Interconnecting Securely

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Agenda

- The Internet Infrastructure & Routing Economics
- BGP & Its Security Risks
- Mitigation & Detection
- Working towards Secure Interconnections

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The Internet Infrastructure & Routing Economics

The Internet Infrastructure & its Routing Economics

- The Internet is a network of networks.
  - A network, or Autonomous System (AS), typically exchanges routing information with another AS through the Border Gateway Protocol (BGP)
- Economics of network for inter-domain routing.
  - Transit (provider-customer) & Peering - the usual types of relationship between two ASes
  - Policy based routing protocol → BGP
  - BGP decides how data is routed between ASes in alignment with the policy interests of two ASes and intermediary ASes
- BGP's role is critical in the global Internet infrastructure
  - But.. it's relying on trust-based configurations between ASes
  - This at times presents security risks in routing within the Internet

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BGP and its Security Risks

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- The common threats:
  - Route leaks
    - Propagation of routing announcements beyond their intended scope (RFC7908)
  - BGP origin hijackings
    - An attack when a malicious or misconfigured AS falsely claims ownership of IP prefixes that it does not own
  - Misconfigurations / malicious peering
    - Incorrect route filtering, missing BGP prefix limits, not honouring or incorrectly tagged BGP communities
    - MitM via peering, reserved prefix announcements
  - Lack of origin / route validation

BGP and its Security Risks

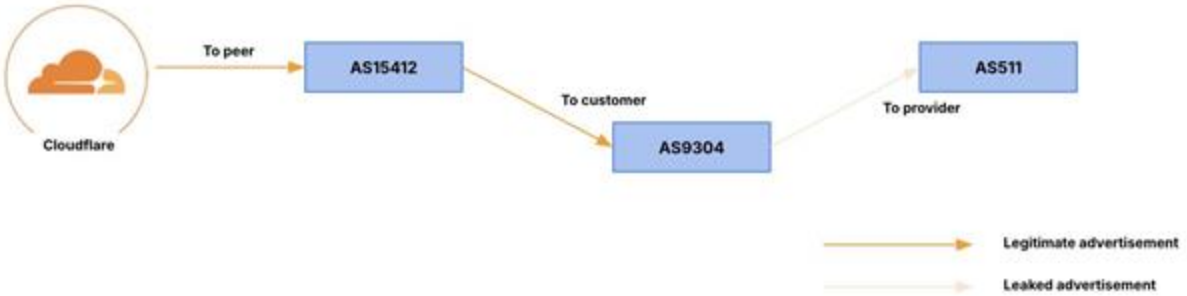
- The impact:
  - Traffic interception, blackholing, suboptimal routing, congestion, etc
  - Causing network outages & service interruptions

- It is critical for all networks to play their part, as routing security matters for both routes received and routes announced
  - Routing security is important in two directions..

BGP and its Security Risks - Events Observed within Cloudflare (#1)

- Example of a recent occurrence
  - Route leak due to BGP AS Path error

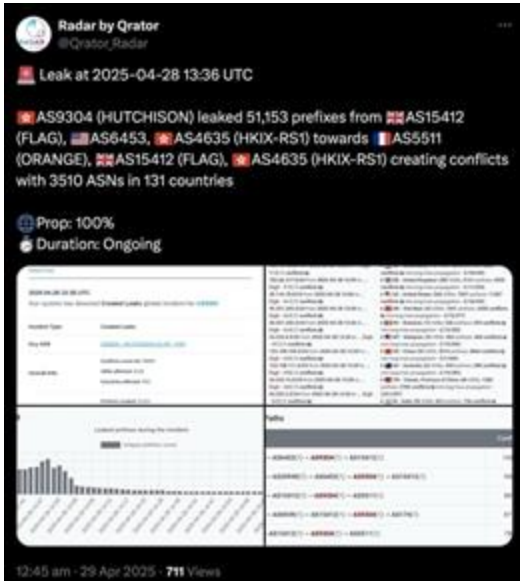
Example path "5746 5511 *9304* 15412 13335" for a Cloudflare originated prefix



BGP and its Security Risks - Events Observed within Cloudflare (#1)

- Example of a recent occurrence
  - Route leak - detected by Cloudflare Radar and other tools
    - Detection on Cloudflare Radar

    - Detection on Qrator Radar



Sources:
https://radar.cloudflare.com/routing/anomalies/leak-307159
https://x.com/Qrator_Radar/status/1916896514292773128

