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Router Keying for BGPsec
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Abstract

BGPsec-speaking routers are provisioned with private keys to sign BGP messages; the corresponding public keys are published in the global RPKI (Resource Public Key Infrastructure) thereby enabling verification of BGPsec messages. This document describes two ways of provisioning the public-private key-pairs: router-driven and operator-driven.

Status of this Memo

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1. Introduction

BGPsec-speaking routers are provisioned with private keys, which allow them to digitally sign BGP messages. To verify the signature, the public key, in the form of a certificate [I-D.ietf-sidr-bgpsec-pki-profiles], is published in the RPKI (Resource Public Key Infrastructure). This document describes two methods for provisioning the necessary public-private key-pairs: router-driven and operator-driven.

The difference between the two methods is where the keys are generated: on the router in the router-driven method and elsewhere in the operator-driven method. Routers are expected to support either one, the other, or both methods to work in various deployment environments. Some routers may not allow the private key to be off-loaded while other routers may. Off-loading of private keys would support swapping of routing engines which could then have the same private key installed in the soon-to-be online engine that had previously been installed in the soon-to-be removed card.

The remainder of this document describes how operators can use the two methods to provision new and existing routers.

Note: [I-D.ietf-sidr-bgpsec-pki-profiles] specifies the format for the PKCS #10 request and [I-D.ietf-sidr-bgpsec-algs] specifies the algorithms used to generate the signature.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" are to be interpreted as described in RFC 2119 [RFC2119] only when they appear in all upper case. They may also appear in lower or mixed case as English words, without normative meaning.

Readers are assumed to be familiar with the BGPsec protocol [I-D.ietf-sidr-bgpsec-overview][I-D.ietf-sidr-bgpsec-protocol] and the RPKI [RFC6480] as well as the BGPsec-specific PKI (Public Key

Infrastructure) specifications [I-D.ietf-sidr-bgpsec-pki-profiles][I-D.ietf-sidr-bgpsec-algs].

3. Provisioning a New Router

Depending on the options supported by the new router, operators are free to use either the router-driven or operator-drive methods. Regardless of the method chosen, operators first establish a secure communication channel (e.g., via SSH (Secure Shell)) between the operator's management platform and the router to allow the operator to securely use the Command Line Interface (CLI). How this channel is established is router-specific and is not in scope of this document. Though other configuration mechanisms might be used, e.g. NetConf (see [RFC6470]), in the remainder of this document, the secure communication channel between the server and the router is assumed to be an SSH-protected CLI.

Encryption, integrity, authentication, and key exchange algorithms used by the secure communication channel SHOULD be of comparable strength to BGPsec keys, which currently is 128-bit, or stronger than BGPsec keys. In other words for the encryption algorithm, do not use export grade crypto (40-56 bits of security), do not use Triple DES (112 bits of security), do use something like or better than AES-128: aes128-cbc [RFC4253] and AEAD_AES_128_GCM [RFC5647]; for integrity use something like hmac-sha2-256 [RFC6668] or AESAD_AES_128_GCM [RFC5647]; for authentication use something like ecdsa-sha2-nistp256 [RFC5656], and; for key exchange use something like ecdh-sha2-nistp256 [RFC5656].

Note that some routers support the use of public key certificates and SSH. The certificates used for the SSH session are different than the certificates used for BGPsec. The certificates used with SSH should also enable a level of security commensurate with BGPsec keys; x509v3-ecdsa-sha2-nistp256 [RFC6187] could be used for authentication.

3.1. Router-Generated Keys

In the router-driven method, once the SSH-protected CLI session is established between the operator and the router, the operator issues a command, or commands, for the router to generate the public/private

key pair, to generate the PKCS#10 request, and to sign the PKCS#10 with the private key. Once generated, the PKCS#10, which includes the public key the router wants certified, is transmitted to the RPKI CA for the CA to certify. This can be via a number of means, two of which might be as follows:

- o Through the SSH-protected CLI session with the operator's RPKI management platform: The operator off-loads the PKCS#10 and uploads the request to the CA. If the CA is operated by an external entity, external network connectivity likely is required.

- o Between the router and the CA: The operator, through a command or commands, prompts the router to send/transfer the PKCS#10 request to the CA over the network. Obviously for this to work, the router requires network connectivity with the CA and if the CA is operated by an external entity external network connectivity may be required.

