

CoRE
Internet-Draft
Intended status: Standards Track
Expires: June 14, 2014

Z. Shelby
ARM
C. Bormann
Universitaet Bremen TZI
S. Krco
Ericsson
December 11, 2013

CoRE Resource Directory
draft-ietf-core-resource-directory-01

Abstract

In many M2M applications, direct discovery of resources is not practical due to sleeping nodes, disperse networks, or networks where multicast traffic is inefficient. These problems can be solved by employing an entity called a Resource Directory (RD), which hosts descriptions of resources held on other servers, allowing lookups to be performed for those resources. This document specifies the web interfaces that a Resource Directory supports in order for web servers to discover the RD and to register, maintain, lookup and remove resources descriptions. Furthermore, new link attributes useful in conjunction with an RD are defined.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <http://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on June 14, 2014.

Copyright Notice

Copyright (c) 2013 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal

Provisions Relating to IETF Documents

(<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1.	Introduction	3
2.	Terminology	3
3.	Architecture and Use Cases	4
3.1.	Use Case: Cellular M2M	5
3.2.	Use Case: Home and Building Automation	6
4.	Simple Directory Discovery	6
4.1.	Finding a Directory Server	7
5.	Resource Directory Function Set	8
5.1.	Discovery	8
5.2.	Registration	10
5.3.	Update	12
5.4.	Removal	14
6.	Group Function Set	15
6.1.	Register a Group	15
6.2.	Group Removal	17
7.	RD Lookup Function Set	18
8.	New Link-Format Attributes	22
8.1.	Resource Instance 'ins' attribute	22
8.2.	Export 'exp' attribute	23
9.	DNS-SD Mapping	23
10.	Security Considerations	23
11.	IANA Considerations	23
11.1.	Resource Types	23
11.2.	Link Extension	24
11.3.	RD Parameter Registry	24
12.	Acknowledgments	25
13.	Changelog	25
14.	References	26
14.1.	Normative References	26
14.2.	Informative References	27
	Authors' Addresses	28

1. Introduction

The Constrained RESTful Environments (CoRE) work aims at realizing the REST architecture in a suitable form for the most constrained nodes (e.g. 8-bit microcontrollers with limited RAM and ROM) and networks (e.g. 6LoWPAN). CoRE is aimed at machine-to-machine (M2M) applications such as smart energy and building automation.

The discovery of resources offered by a constrained server is very important in machine-to-machine applications where there are no humans in the loop and static interfaces result in fragility. The discovery of resources provided by an HTTP Web Server is typically called Web Linking [[RFC5988](#)]. The use of Web Linking for the description and discovery of resources hosted by constrained web servers is specified by the CoRE Link Format [[RFC6690](#)]. This specification however only describes how to discover resources from the web server that hosts them by requesting /.well-known/core. In many M2M scenarios, direct discovery of resources is not practical due to sleeping nodes, disperse networks, or networks where multicast traffic is inefficient. These problems can be solved by employing an entity called a Resource Directory (RD), which hosts descriptions of resources held on other servers, allowing lookups to be performed for those resources.

This document specifies the web interfaces that a Resource Directory supports in order for web servers to discover the RD and to register, maintain, lookup and remove resource descriptions. Furthermore, new link attributes useful in conjunction with a Resource Directory are defined. Although the examples in this document show the use of these interfaces with CoAP [[I-D.ietf-core-coap](#)], they can be applied in an equivalent manner to HTTP [[RFC2616](#)].

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [[RFC2119](#)]. The term "byte" is used in its now customary sense as a synonym for "octet".

This specification requires readers to be familiar with all the terms and concepts that are discussed in [[RFC5988](#)] and [[RFC6690](#)]. Readers should also be familiar with the terms and concepts discussed in [[I-D.ietf-core-coap](#)]. The URI Template format is used to describe the REST interfaces defined in this specification [[RFC6570](#)]. This specification makes use of the following additional terminology:

Resource Directory

An web entity that stores information about web resources and implements the REST interfaces defined in this specification for registration and lookup of those resources.

Domain

In the context of a Resource Directory, a domain is a logical grouping of endpoints. This specification assumes that the list of Domains supported by an RD is pre-configured by that RD.

Group

In the context of a Resource Directory, a group is a logical grouping of endpoints for the purpose of group communications. All groups within a domain are unique.

Endpoint

An endpoint (EP) is a term used to describe a web server or client in [[I-D.ietf-core-coap](#)]. In the context of this specification an endpoint is used to describe a web server that registers resources to the Resource Directory. An endpoint is identified by its endpoint name, which is included during registration, and is unique within the associated domain of the registration.