BGP and its Security Risks - Events Observed within Cloudflare (#2)

- An event causing major impact to Cloudflare (1.1.1.1 incident June 2024)
  - Cloudflare's public DNS resolver 1.1.1.1 was unreachable or reachable with high latency to some users globally, due to a combination of BGP hijacking and a route leak

    - BGP Hijack

1. AS267613 announced 1.1.1.1/32 to peers, providers, and customers
   AS398465 accepted the hijacked route

```
monocle search --start-ts 2024-06-27T18:51:00Z --end-ts 2024-06-27T18:55:00Z --prefix
'1.1.1.1/32'

A|1719514377.130203|206.126.236.209|398465|1.1.1.1/32|398465
267613|IGP|206.126.236.209|0|0||false|||route-views.eqix
-
A|1719514377.681932|206.82.104.185|398465|1.1.1.1/32|398465
267613|IGP|206.82.104.185|0|0|13538:1|false|||route-views.ny
```

2. One Tier-1 transit provider accepted the 1.1.1.1/32 announcement as a RTBH (Remote-Triggered Blackhole) route from AS267613, discarding all traffic at their edge that would normally route to Cloudflare.

Source: https://blog.cloudflare.com/cloudflare-1111-incident-on-june-27-2024/

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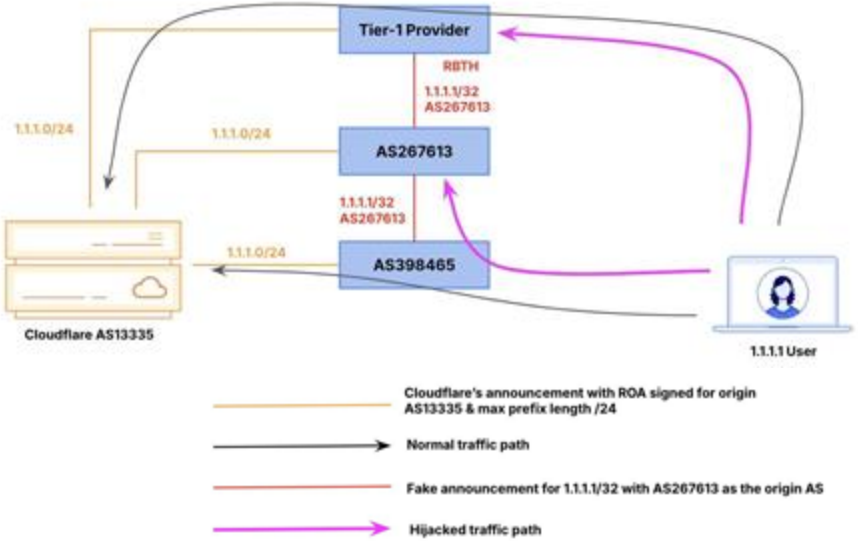

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    - Route Leak

Example path "199524 1031 262504 267613 13335" for the Cloudflare originated prefix 1.1.1.0/24
AS262504 received the prefix from AS267613 and leaked to transit provider AS1031
AS1031 redistributed the prefix advertisement to their IX peers and route-servers, thus widening the impact of the leak

Source: https://blog.cloudflare.com/cloudflare-1111-incident-on-june-27-2024/

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    - Detection - when some users of 1.1.1.1 experienced disruption
    - Remediation - disabled peering location with AS267613 that is receiving traffic toward 1.1.1.0/24, engaged AS262504 regarding the route leak of 1.1.1.0/24 to their upstream providers
    - Possible mitigation - RPKI origin validation, prefix list filter for v4 prefixes longer than /24, IRR filtering by transit provider

Source: https://blog.cloudflare.com/cloudflare-1111-incident-on-june-27-2024/

BGP and its Security Risks - Past Events

- April 2021 - Vodafone Idea BGP Hijack
  - Vodafone Idea announced more than 30k routes (their own routes + routes that don't belong to them) by mistake.
- June 2019 - Verizon / DQE / Allegheny Technologies Route Leak
  - Allegheny learned thousands of IP prefixes from DQE and incorrectly announced to Verizon. Verizon accepted and propagated the leaked routes.
- June 2015 - Telekom Malaysia Route Leak
  - Telekom Malaysia advertised a large number of prefixes (of customers + other networks) to Global Crossing, who then accepted and announced those prefixes to their peers and customers.
- February 2008 - YouTube Hijack by Pakistan Telecom
  - PTCL hijacked YouTube's IP space using BGP to announce a route that was it does not own and announced it to its upstream providers. These was then propagated by one of PTCL's upstream, PCCW.

