files
- APNIC reverse delegation requirements
- Classless in-addr.arpa
- APNIC reverse delegation procedures

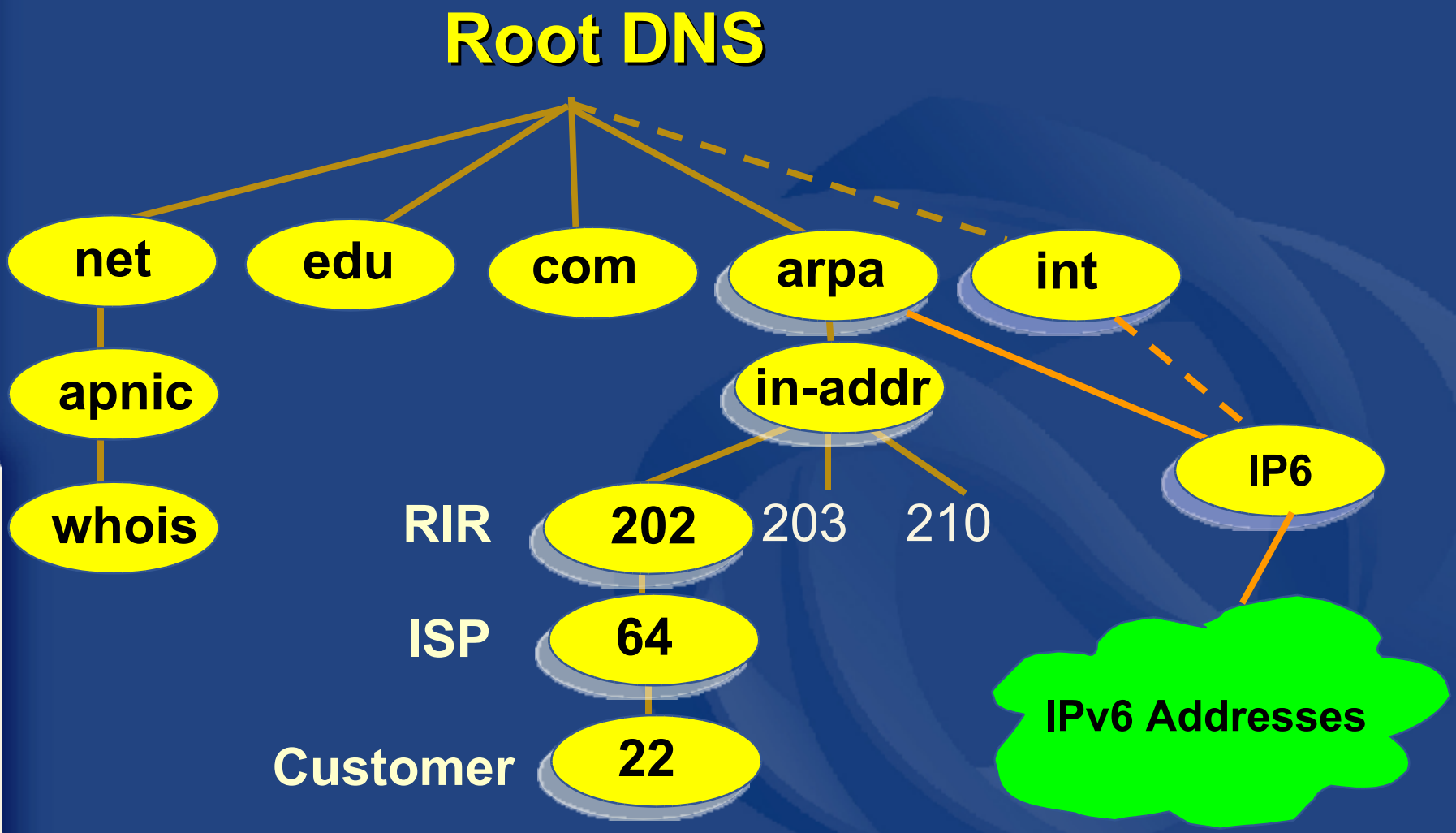
IPv6 representation in the DNS

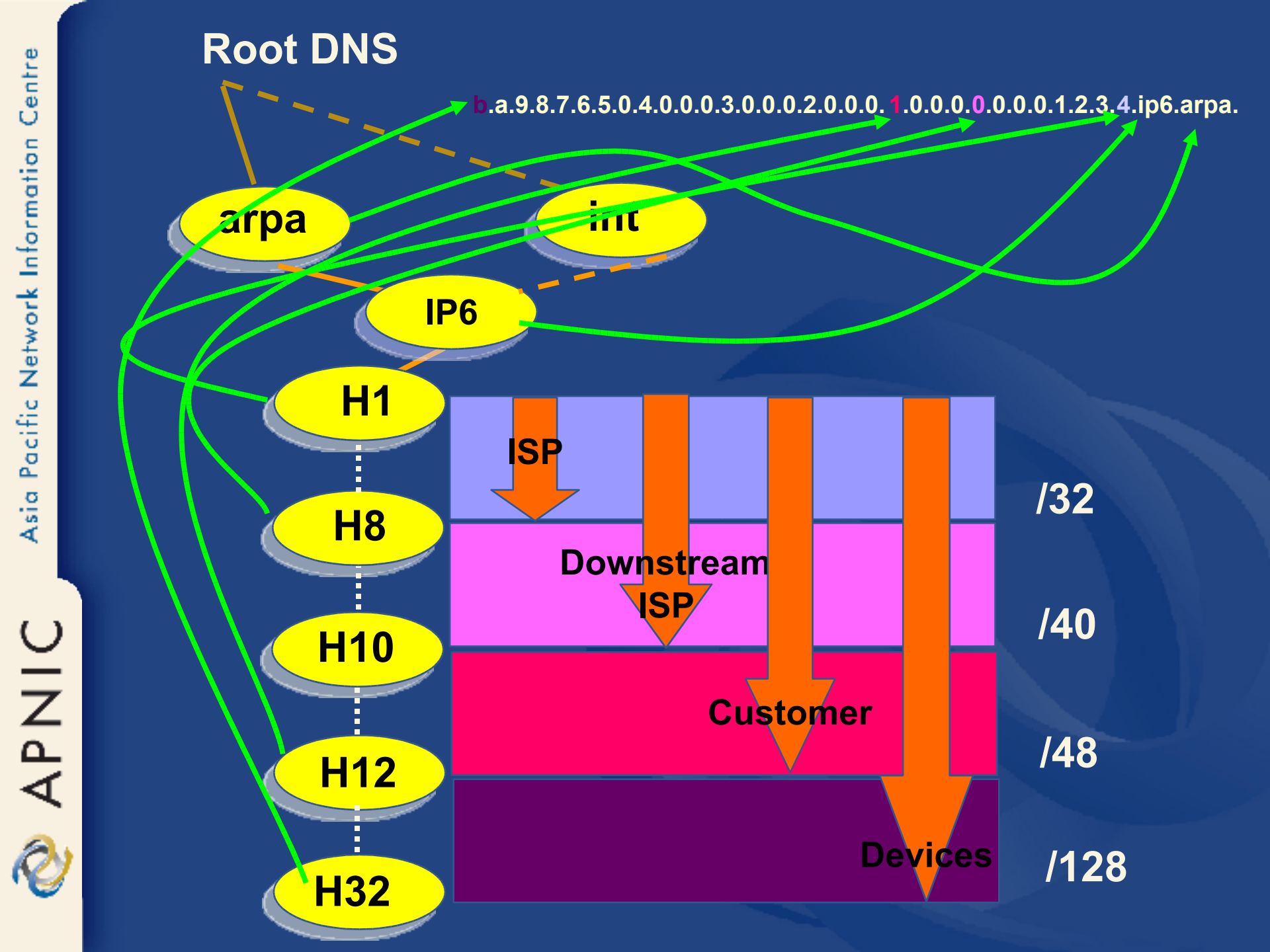
- Forward lookup support: Multiple RR records for name to number
  - AAAA (Similar to A RR for IPv4)
  - A6 without chaining (prefix length set to 0)
- Reverse lookup support:
  - Reverse nibble format for zone ip6.int
  - Reverse nibble format for zone ip6.arpa

IPv6 forward and reverse mappings

- Existing A record will not accommodate IPv6's 128 bit addresses
- BIND expects an A record's record-specific data to be a 32-bit address (in dotted-octet format)
- An address record
  - AAAA (RFC 1886)
- A reverse-mapping domain
  - Ip6.int (now replaced by ip6.arpa)

The reverse DNS tree – with IPv6




Root DNS
b.a.9.8.7.6.5.0.4.0.0.0.3.0.0.0.2.0.0.0.1.0.0.0.0.0.0.0.1.2.3.4.ip6.arpa.
arpa
int
IP6
H1
H8
H10
H12
H32
ISP
Downstream ISP
Customer
Devices
/32
/40
/48
/128
Asia Pacific Network Information Centre
APNIC

IPv6 forward lookups

- Multiple addresses possible for any given name
  - Ex: in a multi-homed situation
- Can assign A records and AAAA records to a given name/domain
- Can also assign separate domains for IPv6 and IPv4

Sample forward lookup file

```
;; domain.edu
$TTL            86400
@     IN       SOA     ns1.domain.edu. root.domain.edu. (
                2002093000    ; serial - YYYYMMDDXX
                21600         ; refresh - 6 hours
                1200          ; retry - 20 minutes
                3600000       ; expire - long time
                86400)        ; minimum TTL - 24 hours
;; Nameservers
                IN     NS     ns1.domain.edu.
                IN     NS     ns2.domain.edu.

;; Hosts with just A records
host1           IN     A      1.0.0.1

;; Hosts with both A and AAAA records
host2           IN     A      1.0.0.2
                IN     AAAA   2001:468:100::2
```

IPv6 reverse lookups

- IETF decided to restandardize IPv6 PTR RRs
  - They will be found in the IP6.ARPA namespace rather than under the IP6.INT namespace
- The ip6.int domains has been deprecated, but some hosts still use them
  - Supported for backwards compatiblity
- Now using ip6.arpa for reverse

IPv6 reverse lookups - AAAA and ip6.arpa

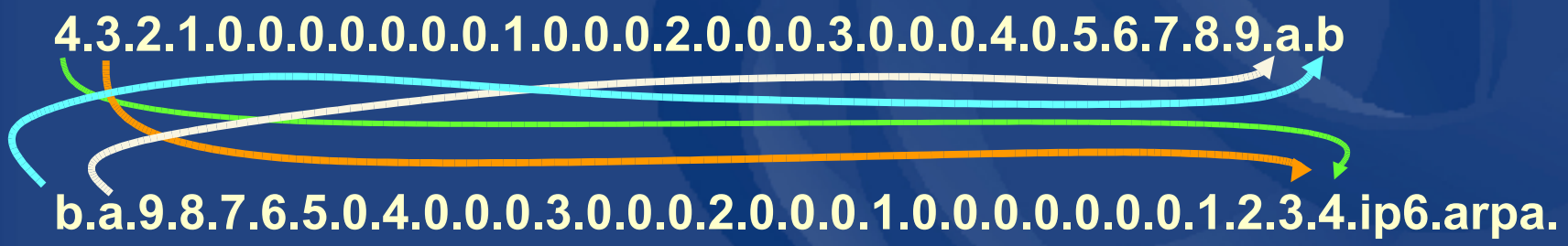
- Address record four times longer than A
  - Quad A (AAAA)
- AAAA record is a parallel to the IPv4 A record
- It specifies the entire address in a single record

IPv6 reverse lookups - AAAA and ip6.arpa

- **Example**

```
Ipv6-host      IN      AAAA      4321:0:1:2:3:4:567:89ab
```

  - Each level of subdomain
    - Represents 4 bits



IPv6 reverse lookups - PTR records

- Similar to the in-addr.arpa

```
b.a.9.8.7.6.5.0.4.0.0.0.3.0.0.0.2.0.0.0.1.0.0.0.0.0.0.0.1.2.3.4.ip6.arpa.
        IN    PTR         test.ip6.example.com.
```

- Example: reverse name lookup for a host with address 3ffe:8050:201:1860:42::1

```
$ORIGIN 0.6.8.1.1.0.2.0.0.5.0.8.e.f.f.3.ip6.arpa.

1.0.0.0.0.0.0.0.0.0.0.0.0.0.0.2.4.0.0   14400   IN PTR host.example.com.
```

Sample reverse lookup file

```
;; 0.0.0.0.0.0.1.0.8.6.4.0.1.0.0.2.rev
;; These are reverses for 2001:468:100::/64)
;; File can be used for both ip6.arpa and ip6.int.
$TTL            86400
@     IN      SOA     ns1.domain.edu. root.domain.edu. (
                              2002093000                ; serial - YYYYMMDDXX
                              21600             ; refresh - 6 hours
                              1200              ; retry - 20 minutes
                              3600000           ; expire - long time
                              86400)            ; minimum TTL - 24 hours
;; Nameservers
                    IN      NS      ns1.domain.edu.
                    IN      NS      ns2.domain.edu.
1.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0    IN      PTR     host1.ip6.domain.edu
2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0    IN      PTR     host2.domain.edu
;;
;; Can delegate to other nameservers in the usual way
;;
```

Sample configuration file

```
// named.conf

zone "domain.edu" {
        type master;
        file "master/domain.edu";
}
zone "0.0.0.0.0.0.1.0.8.6.4.0.1.0.0.2.ip6.int" {
        type master;
        file "master/0.0.0.0.0.0.1.0.8.6.4.0.1.0.0.2.rev";
};
zone "0.0.0.0.0.0.1.0.8.6.4.0.1.0.0.2.ip6.arpa" {
        type master;
        file "master/0.0.0.0.0.0.1.0.8.6.4.0.1.0.0.2.rev";
};
```

Current Status – IPv6 in DNS

- A6 and Bit label specifications has been made experimental
  - RFC3363

- IETF standardized 2 different formats
  - AAAA and A6
  - Confusions on which format to deploy
  - More than one choice will lead to delays in the deployment of IPv6

What we covered so far in reverse DNS

- Why Reverse DNS ?
- The DNS tree
- Files and essential Resource Records
- How to create reverse zones

- Setting up nameservers – config files
- APNIC reverse delegation requirements
- Classless in-addr.arpa
- APNIC reverse delegation procedures

- IPv6 representation in the DNS
- IPv6 forward and reverse mappings
- AAAA and A6 records
- Current status

Questions ?

