

# BGP Configuration from the IRR

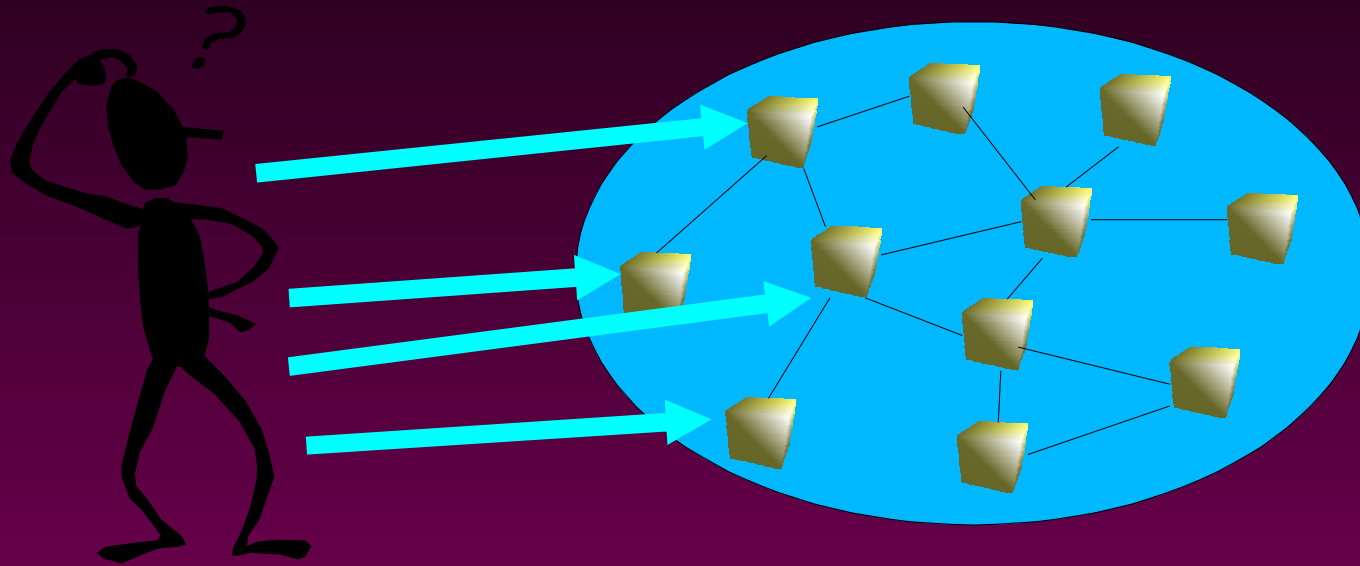
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<http://www.isi.edu/ra/rps/training>

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

# BGP Configuration



**Too many routers**

**Too detailed, large & tedious**

**Consistency**

**Heavy consequences of mistakes**

# Mistakes don't happen!

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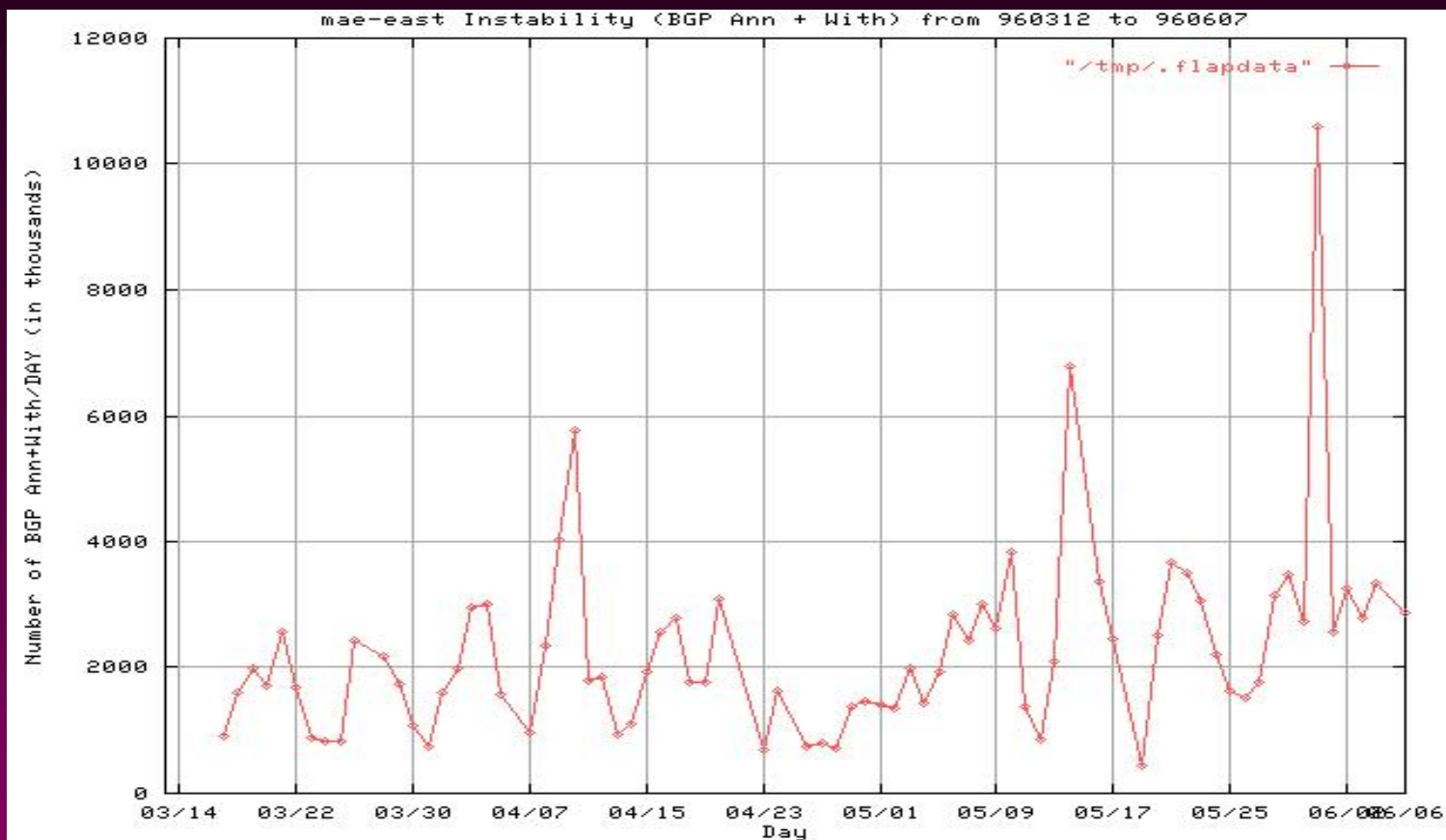
**BGP->RIP->BGP injection**

**128/7 leak**

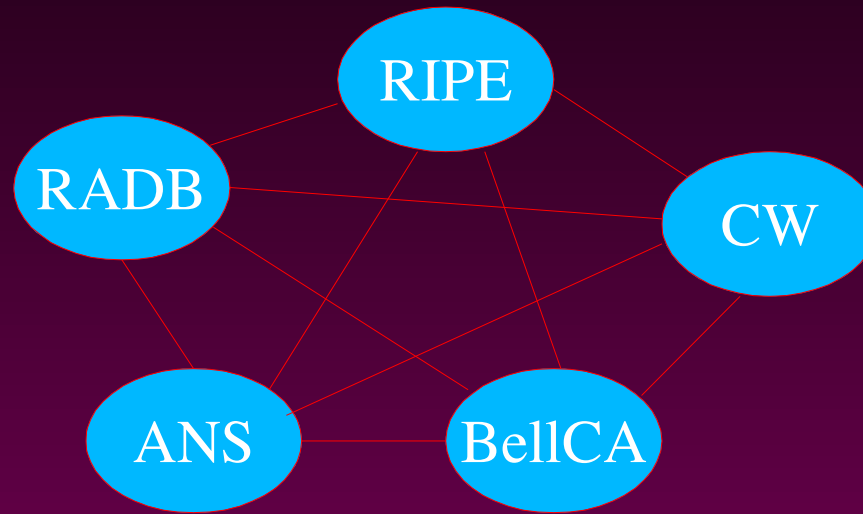
**bogon 0/0, 10/8 leaks**

**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

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**RPSL:** Abstract, high level, per-as policies

