Abstract

This document defines a strategy to securely assign a pledge to an owner, using an artifact signed, directly or indirectly, by the pledge’s manufacturer. This artifact is known as a "voucher".

This document builds upon the work in [RFC8366], encoding the resulting artifact in CBOR. Use with two signature technologies are described.

Additionally, this document explains how constrained vouchers may be transported as an extension to the [I-D.ietf-ace-coap-est] protocol.

Status of This Memo

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1. Introduction

Enrollment of new nodes into constrained networks with constrained nodes present unique challenges.

There are bandwidth and code space issues to contend. A solution such as [I-D.ietf-anima-bootstrapping-keyinfra] may be too large in terms of code space or bandwidth required.

This document defines a constrained version of [RFC8366]. Rather than serializing the YANG definition in JSON, it is serialized into CBOR ([RFC7049]).

This document follows a similar, but not identical structure as [RFC8366]. Some sections are left out entirely. Additional sections have been added concerning:

1. Addition of voucher-request specification as defined in [I-D.ietf-anima-bootstrapping-keyinfra],

2. Addition to [I-D.ietf-ace-coap-est] of voucher transport requests over CoAP.
The CBOR definitions for this constrained voucher format are defined using the mechanism described in [I-D.ietf-core-yang-cbor] using the SID mechanism explained in [I-D.ietf-core-sid]. As the tooling to convert YANG documents into an list of SID keys is still in its infancy, the table of SID values presented here should be considered normative rather than the output of the pyang tool.

Two methods of signing the resulting CBOR object are described in this document:

1. One is CMS [RFC5652].
2. The other is COSE_Sign1 [RFC8152] objects.

2. Terminology

The following terms are defined in [RFC8366], and are used identically as in that document: artifact, imprint, domain, Join Registrar/Coordinator (JRC), Manufacturer Authorized Signing Authority (MASA), pledge, Trust of First Use (TOFU), and Voucher.

3. Requirements Language

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.

4. Survey of Voucher Types

[RFC8366] provides for vouchers that assert proximity, that authenticate the registrar and that include different amounts of anti-replay protection.

This document does not make any extensions to the types of vouchers.

Time based vouchers are included in this definition, but given that constrained devices are extremely unlikely to have accurate time, their use is very unlikely. Most users of these constrained vouchers will be online and will use live nonces to provide anti-replay protection.

[RFC8366] defined only the voucher artifact, and not the Voucher Request artifact, which was defined in [I-D.ietf-anima-bootstrapping-keyinfra].
This document defines both a constrained voucher and a constrained voucher-request. They are presented in the order voucher-request, followed by a voucher response as this is the time order that they occur.

This document defines both CMS-signed voucher requests and responses, and COSE signed voucher requests and responses. The use of CMS signatures implies the use of PKIX format certificates. The pinned-domain-cert present in such a voucher, is the certificate of the Registrar.

The constrained voucher and constrained voucher request MUST be signed.

The use of the two signing formats permit the use of both PKIX format certificates, and raw public keys (RPK). When RPKs are used, the voucher produced by the MASA pins the raw public key of the Registrar: the pinned-domain-subject-public-key-info in such a voucher, is the raw public key of the Registrar. This is described in the YANG definition for the constrained voucher.

5. Discovery and URI

This section describes the BRSKI extensions to EST-coaps [I-D.ietf-ace-coap-est] to transport the voucher between registrar, proxy and pledge over CoAP. The extensions are targeted to low-resource networks with small packets. Saving header space is important and the EST-coaps URI is shorter than the EST URI.

The presence and location of (path to) the management data are discovered by sending a GET request to "/.well-known/core" including a resource type (RT) parameter with the value "ace.est" [RFC6690]. Upon success, the return payload will contain the root resource of the EST resources. It is up to the implementation to choose its root resource; throughout this document the example root resource /est is used.

The EST-coaps server URIs differ from the EST URI by replacing the scheme https by coaps and by specifying shorter resource path names:

coaps://www.example.com/est/short-name

Figure 5 in section 3.2.2 of [RFC7030] enumerates the operations and corresponding paths which are supported by EST. Table 1 provides the mapping from the BRSKI extension URI path to the EST-coaps URI path.
When discovering the root path for the EST resources, the server MAY return the full resource paths and the used content types. This is useful when multiple content types are specified for EST-coaps server. For example, the following more complete response is possible.

REQ: GET /.well-known/core?rt=ace.est*

RES: 2.05 Content
</est>; rt="ace.est"
</est/rv>; rt="ace.est/rv"; ct=TBD2 TBD3
</est/vs>; rt="ace.est/vs"; ct=50 60
</est/es>; rt="ace.est/es"; ct=50 60
</est/ra>; rt="ace.est/ra"; ct=TBD2 TBD3

The return of the content-types allows the client to choose the most appropriate one from multiple content types.

t=TBD2 stands for Content-Format "application/voucher-cms+cbor, and
t=TBD3 stands for Content-Format "application/voucher-cose+cbor".

Content-Formats TBD2 and TBD3 are defined in this document.

The Content-Format ("application/json") 50 MAY be supported. Content-Formats ("application/cbor") 60, TBD2, and TBD3 MUST be supported.
6. Artifacts

This section describes the abstract (tree) definition as explained in [I-D.ietf-netmod-yang-tree-diagrams] first. This provides a high-level view of the contents of each artifact.

Then the assigned SID values are presented. These have been assigned using the rules in [I-D.ietf-core-sid], with an allocation that was made via the http://comi.space service.

6.1. Voucher Request artifact

6.1.1. Tree Diagram

The following diagram is largely a duplicate of the contents of [RFC8366], with the addition of proximity-registrar-subject-public-key-info, proximity-registrar-cert, and prior-signed-voucher-request.

prior-signed-voucher-request is only used between the Registrar and the MASA. proximity-registrar-subject-public-key-info replaces proximity-registrar-cert for the extremely constrained cases.
module: ietf-constrained-voucher-request

grouping voucher-request-constrained-grouping
  +-- voucher
    |   +-- created-on?
    |       |     yang:date-and-time
    |   +-- expires-on?
    |       |     yang:date-and-time
    |   +-- assertion
    |       |     enumeration
    |   +-- serial-number
    |       |     string
    |   +-- idevid-issuer?
    |       |     binary
    |   +-- pinned-domain-cert?
    |       |     binary
    |   +-- domain-cert-revocation-checks?
    |       |     boolean
    |   +-- nonce?
    |       |     binary
    |   +-- last-renewal-date?
    |       |     yang:date-and-time
    |   +-- proximity-registrar-subject-public-key-info?
    |       |     binary
    |   +-- proximity-registrar-sha256-of-subject-public-key-info?
    |       |     binary
    |   +-- proximity-registrar-cert?
    |       |     binary
    |   +-- prior-signed-voucher-request?
    |       |     binary

6.1.2. SID values
6.1.3. YANG Module

In the constrained-voucher-request YANG module, the voucher is "augmented" within the "used" grouping statement such that one continuous set of SID values is generated for the constrained-voucher-request module name, all voucher attributes, and the constrained-voucher-request attribute. Two attributes of the voucher are "refined" to be optional.