IPv6

Technical overview

Policies & Procedures

Overview

- Rationale
- IPv6 Addressing
- Features of IPv6
- Transition Techniques
- Current status
- IPv6 Policies & Procedures
- Statistics

Rationale

- Address depletion concerns
  - Squeeze on available addresses space
    - Probably will never run out, but will be harder to obtain
  - End to end connectivity no longer visible
    - Widespread use of NAT

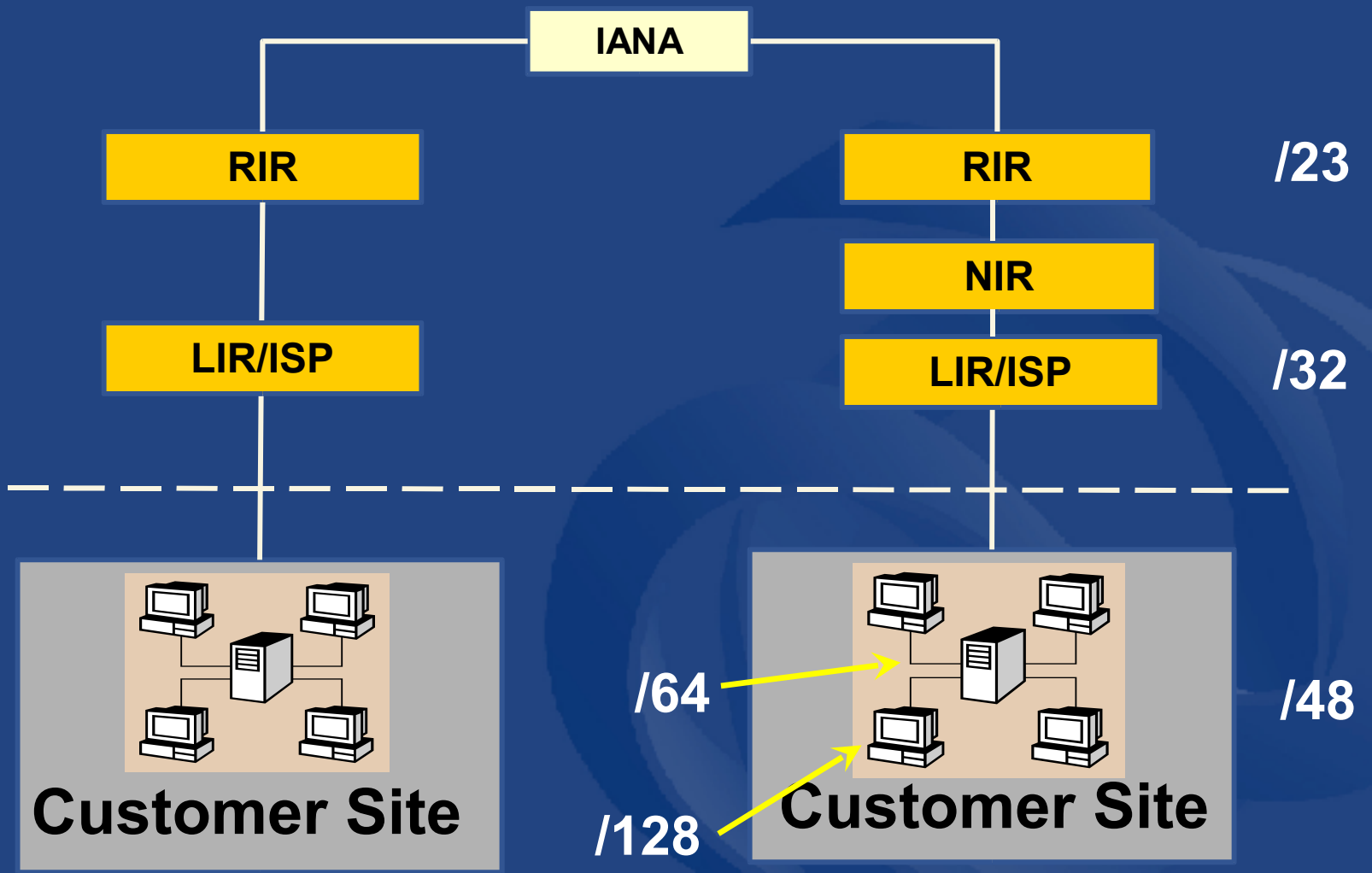
➧ IPv6 provides much larger IP address space than IPv4

Rationale (Cont.)

- Increase of backbone routing table size
  - Current backbone routing table size > 100K
    - CIDR does not guarantee an efficient and scalable hierarchy
    - The lack of uniformity of the current hierarchical system
    - Routing aggregation is still a concern in IPv6

➡ IPv6 address architecture is more hierarchical than IPv4

IPv6 address management hierarchy



Rationale (Cont.)

- Needs to improve the Internet environment
  - Encryption, authentication, and data integrity safeguards needed
    - Necessity of IP level security
  - Plug and Play function needed
    - Reduce network administrators work load
    - Reduce errors caused by individual users

  ➡ More recent technologies (security, Plug and Play, multicast, etc.) available by default in IPv6

- Useful reading:
  - "The case for IPv6": http://www.6bone.net/misc/case-for-ipv6.html

IPv6 addressing

- 128 bits of address space
- Hexadecimal values of eight 16 bit fields
  - X:X:X:X:X:X:X:X (X=16 bit number, ex: A2FE)
  - 16 bit number is converted to a 4 digit hexadecimal number
- Example:
  - FE38:DCE3:124C:C1A2:BA03:6735:EF1C:683D
  - Abbreviated form of address
    - 4EED:0023:0000:0000:0000:036E:1250:2B00

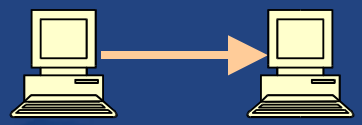
    →4EED:23:0:0:0:36E:1250:2B00

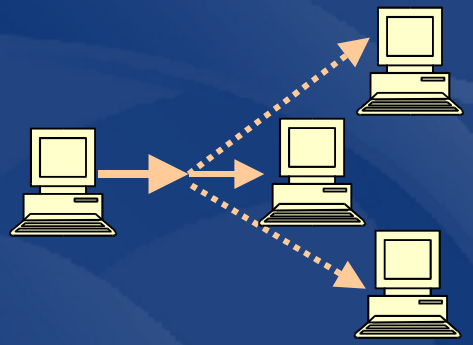
    →4EED:23::36E:1250:2B00

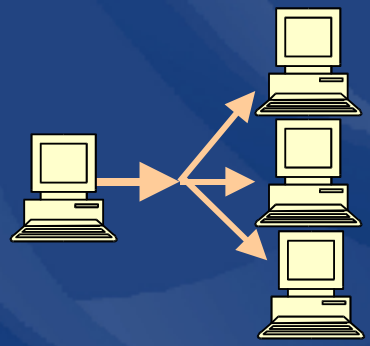
    (Null value can be used only once)

IPv6 addressing model

- **IPv6 Address type**
  - Unicast
    - An identifier for a single interface
  - Anycast
    - An identifier for a set of interfaces
  - Multicast
    - An identifier for a group of nodes

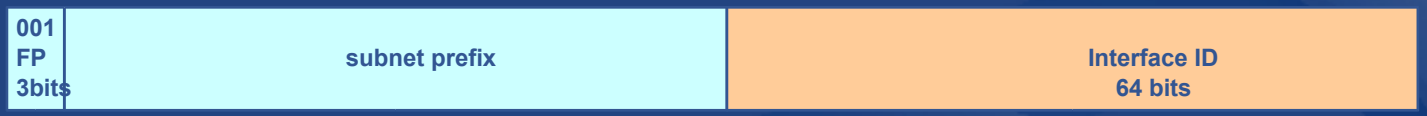




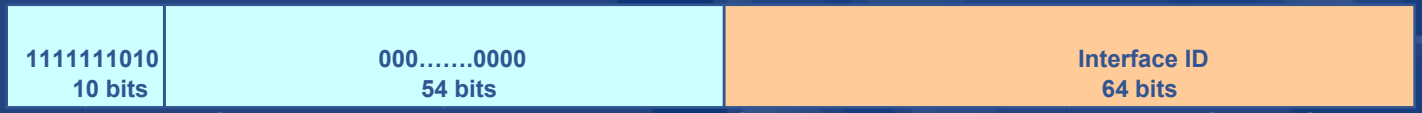


Unicast address

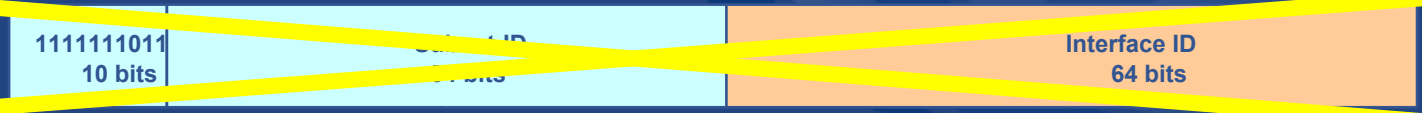
- Address given to interface for communication between host and router
  - Aggregatable global unicast address



  - Local use unicast address
    - Link-local address (starting with FE80::)



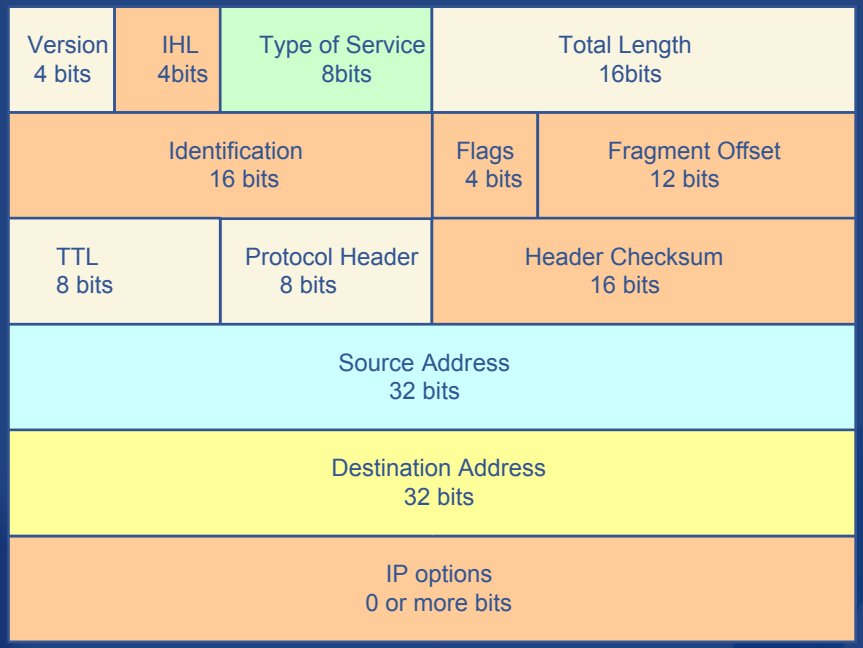
    - Site-local address (starting with FEC0::)