**IRR:** Benefit from others' data & delegation

**RtConfig:** Details/tedious aspects automated



# Outline

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**Motivation**

**Routing Policy Definitions**

**RPSL & RtConfig**

**Basic classes and notations**

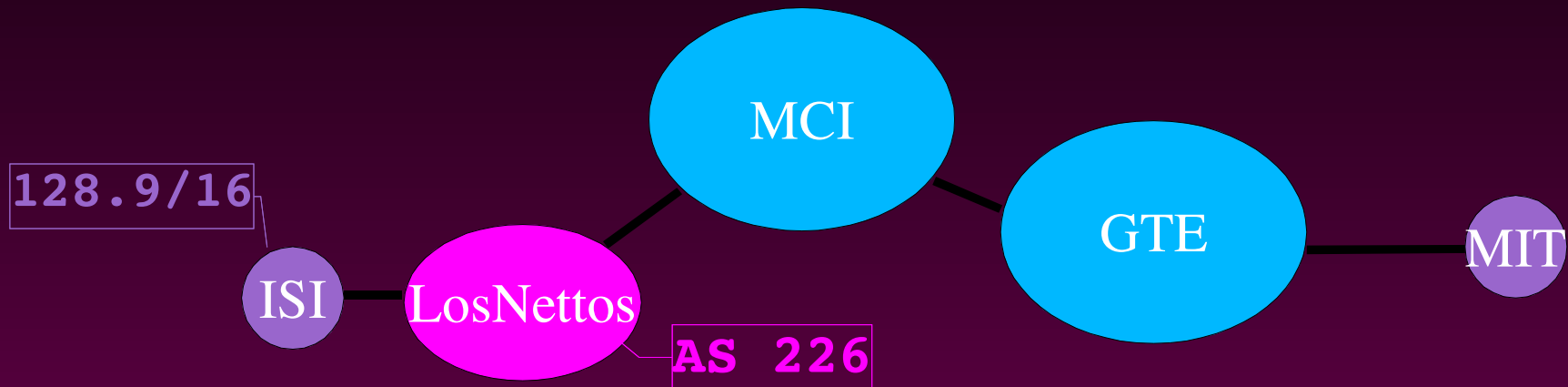
**Set classes**

**import/export policy**

**Structured Policy**

**Other Features & Wrap-up**

# Internet's Routing



**Interior routing is metric based**

**Inside MCI, shortest exit to GTE**

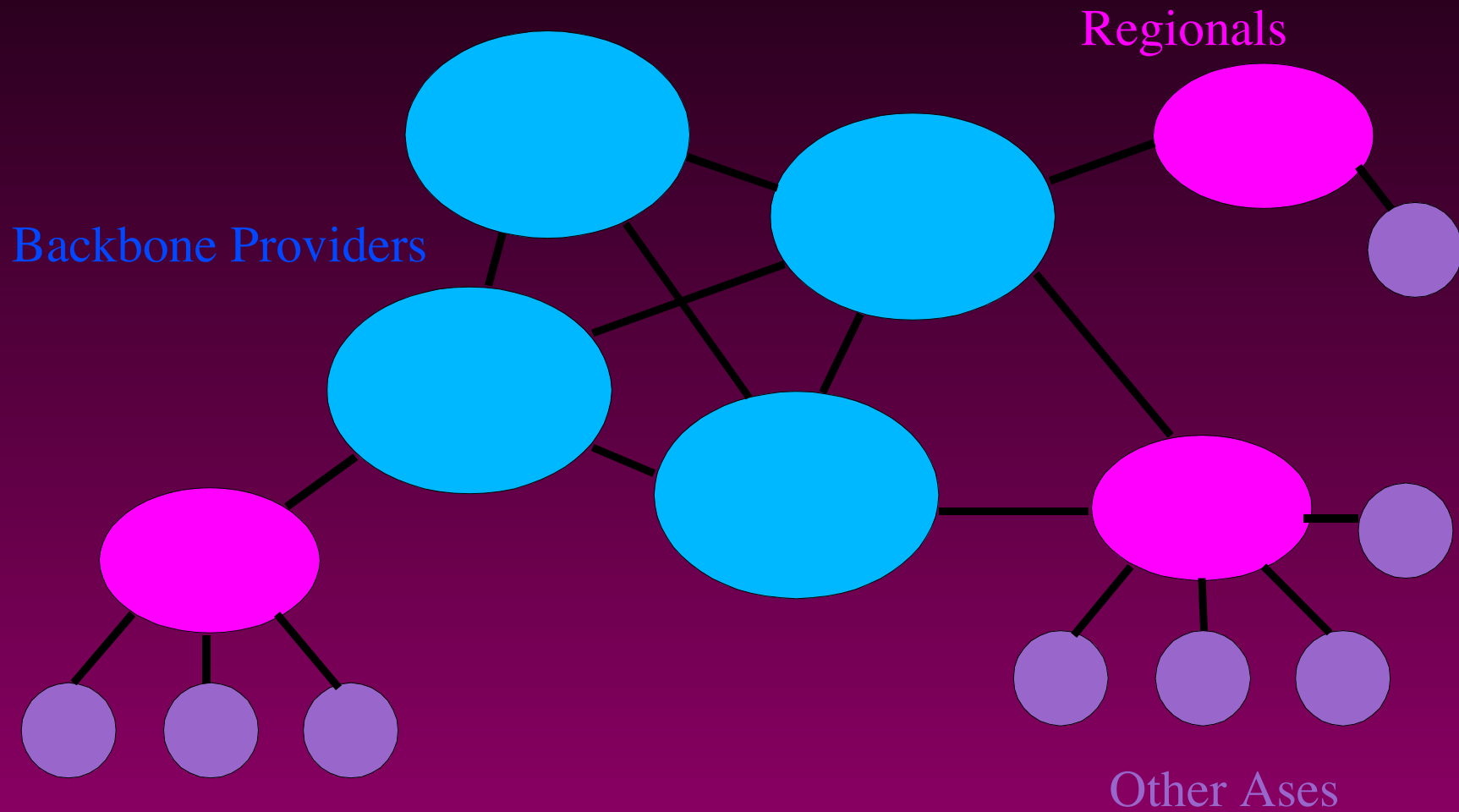
**OSPF, IS-IS,...**

**Exterior routing is policy based**

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

**BGP**

# Inter-AS Topology



# AS Relationships

## Customer

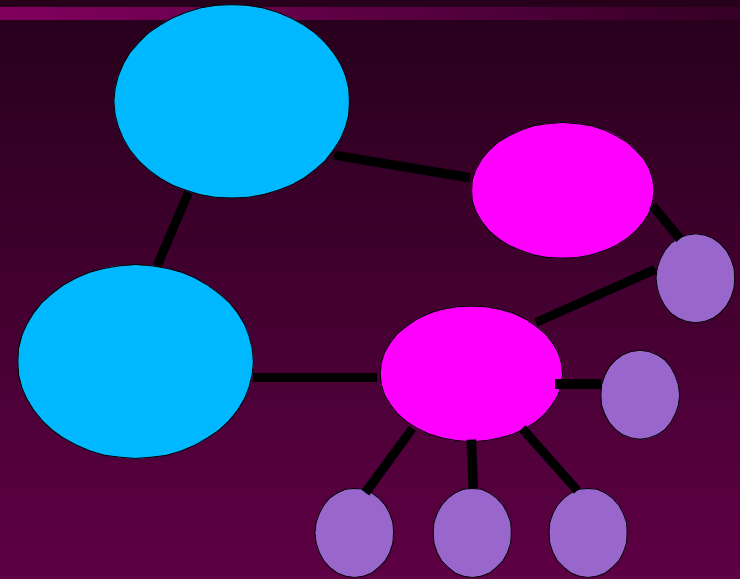
can use its resources

## Provider

prefer one provider over another

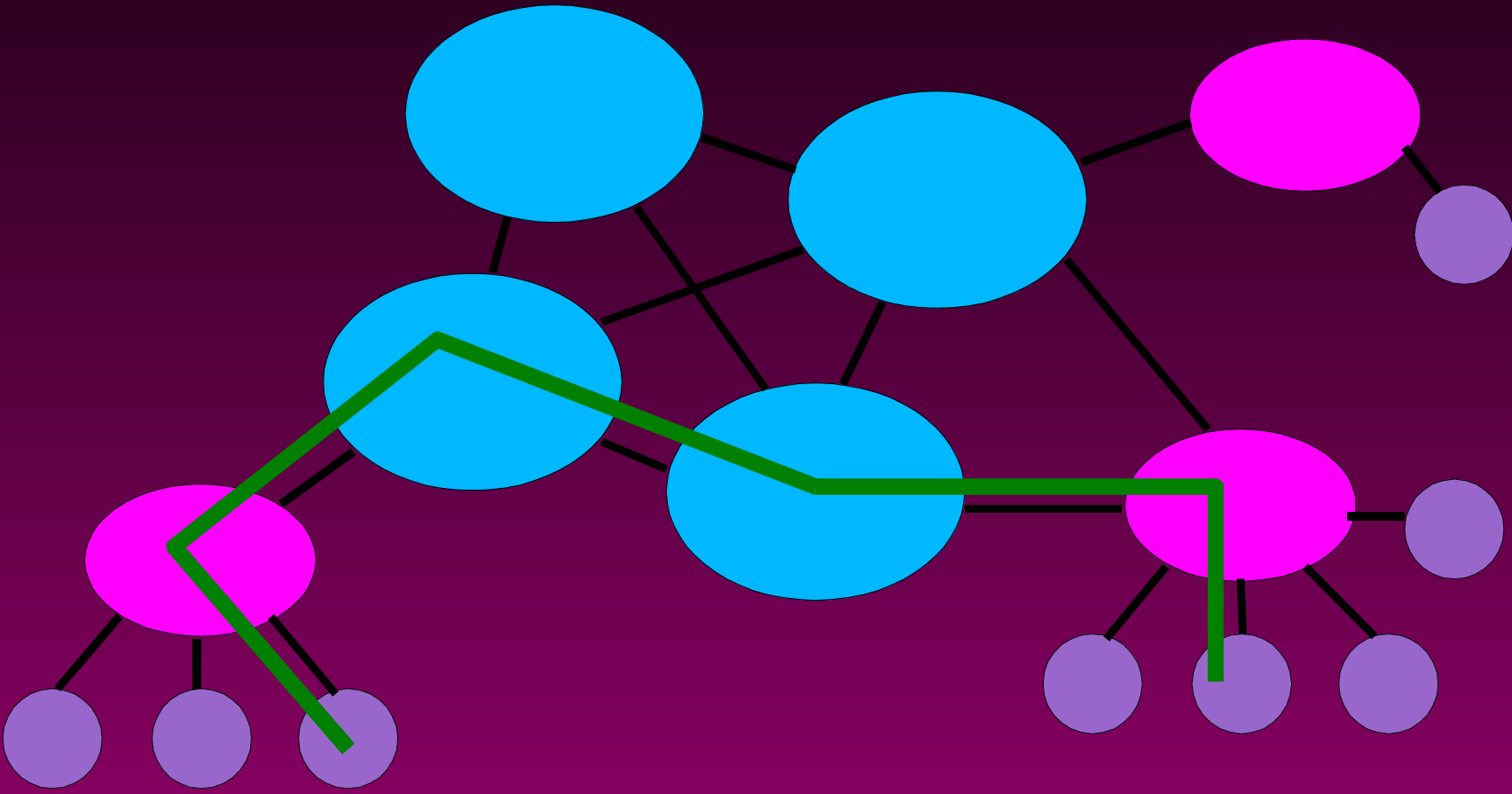
## Peer

can use its resources to reach customers

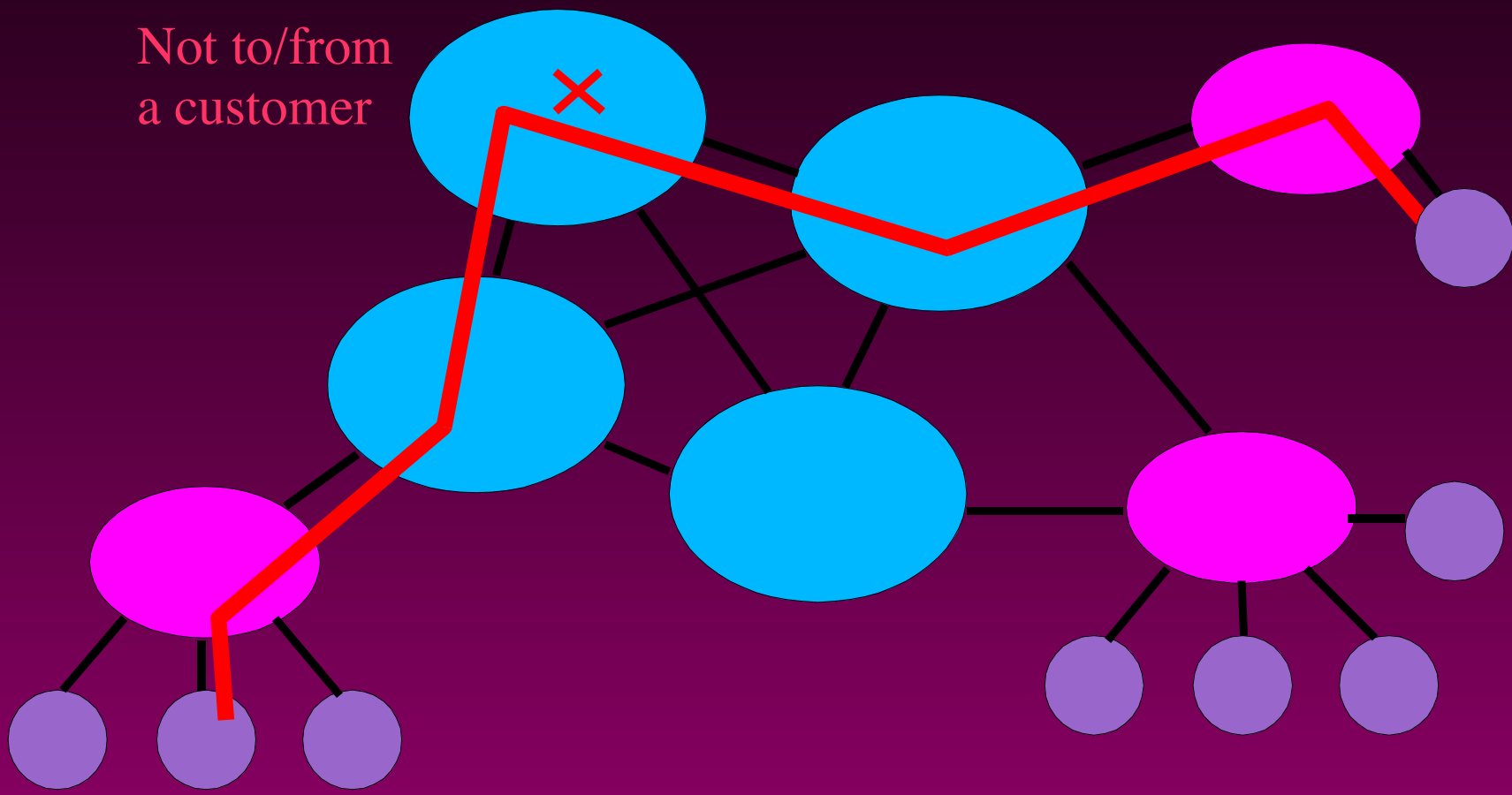


Typical routing policies implement these

# Routing Policy

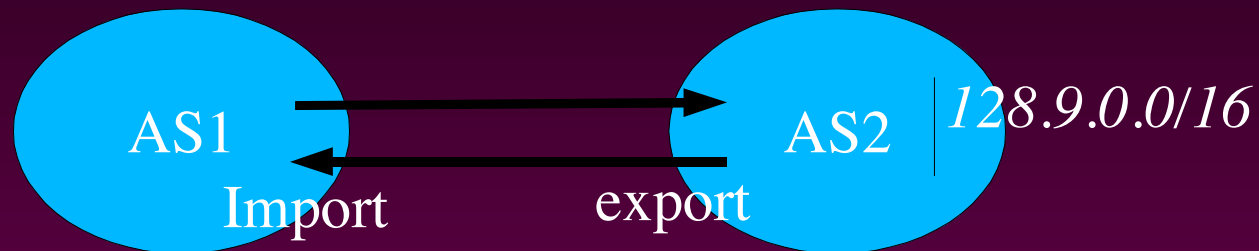


# Routing Policy



# 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**

# Outline

---

**Motivation**

**Routing Policy Definitions**

**RPSL & RtConfig**

**Basic classes and notations**

**Set classes**

**import/export policy**

**Structured Policy**

**Other Features & Wrap-up**

# 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)**

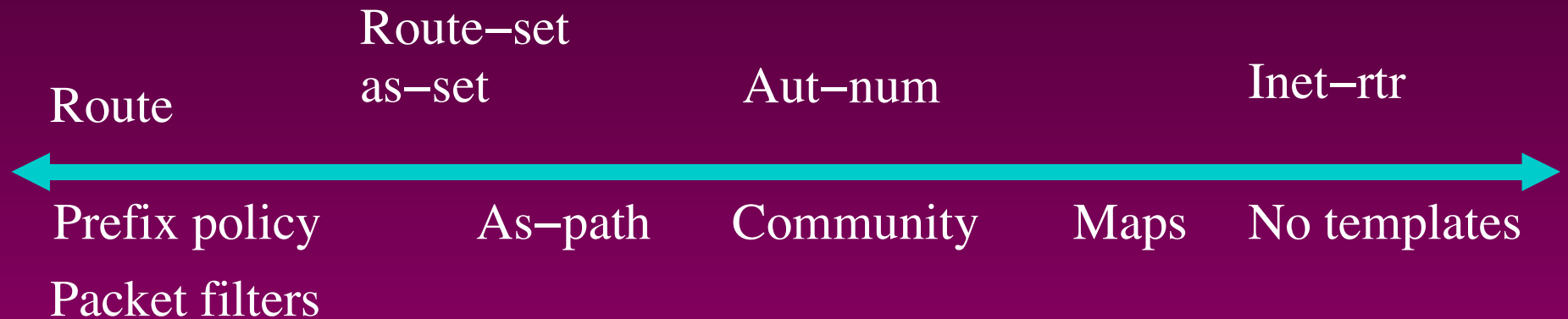
**Based on RIPE-181**

# 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

Attribute name

Attribute value

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

Comment

continuation

# 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  
attributes

```
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

---

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

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

