BGP Configuration from the IRR

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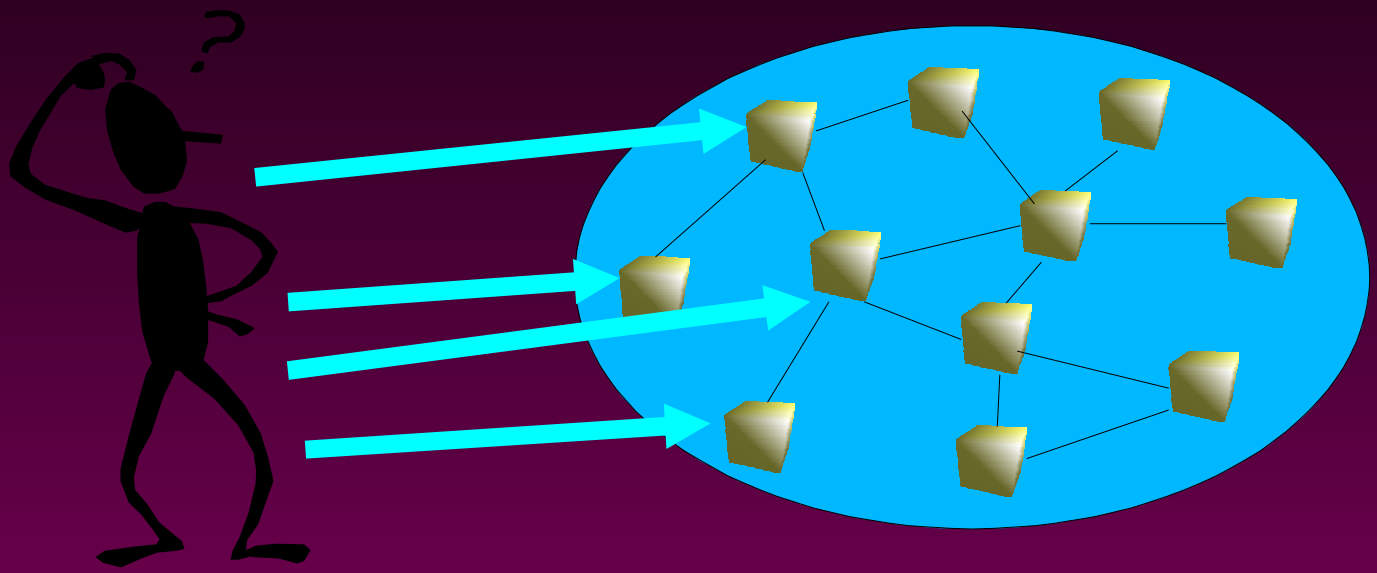
http://www.isi.edu/ra/rps/training
http://www.isi.edu/ra/RAToolSet

BGP Configuration



Too many routers

Too detailed, large & tedious

Consistency

Heavy consequences of mistakes

Mistakes don’t happen!

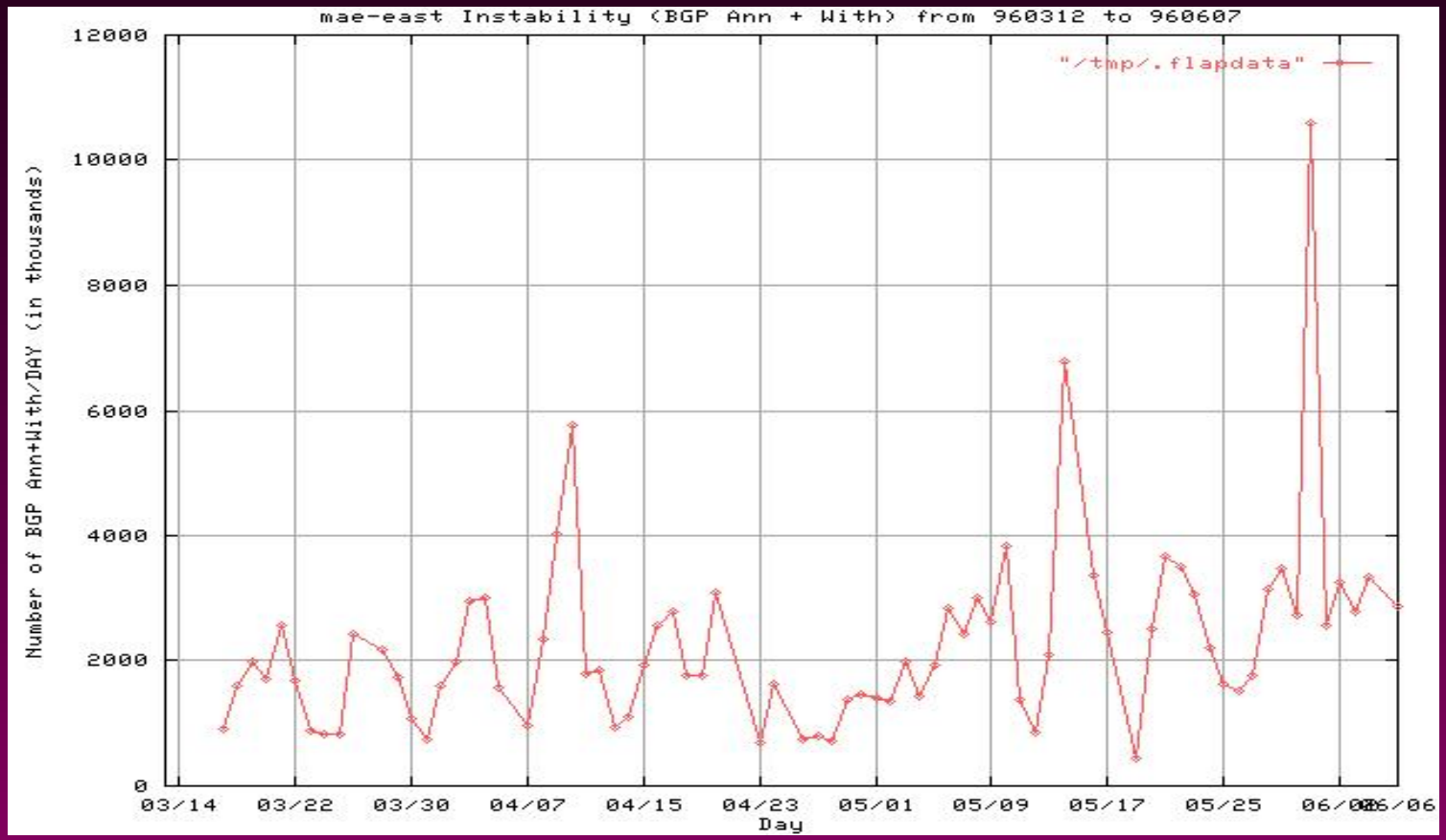
BGP−>RIP−>BGP injection

128/7 leak

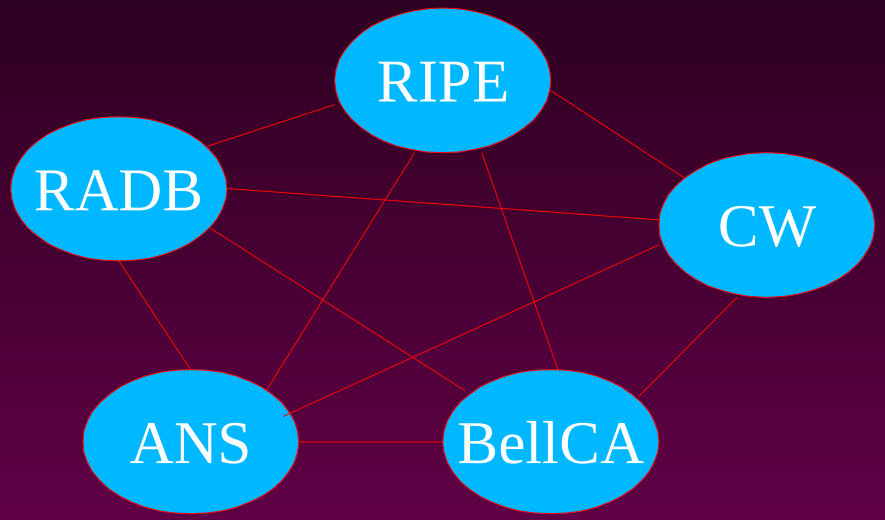
bogon 0/0, 10/8 leaks

daily, someone’s leaking someone else’s prefix

Consequences



Internet Routing Registry



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

Policy & contact information

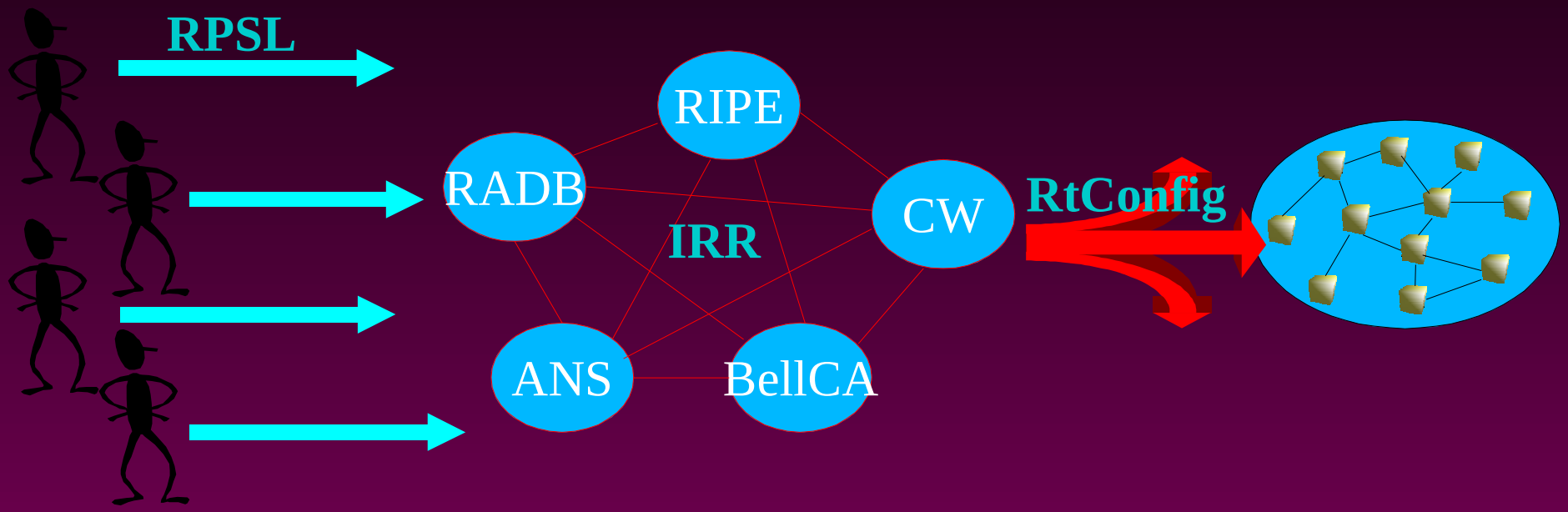
Internet Routing Registry

```
Route:          128.9.0.0/16
descr:          ISI-NET
origin:         AS226
notify:         Prue@isi.edu
mnt-by:         LN-MAINT-MCI
changed:        Prue@isi.edu 950420
source:         CW
```

Internet Routing Registry

```
person:         Walt Prue
address:        USC/Information Sciences Institute
                4676 Admiralty Way Suite 1000
                Marina del Rey, California
                USA
phone:          +1 310 822 1511 x89191
fax-no:         +1 310 823 6714
e-mail:         Prue@isi.edu
nic-hdl:        WP8
notify:         Prue@isi.edu
mnt-by:         LN-MAINT-MCI
changed:        Prue@isi.edu 20000222
source:         CW
```