IPv6 header

- Comparison between IPv4 header and IPv6 header

IPv4 Header



IHL=IP Header Length
TTL=Time to Live

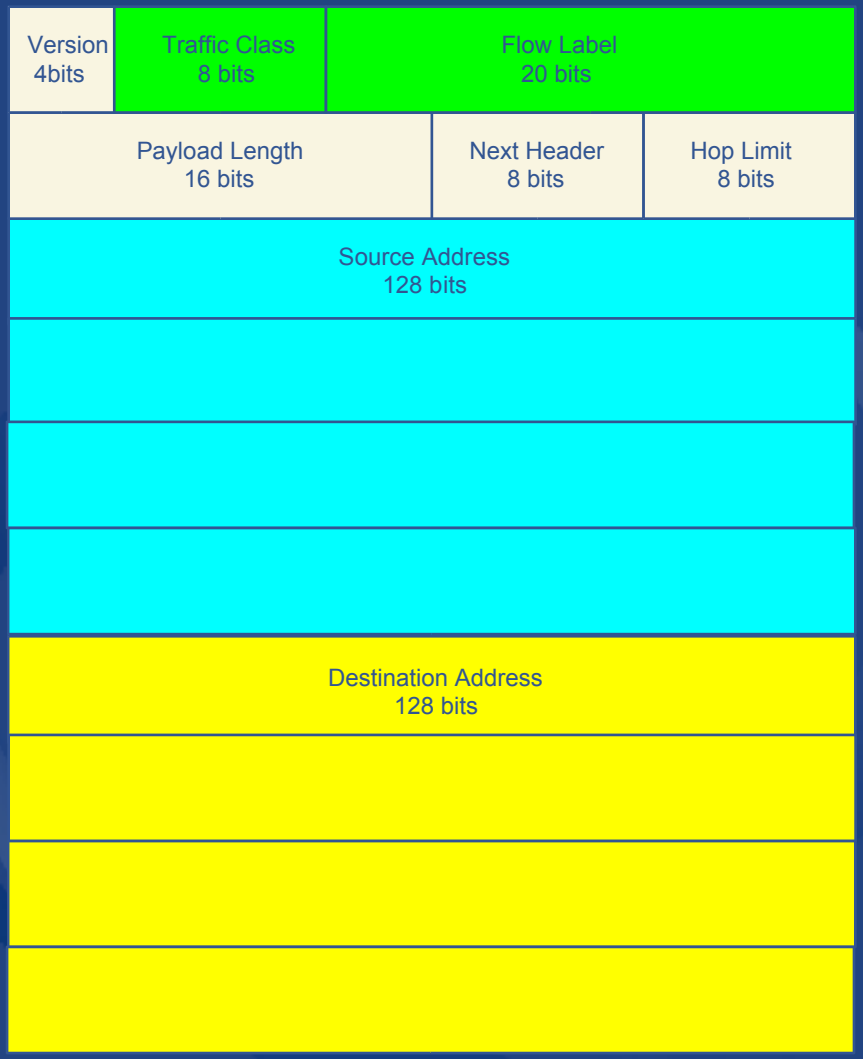
= Eliminated in IPv6

Enhanced in IPv6

Enhanced in IPv6

Enhanced in IPv6

IPv6 Header

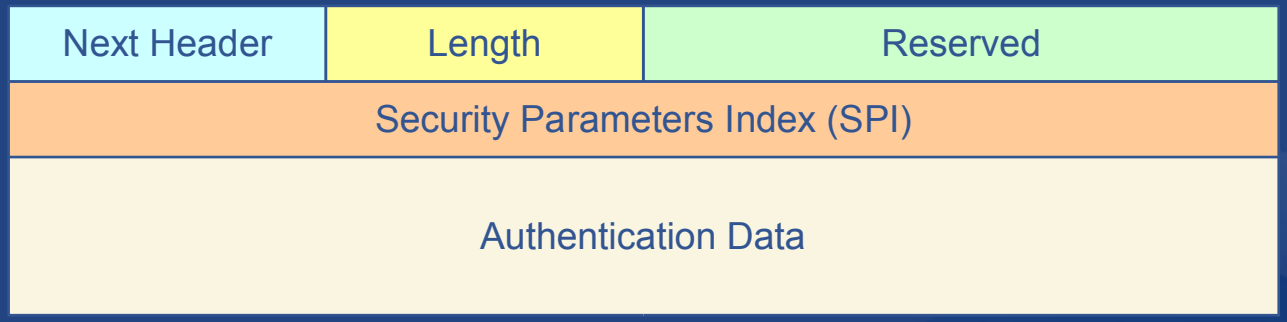


IPv6 header (Cont.)

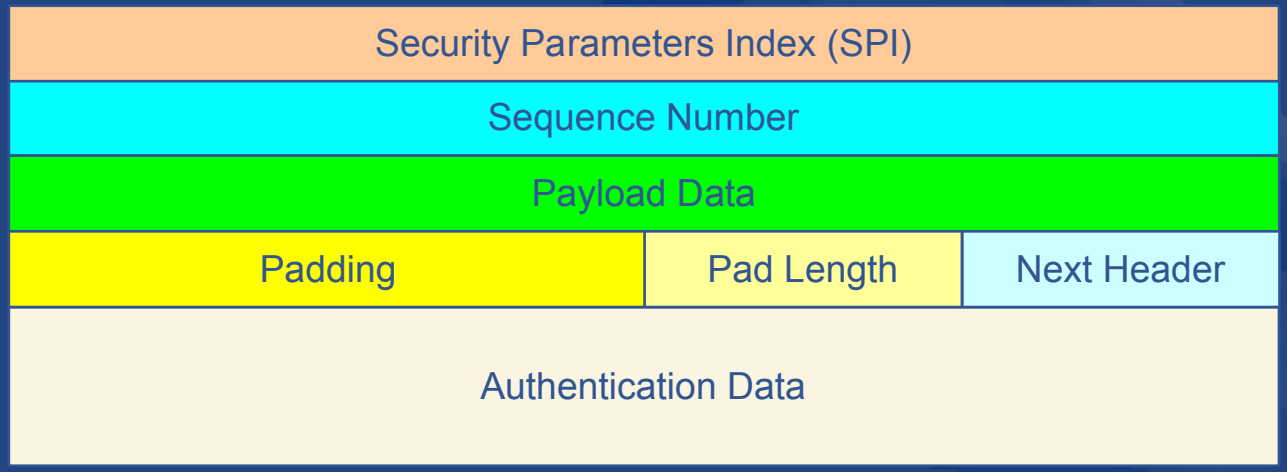
- IPv6 header is considerably simpler than IPv4
  - IPv4: 14 fields, IPv6: 8 fields
- IPv4 header can be variable in length: 196 bits +α
- IPv6 header: Fixed length: 320 bits
  - Eliminated fields in IPv6
    - Header Length
    - Identification
    - Flag
    - Fragmentation Offset
    - Checksum
  - Enhanced fields in IPv6
    - Traffic Class
    - Flow Label
- Authentication and privacy capabilities

IPv6 security

- Convey the authentication information via IPv6 extension header: Authentication header



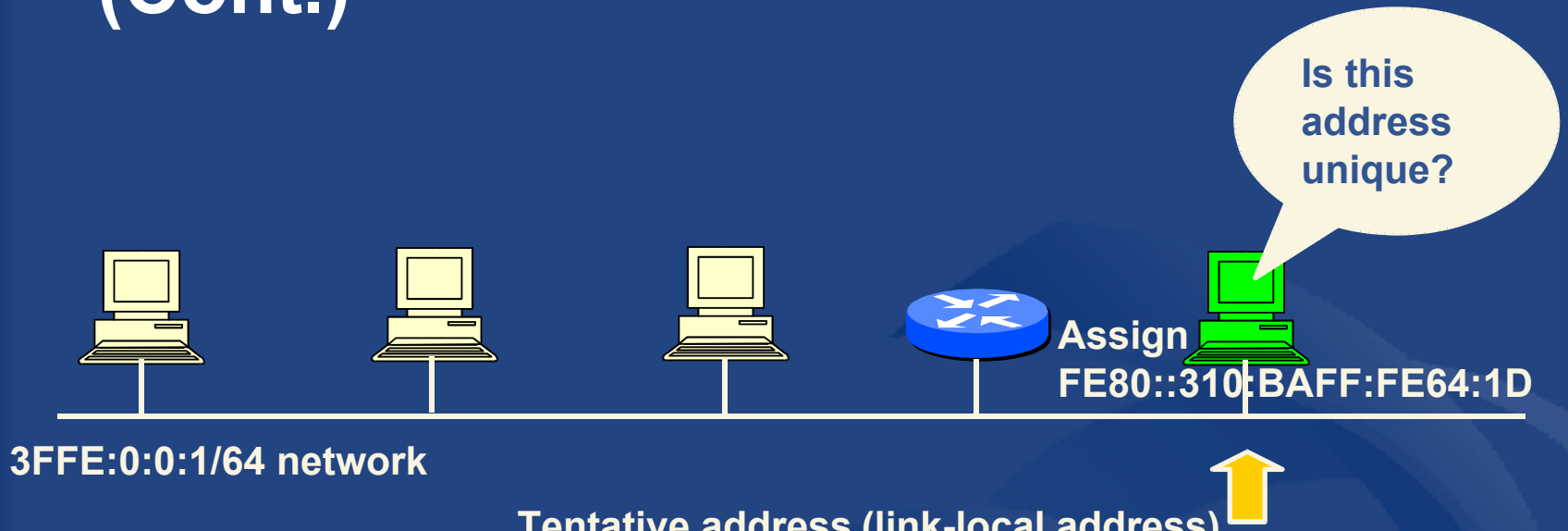
- Method to transport encrypted data: Encapsulating Security Payload (ESP) header



IPv6 features – autoconfiguration

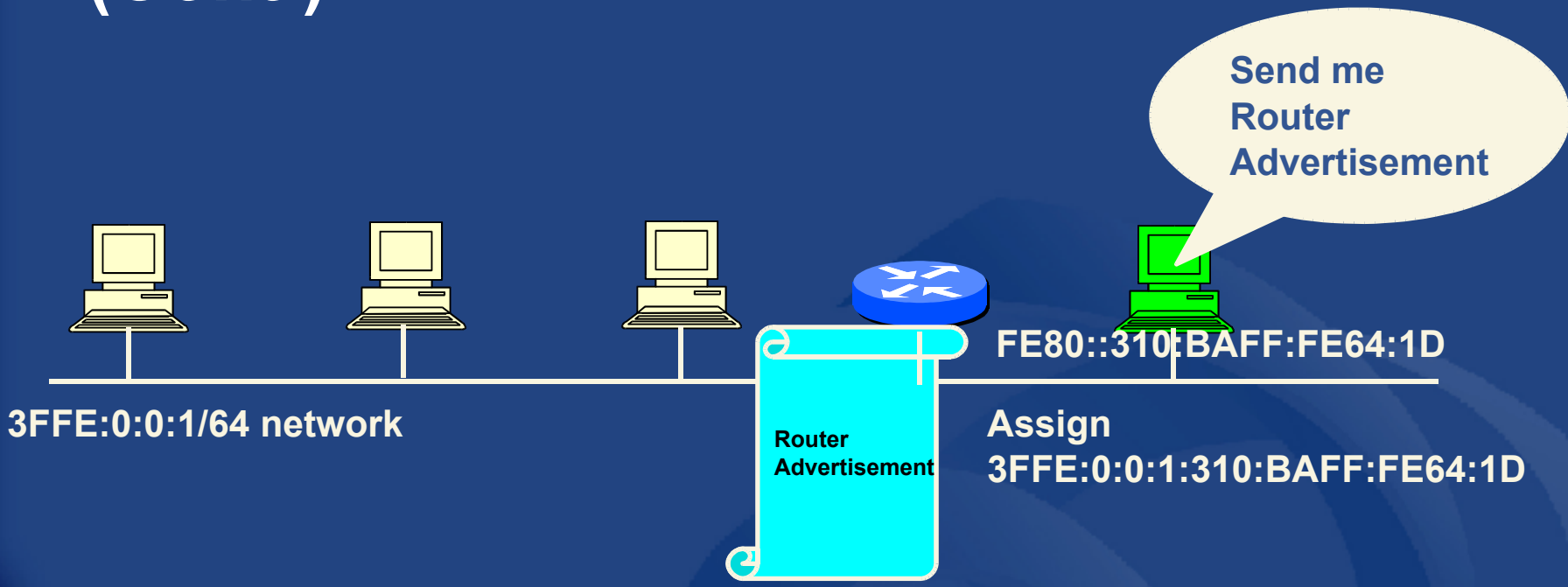
- Stateless mechanism
  - For a site not concerned with the exact addresses
  - No manual configuration required
  - Minimal configuration of routers
  - No additional servers
- Stateful mechanism
  - For a site requires tighter control over exact address assignments
  - Need DHCP server
  - DHCPv6
- Enable “Plug and play”

IPv6 features – autoconfigutation (Cont.)



