Evolution of Taxonomies and A Supply Chain of Things

Daniel E. O’Leary
University of Southern California
©2012
0. Research about Research

- Before I drill down on taxonomies and ontologies I would like to briefly talk about “research about research”
- On Thursday, “Gartner’s Hype Curve” was mentioned.
- I have found that such life cycle curves are very helpful in analysis of research issues
* The recommended adoption time frame may be swayed in either direction for a technology with a particularly high or low level of potential impact within an organization. For example, a Type B company may wait until the Plateau of Productivity to invest in a technology that will result in only marginal efficiency improvements. On the other hand, a Type C company may be prepared to weather some of the learning experiences of the Slope of Enlightenment for a technology that will have a major impact on its core business processes.
Gartner Hype Curve and Information Systems Research

Time

Visibility

Trigger

Peak of Inflated Expectations

Trough of Disillusionment

Plateau of Productivity

Research methods generally vary by location of technology in its life cycle – does not have to use Gartner

Very limited data
Prototype development

Case Studies
Mostly Positive

Case Studies
Mostly bad news

Empirical data available
Economic studies
Research Careers

• Two basic extremes ...
  – Can follow a technology across the life cycle
  – Concentrate on technologies and methodologies at some point in the life cycle
Some Lines of Research in Taxonomies and Ontologies

1. Evolution of Best Business Practices Taxonomy
   – Potential evolution of a taxonomy
   – How do taxonomies change?

2. Evolution of a Supply Chain Taxonomy
   – Start with a promulgated taxonomy
   – Can we use empirical data from user tags (crowd source) to evolve a taxonomy about supply chains?

3. Development of a supply chain ontology for RFID
   – Attempt to structure a “supply chain of things”
1. Taxonomy Evolution of Best Business Practices Taxonomy

- Background: Best business practices, with supporting materials embedded in the taxonomy.
- Concern is with innovation and change in a taxonomy, broadly, a scheme for structuring a knowledge management system
  - Understand evolution of knowledge management systems over time
  - Start with a taxonomy and see what other taxonomies develop from it.
Best Business Practices Taxonomy

1. Understand Markets & Customers
2. Develop Vision & Strategy
3. Design Products & Services
4. Market & Sell
5. Produce & Deliver for Manufacturing Organization
6. Produce & Deliver for Service Organization
7. Invoice & Service Customers
8. Develop and Manage Human Resources
9. Manage Information
10. Manage Financial and Physical Resources
11. Execute Environmental Management Program
12. Manage External Relationships
13. Manage Improvement and Change

“APQC” Original

Drill down on each item for detailed categories
Best Practices Knowledge Bases

• “Best Practices” among the better ways of doing things
  – May include descriptions, pictures, case studies

• Sample from APQC KB
  – 2. Develop Vision and Strategy
    • 2.1 Monitor the external environment
      – 2.1.1 Analyze and understand the competition
Evolved Version “PWC”

Subtle Differences from the APQC taxonomy.

Additional drill down available as other categories.

I captured the differences as “changes”
Approach

• Investigated both semantic and structure

• I analyzed the taxonomies
  – By level (as in example, 3 levels)
  – By semantics (e.g., wording was “identical”, “very similar”, “similar”, “no matching from old to new” and “no matching from new to old”)
  – I analyze the extent of changes by “top level category for each of the 13 categories.”
• Ultimately concerned with the ability to forecast taxonomy changes
  – Evolve the knowledge management systems
  – Understand the past, forecast the future
• Approach: Start with a taxonomy and see what it changed into …
  – APQC … evolved to two other taxonomies
  – One available over the internet and the other a company specific system
• Begin to understand how the knowledge changes …
Findings from Comparing Evolved Taxonomies

• Knowledge that stays the same is highly correlated
• Knowledge that changes is correlated.
• Knowledge that stays the same is correlated with the “populated” chunks of knowledge
• Changes in best practices knowledge base is correlated with a general level of knowledge as measured by Google pages.
Compared Taxonomy Changes to Number of Google Pages