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 p1100
ip prefix-list p1100 permit 128.97.0.0/16
ip prefix-list p1100 permit 128.99.0.0/16
ip prefix-list p1100 permit 128.125.0.0/16
ip prefix-list p1100 permit 128.149.0.0/16
ip prefix-list p1100 permit 129.4.0.0/16
ip prefix-list p1100 permit 129.193.0.0/16
ip prefix-list p1100 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
```

%p prefix

%l length

%L 32-length

%k mask

%K dont-care



# 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 p1100  
ip prefix-list p1100 permit 128.97.0.0/16  
ip prefix-list p1100 permit 131.179.0.0/16  
ip prefix-list p1100 permit 149.142.0.0/16  
ip prefix-list p1100 permit 164.67.0.0/16  
ip prefix-list p1100 deny 0.0.0.0/0 le 32
```

# Roe

The screenshot shows a window titled 'roe' with a menu bar containing 'File', 'Show', 'Selection', and 'Configure'. The main area displays a list of IP ranges and their associated ASes:

IP Range	AS	AS	AS
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

Below the list are two tabs: 'demo 226' (selected) and 'demo 52'. The 'demo 226' tab shows the following details for the selected route:

```
route: 128.97.0.0/16
descr: University of California
       Los Angeles
       Boelter Hall and Mathematical Sciences Bui
       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
```

At the bottom of the window are several buttons: 'Add Template', 'Delete Template', 'Update Template', 'Schedule', 'Cancel', and 'Update IRR'. The status bar at the bottom right indicates 'Pending Replies: 0'.

# Roe

The screenshot shows the 'Roe' application window. At the top is a menu bar with 'File', 'Show', 'Selection', and 'Configure'. Below the menu bar is a table of routes. The table has columns for IP address, status, type, and two AS identifiers. Below the table are two tabs: 'demo 226' and 'demo 52'. The 'demo 226' tab is