Evolution of Taxonomies and A Supply Chain of Things

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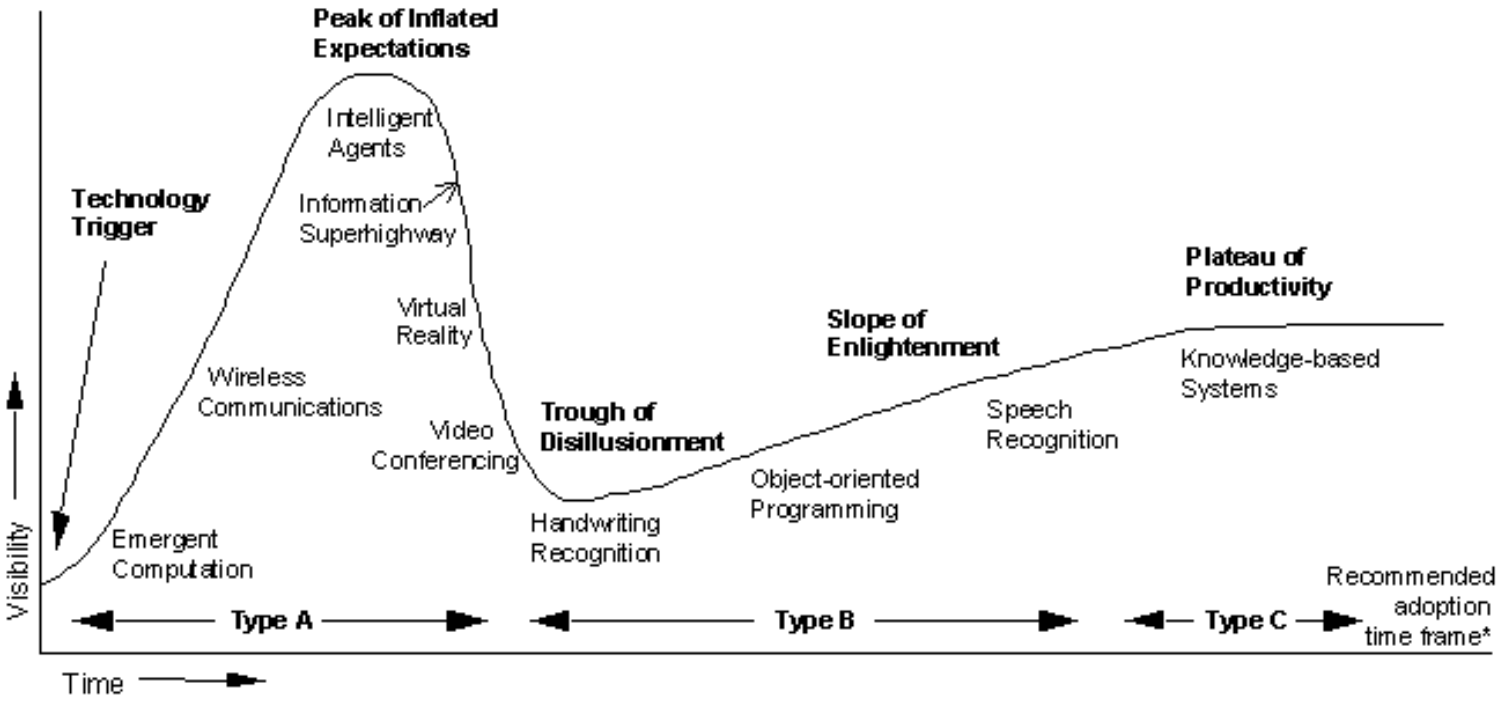
0. Research about Research

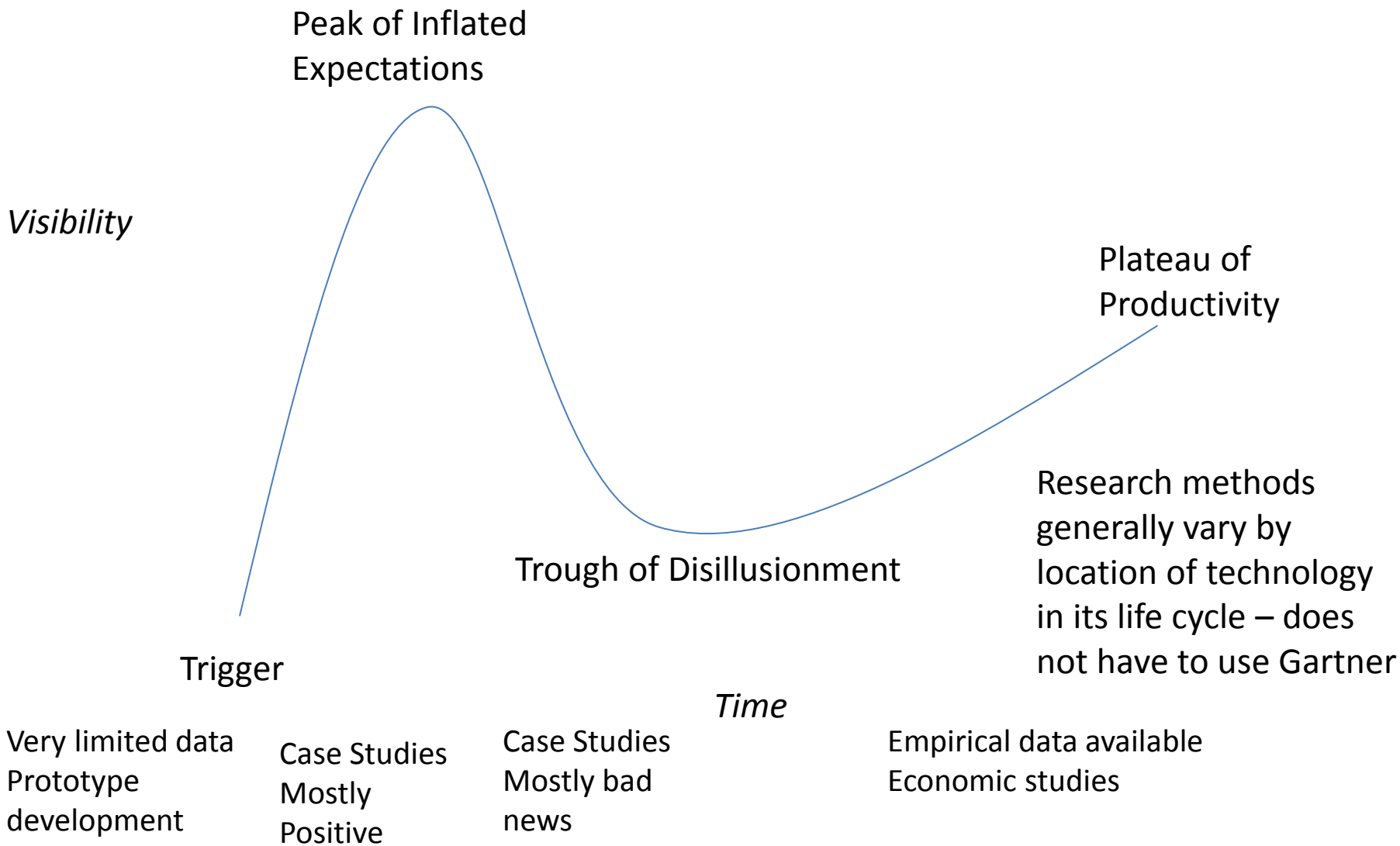
- Before I drill down on taxonomies and ontologies I would like to briefly talk about "research about research"
- On Thursday, "Gartner's Hype Curve" was mentioned.
- I have found that such life cycle curves are very helpful in analysis of research issues

