CoRE Working Group
Internet-Draft
Intended status: Informational
Expires: March 18, 2018

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September 14, 2017

Dynamic Resource Linking for Constrained RESTful Environments
draft-ietf-core-dynlink-04

Abstract

For CoAP [RFC7252] Dynamic linking of state updates between resources, either on an endpoint or between endpoints, is defined with the concept of Link Bindings. This specification defines conditional observation attributes that work with Link Bindings or with CoAP Observe [RFC7641].

Editor's note:

o The git repository for the draft is found at https://github.com/core-wg/dynlink

Status of This Memo

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1. Introduction

IETF Standards for machine to machine communication in constrained environments describe a REST protocol and a set of related information standards that may be used to represent machine data and machine metadata in REST interfaces. CoRE Link-format is a standard for doing Web Linking [RFC5988] in constrained environments.

This specification introduces the concept of a Link Binding, which defines a new link relation type to create a dynamic link between resources over which to exchange state updates. Specifically, a Link Binding is a link for binding the state of 2 resources together such that updates to one are sent over the link to the other. CoRE Link Format representations are used to configure, inspect, and maintain Link Bindings. This specification additionally defines a set of conditional Observe Attributes for use with Link Bindings and with the standalone CoRE Observe [RFC7641] method.

2. Terminology

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

This specification requires readers to be familiar with all the terms and concepts that are discussed in [RFC5988] and [RFC6690]. This specification makes use of the following additional terminology:

Link Binding: A unidirectional logical link between a source resource and a destination resource, over which state information is synchronized.

State Synchronization: Depending on the binding method (Polling, Observe, Push) different REST methods may be used to synchronize the resource values between a source and a destination. The process of using a REST method to achieve this is defined as "State Synchronization". The endpoint triggering the state synchronization is the synchronization initiator.

3. Link Bindings

In a M2M RESTful environment, endpoints may directly exchange the content of their resources to operate the distributed system. For example, a light switch may supply on-off control information that may be sent directly to a light resource for on-off control.

Beforehand, a configuration phase is necessary to determine how the resources of the different endpoints are related to each other. This can be done either automatically using discovery mechanisms or by means of human intervention and a so-called commissioning tool. In this specification the abstract relationship between two resources is called a link Binding. The configuration phase necessitates the exchange of binding information so a format recognized by all CoRE endpoints is essential. This specification defines a format based on the CoRE Link-Format to represent binding information along with the rules to define a binding method which is a specialized relationship between two resources. The purpose of a binding is to synchronize the content between a source resource and a destination resource. The destination resource MAY be a group resource if the authority component of the destination URI contains a group address (either a multicast address or a name that resolves to a multicast address). Since a binding is unidirectional, the binding entry defining a relationship is present only on one endpoint. The binding entry may be located either on the source or the destination endpoint depending on the binding method.

3.1. Binding Methods

A binding method defines the rules to generate the web-transfer exchanges that synchronize state between source and destination resources. By using REST methods content is sent from the source resource to the destination resource.

The following table gives a summary of the binding methods defined in this specification.

Name	Identifier	Location	Method
Polling	poll	Destination	GET
Observe	obs	Destination	GET + Observe
Push	push	Source	PUT

Table 1: Binding Method Summary

The description of a binding method must define the following aspects:

Identifier: This is the value of the "bind" attribute used to identify the method.

Location: This information indicates whether the binding entry is stored on the source or on the destination endpoint.

REST Method: This is the REST method used in the Request/Response exchanges.

Conditions: A binding method definition must state how the condition attributes of the abstract binding definition are actually used in this specialized binding.

The binding methods are described in more detail below.

3.1.1. Polling

The Polling method consists of sending periodic GET requests from the destination endpoint to the source resource and copying the content to the destination resource. The binding entry for this method MUST be stored on the destination endpoint. The destination endpoint MUST ensure that the polling frequency does not exceed the limits defined by the pmin and pmax attributes of the binding entry. The copying process MAY filter out content from the GET requests using value-based conditions (e.g based on the Change Step, Less Than, Greater Than attributes).