1. A new host is turned on.
2. Tentative address will be assigned to the new host.
3. Duplicate Address Detection (DAD) is performed on all unicast address.
4. If no ND message comes back then the address is unique.
5. FE80::310:BAFF:FE64:1D will be assigned to the new host.

IPv6 feature: autoconfiguration (Cont.)



1. The new host will send “router solicitation” request via multicasting to obtain the network prefix.
2. The router will reply “routing advertisement”.
3. The new host will learn the network prefix. Ex: 3FFE:0:0:1
4. The new host will assigned a new address Network prefix+Interface ID
   Ex: 3FFE:0:0:1:310:BAFF:FE64:1D

IPv6 features – autoconfiguration (cont.)

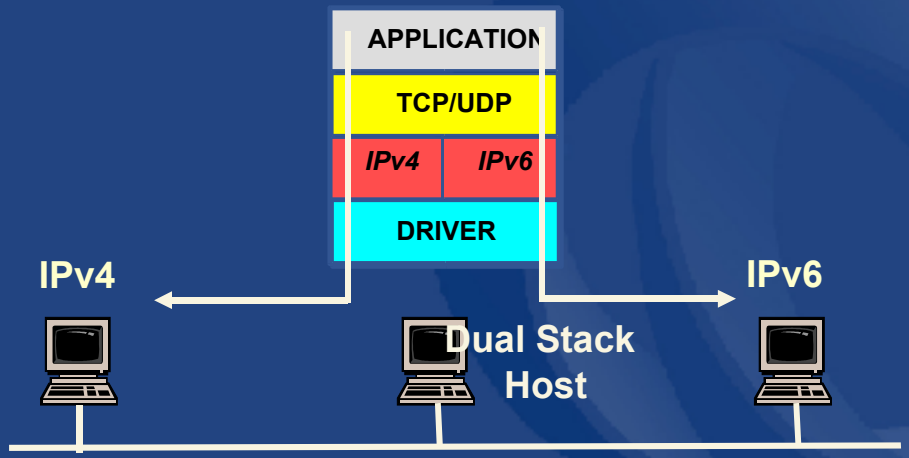
- Keeps end user costs down
  - No need for manual configuration
  - In conjunction with the possibility of low cost network interface
- Helpful when residential networks emerge as an important market

IPv4 to IPv6 transition

- Implementation rather than transition
- The key to successful IPv6 transition
  - Maintaining compatibility with IPv4 hosts and routers while deploying IPv6
    - Millions of IPv4 nodes already exist
    - Upgrading every IPv4 nodes to IPv6 is not feasible
    - Transition process will be gradual
- Commonly utilised transition techniques
  - Dual Stack Transition
  - Tunneling

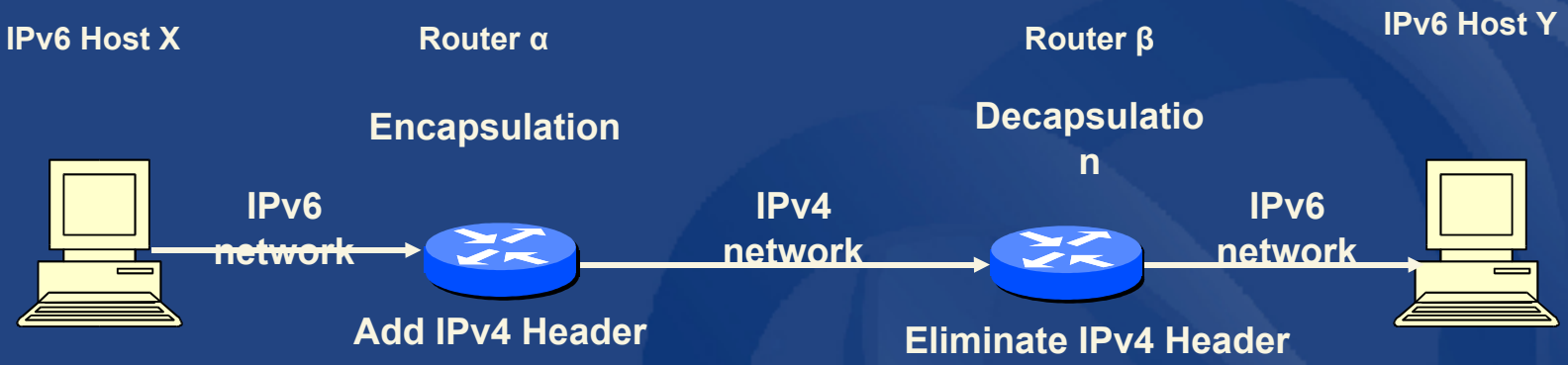
Dual stack transition

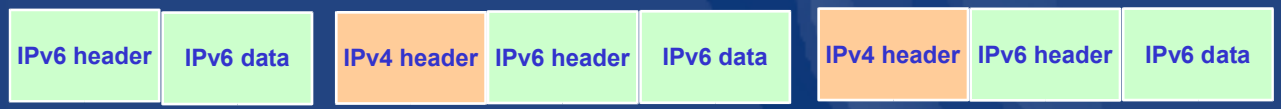
- Dual stack = TCP/IP protocol stack running both IPv4 and IPv6 protocol stacks simultaneously
- Useful at the early phase of transition



Tunneling

- Commonly utilised transition method
- IP v6 packet encapsulated in an IPv4 header
- Destination routers will decapsulate the packets and send IPv6 packets to destination IPv6 host

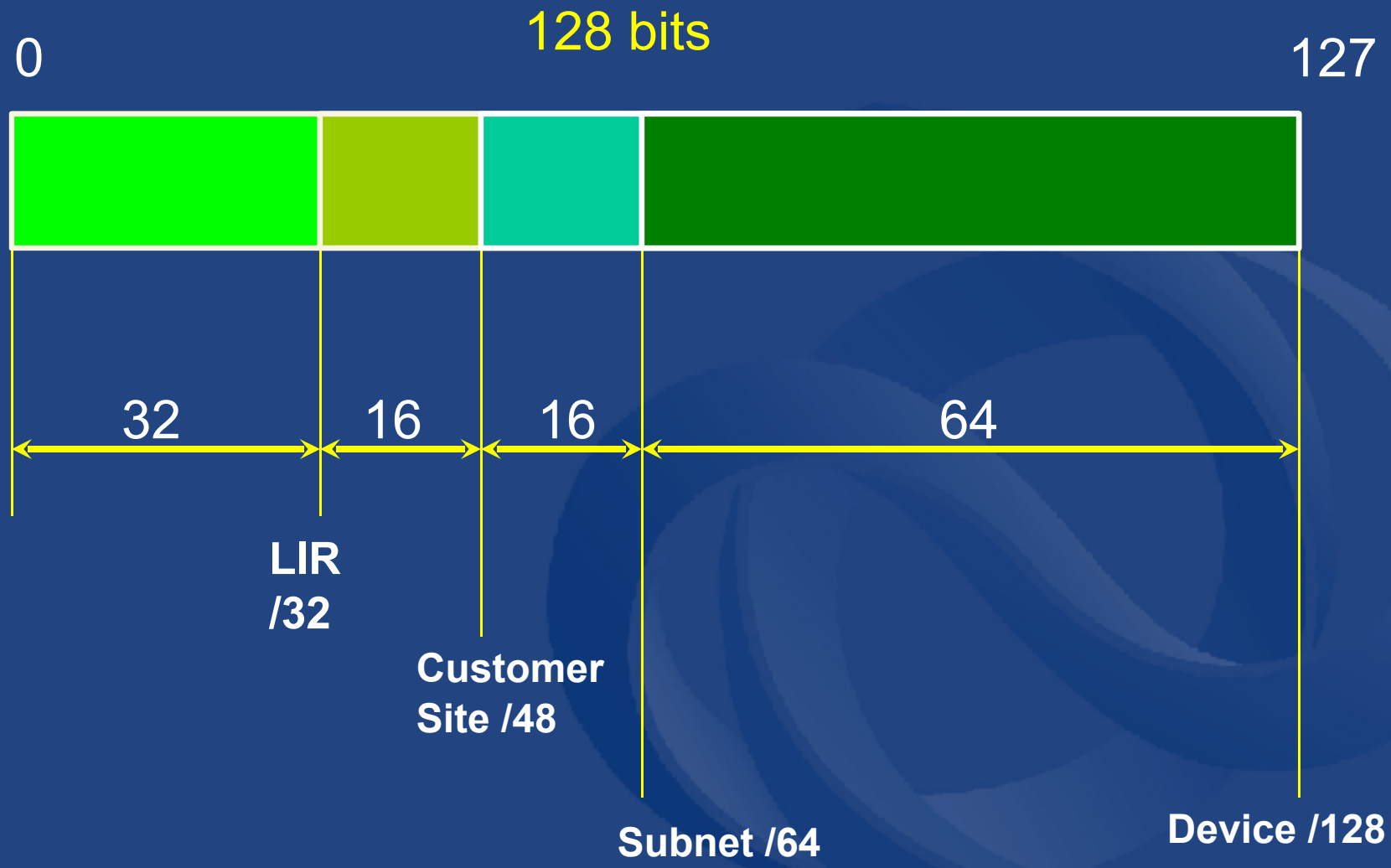




IPv6 address policy goals

- Efficient address usage
  - Avoid wasteful practices
- Aggregation
  - Hierarchical distribution
  - Aggregation of routing information
  - Limiting number of routing entries advertised
- Minimise overhead
  - Associated with obtaining address space
- Registration, Uniqueness, Fairness & consistency
  - Same as IPv4

IPv6 addressing structure



IPv6 initial allocation

- Initial allocation criteria
  - Plan to connect 200 end sites within 2 years
    - Default allocation (“slow start”)
- Initial allocation size is /32
  - Provides 16 bits of site address space

  - Larger initial allocations can be made if justified according to:
    - IPv6 network infrastructure plan
    - Existing IPv4 infrastructure and customer base

IPv6 sub-allocation policy

- LIR to ISP allocation
  - Policy determined by LIR
- DB registration
  - All /48 and shorter prefix allocations and assignments must be registered

IPv6 assignments

- Default assignment /48 for all end sites
  - POP also defined as end site
  - Providing /16 bits of space for subnets

- Other assignment sizes
  - /64 only one subnet
  - /128 only one device connecting
- Larger assignments - Multiple /48s
  - Should be reviewed by RIR/NIR
    - Follow second opinion procedure

What is an end site?

- End Site defined as an end user of an ISP where the ISP:
  - Assigns address space to the end user
  - Provides Internet transit service to the end user
  - Advertises an aggregate prefix route that contains the end user's assignment

IPv6 utilisation

- Utilisation determined from end site assignments
  - LIR responsible for registration of all /48 assignments
  - Intermediate allocation hierarchy not considered
- Utilisation of IPv6 address space is measured differently from IPv4

IPv6 utilisation (Cont.)

- Subsequent allocation may be requested when IPv6 utilisation requirement is met

Recap: IPv4 utilisation

- Under IPv4, address space utilisation measured as simple percentage:

$$\text{utilisation} = \frac{\text{Assigned address space}}{\text{Available address space}}$$

- IPv4 utilisation requirement is 80%
  - When 80% of address space has been assigned or allocated, LIR may receive more
    - E.g. ISP has assigned 55000 addresses of /16

$$\frac{\text{Assigned address space}}{\text{Available address space}} = \frac{55{,}000}{65{,}536} = 84\%$$

IPv6 utilisation requirement

- IPv6 utilisation measured according to HD-Ratio (RFC 3194):

$$\text{Utilisation}_{HD} = \frac{\log(\text{Assigned address space})}{\log(\text{Available address space})}$$

- IPv6 utilisation requirement is HD=0.80
  - Measured according to assignments only
    - E.g. ISP has assigned 10000 (/48s)

$$\frac{\log(\text{Assigned address space})}{\log(\text{Available address space})} = \frac{\log(10{,}000)}{\log(65{,}536)} = 0.83$$

IPv6 utilisation requirement (Cont.)

- HD Ratio utilisation requirement of 0.80

IPv6 Prefix	Site Address Bits	Total site address in /48s	Threshold (HD ratio 0.8)	Utilisation %
42	6	64	28	43.5%
36	12	4096	776	18.9%
35	13	8192	1351	16.5%
32	16	65536	7132	10.9%
29	19	524288	37641	7.2%
24	24	16777216	602249	3.6%
16	32	4294967296	50859008	1.2%
8	40	1099511627776	4294967296	0.4%
3	45	35184372088832	68719476736	0.2%

- RFC 3194
- “In a hierarchical address plan, as the size of the allocation increases, the density of assignments will decrease.”