Gartner Hype Cycle



* 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



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

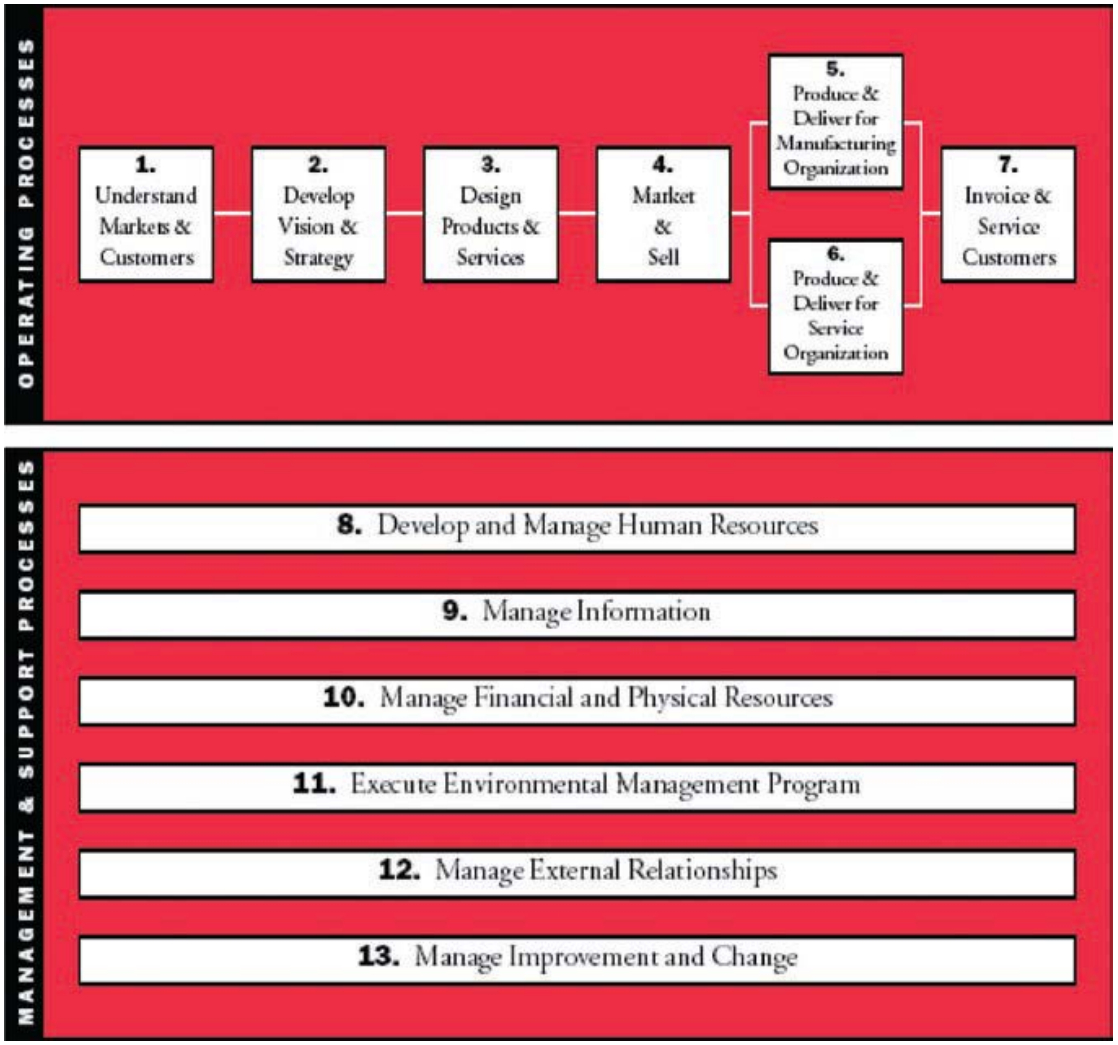
Some Lines of Research in Taxonomies and Ontologies

