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**A Profile for BGPsec Router Certificates,
Certificate Revocation Lists, and Certification Requests
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Abstract

This document defines a standard profile for X.509 certificates for the purposes of supporting validation of Autonomous System (AS) paths in the Border Gateway Protocol (BGP), as part of an extension to that protocol known as BGPsec. BGP is a critical component for the proper operation of the Internet as a whole. The BGPsec protocol is under development as a component to address the requirement to provide security for the BGP protocol. The goal of BGPsec is to design a protocol for full AS path validation based on the use of strong cryptographic primitives. The end-entity (EE) certificates specified by this profile are issued under Resource Public Key Infrastructure (RPKI) Certification Authority (CA) certificates, containing the AS Identifier Delegation extension, to routers within the Autonomous System (AS) or ASes. The certificate asserts that the router(s) holding the private key are authorized to send out secure route advertisements on behalf of the specified AS(es). This document also profiles the Certificate Revocation List (CRL), profiles the format of certification requests, and specifies Relying Party certificate path validation procedures. The document extends the RPKI; therefore, this documents updates the RPKI Resource Certificates Profile ([RFC 6487](#)).

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1. Introduction

This document defines a profile for X.509 end-entity (EE) certificates [[RFC5280](#)] for use in the context of certification of Autonomous System (AS) paths in the Border Gateway Protocol Security (BGPsec) protocol. Such certificates are termed "BGPsec Router Certificates". The holder of the private key associated with a BGPsec Router Certificate is authorized to send secure route advertisements (BGPsec UPDATES) on behalf of the AS(es) named in the certificate. That is, a router holding the private key may send to its BGP peers, route advertisements that contain one or more of the specified AS number as the last item in the AS PATH attribute. A key property that BGPsec will provide is that every AS along the AS PATH can verify that the other ASes along the path have authorized the advertisement of the given route (to the next AS along the AS PATH).

This document is a profile of [[RFC6487](#)], which is a profile of [[RFC5280](#)], and it updates [[RFC6487](#)]. It establishes requirements imposed on a Resource Certificate that is used as a BGPsec Router Certificate, i.e., it defines constraints for certificate fields and extensions for the certificate to be valid in this context. This document also profiles the Certificate Revocation List (CRL) and certification requests. Finally, this document specifies the Relying Party (RP) certificate path validation procedures.

1.1. Terminology

It is assumed that the reader is familiar with the terms and concepts described in "A Profile for X.509 PKIX Resource Certificates" [[RFC6487](#)], "BGPsec Protocol Specification" [[ID.sidr-bgpsec-protocol](#)], "A Border Gateway Protocol 4 (BGP-4)" [[RFC4271](#)], "BGP Security Vulnerabilities Analysis" [[RFC4272](#)], "Considerations in Validating the Path in BGP" [[RFC5123](#)], and "Capability Advertisement with BGP-4" [[RFC5492](#)].

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [[RFC2119](#)].

2. Describing Resources in Certificates

Figure 1 depicts some of the entities in the RPKI and some of the products generated by RPKI entities. IANA issues a Certification Authority (CA) to a Regional Internet Registries (RIR). The RIR, in turn, issues a CA certificate to an Internet Service Providers (ISP). The ISP in turn issues End-Entity (EE) Certificates to itself as well as CRLs. These certificates are referred to as "Resource

Certificates", and are profiled in [RFC6487]. The [RFC6480] envisioned using Resource Certificates to generate Manifests [RFC6486] and Route Origin Authorizations (ROAs) [RFC6482]. ROAs and Manifests also include the Resource Certificates used to sign them.

