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

Abstract

This document defines a standard profile for X.509 certificates used to enable 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 the standard for inter-domain routing in the Internet; it is the "glue" that holds the Internet together. BGPsec is being developed as one component of a solution that addresses the requirement to provide security for BGP. The goal of BGPsec is to provide full AS path validation based on the use of strong cryptographic primitives. The end entity (EE) certificates specified by this profile are issued to routers within an AS. Each of these certificates is issued under a Resource Public Key Infrastructure (RPKI) Certification Authority (CA) certificate. These CA certificates and EE certificates both contain the AS Resource extension. An EE certificate of this type asserts that the router or routers holding the corresponding private key are authorized to emit secure route advertisements on behalf of the AS(es) specified in the certificate. This document also profiles the format of certification requests and specifies Relying Party (RP) certificate path validation procedures for these EE certificates. This document extends the RPKI; therefore, this document updates the RPKI Resource Certificates Profile (RFC 6487).

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## Table of Contents

1. Introduction .....	3
1.1. Terminology .....	4
2. Describing Resources in Certificates .....	4
3. Updates to RFC 6487 .....	6
3.1. BGPsec Router Certificate Fields .....	6
3.1.1. Subject .....	6
3.1.2. Subject Public Key Info .....	6
3.1.3. BGPsec Router Certificate Version 3 Extension Fields .....	6
3.1.3.1. Basic Constraints .....	6
3.1.3.2. Extended Key Usage .....	6
3.1.3.3. Subject Information Access .....	7
3.1.3.4. IP Resources .....	7
3.1.3.5. AS Resources .....	7
3.2. BGPsec Router Certificate Request Profile .....	7
3.3. BGPsec Router Certificate Validation .....	8
3.4. Router Certificates and Signing Functions in the RPKI .....	8
4. Design Notes .....	9
5. Implementation Considerations .....	9
6. Security Considerations .....	10
7. IANA Considerations .....	10
8. References .....	11
8.1. Normative References .....	11
8.2. Informative References .....	12
Appendix A. ASN.1 Module .....	14
Acknowledgements .....	15
Authors' Addresses .....	15

## 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 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. A router holding the private key is authorized to send route advertisements (to its peers) identifying the router's AS number (ASN) as the source of the advertisements. A key property provided by BGPsec 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]; thus, this document 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 certification requests used to acquire BGPsec Router Certificates. Finally, this document specifies the Relying Party (RP) certificate path validation procedures for these certificates.

### 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" [RFC8205], "A Border Gateway Protocol 4 (BGP-4)" [RFC4271], "BGP Security Vulnerabilities Analysis" [RFC4272], "Considerations in Validating the Path in BGP" [RFC5123], and "Capabilities 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 BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

## 2. Describing Resources in Certificates

Figure 1 depicts some of the entities in the Resource Public Key Infrastructure (RPKI) and some of the products generated by RPKI entities. IANA issues a Certification Authority (CA) certificate to each Regional Internet Registry (RIR). The RIR in turn issues a CA certificate to an Internet Service Provider (ISP). The ISP in turn issues EE certificates to itself to enable verification of signatures on RPKI signed objects. The CA also generates Certificate Revocation Lists (CRLs). These CA and EE certificates are referred to as "Resource Certificates" and are profiled in [RFC6487]. [RFC6480] envisioned using Resource Certificates to enable verification of manifests [RFC6486] and Route Origin Authorizations (ROAs) [RFC6482]. ROAs and manifests include the Resource Certificates used to verify them.

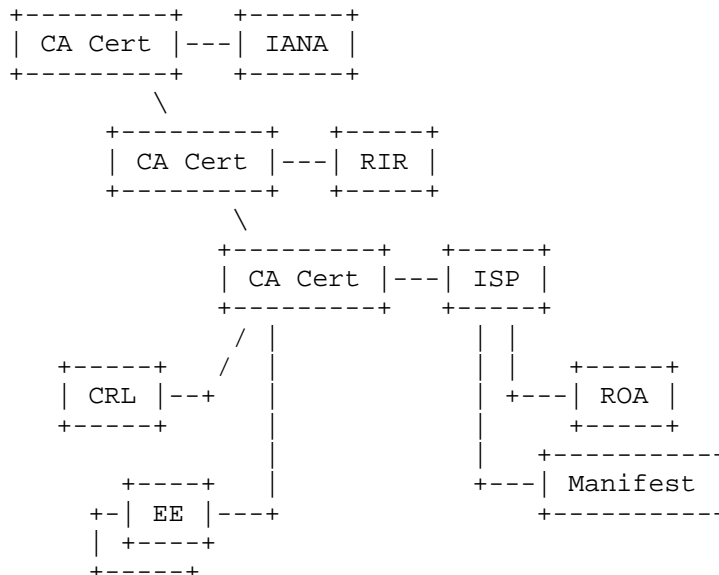


Figure 1

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 [RFC7935]). The only impact is that RPKI CAs will need to be able to process a profiled certificate request (see Section 3.2) signed with algorithms found in [RFC8208]. BGPsec Router Certificates are used only to verify the signature on the BGPsec certificate request (only CAs process these) and the signature on a BGPsec UPDATE message [RFC8205] (only BGPsec routers process these); BGPsec Router Certificates are not used to process manifests and ROAs or verify signatures on Certificates or CRLs.

This document enumerates only the differences between this profile and the profile in [RFC6487]. Note that BGPsec Router Certificates are EE certificates, and as such there is no impact on the algorithm agility procedure described in [RFC6916].

