

Part II

Routing Policy Specification Language (RPSL)

RPSL Features

- ➔ Language features:
 - ➔ AS and route objects, object sets, policy as relations
 - ➔ structured, vendor-neutral, extensible
 - ➔ Standardized in RPS IETF WG
- ➔ History
 - PRDB ➔ RIPE 81 ➔ RIPE 181 ➔ RPSL

Object Oriented

- Each object describes an entity in real world
- Object classes
 - route
 - autonomous system
 - route-set, as-set
 - router
 - person, role, maintainer

Object

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

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

Words

- Words can have – or _ in the middle
 - `RGNET-MAINT-MCI`
- Can have digits
 - `RGNET-MAINT-MCI_1`
- Case insensitive
 - `rgnet-MaInT-MCI`

Person Object

```
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 object
information

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

Maintenance
information

Auxiliary Information

- ➔ **descr:**
 - ➔ short free text description of the object
- ➔ **tech-c, admin-c:**
 - ➔ technical and administrative contact nic handles
- ➔ **remarks:**
 - ➔ free text comment attribute
- ➔ **notify:**
 - ➔ emails to send notification of changes
- ➔ **mnt-by:**
 - ➔ maintainer authorized to do changes
- ➔ **changed:**
 - ➔ <email> <date>
- ➔ **source:**
 - ➔ registry

Role object

```
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 Objects

```
mntner:      MAINT-RGNET
descr:      RGnet RADB maintainer
admin-c:    RB366
tech-c:    RB366
upd-to:    rw@rg.net
mnt-nfy:   randy@psg.com
auth:      PGP-FROM Randy Bush <randy@psg.com>
mnt-by:    MAINT-RGNET
changed:   randy@psg.com 19970804
source:    RADB
```

Defines access control for other objects in database!

Auth Attribute

```
➔ auth: PGP-FROM Randy Bush <randy@psg.com>  
➔ auth: CRYPT-PW lZlA7/JnfkTI  
➔ auth: MAIL-FROM cengiz@isi.edu  
➔ auth: MAIL-FROM .*@canet.ca  
➔ auth: NONE
```

Route Object

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

- ➔ Route 156.36.0.0/16
- ➔ is originated by AS2914
- ➔ is a member of set RS-VERIO

Notations

- ➔ AS numbers
 - ➔ **AS**2914
- ➔ Address prefixes
 - ➔ 156.36.**0.0**/16
- ➔ Route set names
 - ➔ **RS-VERIO**

route-set Objects

```
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
```

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
```

Reserved Routes

```
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: $\wedge+$

Exclusive: $\wedge-$

Length n: \wedge^n

Length n-m: \wedge^{n-m}

as-set Objects

```
as-set: AS-SESQUISTUB
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 objects

aut-num Objects

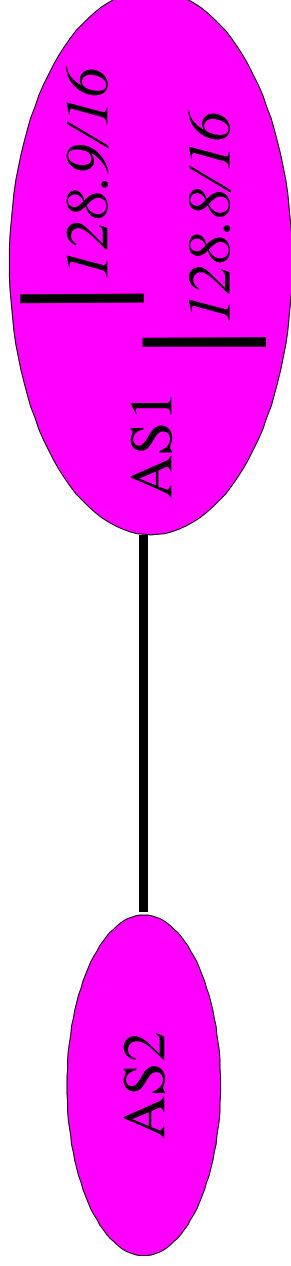
```
aut-num: AS4591
as-name: Syra-NET
import: from AS4590
        action pref=1;
        accept AS4590