<CODE BEGINS> file "ietf-constrained-voucher-request@2018-09-01.yang"
mODULE ietf-constrained-voucher-request {
  yang-version 1.1;

  namespace
  prefix "constrained";

  IMPORT ietf-restconf {
    prefix rc;
    description
      "This import statement is only present to access
the yang-data extension defined in RFC 8040."
    reference "RFC 8040: RESTCONF Protocol";
  }

  IMPORT ietf-voucher {
    prefix "v";
  }

  organization
      "IETF ANIMA Working Group";
</CODE BEGINS>
This module defines the format for a voucher request, which is produced by a pledge to request a voucher. The voucher-request is sent to the potential owner's Registrar, which in turn sends the voucher request to the manufacturer or delegate (MASA).

A voucher is then returned to the pledge, binding the pledge to the owner. This is a constrained version of the voucher-request present in draft-ietf-anima-bootstrap-keyinfra.txt.

This version provides a very restricted subset appropriate for very constrained devices.

In particular, it assumes that nonce-ful operation is always required, that expiration dates are rather weak, as no clocks can be assumed, and that the Registrar is identified by a pinned Raw Public Key.

The key words 'MUST', 'MUST NOT', 'REQUIRED', 'SHALL', 'SHALL NOT', 'SHOULD', 'SHOULD NOT', 'RECOMMENDED', 'MAY', and 'OPTIONAL' in the module text are to be interpreted as described in RFC 2119.

revision "2018-09-01" {
  description
    "Initial version";
  reference
    "RFC XXXX: Voucher Profile for Constrained Devices";
}

rc:yang-data voucher-request-constrained-artifact {
  // YANG data template for a voucher.
  uses voucher-request-constrained-grouping;
}

// Grouping defined for future usage
grouping voucher-request-constrained-grouping {
  description
"Grouping to allow reuse/extensions in future work."

uses v:voucher-artifact-grouping {

refine voucher/created-on {
    mandatory false;
}

refine voucher/pinned-domain-cert {
    mandatory false;
}

augment "voucher" {
    description "Base the constrained voucher-request upon the regular one";

    leaf proximity-registrar-subject-public-key-info {
        type binary;
        description "The proximity-registrar-subject-public-key-info replaces the proximity-registrar-cert in constrained uses of the voucher-request. The proximity-registrar-subject-public-key-info is the Raw Public Key of the Registrar. This field is encoded as specified in RFC7250, section 3. The ECDSA algorithm MUST be supported. The EdDSA algorithm as specified in draft-ietf-tls-rfc4492bis-17 SHOULD be supported. Support for the DSA algorithm is not recommended. Support for the RSA algorithm is MAY, but due to size is discouraged."
    }

    leaf proximity-registrar-sha256-of-subject-public-key-info {
        type binary;
        description "The proximity-registrar-sha256-of-subject-public-key-info is an alternative to proximity-registrar-subject-public-key-info. and pinned-domain-cert. In many cases the public key of the domain has already been transmitted during the key agreement protocol, and it is wasteful to transmit the public key another two times. The use of a hash of public key info, at 32-bytes for sha256 is a significant savings compared to an RSA public key, but is only a minor savings compared to a 256-bit ECDSA public-key."
    }
}
Algorithm agility is provided by extensions to this specifications which define new leaf for other hash types.

leaf proximity-registrar-cert {
  type binary;
  description
  "An X.509 v3 certificate structure as specified by RFC 5280, Section 4 encoded using the ASN.1 distinguished encoding rules (DER), as specified in ITU-T X.690.
  
  The first certificate in the Registrar TLS server certificate_list sequence (see [RFC5246]) presented by the Registrar to the Pledge. This MUST be populated in a Pledge’s voucher request if the proximity assertion is populated."
}

leaf prior-signed-voucher-request {
  type binary;
  description
  "If it is necessary to change a voucher, or re-sign and forward a voucher that was previously provided along a protocol path, then the previously signed voucher SHOULD be included in this field.
  
  For example, a pledge might sign a proximity voucher, which an intermediate registrar then re-signs to make its own proximity assertion. This is a simple mechanism for a chain of trusted parties to change a voucher, while maintaining the prior signature information.
  
  The pledge MUST ignore all prior voucher information when accepting a voucher for imprinting. Other parties MAY examine the prior signed voucher information for the purposes of policy decisions. For example this information could be useful to a MASA to determine that both pledge and registrar agree on proximity assertions. The MASA SHOULD remove all prior-signed-voucher-request information when signing a voucher for imprinting so as to minimize the final voucher size."
}
6.1.4. Example voucher request artifact

Below is a CBOR serialization of the constrained-voucher-request is shown in diagnostic CBOR notation. The enum value of the assertion field is calculated to be zero by following the algorithm described in section 9.6.4.2 of [RFC7950].

```json
{
  1001154: {
    +2 : "2016-10-07T19:31:42Z", / SID= 1001156, created-on /
    +4 : "2016-10-21T19:31:42Z", / SID= 1001158, expires-on /
    +1 : 2,                       / SID= 1001155, assertion /
                             / "proximity" /
    +13: "JADA123456789",        / SID= 1001167, serial-number /
    +5 : h'01020D0F',            / SID= 1001159, idevid-issuer /
    +10: h'01020D0F',           / SID=1001064, proximity-registrar-cert/
      +3 : true,                / SID= 1001157, domain-cert
                             / -revocation-checks/ 
    +6 : "2017-10-07T19:31:42Z", / SID= 1001160, last-renewal-date /
    +12: h'01020D0F'            / SID= 1001166, proximity-registrar
                             / -subject-public-key-info /
  }
}
```

6.2. Voucher artifact

The voucher’s primary purpose is to securely assign a pledge to an owner. The voucher informs the pledge which entity it should consider to be its owner.