3.1.2. Observe

The Observe method creates an observation relationship between the destination endpoint and the source resource. On each notification the content from the source resource is copied to the destination resource. The creation of the observation relationship requires the CoAP Observation mechanism [RFC7641] hence this method is only permitted when the resources are made available over CoAP. The binding entry for this method MUST be stored on the destination endpoint. The binding conditions are mapped as query string parameters (see Section 4.2).

3.1.3. Push

When the Push method is assigned to a binding, the source endpoint sends PUT requests to the destination resource when the binding condition attributes are satisfied for the source resource. The source endpoint MUST only send a notification request if the binding conditions are met. The binding entry for this method MUST be stored on the source endpoint.

3.2. Link Relation

Since Binding involves the creation of a link between two resources, Web Linking and the CoRE Link-Format are a natural way to represent binding information. This involves the creation of a new relation type, named "boundto". In a Web link with this relation type, the target URI contains the location of the source resource and the context URI points to the destination resource.

3.3. Binding Attributes

Web link attributes allow a fine-grained control of the type of state synchronization along with the conditions that trigger an update. This specification defines the attributes below:

Attribute	Parameter	Value
Binding method	bind	xsd:string
Minimum Period (s)	pmin	xsd:integer (>0)
Maximum Period (s)	pmax	xsd:integer (>0)
Change Step	st	xsd:decimal (>0)
Greater Than	gt	xsd:decimal
Less Than	lt	xsd:decimal

Table 2: Binding Attributes Summary

3.3.1. Bind Method (bind)

This is the identifier of a binding method which defines the rules to synchronize the destination resource. This attribute is mandatory.

3.3.2. Minimum Period (pmin)

When present, the minimum period indicates the minimum time to wait (in seconds) before triggering a new state synchronization (even if it has changed). In the absence of this parameter, the minimum period is up to the synchronization initiator. The minimum period MUST be greater than zero otherwise the receiver MUST return a CoAP error code 4.00 "Bad Request" (or equivalent).

3.3.3. Maximum Period (pmax)

When present, the maximum period indicates the maximum time in seconds between two consecutive state synchronizations (regardless if it has changed). In the absence of this parameter, the maximum period is up to the synchronization initiator. The maximum period MUST be greater than zero and MUST be greater than the minimum period parameter (if present) otherwise the receiver MUST return a CoAP error code 4.00 "Bad Request" (or equivalent).

3.3.4. Change Step (st)

When present, the change step indicates how much the value of a resource SHOULD change before triggering a new state synchronization (compared to the value of the previous synchronization). Upon reception of a query including the st attribute the current value (CurrVal) of the resource is set as the initial value (STinit). Once the resource value differs from the STinit value (i.e. CurrVal >= STinit + ST or CurrVal <= STint - ST) then a new state synchronization occurs. STinit is then set to the state synchronization value and new state synchronizations are based on a change step against this value. The change step MUST be greater than zero otherwise the receiver MUST return a CoAP error code 4.00 "Bad Request" (or equivalent).

Note: Due to the state synchronization based update of STint it may result in that resource value received in two sequential state synchronizations differs by more than st.

3.3.5. Greater Than (gt)

When present, Greater Than indicates the upper limit value the resource value SHOULD cross before triggering a new state synchronization. State synchronization only occurs when the resource value exceeds the specified upper limit value. The actual resource value is used for the synchronization rather than the gt value. If the value continues to rise, no new state synchronizations are generated as a result of gt. If the value drops below the upper limit value and then exceeds the upper limit then a new state synchronization is generated.

3.3.6. Less Than (lt)

When present, Less Than indicates the lower limit value the resource value SHOULD cross before triggering a new state synchronization. State synchronization only occurs when the resource value is less than the specified lower limit value. The actual resource value is used for the synchronization rather than the lt value. If the value

continues to fall no new state synchronizations are generated as a result of lt. If the value rises above the lower limit value and then drops below the lower limit then a new state synchronization is generated.

3.3.7. Attribute Interactions

Pmin, pmax, st, gt and lt may be present in the same query.

