BGP Best Practices

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UKNOF 8
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Goodenough College, London
Deploying BGP

- The role of IGPs and iBGP
- Aggregation
- Receiving Prefixes
- Configuration Tips
The role of IGP and iBGP

Ships in the night?
Or
Good foundations?
BGP versus OSPF/ISIS

- Internal Routing Protocols (IGPs)
  
  Examples are ISIS and OSPF

  Used for carrying *infrastructure* addresses

  **NOT** used for carrying Internet prefixes or customer prefixes

  ISP design goal is to *minimise* number of prefixes in IGP to aid scalability and rapid convergence
BGP versus OSPF/ISIS

- BGP used internally (iBGP) and externally (eBGP)
- iBGP used to carry
  - some/all Internet prefixes across backbone
  - customer prefixes
- eBGP used to
  - exchange prefixes with other ASes
  - implement routing policy
- eBGP is NOT the same as iBGP
BGP/IGP model used in ISP networks

- Model representation
BGP versus OSPF/ISIS

- **DO NOT:**
  - distribute BGP prefixes into an IGP
  - distribute IGP routes into BGP
  - use an IGP to carry customer prefixes

- **YOUR NETWORK WILL NOT SCALE**
Injecting prefixes into iBGP

- Use iBGP to carry customer prefixes
  Don’t ever use IGP
- Point static route to customer interface
- Enter network into BGP process
  Ensure that implementation options are used so that the prefix always remains in iBGP, regardless of state of interface
  i.e. avoid iBGP flaps caused by interface flaps
Aggregation

Quality or Quantity?
Aggregation

- Aggregation means announcing the address block received from the RIR to the other ASes connected to your network.

- Subprefixes of this aggregate may be:
  - Used internally in the ISP network
  - Announced to other ASes to aid with multihoming

- Unfortunately too many people are still thinking about class Cs, resulting in a proliferation of /24s in the Internet routing table.
Aggregation

- Address block should be announced to the Internet as an aggregate
- Subprefixes of address block should **NOT** be announced to the Internet unless traffic engineering when multihoming
- Aggregate should be generated internally
  Not on the network borders!
Announcing an Aggregate

- ISPs who don’t and won’t aggregate are held in poor regard by community

- Registries publish their minimum allocation size
  - Anything from a /20 to a /22 depending on RIR
  - Different sizes for different address blocks

- No real reason to see anything longer than a /22 prefix in the Internet
  - BUT there are currently >120000 /24s!
Aggregation – Example

- Customer has /23 network assigned from AS100’s /19 address block
- AS100 announces customers’ individual networks to the Internet
Aggregation – Bad Example

- Customer link goes down
  Their /23 network becomes unreachable
  /23 is withdrawn from AS100’s iBGP
- Their ISP doesn’t aggregate its /19 network block
  /23 network withdrawal announced to peers
  starts rippling through the Internet
  added load on all Internet backbone routers as network is removed from routing table

Customer link returns
Their /23 network is now visible to their ISP
Their /23 network is re-advertised to peers
Starts rippling through Internet
Load on Internet backbone routers as network is reinserted into routing table
Some ISP’s suppress the flaps
Internet may take 10-20 min or longer to be visible
Where is the Quality of Service???
Aggregation – Example

- Customer has /23 network assigned from AS100’s /19 address block
- AS100 announced /19 aggregate to the Internet
Aggregation – Good Example

- Customer link goes down
  their /23 network becomes unreachable
  /23 is withdrawn from AS100’s iBGP
- /19 aggregate is still being announced
  no BGP hold down problems
  no BGP propagation delays
  no damping by other ISPs

Customer link returns

- Their /23 network is visible again
  The /23 is re-injected into AS100’s iBGP
- The whole Internet becomes visible immediately
- Customer has Quality of Service perception
Aggregation – Summary

- Good example is what everyone should do!
  - Adds to Internet stability
  - Reduces size of routing table
  - Reduces routing churn
  - Improves Internet QoS for everyone

- Bad example is what too many still do!
  - Why? Lack of knowledge?
  - Laziness?
The Internet Today (September 2007)