Table X. Number of changes versus change in knowledge

<table>
<thead>
<tr>
<th>Category</th>
<th>Google pages measurea</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PWC</td>
<td>XYZ</td>
</tr>
<tr>
<td>1</td>
<td>29,600,000</td>
<td>27,900,000</td>
</tr>
<tr>
<td>2</td>
<td>5,640,000</td>
<td>5,540,000</td>
</tr>
<tr>
<td>3</td>
<td>15,900,000</td>
<td>16,000,000</td>
</tr>
<tr>
<td>4</td>
<td>16,900,000</td>
<td>10,900,000</td>
</tr>
<tr>
<td>5</td>
<td>513,000</td>
<td>248,000</td>
</tr>
<tr>
<td>6</td>
<td>396,000</td>
<td>360,000</td>
</tr>
<tr>
<td>7</td>
<td>361,000</td>
<td>360,000</td>
</tr>
<tr>
<td>8</td>
<td>45,800,000</td>
<td>45,500,000</td>
</tr>
<tr>
<td>9</td>
<td>26,800,000</td>
<td>28,800,000</td>
</tr>
<tr>
<td>10</td>
<td>3,440,000</td>
<td>23,500,000</td>
</tr>
<tr>
<td>11</td>
<td>38,000,000</td>
<td>11,800,000</td>
</tr>
<tr>
<td>12</td>
<td>5,500,000</td>
<td>5,490,000</td>
</tr>
<tr>
<td>13</td>
<td>5,500,000</td>
<td>5,500,000</td>
</tr>
</tbody>
</table>

a Google pages measure gathered April 2008. Correlation between Google pages and changes for PWC is 0.741 significant at the .002 level, and correlation between Google pages measure and changes for XYZ is 0.372, significant at better than 0.105.

“Evolution” captured in number of changes

Findings
2. Supply Chain Taxonomy Evolution

• A taxonomy of supply chain terms was established in the previous literature ... Swaminathan et al. (1998)
  – What might an updated version look like?

• I investigated the question “Can we use empirical data from user tags to evolve a taxonomy about supply chains?”
  • Specifically, I used “Delicious” tags, based on occurrence and co-occurrence of terms
  • First, I analyzed how often terms from the previous taxonomy were used (following slide)
  • Second, I investigated potential other terms for infrequently occurring terms (subsequent slide)
Unfortunately, MANY terms were not used as tags, as visible from these counts ... As a result, the next question was what “closely” related terms were used?

Based on Swaminathan et al. (1998)
Findings

• Unfortunately, in many cases there is limited use of the terms in the original taxonomy in contemporary analysis of tags applied to documents.

• However, there are a number of “very close” terms.
  – I have used those terms to generate an alternative taxonomy for the supply chain.

• I used tags from Delicious.com but they could come from a tagging type of system or other source of data.
Alternative Taxonomy

Supply Chain Elements

Structural Elements

Supplychain 6503

Control Elements

Production 24

Retail 125

Distribution 110

Supply 184

Manufacture 3

Transportation 103

Trucking 54

Rail/Rails 13

Air 11

Road 18

Logistics 740

Delivery 6

Operations 93

Purchasing 67

Procurement 126

Demand 17

Forecast 17

Contracts 3

Contracts 3

Supply 184

Information 13

Real-Time 4

Periodic 0

“Retailer”/“Manufacturer”

“Distributor”/“Supplier”

“Vehicles”

“Flow,” “Loading” and “Routing”
3. “Internet of Things” and Ontologies

• The “Internet of Things” generally refers to the notion that many different “things” (devices, databases, people, etc.) are connected to the Internet and thus can be connected to each other.
  – “Things” are potentially autonomous or semi-autonomous, and networked, and as they are networked they can become more autonomous
  – “Things” can gather information and knowledge from other “things”
  – Composite of network and “things” is more than anyone “thing” ... There are network effects