Sources:
https://manrs.org/2021/04/a-major-bgp-hijack-by-as55410-vodafone-idea-ltd/
https://blog.cloudflare.com/how-verizon-and-a-bgp-optimizer-knocked-large-parts-of-the-internet-offline-today/
https://www.bgpmon.net/massive-route-leak-cause-internet-slowdown/
https://www.ripe.net/about-us/news/youtube-hijacking-a-ripe-ncc-ris-case-study/

Section

Some ways to mitigate and detect these risks

Mitigation and Detection of BGP Security Risks

- Mitigation
  - Best practices
    - Filtering - prefix limit, AS-Path filter, prefix filter
    - Up-to-date IRR and AS-SET records
    - E.g. Cloudflare performs leak test during peering turn up
  - RPKI
    - Sign ROA, enable RPKI validation
- Detection
  - BGP monitoring tools detecting anomalies - RouteViews, Cloudflare Radar

Section

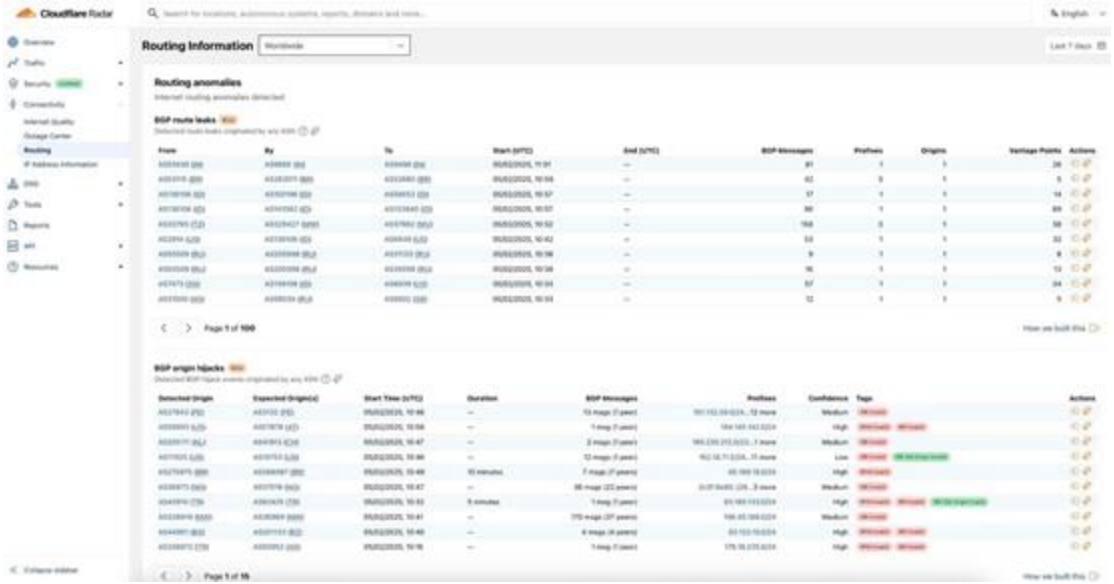
Working towards secure interconnections

Some ongoing developments for routing security

- BGP ASPA (tracked within https://datatracker.ietf.org/doc/html/draft-ietf-sidrops-aspa-verification)
  - BGP AS_PATH Verification based on Autonomous System Provider Authorization (ASPA) objects in the Resource Public Key Infrastructure (RPKI).
- RFC9234 (tracked within https://datatracker.ietf.org/doc/rfc9234/)
  - BGP roles are defined in this RFC - Provider, Customer, RS, RS-Client, Peer
  - Also define the Only to Customer (OTC) BGP attribute - when receiving the OTC attribute from a peer AS, the local AS should only propagate the route to customers.

Cloudflare's advocacy towards routing security

- Best practices to protect routing on the Internet
- Universal RPKI adoption - https://isbgpsafeyet.com/
- Increase observality for data and insights on routing anomalies - https://radar.cloudflare.com/routing



Thank you

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https://www.cloudflare.com/partners/peering-portal/