3. Architecture and Use Cases

The resource directory architecture is shown in Figure 1. A Resource Directory (RD) is used as a repository for Web Links [[RFC5988](#)] about resources hosted on other web servers, which are called endpoints (EP). An endpoint is a web server associated with an IP address and port, thus a physical node may host one or more endpoints. The RD implements a set of REST interfaces for endpoints to register and maintain sets of Web Links (called resource directory entries), for the RD to validate entries, and for clients to lookup resources from the RD. Endpoints themselves can also act as clients. An RD can be logically segmented by the use of Domains. The domain an endpoint is associated with can be defined by the RD or configured by an outside entity.

Endpoints are assumed to proactively register and maintain resource directory entries on the RD, which are soft state and need to be periodically refreshed. An endpoint is provided with interfaces to register, update and remove a resource directory entry. Furthermore, a mechanism to discover a RD using the CoRE Link Format is defined. It is also possible for an RD to proactively discover Web Links from endpoints and add them as resource directory entries, or to validate existing resource directory entries. A lookup interface for discovering any of the Web Links held in the RD is provided using the

CoRE Link Format.

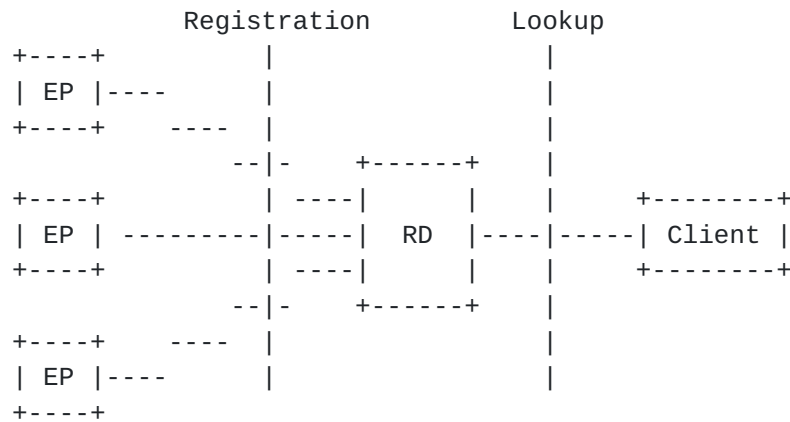


Figure 1: The resource directory architecture.

3.1. Use Case: Cellular M2M

Over the last few years, mobile operators around the world have focused on development of M2M solutions in order to expand the business to the new type of users, i.e. machines. The machines are connected directly to a mobile network using appropriate embedded air interface (GSM/GPRS, WCDMA, LTE) or via a gateway providing short and wide range wireless interfaces. From the system design point of view, the ambition is to design horizontal solutions that can enable utilization of machines in different applications depending on their current availability and capabilities as well as application requirements, thus avoiding silo like solutions. One of the crucial enablers of such design is the ability to discover resources (machines - endpoints) capable of providing required information at a given time or acting on instructions from the end users.

In a typical scenario, during a boot-up procedure (and periodically afterwards), the machines (endpoints) register with a Resource Directory (for example EPs installed on vehicles enabling tracking of their position for the fleet management purposes and monitoring environment parameters) hosted by the mobile operator or somewhere else in the network, periodically a description of its own capabilities. Due to the usual network configuration of mobile networks, the EPs attached to the mobile network do not have routable addresses. Therefore, a remote server is usually used to provide proxy access to the EPs. The address of each (proxy) endpoint on this server is included in the resource description stored in the RD. The users, for example mobile applications for environment monitoring, contact the RD, look-up the endpoints capable of

providing information about the environment using appropriate set of link parameters, obtain information on how to contact them (URLs of the proxy server) and then initiate interaction to obtain information that is finally processed, displayed on the screen and usually stored in a database. Similarly, fleet management systems provide the appropriate link parameters to the RD to look-up for EPs deployed on the vehicles the application is responsible for.

3.2. Use Case: Home and Building Automation

Home and commercial building automation systems can benefit from the use of M2M web services. The use of CoRE in home automation across multiple subnets is described in [[I-D.brandt-coap-subnet-discovery](#)] and in commercial building automation in [[I-D.vanderstok-core-bc](#)]. The discovery requirements of these applications are demanding. Home automation usually relies on run-time discovery to commission the system, whereas in building automation a combination of professional commissioning and run-time discovery is used. Both home and building automation involve peer-to-peer interactions between endpoints, and involve battery-powered sleeping devices.

The exporting of resource information to other discovery systems is also important in these automation applications. In home automation there is a need to interact with other consumer electronics, which may already support DNS-SD, and in building automation larger resource directories or DNS-SD covering multiple buildings.