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



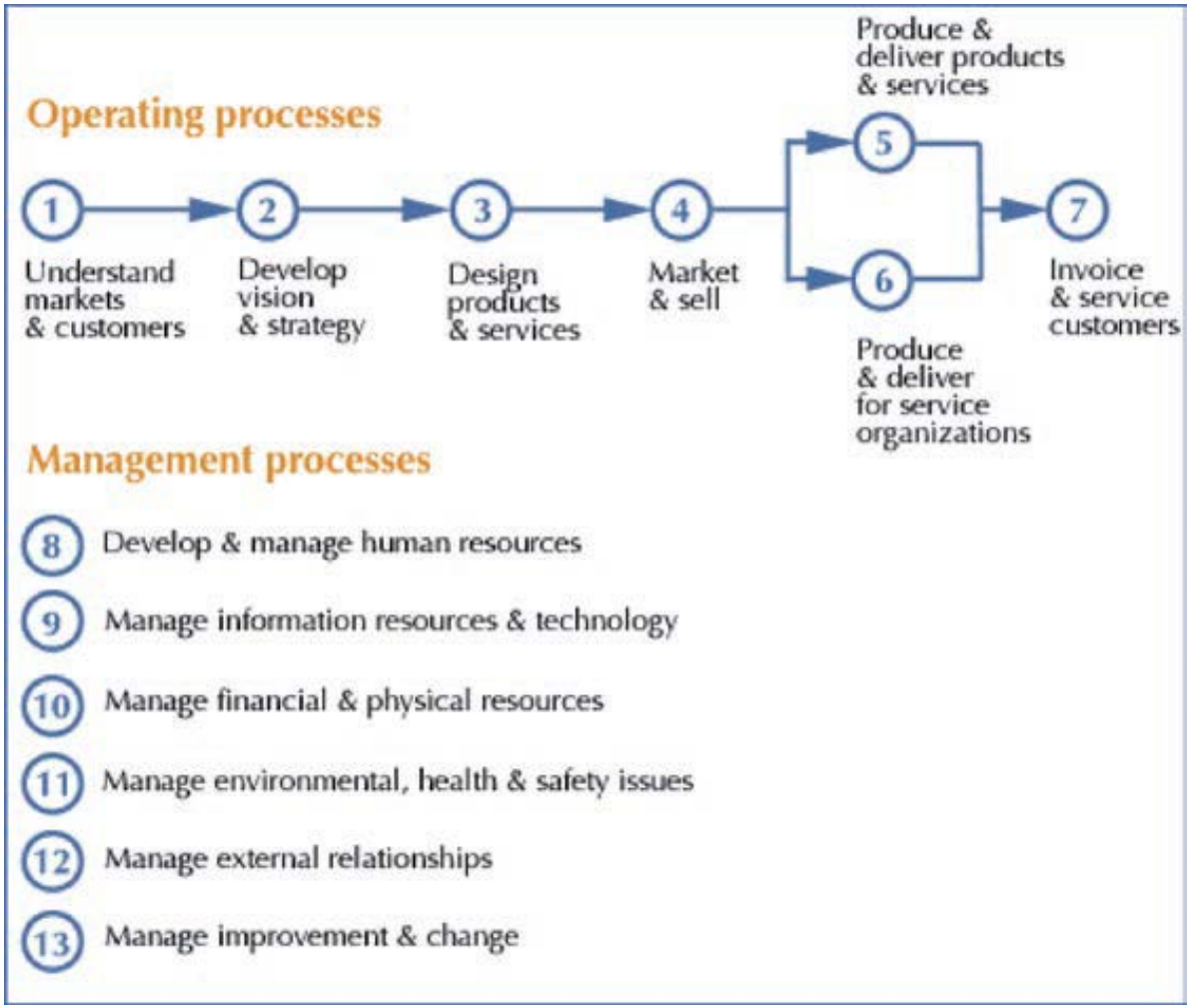
"APQC" Original

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.

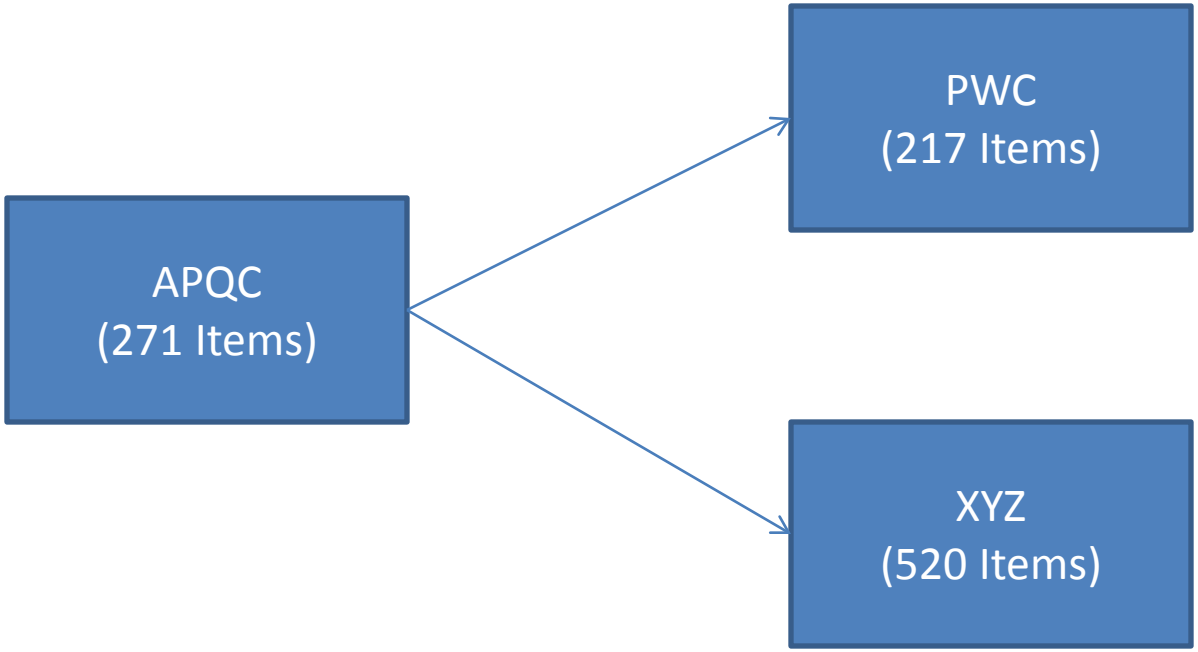
Additional drill down available as other categories.

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.

Taxonomy Evolution



- 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

Category	Google pages measure[a]		Changes	
	PWC	XYZ	PWC	XYZ
1	29,600,000	27,900,000	4	4
2	5,640,000	5540,000	9	11
3	15,900,000	16,000,000	12	19
4	16,900,000	10,900,000	14	64
5	513,000	248,0000	7	35
6	396,000		3	14
7	361,000	360,000	1	3
8	45,800,000	45,500,000	34	42
9	26,800,000	28,800,000	41	160
10	3,440,000	23,500,000	11	31
11	38,000,000	11,800,000	24	36
12	5,500,000	5,490,000	1	24
13	5,500,000	5,500,000	8	10