This document defines a voucher that is a CBOR encoded instance of the YANG module defined in Section 5.3 that has been signed with CMS or with COSE.

6.2.1. Tree Diagram

The following diagram is largely a duplicate of the contents of [RFC8366], with only the addition of pinned-domain-subject-public-key-info.
module: ietf-constrained-voucher

grouping voucher-constrained-grouping
  +-- voucher
    +-- created-on?
        |       yang:date-and-time
    +-- expires-on?
        |       yang:date-and-time
    +-- assertion enumeration
    +-- serial-number string
    +-- idevid-issuer? binary
    +-- pinned-domain-cert? binary
    +-- domain-cert-revocation-checks? boolean
    +-- nonce? binary
    +-- last-renewal-date?
        |       yang:date-and-time
    +-- pinned-domain-subject-public-key-info? binary
    +-- pinned-sha256-of-subject-public-key-info? binary

6.2.2. SID values

    SID Assigned to
    ---------------- --------------------------------------------------
    1001104 data /ietf-constrained-voucher:voucher
    1001105 data /ietf-constrained-voucher:voucher/assertion
    1001106 data /ietf-constrained-voucher:voucher/created-on
    1001107 data .../domain-cert-revocation-checks
    1001108 data /ietf-constrained-voucher:voucher.expires-on
    1001109 data /ietf-constrained-voucher:voucher/idevid-issuer
    1001110 data .../last-renewal-date
    1001111 data /ietf-constrained-voucher:voucher/nonce
    1001112 data .../pinned-domain-cert
    1001113 data .../pinned-domain-subject-public-key-info
    1001115 data .../pinned-sha256-of-subject-public-key-info
    1001114 data /ietf-constrained-voucher:voucher/serial-number

6.2.3. YANG Module

In the constrained-voucher YANG module, the voucher is "augmented" within the "used" grouping statement such that one continuous set of SID values is generated for the constrained-voucher module name, all voucher attributes, and the constrained-voucher attribute. Two attributes of the voucher are "refined" to be optional.

<CODE BEGINS> file "ietf-constrained-voucher@2018-09-01.yang"
module ietf-constrained-voucher {
    yang-version 1.1;
namespace
    "urn:ietf:params:xml:ns:yang:ietf-constrained-voucher";
prefix "constrained";

import ietf-restconf {
    prefix rc;
    description
        "This import statement is only present to access
         the yang-data extension defined in  RFC 8040.";
    reference "RFC 8040: RESTCONF Protocol";
}

import ietf-voucher {
    prefix "v";
}

organization
    "IETF ANIMA Working Group";

contact
    "WG Web:  <http://tools.ietf.org/wg/anima/>
    WG List:  <mailto:anima@ietf.org>
    Author:   Michael Richardson
              <mailto:mcr+ietf@sandelman.ca>
    Author:   Peter van der Stok
              <mailto:consultancy@vanderstok.org>
    Author:   Panos Kampanakis
              <mailto: pkampana@cisco.com";

description
    "This module defines the format for a voucher, which is produced
    by a pledge’s manufacturer or delegate (MASA) to securely assign
    one or more pledges to an ‘owner’, so that the pledges may
    establish a secure connection to the owner’s network
    infrastructure.

    This version provides a very restricted subset appropriate
    for very constrained devices.
    In particular, it assumes that nonce-ful operation is
    always required, that expiration dates are rather weak, as no
    clocks can be assumed, and that the Registrar is identified
    by a pinned Raw Public Key.

    The key words ‘MUST’, ‘MUST NOT’, ‘REQUIRED’, ‘SHALL’,
    and ‘OPTIONAL’ in the module text are to be interpreted as
    described in  RFC 2119.";

revision "2018-09-01" {
description
"Initial version";
reference
"RFC XXXX: Voucher Profile for Constrained Devices";
}

rc:yang-data voucher-constrained-artifact {
  // YANG data template for a voucher.
  uses voucher-constrained-grouping;
}

// Grouping defined for future usage
grouping voucher-constrained-grouping {
  description
    "Grouping to allow reuse/extensions in future work.";

  uses v:voucher-artifact-grouping {

    refine voucher/created-on {
      mandatory false;
    }

    refine voucher/pinned-domain-cert {
      mandatory false;
    }

    augment "voucher" {
      description "Base the constrained voucher
          upon the regular one";

      leaf pinned-domain-subject-public-key-info {
        type binary;
        description
          "The pinned-domain-subject-public-key-info replaces the
          pinned-domain-cert in constrained uses of the voucher. The pinned-domain-subject-public-key-info
          is the Raw Public Key of the Registrar. This field is encoded as specified in RFC7250,
          section 3.
          The ECDSA algorithm MUST be supported.
          The EdDSA algorithm as specified in draft-ietf-tls-rfc4492bis-17 SHOULD be supported.
          Support for the DSA algorithm is not recommended.
          Support for the RSA algorithm is a MAY.";

      }

      leaf pinned-sha256-of-subject-public-key-info {
        type binary;
        description
          "The pinned-sha256-of-subject-public-key-info replaces the
          pinned-sha256-of-subject-cert in constrained uses of
          the voucher. The pinned-sha256-of-subject-cert is the SHA256 hash of the
          Raw Public Key of the Registrar. This field is encoded as specified in RFC7250,
          section 3.
          The ECDSA algorithm MUST be supported.
          The EdDSA algorithm as specified in draft-ietf-tls-rfc4492bis-17 SHOULD be supported.
          Support for the DSA algorithm is not recommended.
          Support for the RSA algorithm is a MAY.";

      }
  }
}
"The pinned-hash-subject-public-key-info is a second alternative to pinned-domain-cert. In many cases the public key of the domain has already been transmitted during the key agreement process, and it is wasteful to transmit the public key another two times. The use of a hash of public key info, at 32-bytes for sha256 is a significant savings compared to an RSA public key, but is only a minor savings compared to a 256-bit ECDSA public-key. Algorithm agility is provided by extensions to this specifications which define new leaf for other hash types";

