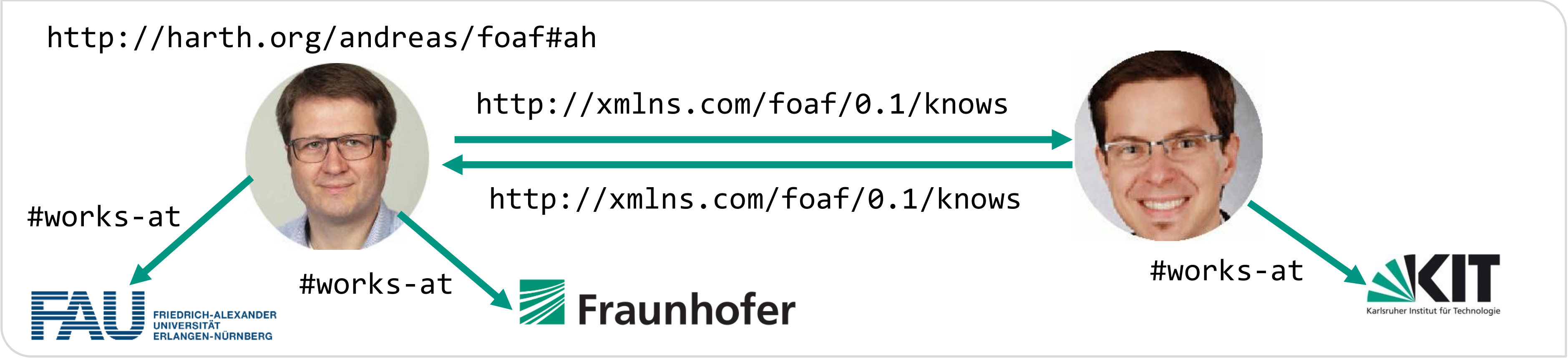
Tutorial on Distributed Knowledge Graphs on the Web of Things, Part II: Read-Write Linked Data

Tobias Käfer (KIT) and Andreas Harth (FAU)