Subsequent allocation

- Must meet HD = 0.8 utilisation requirement of previous allocation
  - (7132 /48s assignments in a /32)
- Other criteria to be met
  - Correct registrations (all /48s registered)
  - Correct assignment practices etc
- Subsequent allocation size is at least double
  - Resulting IPv6 prefix is 1 bit shorter
  - Should be sufficient for 2 years requirement

Other conditions

- License model of allocation
  - Allocations are not considered permanent, but always subject to review and reclamation
- Existing /35 Allocations
  - A number of /35s have been assigned under interim IPv6 policy
  - Holders of /35s eligible to request /32

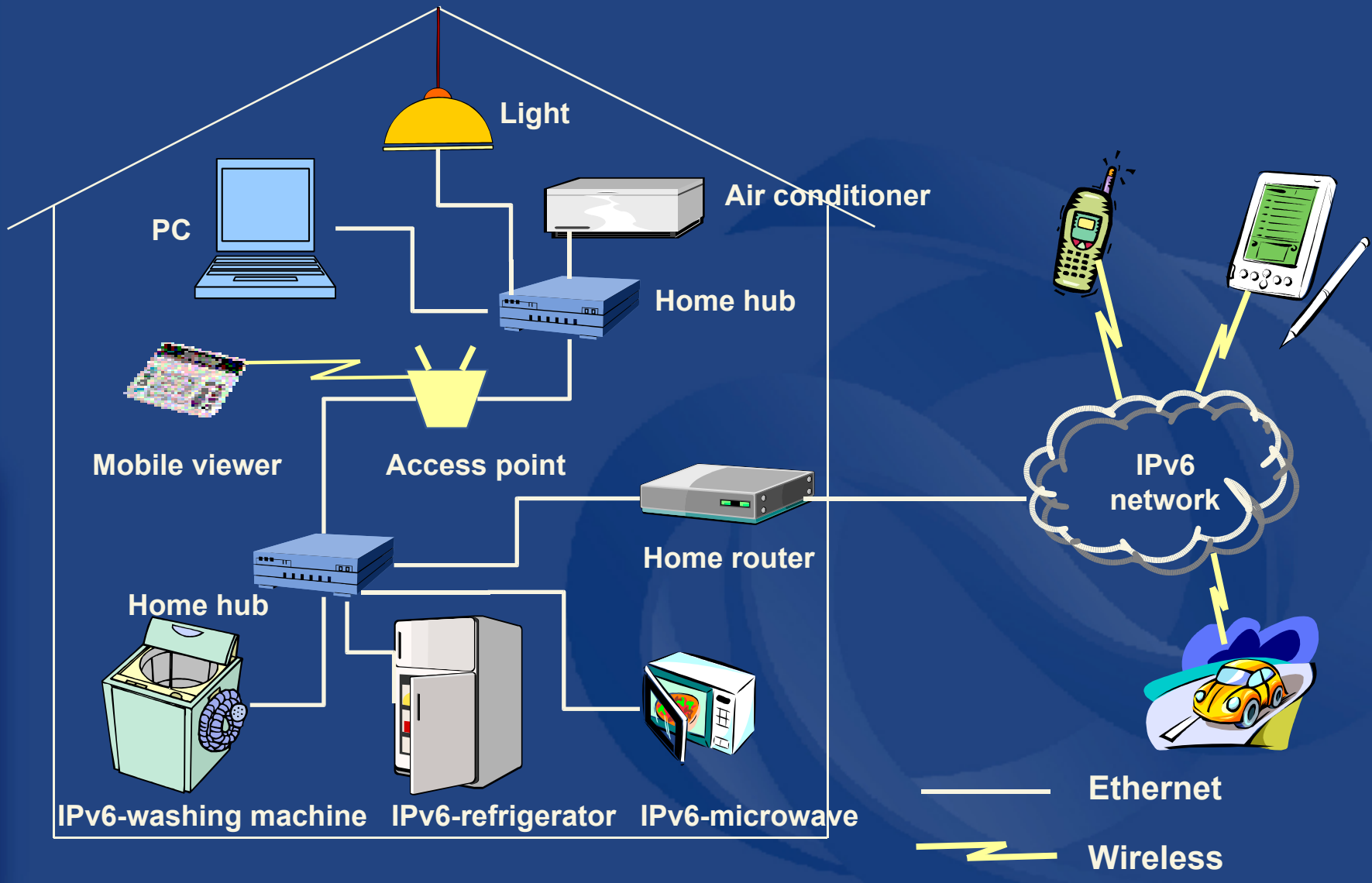
IXP IPv6 assignment policy

- Criteria
  - Demonstrate ‘open peering policy’
  - 3 or more peers
- Portable assignment size: /48
  - All other needs should be met through normal processes
  - /64 holders can “upgrade” to /48
    - Through NIRs/ APNIC
    - Need to return /64

Current Status - Implementations

- Most vendors are shipping supported products today
  - eg. 3Com, Apple, Bay Networks, BSDI, Bull, Cisco, Dassault, Digital, Epilogue, Ericsson/Telebit, FreeBSD, IBM, Hitachi, HP, KAME, Linux, Mentat, Microsoft, Nokia, Novell, Nortel, OpenBSD, SCO, Siemens Nixdorf, Silicon Graphics, Sun, Trumpet

IPv6 deployment current experiments



Current issues: DNS

- Need for a root name server, TLDs name server accessible via IPv6
- Human error easily made in IPv6 reverse DNS record
  - Dynamic update may provide a solution
  - Security system while update required
    - Ex: DNSSEC

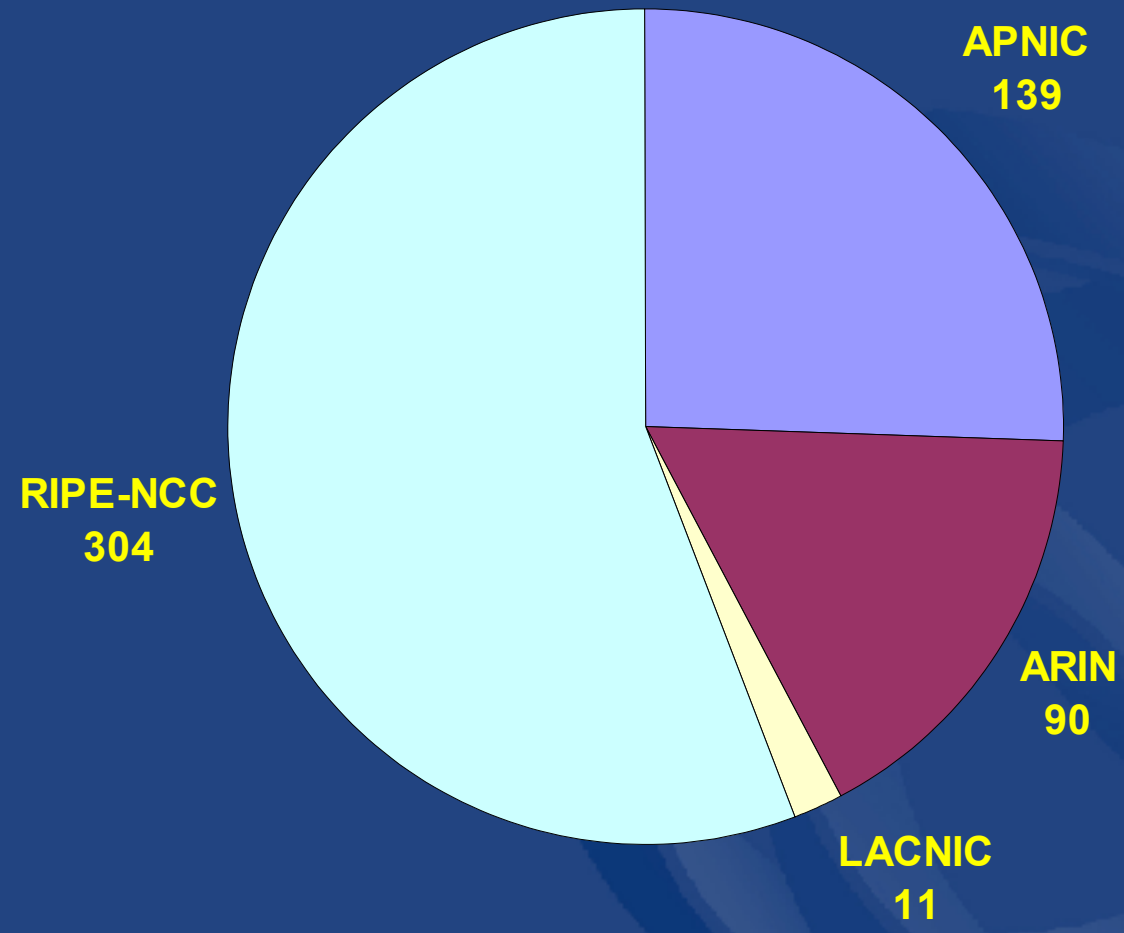
IPv6 Address Allocation Procedures

- IPv6 Allocations to RIRs from IANA
  - APNIC 2001:0200::/23
    2001:0C00::/23
    2001:0E00::/23
  - ARIN 2001:0400::/23
    2001:1800::/23
  - LACNIC 2001:1200::/23
  - RIPE NCC 2001:0600::/23
    2001:0800::/23
    2001:0A00::/23
    2001:1400::/23
    2001:1600::/23
    2001:1A00::/23
- IPv6 Address Request form
  http://ftp.apnic.net/apnic/docs/ipv6-alloc-request
- IPv6 FAQ http://www.apnic.net/faq/IPv6-FAQ.html

APNIC IPv6 Ranges for Assignments

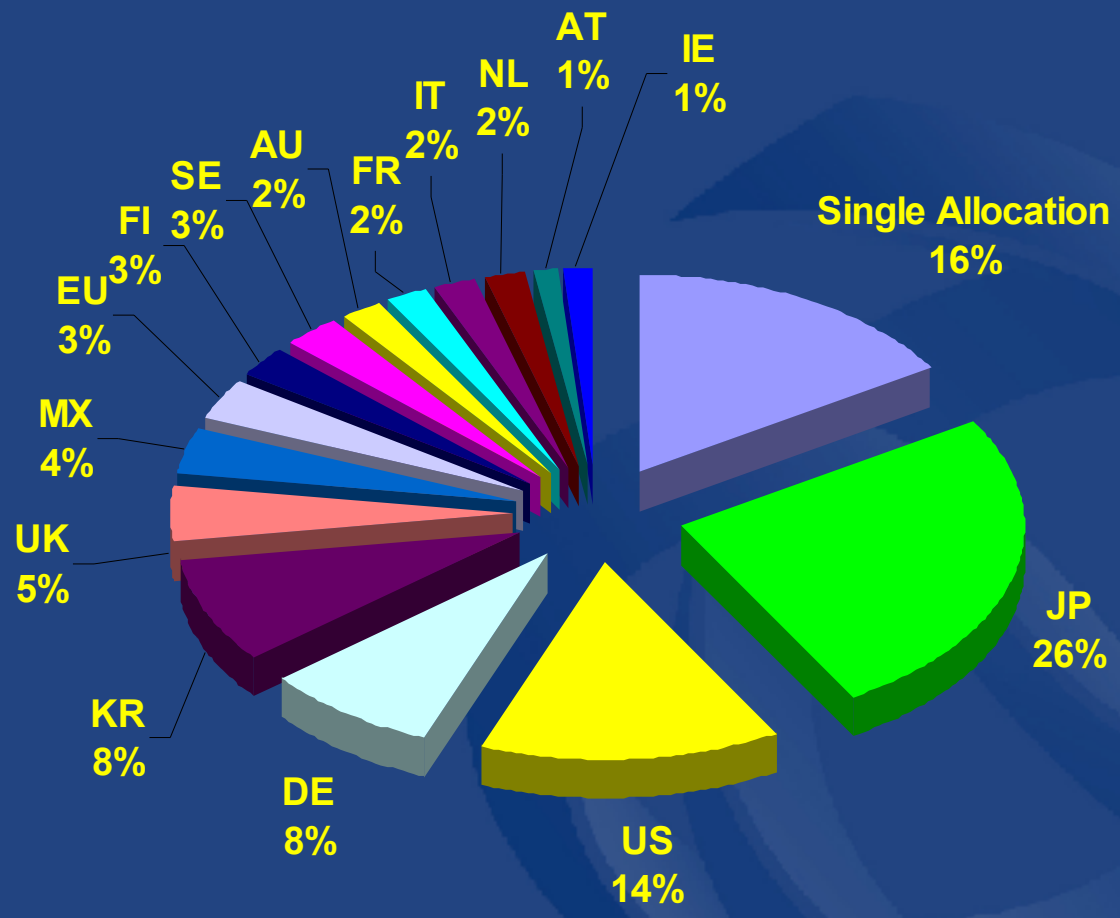
- IXP:
  2001:07FA::/32 (Default assignment size: /48)
- Critical infrastructure:
  2001:0DD8::/29
  (Default assignment size: /32)
- Experimental networks
  2001:0DE0::/29
  (Default assignment size: /32)
- Documentation
  2001:0DB8::/32
  (/32 Address block reserved for documentation purposes)