6.2.4. Example voucher artifacts

Below a the CBOR serialization of the constrained-voucher is shown in diagnostic CBOR notation. The enum value of the assertion field is calculated to be zero by following the algorithm described in section 9.6.4.2 of [RFC7950].

```
{
  1001104: {  
    +2 : "2016-10-07T19:31:42Z", / SID = 1001106, created-on /  
    +4 : "2016-10-21T19:31:42Z", / SID = 1001108, expires-on /  
    +1 : 0, / SID = 1001105, assertion /  
      / "verified" /  
    +11: "JADA123456789", / SID = 1001115, serial-number /  
    +5 : h’01020D0F’, / SID = 1001109, idevid-issuer /  
    +8 : h’01020D0F’, / SID = 1001112, pinned-domain-cert/  
    +3 : true, / SID = 1001107, domain-cert  
        -revocation-checks /  
    +6 : "2017-10-07T19:31:42Z", / SID = 1001110, last-renewal-date /  
    +9 : h’01020D0F’ / SID = 1001113, pinned-domain  
        -subject-public-key-info /  
  }
}
```

The signing of the example is shown in Appendix B.1.
6.3. Signing voucher and voucher-request artifacts

6.3.1. CMS signing

The IETF evolution of PKCS#7 is CMS [RFC5652]. The CMS signed voucher is much like the equivalent voucher defined in [RFC8366].

A different eContentType of TBD1 is used to indicate that the contents are in a different format than in [RFC8366].

The ContentInfo structure contains a payload consisting of the CBOR encoded voucher. The [I-D.ietf-core-yang-cbor] use of delta encoding creates a canonical ordering for the keys on the wire. This canonical ordering is not important as there is no expectation that the content will be reproduced during the validation process.

Normally the recipient is the pledge and the signer is the MASA.

[I-D.ietf-anima-bootstrapping-keyinfra] supports both signed and unsigned voucher requests from the pledge to the JRC. In this specification, voucher-request artifact MUST be signed from the pledge to the registrar. From the JRC to the MASA, the voucher-request artifact MUST be signed by the domain owner key which is requesting ownership.

The considerations of [RFC5652] section 5.1, concerning validating CMS objects which are really PKCS7 objects (cmsVersion=1) applies.

The CMS structure SHOULD also contain all the certificates leading up to and including the signer's trust anchor certificate known to the recipient. The inclusion of the trust anchor is unusual in many applications, but without it third parties can not accurately audit the transaction.

The CMS structure MAY also contain revocation objects for any intermediate certificate authorities (CAs) between the voucher-issuer and the trust anchor known to the recipient. However, the use of CRLs and other validity mechanisms is discouraged, as the pledge is unlikely to be able to perform online checks, and is unlikely to have a trusted clock source. As described below, the use of short-lived vouchers and/or pledge provided nonce provides a freshness guarantee.

[EDnote: compulsory signing algorithms are ....]

In Appendix B.1 an example for the CMS signing of the voucher-request is shown.
6.3.2. COSE signing

The COSE-Sign1 structure is discussed in section 4.2 of [RFC8152]. The CBOR object that carries the body, the signature, and the information about the body and signature is called the COSE_Sign1 structure. It is used when only one signature is used on the body. Support for EdDSA 256 with Ed25519 is compulsory.

The supported COSE-sign1 object structure is shown in Figure 1.

```
COSE_Sign1(
    [h'a10126', #{ "alg": EDdsa 256 }]
    { "crv": Ed25519,
      "kty": OKP,
      "key_ops": "verify"
    },
    h'123', #voucher-request binary content
    h'456', #voucher-request binary public signature
]

Figure 1: The cose-sign1 structure.
```

The [COSE-registry] specifies the integers that replace the strings and the mnemonics in Figure 1. In Appendix C a binary cose-sign1 object is shown based on the voucher-request example of Section 6.1.4.

7. Design Considerations

The design considerations for the CBOR encoding of vouchers is much the same as for [RFC8366].

One key difference is that the names of the leaves in the YANG does not have a material effect on the size of the resulting CBOR, as the SID translation process assigns integers to the names.

8. Security Considerations

8.1. Clock Sensitivity

TBD.
8.2. Protect Voucher PKI in HSM

TBD.

8.3. Test Domain Certificate Validity when Signing

TBD.

9. IANA Considerations

9.1. Resource Type Registry

Additions to the sub-registry "CoAP Resource Type", within the "CoRE parameters" registry are specified below. These can be registered either in the Expert Review range (0-255) or IETF Review range (256-9999).

ace.rt.rv needs registration with IANA
ace.rt.vs needs registration with IANA
ace.rt.es needs registration with IANA
ace.rt.ra needs registration with IANA

9.2. The IETF XML Registry

This document registers two URIs in the IETF XML registry [RFC3688]. Following the format in [RFC3688], the following registration is requested:

Registrant Contact: The ANIMA WG of the IETF.
XML: N/A, the requested URI is an XML namespace.

Registrant Contact: The ANIMA WG of the IETF.
XML: N/A, the requested URI is an XML namespace.

9.3. The YANG Module Names Registry

This document registers two YANG modules in the YANG Module Names registry [RFC6020]. Following the format defined in [RFC6020], the following registration is requested:
9.4. The RFC SID range assignment sub-registry

<table>
<thead>
<tr>
<th>Entry-point</th>
<th>Size</th>
<th>Module name</th>
<th>RFC Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1001100</td>
<td>50</td>
<td>ietf-constrained-voucher</td>
<td>[ThisRFC]</td>
</tr>
<tr>
<td>1001150</td>
<td>50</td>
<td>ietf-constrained-voucher-request</td>
<td>[ThisRFC]</td>
</tr>
</tbody>
</table>

Warning: These SID values will change when they transfer to the range 1000 - 59,999 allocated for SIDs in YANG modules defined in RFCs.

9.5. The SMI Security for S/MIME CMS Content Type Registry

This document registers an OID in the "SMI Security for S/MIME CMS Content Type" registry (1.2.840.113549.1.9.16.1), with the value:

<table>
<thead>
<tr>
<th>Decimal</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBD1</td>
<td>id-ct-animaCBORVoucher</td>
<td>[ThisRFC]</td>
</tr>
</tbody>
</table>

EDNOTE: should a separate value be used for Voucher Requests?