Tutorial @ 10th International Conference on the Internet of Things (IoT), 2020



http://harth.org/andreas/foaf#ah

http://xmlns.com/foaf/0.1/knows

http://xmlns.com/foaf/0.1/knows

#works-at

#works-at

#works-at

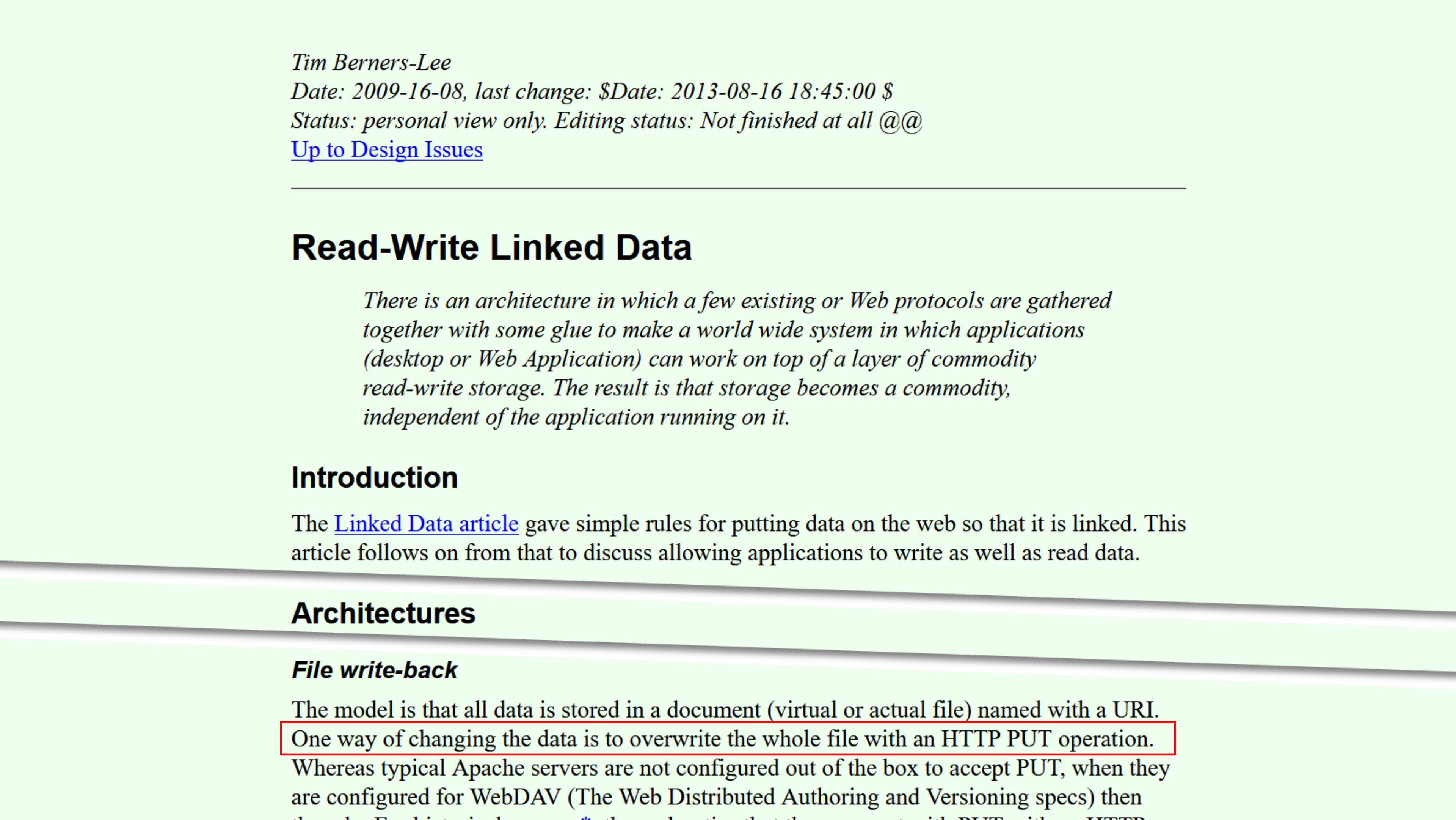
FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
Fraunhofer
KIT Karlsruher Institut für Technologie

Karlsruhe Institute of Technology (KIT); Fraunhofer IIS-SCS; Friedrich-Alexander University Erlangen-Nuremberg (FAU)

http://go.wiwi.kit.edu/togwot

To use REST to Read + Write to IoT Devices is New Since 2000

- Gaetano Borriello and Roy Want. “Embedded Computation Meets the World Wide Web”. In: Communications of the ACM 43.5 (2000).
- Tim Kindberg, John J. Barton, Jeff Morgan, Gene Becker, Debbie Caswell, Philippe Debaty, Gita Gopal, Marcos Frid, Venky Krishnan, Howard Morris, John Schettino, Bill Serra and Mirjana Spasojevic. “People, places, things: Web presence for the real world”. In: Proceedings of the 3rd Workshop on Mobile Computing Systems and Applications (WMCSA). IEEE. 2000
- Witold Drytkiewicz, Ilja Radusch, Stefan Arbanowski, Radu Popescu-Zeletin: “pREST: a REST-based protocol for pervasive systems.” in Proceedings of the IEEE Conference on Mobile Ad-hoc and Sensor Systems (MAAS), 2004
- Erik Wilde. Putting Things to REST. Tech. rep. 2007-015. iSchool, University of Berkeley, CA, USA, Nov. 2007
- Vlad Stirbu. “Towards a RESTful Plug and Play Experience in the Web of Things”. In: Proceedings of the 2th IEEE International Conference on Semantic Computing (ICSC). 2008.
- Dominique Guinard, Vlad Trifa, Thomas Pham, Olivier Liechti: “Towards physical mashups in the Web of Things” In: Proceedings of the 6th International Conference on Networked Sensing Systems (INSS), 2009
- Dogan Yazar and Adam Dunkels. “Efficient Application Integration in IP-based Sensor Networks”. In: Proceedings of the First Workshop on Embedded Sensing Systems for Energy-Efficiency in Buildings (BuildSys) at the 7th Conference on Embedded Network Sensor Systems (SenSys). ACM. 2009.
- Lina Yao, Quan Z. Sheng and Schahram Dustdar. “Web-Based Management of the Internet of Things”. In: IEEE Internet Computing 19.4 (2015).