IPv6 distribution per RIR

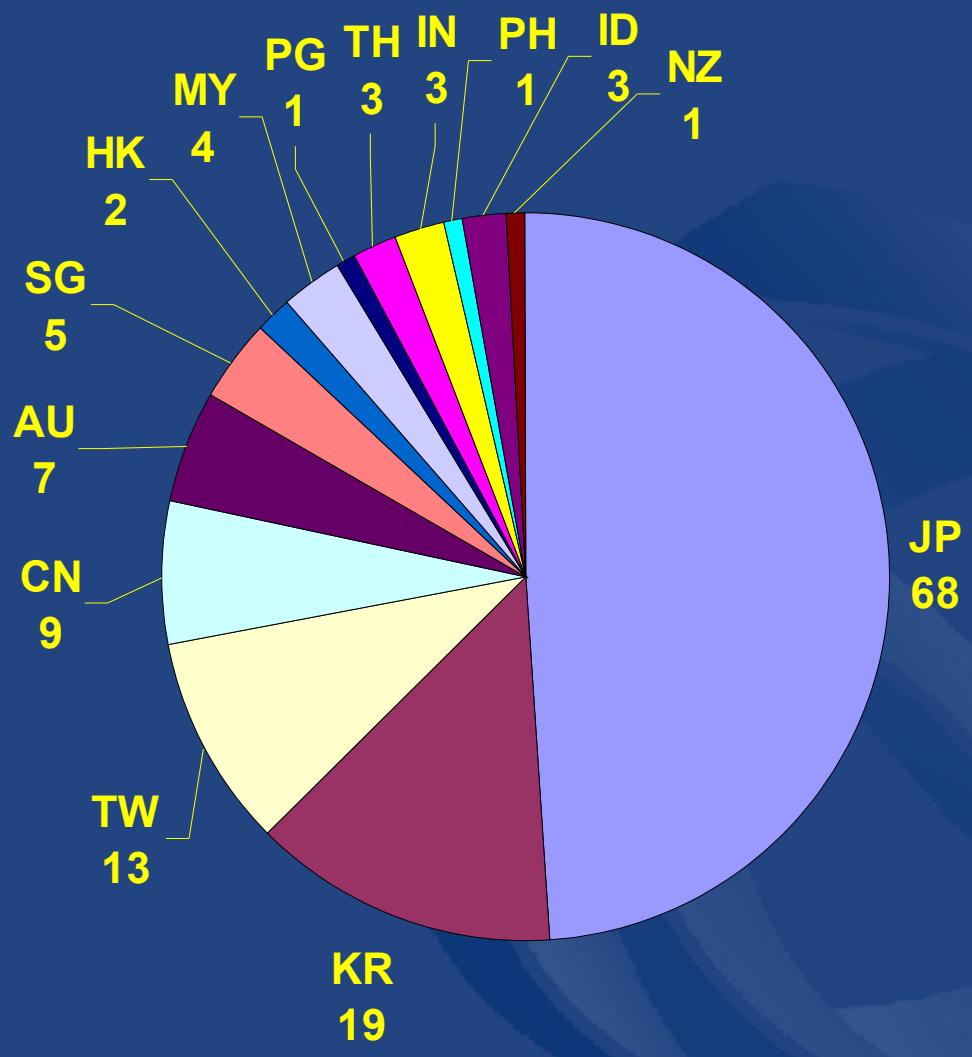


Last updated Feb 2004

IPv6 Allocations - Global

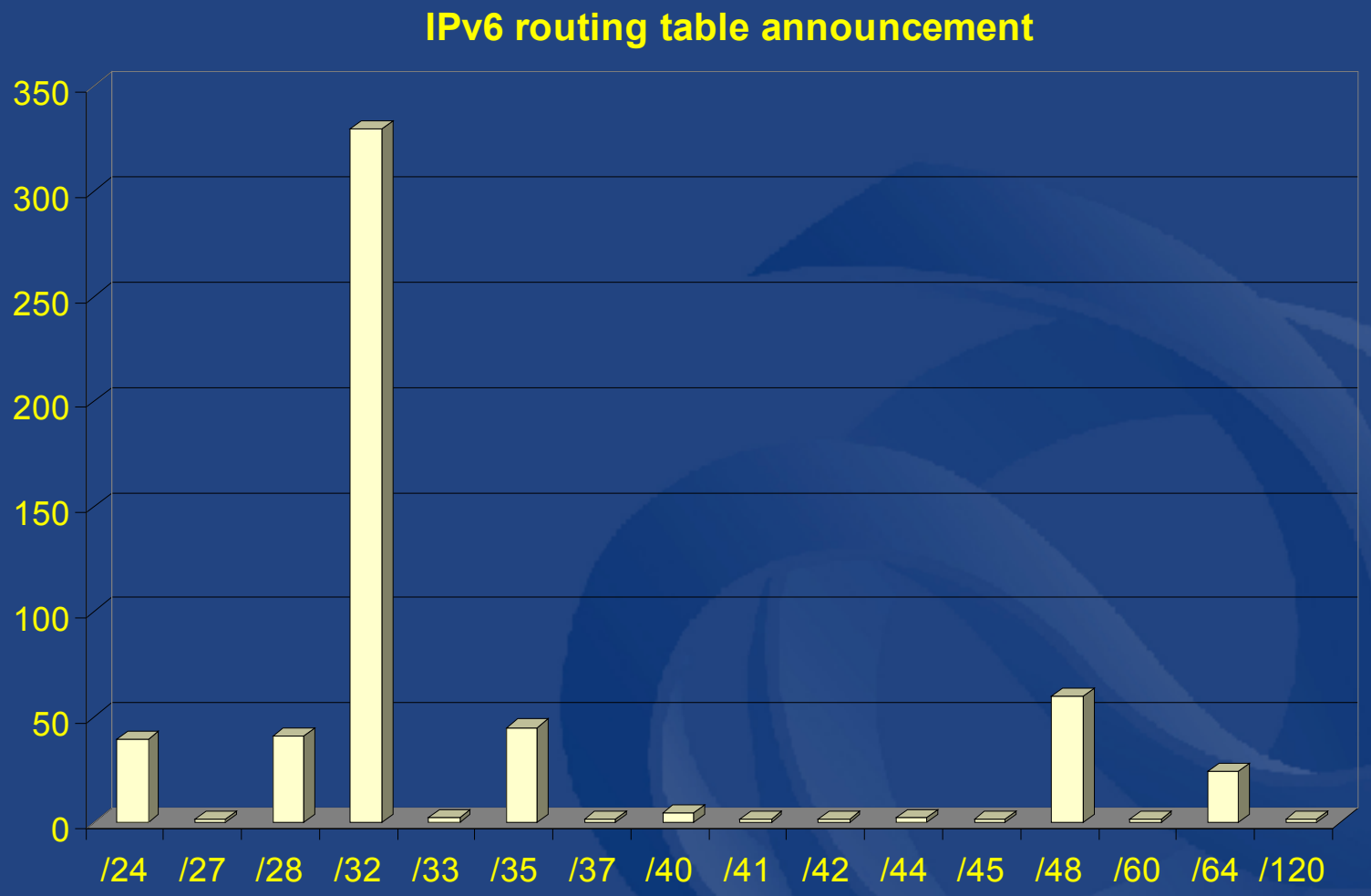


IPv6 allocations in Asia Pacific



Last updated Feb 2004

IPv6 routing table



Source: http://bgp.potaroo.net/v6/as1221/index.html

Last updated 09/03/2004

Supplementary Reading

Introduction

Regional Registry web sites

- APNIC:
  http://www.apnic.net
- ARIN:
  http://www.arin.net
- LACNIC:
  http://www.lacnic.net
- RIPE NCC:
  http://www.ripe.net

APNIC past meetings

http://www.apnic.net/meetings

Introduction

APNIC members

http://www.apnic.net/members.html

Membership

- Membership procedure

  http://www.apnic.net/membersteps.html
- Membership application form

  http://www.apnic.net/apnic-bin/membership-application.pl
- Membership fees

  http://www.apnic.net/docs/corpdocs/FeeSchedule.htm

Introduction to APNIC & IP Policy

Classless techniques

- CIDR
  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1517-19.txt
- Network Addressing when using CIDR
  ftp://ftp.uninett.no/pub/misc/eidnes-cidr.ps.Z
- Variable Length Subnet Table
  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1878.txt

Private Address Space

- Address Allocation for Private Internets
  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1918.txt
- Counter argument: “Unique addresses are good”
  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1814.txt

Bit boundary chart

addrs	bits	pref	class	mask
1	0	/32		255.255.255.255
2	1	/31		255.255.255.254
4	2	/30		255.255.255.252
8	3	/29		255.255.255.248
16	4	/28		255.255.255.240
32	5	/27		255.255.255.224
64	6	/26		255.255.255.192
128	7	/25		255.255.255.128
256	8	/24	1C	255.255.255
512	9	/23	2C	255.255.254
1,024	10	/22	4C	255.255.252
2,048	11	/21	8C	255.255.248
4,096	12	/20	16C	255.255.240
8,192	13	/19	32C	255.255.224
16,384	14	/18	64C	255.255.192
32,768	15	/17	128C	255.255.128
65,536	16	/16	1B	255.255
131,072	17	/15	2B	255.254
262,144	18	/14	4B	255.252
524,288	19	/13	8B	255.248
1,048,576	20	/12	16B	255.240
2,097,152	21	/11	32B	255.224
4,194,204	22	/10	64B	255.192
8,388,608	23	/9	128B	255.128
16,777,216	24	/8	1A	255
33,554,432	25	/7	2A	254
67,108,864	26	/6	4A	252
134,217,728	27	/5	8A	248
268,435,456	28	/4	16A	240
536,870,912	29	/3	32A	224
1,073,741,824	30	/2	64A	192

APNIC Mailing Lists

- apnic-talk
  - Open discussions relevant to APNIC community & members
- apnic-announce
  - Announcements of interest to the AP community
- sig-policy
  - IPv4 and IPv6 allocation and assignment policies
- global-v6
  - Global IPv6 policy mailing list

- subscribe via <majordomo@apnic.net>
- archives:

  http://ftp.apnic.net/apnic/mailing-lists

http://www.apnic.net/net_comm/lists/

The RIR System

- *"Development of the Regional Internet Registry System"* Internet Protocol Journal
  - Short history of the Internet

http://www.cisco.com/warp/public/759/ipj_4-4/ipj_4-4_regional.html

Policies & Policy Environment

Policy Documentation

- Policies for address space management in the Asia Pacific region

  http://www.apnic.net/docs/policy/add-manage-policy.html

- RFC2050: Internet Registry IP allocation Guidelines

  http://ftp.apnic.net/ietf/rfc/rfc2000/rfc2050.txt

Address Request Procedures

Addressing Guidelines

- "Designing Addressing Architectures for Routing & Switching", Howard C. Berkowitz

Address Request Forms

- ISP Address Request Form

  http://www.apnic.net/services/ipv4/

- Second-opinion Request Form

  http://www.apnic.net/services/second-opinion/

- No Questions Asked

  http://ftp.apnic.net/apnic/docs/no-questions-policy

APNIC Database

APNIC Database Documentation

- Updating information in the APNIC Database
  http://ftp.apnic.net/apnic/docs/database-update-info
- Maintainer & Person Object Request Form
  http://ftp.apnic.net/apnic/docs/mntner-person-request
- APNIC Maintainer Object Request
  http://www.apnic.net/apnic-bin/maintainer.pl
- APNIC Whois Database objects resource guide
  http://www.apnic.net/services/whois_guide.html

APNIC Database

RIPE Database Documentation

- RIPE Database Reference Manual

  http://www.ripe.net/docs/databaseref-manual.html

Database 'whois' Client

http://ftp.apnic.net/apnic/dbase/tools/ripe-dbase-client.tar.gz

Database web query

http://www.apnic.net/apnic-bin/whois2.pl

Person object template

```
person:   [mandatory]  [single]    [lookup key]
address:  [mandatory]  [multiple]  [ ]
country:  [optional]   [single]    [ ]
phone:    [mandatory]  [multiple]  [ ]
fax-no:   [optional]   [multiple]  [ ]
e-mail:   [mandatory]  [multiple]  [lookup key]
nic-hdl:  [mandatory]  [single]    [primary/look-up key]
remarks:  [optional]   [multiple]  [ ]
notify:   [optional]   [multiple]  [inverse key]
mnt-by:   [mandatory]  [multiple]  [inverse key]
changed:  [mandatory]  [multiple]  [ ]
source:   [mandatory]  [single]    [ ]
```