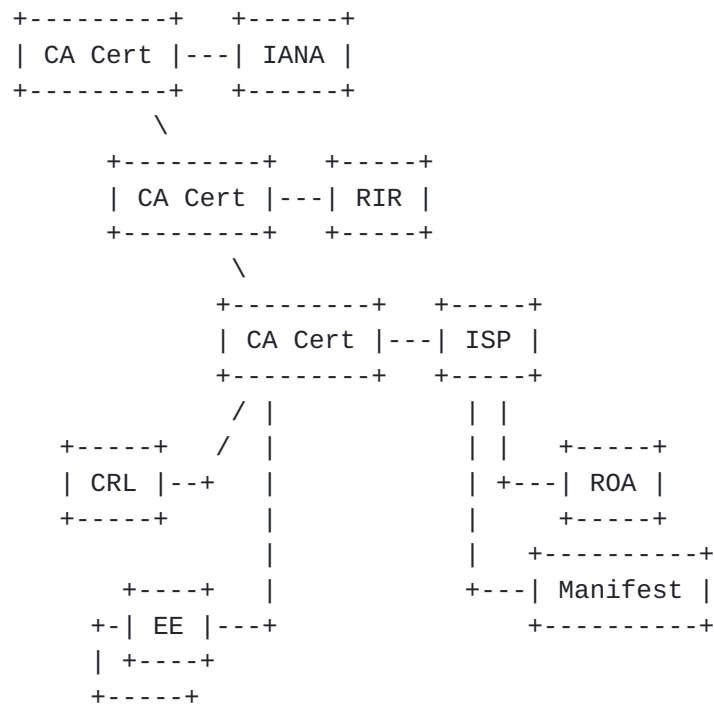


Figure 1

This document defines another type of Resource Certificate, which is referred to as a "BGPsec Router Certificate". The purpose of this certificate is explained in [Section 1](#) and falls within the scope of appropriate uses defined within [RFC6484]. The issuance of BGPsec Router Certificates has minimal impact on RPKI CAs because the RPKI CA certificate and CRL profile remain unchanged (i.e., they are as specified in [RFC6487]). Further, the algorithms used to generate RPKI CA certificates that issue the BGPsec Router Certificates and the CRLs necessary to check the validity of the BGPsec Router Certificates remain unchanged (i.e., they are as specified in [ID.sidr-rfc6485bis]). The only impact is that the RPKI CAs will need to be able to process a profiled certificate request (see [Section 5](#)) signed with algorithms found in [ID.sidr-bgpsec-algs]. The use of BGPsec Router Certificates in no way affects RPKI RPs that process Manifests and ROAs because the public key found in the BGPsec Router Certificate is only ever used to verify the signature on the BGPsec certificate request (only CAs process these) and the signature on a BGPsec Update Message [ID.sidr-bgpsec-protocol] (only BGPsec routers process these).

Only the differences between this profile and the profile in [\[RFC6487\]](#) are listed. Note that BGPsec Router Certificates are EE certificates and as such there is no impact on process described in [\[RFC6916\]](#).

[3.](#) Updates to [\[RFC6487\]](#)

[3.1](#) BGPsec Router Certificate Fields

A BGPsec Router Certificate is a valid X.509 public key certificate, consistent with the PKIX profile [\[RFC5280\]](#), containing the fields listed in this section. This profile is also based on [\[RFC6487\]](#) and only the differences between this profile and the profile in [\[RFC6487\]](#) are listed.

[3.1.1.1.](#) Subject

This field identifies the router to which the certificate has been issued. Consistent with [\[RFC6487\]](#), only two attributes are allowed in the Subject field: common name and serial number. Moreover, the only common name encoding options that are supported are printableString and UTF8String. For BGPsec Router Certificates, it is RECOMMENDED that the common name attribute contain the literal string "ROUTER-" followed by the 32-bit AS Number [\[RFC3779\]](#) encoded as eight hexadecimal digits and that the serial number attribute contain the 32-bit BGP Identifier [\[RFC4271\]](#) (i.e., the router ID) encoded as eight hexadecimal digits. If there is more than one AS number, the choice of which to include in the common name is at the discretion of the Issuer. If the same certificate is issued to more than one router (hence the private key is shared among these routers), the choice of the router ID used in this name is at the discretion of the Issuer. Note that router IDs are not guaranteed to be unique across the Internet, and thus the Subject name in a BGPsec Router Certificate issued using this convention also is not guaranteed to be unique across different issuers. However, each certificate issued by an individual CA MUST contain a Subject name that is unique within that context.