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
```

export/import



aut-num: AS1

export: to AS2

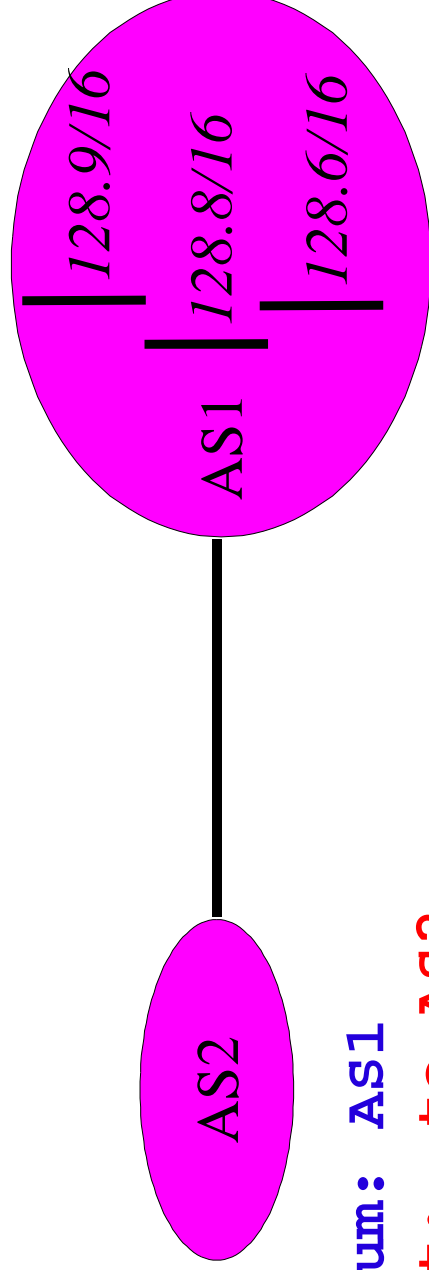
announce {128.9.0.0/16, 128.8.0.0/16}

aut-num: AS2

import: from AS1

accept {128.9.0.0/16, 128.8.0.0/16}

Cumbersome



aut-num: AS1

export: to AS2

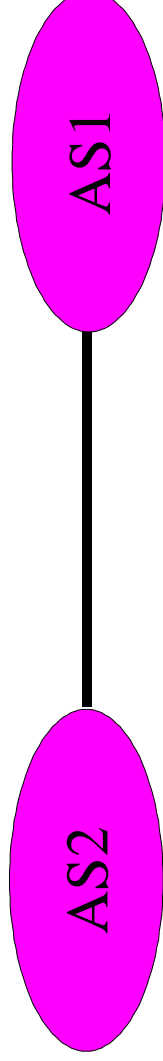
announce {128.9.0.0/16, 128.8.0.0/16,
128.6.0.0/16}

aut-num: AS2

import: from AS1

accept {128.9.0.0/16, 128.8.0.0/16,
128.6.0.0/16}

Per 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}
```

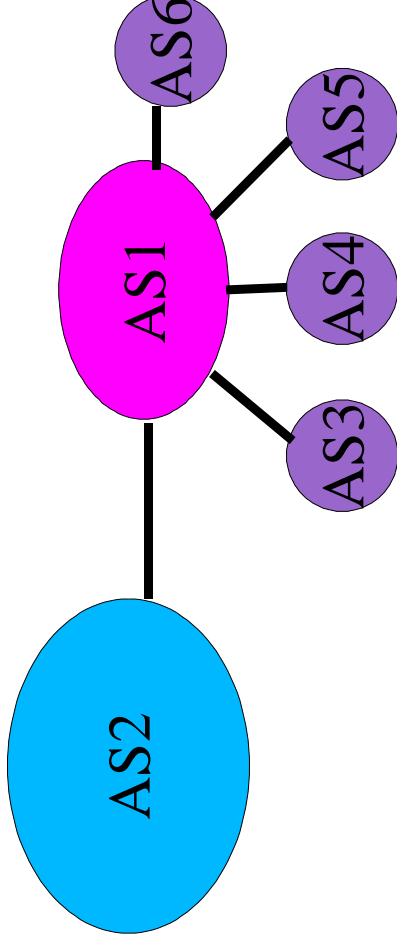
Per route-set

```
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
```