4. Simple Directory Discovery

Not all endpoints hosting resources are expected to know how to implement the Resource Directory Function Set and thus explicitly register with a Resource Directory (or other such directory server). Instead, simple endpoints can implement the generic Simple Directory Discovery approach described in this section. An RD implementing this specification MUST implement Simple Directory Discovery. However, there may be security reasons why this form of directory discovery would be disabled.

This approach requires that the endpoint makes available the hosted resources that it wants to be discovered, as links on its /.well-known/core interface as specified in [[RFC6690](#)].

The endpoint then finds one or more IP addresses of the directory server it wants to know about its resources as described in [Section 4.1](#).

An endpoint that wants to make itself discoverable occasionally sends

a POST request to the /.well-known/core URI of any candidate directory server that it finds. The body of the POST request is either

- o empty, in which case the directory server is encouraged by this POST request to perform GET requests at the requesting server's default discovery URI.

or

- o a non-empty link-format document, which indicates the specific services that the requesting server wants to make known to the directory server.

The directory server integrates the information it received this way into its resource directory. It MAY make the information available to further directories, if it can ensure that a loop does not form. The protocol used between directories to ensure loop-free operation is outside the scope of this document.

The following example shows an endpoint using simple resource discovery, by simply sending a POST with its links in the body to a directory.

EP	RD
-- POST /.well-known/core "</sen/temp>..." --->	
<----- 2.01 Created -----	

4.1. Finding a Directory Server

Endpoints that want to contact a directory server can obtain candidate IP addresses for such servers in a number of ways.

In a 6LoWPAN, good candidates can be taken from:

- o specific static configuration (e.g., anycast addresses), if any,
- o the ABRO option of 6LoWPAN-ND [[RFC6775](#)],

- o other ND options that happen to point to servers (such as RDNSS),
- o DHCPv6 options that might be defined later.

In networks with more inexpensive use of multicast, the candidate IP address may be a well-known multicast address, i.e. directory servers are found by simply sending POST requests to that well-known multicast address (details TBD).

As some of these sources are just (more or less educated) guesses, endpoints MUST make use of any error messages to very strictly rate-limit requests to candidate IP addresses that don't work out. E.g., an ICMP Destination Unreachable message (and, in particular, the port unreachable code for this message) may indicate the lack of a CoAP server on the candidate host, or a CoAP error response code such as 4.05 "Method Not Allowed" may indicate unwillingness of a CoAP server to act as a directory server.

5. Resource Directory Function Set

This section defines the REST interfaces between an RD and endpoint servers, which is called the Resource Directory Function Set. Although the examples throughout this section assume use of CoAP [[I-D.ietf-core-coap](#)], these REST interfaces can also be realized using HTTP [[RFC2616](#)]. An RD implementing this specification MUST support the discovery, registration, update, and removal interfaces defined in this section.

Resource directory entries are designed to be easily exported to other discovery mechanisms such as DNS-SD. For that reason, parameters that would meaningfully be mapped to DNS are limited to a maximum length of 63 bytes.

5.1. Discovery

Before an endpoint can make use of an RD, it must first know the RD's IP address, port and the path of its RD Function Set. There can be several mechanisms for discovering the RD including assuming a default location (e.g. on an Edge Router in a LowPAN), by assigning an anycast address to the RD, using DHCP, or by discovering the RD using the CoRE Link Format (also see [Section 4.1](#)). This section defines discovery of the RD using the well-known interface of the CoRE Link Format [[RFC6690](#)] as the required mechanism. It is however expected that RDs will also be discoverable via other methods depending on the deployment.

Discovery is performed by sending either a multicast or unicast GET

request to `/.well-known/core` and including a Resource Type (`rt`) parameter [[RFC6690](#)] with the value `"core.rd"` in the query string. Likewise, a Resource Type parameter value of `"core.rd-lookup"` is used to discover the RD Lookup Function Set. Upon success, the response will contain a payload with a link format entry for each RD discovered, with the URL indicating the root resource of the RD. When performing multicast discovery, the multicast IP address used will depend on the scope required and the multicast capabilities of the network.

An RD implementation of this specification MUST support query filtering for the `rt` parameter as defined in [[RFC6690](#)].

The discovery request interface is specified as follows:

Interaction: EP -> RD

Method: GET

URI Template: `/.well-known/core{?rt}`

URI Template Variables:

`rt` := Resource Type (optional). MAY contain the value `"core.rd"`, `"core.rd-lookup"`, `"core.rd-group"` or `"core.rd*"`

Content-Type: `application/link-format` (if any)

The following response codes are defined for this interface:

Success: 2.05 "Content" with an `application/link-format` payload containing a matching entry for the RD resource.