BGP Configuration from IRR



RPSL: Abstract, hihg level, per−as policies

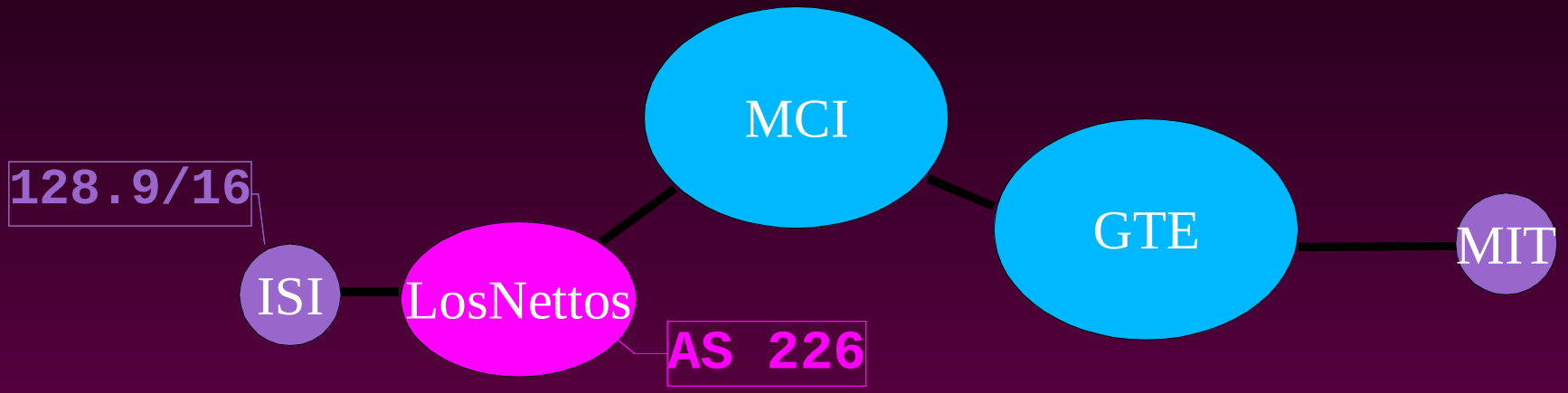
IRR: Benefit from others' data & delegation

RtConfig: Details/tedious aspects automated

Outline

- Motivation
- Routing Policy Definitions
- RPSL & RtConfig
  - Basic classes and notations
  - Set classes
  - import/export policy
  - Structured Policy
  - Other Features & Wrap−up