After the CA certifies the key, it does two things:

- o Publishes the certificate in the Global RPKI. The CA must have connectivity to the relevant publication point, which in turn must have external network connectivity as it is part of the Global RPKI.

- o Returns the certificate to the operator's management station or to the router, normally packaged in a PKCS#7, using the corresponding method by which it received the certificate request.

With network connectivity, the router and CA can exchange the certificate request and the certificate using the application/pkcs10 media type [RFC5967] and application/pkcs7-mime [RFC5751], respectively, with the FTP [RFC2585], the HTTP [RFC2585], or the EST (Enrollment over Secure Transport) [RFC7030].

The router SHOULD extract the certificate from the PCKCS#7 and verify that the private key it holds corresponds to the returned public key. The router SHOULD inform the operator that the certificate was received; by some mechanism which is out of scope of this document.

The router SHOULD inform the operator whether or not the keys correspond, again by a mechanism which is out of scope for this document.

The router SHOULD also verify that the returned certificate validates back to a trust anchor. To perform this verification either the CA's certificate needs to be installed on the router via the CLI or the CA's certificate needs to be returned along with the router's certificate in the PKCS#7. The router SHOULD inform the operator whether or not the signature validates to a trust anchor; this notification mechanism is out of scope. After performing these checks, the router need not retain the CA's certificate because the certificate is not transmitted as part of BGPsec messages.

Note that even if the operator cannot extract the private key from the router, this signature still provides a linkage between a private key and a router. That is the server can verify the proof of possession (POP), as required by [RFC6484].

3.2. Operator-Generated Keys

In the operator-driven method, the operator generates the public/private key pair and installs the private key into the router over the SSH-protected CLI session. Note that cut/copy and paste operations for keys over a certain sizes is error-prone.

The operator uses RPKI management tools to generate the keys, the PKCS#10 certification request, the certificate, and the PKCS#7 certification response, as well as publishing the certificate in the Global RPKI. External network connectivity may needed if the certificate is to be published in the Global RPKI.

Along with the PKCS#7, the operator returns the private key. The private key is encapsulated in a PKCS #8 [RFC5958], the PKCS#8 is further encapsulated in CMS (Cryptographic Message Syntax) SignedData [RFC5652], and signed by the AS's EE (End Entity) certificate.

The router SHOULD verify the signature of the encapsulated PKCS#8 to ensure the returned private key did in fact come from the operator, but this requires that the operator also provision via the CLI or include in the SignedData the RPKI CA certificate and relevant AS's

EE certificate(s). The router SHOULD inform the operator whether or not the signature validates to a trust anchor; this notification mechanism is out of scope.

The router SHOULD extract the certificate from the PKCS#7 and verify that the private key corresponds to the returned public key. The router SHOULD inform the operator whether it successfully received the certificate; this mechanism is out of scope. The router should inform the operator whether or not the keys correspond; this mechanism is out of scope. The router SHOULD also verify the returned certificate back to a trust anchor, but to perform this verification either the CA's certificate needs to be installed on the router via the CLI or the CA's certificate needs to be returned along with the router's certificate in the PKCS#7. The router SHOULD inform the operator whether or not the signature validates to a trust anchor; this notification mechanism is out of scope. After performing these checks, the router need not retain the CA certificate.

Note: The signature on the PKCS#8 and Certificate need not be made by the same entity. Signing the PKCS#8, permits more advanced configurations where the entity that generates the keys is not CA.

4. Key Management

An operator's responsibilities do not end after key generation, key

provisioning, certificate issuance, and certificate distribution. They persist for as long as the operator wishes to operate the BGPsec-speaking router.

Paramount to maintaining a router that can be a continuous BPGsec speaker is ensuring that the router has a valid certificate at all times. To ensure this, the operator needs to ensure the router always has a non-expired certificate. That is the key used when BGP-speaking always has an associated certificate whose expiry time is after the current time.

Ensuring this is not terribly difficult but requires that either:

- o The router has a mechanism to notify the operator that the certificate has an impending expiration, and/or

o The operator notes the expiry time of the certificate and uses a calendaring program to remind them of the expiry time. It is advisable that the expiration warning happen well in advance of the actual expiry time, and/or

o The RPKI CA warns the operaor of pending expiration, and/or

o Use some other kind of automated process to search for and track the expiry times of router certificates.

