Data Modeling and ebXML for Supply Chain Traceability

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The presentation content is based on a subset of the ideas and work reported in the following paper:

A. Bechini, M.G.C.A. Cimino, F. Marcelloni, and A. Tomasi

“Patterns and Technologies for Enabling Supply Chain Traceability through Collaborative e-Business”

Information and Software Technology, Elsevier
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Overview

- Traceability scenarios
- Interaction among parties
- Reference data model
- Supply chain modeling?
- Business Process interoperability (ebXML)
- Overall traceability framework architecture
- Conclusions
Traversing Supply Chains

Goal:
• Effective (& efficient) supply chain traversal; Traceability (tracking/tracing)

Key concepts:
• Lot
• Activity
• Responsible Actor
• Relation

Needs:
• Semantic context
• Generic entities
• Univocal ID
• (Quality)
Interaction among Parties

• Each responsible actor belongs to a company involved in the supply chain
• Information exchanges among responsible actors
• Heterogeneous structure and naming of data
• Tackling heterogeneous semantics
• Large and Dynamic community
  – scalability in number of parties
    (depending on the market…)
• Managing the Business status of agreements
• Facing failure scenarios
Parties and Lot Info Management

- The lot flow through the supply chain is associated with information exchanges among responsible actors (and possibly third-party organizations).
- Lot flow vision (from fluids dynamics): Eulerian vs Lagrangian reference frame.
- Push model: each responsible actor pushes traceability data into a centralized storage.
- Pull model: data stored more advantageously at the source (distribute storage).
- Data Confidentiality and control → Intermediate data trustees.
Central vs. Distributed Management

- (a) distributed and (b) central management
- Identifiers attached to the physical lot
- “Push” strategy
Intermediate Data Trustee

- Distributed management, intermediate data trustee
- “Pull” strategy
Generic Traceability Semantics

a) Lot -> Acquisition -> Lot
   Lot -> Providing -> Lot

b) Lot -> Division -> Lot
   Lot -> Integration -> Lot

c) Lot -> Alteration -> Lot

d) Lot -> Transformation -> Lot

e) Lot

f) Lot
Data Model: Basic Activities

Nature
- [extracted]
  - Acquisition
    - Lot [acquired]
      - Transformation
        - Providing
          - Lot [provided]
  - [damaged]

Responsible Actor
- Lot [transformed]

Consumer
- [consumed]
Data Model: Lot State Diagram

- At the beginning, a lot is acquired by an actor from the "Nature".
- A lot is transformed by an activity into another lot.
- At the end, an actor provides the "Nature" or the "Consumer" with a lot.

Diagram:

- **acquired**
  - Acquisition activity
  - Transformation activity
  - Providing activity

- **transformed**
  - Transformation activity
  - Providing activity

- **provided**
  - Providing activity
Reference Data Model (in UML)

- Two distinct packages
- Notion of **Traceable Entity**
- Traceable ID: EAN/UCC (barcode), EPC (rfid)
Start: Modeling the Supply Chain

- The correct understanding of lot flow comes from correct specs of the supply chain.
- The reference data model helps in the supply chain specification.
- The reference data model drives the focus towards traceability issues.
- Traceability needs may influence the supply chain layout.
Example: Macro-activities

FISH SUPPLIER
- FISHING
  - STORAGE
    - SELLING_1
      - CHECK
        - PROCESSING
          - PACKAGING
            - DISTRIBUTOR
              - DISTRIBUTION

Smocked Salmon

REFRIGERATION
- SELLING_2
  - Packaged Salmon
Supply Chain Model

- UML Activity diagram, pointing out:
  - Activities
  - Lots
  - Actors (swimlanes...)
  - Sites...
Example: Obj Diagram Lot/Activity

- **storageTemperature**: NumericalQF
  - description: "temperature of storage"
  - value = -35
  - unitName = "°C"
  - minValue = -30
  - maxValue = -40

- **processingFirm**: ResponsibleActor
  - A_ID
  - name
  - telephone

- **storedSalmon**: Lot
  - ID

- **storageDefrosting**: Activity
  - date
  - duration

- **cell**: Site
  - S_ID
Example: Assorted Quality Features
Lot Flow Snapshot: Crucial Points

- **acquiredSalmon_1 : Lot**
- **selectedSalmon_1 : Lot**
- **storedSalmon_1 : Lot**
- **selectedSalmon_2 : Lot**
- **selectedSalmon_3 : Lot**
- **salmonFilet_1 : Lot**
- **salmonFilet_2 : Lot**
Pursuing BP Interoperability

**Technological needs:**
- Highly distributed architecture
- Dealing with multiple software interfaces
- Tackling heterogeneity
- Loosely coupled communication
- Facing failure scenarios

**Methodological needs:**
- Relying on standard inter-organizations cooperation models and protocols
- Strongly separating the Business level from the technical one
- Managing the Business status of agreements
Traceability / e-Business Standards

- ebXML
  (Electronic Business using eXtensible Markup Language)

- Globally developed standard (ISO15000) started in 1999 as an initiative of OASIS and the United Nations/ECE agency CEFACT
BP Interoperability: ebXML Outline