9.6. Media-Type Registry

This section registers the ‘application/voucher-cms+cbor’ media type and the ‘application/voucher-cose+cbor’ in the "Media Types" registry. These media types are used to indicate that the content is a CBOR voucher either signed with a cms structure or a COSE_Sign1 structure [RFC8152].

9.6.1. application/voucher-cms+cbor
Type name: application
Subtype name: voucher-cms+cbor
Required parameters: none
Optional parameters: none
Encoding considerations: CMS-signed CBOR vouchers are CBOR encoded.
Security considerations: See Security Considerations, Section
Interoperability considerations: The format is designed to be broadly interoperable.
Published specification: THIS RFC.
Applications that use this media type: ANIMA, 6tisch, and other zero-touch imprinting systems
Additional information:
  Magic number(s): None
  File extension(s): .vch
  Macintosh file type code(s): none
Person & email address to contact for further information: IETF ANIMA WG
Intended usage: LIMITED
Restrictions on usage: NONE
Author: ANIMA WG
Change controller: IETF
Provisional registration? (standards tree only): NO

9.6.2. application/voucher-cose+cbor
Type name: application
Subtype name: voucher-cose+cbor
Required parameters: none
Optional parameters: cose-type
Encoding considerations: COSE_Sign1 CBOR vouchers are COSE objects signed with one signer.
Security considerations: See Security Considerations, Section
Interoperability considerations: The format is designed to be broadly interoperable.
Published specification: THIS RFC.
Applications that use this media type: ANIMA, 6tisch, and other zero-touch imprinting systems
Additional information:
   Magic number(s): None
   File extension(s): .vch
   Macintosh file type code(s): none
Person & email address to contact for further information: IETF ANIMA WG
Intended usage: LIMITED
Restrictions on usage: NONE
Author: ANIMA WG
Change controller: IETF
Provisional registration? (standards tree only): NO

9.7. CoAP Content-Format Registry

Additions to the sub-registry "CoAP Content-Formats", within the "CoRE Parameters" registry are needed for two media types. These can be registered either in the Expert Review range (0-255) or IETF Review range (256-9999).

<table>
<thead>
<tr>
<th>Media type</th>
<th>mime type</th>
<th>Encoding</th>
<th>ID</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>application/voucher-cms+cbor</td>
<td>-</td>
<td>CBOR</td>
<td>TBD2</td>
<td>[This RFC]</td>
</tr>
<tr>
<td>application/voucher-cose+cbor</td>
<td>&quot;COSE-Sign1&quot;</td>
<td>CBOR</td>
<td>TBD3</td>
<td>[This RFC]</td>
</tr>
</tbody>
</table>

10. Acknowledgements

We are very grateful to Jim Schaad for explaining COSE and CMS choices.

Michel Veillette did extensive work on pyang to extend it to support the SID allocation process, and this document was among the first users.

We are grateful for the suggestions done by Esko Dijk.
11. Changelog

-04 voucher and request-voucher MUST be signed examples for signed request are added in appendix IANA SID registration is updated SID values in examples are aligned signed cms examples aligned with new SIDs

-03 Examples are inverted.

-02 Example of requestvoucher with unsigned appllication/cbor is added attributes of voucher "refined" to optional CBOR serialization of vouchers improved Discovery serialization port numbers are specified

-01 application/json is optional, application/cbor is compulsory Cms and cose mediatypes are introduced

12. References

12.1. Normative References


12.2. Informative References

[COSE-registry]
IANA, "CBOR Object Signing and Encryption (COSE) registry", 2017,
<https://www.iana.org/assignments/cose/cose.xhtml>.

[duckling]

[I-D.ietf-netmod-yang-tree-diagrams]

[pledge]
Dictionary.com, "Dictionary.com Unabridged", 2015,

[RFC6690]
Shelby, Z., "Constrained RESTful Environments (CoRE) Link Format", RFC 6690, DOI 10.17487/RFC6690, August 2012,

[RFC7030]
DOI 10.17487/RFC7030, October 2013,
Appendix A. EST messages to EST-coaps

This section extends the examples from Appendix A of [I-D.ietf-ace-coap-est]. The CoAP headers are only worked out for the enrollstatus example.

A.1. enrollstatus

A coaps enrollstatus message can be:

GET coaps://[192.0.2.1:8085]/est/es

The corresponding coap header fields are shown below.

Ver = 1
T = 0 (CON)
Code = 0x01 (0.01 is GET)
Options
  Option (Uri-Path)
    Option Delta = 0xb   (option nr = 11)
    Option Length = 0x3
    Option Value = "est"
  Option (Uri-Path)
    Option Delta = 0x0   (option nr = 11)
    Option Length = 0x2
    Option Value = "es"
Payload = [Empty]

The Uri-Host and Uri-Port Options are omitted because they coincide with the transport protocol destination address and port respectively.

A 2.05 Content response with an unsigned voucher status (ct=60) will then be:

2.05 Content (Content-Format: application/cbor)

With CoAP fields and payload:
Ver=1
T=2 (ACK)
Code = 0x45 (2.05 Content)
Options
  Option1 (Content-Format)
  Option Delta = 0xC  (option nr 12)
  Option Length = 0x2
  Option Value = 60 (application/cbor)

Payload (CBOR diagnostic) = 
{
  "version":"1",
  "Status": 1,  / 1 = Success, 0 = Fail  /
  "Reason":"Informative human readable message",
  "reason-context": "Additional information"
}

Payload (binary) =
A46776657273696F6E61316665374617475730166526561736F6E7822
496E666F726D617469765206756D616E207265616461626C65206D
6573736167656e726561736F6E74657874
7641646974696F6E616C20696E666F72656174696F6E

##voucher_status

A coaps voucher_status message can be:

GET coaps://[2001:db8::2:1]:61616]/est/vs ~~~~

A 2.05 Content response with a non signed CBOR voucher (ct=60) will then be:

  2.05 Content (Content-Format: application/cbor)
  Payload =
A46776657273696F6E61316665374617475730166526561736F6E7822
496E666F726D617469765206756D616E207265616461626C65206D
6573736167656e726561736F6E74657874
7641646974696F6E616C20696E666F72656174696F6E

A.2. requestvoucher

Signed request-voucher-request payloads are sent from pledge to Registrar, as explained in Section 5.2 of
[I-D.ietf-anima-bootstrapping-keyinfra].
A.2.1. signed requestvoucher

