Adaptive Linked Data-driven Web Interfaces

Does my GUI understand my data?

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. The semantics embedded in Linked Data brings new opportunities to enhance the user experience on the Web. In contrast to fixed Web interfaces built on top of syntactic data, Linked Data-driven Web interfaces provide the ability to adapt the user interface based on the meaning of underlying data. In this paper, we present a novel approach to build adaptive Web interfaces driven by Semantic Web and Linked Data. The proposed approach follows a Linked Data-driven component-based architecture that combines the expressiveness of RDF model with the flexibility and reusability features of Web Components. In order to show the feasibility of our approach, we also present an open source software framework which enables creation of adaptive Web interfaces.

Categories and Subject Descriptors

D.2.13 [**Software Engineering**]: Reusable Software

General Terms

Design, Human Factors, Standardization

1. INTRODUCTION

"Intelligence is the ability to adapt to change."
Stephen Hawking

With the growing number of structured data published on the Web, WWW is moving towards becoming a rich ecosystem of machine-understandable Linked Data [1]. Semantically structured content 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

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[1] `lodlaundromat.org` recently reported approx. 38 billion triples published on Linked Open Data cloud.

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.

what are the reasons?

describe what adaption means?

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

model (RDF) + tool (Web Component)

what is required to realize adaption? Web Componenets

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 reusibility, replacability, 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...

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
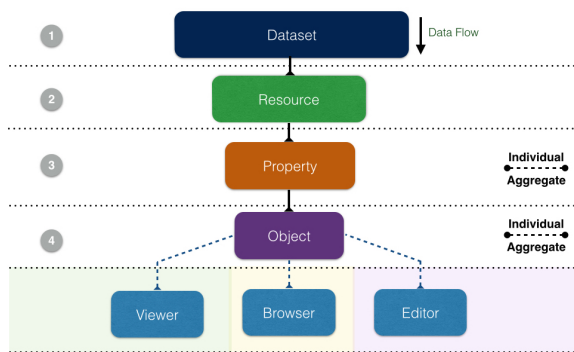
Figure 1: Architecture of LD-R Applications.

Figure 2: LD-R Scopes.

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 datae and end date properties for a date range, etc.). Each property is instantiated by an individual value or mutiple values in case of an aggreagte object. The value(s) of properties are controled 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. 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
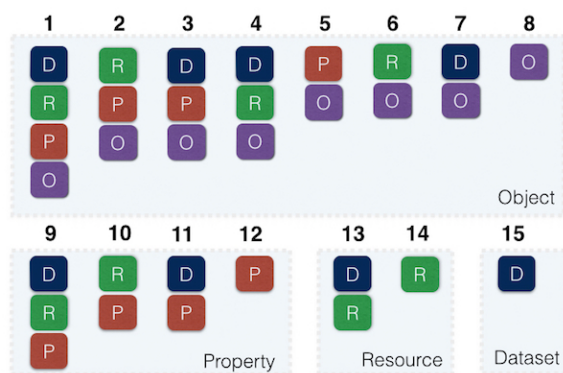
requirments or both. In order to enable customization and personalization, LD-R exploits the concept of *Scope*. A scope is defiened as a directed combination of Dataset, Resource, Property and Object components (cf. Figure 2). Each scope conveys a certain level of specificity on a given context ranging from 1 (most specific) to 15 (least specfic). 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-specifc 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. exmaple: 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:

- *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 fata from LOD2 project
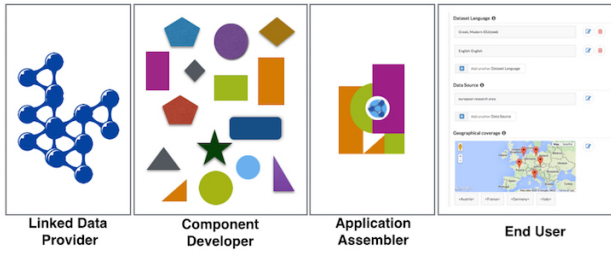
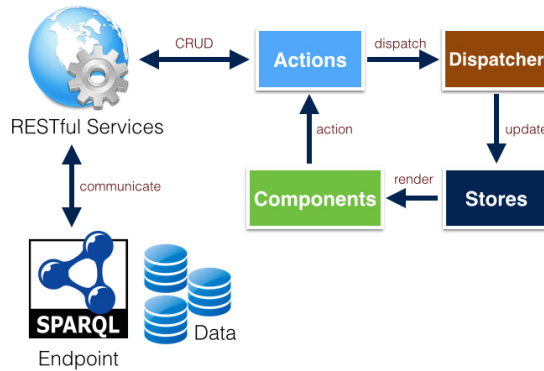Figure 3: LD-R Components Life Cycle.

Figure 4: Data Flow in LD-R framework.

- *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[2] components and Flux[3] architecture, Yahoo!'s Fluxible[4] framework for isomorphic Web applications and Semantic-UI[5] framework for flexible UI themes.

The main reasons we chose *React* components over other existing solutions (e.g. Polymer[6], AngularJS[7], EmberJS[8], etc.) were the maturity of the technology, maintainablity,

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[2] `https://facebook.github.io/react/`
[3] `https://facebook.github.io/flux`
[4] `http://fluxible.io/`
[5] `http://semantic-ui.com/`
[6] `http://www.polymer-project.org/`
[7] `https://angularjs.org/`
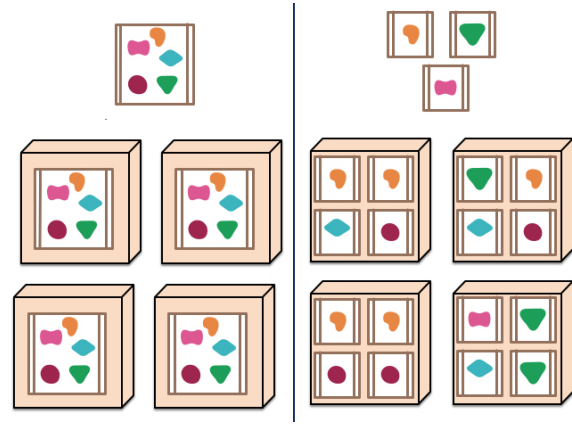[8] `http://emberjs.com/`

Figure 5: Monoliths vs. Microservices [5]

number of developer tools/components/applications, and efficiency[9]. 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 centalized 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 separete 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 occure.

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

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.

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[9]Elaborating on all these factors is beyond the scope of this paper.

Figure 6: Screenshot

9. AKNOWLEDGEMENT

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