If pmin and pmax are present in a query then they take precedence over the other parameters. Thus even if st, gt or lt are met, if pmin has not been exceeded then no state synchronization occurs. Likewise if st, gt or lt have not been met and pmax time has expired then state synchronization occurs. The current value of the resource is used for the synchronization. If pmin time is exceeded and st, gt or lt are met then the current value of the resource is synchronized. If st is also included, a state synchronization resulting from pmin or pmax updates STinit with the synchronized value.

If gt and lt are included gt MUST be greater than lt otherwise an error CoAP error code 4.00 "Bad Request" (or equivalent) MUST be returned.

If st is included in a query with a gt or lt attribute then state synchronizations occur only when the conditions described by st AND gt or st AND gl are met.

4. Binding Table

The binding table is a special resource that gives access to the bindings on a endpoint. A binding table resource MUST support the Binding interface defined below. A profile SHOULD allow only one resource table per endpoint.

4.1. Binding Interface Description

This section defines a REST interface for Binding table resources. The interface supports the link-format type.

The if= column defines the Interface Description (if=) attribute value to be used in the CoRE Link Format for a resource conforming to that interface. When this value appears in the if= attribute of a link, the resource MUST support the corresponding REST interface described in this section. The resource MAY support additional functionality, which is out of scope for this specification. Although this interface description is intended to be used with the CoRE Link Format, it is applicable for use in any REST interface definition.

The Methods column defines the REST methods supported by the interface, which are described in more detail below.

Interface	if=	Methods	Content-Formats
Binding	core.bnd	GET, POST, DELETE	link-format

Table 3: Binding Interface Description

The Binding interface is used to manipulate a binding table. A request with a POST method and a content format of application/link-format simply appends new bindings to the table. All links in the payload MUST have a relation type "boundTo". A GET request simply returns the current state of a binding table whereas a DELETE request empties the table. Individual entries may be deleted from the table by specifying the resource path in a DELETE request.

The following example shows requests for adding, retrieving and deleting bindings in a binding table.

```
Req: POST /bnd/ (Content-Format: application/link-format)
<coap://sensor.example.com/s/light>;
  rel="boundto";anchor="/a/light";bind="obs";pmin="10";pmax="60"
Res: 2.04 Changed

Req: GET /bnd/
Res: 2.05 Content (application/link-format)
<coap://sensor.example.com/s/light>;
  rel="boundto";anchor="/a/light";bind="obs";pmin="10";pmax="60"

Req: DELETE /bnd/a/light
Res: 2.04 Changed

Req: DELETE /bnd/
Res: 2.04 Changed
```

Figure 1: Binding Interface Example

4.2. Resource Observation Attributes

When resource interfaces following this specification are made available over CoAP, the CoAP Observation mechanism [RFC7641] MAY be used to observe any changes in a resource, and receive asynchronous notifications as a result. In addition, a set of query string parameters are defined here to allow a client to control how often a client is interested in receiving notifications and how much a

resource value should change for the new representation to be interesting. These query parameters are described in the following table. A resource using an interface description defined in this specification and marked as Observable in its link description SHOULD support these observation parameters. The Change Step parameter can only be supported on resources with an atomic numeric value.

These query parameters MUST be treated as resources that are read using GET and updated using PUT, and MUST NOT be included in the Observe request. Multiple parameters MAY be updated at the same time by including the values in the query string of a PUT. Before being updated, these parameters have no default value.

Resource	Parameter	Data Format
Minimum Period	/{resource}?pmin	xsd:integer (>0)
Maximum Period	/{resource}?pmax	xsd:integer (>0)
Change Step	/{resource}?st	xsd:decimal (>0)
Less Than	/{resource}?lt	xsd:decimal
Greater Than	/{resource}?gt	xsd:decimal

Table 4: Resource Observation Attribute Summary

inimum Period: As per Section 3.3.2

aximum Period: As per Section 3.3.3

Change Step: As per Section 3.3.4

Greater Than: As per Section 3.3.5

Less Than: As per Section 3.3.6

5. Security Considerations

An implementation of a client needs to be prepared to deal with responses to a request that differ from what is specified in this specification. A server implementing what the client thinks is a resource with one of these interface descriptions could return malformed representations and response codes either by accident or maliciously. A server sending maliciously malformed responses could

attempt to take advantage of a poorly implemented client for example to crash the node or perform denial of service.