Tim Berners-Lee
Date: 2009-16-08, last change: $Date: 2013-08-16 18:45:00 $
Status: personal view only. Editing status: Not finished at all @@
Up to Design Issues

Read-Write Linked Data

> *There is an architecture in which a few existing or Web protocols are gathered together with some glue to make a world wide system in which applications (desktop or Web Application) can work on top of a layer of commodity read-write storage. The result is that storage becomes a commodity, independent of the application running on it.*

Introduction

The Linked Data article gave simple rules for putting data on the web so that it is linked. This article follows on from that to discuss allowing applications to write as well as read data.

Architectures

File write-back

The model is that all data is stored in a document (virtual or actual file) named with a URI. One way of changing the data is to overwrite the whole file with an HTTP PUT operation. Whereas typical Apache servers are not configured out of the box to accept PUT, when they are configured for WebDAV (The Web Distributed Authoring and Versioning specs) then

The Hypertext Transfer Protocol (HTTP) [RFC7230]

- Selected Properties of HTTP
  - Stateless
  - Request/response messages
  - Interaction with resources
  - Message: the current state of a resource
- Focus: requests that implement CRUD
  - Create, Read, Update, Delete, the basic operations of persistent storage [1]
  - POST
    - Append-to-collection vs. RPC
  - OPTIONS
    - Describe communication options
- NB: No events → polling