[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

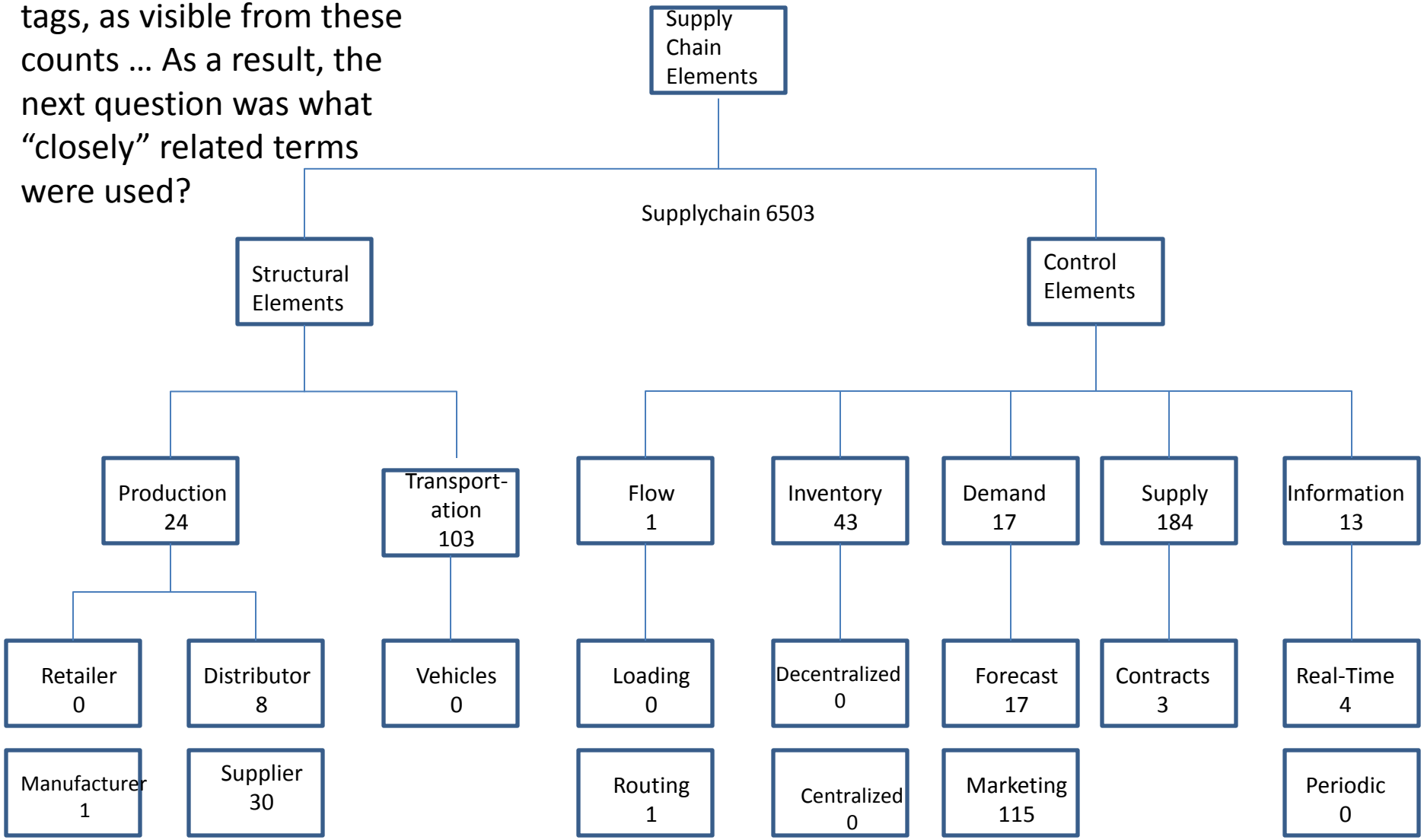
Findings

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?

Occurrences from Original

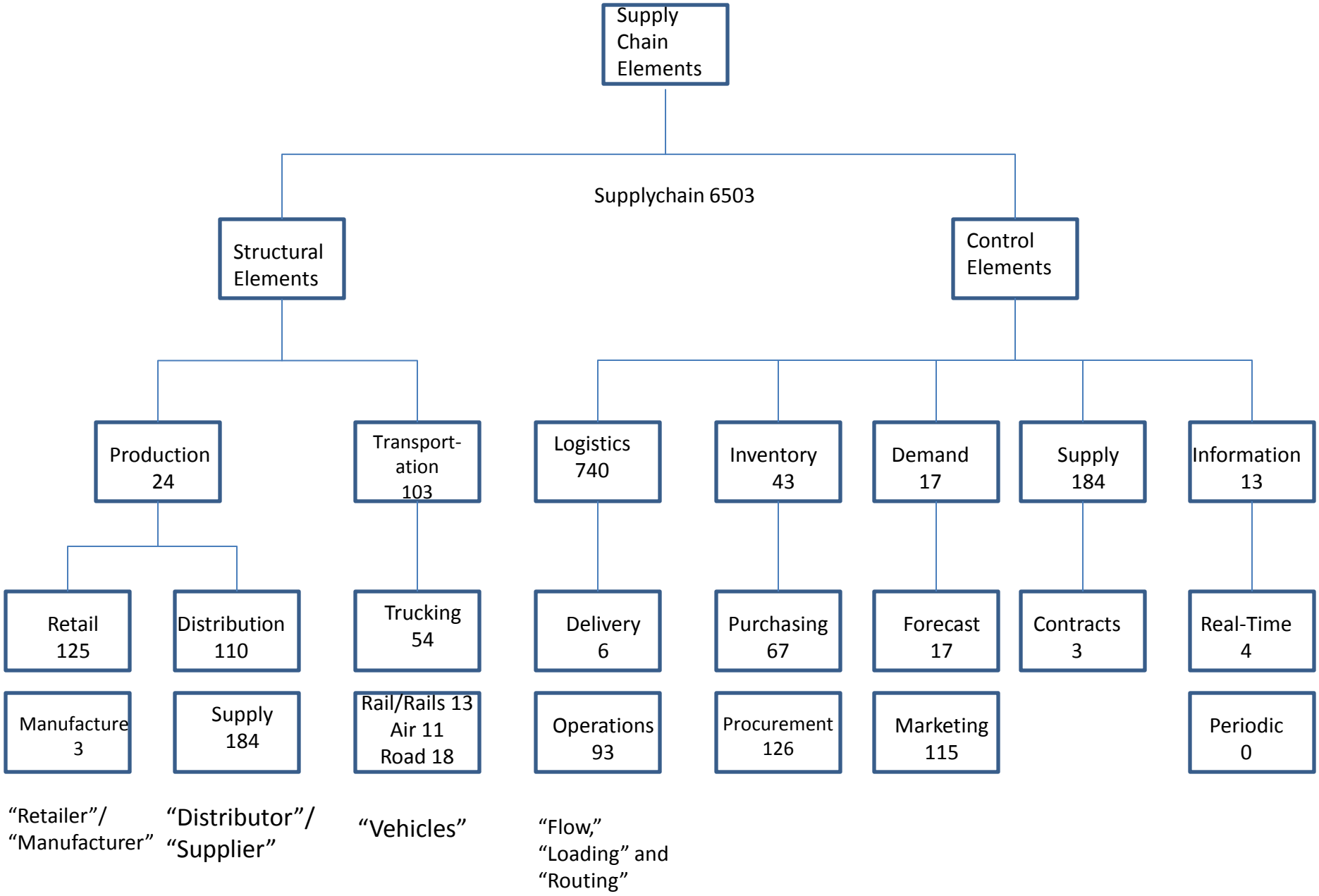


Based on Swaminathan et al. (1998)