6. IANA Considerations

6.1. Interface Description

The specification registers the "binding" CoRE interface description link target attribute value as per [RFC6690].

Attribute Value: core.binding

Description: The binding interface is used to manipulate a binding table which describes the link bindings between source and destination resources for the purposes of synchronizing their content.

Reference: This specification. Note to RFC editor: please insert the RFC of this specification.

Notes: None

6.2. Link Relation Type

This specification registers the new "boundto" link relation type as per [RFC5988].

Relation Name: boundto

Description: The purpose of a boundto relation type is to indicate that there is a binding between a source resource and a destination resource for the purposes of synchronizing their content.

Reference: This specification. Note to RFC editor: please insert the RFC of this specification.

Notes: None

Application Data: None

7. Acknowledgements

Acknowledgement is given to colleagues from the SENSEI project who were critical in the initial development of the well-known REST interface concept, to members of the IPSO Alliance where further requirements for interface types have been discussed, and to Szymon Sasin, Cedric Chauvenet, Daniel Gavelle and Carsten Bormann who have

provided useful discussion and input to the concepts in this specification.

8. Changelog

draft-ietf-core-dynlink-03

- General: Reverted to using "gt" and "lt" from "gth" and "lth" for this draft owing to concerns raised that the attributes are already used in LwM2M with the original names "gt" and "lt".
- New author and editor added.

draft-ietf-core-dynlink-02

- General: Changed the name of the greater than attribute "gt" to "gth" and the name of the less than attribute "lt" to "lth" due to conlict with the core resource directory draft lifetime "lt" attribute.
- Clause 6.1: Addressed the editor's note by changing the link target attribute to "core.binding".
- Added Appendix A for examples.

draft-ietf-core-dynlink-01

- General: The term state synchronization has been introduced to describe the process of synchronization between destination and source resources.
- General: The document has been restructured the make the information flow better.
- Clause 3.1: The descriptions of the binding attributes have been updated to clarify their usage.
- Clause 3.1: A new clause has been added to discuss the interactions between the resources.
- Clause 3.4: Has been simplified to refer to the descriptions in 3.1. As the text was largely duplicated.
- Clause 4.1: Added a clarification that individual resources may be removed from the binding table.
- Clause 6: Formailised the IANA considerations.

draft-ietf-core-dynlink Initial Version 00:

- This is a copy of draft-groves-core-dynlink-00

draft-groves-core-dynlink Draft Initial Version 00:

- This initial version is based on the text regarding the dynamic linking functionality in I.D.ietf-core-interfaces-05.

- The WADL description has been dropped in favour of a thorough textual description of the REST API.

9. References

9.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC5988] Nottingham, M., "Web Linking", RFC 5988, DOI 10.17487/RFC5988, October 2010, <https://www.rfc-editor.org/info/rfc5988>.

[RFC6690] Shelby, Z., "Constrained RESTful Environments (CoRE) Link Format", RFC 6690, DOI 10.17487/RFC6690, August 2012, <https://www.rfc-editor.org/info/rfc6690>.

9.2. Informative References

[RFC7252] Shelby, Z., Hartke, K., and C. Bormann, "The Constrained Application Protocol (CoAP)", RFC 7252, DOI 10.17487/RFC7252, June 2014, <https://www.rfc-editor.org/info/rfc7252>.

[RFC7641] Hartke, K., "Observing Resources in the Constrained Application Protocol (CoAP)", RFC 7641, DOI 10.17487/RFC7641, September 2015, <https://www.rfc-editor.org/info/rfc7641>.

Appendix A. Examples

This appendix provides some examples of the use of binding attribute / observe attributes.

Note: For brevity the only the method or response code is shown in the header field.

