

# Linked Data-driven Web Components: Building Adoptive and Flexible Linked Data Applications

Ali Khalili  
Dept. of Computer Science  
VU University Amsterdam  
The Netherlands  
a.khalili@vu.nl

Antonis Loizou  
Dept. of Computer Science  
VU University Amsterdam  
The Netherlands  
a.loizou@vu.nl

Frank van Harmelen  
Dept. of Computer Science  
VU University Amsterdam  
The Netherlands  
frank.van.harmelen@vu.nl

## ABSTRACT

The amount of published Linked Data on the Web is increasing day by day. As a result, the applications driven by Semantic Web and Linked Data are taking momentum on the Web. One of the major entrance barriers for Web developers to contribute to this wave of Linked Data Applications (LDAs) is the required knowledge of Semantic Web technologies such as RDF data model and SPARQL query language to interact with the triple stores. This paper presents a component-based approach for creating adoptive and flexible Web applications driven by Linked Data. Linked Data-driven (LD-R) Web components abstract the complexity of underlying Semantic Web technologies in order to allow reuse of existing Web components in LDAs and to enable Web developers who are not expert in Semantic Web to develop components to view, edit and browse Linked Data. In addition to modularity provided by LD-R components, the proposed RDF-based configuration method allows application assemblers to reshape their applications for different use cases, by either reusing existing shared configs or by creating their proprietary configs.

## Categories and Subject Descriptors

D.2.13 [Software Engineering]: Reusable Software

## General Terms

Design, Human Factors, Standardization

## 1. INTRODUCTION

“One way of overcoming the fear of new is to make it look like the old.” Donald A. Norman

With the growing number of structured data published on the Web, WWW is moving towards becoming a rich ecosystem of machine-understandable Linked Data <sup>1</sup>. Semanti-

<sup>1</sup>lodlaundromat.org recently (17.09.2015) reported approx. 38 billion triples published on Linked Open Data cloud.

cally structured data facilitate a number of important aspects of information management such as information retrieval, search, visualization, customization, personalization and integration [4]. Despite all these benefits, Linked Data applications have not yet grasped well by the Web developers and end users on the Web. Most of the currently published Linked Data are generated by a relatively small amount of publishers [3] which indicates some usability issues particularly when authoring Linked Data by non-experts. One of the main barriers to adopt Linked Data application (LDAs), from our point of view, is *Affordances* – potential actions that are possible in LDAs.

what are the reasons?[6]

describe what adaption means?

An alternative approach to interface personalization is the adaptive approach, where the interface changes automatically based on the user's behavior. This approach ensures that the interface is customized to the user, without requiring any effort on the user's part.

model (RDF) + tool (Web Component)

what is required to realize adaption? Web Component

how SW and Linked Data can help adaption of UI?

*Web Components* are a set of W3C standards that enable the creation of reusable widgets or components in Web documents and Web applications. Web components aim to bring *Component-Based Software Development* (CBSD) to the World Wide Web. Some advantages of CBSD approach are reusability, replaceability, extensibility, encapsulation and independence.

W3C specifications of Web Components [2]

introducing LD-R

Ld-R offers many benefits that we will describe in the remainder of the paper. Among them are: - -

## 2. CONTRIBUTIONS AND OUTLINE

The contributions of this work are...

We evaluate this claim by...

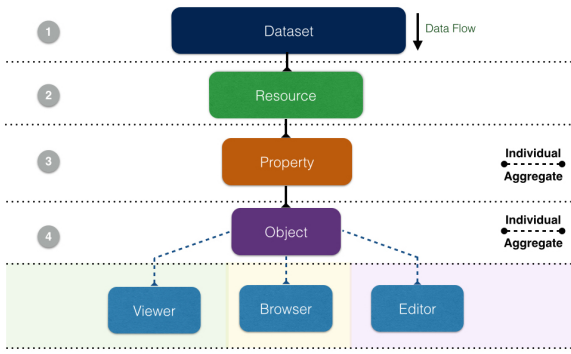


Figure 1: Architecture of LD-R Applications.

We explore these claims in stages...

### 3. LINKED DATA-DRIVEN WEB COMPONENTS

We define a *Linked Data-driven* (LD-R) Web Component as a Web component that employs RDF data model for representing its content and specification (i.e. metadata about the component).

#### 3.1 Features

Linked Data-driven Web components provide the following features:

- *Fine-grained Web applications.* Resource Description Framework (RDF) provides a common data model that allows data-driven components to be created, shared and integrated in a structured way across different applications. Figure 1 depicts the 4 main component levels in a Linked Data-driven Web application. The dataflow in the application starts from the *Dataset* component which handles all the events related to a set of resources embedded in a named graph. The next level is the *Resource* component which is identified by a URI and indicates what is described in the application. A resource is specified by a set of properties which are handled by the *Property* component. Properties can be either individual or aggregate when combining multiple features of a resource (e.g. a component that combines longitude and latitude properties; start date and end date properties for a date range, etc.). Each property is instantiated by an individual value or multiple values in case of an aggregate object. The value(s) of properties are controlled by the *Object* component. Object component invokes different components to view, edit and browse the property values. *Viewer*, *Editor* and *Browser* components are terminals in the LD-R single directional data flow where customized user-generated components can be plugged into the system. These components apply on individual and aggregate objects (e.g. to show multiple coordinates on a the map).