Failure: 4.04 "Not Found" is returned in case no matching entry is found for a unicast request.

Failure: 4.00 "Bad Request" is returned in case of a malformed request for a unicast request.

Failure: No error response to a multicast request.

The following example shows an endpoint discovering an RD using this interface, thus learning that the base RD resource is at `/rd`. Note that it is up to the RD to choose its base RD resource, although it is recommended to use the base paths specified here where possible.


```

EP                                     RD
|                                     |
| ----- GET /.well-known/core?rt=core.rd* -----> |
|                                     |
|                                     |
| <----- 2.05 Content "</rd>; rt="core.rd" ----- |
|                                     |

```

Req: GET coap://[ff02::1]/.well-known/core?rt=core.rd*

Res: 2.05 Content
 </rd>;rt="core.rd",
 </rd-lookup>;rt="core.rd-lookup",
 </rd-group>;rt="core.rd-group"

5.2. Registration

After discovering the location of an RD Function Set, an endpoint MAY register its resources using the registration interface. This interface accepts a POST from an endpoint containing the list of resources to be added to the directory as the message payload in the CoRE Link Format [[RFC6690](#)] or JSON Link Format [[I-D.ietf-core-links-json](#)] along with query string parameters indicating the name of the endpoint, its domain and the lifetime of the registration. All parameters except the endpoint name are optional. It is expected that other specifications MAY define further parameters (it is to be determined if a registry of parameters is needed for this purpose). The RD then creates a new resource or updates an existing resource in the RD and returns its location. An endpoint MUST use that location when refreshing registrations using this interface. Endpoint resources in the RD are kept active for the period indicated by the lifetime parameter. The endpoint is responsible for refreshing the entry within this period using either the registration or update interface. The registration interface MUST be implemented to be idempotent, so that registering twice with the same endpoint parameter does not create multiple RD entries.

The registration request interface is specified as follows:

Interaction: EP -> RD

Method: POST

URI Template: /{+rd}{?ep,d,et,lt,con}

URI Template Variables:

rd := RD Function Set path (mandatory). This is the path of the RD Function Set. An RD SHOULD use the value "rd" for this variable whenever possible.

ep := Endpoint (mandatory). The endpoint identifier or name of the registering node, unique within that domain. The maximum length of this parameter is 63 bytes.

d := Domain (optional). The domain to which this endpoint belongs. The maximum length of this parameter is 63 bytes. Optional. When this parameter is elided, the RD MAY associate the endpoint with a configured default domain.

et := Endpoint Type (optional). The semantic type of the endpoint. The maximum length of this parameter is 63 bytes. Optional.

lt := Lifetime (optional). Lifetime of the registration in seconds. Range of 60-4294967295. If no lifetime is included, a default value of 86400 (24 hours) SHOULD be assumed.

con := Context (optional). This parameter sets the scheme, address and port at which this server is available in the form scheme://host:port. Optional. In the absence of this parameter the scheme of the protocol, source IP address and source port of the register request are assumed.

Content-Type: application/link-format

Content-Type: application/link-format+json

The following response codes are defined for this interface:

Success: 2.01 "Created". The Location header MUST be included with the new resource entry for the endpoint. This Location MUST be a stable identifier generated by the RD as it is used for all subsequent operations on this registration. The resource returned in the Location is only for the purpose of the Update (PUT) and Removal (DELETE), and MUST NOT implement GET or POST methods.

Failure: 4.00 "Bad Request". Malformed request.

Failure: 5.03 "Service Unavailable". Service could not perform the operation.

The following example shows an endpoint with the name "node1" registering two resources to an RD using this interface. The resulting location /rd/4521 is just an example of an RD generated location.

EP	RD
--- POST /rd?ep=node1 "</sensors..." ----->	
<-- 2.01 Created Location: /rd/4521 -----	

Req: POST coap://rd.example.com/rd?ep=node1

Payload:

```
</sensors/temp>;ct=41;rt="temperature-c";if="sensor",
</sensors/light>;ct=41;rt="light-lux";if="sensor"
```

Res: 2.01 Created

Location: /rd/4521

[5.3.](#) Update

The update interface is used by an endpoint to refresh or update its registration with an RD. To use the interface, the endpoint sends a PUT request to the resource returned in the Location option in the response to the first registration. An update MAY contain registration parameters if there have been changes since the last registration or update. Parameters that have not changed SHOULD NOT be included in an update. Upon receiving an update request, the RD resets the timeout for that endpoint and stores the values of the parameters included in the update (if any).