A.1. Greater Than (gt) example

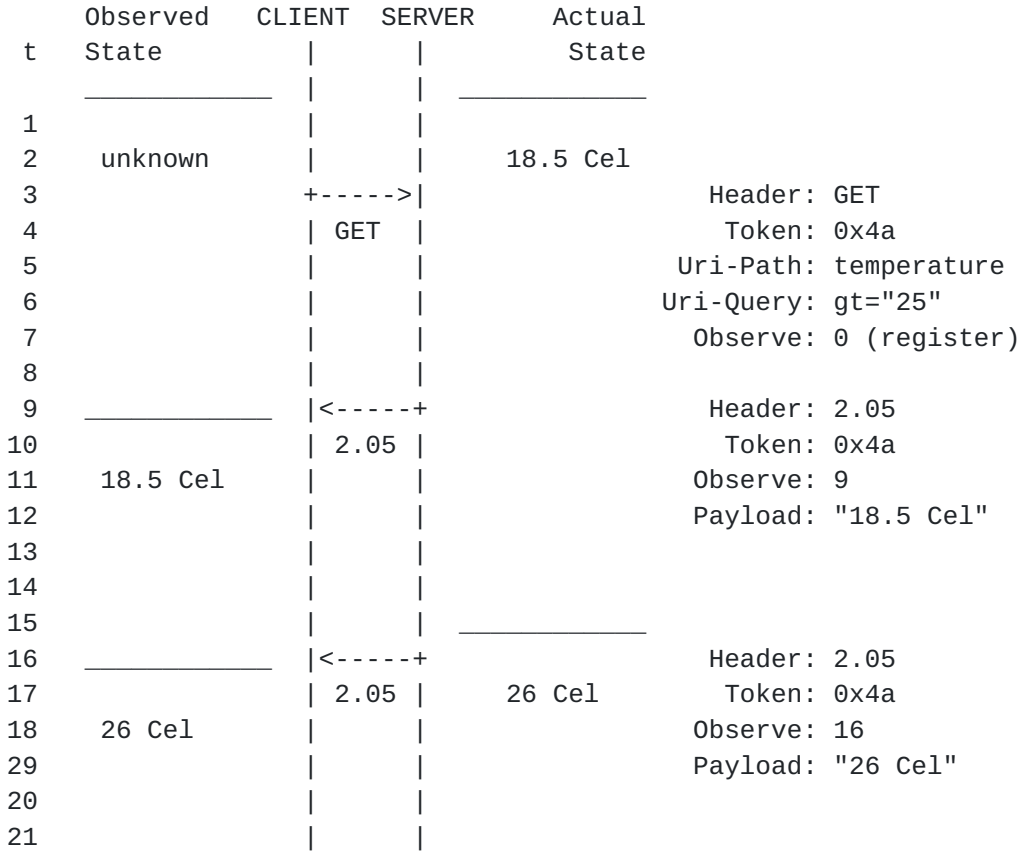
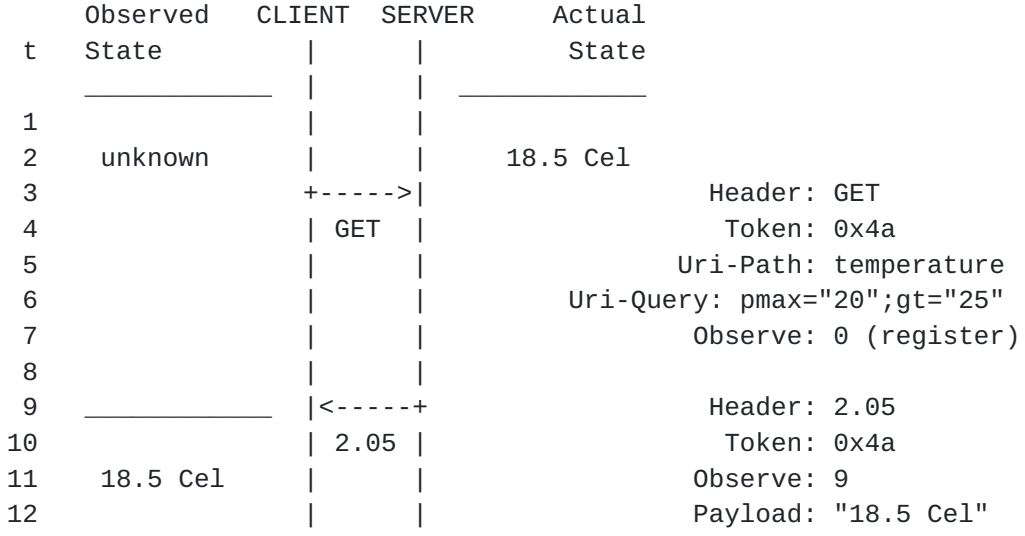


Figure 2: Client Registers and Receives one Notification of the Current State and One of a New State when it passes through the greather than threshold of 25.