A CMS signed requestvoucher message from JRC to MASA is shown below. It would be CoAP POSTED to /est/rv.

```
POST coaps://[2001:db8::2:1]:61616]/est/rv
(Content-Format: application/voucher-cms+cbor)
```

The payload would be in binary, but is presented in base64 in this document.

```
MIIDugYJKoZIhvcNAQcCoIIDqzCCA6cCAQEXDTALBglghkgBZQMEAgEwYJ
KoZIhvcNAQcBoIICQTCCAj0wggHioAMCAQICCH52Yde1TkYyNAoGCCqGSM49
BAMCMF0xCzAJBgNVBAU1VMTQwCQYDVQQIDQTEUMBIGA1UECgwLRXhh
bXBsb2dpZjAAMjAAMGA1UdEQQMeIwYjAfMDQwMDEyMTUxNzoy
MI4xOQIgQ0EwIhIBMTMAMGATMEQwMTk3MTQwMjEwMBMGA1UEAwwvCQYD
VQQIDAQDBgAIeMA4GA1UdDwEB/wQEAwIBurtgMB8GA1UdAQQD/AwQBCw
A1UdEQQMeIwYjAfMDQwMDEyMTUxNzoy
```

A 2.04 Changed response returning CBOR voucher signed with a cms structure(ct=TBD2) will then be:

```
2.04 Changed (Content-Format: application/voucher-cms+cbor)
```
A.3. requestauditing

A coaps requestauditing message contains the signed CBOR voucher:
A 2.05 Content response returning a log of the voucher (ct=60) will then be:
2.05 Content (Content-Format: application/cbor)

Payload =
{
  "version": "1",
  "events": [
    {
      "date": "<date/time of the entry>",
      "domainID": "<domainID extracted from voucher-request>",
      "nonce": "<any nonce if supplied (or the exact string ‘NULL’)>",
      "assertion": "<the value from the voucher assertion leaf>",
      "truncated": "<the number of domainID entries truncated>"
    },
    {
      "date": "<date/time of the entry>",
      "domainID": "<anotherDomainID extracted from voucher-request>",
      "nonce": "<any nonce if supplied (or the exact string ‘NULL’)>",
      "assertion": "<the value from the voucher assertion leaf>"
    }
  ],
  "truncation": {
    "nonced duplicates": "<total number of entries truncated>",
    "nonceless duplicates": "<total number of entries truncated>",
    "arbitrary": "<number of domainID entries removed entirely>"
  }
}

[EDNOTE: Change JSON to CBOR; Serialize CBOR payload to binary]

Appendix B. Signed voucher-request examples

B.1. CMS signed voucher-request example

The voucher-request example, visualized in CBOR diagnostic notation in Section 6.1.4 is shown as a hexadecimal dump of the binary file.

```
A11A00F46C2A90274323031362D31302D30375431393A33313A34325A0
47432303362D31302D32315431393A33313A34325A01020D64A414441
31323334353637383905401020D0F0A4401020D0F03F50674323031372
D31302D30375431393A33313A34325A0c4401020D0F
```

The voucher-request example has been signed by using the WT1234 certificate and key pair shown in Appendix C of [I-D.ietf-ace-coap-est]. The CMS signing of the binary voucher-request leads to a binary signed voucher-request, shown with a hexadecimal representation shown in the payload of the request part of Appendix A.2.1 and Appendix A.3.
The breakdown of the CMS signed binary voucher-request file is visualized below:

CMS_ContentInfo:
- contentType: pkcs7-signedData (1.2.840.113549.1.7.2)
- d.signedData:
  - version: 1
  - digestAlgorithms:
    - algorithm: sha256 (2.16.840.1.101.3.4.2.1)
    - parameter: <ABSENT>
- encapContentInfo:
  - eContentType: pkcs7-data (1.2.840.113549.1.7.1)
  - eContent: <ABSENT>
- certificates:
  - d.certificate:
    - cert_info:
      - version: 2
      - serialNumber: 9112578475118446130
      - signature:
        - algorithm: ecdsa-with-SHA256 (1.2.840.10045.4.3.2)
        - parameter: <ABSENT>
        - issuer: C=US, ST=CA, O=Example Inc, OU=certification,
          CN=802.1AR CA
      - validity:
        - notBefore: Jan 31 11:29:16 2019 GMT
        - notAfter: Dec 31 23:59:59 9999 GMT
        - subject: C=US, ST=CA, L=LA, O=example Inc,
          OU=IoT/serialNumber=Wt1234
      - key:
        - alg:
          - algorithm: id-ecPublicKey (1.2.840.10045.2.1)
          - parameter: OBJECT:prime256v1 (1.2.840.10045.3.1.7)
          - public_key: (0 unused bits)
            0000 - 04 c8 b4 21 f1 1c 25 e4-7e 3a c5 71 23 bf
            000e - 2d 9f dc 49 4f 02 8b c3-51 cc 80 c0 3f 15
            001c - 0b f5 0c ff 95 8d 75 41-9d 81 a6 a2 45 df
            002a - fa e7 90 be 95 cf 75 f6-02 f9 15 26 18 f8
            0038 - 16 a2 b2 3b 56 38 e5 9f-d9
      - issuerUID: <ABSENT>
      - subjectUID: <ABSENT>
      - extensions:
        - object: X509v3 Basic Constraints (2.5.29.19)
          - critical: BOOL ABSENT
          - value:
            0000 - 30
            0002 - <SPACES/NULS>
        - object: X509v3 Subject Key Identifier (2.5.29.14)
critical: BOOL ABSENT
value:
  0000 - 04 14 96 60 0d 87 16 bf-7f d0 e7 52 d0
  000d - ac 76 07 77 ad 66 5d 02-a0

object: X509v3 Authority Key Identifier (2.5.29.35)
critical: BOOL ABSENT
value:
  0000 - 30 16 80 14 68 d1 65 51-f9 51 bf c8 2a
  000d - 43 1d 0d 9f 08 bc 2d 20-5b 11 60

object: X509v3 Key Usage (2.5.29.15)
critical: TRUE
value:
  0000 - 03 02 05 a0

object: X509v3 Subject Alternative Name (2.5.29.17)
critical: BOOL ABSENT
value:
  0000 - 30 21 a0 1f 06 08 2b 06-01 05 05 07 08
  000d - 04 a0 13 30 11 06 09 2b-06 01 04 01 b4
  001a - 3b 0a 01 04 04 01 02 03-04

