An RFID architecture based on an event-oriented component model

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ABSTRACT

In this paper we present a modular, flexible and extensible RFID middleware architecture. The functionalities needed by an RFID middleware are already well studied, also there exists some standards which define them. We propose an architecture where these functionalities are developed in an event-oriented component model. This provides extra benefits such as loose coupling between components and an easy-to-scale architecture.

1. INTRODUCTION

Radio Frequency Identification (RFID) technology allows tracking physical objects and connecting them to the virtual world. Actually RFID-enabled information infrastructures are used in a several areas such as supply chain management, payment using mobile phones and health-care, etc. These RFID infrastructures are equipped with RFID readers deployed across several places. Readers gather raw data that must be filtered and aggregated before transfer them to IT infrastructure. As an attempt to specify functionality that must be offered by any RFID infrastructure, EPC-Global [1] proposes an RFID architectural framework. In this framework a module known as Filtering and Collection (F&C) must implement the ALE (Application Level Event) in order to filter, aggregate and produce high level reports that will be consumed by the IT infrastructure.

Some open-source implementations of the ALE interface defined by EPC-Global exist. The Fosstrak middleware [2], is the de facto reference project which implements the ALE interface. Fosstrak implements the F&C module as a monolithic (Java) web application. On the other hand, the Aspire project [4], which aims to extend the EPC-global specification to sensors and NFC1 applications, proposes a more flexible implementation of an F&C module based on the OSGi2 framework. However, the Aspire F&C module is based on the Fosstrak one, carrying with it the problems associated with the monolithic implementation.

The monolithic architecture of these implementations brings with it problems when the RFID middleware needs to meet requirements such as evolution and scalability. For example, a planned feature to be implemented in the Aspire middleware is the inclusion of sensor-based data in reports produced by the F&C module. To implement this feature, developers need to modify the source code of the F&C module in order to consider the sensor’s information and generate modified reports. On the other hand, scalability is a required property when applications need to deal with an important number of objects (and their associated cases and pallets), warehouses, readers and clients.

In this paper we propose the utilization of an event-oriented component model, named Cilia [3], to implement a flexible and extensible F&C module. In Cilia, components are interconnected transparently allowing centralized or distributed deployment of the RFID infrastructure. In addition, component instances may be added, updated or removed dynamically permitting evolution of architecture according with the applications’ load. In the same way, new types of components can be added to the implementation in order to add new features to the RFID infrastructure.

2. CILIA COMPONENT MODEL

We have decomposed the functionality of the F&C module into small tasks that are interconnected in a data-flow way, where the result of each task is the input to the following one. Cilia provides data-flow oriented construction of applications, which can be adequately used to build the F&C module. In Cilia component model, each component called mediator (figure 1) is composed by three elements which performs specific functions: The Processor is in charge of the functional logic, each task is performed by one processor. The Scheduler is in charge of stocking the collected data and triggering the processing, and the Dispatcher will forward the processed data to next components.

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1http://www.nfc-forum.org  
2http://www.osgi.org
In order to build an application we link the mediators together using their ports, forming a mediation chain. The communication style used to wire mediators is completely transparent to mediators and is indicated in configuration of mediation chains. This characteristic provides two properties to Cilia applications, first mediators are completely decoupled, and in addition different kind of communication models may be used. This allow us to have distributed mediators. For example, using a distributed messaging system (e.g. JMS) to enable inter-mediators communication.

3. MIDDLEWARE IMPLEMENTATION

The ALE interface [1] states that a client, which will interact with the RFID middleware, specifies the needed reports using a declarative language. In this specification, named Event Cycle Specification (or ECSpec), clients can define the logical reader sources, the boundaries of the report production (e.g. duration, report period), the interested set of tags (all read tags, tag additions or deletions since last report), and finally filter conditions on read tags.

Following the Cilia approach, the F&C module has been built using a mediation chain as follows. The first mediators in the chain are the logical readers. Read tags by physical devices are gathered by these components. The scheduler of this component triggers the data processing (i.e. tags gathering) periodically (i.e., read period). The processing of this component eliminates duplicated tags. Next, event cycle mediators are in charge of aggregating tags read from logical readers. The scheduler of this component is also configured to trigger the processing periodically (i.e., event period). The processing will eliminate duplicated read tags from different logical readers. Then, report set mediators found in the chain, are in charge of calculating the set of tags to be included in the report (i.e, current tags, additions, or deletions). Later, filter mediators apply filters on the set of data produced by the previous mediators. Finally, generator mediator produces the requested report (generally as an XML document), called ECReports in the EPC Global specification, and sends it to the interested clients (e.g. BEG [4] and EPCIS [1]).

3.1 Benefits of Cilia implementation

Cilia architectural style brings benefits to such kind of applications. Among the principal ones, as illustrated in the example of Fig 3, we can enumerate the following:

**Evolution:** Components may be easily replaced. In the example the XML Generator has been replaced by a Text Generator.

**Extensibility:** The architecture may be enriched with new component types. A Temperature Sensor component type has been added to enrich the final reports.

**Transparent Distribution:** Since communication among components is independent from their functionality, it is possible to reconfigure the mediation chain to obtain a distributed architecture of the F&C module (using a distributed messaging system, like JMS).

**Flexibility:** The Cilia framework could run in small devices. Consequently, the F&C module can be embedded in smart RFID readers.

4. CONCLUSIONS AND FUTURE WORK

From the RFID middleware requirements study and our experiences doing this initial work implementation, we can conclude that a modular architecture using an event-oriented component model provides benefits, such as, evolving the F&C component adding new functionality or obtaining scalability by means of transparent distribution. We plan to add support for sensor information in order to generate richer reports. Also, we plan to use the currently developed components in embedded systems, changing only the communication technology, which needs to be appropriate for constrained devices.

5. ACKNOWLEDGMENTS

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6. REFERENCES