[3.1.2.](#) Subject Public Key Info

Refer to section 3.1 of [\[ID.sidr-bgpsec-algs\]](#).

[3.1.3.](#) BGPsec Router Certificate Version 3 Extension Fields

[3.1.3.1.](#) Basic Constraints

BGPsec speakers are EEs; therefore, the Basic Constraints extension must not be present, as per [[RFC6487](#)].

[3.1.3.2.](#) Extended Key Usage

BGPsec Router Certificates MUST include the Extended Key Usage (EKU) extension. As specified in [[RFC6487](#)] this extension MUST be marked as non-critical. This document defines one EKU for BGPsec Router Certificates:

```
id-kp OBJECT IDENTIFIER ::=
  { iso(1) identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) kp(3) }
```

```
id-kp-bgpsec-router OBJECT IDENTIFIER ::= { id-kp 30 }
```

Relying Parties MUST require the extended key usage extension to be present in a BGPsec Router Certificate. If multiple KeyPurposeId values are included, the relying parties need not recognize all of them, as long as the required KeyPurposeId value is present. BGPsec RPs MUST reject certificates that do not contain the BGPsec Router EKU even if they include the anyExtendedKeyUsage OID defined in [[RFC5280](#)].

[3.1.3.3.](#) Subject Information Access

This extension is not used in BGPsec Router Certificates. It MUST be omitted.

[3.1.3.4.](#) IP Resources

This extension is not used in BGPsec Router Certificates. It MUST be omitted.

[3.1.3.5.](#) AS Resources

Each BGPsec Router Certificate MUST include the AS Resource Identifier Delegation extension, as specified in [section 4.8.11 of \[\[RFC6487\]\(#\)\]](#). The AS Resource Identifier Delegation extension MUST include one or more AS numbers, and the "inherit" element MUST NOT be specified.

3.2. BGPsec Router Certificate Request Profile

Refer to [section 6 of \[RFC6487\]](#). The only differences between this profile and the profile in [\[RFC6487\]](#) are:

- o The ExtendedKeyUsage extension request MUST be included and the CA MUST honor the request;
- o The SubjectPublicKeyInfo and PublicKey fields are specified in [\[ID.sidr-bgpsec-algs\]](#); and,
- o The request is signed with the algorithms specified in [\[ID.sidr-bgpsec-algs\]](#).

3.3. BGPsec Router Certificate Validation

The validation procedure used for BGPsec Router Certificates is identical to the validation procedure described in [Section 7 of \[RFC6487\]](#). The exception is that the constraints applied come from this specification (e.g., in step 3: the certificate contains all the field that must be present - refers to the fields that are required by this specification).

The differences are as follows:

- o BGPsec Router Certificates MUST include the BGPsec EKU defined in [Section 3.1.3.1](#).
- o BGPsec Router Certificates MUST NOT include the SIA extension.
- o BGPsec Router Certificates MUST NOT include the IP Resource extension.
- o BGPsec Router Certificates MUST include the AS Resource Identifier Delegation extension.
- o BGPsec Router Certificate MUST include the "Subject Public Key Info" described in [\[ID.sidr-bgpsec-algs\]](#) as it updates [\[ID.sidr-rfc6485bis\]](#).

NOTE: The cryptographic algorithms used by BGPsec routers are found in [\[ID.sidr-bgpsec-algs\]](#). Currently, the algorithms specified in [\[ID.sidr-bgpsec-algs\]](#) and [\[ID.sidr-rfc6485bis\]](#) are different. BGPsec RPs will need to support algorithms that are needed to validate BGPsec signatures as well as the algorithms that are needed to validate signatures on BGPsec certificates, RPKI CA certificates, and RPKI CRLs.

4. Design Notes

The BGPsec Router Certificate profile is based on the Resource Certificate profile as specified in [[ID.sidr-rfc6485bis](#)]. As a result, many of the design choices herein are a reflection of the design choices that were taken in that prior work. The reader is referred to [[RFC6484](#)] for a fuller discussion of those choices.