Cumbersome?



aut-num: AS1

export: to AS2

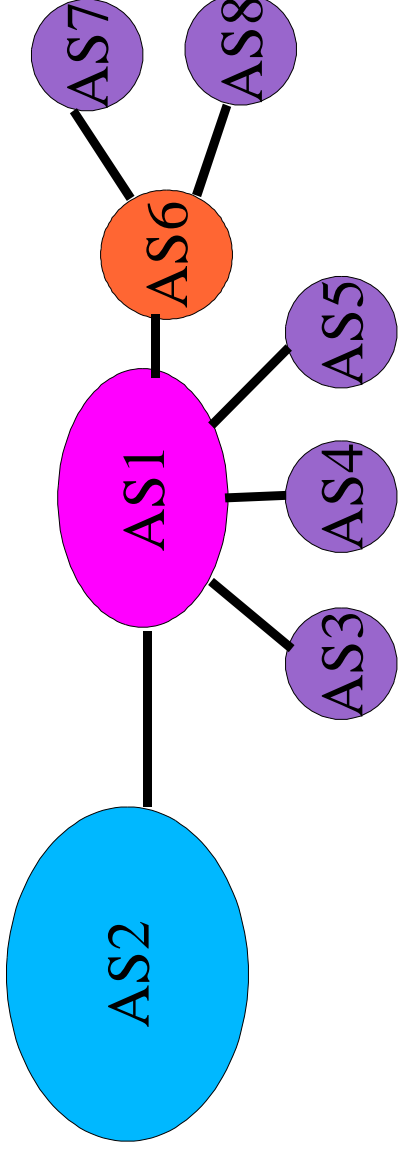
announce AS1 OR AS3 OR ... AS6

aut-num: AS2

import: from AS1

accept AS1 OR AS3 OR ... AS6

Per as-set

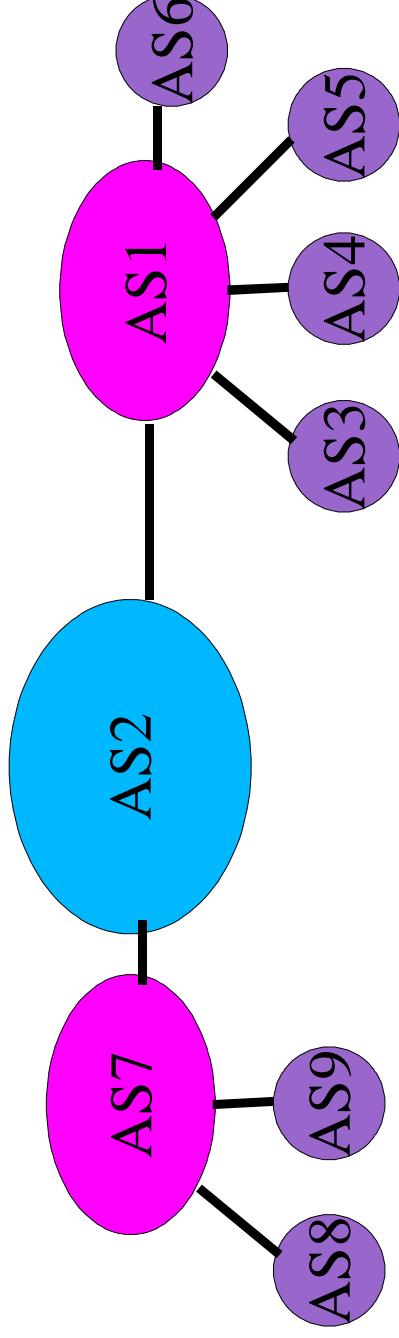


```
as-set: AS1:AS-Customers
members: AS1, AS3, AS4, AS5, AS6:AS-Customers

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

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

Cumbersome?



as-set: AS1:AS-Customers

members: AS1, AS3, AS4, AS5, AS6