Internet's Routing



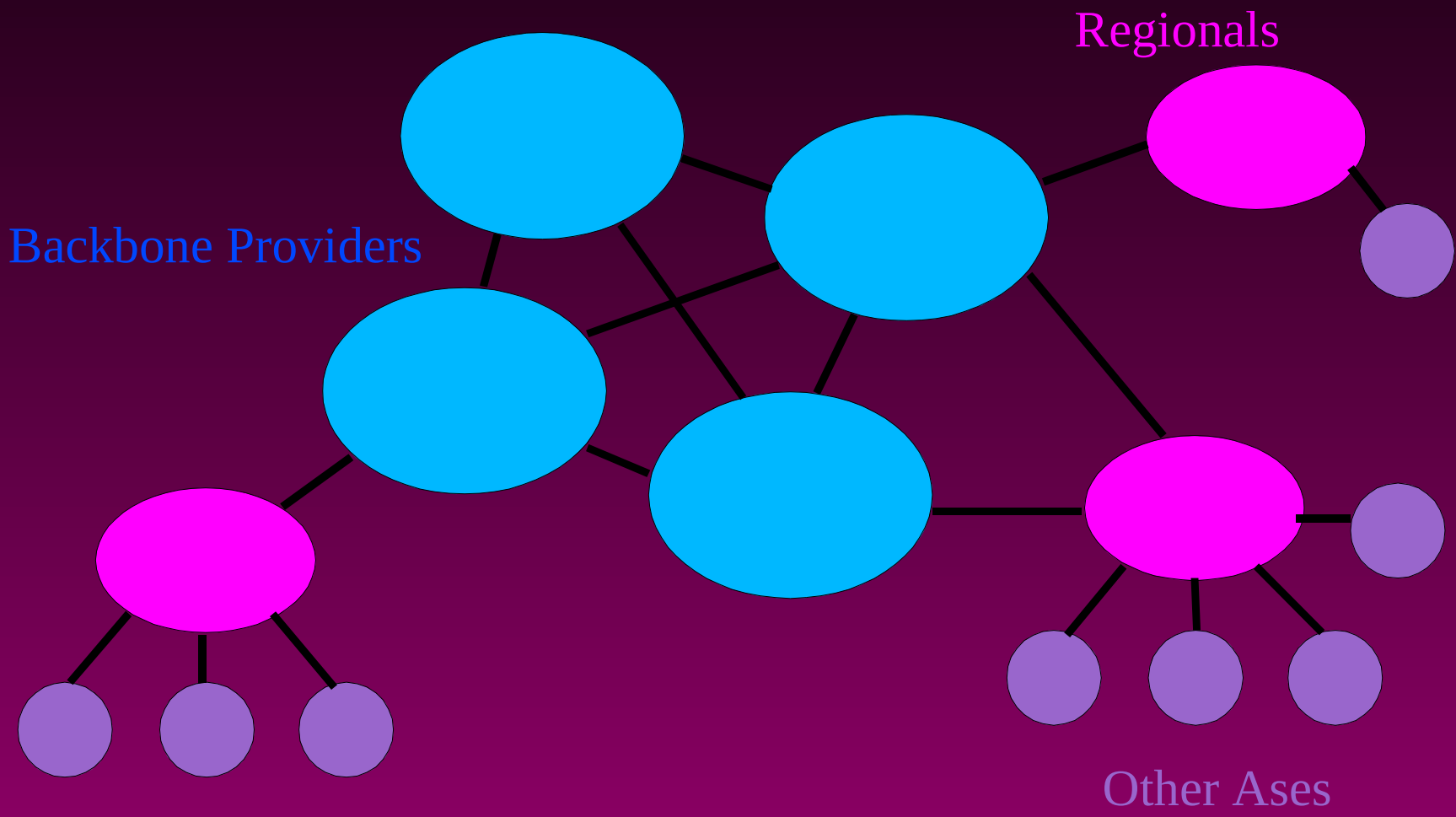
Interior routing is metric based

- **Inside MCI, shortest exit to GTE**
- **OSPF, IS−IS,...**

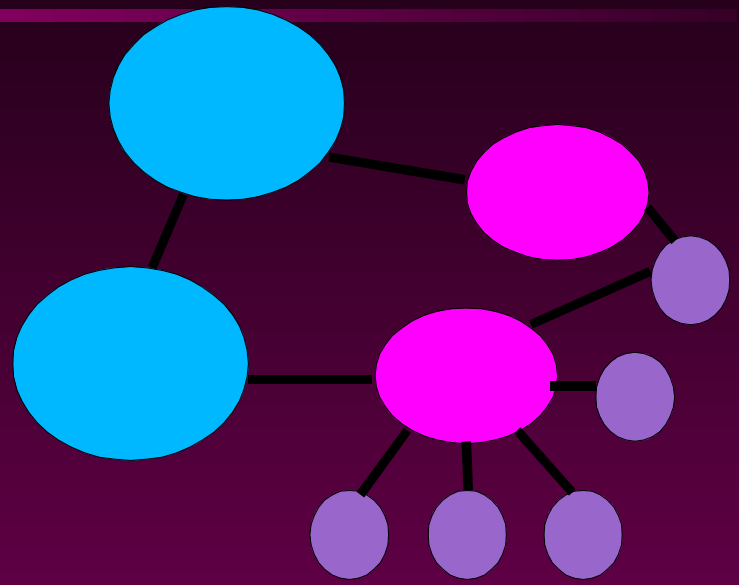
Exterior routing is policy based

- **can ISI use GTE to reach MIT?**
- **BGP**

Inter–AS Topology



AS Relationships



Customer

can use its resources

Provider

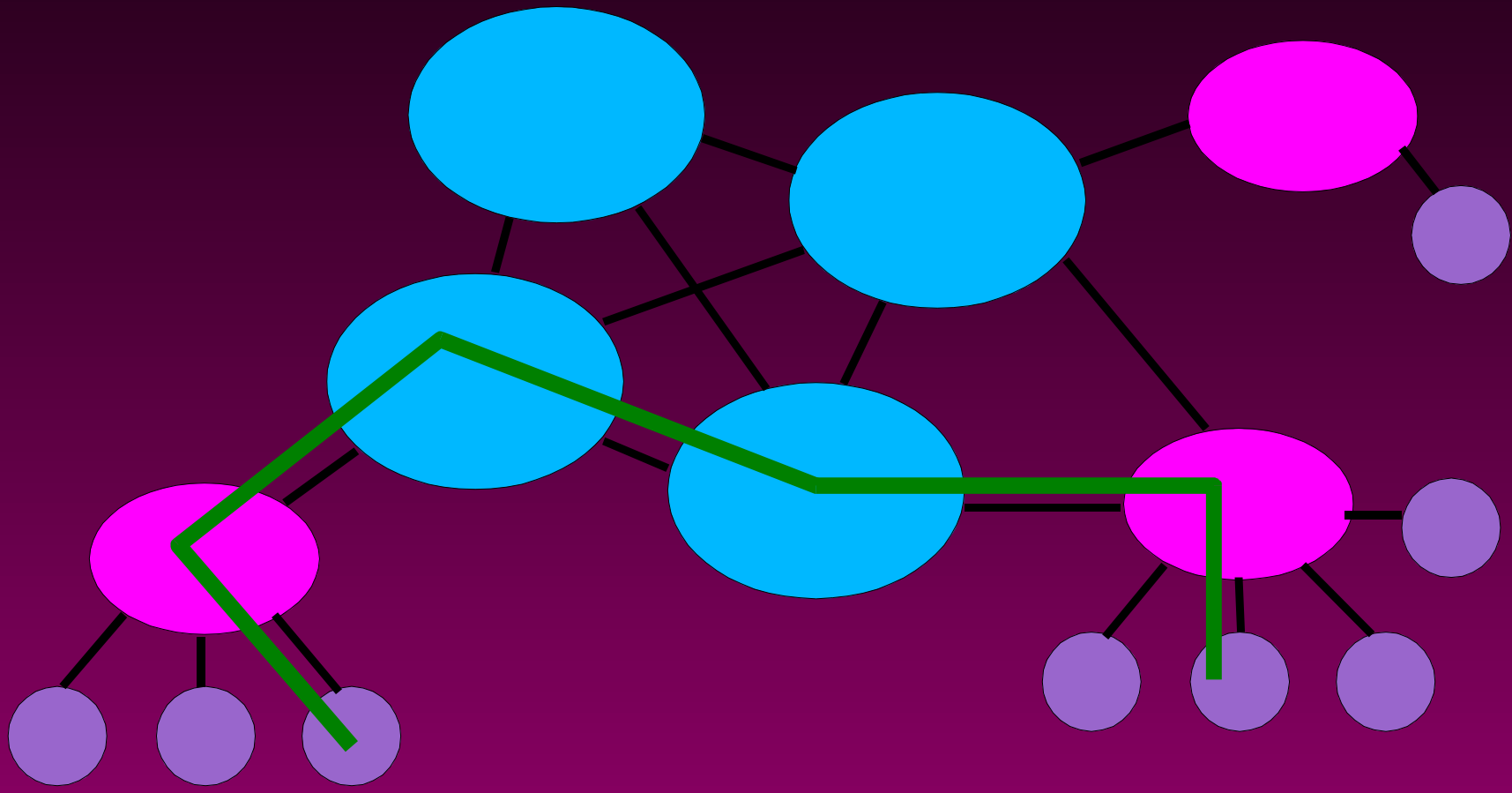
prefer one provider over another

Peer

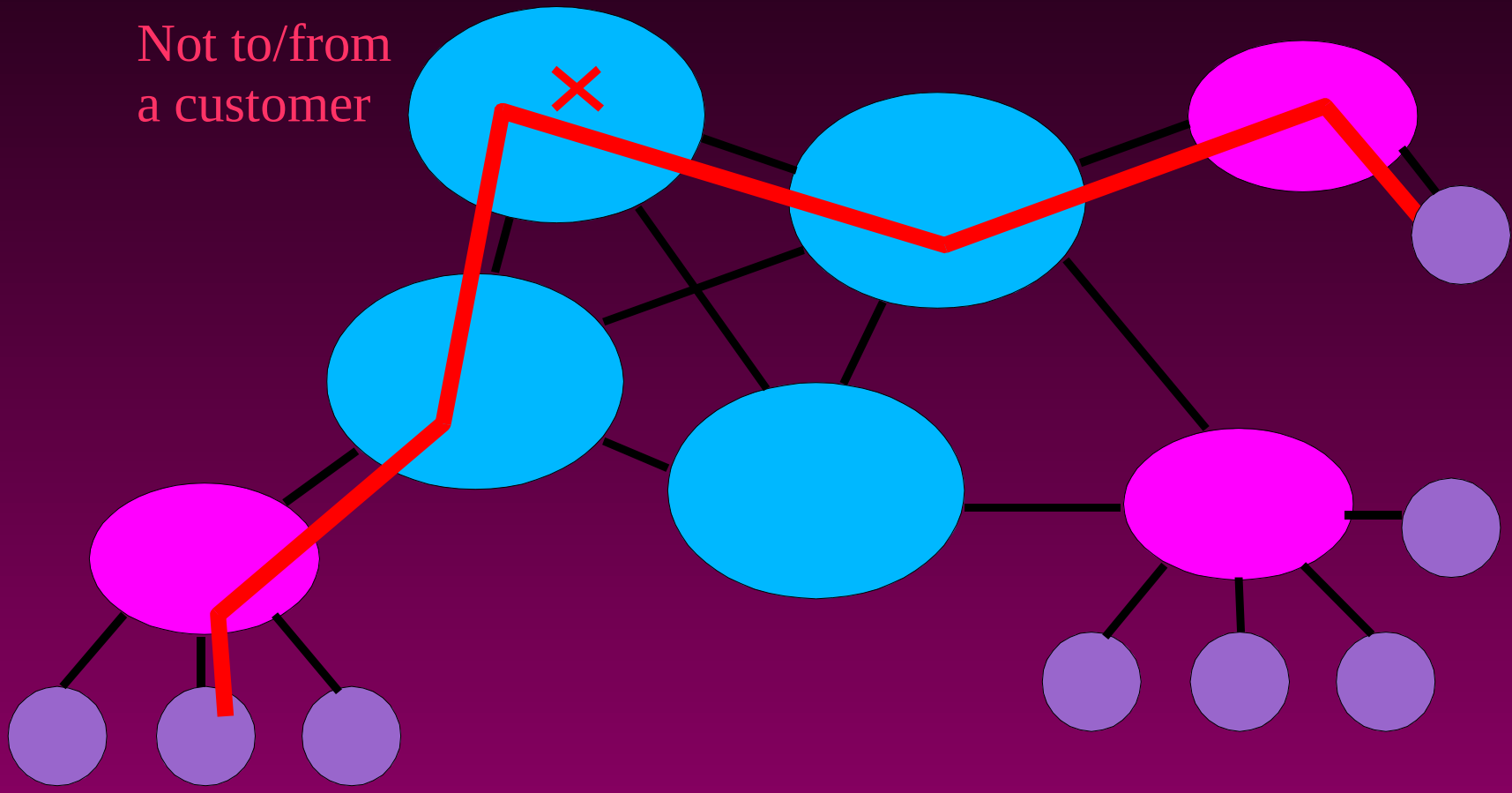
can use its resources to reach customers

Typical routing policies implement these

Routing Policy

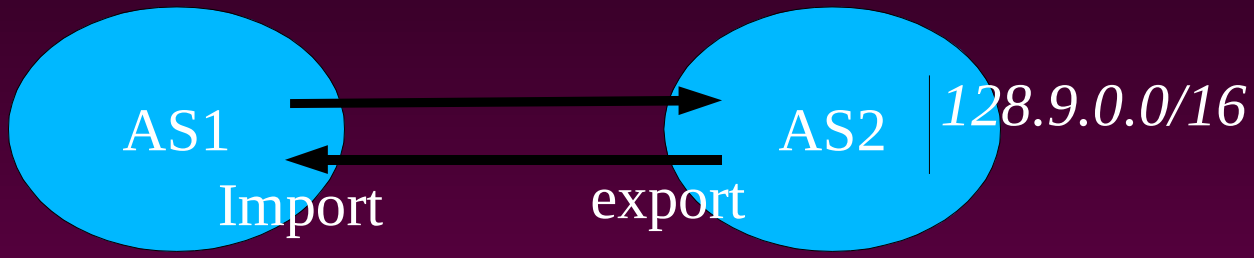


Routing Policy



InterAS Routing

AS Level Peering



AS2 originates 128.9.0.0/16

AS2 exports 128.9.0.0/16 to AS1

AS1 imports 128.9.0.0/16 from AS2

BGP

Each route carries *path attributes*

- **Destination address prefixes**
- **AS path**
- **Originator AS**
- **List of communities (flags)**
- **Metrics: med, pref**

Routing Policy

who are the peers

what routes are
- **originated**
- **imported**
- **exported**
- **preferred**

what to do when no route
what routes to aggregate

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  - import/export policy
  - Structured Policy
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Routing Policy Specification Language (RPSL)

Object oriented language

- **route, autonomous system, router, contact and set objects**

Defines the syntax/semantics/format of data in IRR

Vendor independent

Extensible

IETF Proposed Standard (RFC 2622)

Based on RIPE−181

RtConfig

Router configuration tool

cisco, juniper, bay, gated, rsd

user−controlled level of features/publishing

RPSL Classes

route

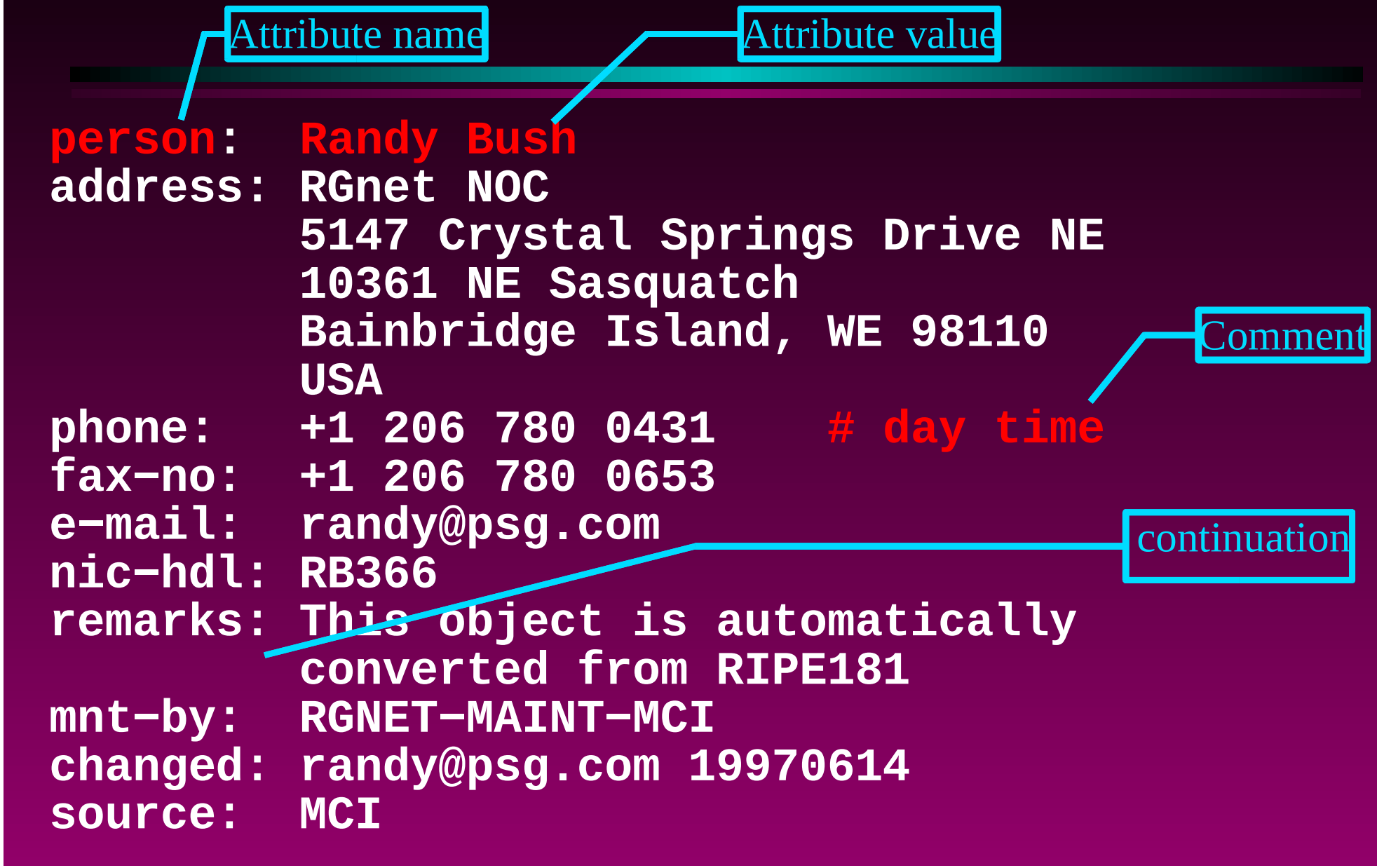
autonomous system

router

person, role, maintainer

set classes

Object Representation



Person Class

```
person:   Randy Bush
address:  RGnet NOC
          5147 Crystal Springs Drive NE
          10361 NE Sasquatch
          Bainbridge Island, WE 98110
          USA
phone:    +1 206 780 0431     # day time
fax-no:   +1 206 780 0653
e-mail:   randy@psg.com
nic-hdl:  RB366
```

Person class atrributes

```
remarks:  This object is automatically
          converted from RIPE181
mnt-by:   RGNET-MAINT-MCI
changed:  randy@psg.com 19970614
source:   MCI
```

Common attributes

Maintenance

Common Attributes

descr:	short free text description of the object
remarks:	free text comment attribute
tech-c:	Technical contact nic handles
admin-c:	Administrative contact nic handles
notify:	emails to send notification of changes
mnt-by:	maintainer authorized to do changes
changed:	<email> <date>
Source:	registry

Role Class

```
role:     RIPE NCC Operations
address:  Singel 258
          1016 AB Amsterdam
          The Netherlands
phone:    +31 20 535 4444
fax-no:   +31 20 545 4445
e-mail:   ops@ripe.net
admin-c:  CO19-RIPE
tech-c:   RW488-RIPE
tech-c:   JLSD1-RIPE
nic-hdl:  OPS4-RIPE
notify:   ops@ripe.net
changed:  roderik@ripe.net 19970926
source:   RIPE
```

Mntner Class

```
mntner:   MAINT-RGNET
descr:    RGnet RADB maintainer
admin-c:  RB366
tech-c:   RB366
upd-to:   rw@rg.net
mnt-nfy:  randy@psg.com
auth:     PGPKEY-23F5CE3
mnt-by:   MAINT-RGNET
changed:  randy@psg.com 19970804
source:   RADB
```

Defines access control for other objects in database!