Role object template

```
role:     [mandatory] [single]    [lookup key]
address:  [mandatory] [multiple]  [ ]
country:  [optional]  [single]    [ ]
phone:    [mandatory] [multiple]  [ ]
fax-no:   [optional]  [multiple]  [ ]
e-mail:   [mandatory] [multiple]  [lookup key]
trouble:  [optional]  [multiple]  [ ]
admin-c:  [mandatory] [multiple]  [inverse key]
tech-c:   [mandatory] [multiple]  [inverse key]
nic-hdl:  [mandatory] [single]    [primary/look-up
   key]
remarks:  [optional]  [multiple]  [ ]
notify:   [optional]  [multiple]  [inverse key]
mnt-by:   [mandatory] [multiple]  [inverse key]
changed:  [mandatory] [multiple]  [ ]
source:   [mandatory] [single]    [ ]
```

Maintainer Object Template

```
mntner:      [mandatory] [single]   [primary/look-up key]
descr:       [mandatory] [multiple] [ ]
country:     [optional]  [single]   [ ]
admin-c:     [mandatory] [multiple] [inverse key]
tech-c:      [optional]  [multiple] [inverse key]
upd-to:      [mandatory] [multiple] [inverse key]
mnt-nfy:     [optional]  [multiple] [inverse key]
auth:        [mandatory] [multiple] [ ]
remarks:     [optional]  [multiple] [ ]
notify:      [optional]  [multiple] [inverse key]
mnt-by:      [mandatory] [multiple] [inverse key]
referral-by: [mandatory] [single]   [inverse key]
changed:     [mandatory] [multiple] [ ]
source:      [mandatory] [single]   [ ]
```

Inetnum object template

inetnum:	[mandatory]	[single]	[primary/look-up key]
netname:	[mandatory]	[single]	[lookup key]
descr:	[mandatory]	[multiple]	[ ]
country:	[mandatory]	[multiple]	[ ]
admin-c:	[mandatory]	[multiple]	[inverse key]
tech-c:	[mandatory]	[multiple]	[inverse key]
rev-srv:	[optional]	[multiple]	[inverse key]
status:	[mandatory]	[single]	[ ]
remarks:	[optional]	[multiple]	[ ]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
mnt-lower:	[optional]	[multiple]	[inverse key]
mnt-routes:	[optional]	[multiple]	[inverse key]
mnt-irt:	[optional]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Aut-num Object Template

aut-num:	[mandatory]	[single]	[primary/look-up key]
as-name:	[mandatory]	[single]	[ ]
descr:	[mandatory]	[multiple]	[ ]
country:	[optional]	[single]	[ ]
member-of:	[optional]	[multiple]	[ ]
import:	[optional]	[multiple]	[ ]
export:	[optional]	[multiple]	[ ]
default:	[optional]	[multiple]	[ ]
remarks:	[optional]	[multiple]	[ ]
admin-c:	[mandatory]	[multiple]	[inverse key]
tech-c:	[mandatory]	[multiple]	[inverse key]
cross-mnt:	[optional]	[multiple]	[inverse key]
cross-nfy:	[optional]	[multiple]	[inverse key]
notify:	[optional]	[multiple]	[inverse key]
mnt-lower:	[optional]	[multiple]	[inverse key]
mnt-routes:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Domain object template

```
domain:     [mandatory]  [single]     [primary/look-up
   key]
descr:      [mandatory]  [multiple]   [ ]
country:    [optional]   [single]     [ ]
admin-c:    [mandatory]  [multiple]   [inverse key]
tech-c:     [mandatory]  [multiple]   [inverse key]
zone-c:     [mandatory]  [multiple]   [inverse key]
nserver:    [mandatory]  [multiple]   [inverse key]
sub-dom:    [optional]   [multiple]   [inverse key]
dom-net:    [optional]   [multiple]   [ ]
remarks:    [optional]   [multiple]   [ ]
notify:     [optional]   [multiple]   [inverse key]
mnt-by:     [mandatory]  [multiple]   [inverse key]
mnt-lower:  [optional]   [multiple]   [inverse key]
refer:      [optional]   [single]     [ ]
changed:    [mandatory]  [multiple]   [ ]
source:     [mandatory]  [single]     [ ]
```

Reverse DNS

Request Forms

- Guide to reverse zones

  http://www.apnic.net/db/revdel.html

- Registering your Rev Delegations with APNIC

  http://www.apnic.net/db/domain.html

Relevant RFCs

- Classless Delegations

  http://ftp.apnic.net/ietf/rfc/rfc2000/rfc2317.txt

- Common DNS configuration errors

  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1537.txt

Reverse DNS

Documentation

- Domain name structure and delegation

  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1591.txt

- Domain administrators operations guide

  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1033.txt

- Taking care of your domain

  ftp://ftp.ripe.net/ripe/docs/ripe-114.txt

- Tools for DNS debugging

  http://ftp.apnic.net/ietf/rfc/rfc2000/rfc2317.txt

AS Assignment Procedures

Policy

- Guidelines for the creation, selection, and registration of an AS

  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1930.txt

RFCs

- Routing Policy Specification Language (RPSL)

  http://ftp.apnic.net/ietf/rfc/rfc2000/rfc2280.txt

- A dedicated AS for sites homed to a single provider

  http://ftp.apnic.net/ietf/rfc/rfc2000/rfc2270.txt

- RFC1997: BGP Communities attribute

  http://ftp.apnic.net/ietf/rfc/rfc2000/rfc2270.txt

IPv6

Policy Documents

- IPv6 Address Policy

  http://ftp.apnic.net/apnic/docs/ipv6-address-policy

- IPv6 Address request form

  http://ftp.apnic.net/apnic/docs/ipv6-alloc-request

Useful reading

- The case for IPv6

  http://www.6bone.net/misc/case-for-ipv6.html

FAQ

http://www.apnic.net/info/faq/IPv6-FAQ.html

IPv6: HD Ratio 0.8

IPv6 prefix	Site addr bits	Total site addrs in /48s	Threshold	Util%
42	6	64	28	**43.5%**
36	12	4096	776	**18.9%**
35	13	8192	1351	**16.5%**
32	16	65536	7132	**10.9%**
29	19	524288	37641	**7.2%**
24	24	16777216	602249	**3.6%**
16	32	4294967296	50859008	**1.2%**
8	40	1099511627776	4294967296	**0.4%**
3	45	35184372088832	68719476736	**0.2%**

RFC3194 “The Host-Density Ratio for Address Assignment Efficiency”

Other supplementary reading

Operational Content Books

- *ISP Survival Guide*, Geoff Huston
- *Cisco ISP Essentials*, Philip Smith

BGP Table

http://www.telstra.net/ops/bgptable.html

http://www.merit.edu/ipma/reports

http://www.merit.edu/ipma/routing_table/mae-east/prefixlen.990212.html

http://www.employees.org/~tbates/cidr.hist.plot.html

Routing Instability

http://zounds.merit.net/cgi-bin/do.pl

Other supplementary reading

Routing & Mulithoming

- *Internet Routing Architectures* - Bassam Halabi
- BGP Communities Attribute

  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1997.txt

  http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1998.txt

Filtering

- Egress Filtering

  http://www.cisco.com/public/cons/isp

- Network Ingress Filtering: Defeating Denial of Service Attacks which employ IP Source Address Spoofing

  http://ftp.apnic.net/ietf/rfc/rfc2000/rfc2267.txt

Other Supplementary Reading

- Dampening case studies at
  http://www.cisco.com/warp/public/459/16.html
- Traceroute Server
  http://nitrous.digex.net
- Network Renumbering Overview: Why Would I Want It and What Is It Anyway?
  http://ftp.apnic.net/ietf/rfc/rfc2000/rfc2071.txt
- Procedures for Enterprise Renumbering
  http://www.isi.edu/div7/pier/papers.html
- NAT
  - The IP Network Address Translator
    http://ftp.apnic.net/ietf/rfc/rfc1000/rfc1631.txt

Supplementary Reading

Introduction

- Regional Internet Registry web sites
  - APNIC
    - http://www.apnic.net
  - ARIN
    - http://www.arin.net
  - LACNIC
    - www.lacnic.net
  - RIPE NCC
    - http://www.ripe.net
- APNIC past meetings
    - http://www.apnic.net/meetings

Introduction

- APNIC members
  - http://www.apnic.net/members.html
- Membership
  - Membership procedure
    - http://www.apnic.net/membersteps.html
  - Membership application form
    - http://www.apnic.net/apnic-bin/membership-application.pl
  - Membership fees
    - http://www.apnic.net/docs/corpdocs/FeeSchedule.htm

Member Services Helpdesk

- One point of contact for all member enquiries

Helpdesk hours
9:00 am - 7:00 pm (AU EST, UTC + 10 hrs)

ph: +61 7 3858 3188 **fax: 61 7 3858 3199**

- *More personalised service*
  - Range of languages:
    Cantonese, Filipino, Mandarin, Thai, Vietnamese etc.

- *Faster response and resolution of queries*
  - IP resource applications, status of requests, obtaining help in completing application forms, membership enquiries, billing issues & database enquiries

APNIC & IR policies

- Classless techniques/CIDR
  - http://nori.apnic.net/ietf/rfc/rfc1517.txt
  - http://nori.apnic.net/ietf/rfc/rfc1518.txt
  - http://nori.apnic.net/ietf/rfc/rfc1519.txt
- Network Addressing when using CIDR
  - ftp://ftp.uninett.no/pub/misc/eidnes-cidr.ps.Z
- Variable Length Subnet Table
  - http://nori.apnic.net/ietf/rfc/rfc1878.txt

Private address space

- Private Address Space
  - Address Allocation for Private Internets
    - http://nori.apnic.net/ietf/rfc/rfc1918.txt
  - Counter argument: Unique addresses are good
    - http://nori.apnic.net/ietf/rfc/rfc1814.txt

Bit boundary chart

addrs	bits	pref	class	mask
1	0	/32		255.255.255.255
2	1	/31		255.255.255.254
4	2	/30		255.255.255.252
8	3	/29		255.255.255.248
16	4	/28		255.255.255.240
32	5	/27		255.255.255.224
64	6	/26		255.255.255.192
128	7	/25		255.255.255.128
256	8	/24	1C	255.255.255
512	9	/23	2C	255.255.254
1,024	10	/22	4C	255.255.252
2,048	11	/21	8C	255.255.248
4,096	12	/20	16C	255.255.240
8,192	13	/19	32C	255.255.224
16,384	14	/18	64C	255.255.192
32,768	15	/17	128C	255.255.128
65,536	16	/16	1B	255.255
131,072	17	/15	2B	255.254
262,144	18	/14	4B	255.252
524,288	19	/13	8B	255.248
1,048,576	20	/12	16B	255.240
2,097,152	21	/11	32B	255.224
4,194,204	22	/10	64B	255.192
8,388,608	23	/9	128B	255.128
16,777,216	24	/8	1A	255
33,554,432	25	/7	2A	254
67,108,864	26	/6	4A	252
134,217,728	27	/5	8A	248
268,435,456	28	/4	16A	240
536,870,912	29	/3	32A	224
1,073,741,824	30	/2	64A	192

APNIC mailing lists

- apnic-talk
  - Open discussion relevant to APNIC community and members
    - e.g. policies, procedures etc
- apnic-announce
  - Announcements of interest to the AP community
- ipv6-registry
  - IPv6 allocation and assignment policies

- http://www.apnic.net/net_comm/lists/
  - subscribe via <majordomo@apnic.net>
  - archives at
    - http://ftp.apnic.net/apnic/mailing-lists

The RIR system

- “Development of the Regional Internet Registry System”
  - Internet Protocol Journal
    - Short history of the Internet
  - http://www.cisco.com/warp/public/759/ipj_

Policies & policy environment

- Policy Documentation
  - Policies for address space management in the Asia Pacific region
    - http://www.apnic.net/docs/policy/add-manage-policy.html
  - Internet Registry IP allocation Guidelines
    - http://nori.apnic.net/ietf/rfc/rfc2050.txt

Address request procedures

- Addressing Guidelines
  - Designing Addressing Architectures for Routing & Switching Howard C. Berkowitz
- Address Request Forms
  - ISP Address Request Form
    - http://www.apnic.net/services/ipv4/
  - Second-opinion Request For
    - http://cgi.apnic.net/apnic-bin/second-opinion-request.pl
  - No Questions Asked
    - http://ftp.apnic.net/apnic/docs/no-questions-policy

APNIC Database

- APNIC Database Documentation
  - http://ftp.apnic.net/apnic/docs/database-update-info
  - http://ftp.apnic.net/apnic/docs/maintainer-request
  - http://www.apnic.net/apnic-bin/maintainer.pl
  - http://www.apnic.net/services/whois_guide.html
- RIPE Database Documentation
  - http://www.ripe.net/ripe/docs/databaseref-manual.html
- Database ‘whois’ Client
  - http://ftp.apnic.net/apnic/dbase/tools/ripe-dbase-client.tar.gz
  - http://www.apnic.net/apnic-bin/whois2.pl