as-set: AS7:AS-Customers

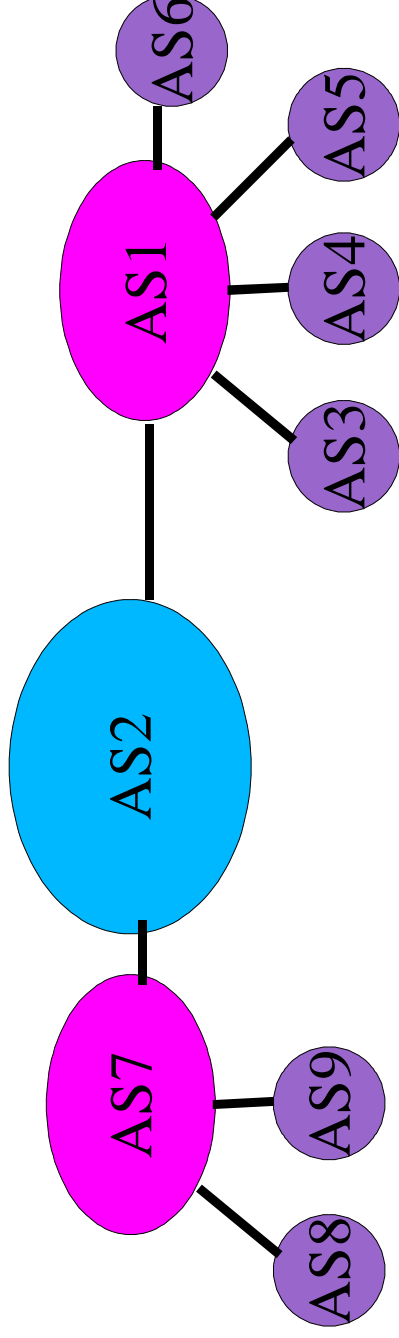
members: AS7, AS8, AS9

aut-num: AS2

import: from AS1 accept AS1:AS-Customers

import: from AS7 accept AS7:AS-Customers

Cumbersome?



as-set: AS2:AS-Customers

members: AS1, AS7

aut-num: AS2

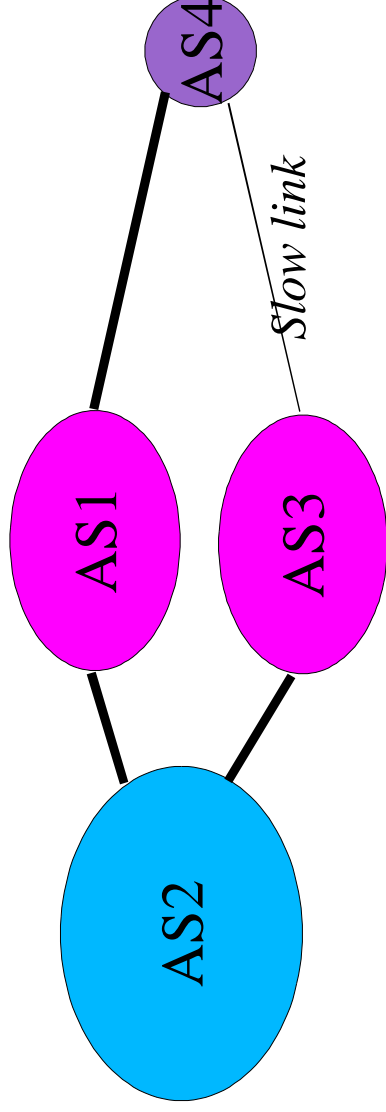
import: from AS2:AS-Customers
accept PeerAS:AS-Customers

Same as:

from AS1 accept AS1:AS-Customers

from AS7 accept AS7:AS-Customers

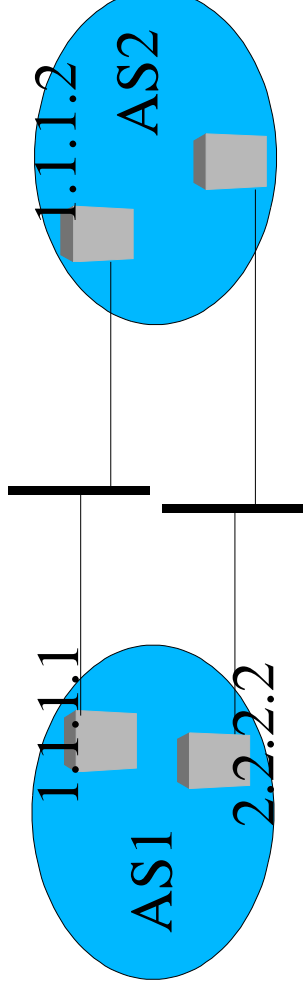
Choice