active, showing a detailed view of a route. The detailed view includes fields for 'route:', 'descr:', 'origin:', 'member-of:', 'mnt-by:', 'changed:', 'integrity:', and 'source:'. A 'Show' menu is open, displaying various filter options with checkboxes. At the bottom of the application are buttons for 'Add Template', 'Delete Template', 'Update Template', 'Schedule', and 'Cancel'. The status bar at the bottom right shows 'Pending replies: 0'.

IP Address	Status	Type	AS1	AS2
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 Bui.  
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

**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

RR

Adding replies: 0

# Operators

```
RtConfig> @RtConfig access_list filter as226 and as52  
no ip prefix-list p1100  
ip prefix-list p1100 permit 128.97.0.0/16  
ip prefix-list p1100 permit 131.179.0.0/16  
ip prefix-list p1100 permit 149.142.0.0/16  
ip prefix-list p1100 permit 164.67.0.0/16  
ip prefix-list p1100 deny 0.0.0.0/0 le 32
```

# Operators

```
@RtConfig access_list filter as226 and not as52
no ip prefix-list p1100
ip prefix-list p1100 permit 128.99.0.0/16
ip prefix-list p1100 permit 128.125.0.0/16
ip prefix-list p1100 permit 128.149.0.0/16
ip prefix-list p1100 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})
```

# Outline

---

**Motivation**

**Routing Policy Definitions**

**RPSL & RtConfig**

**Basic classes and notations**

**Set classes**

**import/export policy**

**Structured Policy**

**Other Features & Wrap-up**



# 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 p1100  
ip prefix-list p1100 permit 128.249.0.0/16  
ip prefix-list p1100 permit 192.31.88.0/24  
ip prefix-list p1100 permit 192.147.26.0/24  
ip prefix-list p1100 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:  0.0.0.0/032,          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+,        0.0.0.0/026-32
```