- Current Internet Routing Table Statistics

  - BGP Routing Table Entries: 230291
  - Prefixes after maximum aggregation: 120032
  - Unique prefixes in Internet: 111045
  - Prefixes smaller than registry alloc: 122198
  - /24s announced: 121356
    - only 5708 /24s are from 192.0.0.0/8
  - ASes in use: 26164
BGP Report (bgp.potaroo.net)

- 199336 total announcements in October 2006
- 129795 prefixes
  After aggregating including full AS PATH info
  i.e. including each ASN’s traffic engineering
  35% saving possible
- 109034 prefixes
  After aggregating by Origin AS
  i.e. ignoring each ASN’s traffic engineering
  10% saving possible
Efforts to Improve Aggregation

- The CIDR Report
  Initiated and operated for many years by Tony Bates
  Now combined with Geoff Huston’s routing analysis
  www.cidr-report.org
  Results e-mailed on a weekly basis to most operations lists around the world
  Lists the top 30 service providers who could do better at aggregating

- RIPE Routing WG aggregation recommendation
  RIPE-399 — http://www.ripe.net/ripe/docs/ripe-399.html
Efforts to Improve Aggregation
The CIDR Report

- Also computes the size of the routing table assuming ISPs performed optimal aggregation

- Website allows searches and computations of aggregation to be made on a per AS basis
  Flexible and powerful tool to aid ISPs
  Intended to show how greater efficiency in terms of BGP table size can be obtained without loss of routing and policy information
  Shows what forms of origin AS aggregation could be performed and the potential benefit of such actions to the total table size
  Very effectively challenges the traffic engineering excuse
Status Summary

Table History

<table>
<thead>
<tr>
<th>Date</th>
<th>Prefixes</th>
<th>CIDR Aggregated</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-05-07</td>
<td>218365</td>
<td>1.00025</td>
</tr>
<tr>
<td>22-05-07</td>
<td>218650</td>
<td>1.99831</td>
</tr>
<tr>
<td>23-05-07</td>
<td>218653</td>
<td>1.99850</td>
</tr>
<tr>
<td>24-05-07</td>
<td>218776</td>
<td>1.99698</td>
</tr>
<tr>
<td>25-05-07</td>
<td>219469</td>
<td>1.99898</td>
</tr>
<tr>
<td>26-05-07</td>
<td>219203</td>
<td>1.99943</td>
</tr>
<tr>
<td>27-05-07</td>
<td>219232</td>
<td>1.99870</td>
</tr>
<tr>
<td>28-05-07</td>
<td>219115</td>
<td>1.00020</td>
</tr>
</tbody>
</table>

Plot: BGP Table Size

AS Summary

- 25190: Number of ASes in routing system
- 10666: Number of ASes announcing only one prefix
- 1403: Largest number of prefixes announced by an AS
  - AS7018: ATT-INTERNET4 - AT&T WorldNet Services
- 89989048: Largest address span announced by an AS (/32s)
  - AS721: DISA-ASNBLK - DoD Network Information Center

Plot: AS count
Plot: Average announcements per origin AS
Report: ASes ordered by originating address span
Report: ASes ordered by transit address span
Report: Autonomous System number-to-name mapping (from Registry WHOIS data)
## Announced Prefixes

<table>
<thead>
<tr>
<th>Rank</th>
<th>AS</th>
<th>Type</th>
<th>Origin Addr</th>
<th>Space (pfx)</th>
<th>Transit Addr</th>
<th>Space (pfx)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>AS4134</td>
<td>ORG-TRN</td>
<td>Origin: 56.676.672</td>
<td>/4.25</td>
<td>Transit: 30243328</td>
<td>/7.15</td>
<td>CHINANET-BACKBONE No.31, Jin-rong Street</td>
</tr>
</tbody>
</table>

### Aggregation Suggestions

This report does not take into account conditions local to each origin AS in terms of policy or traffic engineering requirements, so this is an approximate guideline as to aggregation possibilities.