The update request interface is specified as follows:

Interaction: EP -> RD

Method: PUT

URI Template: /{+location}{?et,lt,con}

URI Template Variables:

location := This is the Location path returned by the RD as a result of a successful registration.

et := Endpoint Type (optional). The semantic type of the endpoint. The maximum length of this parameter is 63 bytes. Optional.

lt := Lifetime (optional). Lifetime of the registration in seconds. Range of 60-4294967295. If no lifetime is included, a default value of 86400 (24 hours) SHOULD be assumed.

con := Context (optional). This parameter sets the scheme, address and port at which this server is available in the form scheme://host:port. Optional. In the absence of this parameter the scheme of the protocol, source IP address and source port used to register are assumed.

Content-Type: None

The following response codes are defined for this interface:

Success: 2.04 "Changed" in the update was successfully processed.

Failure: 4.00 "Bad Request". Malformed request.

Failure: 5.03 "Service Unavailable". Service could not perform the operation.

The following example shows an endpoint updating a new set of resources to an RD using this interface.

EP	RD
--- PUT /rd/4521 ----->	
<-- 2.04 Changed -----	

Req: PUT /rd/4521

Res: 2.04 Changed

5.4. Removal

Although RD entries have soft state and will eventually timeout after their lifetime, an endpoint **SHOULD** explicitly remove its entry from the RD if it knows it will no longer be available (for example on shut-down). This is accomplished using a removal interface on the RD by performing a DELETE on the endpoint resource.

The removal request interface is specified as follows:

Interaction: EP -> RD

Method: DELETE

URI Template: /{+location}

URI Template Variables:

location := This is the Location path returned by the RD as a result of a successful registration.

The following responses codes are defined for this interface:

Success: 2.02 "Deleted" upon successful deletion

Failure: 4.00 "Bad Request". Malformed request.

Failure: 5.03 "Service Unavailable". Service could not perform the operation.

The following examples shows successful removal of the endpoint from the RD.

```

EP                                     RD
|                                     |
| --- DELETE /rd/4521 ----->    |
|                                     |
|                                     |
| <-- 2.02 Deleted -----         |
|                                     |

```


Req: DELETE /rd/4521

Res: 2.02 Deleted

6. Group Function Set

This section defines a function set for the creation of groups of endpoints for the purpose of managing and looking up endpoints for group operations. The group function set is similar to the resource directory function set, in that a group may be created or removed. However unlike an endpoint entry, a group entry consists of a list of endpoints and does not have a lifetime associated with it. In order to make use of multicast requests with CoAP, a group MAY have a multicast address associated with it.

6.1. Register a Group

In order to create a group, a management entity used to configure groups, makes a request to the RD indicating the name of the group to create (or update), the optional domain the group belongs to, and the optional multicast address of the group. The registration message includes the list of endpoints that belong to that group. If an endpoint has already registered with the RD, the RD attempts to use the context of the endpoint from its RD endpoint entry. If the client registering the group knows the endpoint has already registered, then it MAY send a blank target URI for that endpoint link when registering the group. Configuration of the endpoints themselves is out of scope of this specification. Such an interface for managing the group membership of an endpoint has been defined in [[I-D.ietf-core-groupcomm](#)].

The registration request interface is specified as follows:

Interaction: Manager -> RD

Method: POST

URI Template: /{+rd-group}{?gp,d,con}

URI Template Variables:

rd-group := RD Group Function Set path (mandatory). This is the path of the RD Group Function Set. An RD SHOULD use the value "rd-group" for this variable whenever possible.

gp := Group Name (mandatory). The name of the group to be created or replaced, unique within that domain. The maximum length of this parameter is 63 bytes.

d := Domain (optional). The domain to which this group belongs. The maximum length of this parameter is 63 bytes. Optional. When this parameter is elided, the RD MAY associate the endpoint with a configured default domain.

con := Context (optional). This parameter is used to set the IP multicast address at which this server is available in the form scheme://multicast-address:port. Optional. In the absence of this parameter no multicast address is configured.

Content-Type: application/link-format

Content-Type: application/link-format+json

The following response codes are defined for this interface:

Success: 2.01 "Created". The Location header MUST be included with the new group entry. This Location MUST be a stable identifier generated by the RD as it is used for delete operations on this registration.

Failure: 4.00 "Bad Request". Malformed request.

Failure: 5.03 "Service Unavailable". Service could not perform the operation.

The following example shows a group with the name "lights" registering two endpoints to an RD using this interface. The resulting location /rd-group/12 is just an example of an RD generated group location.