Inclusive more specifics: <sup>+</sup>

Exclusive more specifics: <sup>-</sup>

Length n more specifics: <sup>n</sup>

Length n-m more specifics: <sup>n-m</sup>

# 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 p1100
ip prefix-list p1100 permit 12.10.231.0/24
ip prefix-list p1100 permit 63.140.0.0/16
ip prefix-list p1100 permit 64.16.64.0/20
ip prefix-list p1100 permit 64.16.75.0/24
ip prefix-list p1100 permit 64.16.128.0/20
ip prefix-list p1100 permit 64.16.128.0/24
ip prefix-list p1100 permit 64.16.138.0/23
...
```

# Outline

---

**Motivation**

**Routing Policy Definitions**

**RPSL & RtConfig**

**Basic classes and notations**

**Set classes**

**import/export policy**

**Structured Policy**

**Other Features & Wrap-up**

# 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**

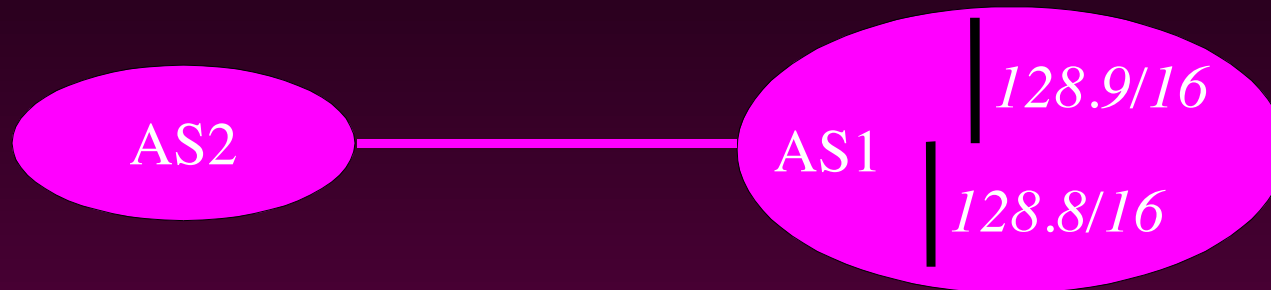
**AS Path**

**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}



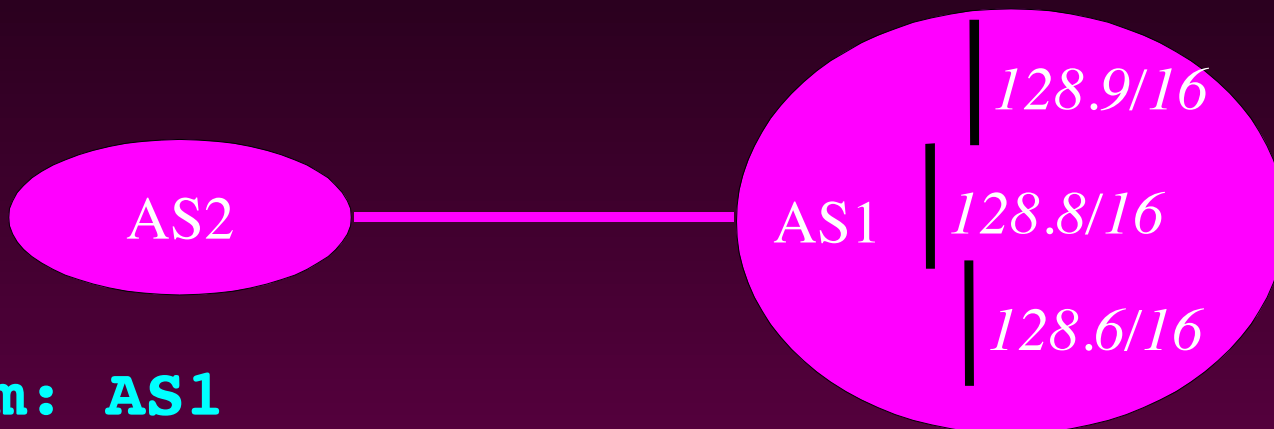
# RtConfig: A tool to configure routers

---

```
% 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  
origin: AS1
```

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

```
aut-num: AS1  
export: to AS2 announce AS1
```

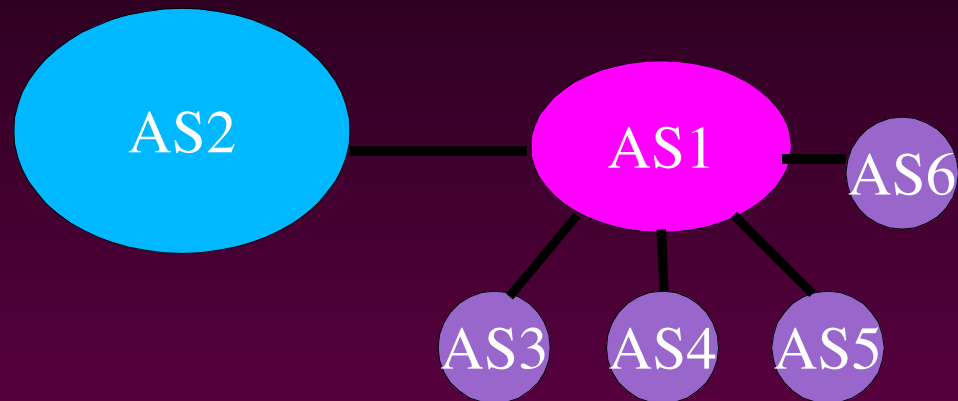
```
aut-num: AS2  
import: from AS1 accept AS1
```