<table>
<thead>
<tr>
<th>Rank</th>
<th>AS</th>
<th>AS Name</th>
<th>Current</th>
<th>Withd</th>
<th>Aggte</th>
<th>Annce</th>
<th>Redctn</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>AS4134</td>
<td>CHINANET-BACKBONE No.31, Jin-rong Street</td>
<td>1257</td>
<td>1005</td>
<td>64</td>
<td>316</td>
<td>941</td>
<td>74.86</td>
</tr>
</tbody>
</table>

### AS 4134: CHINANET-BACKBONE No.31, Jin-rong Street

<table>
<thead>
<tr>
<th>Prefix</th>
<th>(AS Path)</th>
<th>Aggregation Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>58.42.0.0/16</td>
<td>4608 1221 4637 4134</td>
<td>+ Announce - aggregate of 58.42.0.0/16 (4608 1221 4637 4134) and 58.43.0.0/16 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.42.128.0/17</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.42.128.0/17 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.43.0.0/16</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.42.0.0/16 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.44.0.0/14</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.44.0.0/14 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.48.0.0/13</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.48.0.0/13 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.46.0.0/14</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.46.0.0/14 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.52.0.0/14</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.52.0.0/14 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.56.0.0/15</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.56.0.0/15 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.58.0.0/15</td>
<td>4608 1221 4637 4134</td>
<td>+ Announce - aggregate of 58.56.0.0/16 (4608 1221 4637 4134) and 58.58.0.0/16 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.58.128.0/17</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.58.128.0/17 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.59.0.0/17</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.59.0.0/17 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.59.128.0/17</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.59.128.0/17 (4608 1221 4637 4134)</td>
</tr>
<tr>
<td>58.59.128.0/19</td>
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<td>- Withdrawn - aggregated with 58.59.128.0/19 (4608 1221 4637 4134)</td>
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<tr>
<td>58.59.192.0/19</td>
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<td>58.59.224.0/19</td>
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<tr>
<td>58.62.0.0/15</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.62.0.0/15 (4608 1221 4637 4134)</td>
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<tr>
<td>58.64.0.0/17</td>
<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.64.0.0/17 (4608 1221 4637 4134)</td>
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<td>58.66.0.0/17</td>
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<td>- Withdrawn - aggregated with 58.66.0.0/17 (4608 1221 4637 4134)</td>
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<td>4608 1221 4637 4134</td>
<td>- Withdrawn - aggregated with 58.82.192.0/19 (4608 1221 4637 4134)</td>
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### Announced Prefixes

<table>
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<th>Rank</th>
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<th>Type</th>
<th>Originate Addr</th>
<th>Space (pfx)</th>
<th>Transit Addr</th>
<th>space (pfx)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>144</td>
<td>AS18566</td>
<td>ORIGIN</td>
<td>2256160 /10.89</td>
<td></td>
<td>0 /6.00</td>
<td></td>
<td>COVAD - Covad Communications Co.</td>
</tr>
</tbody>
</table>

### Aggregation Suggestions

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<th>Annce</th>
<th>Redctn</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>AS18566</td>
<td>COVAD - Covad Communications Co.</td>
<td>1010</td>
<td>979</td>
<td>0</td>
<td>31</td>
<td>979</td>
<td>96.93%</td>
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</tbody>
</table>

