Representing Supply Chain Events on the Web of Data

http://windermere.aston.ac.uk/~monika/papers/SolankiDeRiVE2013.pdf

Monika Solanki and Christopher Brewster Aston Business School Aston University, Birmingham, UK



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Motivation

- RFID/Barcodes enable the capture of the identity and location of physical items and goods as they move along the supply chain.
- The Electronic Product Code(EPC) provides products with identities.
- The Electronic Product Code Information Service (EPCIS)* provides a set of specifications for the syntactic capture and informal semantic interpretation of EPC based product information.

*http://www.gs1.org/gsmp/kc/epcglobal/epcis

Motivation

Supply chain product information sharing limitations

- Large volumes of traceability data are recorded at each partner's end. While the datasets are inherently related, the underlying schemas and data storage mechanisms employed render the datasets disconnected.
- The EPCIS XML schemas define only the structure of the event data to be recorded. The semantics of event data and data curation processes are informally defined in the specification.

Declarative representative of EPCIS events

EEM: EPCIS Event Model

- Enables the sharing and semantic interpretation of EPCIS event data.
- Exploits SW/LD technologies, while drawing requirements from business processes involved in the tracking and tracing of goods.
- Encodes informal EPCIS integrity constraints as SWRL rules.

Declarative representative of EPCIS events

EEM: EPCIS Event Model

- EEM based linked datasets can be exploited in order to improve visibility, accuracy and automation along the supply chain.
- EEM can be used to derive implicit knowledge that can expose inefficiencies such as shipment delay, inventory shrinkage and out-of-stock situation.

What is an EPC?

Electronic Product Code

- A universal identifier that gives a unique, serialised identity to a specific physical object.
- Encoded on data carriers: Active/Passive RFID tags, Barcodes, Human Readable Number and more.
- Can be used to track all kinds of objects: trade items, fixed assets, documents, or reusable transport items.
- While barcodes are commonly used to distinguish a can of soup from a box of chocolate chip biscuits, the EPC can identify a specific can of soup or box of biscuits.
- "Next Generation Barcode".

What is an EPC?

EPC: Three forms of representation with multiple identifier schemes

EPC Pure identity URI: the text form the EPC takes within eletronic information exchange documents, systems and applications.

urn:epc:id:sgtin:0614141.112345.400

EPC Tag URI: Pure identity EPC URIs but with added control information.

```
urn:epc:tag::sgtin-96:3.0614141.112345.400
```

EPC Raw URI (binary encoding):

urn:epc:raw:96.x0123456890ABCDEF01234567

*http://www.gsl.org/sites/default/files/docs/tds/ tds_1_7-Std.pdf

Example: EPC Pure identity URI





http://www.epc-rfid.info/sgtin

What is EPCIS?

Electronic Product Code Information Services

- A ratified(2007) EPCglobal standard for sharing EPC related information between trading partners in a supply chain.
- Visibility (tracking and tracing) information takes the form of "events" that describe specific occurrences in the supply chain.
- Specifies two interfaces and a data model.
- Enables persisting supply chain events and sharing the events with internal and external applications.

What is EPCIS?

Electronic Product Code Information Services

- Data captured through EPCIS capture interfaces and made available for query through the EPCIS query interfaces.
- Data persisted (Information dimensions):
 What(product(s)), Where(location), When(time), and Why(business step and status) of events (product movement) occurring in any supply chain.
- Event data model made available as an EPCglobal base XML schema.

Examples: EPCIS events

- "At time T, the association of the following case tags to the following pallet tag was created at palletizer #3, to fulfill order #1234".
- Between the time the case crossed the first beam and the second beam at location L, the following tag was read".
- "At Time T, Object X was observed at Location L.".



EPCIS Events: An informal Intuition

One generic and four specific physical event types

- **EPCISEvent:** the generic EPCIS event.
- ObjectEvent: an event that occurred as a result of some action on one or more entities denoted by EPCs.
 "This list of objects was observed entering DC #9 at 10:01AM, during Receiving".
- AggregationEvent: an event that happened to one or more EPC-denoted entities that are physically aggregated.
 "This list of objects was just Palletized with this Pallet ID at Palletizer #27 at 12:32PM".

EPCIS Events: An informal Intuition

One generic and four specific physical event types.

 QuantityEvent: an event concerned with a specific number of objects all having the same type, but where the individual instances are not identified.
 "There were 200 bottles of Brand X cola in store #4123

backroom at 3:20PM".