```
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



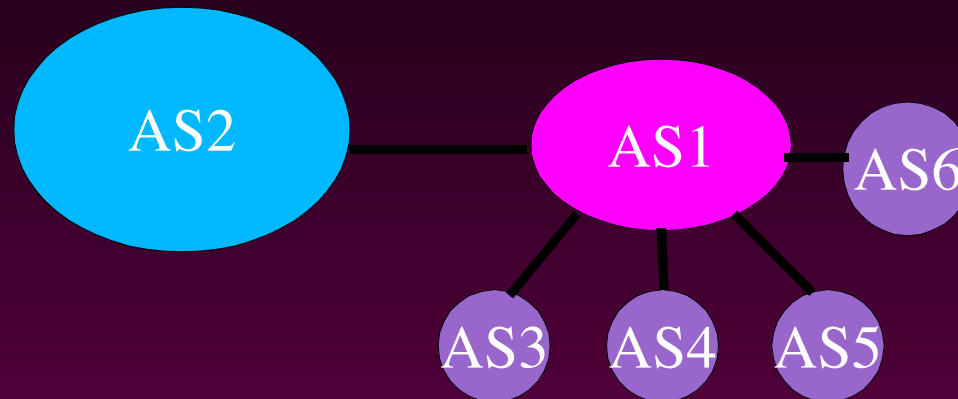
**aut-num:** AS1

**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

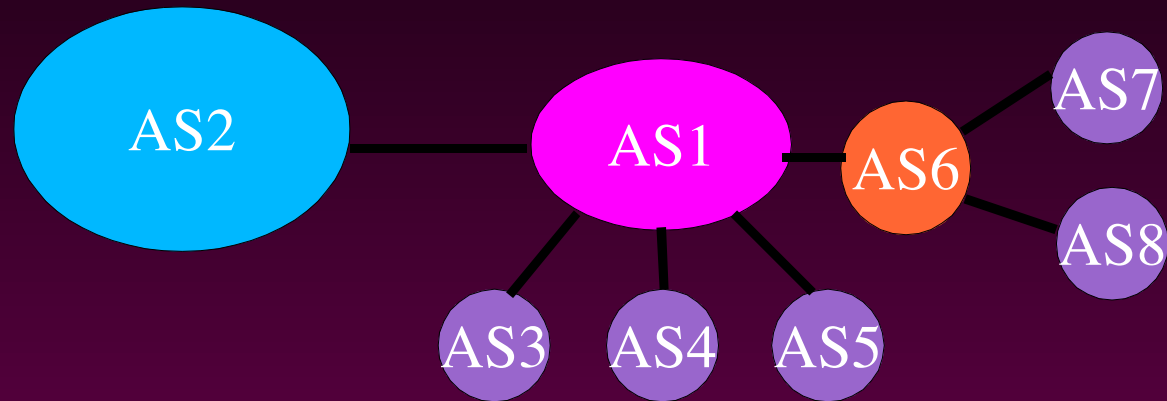
**aut-num:** AS1

**export:** to AS2      announce AS1:AS-Customers

**aut-num:** AS2

**import:** from AS1      accept AS1:AS-Customers

# Customers of Customers



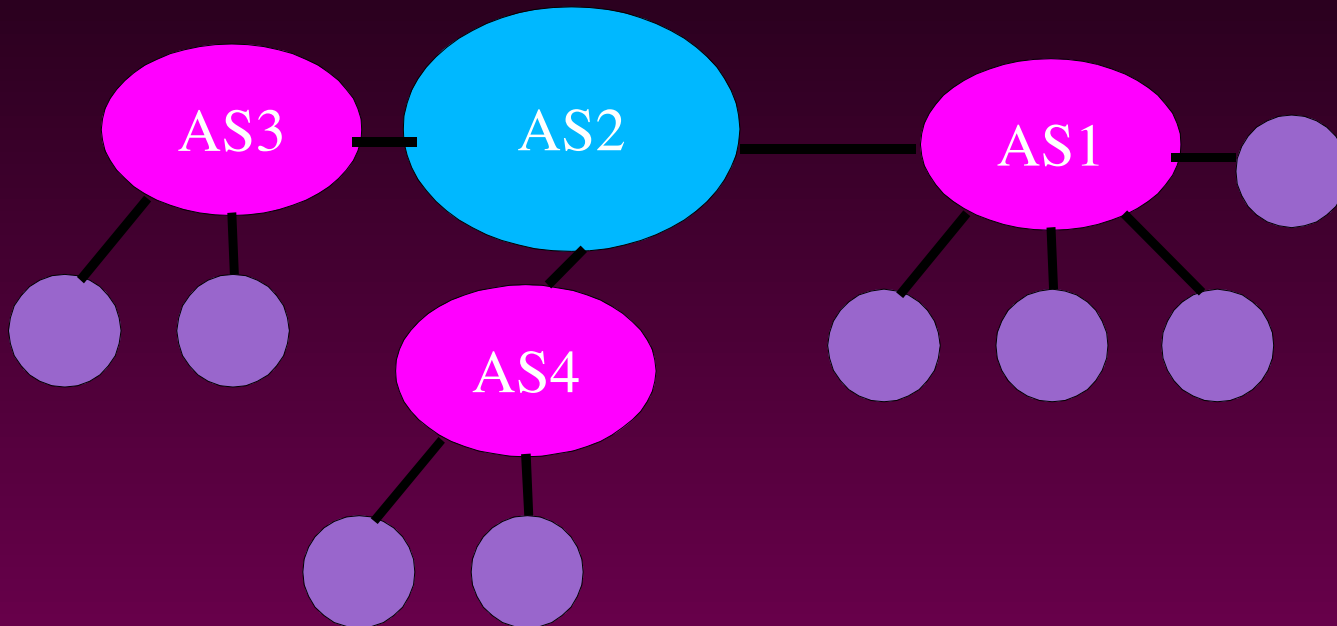
**Aut-num:** AS1  
**export:** to AS2      announce **AS1:AS-Customers**