• Ontology – “a specification of a conceptualization”
“Supply Chain of Things” (1/2)

• Work done with Guido Geerts of University of Delaware
• Goal was to generate supply chain “equivalent” of “Internet of Things”
  – Not concerned with eliciting all possible supply chain concepts
• What happened if we gave an individual identity to inventory things in the supply chain?
  – What if we tagged those “things” with, e.g., RFID tags?
• We would have a “Supply chain of things”, in the same sense of an “Internet of things”
  – The goods would be the “things” of concern
  – “Things” could tell us where they are, where they are from and where they are going.
  – We would have a highly visible supply chain (HVSC)
Supply Chain of Things (2/2)

• We were interested in generating a highly parsimonious ontology. Thus we were concerned with ...
  – What is the minimal level of definition needed to define in order to have a “supply chain of things”
  – What is the smallest number of “components” that would be needed to generate such an ontology?
• Further, the ontology would be parsimonious in the following ways
  – “Things” were defined as “things” that could be broken into smaller groups of things, but we did not define all such levels, e.g., carton, pallet, truck, etc.
  – Ultimately, we differentiated between agents and equipment
  – “Equipment” used to handle the “things” was not specified at the many available levels, e.g., forklift.
  – We felt that these concepts could vary by domain, company, etc.
Selected Supply Chain Issues

• As we built the ontology we designed it in anticipation of some of the decision problems of interest related to visibility of “things” for different reasons.

• Traceability of “Things”
  – Food chain traceability (tainted)
  – Drug traceability (legitimacy)
  – Machine part traceability (failure)

• Decision making
  – JIT – Where are the goods? Do we need to allocate more resources to get them where they need to be, “just-in-time”?
Potential Technologies and Architectures

• The ontology we develop is not technology dependent.
  – Although inevitably I will talk of RFID, any technology that allows identification of supply chain objects ("things") could be used.

• Dependent vs. Independent View
  – Dependent (trading partner, proprietary, etc.)
    • Partners record information from their perspective
    • Unloading for one may be loading for another
  – Independent (supply chain, public view, cloud)
    • Data are recorded from supply chain view
    • Rather than both loading and unloading, there is one “handling” event.
Components of the Ontology

Differentiate between inventory things, agents and equipment

E.g., Read point vs. assumed location

E.g., truck or forklift
Event Driven System

• We structured around the events that occurred to the things (changes to the things) ... events are basic units of analysis
  – For example, “Things” “enter”, “things” change custody, “things” change ownership

• We also found a need for time concepts
  – Some events occur instantly (thing leaves shipment area) and some have duration over time (transportation)
Events Interact in Operations with Other Four Components

“Exchanges”

**A**
- **Event-Agent**
  - from
  - to
  - participates

**B**
- **Event-Thing**
  - takes into
  - breaks forms
  - custody ownership

**C**
- **Event-Location**
  - origin
  - destination

**D**
- **Event-Equipment**
  - from
  - to
  - uses
Operations to Things (1/3) Stereotypical Patterns

A. Takes into forms breaks participates

B. Applies-to participates at origin destination

C. Applies_to at from to participates

D. Applies_to participates at uses

E.g., cooling
Operations to Things (2/3)
Operations to Things (3/3)

Exchange of Custody

- Thing
- Economic Event
- Agent
- Location

Exchange of Ownership

- Thing
- Economic Event
- Agent
- Location
Integrated Operations: Load, Relocate, Unload
Research Implications

• Study how to evolve taxonomies
  – Predict taxonomy or even knowledge management evolution based on how taxonomies change over time
  – Use Google as a basis to anticipate evolution
  – Use user tags as a basis to facilitate evolution

• Examine impact of using the Internet of Things as a basis for generation of an ontology for the supply chain
References

• “Gartner’s Hype cycle and information systems research issues” International Journal of Accounting Information Systems, 2008.
• “A supply chain of things: An Ontology for Highly Visible Supply Chains”
Questions?

• oleary@usc.edu