RUTGERS

26:010:680 Current Topics in Accounting Research

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OVERVIEW

- Seminal Papers from Week 1
- Homework 2
- REA as an Accounting Ontology
- Some Ontological Issues
- Literature Review for Ethics in Accounting
- Assignments for Week 4
- Homework 3

Seminal Papers from Week 1

- Chen, Peter P-S.1976. "The Entity-relationship Model – Toward a Unified Model of Data" *ACM Transactions on Database Systems* (Vol.1, No.1): pp. 9-36.
- McCarthy, William E. 1979. "An Entity-relationship View of Accounting Models" *The Accounting Review* (Vol. LIV, No. 4): pp. 667-696.
- McCarthy, William E. 1982. "The REA Accounting Model: A Generalized Framework for Accounting Systems in a Shared Data Environment" *The Accounting Review* (Vol. LVII, No. 3): pp. 554-578.
- McCarthy, William E. 2003. "The REA Modeling Approach to Teaching Accounting Information Systems" *Issues in Accounting Education* (Vol. 18, No. 4): pp. 427-441.

Chen 1976

- Proposes an entity-relationship model that subsumes three major prior data models:
  - Network model
  - Relational model
  - Entity set model
- "The real world consists of entities and relationships"

Chen 1976

- Entities and entity sets
  - Cf. Objects and Classes
- Relationships and relationship sets
- ‘Roles’ in relationships
- Values and value sets
- Attributes
  - Functions from entity sets to value sets
- Separate the information about entities from the information about relationships
- “Note that relationships also have attributes” (*)

Chen 1976

- Entity keys and primary keys
- The primary key of a relationship can be represented by the primary keys of the involved entities
- In certain cases, the entities in an entity set cannot be uniquely identified by the values of their own attributes; thus we must use a relationship to identify them
  - E.g. dependents of employees
    - Identified by names and primary keys of employees

Chen 1976

- Two forms of entity relations:
  - If relationships are used for identifying the entities, *weak entity relation*
  - Otherwise, *regular entity relation*
- Similarly, two forms of relationship relations:
  - If all entities are identified by their own attributes, *regular relationship relation*
  - Otherwise, *weak relationship relation*

Chen 1976

- Note that the cardinalities of relationships are marked at opposite ends from the notation I introduced in Class 1
- Arrows are used to indicate *existence dependency*
- Double rectangles indicate weak entity relations
- Other data models can be derived from entity-relationship models
  - Semantics of data are then less apparent
- Entity-relationship models essentially 3NF

Chen 1976

- Characteristics of relationships:
  - May be defined on more than two entity sets
  - May be defined on only one entity set
    - Cf. Recursive associations in UML
  - May be more than one relationship defined on given entity sets
  - Cardinalities can be distinguished
  - Existence dependency can be expressed

McCarthy 1979

- Goal
  - Integrating accounting with database
- Most natural model
  - Entity-relationship (Chen 1976)
- Structured abstraction process:
  - Economic enterprise defined by business entity principle (Yu 1976)
  - Economic states & events that over time alter states
  - Entity-Relationship instead of accounting artifacts (Everest & Weber 1977)
  - Storage structure definition e.g. RDBMS

McCarthy 1979

- Economic exchanges (Mattessich 1964)
- Cardinalities of relationships
- Database theory exemplified by accounting examples
- It is not necessary for all relationships to have properties of their own (*)
- The purpose of accounting (Sorter 1969)
- Derivation of accounts receivable
- Stock-flow interactions
- Conclusion materialization (Bubenko 1976)
- Automatic 4NF

McCarthy 1982

- Database design
  - Requirements analysis
  - View modeling (REA)
  - View integration (REA)
- Entity: person, object or happening
- Relationship: association or generalization (Smith & Smith 1977)
- Semantic modeling
  - Should not include elements of double-entry bookkeeping
  - Double-entry manipulation effected only in external schemata presented to users

McCarthy 1982

- Economic resources, events, agents (REA)
- Stocks and flows
- In theory
  - Detailed description of all transactions stored indefinitely in disaggregated individual form
- In practice
  - Implementation compromises
- Duality
  - Increments linked to decrements

McCarthy 1982

- Participation and responsibility
- Control: 3-way associations (???)
- REA
- Conclusion materialization
  - Resources and claims
- In a working data model
  - Triggered procedures
  - Adjustment procedures
  - View procedures
  - Derivation procedures
- Periodicity problems not solved by REA