CRUD Operation	HTTP Method
Read	GET
Update	PUT
Create	POST / PUT
Delete	DELETE

CRUD – HTTP Corresponcence

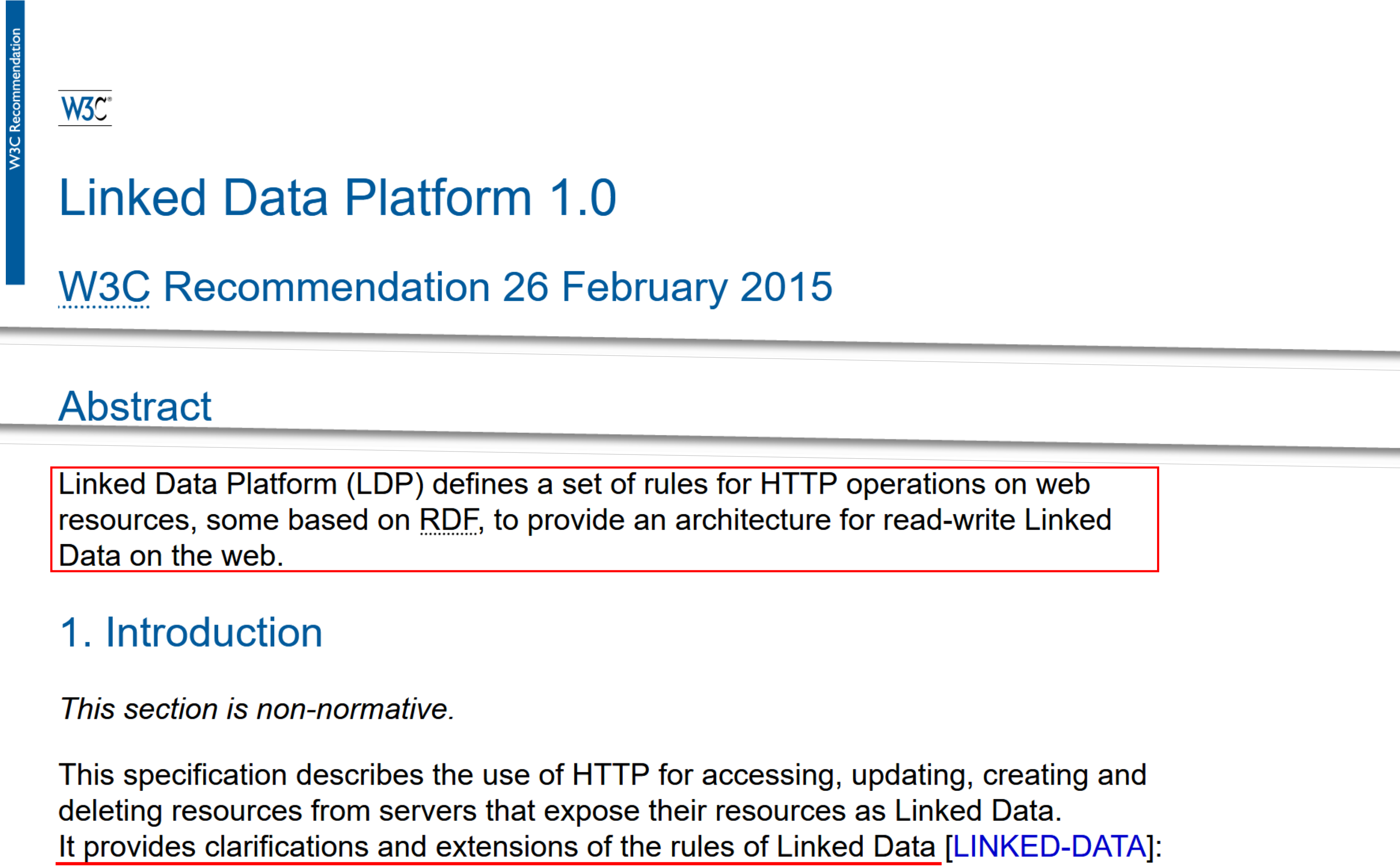
HTTP Method	Safe?	Idempotent?
GET	✓	✓
PUT		✓
POST		
DELETE		✓

Properties of HTTP Requests

[1] James Martin: Managing the Data-Base Environment, Pearson (1983)

When Resource State is (Not) Sent/Received? – HTTP Message Semantics [RFC7231]

HTTP Request Method	HTTP Request or Response Code	HTTP Message Semantics: The HTTP Message Body Contains…
GET	Request	Nothing
PUT	Request	State of the resource
POST	Request	Arbitrary data or state of resource
DELETE	Request	Nothing
any	Non-2xx	State of the request
GET	2xx	State of the resource
PUT	2xx	State of the resource or empty
POST	2xx	State of the request (refering to new resource)
DELETE	2xx	State of the request or empty



W3C Recommendation

Linked Data Platform 1.0

W3C Recommendation 26 February 2015

Abstract

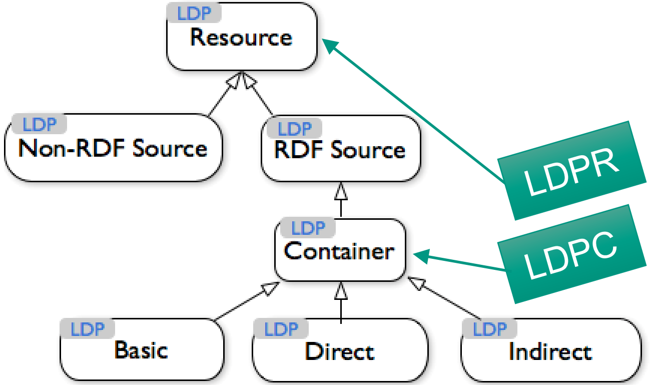
Linked Data Platform (LDP) defines a set of rules for HTTP operations on web resources, some based on RDF, to provide an architecture for read-write Linked Data on the web.