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

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

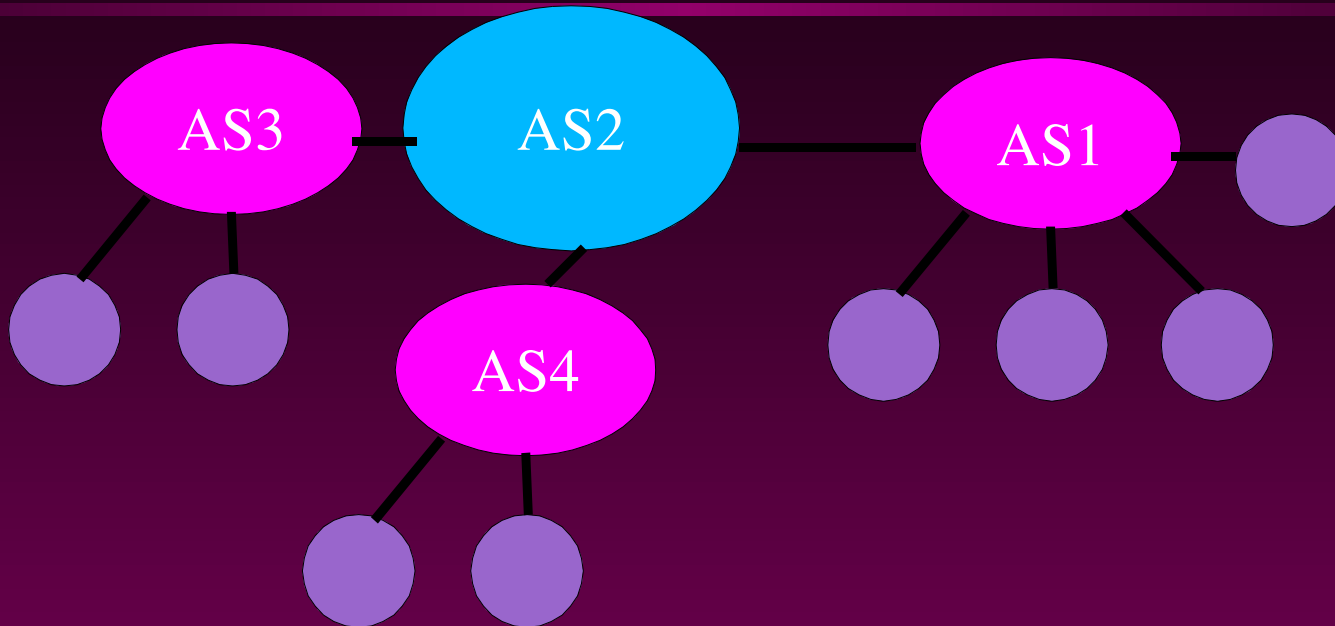


# More Customers?



```
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

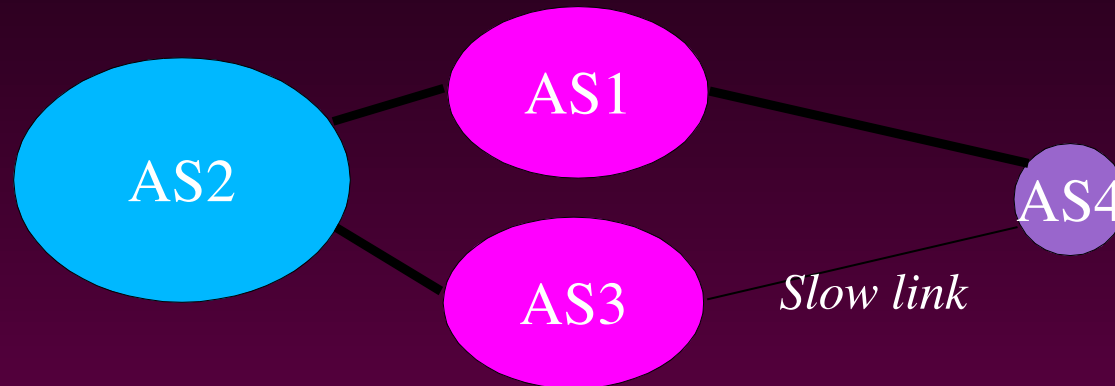


```
as-set: AS2:AS-Customers  
members: AS1, AS3, AS4
```

```
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

---

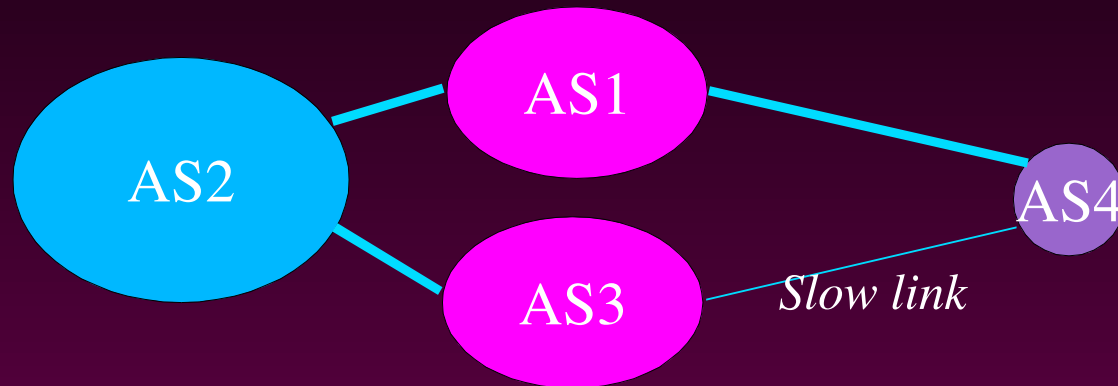
```
import: from ... action XXX; accept ...  
export: to ... action XXX; announce ...
```

```
med = 0;  
med = igp_cost;
```

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

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

# Action



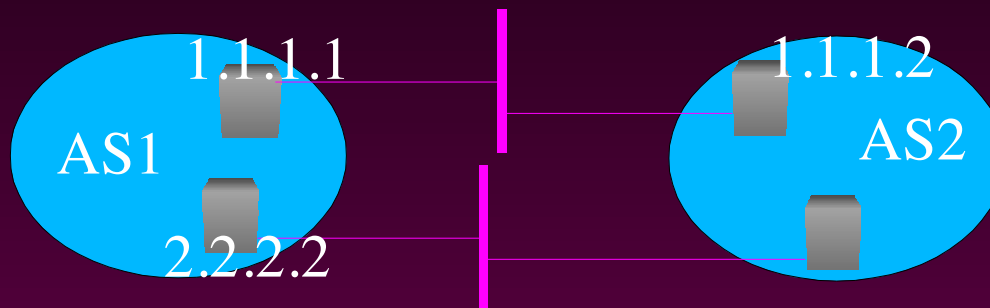
**aut-num: AS4**

**export: to AS1 announce AS4**

**export: to AS3 `action aspath.prepend(AS4);`  
announce AS4**

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

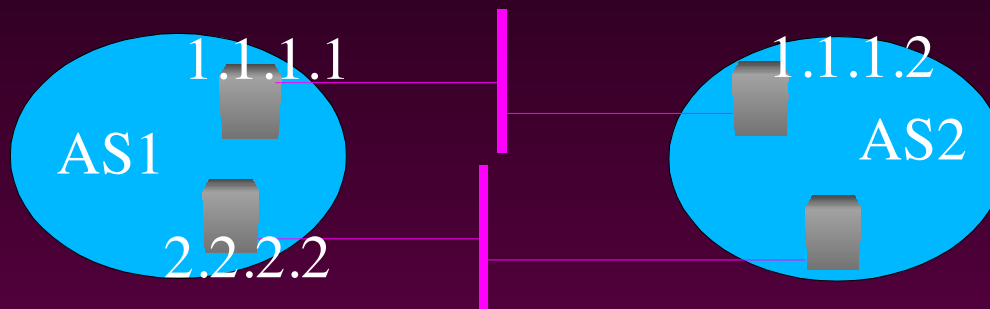
# Peering Choice



```
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}
```