Auth Attribute

- auth: PGPKEY-23F5CE3
- auth: CRYPT-PW lz1A7/JnfkTI
- auth: MAIL-FROM cengiz@isi.edu
- auth: MAIL-FROM .*@canet.ca
- auth: NONE

Route Class

```
Route:      156.36.0.0/16
origin:     AS2914
descr:      my routes
mnt-by:     MAINT-RGNET
tech-c:     RB366
changed:    randy@psg.com 19960829
source:     RADB
```

Policy information

Route 156.36.0.0/16 is originated by AS2914

Notations

AS Numbers	AS2914
Address prefixes	156.36.0.0/16
Route set names	RS-VERIO
AS set names	AS-VERIO

Words

Words can have - or _ in the middle

```
RGNET-MAINT-MCI
```

Can have digits

```
RGNET-MAINT-MCI_1
```

Case insensitive

```
rgnet-MaInT-MCI
```

RtConfig Steps

- Register objects
- Create template, input file for `RtConfig`
- Invoke `RtConfig`

RtConfig Templates

```
version 10.3
!
interface Ethernet0/0
 ip address 198.32.4.1 255.255.255.0
!
! other usual cisco command should be put around here
!
router bgp 3561
 neighbor 198.32.4.25 remote-as 4551
!
@RtConfig set cisco_map_name = "mymap"
@RtConfig set cisco_access_list_no = 500
@RtConfig import AS3561 1.1.1.1 AS114 1.1.1.2
! other usual cisco command should be put around here
end
```

RtConfig Invocation

```
% RtConfig < template > config-file
% RtConfig -config junos < template > config-file
% RtConfig -f file < template > config-file
```

access_list

```
% ./RtConfig
RtConfig> @RtConfig access_list filter as226
!
no access-list 100
access-list 100 permit ip 128.97.0.0   0.0.0.0   255.255.0.0   0.0.0.0
access-list 100 permit ip 128.99.0.0   0.0.0.0   255.255.0.0   0.0.0.0
access-list 100 permit ip 128.125.0.0   0.0.0.0   255.255.0.0   0.0.0.0
access-list 100 permit ip 128.149.0.0   0.0.0.0   255.255.0.0   0.0.0.0
access-list 100 permit ip 129.4.0.0   0.0.0.0   255.255.0.0   0.0.0.0
access-list 100 permit ip 129.193.0.0   0.0.0.0   255.255.0.0   0.0.0.0
access-list 100 permit ip 130.152.0.0   0.0.0.0   255.255.0.0   0.0.0.0
access-list 100 permit ip 130.154.0.0   0.0.0.0   255.255.0.0   0.0.0.0
```

Prefix_list

```
% ./RtConfig -cisco_use_prefix_lists
RtConfig> @RtConfig access_list filter as226
no ip prefix-list pl100
ip prefix-list pl100 permit 128.97.0.0/16
ip prefix-list pl100 permit 128.99.0.0/16
ip prefix-list pl100 permit 128.125.0.0/16
ip prefix-list pl100 permit 128.149.0.0/16
ip prefix-list pl100 permit 129.4.0.0/16
ip prefix-list pl100 permit 129.193.0.0/16
ip prefix-list pl100 permit 130.152.0.0/16
```

Juniper

```
% ./RtConfig -config junos
RtConfig> @RtConfig access_list filter as226
   policy-statement prefix-list-100 {
      term prefixes {
         from {
            route-filter 128.97.0.0/16 exact accept;
            route-filter 128.99.0.0/16 exact accept;
            route-filter 128.125.0.0/16 exact accept;
            route-filter 128.149.0.0/16 exact accept;
            route-filter 129.4.0.0/16 exact accept;
```

Gated

```
% ./RtConfig -config gated
RtConfig> @RtConfig access_list filter as226
   128.97.0.0 masklen 16 exact;
   128.99.0.0 masklen 16 exact;
   128.125.0.0 masklen 16 exact;
   128.149.0.0 masklen 16 exact;
   129.4.0.0 masklen 16 exact;
```

Bay/Nortel

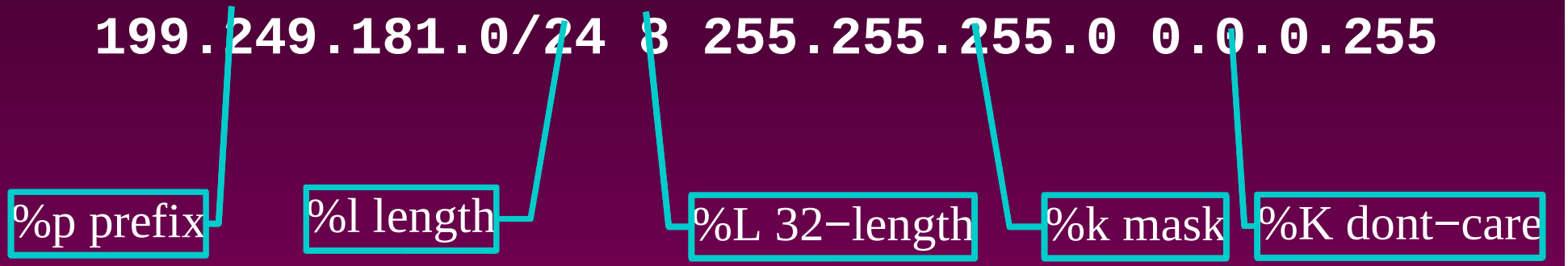
```
% ./RtConfig –config bcc
RtConfig> @RtConfig access_list filter as226
     network address 128.97.0.0 mask 255.255.0.0 match Exact
     network address 128.99.0.0 mask 255.255.0.0 match Exact
     network address 128.125.0.0 mask 255.255.0.0 match Exact
     network address 128.149.0.0 mask 255.255.0.0 match Exact
     network address 129.4.0.0 mask 255.255.0.0 match Exact
```

Other Formats

```
@RtConfig printPrefixes "my format %p/%l;\n" filter
 as226
  my format 128.97.0.0/16;
  my format 128.99.0.0/16;
  my format 128.125.0.0/16;
  my format 128.149.0.0/16;
  my format 129.4.0.0/16;
```

Other Options

```
@RtConfig printPrefixes "%p/%l %L %k %K\n"
                    filter AS226
198.178.204.0/24 8 255.255.255.0 0.0.0.255
198.178.205.0/24 8 255.255.255.0 0.0.0.255
199.249.180.0/24 8 255.255.255.0 0.0.0.255
199.249.181.0/24 8 255.255.255.0 0.0.0.255
```



printPrefixRanges

```
@RtConfig printPrefixRanges "%p/%l from %n to %m\n"
  filter AS226
```

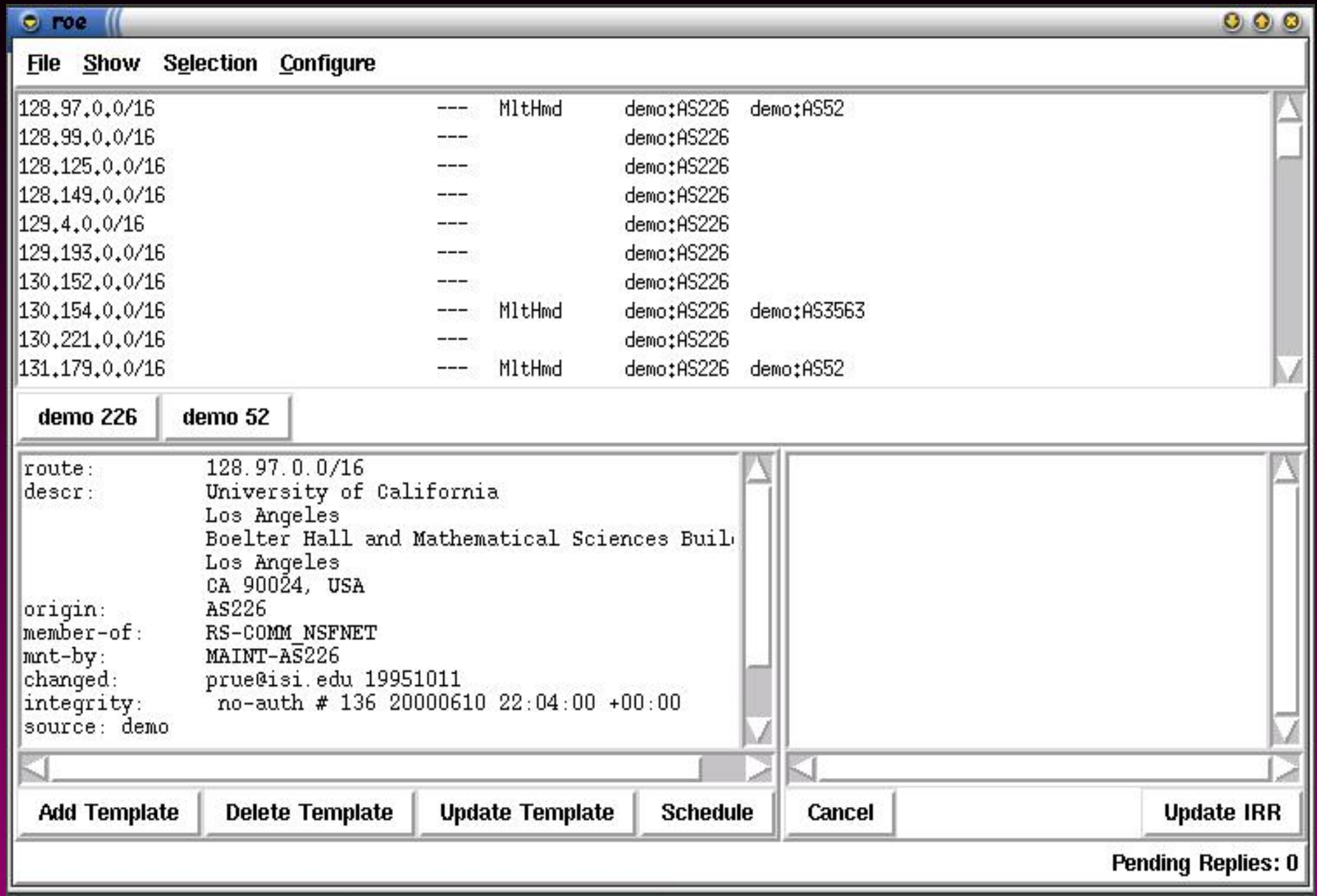
```
198.178.204.0/23 from 24 to 24

199.249.180.0/23 from 24 to 24
```