In addition to the fine-grained component architecture, LD-R Web applications provide a fine-grained access control over the data provided by the components.

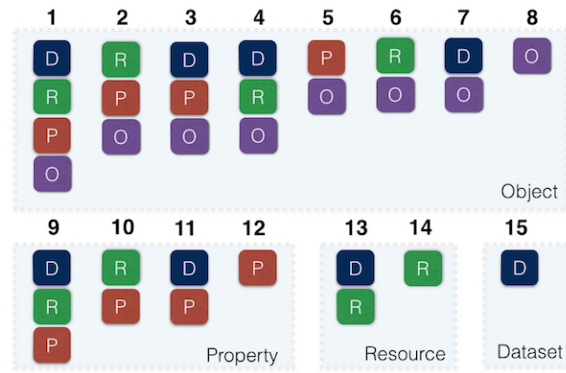


Figure 2: LD-R Scopes.

RDF-based access control in LD-R applications operates at four different granularities provided by Dataset, Resource, Property and Object component levels. For example, we can restrict access to a specific property of a specific resource in a certain dataset.

- *Customization and Personalization.* LD-R provide a versatile approach for context adaptation. A context can be a specific domain of interest, a specific user requirements or both. In order to enable customization and personalization, LD-R exploits the concept of *Scope*. A scope is defined as a directed combination of Dataset, Resource, Property and Object components (cf. Figure 2). Each scope conveys a certain level of specificity on a given context ranging from 1 (most specific) to 15 (least specific). Scopes are defined by using the URIs for RDF resources and types. For example, on the property level, we can define a generic configuration for all properties and then for some specific properties (e.g. `dcterms:title`, `rdfs:label`) within a specific resource (e.g. `<http://ld-r.org>`), we can change or overwrite those configurations.

Scopes can also be defined under a specific user which facilitates versioning and reuse of user-specific configs. User-specific configs provide different views on components and thereby data, based on the different personas dealing with those components and data.

- *Component Visibility and Reusability.* metadata about components (<https://github.com/ali1k/ld-r-metadata-generator>) in JSON-LD  
general metadata: name, description, version, homepage, author, etc.  
specific metadata: level, granularity (individual, aggregate), mode (view, edit, browse), dependencies (internal, external), config parameters with description use Schema.org SoftwareApplication schema.
- *Content Visibility and Reusability.* Component content represented in RDFa, Microdata. example: good relations for online shopping and SEO

#### 3.2 Life Cycle

As shown in Figure 3, the LD-R components lifecycle encompasses four primary types of stakeholders:

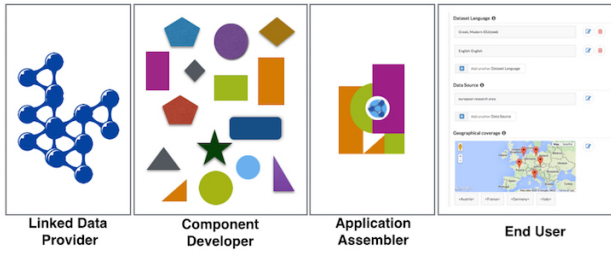


Figure 3: LD-R Components Life Cycle.

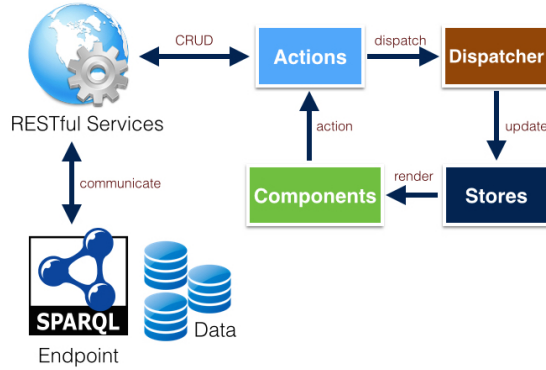


Figure 4: Data Flow in LD-R framework.

- *Linked Data Provider.* Since the LD-R approach focuses mainly on Linked Data applications, provision of RDF-compliant data is an essential phase in developing the LD-R components. \*Data Scientists and different steps in providing data from LOD2 project
- *Component Developer.* It includes programmers who are involved in component fabrication.
- *Application Assembler.* The main task of application assembler is to identify the right components and configurations for the application; and combine them in a way which fits the application requirement.
- *End User.* It is the user who experiences working with components to pursue his goals on a certain application domain. The end user is the one who requests developing a component and the one who sends feedback on the existing components.