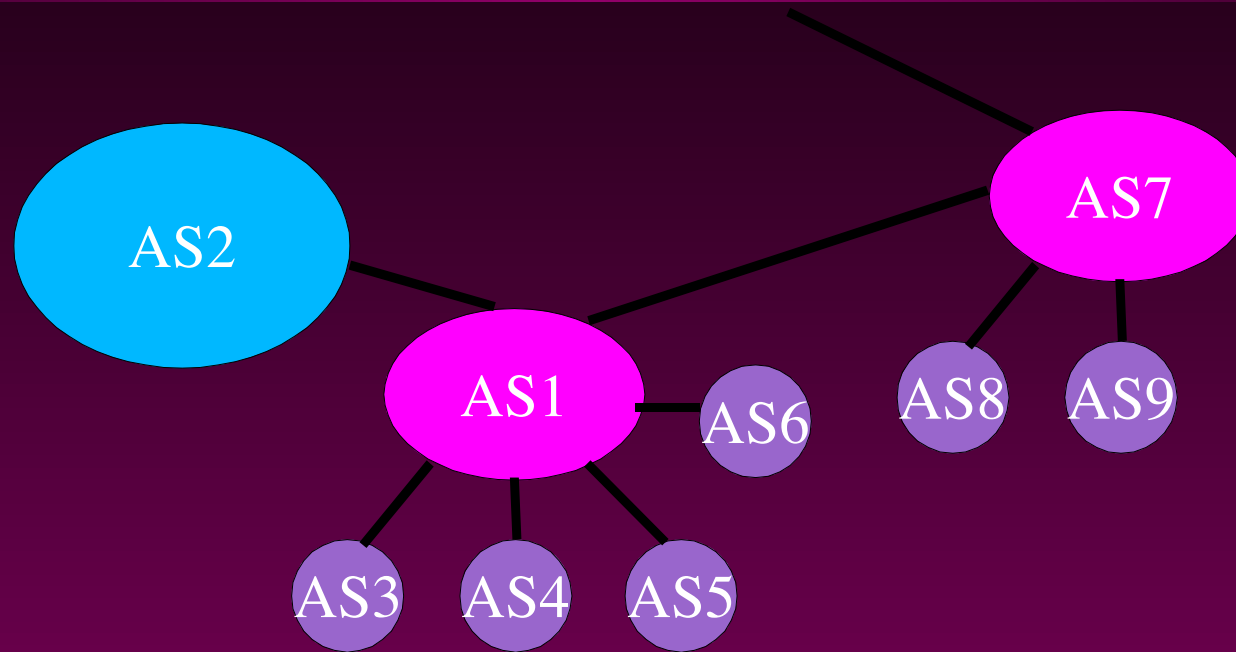
```
AS1 OR rs-red == {128.6.0.0/16, 128.8.0.0/16, 128.9.0.0/16}
```

```
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:

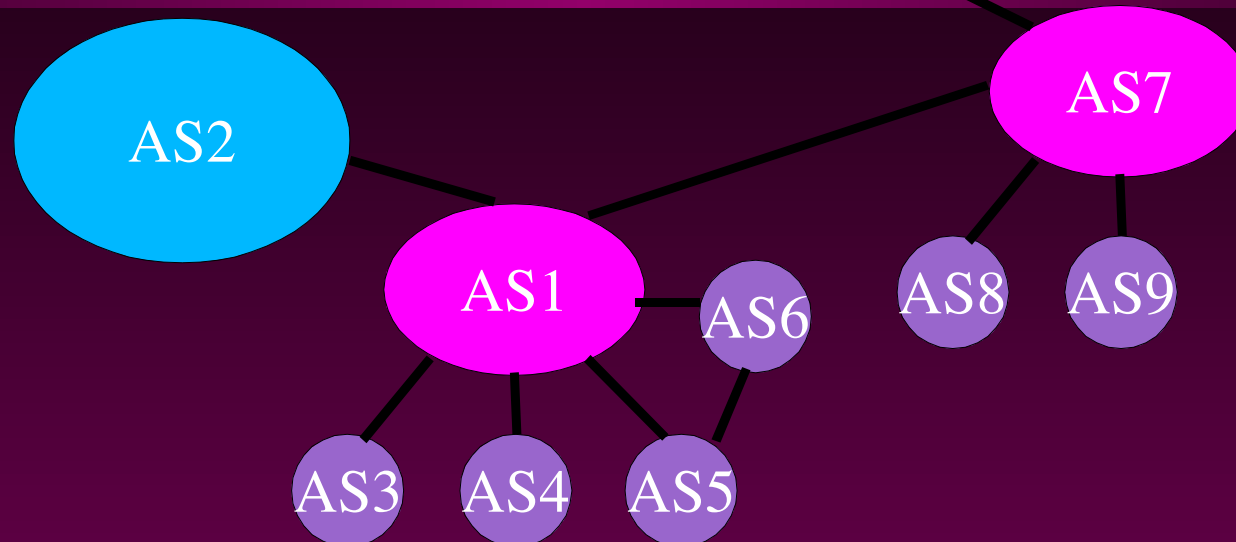
**<^AS1 .\* AS8\$>**

**No prefix filters here!**

# AS Path Regular Expressions

<b>AS1</b>	AS1 only
<b>.</b>	Any AS
<b>as-foo</b>	Any member of as-foo
<b>x*</b>	0 or more occurrence of x
<b>x+</b>	1 or more occurrence of x
<b>x?</b>	0 or 1 occurrence of x
<b>^</b>	beginning of path
<b>\$</b>	end of path
<b>x   y</b>	x or y
<b>x y</b>	x followed by y

# AS Paths into AS1's Customers



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

AS1

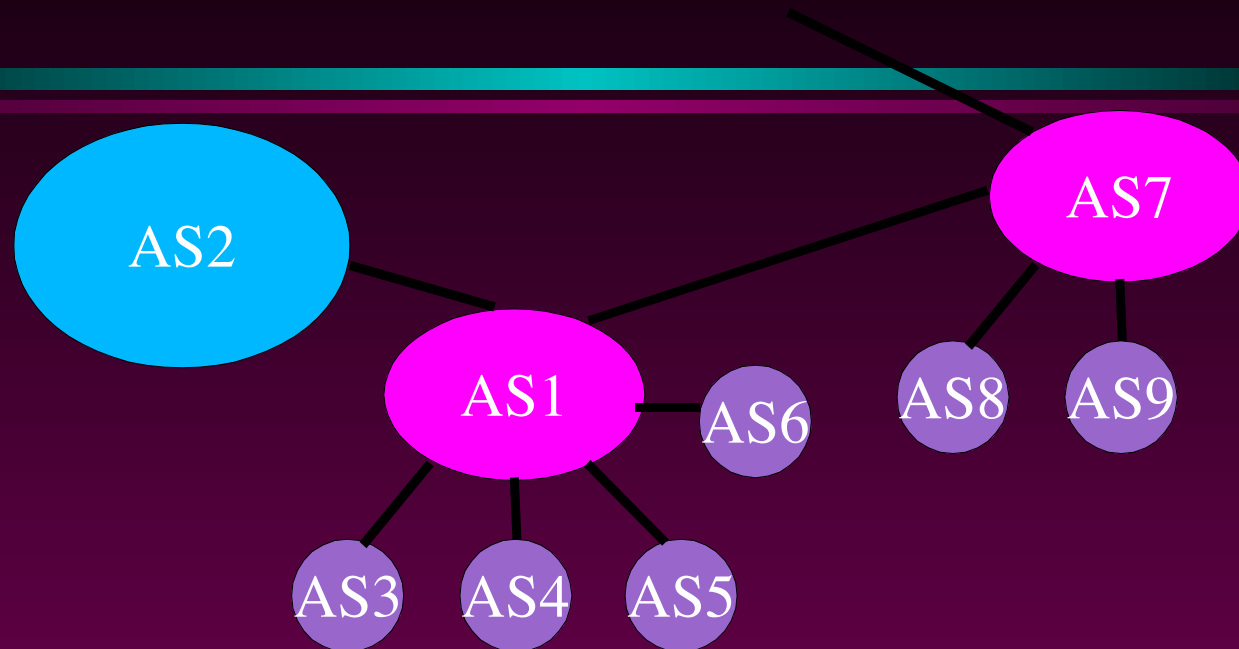
AS1 AS3

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

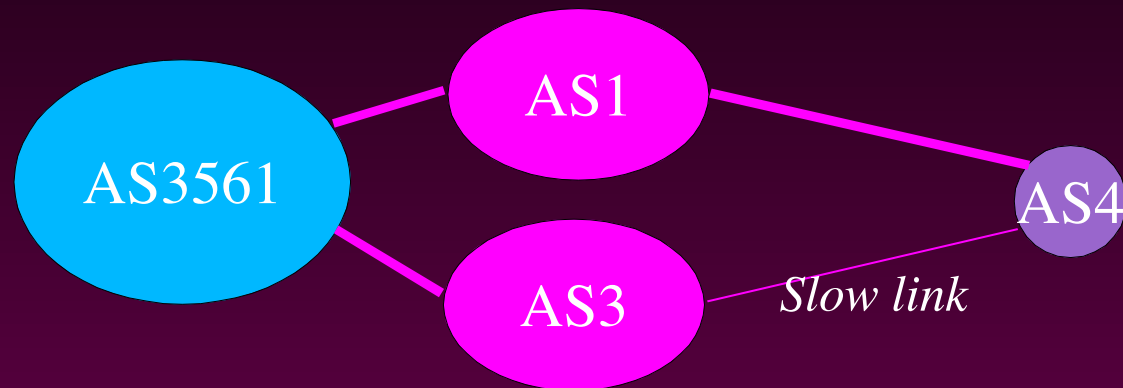
with community 3561:80

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 { 0.0.0.0/019-32 }
```

# Outline

---

**Motivation**

**Routing Policy Definitions**

**RPSL & RtConfig**

**Basic classes and notations**

**Set classes**

**import/export policy**

**Structured Policy**

**Other Features & Wrap-up**

# 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 communitiy(1:20);  
from AS-ANY action pref=10;  
    accept communitiy(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

# Outline

---

**Motivation**

**Routing Policy Definitions**

**RPSL & RtConfig**

**Basic classes and notations**

**Set classes**

**import/export policy**

**Structured Policy**

**Other Features & Wrap-up**

# 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 p1102 permit 216.246.0.0/17
```

```
ip prefix-list p1102 permit 216.246.0.0/18
```

```
ip prefix-list p1102 deny 0.0.0.0/0 le 32
```

```
route-map MyMap_6402_15 permit 1
```

```
    match ip address prefix-list p1102
```

```
    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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