**AS18566: COVAD - Covad Communications Co.**

<table>
<thead>
<tr>
<th>Prefix</th>
<th>(AS Path)</th>
<th>Aggregation Action</th>
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</thead>
<tbody>
<tr>
<td>64.105.0.0/16</td>
<td>4608 1221 4637 3356 18566</td>
<td>Withdrawn - matching aggregate 64.105.0.0/16 4608 1221 4637 3356 18566</td>
</tr>
<tr>
<td>64.105.0.0/23</td>
<td>4608 1221 4637 3356 18566</td>
<td>Withdrawn - matching aggregate 64.105.0.0/16 4608 1221 4637 3356 18566</td>
</tr>
<tr>
<td>64.105.4.0/23</td>
<td>4608 1221 4637 3356 18566</td>
<td>Withdrawn - matching aggregate 64.105.0.0/16 4608 1221 4637 3356 18566</td>
</tr>
<tr>
<td>64.105.6.0/23</td>
<td>4608 1221 4637 3356 18566</td>
<td>Withdrawn - matching aggregate 64.105.0.0/16 4608 1221 4637 3356 18566</td>
</tr>
<tr>
<td>64.105.8.0/23</td>
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<td>Withdrawn - matching aggregate 64.105.0.0/16 4608 1221 4637 3356 18566</td>
</tr>
<tr>
<td>64.105.10.0/23</td>
<td>4608 1221 4637 3356 18566</td>
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</tr>
<tr>
<td>64.105.12.0/23</td>
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<td>Withdrawn - matching aggregate 64.105.0.0/16 4608 1221 4637 3356 18566</td>
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<tr>
<td>64.105.14.0/23</td>
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<tr>
<td>64.105.16.0/23</td>
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<td>Withdrawn - matching aggregate 64.105.0.0/16 4608 1221 4637 3356 18566</td>
</tr>
<tr>
<td>64.105.18.0/23</td>
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<tr>
<td>64.105.20.0/23</td>
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<tr>
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<td>Withdrawn - matching aggregate 64.105.0.0/16 4608 1221 4637 3356 18566</td>
</tr>
</tbody>
</table>
Receiving Prefixes
Receiving Prefixes

- There are three scenarios for receiving prefixes from other ASNs
  - Customer talking BGP
  - Peer talking BGP
  - Upstream/Transit talking BGP

- Each has different filtering requirements and need to be considered separately
Receiving Prefixes: From Customers

- ISPs should only accept prefixes which have been assigned or allocated to their downstream customer.

- If ISP has assigned address space to its customer, then the customer IS entitled to announce it back to his ISP.

- If the ISP has NOT assigned address space to its customer, then:
  
  Check the five RIR databases to see if this address space really has been assigned to the customer.

  The tool: **whois** - look the address up!!
Receiving Prefixes: From Peers

- A peer is an ISP with whom you agree to exchange prefixes you originate into the Internet routing table.
  - Prefixes you accept from a peer are only those they have indicated they will announce.
  - Prefixes you announce to your peer are only those you have indicated you will announce.
Receiving Prefixes: From Peers

- Agreeing what each will announce to the other:
  - Exchange of e-mail documentation as part of the peering agreement, and then ongoing updates
  - OR
  - Use of the Internet Routing Registry and configuration tools such as the IRRToolSet
    - www.isc.org/sw/IRRToolSet/
Receiving Prefixes: From Upstream/Transit Provider

- Upstream/Transit Provider is an ISP who you pay to give you transit to the WHOLE Internet
- Receiving prefixes from them is not desirable unless really necessary

  **Traffic engineering when multihoming**

- Ask upstream/transit provider to either:
  - originate a default-route
    - OR
  - announce one prefix you can use as default
Receiving Prefixes: From Upstream/Transit Provider

- If necessary to receive prefixes from any provider, care is required
  - don’t accept RFC1918 etc prefixes
  - don’t accept your own prefixes
  - don’t accept default (unless you need it)
  - don’t accept prefixes longer than /24

- Check Project Cymru’s list of “bogons”
Receiving Prefixes

- Paying attention to prefixes received from customers, peers and transit providers assists with:
  - The integrity of the local network
  - The integrity of the Internet
- Responsibility of all ISPs to be good Internet citizens
Configuration Tips

Of passwords, tricks and templates
iBGP and IGPs
Reminder!