```
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!

Router 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 AND NOT rs-red

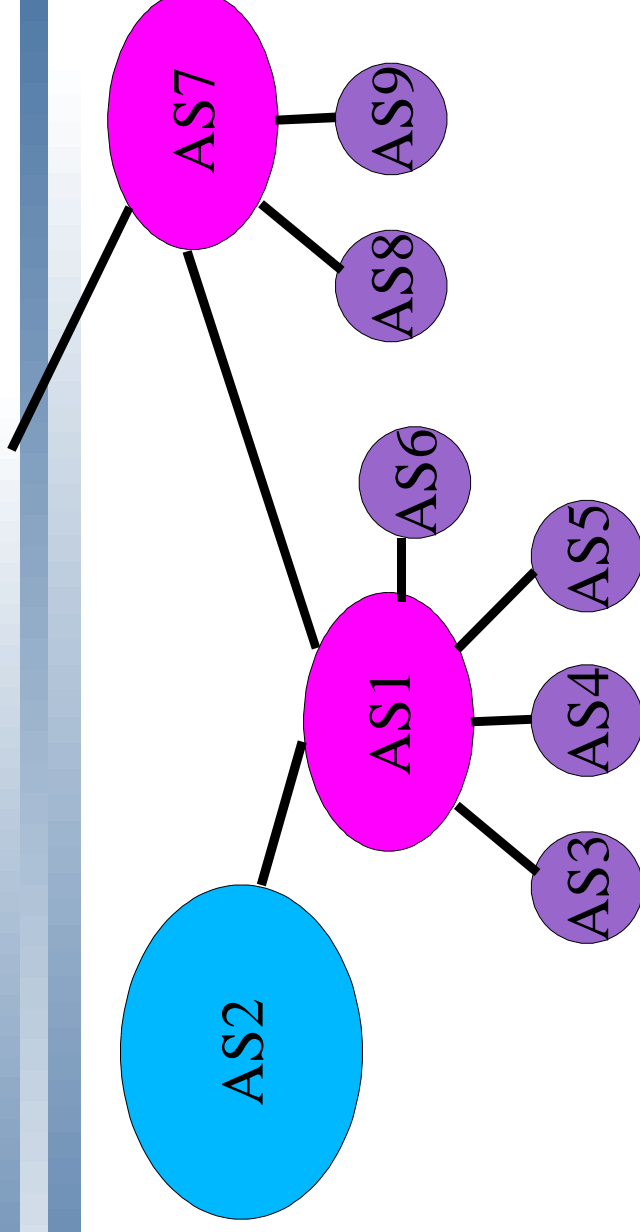
AS1      == {128.9.0.0/16, 128.9.0.0/16}
rs-red   == {128.6.0.0/16, 128.9.0.0/16}