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



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

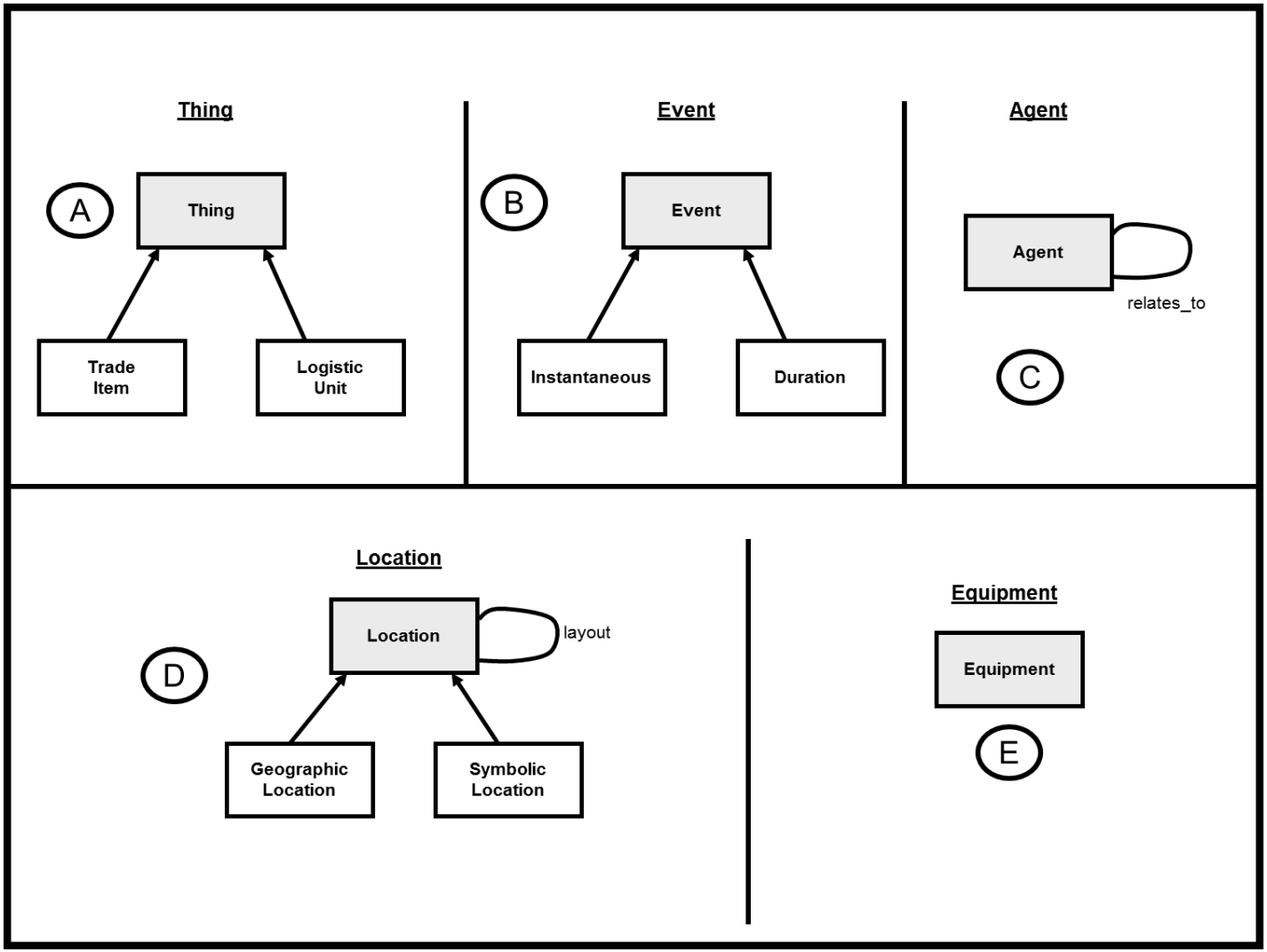
- As we built the ontology we designed it in anticipation of some of the decision problems of interest related to visibility of “things” for different reasons.
- Traceability of “Things”
  - Food chain traceability (tainted)
  - Drug traceability (legitimacy)
  - Machine part traceability (failure)
- 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

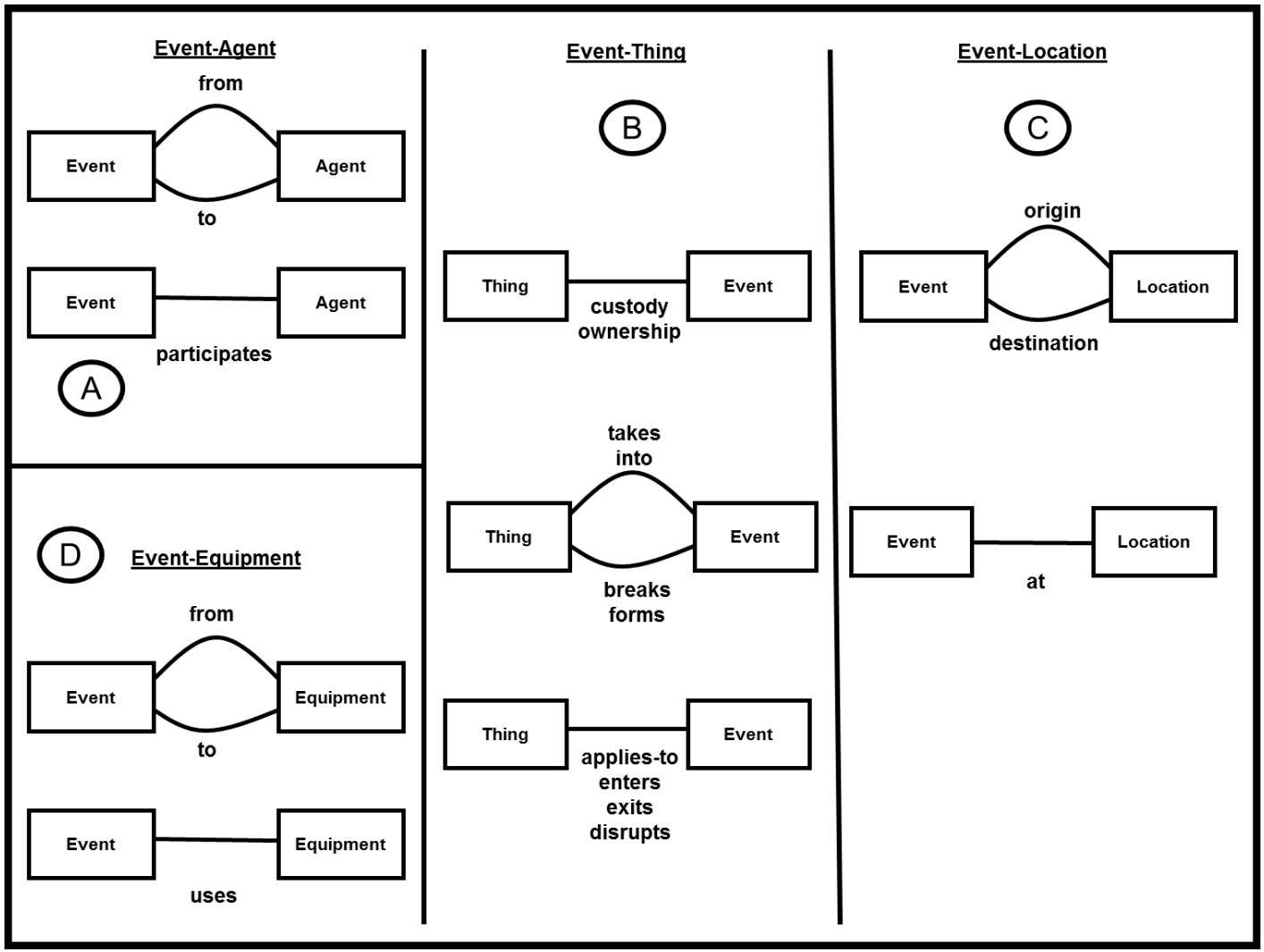
E.g., truck or forklift

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)