 TransactionEvent: an event in which one or more entities denoted by EPCs become associated or disassociated with one or more identified business transactions.
 "Order #123 was fulfilled with objects x, y and z".

Data model components

- EPCs
- 🔁 Time
- Read Points
- Business Location
- Business steps
- Disposition
- Transaction types
- Action

EEM: The EPCIS Event Model

- A domain specific, ontological information/data model.
- Restricts the entities, relationship and attributes to a large subset of the EPCIS specification.
- Defines conceptual primitives with the appropriate level of semantic abstraction required to model the various kinds of EPCIS events that can be raised and the four information dimensions they encapsulate.
- Focuses on a tight conformance with the EPCIS standard and Simplicity.

EEM: Modelling Decisions

Level of Expressivity

- Most data models for the Web of data are designed with relatively weak semantics to facilitate integration.
- We wanted a model that could constrain the formal interpretation of EPCIS events to align with the informal intuition given by the standard.
- The model should have the appropriate level of formality needed to enforce the desired consequences.
- EEM has been represented in the OWL DL profile, with plans to refine it to OWL QL/RL to fcailitate querying and rule based reasoning.

EEM: Modelling Decisions

Relationship with the Event entity in other event model

- For the first version, we deliberately avoid a mapping of the EEM event entity with event related entities in other models.
- EEM addresses the need of knowledge representation for a very specific class of events.
- The requirements, motivation and viewpoints behind the design of EEM are orthogonal to those presented by other event models.

EEM: Modelling Decisions

Extensibility

- The EPCIS standard allows extensibility of event types and event attributes.
- Being an ontological model, designed with modularity as one of its inherent strengths, EEM provides the flexibility required to add new entities, attributes and relationships.

Modelling Decisions: Concrete Implications

Existential property restrictions

An ObjectEvent is required to have associated EPCs, an action type and the time of event.

A QuantityEvent is required to have an EPCClass associated with it.

Functional properties

An event occurs at a unique location, it has a unique action type and is part of a singular business process.

Semantics of Action

EEM encodes the informal semantics by defining SWRL rules over event types and action attribute values.



 EPCISEvent is the root or super class of all events.
 ObjectEvent, AggregationEvent, QuantityEvent and TransactionEvent are specialised classes of EPCISEvent.

http://purl.org/FIspace/eem#



- The class EPC provides a placeholder for EPCs.
- The list of EPCs is represented by SetOfEPCs, specialising from Set*.

*http://purl.org/co/

- Action denotes the activity undertaken on objects represented by SetOfEPCs.
 Individuals: ADD, OBSERVE and DELETE.
- BusinessLocation and ReadPointLocation classes capture physical location details and specialise from the Location class defined in the vcard* vocabulary.

*http://www.w3.org/2006/vcard/ns#

```
Class: EPCISEvent
    SubClassOf:
        eventTimeZoneOffset exactly 1 xsd:dateTime,
        eventRecordedAt exactly 1 xsd:dateTime,
        eventOccurredAt exactly 1 xsd:dateTime
Class: ObjectEvent
    SubClassOf:
        (actionType some Action)
         and (associatedWithEPCList some SetofEPCs),
        EPCISEvent
Class: QuantityEvent
    SubClassOf:
        (hasEPCClass exactly 1 xsd:anyURI)
         and (quantity exactly 1 xsd:integer),
```

```
EPCISEvent
```

EEM Entities: Event Properties

📴 Generic

• eventID

Specific

- AggregationEvent: hasAggregationID
- QuantityEvent: hasEPCClass
- 📴 Temporal
 - eventOccurredAt: subproperty of hasEventDate from the DOLCE+DnS Ultralite (DUL*) ontology.
 - eventRecordedAt
 - eventTimeZoneOffset
- Location
 - hasBusinessLocation
 - hasReadPointLocation

*http://ontologydesignpatterns.org/ont/dul/DUL.owl

Core Business Vocabulary

- A companion standard to the EPCIS standard is the Core Business Vocabulary(CBV)* standard.
- The CBV standard supplements the EPCIS framework by defining vocabularies and specific data values, e.g.,
 - Disposition: returned, in_progress, active.
 - BusinessStep: receiving, stocking, shipping.
- CBVVocab* provides an ontological information model corresponding to the terminology and data values defined in the CBV standard.