## 4. IMPLEMENTATION

In order to realize the idea of Linked Data-driven Web components, we implemented a software framework called *Linked Data Reactor (LD-R)* which is available online at <http://ld-r.org>. LD-R utilizes Facebook's ReactJS<sup>2</sup> components and Flux<sup>3</sup> architecture, Yahoo!'s Fluxible<sup>4</sup> framework for isomorphic Web applications and Semantic-UI<sup>5</sup> framework for flexible UI themes.

<sup>2</sup><https://facebook.github.io/react/>

<sup>3</sup><https://facebook.github.io/flux>

<sup>4</sup><http://fluxible.io/>

<sup>5</sup><http://semantic-ui.com/>

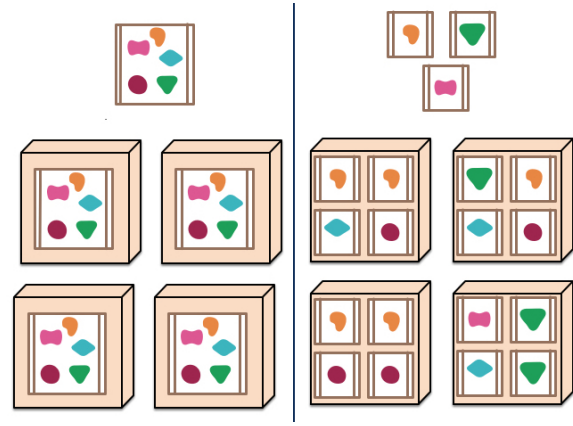


Figure 5: Monoliths vs. Microservices [5]

The main reasons we chose *React* components over other existing solutions (e.g. Polymer<sup>6</sup>, AngularJS<sup>7</sup>, EmberJS<sup>8</sup>, etc.) were the maturity of the technology, maintainability, number of developer tools/components/applications, and efficiency<sup>9</sup>. As shown in Figure 4, LD-R follows the Flux architecture which eschews MVC (Model-View-Controller) in favor of a unidirectional data flow. When a user interacts with a React component, the component propagates an action through a central dispatcher, to the various stores that hold the application's data and business logic, which updates all of the components that are affected. The component interaction with SPARQL endpoints to retrieve and update Linked Data occurs via invoking RESTful services in actions.

In contrast to the centralized monolithic architecture, LD-R components comply with *Microservices Architecture* [5]. As shown in Figure 5, microservices architecture puts the main functionalities of a component into separate services (instead of in-memory function calls) and scales by distributing these services across servers, replicating as needed. This architectural style also minimizes the redeploying of the entire application when changes in components occur.

## 5. EVALUATION

RISIS

OpenPhacts

## 6. DISCUSSION

## 7. RELATED WORK

Web Components and the Semantic Web [1]

Semantic Web Services

Existing tools to view/edit and browse LD e.g. OntoWiki, Saha

<sup>6</sup><http://www.polymer-project.org/>

<sup>7</sup><https://angularjs.org/>

<sup>8</sup><http://emberjs.com/>

<sup>9</sup>Elaborating on all these factors is beyond the scope of this paper.

**EUPRO - Database on European Framework Programmes**

Overview | People | Date | Legal Aspects | Technical Aspects | Content/Structural Aspects

**Title** ⓘ

EUPRO - Database on European Framework Programmes

**Textual description** ⓘ

The EUPRO dataset comprises information on R&D projects and all participating organizations funded by the European Framework Programmes (FP).

**Keywords** ⓘ

European Framework Programmes

New Keywords

**Dataset Language** ⓘ

English-English

English-English

Cancel adding new Dataset Language

**Figure 6: Screenshot**

## 8. CONCLUSION

LD-R approach not only facilitates the discovery and reuse of Web components but also makes the creation of Linked Data application easier.

## 9. ACKNOWLEDGEMENT

We would like to thank our colleagues from the KRR research group at VU University Amsterdam for their helpful comments during the development of the LD-R framework. This work was supported by a grant from the European Union's 7th Framework Programme provided for the project RISIS (GA no. 313082).

## 10. REFERENCES

- [1] M. Casey and C. Pahl. Web components and the semantic web. *Electr. Notes Theor. Comput. Sci.*, 82(5):156–163, 2003.
- [2] D. Cooney. Introduction to web components, 2014. <http://www.w3.org/TR/components-intro/>.
- [3] P. Frischmuth, M. Martin, S. Tramp, T. Riechert, and S. Auer. OntoWiki—An Authoring, Publication and Visualization Interface for the Data Web. *Semantic Web Journal*, 2014.
- [4] A. Khalili and S. Auer. User interfaces for semantic authoring of textual content: A systematic literature review. *Web Semantics: Science, Services and Agents on the World Wide Web*, 22(0):1 – 18, 2013.
- [5] J. Lewis and M. Fowler. Microservices, 2014. <http://martinfowler.com/articles/microservices.html>.
- [6] D. A. Norman. *The Design of Everyday Things: Revised and Expanded Edition*. Basic Books, Inc., New York, NY, USA, 2013.