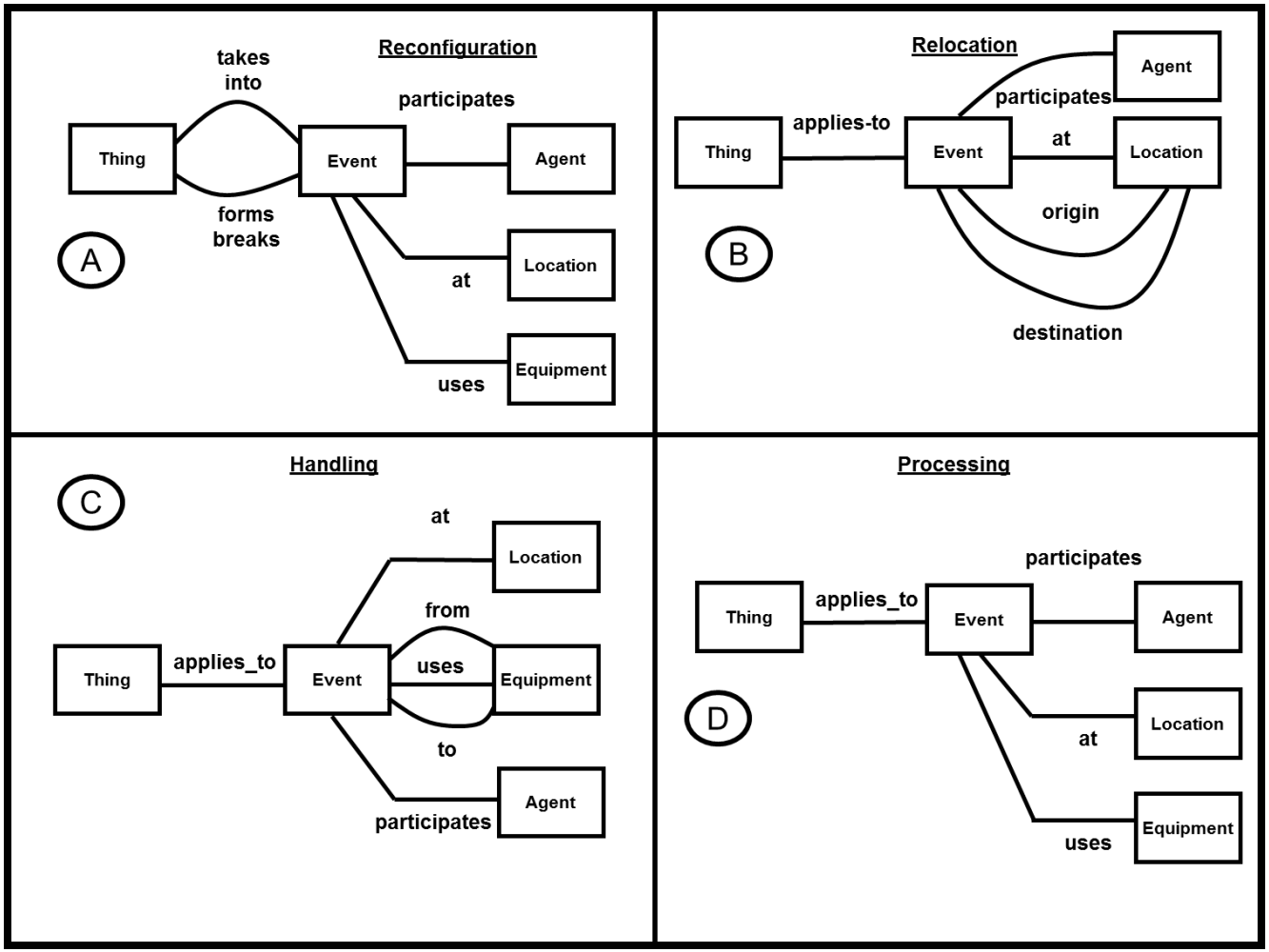
Events Interact in Operations with Other Four Components

"Exchanges"



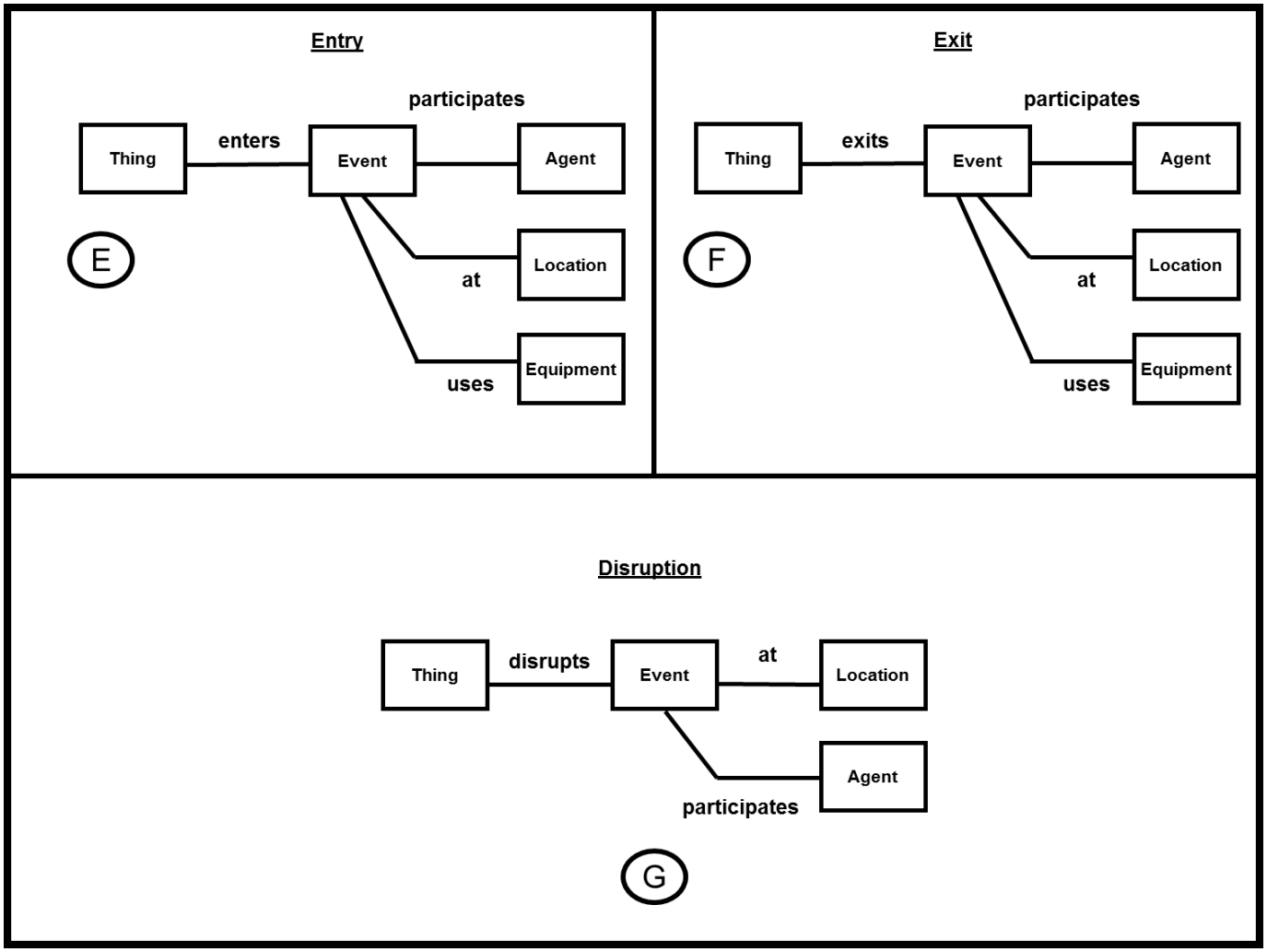
Operations to Things (1/3)