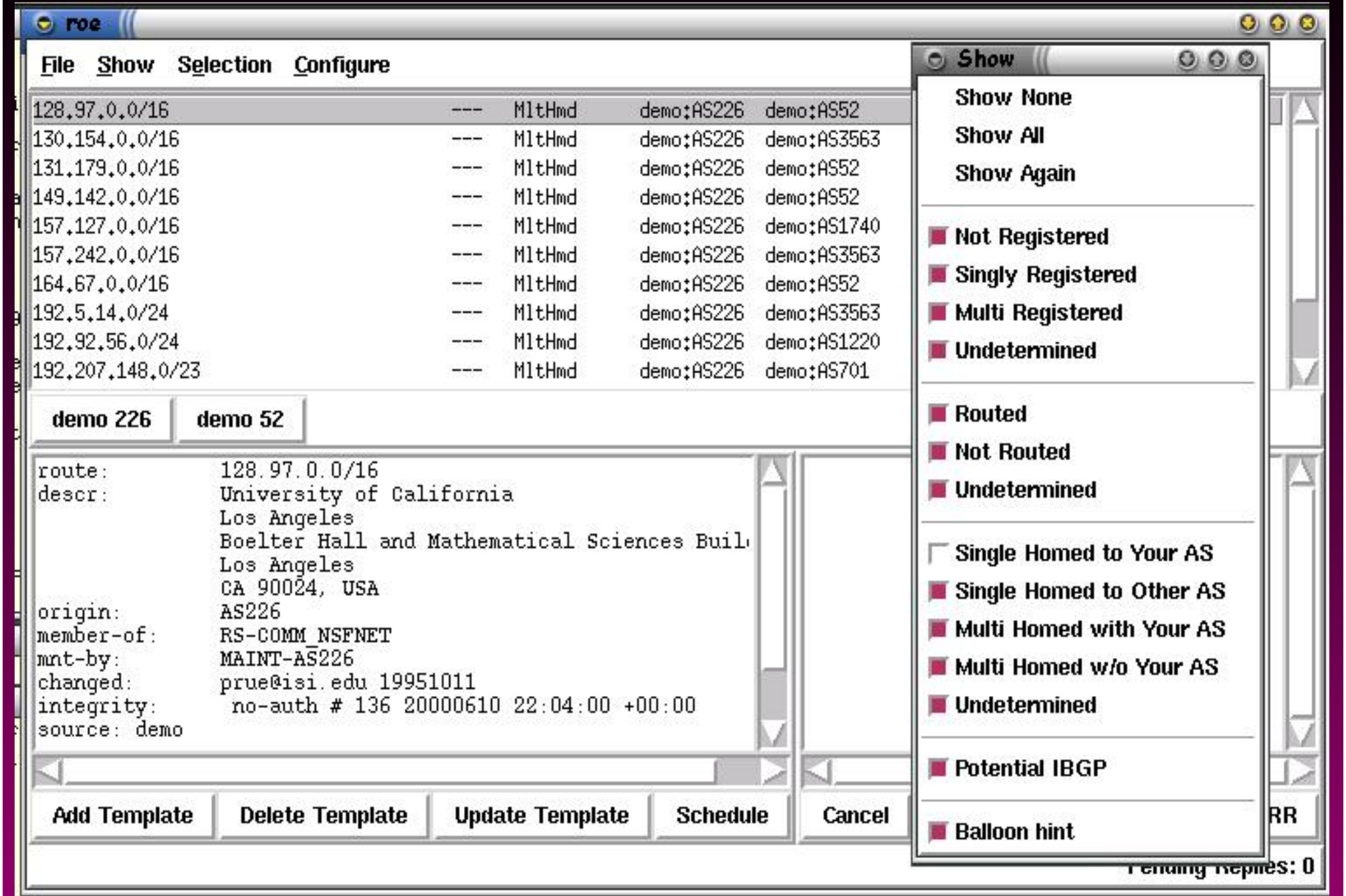
Operators

```
RtConfig> @RtConfig access_list filter as226 and as52
no ip prefix-list pl100
ip prefix-list pl100 permit 128.97.0.0/16
ip prefix-list pl100 permit 131.179.0.0/16
ip prefix-list pl100 permit 149.142.0.0/16
ip prefix-list pl100 permit 164.67.0.0/16
ip prefix-list pl100 deny 0.0.0.0/0 le 32
```

Roe


roe
File Show Selection Configure
128.97.0.0/16 --- MltHmd demo:AS226 demo:AS52
128.99.0.0/16 --- demo:AS226
128.125.0.0/16 --- demo:AS226
128.149.0.0/16 --- demo:AS226
129.4.0.0/16 --- demo:AS226
129.193.0.0/16 --- demo:AS226
130.152.0.0/16 --- demo:AS226
130.154.0.0/16 --- MltHmd demo:AS226 demo:AS3563
130.221.0.0/16 --- demo:AS226
131.179.0.0/16 --- MltHmd demo:AS226 demo:AS52
demo 226
demo 52
route: 128.97.0.0/16
descr: University of California
Los Angeles
Boelter Hall and Mathematical Sciences Buil
Los Angeles
CA 90024, USA
origin: AS226
member-of: RS-COMM_NSFNET
mnt-by: MAINT-AS226
changed: prue@isi.edu 19951011
integrity: no-auth # 136 20000610 22:04:00 +00:00
source: demo
Add Template
Delete Template
Update Template
Schedule
Cancel
Update IRR
Pending Replies: 0

Roe


roe
File Show Selection Configure
128.97.0.0/16 --- MltHmd demo:AS226 demo:AS52
130.154.0.0/16 --- MltHmd demo:AS226 demo:AS3563
131.179.0.0/16 --- MltHmd demo:AS226 demo:AS52
149.142.0.0/16 --- MltHmd demo:AS226 demo:AS52
157.127.0.0/16 --- MltHmd demo:AS226 demo:AS1740
157.242.0.0/16 --- MltHmd demo:AS226 demo:AS3563
164.67.0.0/16 --- MltHmd demo:AS226 demo:AS52
192.5.14.0/24 --- MltHmd demo:AS226 demo:AS3563
192.92.56.0/24 --- MltHmd demo:AS226 demo:AS1220
192.207.148.0/23 --- MltHmd demo:AS226 demo:AS701
demo 226
demo 52
route: 128.97.0.0/16
descr: University of California
Los Angeles
Boelter Hall and Mathematical Sciences Buil
Los Angeles
CA 90024, USA
origin: AS226
member-of: RS-COMM_NSFNET
mnt-by: MAINT-AS226
changed: prue@isi.edu 19951011
integrity: no-auth # 136 20000610 22:04:00 +00:00
source: demo
Add Template
Delete Template
Update Template
Schedule
Cancel
Show
Show None
Show All
Show Again
Not Registered
Singly Registered
Multi Registered
Undetermined
Routed
Not Routed
Undetermined
Single Homed to Your AS
Single Homed to Other AS
Multi Homed with Your AS
Multi Homed w/o Your AS
Undetermined
Potential IBGP
Balloon hint

Operators

```
RtConfig> @RtConfig access_list filter as226 and as52
no ip prefix-list pl100
ip prefix-list pl100 permit 128.97.0.0/16
ip prefix-list pl100 permit 131.179.0.0/16
ip prefix-list pl100 permit 149.142.0.0/16
ip prefix-list pl100 permit 164.67.0.0/16
ip prefix-list pl100 deny 0.0.0.0/0 le 32
```

Operators

```
@RtConfig access_list filter as226 and not as52
no ip prefix-list pl100
ip prefix-list pl100 permit 128.99.0.0/16
ip prefix-list pl100 permit 128.125.0.0/16
ip prefix-list pl100 permit 128.149.0.0/16
ip prefix-list pl100 permit 129.4.0.0/16
```

Peval

```
./peval as226
({205.147.0.0/20, 204.140.128.0/17, 204.80.138.0/24,
 204.80.96.0/19, 204.57.0.0/21, 199.249.182.0/24,
 199.249.180.0/24, 199.249.181.0/24, 199.249.179.0/24,
 199.182.86.0/24, 199.182.81.0/24, 199.165.231.0/24,
 199.120.212.0/24, 198.186.216.0/24, 198.178.206.0/24,
 198.178.204.0/24, 198.178.205.0/24, 198.178.203.0/24,
 198.147.64.0/18, 198.32.0.0/23, 192.251.121.0/24,
 192.88.8.0/24, 192.45.0.0/16, 192.27.235.0/24,
 192.12.44.0/24, 192.12.19.0/24, 192.5.133.0/24,
 192.5.14.0/24, 192.5.10.0/24, 165.192.0.0/16, 164.67.0.0/16,
 163.40.0.0/16, 157.242.0.0/16, 157.127.0.0/16,
 155.157.0.0/16, 149.142.0.0/16, 144.215.0.0/16,
 143.127.0.0/16, 140.171.0.0/16, 137.78.0.0/15, 134.70.0.0/16,
 134.4.0.0/16, 131.215.0.0/16, 131.179.0.0/16, 130.221.0.0/16,
 130.154.0.0/16, 130.152.0.0/16, 129.193.0.0/16, 129.4.0.0/16,
 128.149.0.0/16, 128.125.0.0/16, 128.97.0.0/16})
```

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route-set Class

```
route-set: rs-foo
members:   128.9.0.0/16, 128.9.0.0/24,
           128.8.0.0/16
descr:     some address prefixes
mnt-by:    MAINT-RGNET
tech-c:    RB366
changed:   randy@psg.com 19960829
source:    RADB


route-set: rs-bar
members:   128.7.0.0/16, rs-foo
```

Route-set

```
route-set: RS-BCMI2
descr:     routes via BCM to be announced to I2
members:   128.249.0.0/16, 192.31.88.0/24,
           192.147.26.0/24
admin-c:   JCY
tech-c:    SM346
mnt-by:    MAINT-AS302
changed:   smace@intt.org 20000213
source:     demo
```

Route-set

```
RtConfig> @RtConfig access_list filter RS-BCMI2
no ip prefix-list pl100
ip prefix-list pl100 permit 128.249.0.0/16
ip prefix-list pl100 permit 192.31.88.0/24
ip prefix-list pl100 permit 192.147.26.0/24
ip prefix-list pl100 deny 0.0.0.0/0 le 32
```

Indirect Members

```
route-set:    RS-ANS-IGP_ONLY
descr:        ANS IGP aggregates
mbrs-by-ref:  any


route:        207.25.17.0/24
origin:       AS1675
member-of:    RS-ANS-IGP_ONLY
mnt-by:       MNT-ANS

route:        192.157.69.0/24
origin:       AS1675
member-of:    RS-ANS-IGP_ONLY
mnt-by:       MNT-ANS
```

Restricted Indirect Members

```
route-set:    RS-ANS-IGP_ONLY
descr:        ANS IGP aggregates
mbrs-by-ref: MNT-ANS, MNT-CENGIZ

route:       207.25.17.0/24
origin:      AS1675
member-of:  RS-ANS-IGP_ONLY
mnt-by:      MNT-ANS

route:       192.157.69.0/24
origin:      AS1675
member-of:  RS-ANS-IGP_ONLY
mnt-by:      MNT-ANS
```

Direct & Indirect Members

```
route-set:    RS-ANS-IGP_ONLY
descr:        ANS IGP aggregates
members:      207.25.17.0/24, 207.25.16.0/24,
              207.25.20.0/24
mbrs-by-ref:  MNT-ANS

route:        207.25.17.0/24
origin:       AS1675
member-of:    RS-ANS-IGP_ONLY
mnt-by:       MNT-ANS

route:        192.157.69.0/24
origin:       AS1675
member-of:    RS-ANS-IGP_ONLY
mnt-by:       MNT-ANS
```

More Specific Operators

```
route-set: rs-martians
descr:     most ASes do not import these routes
members:   0.0.0.0/0^32,        127.0.0.0/8^+,
           10.0.0.0/8^+,        172.16.0.0/20^+,
           192.168.0.0/16^+,    192.0.2.0/24^+,
           128.0.0.0/16^+,      191.255.0.0/16^+,
           192.0.0.0/24^+,      223.255.255.0/24^+,
           224.0.0.0/3^+,       0.0.0.0/0^26-32
```

Inclusive more specifics: ^+
Exclusive more specifics: ^-
Length n more specifics: ^n
Length n-m more specifics: ^n-m

Route-set Namespaces

```
Route-set: AS4763:RS-ROUTES:AS681
descr:     prefix filter for AS681
members:   130.216.0.0/16, 130.217.0.0/16,
   132.181.0.0/16, 138.75.0.0/16, 139.80.0.0/16,
   140.200.0.0/16, 156.62.0.0/16, 192.73.21.0/24
tech-c:    JA39
mnt-by:    MAINT-TELSTRA-NZ
changed:   jabley@patho.gen.nz 19991118
source:    RADB
```

as-set Class

```
as-set:   AS-SESQUI-STUB
descr:    Single Homed Sesquinet Customer ASs
members:  AS1832, AS2712, AS302, AS3526, AS8
tech-c:   SB98
mnt-by:   MAINT-AS114
source:   RADB
```

Same flexibility as route-set class

Indirect as-sets

```
as-set:         as-aads-mlpa
descr:          MLPA participants at the AADS NAP
mbrs-by-ref:    any
admin-c:        Andrew Schmidt
tech-c:         Mark Cnota
notify:         mlpa-participants@aads.net
mnt-by:         MAINT-RSPEER
changed:        auto-mlpa@aads.net 19971123
source:         RADB

aut-num:        AS4550
member-of:      as-aads-mlpa

aut-num:        AS683
member-of:      as-aads-mlpa
```