EP	RD
- POST /rd-group?gp=lights "<>;ep=node1..." -->	
<----- 2.01 Created Location: /rd-group/12 -----	

Req: POST coap://rd.example.com/rd-group?gp=lights

Payload:

<>;ep="node1",

<>;ep="node2"

Res: 2.01 Created

Location: /rd-group/12

6.2. Group Removal

A group can be removed simply by sending a removal message to the location returned when registering the group. Removing a group **MUST NOT** remove the endpoints of the group from the RD.

The removal request interface is specified as follows:

Interaction: Manager -> RD

Method: DELETE

URI Template: /{+location}

URI Template Variables:

location := This is the Location path returned by the RD as a result of a successful group registration.

The following responses codes are defined for this interface:

Success: 2.02 "Deleted" upon successful deletion

Failure: 4.00 "Bad Request". Malformed request.

Failure: 5.03 "Service Unavailable". Service could not perform the operation.

The following examples shows successful removal of the group from the RD.

EP	RD
--- DELETE /rd-group/412 ----->	
<-- 2.02 Deleted -----	

Req: DELETE /rd-group/12

Res: 2.02 Deleted

7. RD Lookup Function Set

In order for an RD to be used for discovering resources registered with it, a lookup interface can be provided using this function set. This lookup interface is defined as a default, and it is assumed that RDs may also support lookups to return resource descriptions in alternative formats (e.g. Atom or HTML Link) or using more advanced interfaces (e.g. supporting context or semantic based lookup).

This function set allows lookups for domains, groups, endpoints and resources using attributes defined in the RD Function Set and for use with the CoRE Link Format. The result of a lookup request is the list of links (if any) in CoRE Link Format corresponding to the type of lookup. The target of these links SHOULD be the actual location of the domain, endpoint or resource, but MAY be an intermediate proxy e.g. in the case of an HTTP lookup interface for CoAP endpoints. Multiple query parameters MAY be included in a lookup, all included parameters MUST match for a resource to be returned. The character '*' MAY be included at the end of a parameter value as a wildcard operator.

The lookup interface is specified as follows:

Interaction: Client -> RD

Method: GET

URI Template: `/[+rd-lookup-base]/
{lookup-type}{?d,ep,gp,et,rt,page,count,resource-param}`

Parameters:

`rd-lookup-base` := RD Lookup Function Set path (mandatory). This is the path of the RD Lookup Function Set. An RD SHOULD use the value "rd-lookup" for this variable whenever possible.

`lookup-type` := ("d", "ep", "res", "gp") (mandatory) This variable is used to select the kind of lookup to perform (domain, endpoint or resource).

ep := Endpoint (optional). Used for endpoint, group and resource lookups.

d := Domain (optional). Used for domain, group, endpoint and resource lookups.

page := Page (optional). Parameter can not be used without the count parameter. Results are returned from result set in pages that contains 'count' results starting from index (page * count).

count := Count (optional). Number of results is limited to this parameter value. If the parameter is not present, then an RD implementation specific default value SHOULD be used.

rt := Resource type (optional). Used for group, endpoint and resource lookups.

et := Endpoint type (optional). Used for group, endpoint and resource lookups.

resource-param := Link attribute parameters (optional). Any link attribute as defined in [Section 4.1 of \[RFC6690\]](#), used for resource lookups.

The following responses codes are defined for this interface:

Success: 2.05 "Content" with an application/link-format or application/link-format+json payload containing a matching entries for the lookup.

Failure: 4.04 "Not Found" in case no matching entry is found for a unicast request.

Failure: No error response to a multicast request.

Failure: 4.00 "Bad Request". Malformed request.

Failure: 5.03 "Service Unavailable". Service could not perform the operation.

The following example shows a client performing a resource lookup:

[illegible]

Req: GET /rd-lookup/res?rt=temperature

```
Res: 2.05 Content
<coap://{ip:port}/temp>
```

The following example shows a client performing an endpoint lookup:

```
Client                                                                    RD
|                                                                           |
| ----- GET /rd-lookup/ep?et=power-node -----> |
|                                                     |
|                                                     |
| <-- 2.05 Content "<coap://{ip:port}>;ep="node5" ----- |
|                                                     |
```

Req: GET /rd-lookup/ep?et=power-node

```
Res: 2.05 Content
<coap://{ip:port}>;ep="node5",
<coap://{ip:port}>;ep="node7"
```

The following example shows a client performing a domain lookup:

```

Client                                                                    RD
|                                                                           |
| ----- GET /rd-lookup/d -----> |
|                                     |
|                                     |
| <-- 2.05 Content "</rd>;d=domain1,</rd>;d=domain2 ----- |
|                                     |

```


Req: GET /rd-lookup/d

Res: 2.05 Content

</rd>;d="domain1",

</rd>;d="domain2"

The following example shows a client performing a group lookup for all groups:

Client		RD
	----- GET /rd-lookup/gp ----->	
	<-- 2.05 Content </rd-group/12>;gp="lights1";d="domain1" --	

Req: GET /rd-lookup/gp

Res: 2.05 Content

</rd-group/12>;gp="lights1";d="domain1"

The following example shows a client performing a lookup for all endpoints in a particular group:

Client		RD
	----- GET GET /rd-lookup/ep?gp=lights1----->	
	<-- 2.05 Content "</rd>;d=domain1,</rd>;d=domain2 -----	

Req: GET /rd-lookup/ep?gp=lights1

Res: 2.05 Content

<coap://host:port>;ep="node1",

<coap://host:port>;ep="node2",

The following example shows a client performing a lookup for all groups an endpoint belongs to:

Client	RD
----- GET /rd-lookup/gp?ep=node1 ----->	
<-- 2.05 Content "</rd>;d=domain1,</rd>;d=domain2 -----	

Req: GET /rd-lookup/gp?ep=node1

Res: 2.05 Content
 <coap://host:port>;gp="lights1";ep="node1",

8. New Link-Format Attributes

When using the CoRE Link Format to describe resources being discovered by or posted to a resource directory service, additional information about those resources is useful. This specification defines the following new attributes for use in the CoRE Link Format [[RFC6690](#)]:

```
link-extension    = ( "ins" "=" quoted-string ) ; Max 63 bytes
link-extension    = ( "exp" )
```

8.1. Resource Instance 'ins' attribute

The Resource Instance "ins" attribute is an identifier for this resource, which makes it possible to distinguish from other similar resources. This attribute is similar in use to the "Instance" portion of a DNS-SD record, and SHOULD be unique across resources with the same Resource Type attribute in the domain it is used. A Resource Instance might be a descriptive string like "Ceiling Light, Room 3", a short ID like "AF39" or a unique UUID or iNumber. This attribute is used by a Resource Directory to distinguish between multiple instances of the same resource type within a system.

This attribute MUST be no more than 63 bytes in length. The resource

identifier attribute MUST NOT appear more than once in a link description.

8.2. Export 'exp' attribute

The Export "exp" attribute is used as a flag to indicate that a link description MAY be exported by a resource directory to external directories.

The CoRE Link Format is used for many purposes between CoAP endpoints. Some are useful mainly locally, for example checking the observability of a resource before accessing it, determining the size of a resource, or traversing dynamic resource structures. However, other links are very useful to be exported to other directories, for example the entry point resource to a functional service.

9. DNS-SD Mapping

TODO

10. Security Considerations

This document needs the same security considerations as described in [Section 7 of \[RFC5988\]](#) and [Section 6 of \[RFC6690\]](#). The /.well-known/core resource may be protected e.g. using DTLS when hosted on a CoAP server as described in [\[I-D.ietf-core-coap\]](#).

Access control SHOULD be performed separately for the RD Function Set and the RD Lookup Function Set, as different endpoints may be authorized to register with an RD from those authorized to lookup endpoints from the RD. Such access control SHOULD be performed in as fine-grained a level as possible. For example access control for lookups could be performed either at the domain, endpoint or resource level.

11. IANA Considerations

11.1. Resource Types

"core.rd", "core.rd-group" and "core.rd-lookup" resource types need to be registered with the resource type registry defined by [\[RFC6690\]](#).

11.2. Link Extension

The "exp" attribute needs to be registered when a future Web Linking link-extension registry is created (e.g. in RFC5988bis).

11.3. RD Parameter Registry

This specification defines a new sub-registry for registration and lookup parameters called "RD Parameters" under "CoRE Parameters". Although this specification defines a basic set of parameters, it is expected that other standards that make use of this interface will define new ones.

Each entry in the registry must include the human readable name of the parameter, the query parameter, validity requirements if any and a description. The query parameter MUST be a valid URI query key [[RFC3986](#)].

Initial entries in this sub-registry are as follows:

Name	Query	Validity	Description
Endpoint Name	ep	< 63 bytes	Name of the endpoint
Lifetime	lt	60-4294967295	Lifetime of the registration in seconds
Domain	d	< 63 bytes	Domain to which this endpoint belongs
Endpoint Type	et		Semantic name of the endpoint
Context	con	URI	The scheme, address and port at which this server is available
Endpoint Name	ep		Name of the endpoint, max 63 bytes
Group Name	gp		Name of a group in the RD
Page	page	Integer	Used for pagination
Count	count	Integer	Used for pagination

Table 1: RD Parameters

The IANA policy for future additions to the sub-registry is "Expert Review" as described in [[RFC5226](#)]

12. Acknowledgments

Szymon Sasin, Kerry Lynn, Esko Dijk, Peter van der Stok, Anders Brandt, Matthieu Vial, Sampo Ukkola and Linyi Tian have provided helpful comments, discussions and ideas to improve and shape this document. The authors would also like to thank their colleagues from the EU FP7 SENSEI project, where many of the resource directory concepts were originally developed.