Stereotypical Patterns

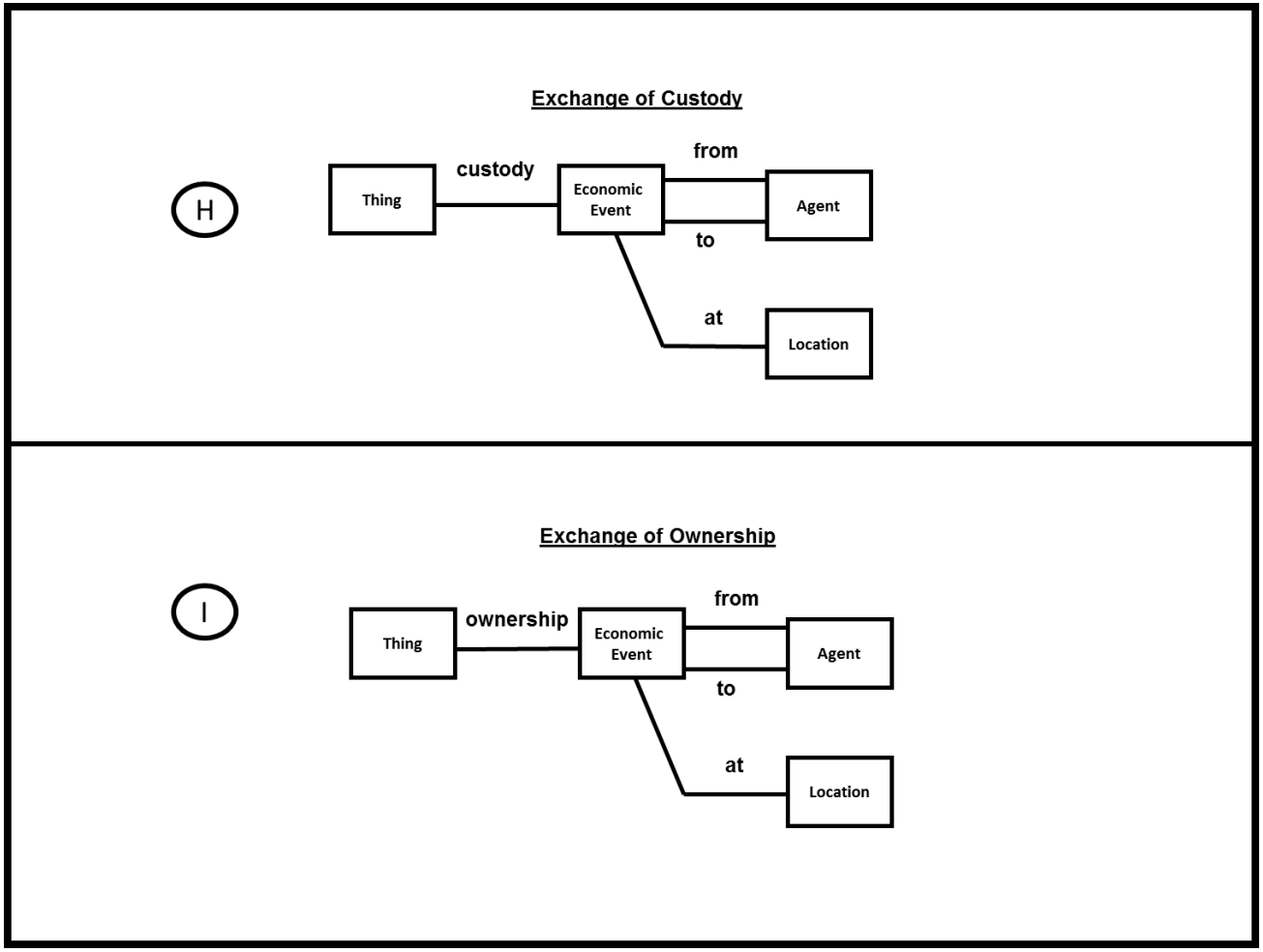


E.g., cooling

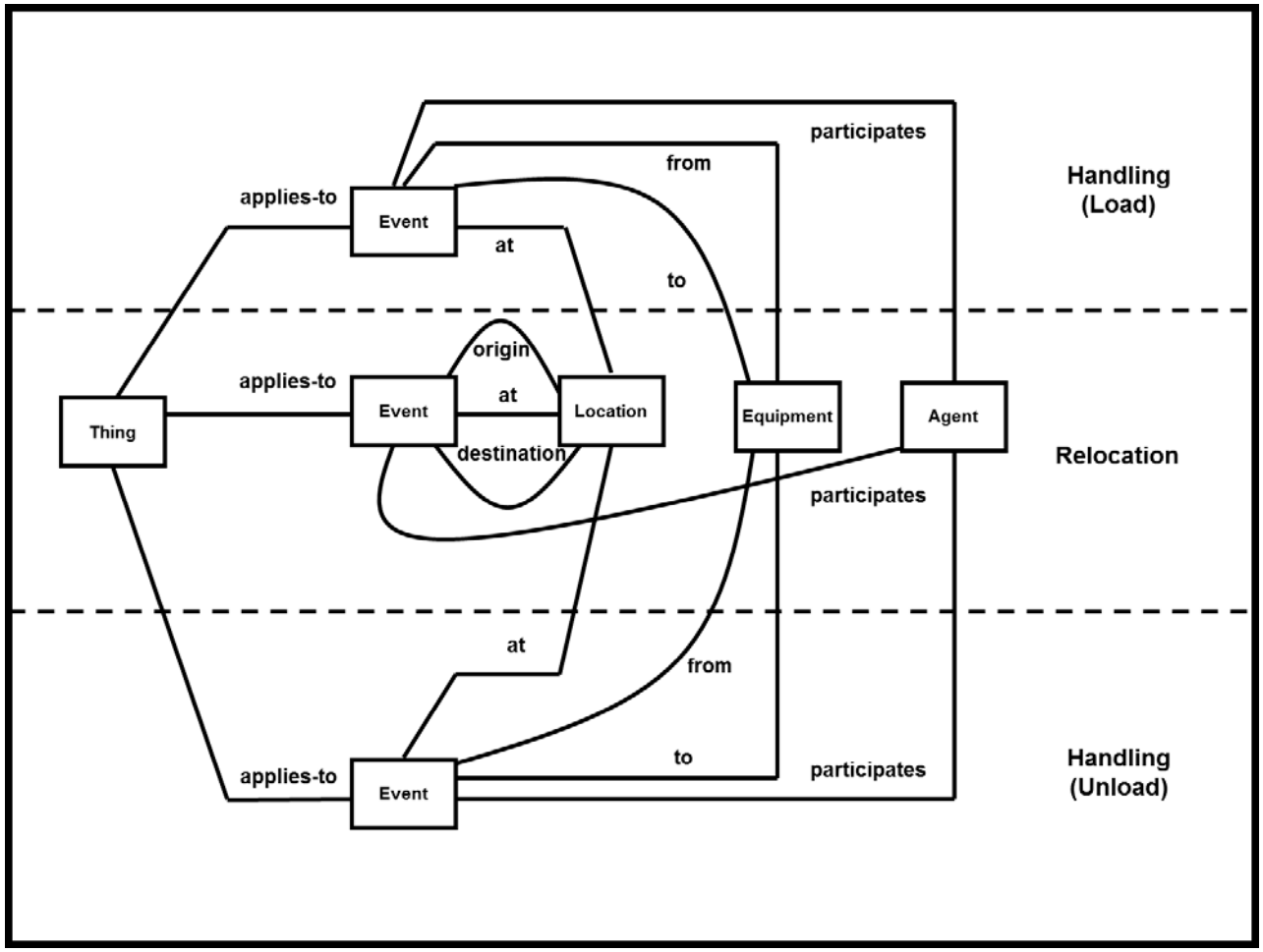
Operations to Things (2/3)



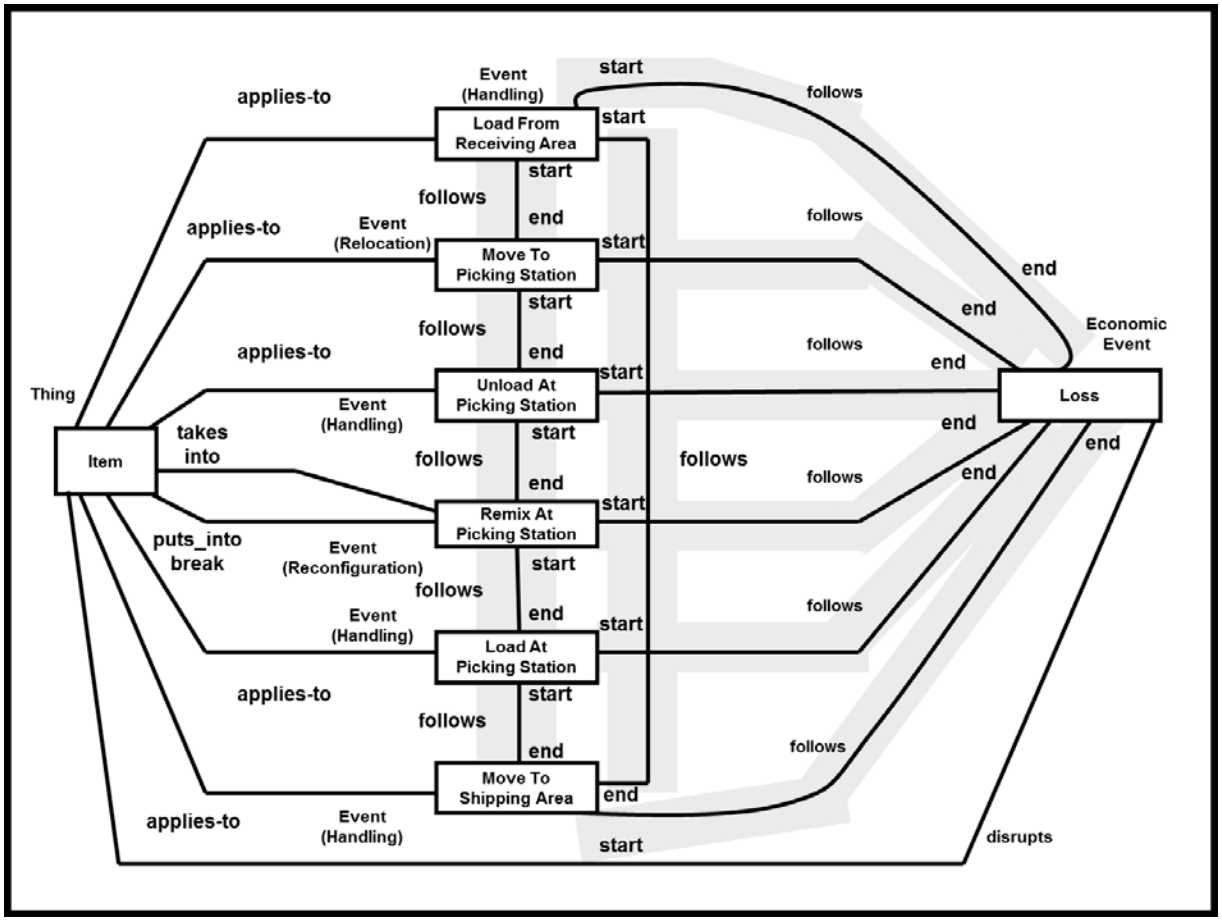
Operations to Things (3/3)



Integrated Operations: Load, Relocate, Unload



Composite


Thing
Item
takes into
puts_into break
applies-to
applies-to
applies-to
applies-to
Event (Handling)
Event (Relocation)
Event (Handling)
Event (Reconfiguration)
Event (Handling)
Event (Handling)
Load From Receiving Area
Move To Picking Station
Unload At Picking Station
Remix At Picking Station
Load At Picking Station
Move To Shipping Area
start
end
follows
Economic Event
Loss
disrupts

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

- “Empirical analysis of the evolution of a taxonomy for best practices” Decision Support Systems, 2007.
- “Gartner’s Hype cycle and information systems research issues” International Journal of Accounting Information Systems, 2008.
- “A comparative analysis of the evolution of a taxonomy for best practices” Intelligent Systems in Accounting, Finance and Management, 2009.
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- “A supply chain of things: An Ontology for Highly Visible Supply Chains”

Questions?

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