As-sets

```
as-set:    AS-GOODNET
descr:     ASs routed through GoodNet
members:   AS5696, AS1808, AS1932, AS2900, AS3111,
   AS3365, AS3393, AS3844, AS3901, AS4314, ...  AS-
   ACESRESEARCH, AS-ALPHA, AS-GST, AS-DERU,AS-INQUO
admin-c:   IP Admin DW970
tech-c:    IP Admin DW970
notify:    ipadmin@winstar.net
mnt-by:    MAINT-AS5696
changed:   darin@good.net 19990731
source:    demo
```

as-set

```
@RtConfig access_list filter as-goodnet
no ip prefix-list pl100
ip prefix-list pl100 permit 12.10.231.0/24
ip prefix-list pl100 permit 63.140.0.0/16
ip prefix-list pl100 permit 64.16.64.0/20
ip prefix-list pl100 permit 64.16.75.0/24
ip prefix-list pl100 permit 64.16.128.0/20
ip prefix-list pl100 permit 64.16.128.0/24
ip prefix-list pl100 permit 64.16.138.0/23
...
```

Outline

- Motivation
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  - Basic classes and notations
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  - Structured Policy
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aut-num Class

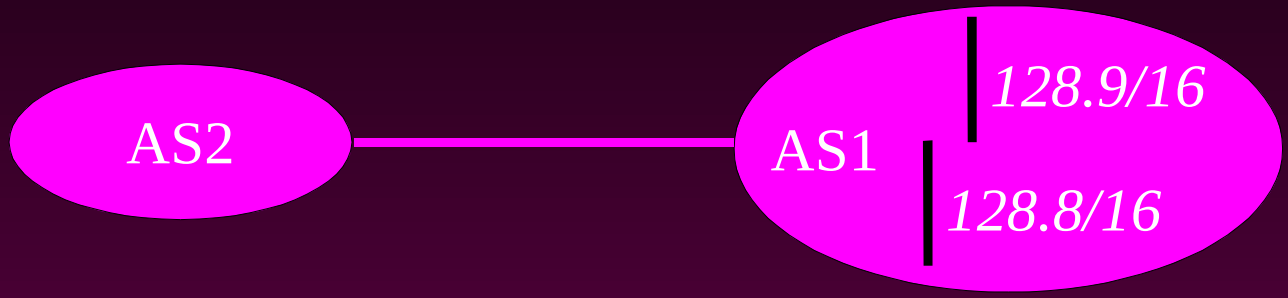
```
aut-num:  AS4591
as-name:  Syra-NET
import:   from AS4590
          action pref=1;
          accept AS4590
export:   to AS4590
          announce AS4591
default:  to AS4590
          action pref=1;
          networks {140.222.0.0/16}
admin-c:  Warren Lavallee
tech-c:   Warren Lavallee
mnt-by:   MAINT-AS4591
changed:  warren@Syra.NET 19950522
source:   RADB
```

Policy Styles

RPSL allows import/export policies based on:

- **prefix**
- **AS Path**
- **community**
- **prefix−length**
- **other/future attributes thru its dictionary**

Prefix Based




```
aut-num: AS1
export:  to AS2
         announce {128.9.0.0/16, 128.8.0.0/16}

aut-num: AS2
import:  from AS1
         accept   {128.9.0.0/16, 128.8.0.0/16}
```

RtConfig:
A tool to configure routers

```
% RtConfig
RtConfig> @RtConfig export AS1 1.1.1.1 AS2 2.2.2.2
no access-list 1
access-list 1 permit ip 128.8.0.0 0.0.0.0 255.255.0.0 0.0.0.0
access-list 1 permit ip 128.9.0.0 0.0.0.0 255.255.0.0 0.0.0.0
access-list 1 deny ip 0.0.0.0 255.255.255.255 0.0.0.0 255.255.255.255
!
no route-map foo
route-map foo permit 1
 match ip address 1
!
!
```

Aut-num for AS2 is not needed!!!

Cumbersome?


```
aut-num: AS1
export:  to AS2
         announce {128.9.0.0/16, 128.8.0.0/16,
                   128.6.0.0/16}

aut-num: AS2
import:  from AS1
         accept   {128.9.0.0/16, 128.8.0.0/16,
                   128.6.0.0/16}
```

Per route-set

```
route-set:    rs-red
members:      128.6.0.0/16, 128.9.0.0/16,
              128.8.0.0/16


aut-num: AS1
export:  to AS2     announce rs-red

aut-num: AS2
import:  from AS1   accept   rs-red
```

Per Origin AS

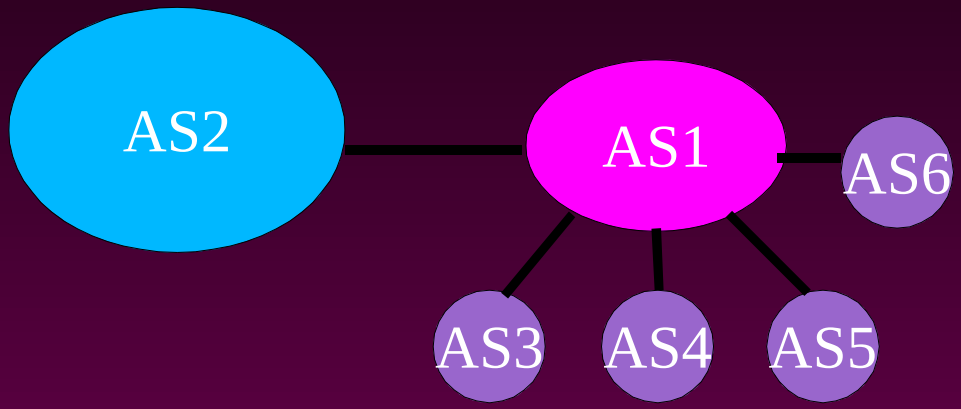

```
route:  128.9.0.0/16          route:  128.8.0.0/16
origin: AS1                   origin: AS1

aut-num: AS1
export:  to AS2   announce AS1

aut-num: AS2
import:  from AS1 accept   AS1
```

AS1 == {128.9.0.0/16, 128.8.0.0/16}

RtConfig

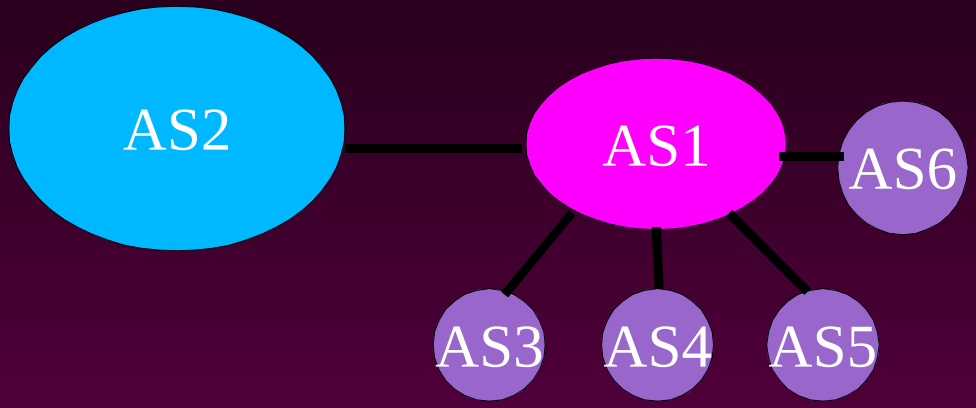
```
% RtConfig
RtConfig> @RtConfig export AS1 1.1.1.1 AS2 2.2.2.2
no access-list 1
access-list 1 permit ip 128.8.0.0 0.0.0.0 255.255.0.0 0.0.0.0
access-list 1 permit ip 128.9.0.0 0.0.0.0 255.255.0.0 0.0.0.0
access-list 1 deny ip 0.0.0.0 255.255.255.255 0.0.0.0 255.255.255.255
!
no route-map foo
route-map foo permit 1
 match ip address 1
!
!
```

Customers



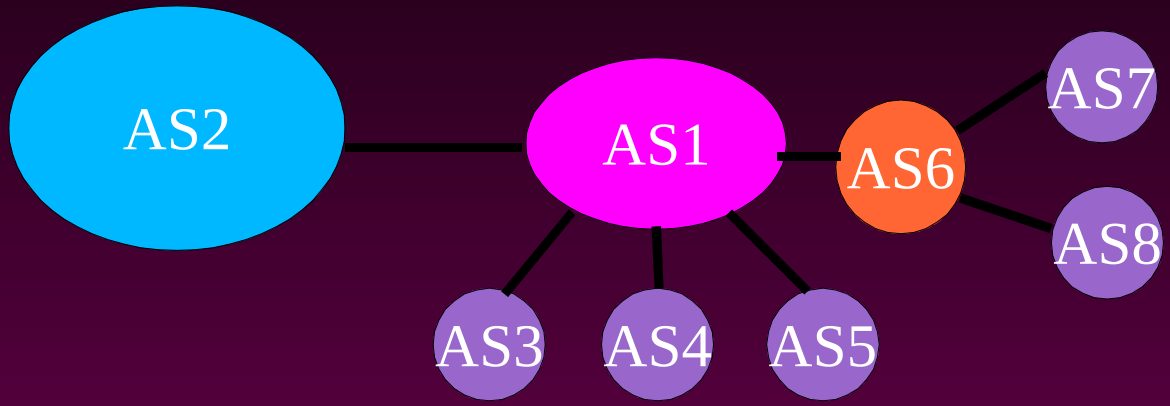

```
aut-num: AS1
export:  to AS2     announce AS1 OR AS3 OR ... AS6

aut-num: AS2
import:  from AS1   accept   AS1 OR AS3 OR ... AS6
```

Customers in a set



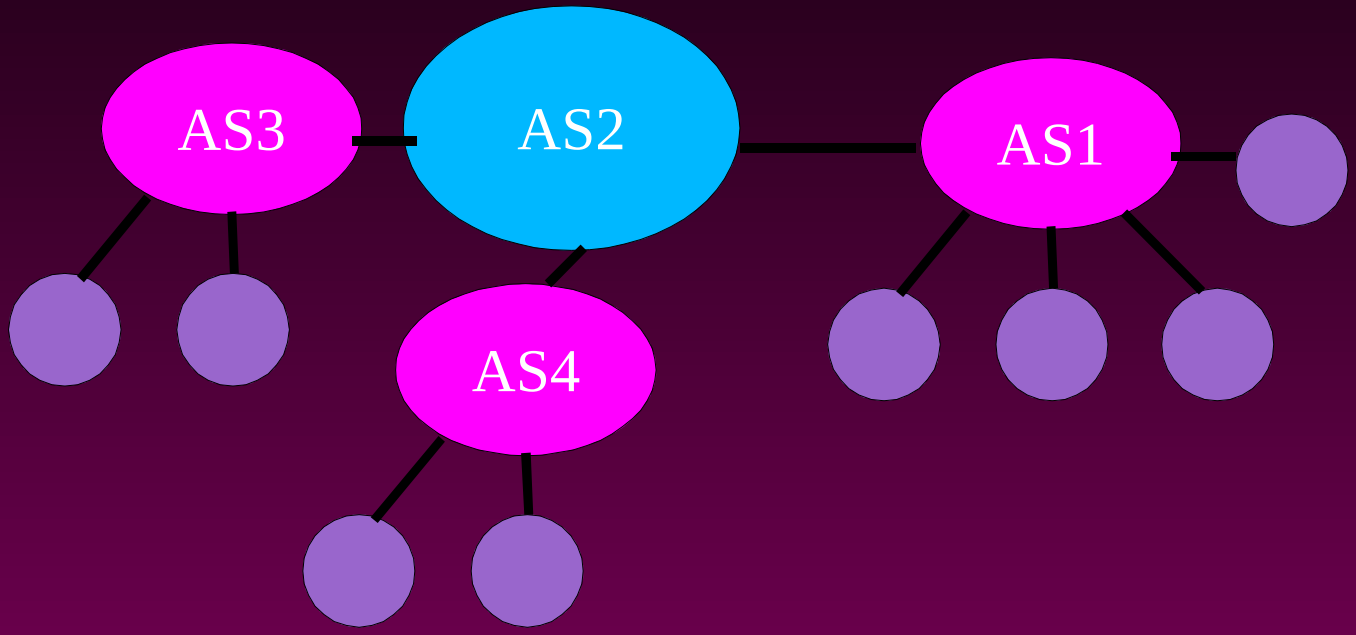

```
as-set:  AS1:AS-Customers
members: AS1, AS3, AS4, AS5, AS6

aut-num: AS1
export:  to AS2     announce AS1:AS-Customers

aut-num: AS2
import:  from AS1   accept   AS1:AS-Customers
```