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

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

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

What about AS Paths?



import: from AS1 accept <^AS1 .*>

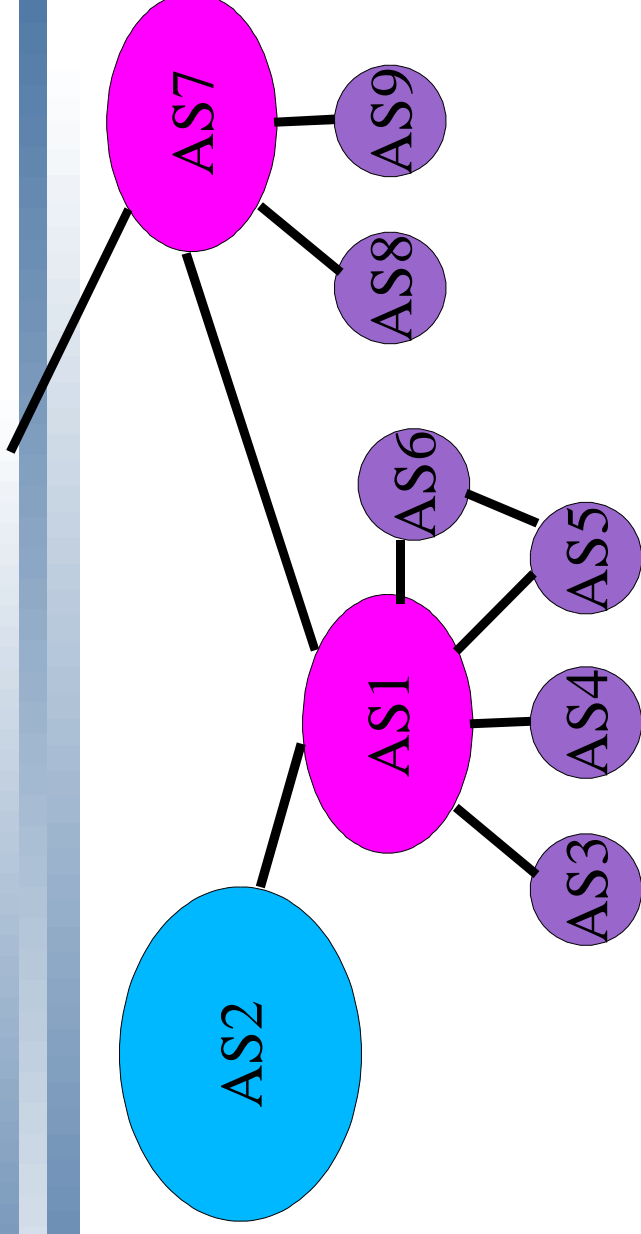
import: from AS1 accept <^AS1 AS1:AS-Customers* \$>

No prefixes here!

AS Path Regular Expressions

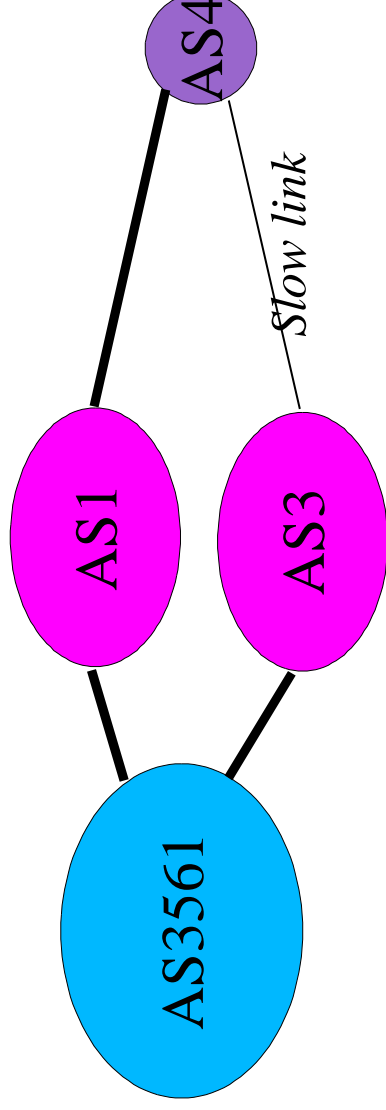
AS1	Matches AS1
as-foo	Matches any AS in as-foo
X*	Matches 0 or more occurrence of X
X+	Matches 1 or more occurrence of X
X?	Matches 0 or 1 occurrence of X
^	Matches beginning of path
\$	Matches end of path
X Y	Matches X or Y
X Y	Matches S followed by Y