Reverse DNS

- Request Forms
  - http://www.apnic.net/db/revdel.html
  - http://www.apnic.net/db/domain.html
- Classless Delegations
  - http://nori.apnic.net/ietf/rfc/rfc2317.txt
- Common DNS configuration errors
  - http://nori.apnic.net/ietf/rfc/rfc1537.txt

Reverse DNS

- Domain name structure and delegation
  - http://nori.apnic.net/ietf/rfc/rfc1591.txt
- Domain administrators operations guide
  - http://nori.apnic.net/ietf/rfc/rfc1033.txt
- Taking care of your domain
  - ftp://ftp.ripe.net/ripe/docs/ripe-114.txt
- Tools for DNS debugging
  - http://nori.apnic.net/ietf/rfc/rfc2317.txt

AS assignment procedures

- ASN policy document
  - http://www.apnic.net/docs/policy/asn-policy.html
- ASN request form
  - http://www.apnic.net/db/aut-num.html
- Using a Dedicated AS for Sites Homed to a Single Provider
  - http://nori.apnic.net/ietf/rfc/rfc2270.txt
- Guidelines for the creation, selection, and registration of an AS
  - http://nori.apnic.net/ietf/rfc/rfc1930.txt

Internet Routing Registry

- APNIC Routing Registry Guide
  - http://www.apnic.net/services/apnic-rr-guide.html
- Routing Policy Specification Language (RPSL)
  - http://nori.apnic.net/ietf/rfc/rfc2280.txt
- Using RPSL in Practice
  - http://nori.apnic.net/ietf/rfc/rfc2650.txt
- Routing Policy System Security
  - http://nori.apnic.net/ietf/rfc/rfc2725.txt
- IRRToolSet
  - http://www.ripe.net/ripencc/pub-services/db/irrtoolset/index.html

IPv6

- IPv6 Address Allocation & Assignment Policy
  - http://ftp.apnic.net/apnic/docs/ipv6-address-policy
- IPv6 Address request form
  - http://ftp.apnic.net/apnic/docs/ipv6-alloc-request
- FAQ
  - http://www.apnic.net/info/faq/IPv6-FAQ.html

IPv6

- The case for IPv6
  - draft-ietf-iab-case-for-ipv6-06.txt
    - http://www.6bone.net/misc/case-for-ipv6.html
- Internet Protocol Version 6 (IPv6) Addressing Architecture
    - http://nori.apnic.net/ietf/rfc/rfc3513.txt
- IPv6 Stateless Address Autoconfiguration
    - http://nori.apnic.net/ietf/rfc/rfc2462.txt

IPv6

- The H Ratio for Address Assignment Efficiency
  - http://nori.apnic.net/ietf/rfc/rfc1715.txt
- The Host-Density Ratio for Address Assignment Efficiency: An update on the H ratio
  - http://nori.apnic.net/ietf/rfc/rfc3194.txt

IPv6: HD ratio 0.8

IPv6 prefix	Site addr bits	Total site addrs in /48s	Threshold	Util%
42	6	64	28	**43.5%**
36	12	4096	776	**18.9%**
35	13	8192	1351	**16.5%**
32	16	65536	7132	**10.9%**
29	19	524288	37641	**7.2%**
24	24	16777216	602249	**3.6%**
16	32	4294967296	50859008	**1.2%**
8	40	1099511627776	4294967296	**0.4%**
3	45	35184372088832	68719476736	**0.2%**

RFC3194 “The Host-Density Ratio for Address Assignment Efficiency”

Other supplementary reading

- Operational Content Books
  - ISP Survival Guide - Geoff Huston
- BGP Table
  - http://www.telstra.net/ops/bgptable.html
  - http://www.merit.edu/ipma/reports
  - http://www.merit.edu/ipma/routing_table/mae-east/prefixlen.990212.html
  - http://www.employees.org/~tbates/cidr.hist.plot.html
- Routing Instability
  - http://zounds.merit.net/cgi-bin/do.pl

Other supplementary reading

- Routing & Mulithoming
  - Internet Routing Architectures - Bassam Halabi
  - BGP Communities Attribute
    - http://nori.apnic.net/ietf/rfc/rfc1997.txt
    - http://nori.apnic.net/ietf/rfc/rfc1998.txt
  - Using a Dedicated AS for Sites homed to a Single Provider
    - http://nori.apnic.net/ietf/rfc/rfc2270.txt

Other supplementary reading

- Filtering
  - Egress Filtering http://www.cisco.com/public/cons/isp
  - Network Ingress Filtering: Defeating Denial of Service Attacks which employ IP Source Address Spoofing
    - http://nori.apnic.net/ietf/rfc/rfc2267.txt
- Dampening
  - case studies at http://www.cisco.com/warp/public/459/16.html
- Traceroute Server
  - http://nitrous.digex.net

Other supplementary reading

- Renumbering
  - Network Renumbering Overview: Why Would I Want It and What Is It Anyway?
    - http://nori.apnic.net/ietf/rfc/rfc2071.txt
  - Procedures for Enterprise Renumbering
    - http://www.isi.edu/div7/pier/papers.html
- NAT
  - The IP Network Address Translator
    - http://nori.apnic.net/ietf/rfc/rfc1631.txt

Person object template

person:	[mandatory]	[single]	[lookup key]
address:	[mandatory]	[multiple]	[ ]
country:	[optional]	[single]	[ ]
phone:	[mandatory]	[multiple]	[ ]
fax-no:	[optional]	[multiple]	[ ]
e-mail:	[mandatory]	[multiple]	[lookup key]
nic-hdl:	[mandatory]	[single]	[primary/look-up key]
remarks:	[optional]	[multiple]	[ ]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Role object template

role:	[mandatory]	[single]	[lookup key]
address:	[mandatory]	[multiple]	[ ]
country:	[optional]	[single]	[ ]
phone:	[mandatory]	[multiple]	[ ]
fax-no:	[optional]	[multiple]	[ ]
e-mail:	[mandatory]	[multiple]	[lookup key]
trouble:	[optional]	[multiple]	[ ]
admin-c:	[mandatory]	[multiple]	[inverse key]
tech-c:	[mandatory]	[multiple]	[inverse key]
nic-hdl:	[mandatory]	[single]	[primary/look-up key]
remarks:	[optional]	[multiple]	[ ]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Maintainer object template

mntner:	[mandatory]	[single]	[primary/look-up key]
descr:	[mandatory]	[multiple]	[ ]
country:	[optional]	[single]	[ ]
admin-c:	[mandatory]	[multiple]	[inverse key]
tech-c:	[optional]	[multiple]	[inverse key]
upd-to:	[mandatory]	[multiple]	[inverse key]
mnt-nfy:	[optional]	[multiple]	[inverse key]
auth:	[mandatory]	[multiple]	[ ]
remarks:	[optional]	[multiple]	[ ]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
referral-by:	[mandatory]	[single]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Inetnum object template

inetnum:	[mandatory]	[single]	[primary/look-up key]
netname:	[mandatory]	[single]	[lookup key]
descr:	[mandatory]	[multiple]	[ ]
country:	[mandatory]	[multiple]	[ ]
admin-c:	[mandatory]	[multiple]	[inverse key]
tech-c:	[mandatory]	[multiple]	[inverse key]
rev-srv:	[optional]	[multiple]	[inverse key]
status:	[mandatory]	[single]	[ ]
remarks:	[optional]	[multiple]	[ ]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
mnt-lower:	[optional]	[multiple]	[inverse key]
mnt-routes:	[optional]	[multiple]	[inverse key]
mnt-irt:	[optional]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Aut-num object template

aut-num:	[mandatory]	[single]	[primary/look-up key]
as-name:	[mandatory]	[single]	[ ]
descr:	[mandatory]	[multiple]	[ ]
country:	[optional]	[single]	[ ]
member-of:	[optional]	[multiple]	[ ]
import:	[optional]	[multiple]	[ ]
export:	[optional]	[multiple]	[ ]
default:	[optional]	[multiple]	[ ]
remarks:	[optional]	[multiple]	[ ]
admin-c:	[mandatory]	[multiple]	[inverse key]
tech-c:	[mandatory]	[multiple]	[inverse key]
cross-mnt:	[optional]	[multiple]	[inverse key]
cross-nfy:	[optional]	[multiple]	[inverse key]
notify:	[optional]	[multiple]	[inverse key]
mnt-lower:	[optional]	[multiple]	[inverse key]
mnt-routes:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Domain object template

domain:	[mandatory]	[single]	[primary/look-up key]
descr:	[mandatory]	[multiple]	[ ]
country:	[optional]	[single]	[ ]
admin-c:	[mandatory]	[multiple]	[inverse key]
tech-c:	[mandatory]	[multiple]	[inverse key]
zone-c:	[mandatory]	[multiple]	[inverse key]
nserver:	[mandatory]	[multiple]	[inverse key]
sub-dom:	[optional]	[multiple]	[inverse key]
dom-net:	[optional]	[multiple]	[ ]
remarks:	[optional]	[multiple]	[ ]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
mnt-lower:	[optional]	[multiple]	[inverse key]
refer:	[optional]	[single]	[ ]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Route object template

route:	[mandatory]	[single]	[primary/look-up key]
descr:	[mandatory]	[multiple]	[ ]
country:	[optional]	[single]	[ ]
origin:	[mandatory]	[single]	[primary/inverse key]
holes:	[optional]	[multiple]	[ ]
member-of:	[optional]	[multiple]	[ ]
inject:	[optional]	[multiple]	[ ]
aggr-mtd:	[optional]	[single]	[ ]
aggr-bndry:	[optional]	[single]	[ ]
export-comps:	[optional]	[single]	[ ]
components:	[optional]	[single]	[ ]
remarks:	[optional]	[multiple]	[ ]
cross-mnt:	[optional]	[multiple]	[inverse key]
cross-nfy:	[optional]	[multiple]	[inverse key]
notify:	[optional]	[multiple]	[inverse key]
mnt-lower:	[optional]	[multiple]	[inverse key]
mnt-routes:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

As-set object template

as-set:	[mandatory]	[single]	[primary/look-up key]
descr:	[mandatory]	[multiple]	[ ]
country:	[optional]	[single]	[ ]
members:	[optional]	[multiple]	[ ]
mbrs-by-ref:	[optional]	[multiple]	[inverse key]
remarks:	[optional]	[multiple]	[ ]
tech-c:	[mandatory]	[multiple]	[inverse key]
admin-c:	[mandatory]	[multiple]	[inverse key]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Route-set object template

route-set:	[mandatory]	[single]	[primary/look-up key]
descr:	[mandatory]	[multiple]	[ ]
members:	[optional]	[multiple]	[ ]
mbrs-by-ref:	[optional]	[multiple]	[inverse key]
remarks:	[optional]	[multiple]	[ ]
tech-c:	[mandatory]	[multiple]	[inverse key]
admin-c:	[mandatory]	[multiple]	[inverse key]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Inet-rtr object template

inet-rtr:	[mandatory]	[single]	[primary/look-up key]
descr:	[mandatory]	[multiple]	[ ]
alias:	[optional]	[multiple]	[ ]
local-as:	[mandatory]	[single]	[inverse key]
ifaddr:	[mandatory]	[multiple]	[lookup key]
peer:	[optional]	[multiple]	[ ]
member-of:	[optional]	[multiple]	[inverse key]
remarks:	[optional]	[multiple]	[ ]
admin-c:	[mandatory]	[multiple]	[inverse key]
tech-c:	[mandatory]	[multiple]	[inverse key]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Peering-set object template

peering-set:	[mandatory]	[single]	[primary/look-up key]
descr:	[mandatory]	[multiple]	[ ]
peering:	[mandatory]	[multiple]	[ ]
remarks:	[optional]	[multiple]	[ ]
tech-c:	[mandatory]	[multiple]	[inverse key]
admin-c:	[mandatory]	[multiple]	[inverse key]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Filter-set object template

filter-set:	[mandatory]	[single]	[primary/look-up key]
descr:	[mandatory]	[multiple]	[ ]
filter:	[mandatory]	[single]	[ ]
remarks:	[optional]	[multiple]	[ ]
tech-c:	[mandatory]	[multiple]	[inverse key]
admin-c:	[mandatory]	[multiple]	[inverse key]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	[ ]
source:	[mandatory]	[single]	[ ]

Rtr-set object template

rtr-set:	[mandatory]	[single]	[primary/look-up key]
descr:	[mandatory]	[multiple]	
members:	[optional]	[multiple]	
mbrs-by-ref:	[optional]	[multiple]	
remarks:	[optional]	[multiple]	
tech-c:	[mandatory]	[multiple]	[inverse key]
admin-c:	[mandatory]	[multiple]	[inverse key]
notify:	[optional]	[multiple]	[inverse key]
mnt-by:	[mandatory]	[multiple]	[inverse key]
changed:	[mandatory]	[multiple]	
source:	[mandatory]	[single]	