A.2. Greater Than (gt) and Period Max (pmax) example



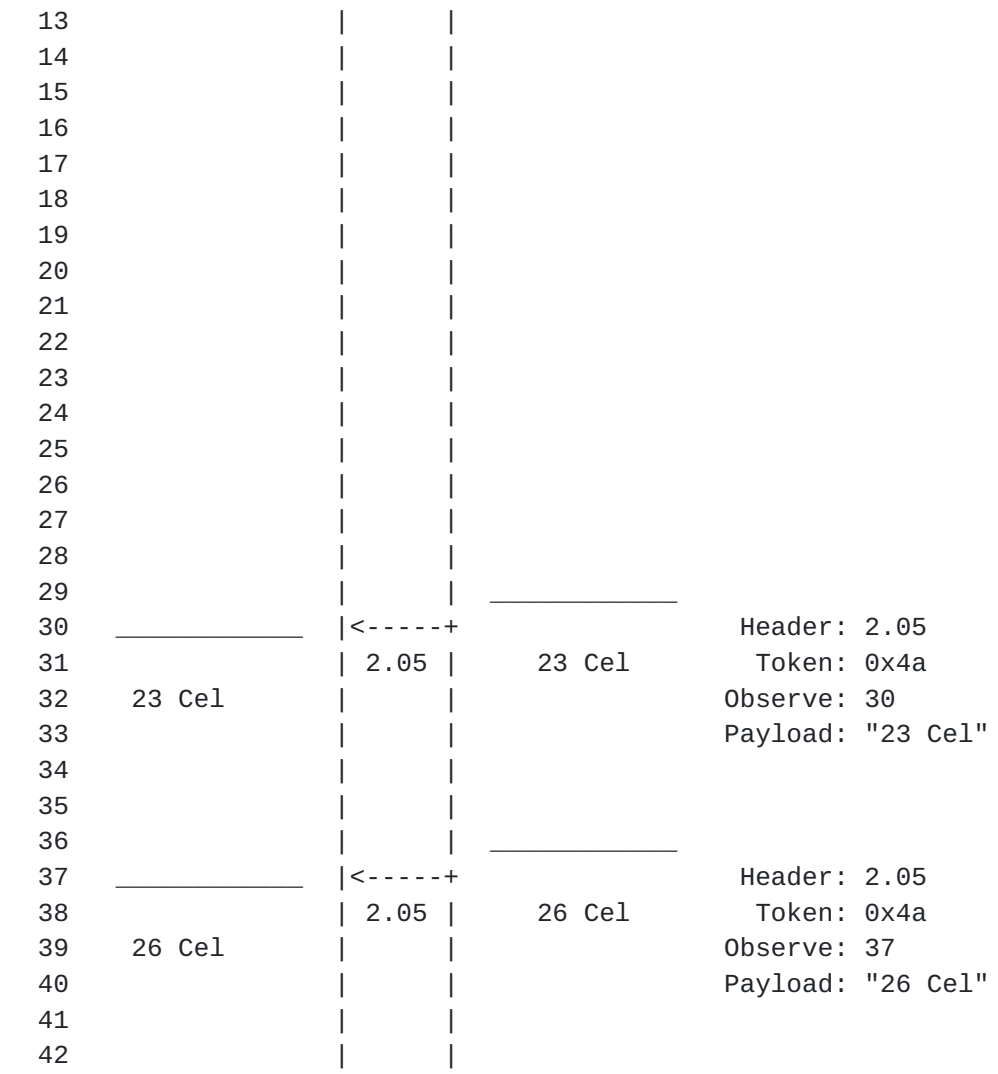


Figure 3: Client Registers and Receives one Notification of the Current State, one when pmax time expires and one of a new State when it passes through the greather than threshold of 25.

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