- Many trading partners collaborate to create working relationship
- Interchange defined as requestor / responder
- Business transactions control the process progression state
- Partners within a community share business definitions/understanding
- Support for Business Scalability (SMEs can effectively participate, not just large corporations)
ebXML Specifications

- Technical Architecture (TA)
- Message Services (ebMS)
- Collaboration Protocol Agreements - Collaboration Protocol Profile (CPA/CPP)
- Business Process Spec. Schema (BPSS)
Setting Up the Collaboration

- Parties, roles, contributions, processes in a supply chain undergo *evolution*
- The collaboration framework in the traceability system requires formal agreements on functional and technical details
- Exploiting ebXML: why not?
- What degree of automation can be reached?
ebXML: Business Collaboration
ebXML Messaging Service

Main features:
- message packaging
- reliable messaging
- message ordering
- error handling

- security
- synchronous reply
- message status service
- persistent storage
- QoS support (CPA)

Basic Message Service Handler Architecture
BPSS, UMM, CPP/CPA…

Diagram showing the relationship between various models and schemas:

- UMM Metamodel
- Semantic Subset
- Specification Schema (UML)
- Production Rules
- Specification Schema (XML)
  - DTD
  - W3C Schema
- Business Signal Definitions
- Core Components
- Business Document Definitions
- CPP
- CPA
- TP Document DTD’s
Purchase Activity: Example

Messages between provider/requestor agents
distributed storage (a)
central storage (b)

- Identifier attached to the physical lot
Purchase Info in XML

```xml
<activity type ="purchase">
  <id>A055</id>
  <respActorId>A009</respActorId>
  <startingDate>2004-04-15 16:20:19</startingDate>
  <duration unit ="hour">1</duration>
  <siteId>S007</siteId>
  <qualityFeature>...</qualityFeature>
  <generatedLot>
    <id>T047</id>
  </generatedLot>
  <componentLots>
    <id>L033</id>
    <respActorId>A009</respActorId>
  </componentLots>
</activity>

b) lot

<lot type ="Wine Cask">
  <id>T047</id>
  <respActorId>A009</respActorId>
  <generationDate>2004-04-15 16:20:19</generationDate>
  <siteId>T038</siteId>
  <activityId>A005</activityId>
  <qualityFeature>...</qualityFeature>
</lot>

a) activity
Info on Quality Features

```
red winery : Site
S_ID = "S007"
address = "Via Bottinaccio, 37 - 41066 Montelupo (Fi) - Italy"

producer : Responsible Actor
RA_ID = "A001"
name = "Tom White"

: Categorical QF
description = "rating"
value = "2 stars"

: Numerical QF
description = "color intensity"
value = 8.21
unit name = "Intensity"
min value = 1
max value = 10

: Categorical Value
value = "1 stars"
ordering = 0
description = "good"

: Categorical Value
value = "2 stars"
ordering = 1
description = "very good"

: Categorical Value
value = "3 stars"
ordering = 2
description = "excellent"
```

Quality Package

```
Quality Feature
description

Categorical QF
defines
Numerical QF
value
unit name
min value
max value
```
Overall XML Description

```xml
<activity type ="purchase">
  <id>A055</id>
  <respActorId>A009</respActorId>
  <startingDate>2004-04-15 16:20:19</startingDate>
  <duration unit ="hour">1</duration>
  <siteId>S007</siteId>
  <qualityFeature>...</qualityFeature>
  <generatedLot>
    <id>T047</id>
    <respActorId>A009</respActorId>
  </generatedLot>
  <componentLots>
    <id>L033</id>
    <respActorId>A009</respActorId>
  </componentLots>
</activity>

b) lot

```xml
<lot type ="Wine Cask">
  <id>T047</id>
  <respActorId>A009</respActorId>
  <startingDate>2004-04-15 16:20:19</startingDate>
  <generationDate>2004-04-15 16:20:19</generationDate>
  <siteId>T038</siteId>
  <activityId>A005</activityId>
  <qualityFeature>...</qualityFeature>
</lot>

c) numerical quality feature

```xml
<qualityFeature>
  <description>color intensity</description>
  <numericalQF>
    <unitName>"Intensity"
    <minValue>"1"
    <maxValue>"10"
    <value>8.21</value>
  </numericalQF>
</qualityFeature>
```

d) categorical quality feature

```xml
<qualityFeature>
  <description>ratings</description>
  <categoricalQF>
    <value>2 stars</value>
    <categoricalValue value="1 stars" ordering="0" description="good"/>
    <categoricalValue value="2 stars" ordering="1" description="very good"/>
    <categoricalValue value="3 stars" ordering="2" description="excellent"/>
  </categoricalQF>
</qualityFeature>
```
Traceability Framework Architecture
Conclusions

- Role of the Data Model
- Logical view of the supply chain
- Figure out what a lot is!
- Message Orientation (ebMS)
- Description Orientation (UML, XML)
- Granularity (small number of activity)
- Network Orientation (SOAP/HTTP)
- Platform Neutral (XML)