### 3. Updates to RFC 6487

#### 3.1. BGPsec Router Certificate Fields

A BGPsec Router Certificate is consistent with the profile in [RFC6487] as modified by the specifications in this section. As such, it is a valid X.509 public key certificate and consistent with the PKIX profile [RFC5280]. The differences between this profile and the profile in [RFC6487] are specified in this section.

##### 3.1.1. Subject

Encoding options for the common name 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 ASN [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 ASN, 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 (and 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.

##### 3.1.2. Subject Public Key Info

Refer to Section 3.1 of [RFC8208].

##### 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 not be marked 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 }
```

A BGPsec router MUST require the EKU extension be present in a BGPsec Router Certificate it receives. If multiple KeyPurposeId values are included, the BGPsec routers need not recognize all of them, as long as the required KeyPurposeId value is present. BGPsec routers 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 Resources extension, as specified in Section 4.8.11 of [RFC6487]. The AS Resources extension MUST include one or more ASNs, 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 as follows:

- o The Basic Constraints extension:

- If included, the CA MUST NOT honor the cA boolean if set to TRUE.

- o The EKU extension:

- If included, id-kp-bgpsec-router MUST be present (see Section 3.1.3.2). If included, the CA MUST honor the request for id-kp-bgpsec-router.

- o The Subject Information Access (SIA) extension:

- If included, the CA MUST NOT honor the request to include the extension.

- o The SubjectPublicKeyInfo field is specified in [RFC8208].

- o The request is signed with the algorithms specified in [RFC8208].

### 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] (and any RFC that updates that procedure), as modified below. For example, in step 3 (of the criteria listed in Section 7.2 of [RFC6487]), "The certificate contains all fields 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 Router EKU defined in Section 3.1.3.2.
- o BGPsec Router Certificates MUST NOT include the SIA extension.
- o BGPsec Router Certificates MUST NOT include the IP Resources extension.
- o BGPsec Router Certificates MUST include the AS Resources extension.
- o BGPsec Router Certificates MUST include the subjectPublicKeyInfo field described in [RFC8208].

NOTE: BGPsec RPs will need to support the algorithms in [RFC8208], which are used to validate BGPsec signatures, as well as the algorithms in [RFC7935], which are needed to validate signatures on BGPsec certificates, RPKI CA certificates, and RPKI CRLs.

### 3.4. Router Certificates and Signing Functions in the RPKI

As described in Section 1, the primary function of BGPsec Router Certificates in the RPKI is for use in the context of certification of AS paths in the BGPsec protocol.

The private key associated with a router EE certificate may be used multiple times in generating signatures in multiple instances of the BGPsec\_PATH attribute Signature Segments [RFC8205]. That is, the BGPsec Router Certificate is used to validate multiple signatures.

BGPsec Router Certificates are stored in the issuing CA's repository, where a repository following [RFC6481] MUST use a .cer filename extension for the certificate file.



#### 4. Design Notes

The BGPsec Router Certificate profile is based on the Resource Certificate profile as specified in [RFC6487]. 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.

CAs are required by the Certificate Policy (CP) [RFC6484] to issue properly formed BGPsec Router Certificates regardless of what is present in the certificate request, so there is some flexibility permitted in the certificate requests:

- o BGPsec Router Certificates are always EE certificates; therefore, requests to issue a CA certificate result in EE certificates;
- o BGPsec Router Certificates are always EE certificates; therefore, requests for Key Usage extension values keyCertSign and cRLSign result in certificates with neither of these values;
- o BGPsec Router Certificates always include the BGPsec Router EKU value; therefore, requests without the value result in certificates with the value; and,
- o BGPsec Router Certificates never include the SIA extension; therefore, requests with this extension result in certificates without the extension.

Note that this behavior is similar to the CA including the AS Resources extension in issued BGPsec Router Certificates, despite the fact that it is not present in the request.

#### 5. Implementation Considerations

This document permits the operator to include a list of ASNs in a BGPsec Router Certificate. In that case, the router certificate would become invalid if any one of the ASNs is removed from any superior CA certificate along the path to a trust anchor. Operators could choose to avoid this possibility by issuing a separate BGPsec Router Certificate for each distinct ASN, so that the router certificates for ASNs that are retained in the superior CA certificate would remain valid.

## 6. Security Considerations

The security considerations of [RFC6487] apply.

A BGPsec Router Certificate will fail RPKI validation as defined in [RFC6487] because the cryptographic algorithms used are different. Consequently, an RP needs to identify the EKU to determine the appropriate Validation constraint.

A BGPsec Router Certificate is an extension of the RPKI [RFC6480] to encompass routers. It is a building block of BGPsec and is used to validate signatures on BGPsec Signature Segment origination of signed path segments [RFC8205]. Thus, its essential security function is the secure binding of one or more ASNs to a public key, consistent with the RPKI allocation/assignment hierarchy.

Hash functions [RFC8208] are used when generating the two key identifier extensions (i.e., Subject Key Identifier and Issuer Key Identifier) 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 unlikely, but they are possible, and if detected an operator should be alerted. A Subject Key Identifier collision might cause the incorrect certificate to be selected from the cache, resulting in a failed signature validation.

## 7. IANA Considerations

This document makes use of two OIDs in the SMI registry for PKIX. One is for the ASN.1 module [X680] [X690] 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 (id-kp-bgpsec-router). These OIDs were assigned before management of the PKIX Arc was handed to IANA. The references in those registries have been updated to point to this document.

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## 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) pkix(7) kp(3) }

-- BGPsec Router Extended Key Usage --

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

END
```

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