sig_alg:
  algorithm: ecdsa-with-SHA256 (1.2.840.10045.4.3.2)
  parameter: <ABSENT>
  signature: (0 unused bits)
    0000 - 30 46 02 21 00 c0 d8 19-96 d2 50 7d 69 3f 3c
    000f - 48 ea a5 ee 94 91 bd a6-db 21 40 99 d9 81 17
    001e - c6 3b 36 13 74 cd 86 02-21 00 a7 74 98 9f 4c
    002d - 32 1a 5c f2 5d 83 2a 4d-33 6a 08 ad 67 df 20
    003c - f1 50 64 21 18 8a 0a de-6d 34 92 36

crls:
  <EMPTY>
signerInfos:
  version: 1
d.issuerAndSerialNumber:
    issuer: C=US, ST=CA, O=Example Inc, OU=certification,
    CN=802.1AR CA
    serialNumber: 9112578475118446130
digestAlgorithm:
  algorithm: sha256 (2.16.840.1.101.3.4.2.1)
  parameter: <ABSENT>
signedAttrs:
  object: contentType (1.2.840.113549.1.9.3)
  value.set:
    OBJECT:pkcs7-data (1.2.840.113549.1.7.1)
  object: signingTime (1.2.840.113549.1.9.5)
value.set:
  UTCTIME: Jul 3 08:53:30 2019 GMT

object: messageDigest (1.2.840.113549.1.9.4)
value.set:
  OCTET STRING:
    0000 - d4 b0 5c dd c8 b4 91 28-4a 18 ca 25 9d
    000d - be d0 60 23 cf ad a0 aa-c2 95 ac e9 3f
    001a - 0b 4f 44 9e 25
    0020 - <SPACES/NULS>

signatureAlgorithm:
  algorithm: ecdsa-with-SHA256 (1.2.840.10045.4.3.2)
  parameter: <ABSENT>

signature:
  0000 - 30 46 02 21 00 e5 e1 7f-23 c3 aa 14 9f 35 64
  000f - 1e c4 4a 0f 68 fe b0 16-3b e6 7c 06 51 af bf
  001e - 5a a0 99 59 e0 28 1f 02-21 00 b4 07 2f 7c c4
  002d - f9 26 0c 6d 47 a7 93 56-de b8 da f7 23 f0 af
  003c - 2b 59 16 cc 36 63 e7 91-89 39 df df

unsignedAttrs:
  <EMPTY>

Appendix C.  COSE examples

These examples are from the https://minerva.sandelman.ca/ reference code, using the unit test case key pairs, with a flow between pledge ("reach" code), JRC ("fountain") code, and MASA ("highway") code. This example comes from the spec/files/product/00-D0-E5-F2-00-03 directory.

Thanks to Jim Schaad for verifying the COSE Sign1 objects: faults were found and corrected.

C.1. Device, Registrar and MASA keys

This first section documents the public and private keys used in the subsequent test vectors below. These keys come from test code and are not used in any production system, and should only be used only to validate implementations.

C.1.1. Device IDevID certificate
Certificate:
Data:
  Version: 3 (0x2)
  Serial Number: 787697345 (0x2ef34ec1)
  Signature Algorithm: ecdsa-with-SHA256
  Issuer: C = Canada, ST = Ontario, OU = Sandelman, CN = highway-test.example.com CA
Validity
  Not Before: Feb 14 17:05:09 2019 GMT
  Not After : Dec 31 00:00:00 2999 GMT
Subject: serialNumber = 00-D0-E5-F2-00-03
Subject Public Key Info:
  Public Key Algorithm: id-ecPublicKey
  Public-Key: (256 bit)
    pub:
      4d:7e:b0:00:ed:c0:de:bd:4d:25:55:4e:35:5f:d9:d5:
      86:a4:0c:8b:b7
  ASN1 OID: prime256v1
  NIST CURVE: P-256
X509v3 extensions:
  X509v3 Subject Key Identifier:
  X509v3 Basic Constraints:
    CA:FALSE
  X509v3 Subject Alternative Name:
    othername:<unsupported>
      1.3.6.1.4.1.46930.2:
        ..highway-test.example.com:9443
Signature Algorithm: ecdsa-with-SHA256

C.1.2. Device private key

-----BEGIN EC PRIVATE KEY-----
MHcCAQEElha014bkj/rJxPUN1bKSBNYo1VVzx+t28wo60cYpuaoAoGCCqGSM49
AwEHoUQQgAEgsQcW3zwNnjHkBtcY/RNfrAA7cDevU01Vu41+dVqVxs01k/ObVPI
YMLQRez8sG0Lwx1fswXs98y1UhoAgpAyI+tw==
-----END EC PRIVATE KEY-----
C.1.3. Registrar Certificate

-----BEGIN CERTIFICATE-----
MIIB0TCCAVagAwIBAgIBAjAKBggqhkjOPQDAzBxAzMIwEAYKCZIimiZPyLGQBGRYC
Y2ExGTAXBgoJkiaJk/IsZAEZFglzYW5kZ2xtYW4xQDAR+BgNVBAMMYmM8U31zdGVt
VmFyaWFibGU6MHgwdGApM0JdMFkwEwYHdhc3QxMTIwMjEDMCNjMCUGA1UECgwK

C.1.4. Registrar private key

-----BEGIN EC PRIVATE KEY-----
MHcCAQEEIFZodk+PC5Mu24+ra0sb0jKzan+dW5rvDAR7yuJUC1YoAoGCCqGSM49
AwEHoQDGqAgA1ElnVqjS6n+Xd51/28IFv6iiegQwSBztGj5dkK2MAjQIPV8181H+E
jLOydjiI0VTEiF1/Jqt+TO8fI16o7jg==
-----END EC PRIVATE KEY-----

C.1.5. MASA Certificate

-----BEGIN CERTIFICATE-----
MIIB3zCCAWSgAwIBAgIEG5lfVDAKBggqhkjOPQDAjBdMQ8wDQYDVQQGEwZDYW5h
ZGEEXDDOgBqNVBAM6B09udGyA8E1AQBqNVBAcMVhbmRlbißjekMCIG1AUE
AwwbaGlinaHdheSIXZXNOlM4VYW1wbGUY29tIENMBBM4XDE5IM1xNjlyMjI0MVQX
DTIxMDIxMTIxMjI0MVQxZEVQVzEAEEAwHliMRAwMRAwDQYDVQQIDAdPbmcgQ0Eg

C.1.6. MASA private key

-----BEGIN EC PRIVATE KEY-----
MHcCAQEEIFhdd0eDdzip67kXx72K+KHQXKQYJHNy8pkiLJ6CcvxMGgAoGACcGgGSM49
AwEHoQDGqAgEeqQ0V54kTI4yfkbXumdB0MHzvc3QxMTIwMjEDMCNjMCUGA1UECgwK

C.2. COSE signed request voucher with registrar certificate pinned

This voucher request has been signed by the pledge, using the private key given above, and has been sent to the JRC over CoAPS. This example uses the proximity-registrar-cert mechanism to request a voucher that pins the certificate of the registrar.