*http://purl.org/FIspace/cbv#
*http://www.gsl.org/gsmp/kc/epcglobal/cbv

EEM Entities: Business Context



Modelling the Semantics of "Action"

- An event field defined for Object, Aggregation and Transaction events
- Action: an activity that has taken place on the object(s) during the business step that generated the event.
- Values (individuals in EEM): ADD, OBSERVE and DELETE.
 - ADD: The entity has been created or added to (commissioned).
 - OBSERVE: The entity has not been changed.
 - DELETE: The entity has been removed from or destroyed altogether.
- hasActionType relates an event to the action type.

Modelling the Semantics of Action

For an ObjectEvent what are the informal semantics of the ADD action type ?

Object Event: Informal semantics of ADD

"EPC(s) named in the event have been commissioned as part of this event".

SWRL Rule encoding the informal semantics

ObjectEvent(?e), *actionType*(?e, *ADD*), *associatedWithEPCList*(?e, ?*list*), *hasBusinessStepType*(?e, *commissioning*)

 \rightarrow commissioned(?e,?list)

Implementing EEM: LinkedEPCIS library

- EEM is a complex data model.
- Non trivial to generate class assertions and complex queries without knowing the structure of the model and nomenclature of the entities.
- LinkedEPCIS* an open source Java API to,
 - Encourage the uptake of EEM among EPCIS conforming organisations and industries
 - Ease the creation of EEM instances
 - Facilitate querying over the instantiated datasets

* http://code.google.com/p/linked-epcis/

Implementing EEM: LinkedEPCIS library

- Capture EPCIS events as linked data.
- Provides classes, interfaces and RESTful Web services for capturing, storing and querying EPCIS events.
- Built over the Sesame* framework.
- Every event generated using LinkedEPCIS, is systematically assigned a HTTP URI.
- Query classes encoding templated SPARQL queries for the most commonly made queries on EPCIS events.
- Results are made available in RDF/XML, JSON and Turtle serialisations through the Web services.

*http://openrdf.org

Interlinking EPCIS Event data



Applying EEM to the Agri-food domain



The tomato supply chain involves thousands of farmers, hundreds of traders and few retail groups.

Agri-food scenario

- The tomatoes are packaged and shipped to downstream traders.
- The packaging of tomatoes is done in crates, each of which is tagged with an RFID chip that carries an EPC(SGTIN).
- Sensors installed at the packaging unit register the EPCs of the crates as they are being packed.
- Every read is recorded and registered as an EPCIS event type based on the business process, the location and the supply chain operation.

Agri-food scenario: Subset of EPCIS events



Readers installed at Docks: D1, D2, D3, D4, D5, D6

@prefix ffd: http://data.franzfarmer.com/epcis/locations/sgln/ @prefix rdr: http://data.franzfarmer.com/epcis/reader/ @prefix cbv: http://purl.org/Flspace/cbv#

	Supply chain operation	EPCIS event type	Business Step	Disposition	Action type
1.	Commissioning crates for tomatoes	Object event	commissioning	active	ADD
2.	Storing crates	Quantity event	storing	in_progress	-
3.	Aggregating crates in pallets	Aggregation event	packing	in_progress	ADD
4.	Loading and shipping pallets	Transaction event	shipping	in_transit	ADD

Agri-food scenario: Linked data



Related Work

- Event Ontology: Music related events
- DOLCE+DnS Ultralite (DUL): Upper ontology
- Diagonal Strain The Event Model F: Formal model built over DUL
- SEM (Simple Event Model): Historical events
- CIDOC-CRM: Historical events, museum artifacts
- LODE: Closely related to EEM in terms of describing the 4 Ws, except that EEM incorporates the Why for an event rather than Who.

Conclusions

The representation of EPCIS events on the Web of data is an important step towards achieving the objectives of,

- sharing traceability information
- detecting inconsistencies
- EEM provides the ontological primitives required to represent EPCIS events using Semantic Web standards on the Web of data.
- The capture, storage and querying of EPCIS events linked datasets is realised using the LinkedEPCIS library, which can be integrated with existing RFID and EPCIS implementations.
- EEM and the LinkedEPCIS library has been exemplified by modelling and curating events from the agri-food supply chain.

Another application of EEM/LinkedEPCIS

Consuming Linked data in Supply Chains: Enabling data visibility via Linked Pedigrees

http://windermere.aston.ac.uk/~monika/papers/SolankiCOLD2013.pdf

paper at COLD2013

Future: Data into Food

Edible RFID tags describe your food

An RFID in a cake could tell you how many calories it contains!!!



http://www.newscientist.com/blogs/onepercent/2011/ 06/chips-for-dinner-edible-rfid-t.html

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