5. Security Considerations

The Security Considerations of [[RFC6487](#)] apply.

A BGPsec certificate will fail RPKI validation, as defined in [[RFC6487](#)], because the algorithm suite is different. Consequently, a RP needs to identify the EKU before applying the correspondent validation.

A BGPsec Router Certificate is an extension of the RPKI [[RFC6480](#)] to encompass routers. It is a building block of the larger BGPsec security protocol used to validate signatures on BGPsec Signature-Segment origination of Signed-Path segments [[ID.sidr-bgpsec-protocol](#)]. Thus its essential security function is the secure binding of one or more AS numbers to a public key, consistent with the RPKI allocation/assignment hierarchy.

Hash functions [[ID.sidr-bgpsec-algs](#)] are used when generating the two key identifiers extension included in BGPsec certificates. However as noted in [[RFC6818](#)], collision resistance is not a required property of one-way hash functions when used to generate key identifiers. Regardless, hash collisions are possible and if detected the operator should be alerted.

6. IANA Considerations

This document makes use of two object identifiers in the SMI Registry for PKIX. One is for the ASN.1 module in [Appendix A](#) and it comes from the SMI Security for PKIX Module Identifier IANA registry (id-mod-bgpsec-eku). The other is for the BGPsec router EKU defined in [Section 3.1.3.2](#) and [Appendix A](#) and it comes from the SMI Security for PKIX Extended Key Purpose IANA registry. These OIDs were assigned before management of the PKIX Arc was handed to IANA. No IANA allocations are request of IANA, but please update the references in those registries when this document is published by the RFC editor.

7. Acknowledgements

We would like to thank Geoff Huston, George Michaelson, and Robert Loomans for their work on [[RFC6487](#)], which this work is based on. In

addition, the efforts of Steve Kent and Matt Lepinski were instrumental in preparing this work. Additionally, we'd like to thank Roque Gagliano, Sandra Murphy, Geoff Huston, Richard Hansen, and David Mandelberg for their reviews and comments.

8. References

8.1. Normative References

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- [RFC6818] Yee, P., "Updates to the Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile", [RFC 6818](#), January 2013.
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8.2. Informative References

- [RFC4272] Murphy, S., "BGP Security Vulnerabilities Analysis", [RFC 4272](#), January 2006.
- [RFC5123] White, R. and B. Akyol, "Considerations in Validating the Path in BGP", [RFC 5123](#), February 2008.
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- [RFC6482] Lepinski, M., Kent, S., and D. Kong, "A Profile for Route Origin Authorizations (ROAs)", [RFC 6482](#), February 2012.
- [RFC6484] Kent, S., Kong, D., Seo, K., and R. Watro, "Certificate Policy (CP) for the Resource Public Key Infrastructure (RPKI)", [BCP 173](#), [RFC 6484](#), February 2012.
- [RFC6486] Austein, R., Huston, G., Kent, S., and M. Lepinski, "Manifests for the Resource Public Key Infrastructure (RPKI)", [RFC 6486](#), February 2012.
- [RFC6916] Gagliano, R., Kent, S., and S. Turner, "Algorithm Agility Procedure for the Resource Public Key Infrastructure (RPKI)", [BCP 182](#), [RFC 6916](#), April 2013.
- [ID.sidr-bgpsec-protocol] Lepinski, M., "BGPsec Protocol Specification", [draft-ietf-sidr-bgpsec-protocol](#), work-in-progress.

[Appendix A](#). ASN.1 Module

```
BGPSECEKU { iso(1) identified-organization(3) dod(6) internet(1)
  security(5) mechanisms(5) pkix(7) id-mod(0) id-mod-bgpsec-eku(84) }

DEFINITIONS EXPLICIT TAGS ::=

BEGIN

-- EXPORTS ALL --

-- IMPORTS NOTHING --

-- OID Arc --

id-kp OBJECT IDENTIFIER ::= {
  iso(1) identified-organization(3) dod(6) internet(1)
  security(5) mechanisms(5) kp(3) }

-- BGPsec Router Extended Key Usage --

id-kp-bgpsec-router OBJECT IDENTIFIER ::= { id-kp 30 }

END
```


Appendix B. Change Log

Please delete this section prior to publication.