Customers of Customers



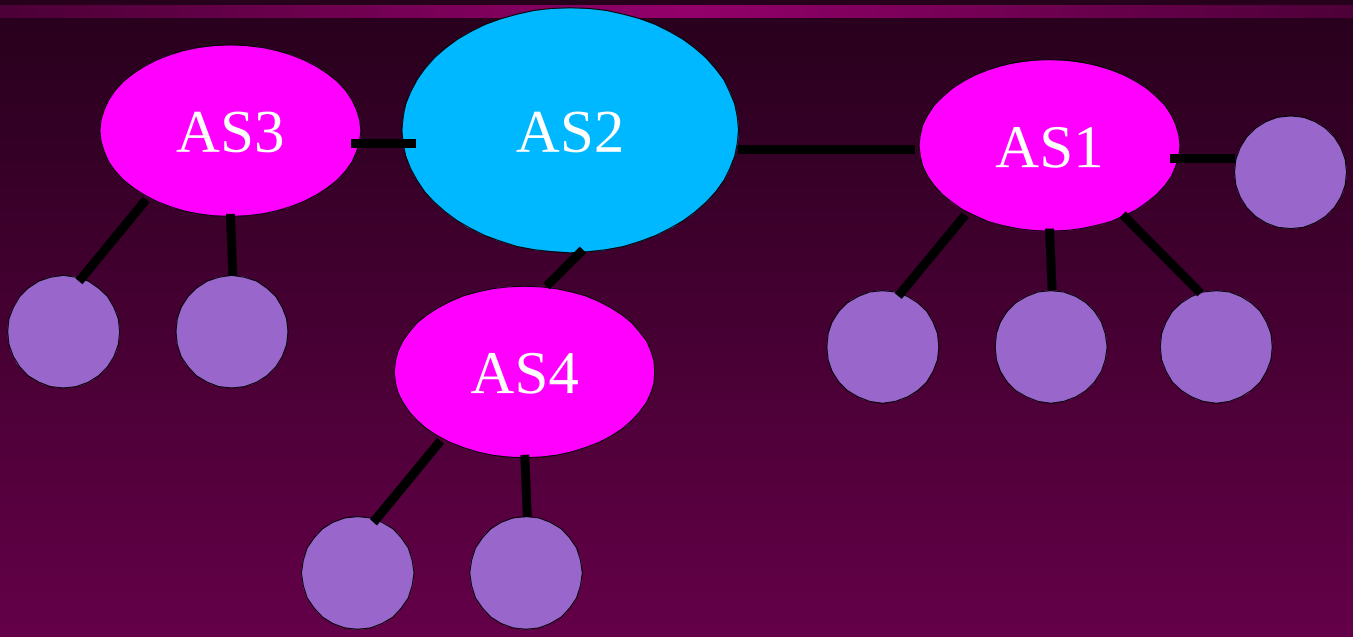

```
Aut-num: AS1
export:  to AS2     announce AS1:AS-Customers

as-set:  AS1:AS-Customers
members: AS1, AS3, AS4, AS5, AS6:AS-Customers

as-set:  AS6:AS-Customers
members: AS6, AS7, AS8
```

More Customers?




```
aut-num: AS2
import:  from AS1 accept AS1:AS-Customers
import:  from AS3 accept AS3:AS-Customers
import:  from AS4 accept AS4:AS-Customers
```

Shortcut: PeerAS




```
as-set:  AS2:AS-Customers
members: AS1, AS3, AS4

aut-num: AS2
import:  from   AS2:AS-Customers
         accept PeerAS:AS-Customers
```

Preference/Cost


```
aut-num: AS4
import:  from AS1 action pref = 10; accept ANY
import:  from AS3 action pref = 15; accept ANY
```

Smaller the number, higher the preference!

Actions

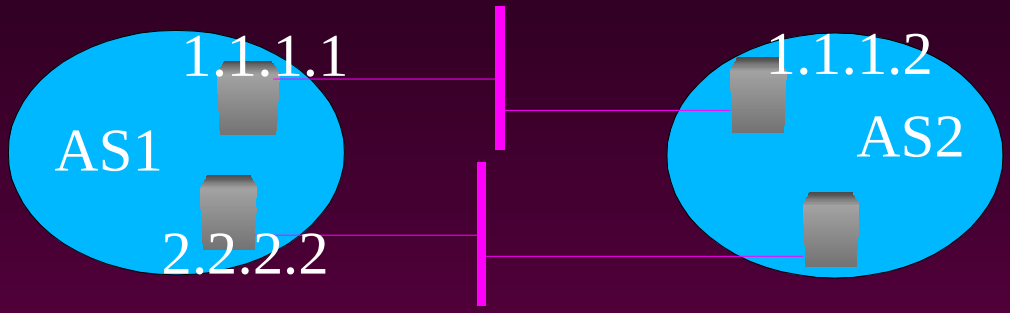
```
import: from ... action XXX; accept ...
export: to   ... action XXX; announce ...

med = 0;
med = igp_cost;

community.append(NO_EXPORT, 10250, 3561:90);
community.delete(NO_EXPORT);

aspath.prepend(AS1, AS1, AS1);
```

Action


```
aut-num: AS4
export:  to AS1 announce AS4
export:  to AS3 action aspath.prepend(AS4);
                announce AS4
```

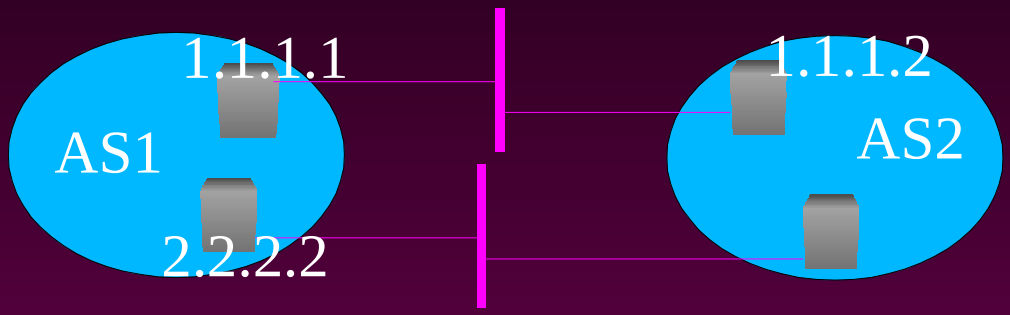
What would happen if `aspath.prepend(AS4,AS4,AS4,AS4)`?

Peering Choice




```
aut-num: AS1
import:  from    AS2 accept AS2
```

Peering Choice



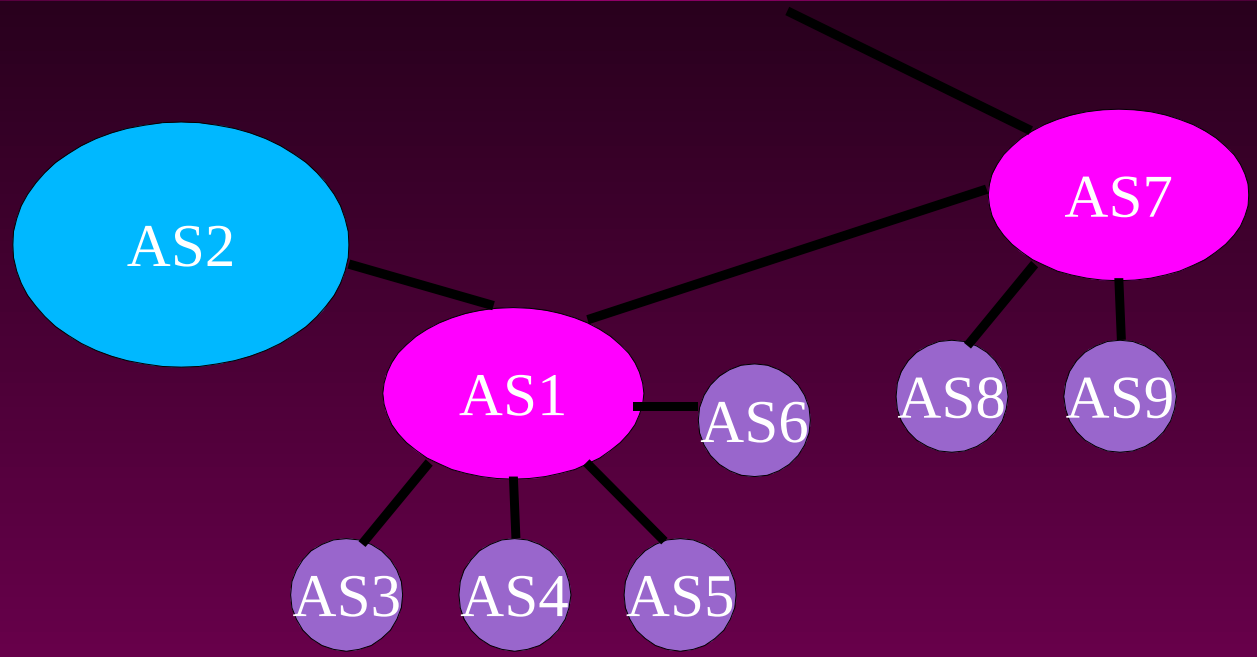

```
aut-num: AS1
import:  from   AS2              at 2.2.2.2
         action pref = 10;
         accept AS2
import:  from   AS2 1.1.1.2 at 1.1.1.1
         action pref =  5;
         accept AS2
```

Logical/Set Operators

```
Aut-num: AS1
import:  from AS1
         accept (AS1 OR rs-red) AND NOT {0.0.0.0/0}
```

```
AS1             == {128.9.0.0/16, 128.8.0.0/16}
rs-red          == {128.6.0.0/16, 128.9.0.0/16}

AS1 OR rs-red == {128.6.0.0/16, 128.8.0.0/16, 128.9.0.0/16}

AS1 AND rs-red == {128.9.0.0/16}

AS1 AND NOT rs-red == {128.8.0.0/16}
```

AS Path Based



AS paths that start in AS1 and end in AS8:

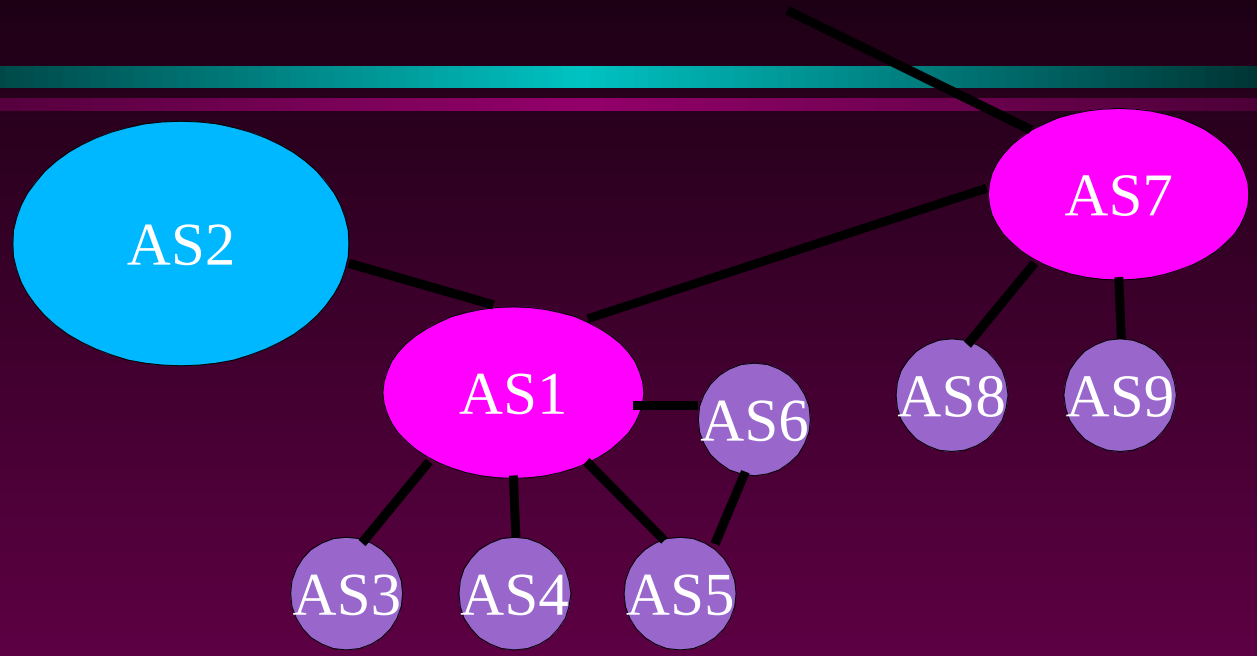
<^AS1 .* AS8$>

No prefix filters here!