1. Introduction

This section is non-normative.

This specification describes the use of HTTP for accessing, updating, creating and deleting resources from servers that expose their resources as Linked Data. It provides clarifications and extensions of the rules of Linked Data [LINKED-DATA]:

Linked Data Platform [1]



- Classification of resources →
- Clarifications for the use of the combination HTTP + RDF, eg.:
  - 4.2.8 HTTP OPTIONS and LDPR
    - 4.2.8.1 LDP servers MUST support the HTTP OPTIONS method.
    - 4.2.8.2 LDP servers MUST indicate their support for HTTP Methods by responding to a HTTP OPTIONS request on the LDPR's URL with the **HTTP Method tokens in the HTTP response header Allow**.
  - 5.2.3 HTTP POST and LDPC
    - 5.2.3.1 LDP clients SHOULD create member resources by submitting a representation as the entity body of the HTTP POST to a known LDPC. If the resource was created successfully, LDP servers MUST respond with status code 201 (Created) and the Location header set to the new resource's URL. **Clients shall not expect any representation in the response entity body on a 201 (Created) response**.
- Cf. ATOM publishing protocol [RFC5023]: interactions with collections

[1] Speicher, Arwe, Malhotra: "Linked Data Platform 1.0" W3C Recommendation (2015)

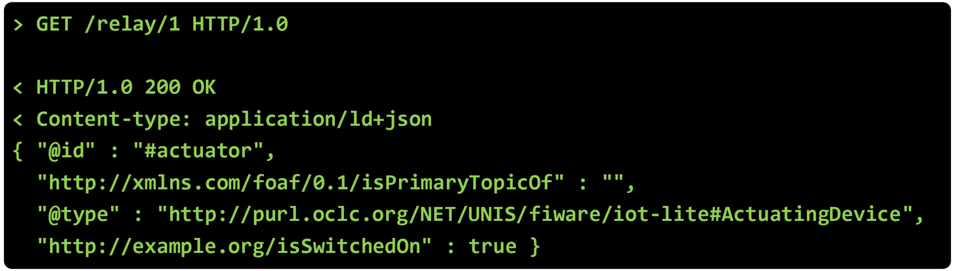
SoLiD – Social Linked Data

- A Decentralised Social Network
- Built on Read-Write Linked Data
- Adds libraries for Access Control and User Interfaces for Read-Write Linked Data
- Everybody maintains their own data pod
- To put you in control over your own personal data
- http://solid.mit.edu/
  http://inrupt.com/

Controlling an IoT Device using Read-Write Linked Data [1]

- Tessel2: a circuit board with Wi-Fi + Ethernet →
- Modules, eg.:
  - Ambient Module: Light and sound sensor
  - Relay Module: 2 relays for 230V
- Programmable using JavaScript

- Approach:
  - ExpressJS + RDF-EXT.js
  - GET for all
  - PUT for relays, LEDs
  - http://github.com/kaefer3000/t2-rest-leds



```
> GET /relay/1 HTTP/1.0

< HTTP/1.0 200 OK
< Content-type: application/ld+json
{ "@id" : "#actuator",
  "http://xmlns.com/foaf/0.1/isPrimaryTopicOf" : "",
  "@type" : "http://purl.oclc.org/NET/UNIS/fiware/iot-lite#ActuatingDevice",
  "http://example.org/isSwitchedOn" : true }
```

Sample request from the user agent and response about one relay

[1] Bader, Käfer, Heling, Manke, Harth: “Exposing Internet of Things Devices via REST and Linked Data Interfaces”. Proceedings of the 2nd Workshop on Semantic Web Technologies for the Internet of Things at the 16th International Semantic Web Conference (ISWC), 2017.