13. Changelog

Changes from -00 to -01:

- o Removed the ETag validation feature.
- o Place holder for the DNS-SD mapping section.
- o Explicitly disabled GET or POST on returned Location.
- o New registry for RD parameters.
- o Added support for the JSON Link Format.
- o Added reference to the Groupcomm WG draft.

Changes from -05 to WG Document -00:

- o Updated the version and date.

Changes from -04 to -05:

- o Restricted Update to parameter updates.
- o Added pagination support for the Lookup interface.
- o Minor editing, bug fixes and reference updates.
- o Added group support.
- o Changed rt to et for the registration and update interface.

Changes from -03 to -04:

- o Added the ins= parameter back for the DNS-SD mapping.
- o Integrated the Simple Directory Discovery from Carsten.

- o Editorial improvements.
- o Fixed the use of ETags.

Changes from -02 to -03:

- o Changed the endpoint name back to a single registration parameter `ep=` and removed the `h=` and `ins=` parameters.
- o Updated REST interface descriptions to use [RFC6570](#) URI Template format.
- o Introduced an improved RD Lookup design as its own function set.
- o Improved the security considerations section.
- o Made the POST registration interface idempotent by requiring the `ep=` parameter to be present.

Changes from -01 to -02:

- o Added a terminology section.
- o Changed the including of an ETag in registration or update to a MAY.
- o Added the concept of an RD Domain and a registration parameter for it.
- o Recommended the Location returned from a registration to be stable, allowing for endpoint and Domain information to be changed during updates.
- o Changed the lookup interface to accept endpoint and Domain as query string parameters to control the scope of a lookup.

[14.](#) References

[14.1.](#) Normative References

- [I-D.ietf-core-links-json]
Bormann, C., "Representing CoRE Link Collections in JSON", [draft-ietf-core-links-json-00](#) (work in progress), June 2013.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.

- [RFC3986] Berners-Lee, T., Fielding, R., and L. Masinter, "Uniform Resource Identifier (URI): Generic Syntax", STD 66, [RFC 3986](#), January 2005.
- [RFC5226] Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", [BCP 26](#), [RFC 5226](#), May 2008.
- [RFC5988] Nottingham, M., "Web Linking", [RFC 5988](#), October 2010.
- [RFC6570] Gregorio, J., Fielding, R., Hadley, M., Nottingham, M., and D. Orchard, "URI Template", [RFC 6570](#), March 2012.
- [RFC6690] Shelby, Z., "Constrained RESTful Environments (CoRE) Link Format", [RFC 6690](#), August 2012.

[14.2.](#) Informative References

- [I-D.brandt-coap-subnet-discovery]
Brandt, A., "Discovery of CoAP servers across subnets", [draft-brandt-coap-subnet-discovery-00](#) (work in progress), March 2011.
- [I-D.ietf-core-coap]
Shelby, Z., Hartke, K., and C. Bormann, "Constrained Application Protocol (CoAP)", [draft-ietf-core-coap-18](#) (work in progress), June 2013.
- [I-D.ietf-core-groupcomm]
Rahman, A. and E. Dijk, "Group Communication for CoAP", [draft-ietf-core-groupcomm-16](#) (work in progress), October 2013.
- [I-D.vanderstok-core-bc]
Stok, P. and K. Lynn, "CoAP Utilization for Building Control", [draft-vanderstok-core-bc-05](#) (work in progress), October 2011.
- [RFC2616] Fielding, R., Gettys, J., Mogul, J., Frystyk, H., Masinter, L., Leach, P., and T. Berners-Lee, "Hypertext Transfer Protocol -- HTTP/1.1", [RFC 2616](#), June 1999.
- [RFC6775] Shelby, Z., Chakrabarti, S., Nordmark, E., and C. Bormann, "Neighbor Discovery Optimization for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)", [RFC 6775](#), November 2012.

Authors' Addresses

Zach Shelby
ARM
150 Rose Orchard
San Jose 95134
FINLAND

Phone: +1-408-203-9434
Email: zach.shelby@arm.com

Carsten Bormann
Universitaet Bremen TZI
Postfach 330440
Bremen D-28359
Germany

Phone: +49-421-218-63921
Email: cabo@tzi.org

Srdjan Krco
Ericsson

Phone:
Email: srdjan.krco@ericsson.com