This is the CBOR diagnostic format, folded to 60 characters:

```
18([h’A0’, {}, h’A11A000F46C2A5016970726F78696D69747902C11A5
D1E49970A5130302D44302D45352D46322D3032D303307765F715674777
38565342626C65394D34557036354C770C5901D4308201D030820157A00
320102020228ED273000A06082A8648CE3D040302306E31123010060A0
** KNOWN TO BE BAD, NOT YET VALIDATED **
03404E6D0F9F702553FA53BE572ACF0EED858275B6AC75994332FB25FB3
A54411E9FA02E6F75FD11ADB7EA9A61F5409E0230E615E75C8F07432A59
0CB84B99B5DAE4BEB49E5787E0EA518BD17A02D02F031D144816002F756
B528ABD180ADB749D’, h’96B82530AC57650346C2BFFB5A66CC16B28F16F
ACFE5A2F1D8CF3D5F5D62733F7F7812D67D43BE1CF9906E356FB0C2BDD36
777FD7DBAE22B8CEB07D518F55AD3’})
```

This is the raw binary, encoded in base64:

```
0oRBoKBZAhyyGgAPRsKLAW1wc94a1WpdHkCwrpdHkmXC1EmC1EMC1FNS1G
Mi0wMC0wMwd2X3FwEd3OFZtQmJsZTiNNFVwNjWmdwZAdQwggHQMIBV6AD
** KNOWN TO BE BAD, NOT YET VALIDATED **
NA90bQ+fcCVT+i0+YvrFdu2FgmnW2rHWZQzL7Jfs6VEEn6Aub3X9Gq236pFh
9UCeAjA+YV5lyPB0MqQynyNShml7aHrSeXn20DqEYvRegLQlwMT0USBYAL3Vr
Uog9GrbdJYQQa4JTCsV2UDRsK/+ipswWso8W+s/lov0bz9fXWJzP394Et
Z9Q74c+ZBuNW+wwr3T3f9fbrIK4zrB9udjlWtM=
```

C.3. COSE signed parboiled request voucher

This voucher request has been signed by the JRC using the private key from Appendix C.1.4. Contained within this voucher request is the pledge voucher request above.

This is the CBOR diagnostic format, folded to 60 characters:
The resulting voucher is created by the MASA and returned via the JRC to the Pledge. It is signed by the MASA’s private key Appendix C.1.6 and can be verified by the pledge using the MASA’s public key.

This is the CBOR diagnostic format, folded to 60 characters:

```
C.4. COSE signed voucher

The resulting voucher is created by the MASA and returned via the JRC to the Pledge. It is signed by the MASA’s private key Appendix C.1.6 and can be verified by the pledge using the MASA’s public key.

This is the CBOR diagnostic format, folded to 60 characters:
```
This is the raw binary, encoded in base64:

```
0oRBoKBZArmhGgAPRoylBWZsb2dnZWQGwRpdHkmaDnEwMC1EMC1FNS1GMi0wMC0wMwt2X3FwEdE3OFZTqmJ5zZ11NNFwWjVMdwX5AnRNSUICMFRQOFWyWyDbd1OeQWd3QfQucCzzdaGtqT1BRURURBekJ4TVjJd0VBBUtdWKltaVpQeUxHUUJHU11DWTJFEdEUQVHKx29ka2hSmsvSXAnQVUArdmsel1XNwtaV3h0WvC0eEFQgScZ050qFKnENtU55THVMv2x6EDwdFtzEtnhV0ZpykVDNk11IZndNREF3TURBud505HTWNVEzCTUQO21ZNXpksEoxYmljZ1JuOTlfbJJoVycQ021EwRXdiaGNOnTVrjeE1UQTNXak0w0T1RJNe0d0Y5NGT4tTVRBM01qTVTBBE02pCRE1SXdQFVQlQ1jWlaU1HmNR1FCR1JQqlyRXhHEFYQmdvSmtpYjprlOl1wzKFWkZnBhHpvVzWrd4dFLXHhFakFRQmdvOKjBTU1DV3h2WTJiC2FHOXpRUEaTUJRJnu05cdUtTDTTQ5QdFROdUdTTTQ5QdFSEeweSUCh1psVUHJMVWvL2w2VzpmOZDQmIrbE1ubOVNRGd3j11JkVIkaQ3RqOuKQoQx2kpmS11vaE15eURtSdF5W10RMJ5SQg5zn1hcmZredYNAwelr1pEnFqRFBTE1Ba0dBMVVRXDRQ1OQXdZ1IJ2osA3xPqMEVBd01EYVFBD1pNSXhBTFNFNtVYz2jh0dj9wbfJPRDVEUVhJ1URkS5X1MFWMc5UUvKFrRNMr1KZo0VU1JCU21H050qAHRvBEPaEv1TvdjeEFKNG5Zkx5K0Qjyl1pST21JaVVFYR3S1eoR12YYU11WSGN24zOxd3S2NC1NPbRomROUHHDcE9FTGw2YnEzQ1pxUT09WEB0PsWpANf2vUQ2/WoJ2e2+4Sc+6iw1ld61SSJAOS81usi/nSzmChy3S3GUS+1NHLS419Z1S6aKtIEacch2
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Authors’ Addresses

Michael Richardson
Sandelman Software Works
Email: mcr+ietf@sandelman.ca

Peter van der Stok
vanderstok consultancy
Email: consultancy@vanderstok.org

Panos Kampanakis
Cisco Systems
Email: pkampana@cisco.com