Regardless of the technique used to track router certificate expiry times, it is advisable to notify additional operators in the same organization as the expiry time approaches thereby ensuring that the forgetfulness of one operator does not affect the entire organization.

Depending on inter-operator relationship, it may be appropriate to notify a peer operator that one or more of their certificates are about to expire.

Routers that support multiple private keys also greatly increase the chance that routers can continuously speak BGPsec because the new private key and certificate can be obtained prior to expiration of the operational key. Obviously, the router needs to know when to start using the new key. Once the new key is being used, having the already distributed certificate ensures continuous operation.

Whether the certificate is rekeyed (i.e., different key in the certificate with a new expiry time) or renewed (i.e., the same key in the certificate with a new expiry time) depends on the key's lifetime and operational use. Arguably, rekeying the router's BGPsec certificate every time the certificate expires is more secure than

renewal because it limits the private key's exposure. However, if the key is not compromised the certificate could be renewed as many times as allowed by the operator's security policy. Routers that support only one key can use renewal to ensure continuous operation, assuming the certificate is renewed and distributed prior to the operational's certificate expiry time.

Certain unfortunate circumstances exist when the operator will need

to revoke the router's BGPsec certificate. When this occurs, the operator needs to use the RPKI CA system to revoke the certificate by placing the router's BGPsec certificate on the CRL (Certificate Revocation List) as well as rekeying the router's certificate.

When it is decided that an active router key is to be revoked, the process of requesting the CA to revoke, the process of the CA actually revoking the router's certificate, and then the process of rekeying/renewing the router's certificate, (possibly distributing a new key and certificate to the router), and distributing the status takes time during which the operator must decide how they wish to maintain continuity of operations, with or without the compromised private key, or whether they wish to to bring the router offline to address the compromise.

Keeping the router operational and BGPsec-speaking is the ideal goal, but if operational practices do not allow this then reconfiguring the router to disabling BGPsec is likely preferred to bringing the router offline.

Routers which support more than one private key, where one is operational and the other(s) are soon-to-be-opertional, facilitate revocation events because the operator can configure the router to make a soon-to-be-operational key operational, request revocation of the compromised key, and then make a new soon-to-be-operational key, all hopefully without needing to take offline or reboot the router. For routers which support only one operational key, the operators should create or install the new private key, and then request revocation of the compromised private key.

5. Other Use Cases

Current router code generates private keys for uses such as SSH, but the private keys may not be seen or off-loaded via the SSH-protected CLI session or any other means. While this is good security, it creates difficulties when a routing engine or whole router must be replaced in the field and all software which accesses the router must be updated with the new keys. Also, any network based initial contact with a new routing engine requires trust in the public key presented on first contact.

To allow operators to quickly replace routers without requiring

update and distribution of the corresponding public keys in the RPKI, routers SHOULD allow the private BGPsec key to be off-loaded via the SSH-protected CLI, NetConf (see [RFC6470]), SNMP, etc. This lets the operator upload the old private key via the mechanism used for operator-generated keys, see Section 3.2.

6. Security Considerations

Operator-generated keys could be intercepted in transport and the recipient router would have no way of knowing a substitution had been made or that the key had been disclosed by a monkey in the middle. Hence transport security is strongly RECOMMENDED. As noted in Section 3, the level of security provided by the transport security SHOULD be commensurate with the BGPsec key. Additionally, operators SHOULD ensure the transport security implementation is up to date and addresses all known implementation bugs.

All generated key pairs MUST be generated from a good source of non-deterministic random input [RFC4086] and the private key MUST be protected in a secure fashion. Disclosure of the private key leads to masquerade [RFC4949]. The local storage format for the private key is a local matter.

Though the CA's certificate is installed on the router and used to verify the returned certificate is in fact signed by the CA, the revocation status of the CA's certificate is not checked. The operator MUST ensure that installed CA certificate is valid.

Operators need to manage their SSH keys to ensure only those authorized to access the router may do so. As employees no longer need access to the router, their keys SHOULD be removed from the router.

7. IANA Considerations

This document has no IANA Considerations.

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