AS Path Regular Expressions

`AS1`	AS1 only
`.`	Any AS
`as-foo`	Any member of `as-foo`
`X*`	0 or more occurance of X
`X+`	1 or more occurance of X
`X?`	0 or 1 occurance of X
`^`	beginning of path
`$`	end of path
`X|Y`	X or Y
`X Y`	X followed by Y

AS Paths into AS1's Customers



<^AS1* AS1:AS-Customers* $> matches:

AS1

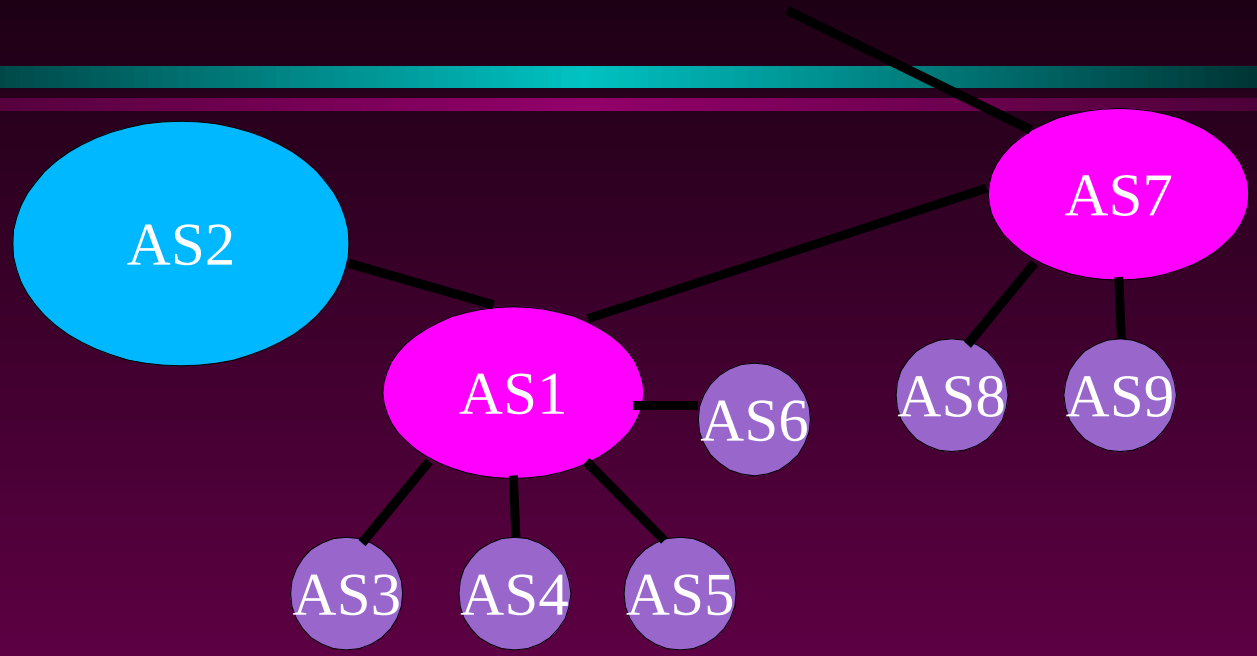
AS1 AS3

AS1 AS4

AS1 AS5 AS6

AS1 AS1 AS5 AS5 AS6

AS Path Based import/export




```
import: from AS1 accept <^AS1 .* AS8$>

import: from AS1 accept <^AS1 AS1:AS-Customers*$>
```

RtConfig

```
RtConfig> @RtConfig import AS2 1.1.1.1 AS1 2.2.2.2
!
no ip as-path access-list  1
ip as-path access-list 1 permit ^_1((_[0-9]+))*_8$
!
no route-map foo
route-map foo permit 1
 match as-path 1
!
router bgp 2
neighbor 2.2.2.2 route-map foo in
```

community Based

AS4 wants **AS3561** to prefer **AS1** path

AS3561 prefers routes with

- **no community**
- **with community 3561:90**
- **with community 3561:80**
- **with community 3561:70**

AS3561's Policies

```
aut-num: AS3561
import: from   AS-ANY
        action pref = 30;
        accept community(3561:70)
import: from   AS-ANY
        action pref = 20;
        accept community(3561:80)
import: from   AS-ANY
        action pref = 10;
        accept community(3561:90)
import: from   AS-ANY
        action pref = 0;
        accept ANY
```

AS4's Policies


```
aut-num: AS4
export: to AS1 action community.={3561:90};
        to AS3 action community.={3561:80};
        announce AS4
```

RtConfig

```
aut-num: AS1
export:  to AS2
         announce AS2764 AND NOT { 0.0.0.0/0 }
                     AND <^AS2764*$>
                     AND NOT community(2764:1)
```

RtConfig

```
RtConfig> @RtConfig export AS1 1.1.1.1 AS2 2.2.2.2
access-list 1 permit ip 210.8.248.0 0.0.0.0   255.255.248.0   0.0.0.0
...
access-list 1 permit ip 210.9.2.0   0.0.0.0   255.255.254.0   0.0.0.0
access-list 1 deny ip 0.0.0.0 255.255.255.255 0.0.0.0 255.255.255.255
!
no ip as-path access-list  1
ip as-path access-list 1 permit ^(_2764)*$
!
ip bgp-community new-format
no community-list 1
ip community-list 1 deny 2764:1
ip community-list 1 permit internet
!
```

RtConfig (cont)

```
no route-map foo
route-map foo permit 1
 match as-path 1
 match community 1
 match ip address 1
!
router bgp 1
neighbor 0.0.0.0 route-map foo out
```

Prefix Length Based

```
aut-num: AS1
import: from as-any
        accept ANY AND NOT { 0.0.0.0/0^19-32 }
```

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  - Structured Policy
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Accept Good Routes

```
from AS-ANY
     accept ANY and not {0.0.0.0/0};
```

Better yet:

```
from AS-ANY
     accept ANY and not RS-MARTIANS;
```

```
route-set: RS-MARTIANS
members:   0.0.0.0/0, 127.0.0.0/8^+, 10.0.0.0/8^+,
   172.16.0.0/20^+, 192.168.0.0/16^+, 192.0.2.0/24^+,
   128.0.0.0/16^+, 191.255.0.0/16^+, 192.0.0.0/24^+,
   223.255.255.0/24^+, 224.0.0.0/3^+, 0.0.0.0/0^26-32
```

Set Preference Using Communities

```
from AS-ANY action pref=20;
            accept communtiy(1:20);
from AS-ANY action pref=10;
            accept communtiy(1:10);
from AS-ANY action pref=0;
            accept any;
```

Filter (at least) the customers

```
from AS2 accept AS2;
from AS3 accept AS3 or AS4;
from AS5 accept AS5:AS-Customers;
...
```

Combine: Structured Policy

```
import:{
        from AS-ANY
             accept ANY and not RS-MARTIANS;
      } refine {
        from AS-ANY action pref=10;
             accept communtiy(1:10);
        from AS-ANY action pref=20;
             accept communtiy(1:20);
        from AS-ANY action pref=0;
             accept any;
      } refine {
        from AS2 accept AS2;
        from AS3 accept AS3 or AS4;
        from AS5 accept AS5:AS-Customers;
      }
```

Structured Policy

```
aut-num: AS3561
import: {
          from   AS-ANY action pref = 30;
          accept community(3561:70);
          from   AS-ANY action pref = 20;
          accept community(3561:80);
        } refine {
            from AS1 accept AS1:AS-Customers;
            } except {
               from AS2 accept AS2;
               from AS3 accept AS3;
            }
```

AS1:AS-Customers contains AS2 and AS3

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Static Routes

```
route:  128.7.0.0/16
origin: AS1
inject: at 7.7.7.1
        action next-hop = 7.7.7.2; cost = 10;
        upon static
inject: at 7.7.7.1
        action next-hop = 7.7.7.3; cost = 20;
        upon static
```

Aggregation

```
route:        128.8.0.0/15
origin:       AS1
components:   {128.8.0.0/15^-}
aggr-mtd:     outbound AS-ANY
inject:       at 1.1.1.1 action dpa = 100;
inject:       at 1.1.1.2 action dpa = 110;
```

Inet-rtr

```
inet-rtr:       aads.OneCall.Net
local-as:       AS6402
ifaddr:         207.7.19.254 masklen 24
ifaddr:         207.112.228.254 masklen 24
peer:           BGP4 198.32.130.52 asno(AS6583)
peer:           BGP4 198.32.130.49 asno(AS5696)
admin-c:        RI69
tech-c:         RI69
remarks:        AADS router for the OneCall NetWork
mnt-by:         MAINT-AS6402
```

RtConfig

```
@RtConfig configureRouter aads.OneCall.Net
```

Generates import/export for:

```
peer:  BGP4 198.32.130.52 asno(AS6583)
peer:  BGP4 198.32.130.49 asno(AS5696)
```

ConfigureRouter

```
RtConfig> @RtConfig configureRouter aads.onecall.net
...
ip prefix-list pl102 permit 216.246.0.0/17
ip prefix-list pl102 permit 216.246.0.0/18
ip prefix-list pl102 deny 0.0.0.0/0 le 32
route-map MyMap_6402_15 permit 1
 match ip address prefix-list pl102
 set local-preference 980
router bgp 6402
neighbor 198.32.130.49 route-map MyMap_6402_15 in
```

RtConfig

```
@RtConfig import AS1 1.1.1.1 AS2 2.2.2.2
@RtConfig export AS1 1.1.1.1 AS2 2.2.2.2
@RtConfig configureRouter c56-11.t3.ans.net
@RtConfig networks AS1
@RtConfig default AS1 AS2
@RtConfig pkt_filter "eth0" AS1 1.1.1.1 AS2 2.2.2.2
@RtConfig outbound_pkt_filter "eth0" AS1 1.1.1.1 AS2 2.2.2
@RtConfig static2bgp AS1 1.1.1.1
@RTConfig printPrefixes "format" filter <filter>
```

Configuration formats:

cisco, juniper, gated, rsd, bay/nortel

lucent coming soon

Extensible thru dictionary

```
dictionary:    RPSL
rp-attribute: pref # smaller values are preferred
              operator=(integer[0, 65535])
rp-attribute: med # BGP multi_exit_discriminator
              operator=(integer[0, 65535])
              operator=(enum[igp_cost])
typedef:      community_elm union
              integer[1, 4294967200],
              enum[internet, no_export, no_advertise]
rp-attribute: community   # BGP community attribute
              operator.=(list of community_elm)
              operator()(community_elm, ...)
...
```

Pointers

http://www.isi.edu/ra/rps/training

- **Tutorial slides**
- **RFC2622 (RPSL)**
- **RFC2650 (RPSL Applications)**

http://www.isi.edu/ra/RAToolSet

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