- Make sure loopback is configured on router
  iBGP between loopbacks, NOT real interfaces
- Make sure IGP carries loopback /32 address
- Consider the DMZ nets:
  Use unnumbered interfaces?
  Use next-hop-self on iBGP neighbours
  Or carry the DMZ /30s in the iBGP
  Basically keep the DMZ nets out of the IGP!
iBGP: Next-hop-self

- BGP speaker announces external network to iBGP peers using router’s local address (loopback) as next-hop

- Used by many ISPs on edge routers
  - Preferable to carrying DMZ /30 addresses in the IGP
  - Reduces size of IGP to just core infrastructure
  - Alternative to using unnumbered interfaces
  - Helps scale network
  - Many ISPs consider this “best practice”
Limiting AS Path Length

- Some BGP implementations have problems with long AS_PATHS
  - Memory corruption
  - Memory fragmentation

- Even using AS_PATH prepends, it is not normal to see more than 20 ASes in a typical AS_PATH in the Internet today
  - The Internet is around 5 ASes deep on average
  - Largest AS_PATH is usually 16-20 ASNs
Limiting AS Path Length

- Some announcements have ridiculous lengths of AS-paths:

  ```
  *> 3FFE:1600::/24  22 11537 145 12199 10318
  10566 13193 1930 2200 3425 293 5609 5430 13285 6939
  14277 1849 33 15589 25336 6830 8002 2042 7610  i
  ```

  This example is an error in one IPv6 implementation.

  ```
  *> 194.146.180.0/22  2497 3257 29686 16327 16327
  16327 16327 16327 16327 16327 16327 16327 16327
  16327 16327 16327 16327 16327 16327 16327 16327
  16327 16327 16327 16327 16327 i
  ```

  This example shows 20 prepends (for no obvious reason).

- If your implementation supports it, consider limiting the maximum AS-path length you will accept.
BGP TTL “hack”

- Implement RFC3682 on BGP peerings
  - Neighbour sets TTL to 255
  - Local router expects TTL of incoming BGP packets to be 254
  - No one apart from directly attached devices can send BGP packets which arrive with TTL of 254, so any possible attack by a remote miscreant is dropped due to TTL mismatch
BGP TTL “hack”

- TTL Hack:
  Both neighbours must agree to use the feature
  TTL check is much easier to perform than MD5
  (Called BTSH – BGP TTL Security Hack)

- Provides “security” for BGP sessions
  In addition to packet filters of course
  MD5 should still be used for messages which slip through the TTL hack
  See [www.nanog.org/mtg-0302/hack.html](http://www.nanog.org/mtg-0302/hack.html) for more details
Templates

- Good practice to configure templates for everything
  - Vendor defaults tend not to be optimal or even very useful for ISPs
  - ISPs create their own defaults by using configuration templates

- eBGP and iBGP examples follow
  - Also see Project Cymru’s BGP templates
    - www.cymru.com/Documents
iBGP Template Example

- iBGP between loopbacks!
- Next-hop-self
  - Keep DMZ and external point-to-point out of IGP
- Always send communities in iBGP
  - Otherwise accidents will happen
- Hardwire BGP to version 4
  - Yes, this is being paranoid!
iBGP Template
Example continued

- Use passwords on iBGP session
  
  Not being paranoid, \textit{VERY} necessary
  
  It’s a secret shared between you and your peer
  
  If arriving packets don’t have the correct MD5 hash, they are ignored
  
  Helps defeat miscreants who wish to attack BGP sessions

- Powerful preventative tool, especially when combined with filters and the TTL “hack”
eBGP Template Example

- BGP damping
  Do **NOT** use it unless you understand the impact
  Do **NOT** use the vendor defaults without thinking

- Remove private ASes from announcements
  Common omission today

- Use extensive filters, with “backup”
  Use as-path filters to backup prefix filters
  Keep policy language for implementing policy, rather than basic filtering

- Use password agreed between you and peer on eBGP session
eBGP Template
Example continued

- Use maximum-prefix tracking
  Router will warn you if there are sudden increases in BGP table size, bringing down eBGP if desired

- Limit maximum as-path length inbound

- Log changes of neighbour state
  …and monitor those logs!

- Make BGP admin distance higher than that of any IGP
  Otherwise prefixes heard from outside your network could override your IGP!!
Summary

- Use configuration templates
- Standardise the configuration
- Be aware of standard “tricks” to avoid compromise of the BGP session
- Anything to make your life easier, network less prone to errors, network more likely to scale
- It’s all about scaling – if your network won’t scale, then it won’t be successful