B.0 Changes from sidr-bgpsec-pki-profiles-11 to sidr-bgpsec-pki-profiles-12

Added security consideration to address SKI collisions. Also updated the IANA considerations section.

B.1 Changes from sidr-bgpsec-pki-profiles-10 to sidr-bgpsec-pki-profiles-11

Removed text in s3.1.3. Consistently used BGPsec to refer to BGP Security. Fixed typos. Refer to RFC6485bis instead of [RFC6485](#). Included OIDs.

B.2. Changes from sidr-bgpsec-pki-profiles-09 to sidr-bgpsec-pki-profiles-10

Updated dates.

B.3. Changes from sidr-bgpsec-pki-profiles-08 to sidr-bgpsec-pki-profiles-09

Editorial fixes for the sake of brevity.

B.4. Changes from sidr-bgpsec-pki-profiles-07 to sidr-bgpsec-pki-profiles-08

Fixed section numbering.

B.5. Changes from sidr-bgpsec-pki-profiles-06 to sidr-bgpsec-pki-profiles-07

Added text to multiple AS numbers in a single certificate. Updated reference to [RFC 6916](#).

B.6. Changes from sidr-bgpsec-pki-profiles-05 to sidr-bgpsec-pki-profiles-06

Keep alive version.

B.7. Changes from sidr-bgpsec-pki-profiles-04 to sidr-bgpsec-pki-profiles-05

Keep alive version.

B.8. Changes from sidr-bgpsec-pki-profiles-03 to sidr-bgpsec-pki-profiles-04

In s2.1, removed the phrase "another BGPSEC Router Certificate (only BGPSEC routers process these)" because the BGPSEC certificates are only ever EE certificates and they're never used to verify another certificate only the PDUs that are signed.

Added new s3.1.3.1 to explicitly state that EE certificates are only ever EE certs.

B.9. Changes from sidr-bgpsec-pki-profiles-02 to sidr-bgpsec-pki-profiles-03

Updated s3.3 to clarify restrictions on path validation procedures are in this specification (1st para was reworded).

Updated s3.3 to point to s3.1.3.1 for BGPSEC ECU (thanks Tom).

B.10. Changes from sidr-bgpsec-pki-profiles-01 to sidr-bgpsec-pki-profiles-02

Updated references.

B.11. Changes from sidr-bgpsec-pki-profiles-00 to sidr-bgpsec-pki-profiles-01

Added an ASN.1 Module and corrected the id-kp OID in s3.1.3.1.

B.12. Changes from turner-bgpsec-pki-profiles-02 to sidr-bgpsec-pki-profiles-00

Added this change log.

Amplified that a BGPSEC RP will need to support both the algorithms in [[ID.sidr-bgpsec-algs](#)] for BGPSEC and the algorithms in [ID.sidr-rpki-algs] for certificates and CRLs.

Changed the name of AS Resource extension to AS Resource Identifier Delegation to match what's in [RFC 3779](#).

B.13. Changes from turner-bgpsec-pki-profiles -01 to -02

Added text in [Section 2](#) to indicate that there's no impact on the procedures defined in [[RFC6916](#)].

Added a security consideration to let implementers know the BGPSEC certificates will not pass RPKI validation [[RFC6487](#)] and that keying

off the EKU will help tremendously.

B.14. Changes from turner-bgpsec-pki-profiles -00 to -01

Corrected [Section 2](#) to indicate that CA certificates are also RPKI certificates.

Removed sections and text that was already in [[RFC6487](#)]. This will make it easier for reviewers to figure out what is different.

Modified [Section 6](#) to use 2119-language.

Removed requirement from [Section 6](#) to check that the AS # in the certificate is the last number in the AS path information of each BGP UPDATE message. Moved to [[ID.sidr-bgpsec-protocol](#)].

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