What about AS Paths?



- ➔ $\langle \wedge AS1 * AS1 : AS - Customers * \$ \rangle$ matches
- ➔ AS1
- ➔ AS1 AS3
- ➔ AS1 AS4
- ➔ AS1 AS5 AS6
- ➔ AS1 AS1 AS5 AS5 AS6

BGP communities



- ➔ 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

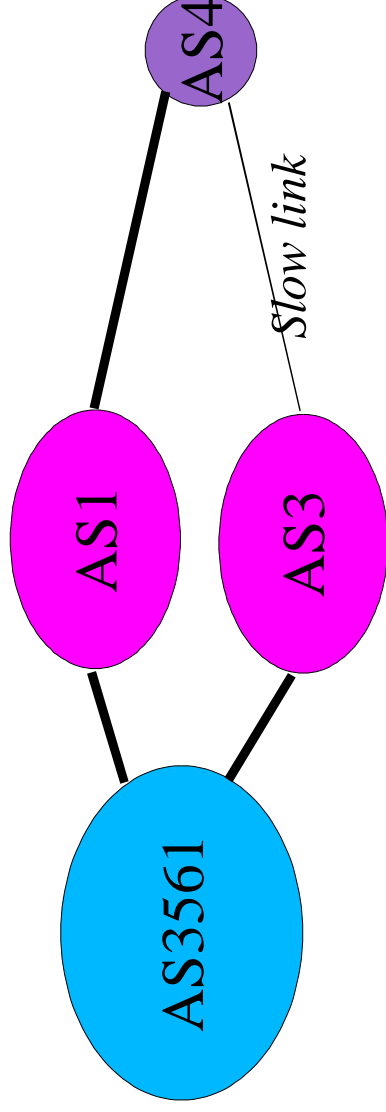
```
aut-num: AS3561
import: from AS-ANY
       action pref = 30;
       accept community({3561,70})

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
```

Actions

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

med = 0;
med = igp;

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

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

Part II

Advanced Features

Extensible thru dictionary

```
dictionary: RPSL
rp--attribute: pref # preference, smaller values represent higher preferences
                operator=(integer[0, 65535])
rp--attribute: med # BGP multi_exit_discriminator attribute
                operator=(integer[0, 65535])
                operator=(enum[igp_cost])
typedef: community_elm union
        integer[1, 4294967200],
        enum[internet, no_export, no_advertise],
        list[2:2] of integer[0, 65535]
rp--attribute: community # BGP community attribute
                operator.=(community_elm) # append community
```

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;
```

Specifying Routers

```
inet-rtr:          c56-11.t3.ans.net  
local-as:       AS1664  
ifaddr:        140.222.56.200 masklen 26  
ifaddr:        140.222.56.65  masklen 26  
ifaddr:        204.151.29.9   masklen 30  
peer:          BGP4 140.222.56.199 asno(AS1673)  
peer:          BGP4 140.222.56.66  asno(AS1673)  
admin-c:       Steve Heimlich  
tech-c:       Selina Priestley  
mnt-by:       ANS  
changed:      configs@ans.net 19970320  
source:       ANS
```

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;
          from AS2 accept AS2;
          from AS3 accept ...;
        }
```

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

RPSL

- RPSL
- compact representation of policy
- accurate representation of policy