“Each of us protecting all of us”

Ensuring packets arrive at their destinations with no detours, no delays, and no outages

The Path to a Routing Integrity Program

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This is about organizing to improve routing security

Many routing security talks will focus on technologies such as:

- Internet Routing Registries
- Resources Public Key Infrastructure (RPKI)
- Anti-spoofing filters
- BGPsec
- Autonomous System Provider Authorization

This talk addresses how to organize around a program to promote/enable routing security, and the support role larger networks can provide to their customers.
What is Internet2?

● Not-for-profit
● Not a full transit provider
● Interconnects state research and education networks
● ~1,200 Networks (ASNs) are interconnected via Internet2
● We aim to reduce the friction of using advanced networking-related technologies (e.g., cloud, federated authentication, faster than the speed-of-light data transfers, etc.)
What is Routing Integrity?

Routing Security, as defined by Mutually Agreed Norms for Routing Security (manrs.org), is a set of technical controls and collaborative activities. These include:

1. **Filtering** to prevent the propagation of incorrect routing information.
2. **Anti-spoofing**, or source address validation, to reduce a network’s contribution to DDoS attacks.
3. **Coordination** with other network operators by maintaining accurate contact information.
4. **Global Validation** of routing information by ensuring it is consistent with published routing policy.

Routing Integrity includes Routing Security and more…
What is a Routing Integrity Program?

- An organization’s coordinated efforts to **protect the Internet's routing infrastructure** from threats, such as misconfiguration, mistakes, or malicious activities.
- Ensuring packets arrive at their destinations with no detours, no delays, and no outages

“Each of us protecting all of us”
Internet2’s Routing Integrity Program Scope

While the roles vary, the program’s scope includes:

- The network infrastructure operated by Internet2
- The regional (typically state-based) networks that connect directly to Internet2
- The individual networks of universities, state agencies, community anchor institutions, etc., that connect to the regional networks and directly support their own users
- Stakeholders such as network equipment providers, routing security providers such as Regional Internet Registries (RIRs), and other national research and education networks (i.e., Internet2-like networks)
Components of a Routing Integrity Program
Targeted Outreach

- Routing Integrity is new to many organizations
- Like any activity that requires resources, outreach needs to target multiple audiences:
  - **Leaders** (CISOs, CIOs, leaders of network departments, etc.) - Messaging needs to convey why routing integrity is important.
  - **Doers** (network engineers, software developers, etc.) - Messaging of both why and how.
  - **Early Adopters** - Invite them to be part of the campaign.
Education

Outreach conveys why it is important to ensure a stable Internet. Education supports the development of the skills required for implementation and operation.

- **Webinars** to present the tools and their uses. Examples include creating Internet Routing Registry objects, ROAs, and PeeringDB entries, etc.
- **Workshops** to develop deeper implementation skills, such as router policy configurations, network automation, etc.
- **Office Hours** to provide for ongoing dialog, maintain an understanding of the community’s challenges, and allow community experts to engage in supporting their peers.
- **Online resources**
Reporting

A routing integrity program requires both a yardstick (to inform the overall progress) and a detailed squawk list (to identify individual items needing attention).

- Internet2 developed a Routing Integrity Assessment questionnaire to serve as our yardstick. Its goal is to inform the organization's leadership on the maturity of their routing integrity. The questionnaire is publicly available here: [Routing Integrity Assessment Master v2.1](#).

- We also generate “Internet2 Route Reports,” which are squawk lists that provide detailed information on issues related to rejected routes, inconsistent routing objects, etc.
Adoption of Best Practices

Internet2 interconnects over 1,000 individual networks, and much of our Routing Integrity Program is outwardly focused. However, we also need to continue to evolve and adopt best practices within our own network infrastructure.

- Signing ROAs for network we originate
- Implementation of RPKI Route Origin Validation
- Hardening operations of the network infrastructure (e.g., MFA on routers)
Internet2 Routing Integrity Milestones
May 2023

(A) = Routing Integrity Assessment
(R) = RPKI-ROC
(M) = MANRS Participant
Many external agencies and organizations contribute to our community’s overall routing integrity posture. We advocate for the needs of our community to:

- **American Registry for Internet Numbers (ARIN)**
- The **National Science Foundation** (funding agency for many network programs)
- The **Mutually Agreed Norms for Routing Security** (MANRS.org) project of the Internet Society
- The **Federal Communications Commission**
- etc.
Final Remarks

- Routing security has shifted some of the technical burden from service providers towards IP address holders.
- Service providers have a more comprehensive view of routing security metrics for their entire customer base.
- Service providers are better resourced in routing security.
- There’s an opportunity for service providers, large and small, to positive impact the diffusion of routing security practices across their customer networks through a routing integrity program.