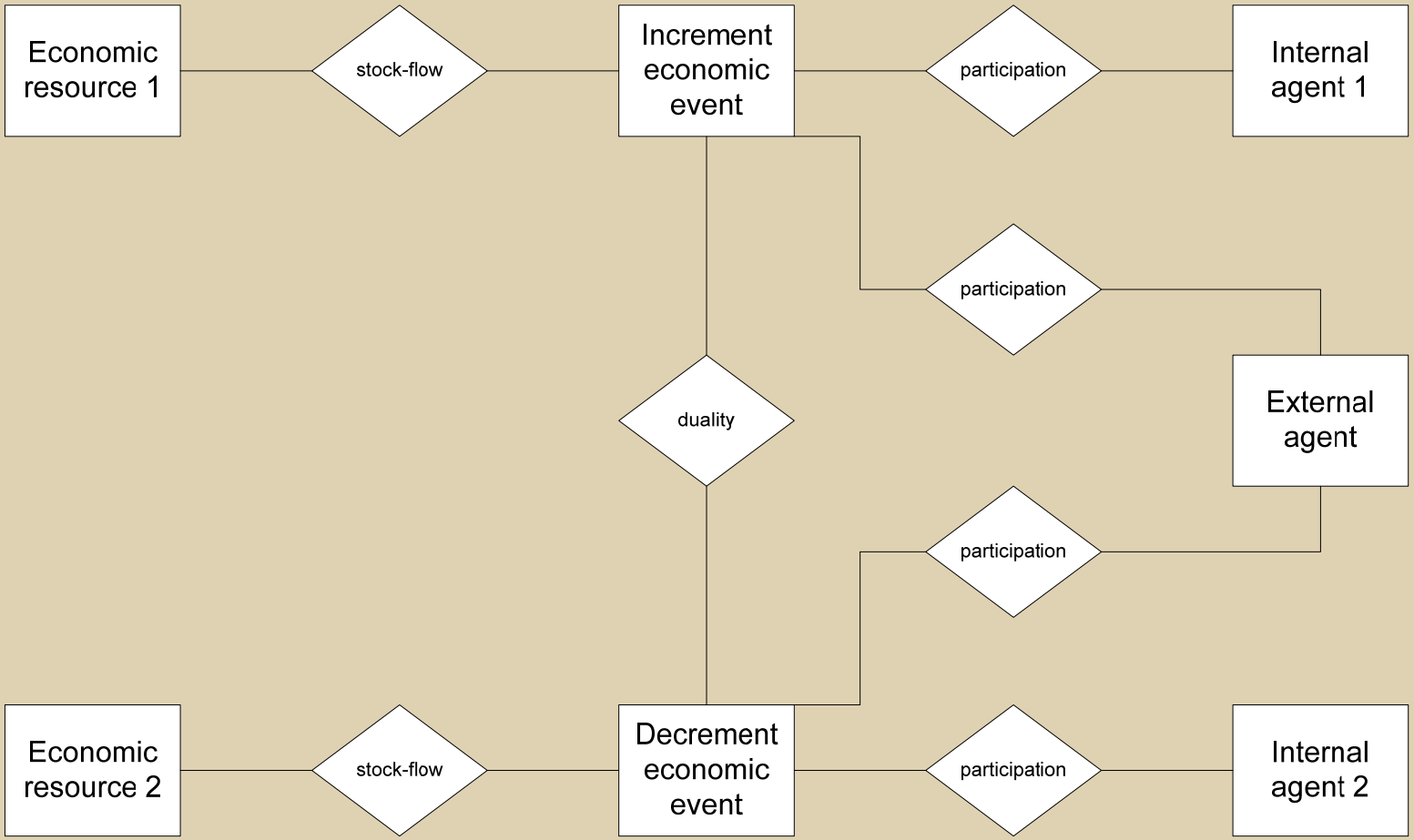
McCarthy 1982

- Final considerations
  - Claims as base objects with attributes
  - Temporal summarization
  - Event partitioning
  - Macro-level duality
    - Matched expenses
    - Gains and losses
  - Equity transactions

McCarthy 2003

- Origins
  - Codd: relational systems
  - Abrial: semantic databases
  - Chen: entity-relationship models
  - Smith & Smith: abstraction
- Normalization: bottom-up
- Semantic modeling: top-down
- Basic REA pattern
- REA as a Business Process Pattern and Value Chain Component
- Types and Commitment – REA Ontology

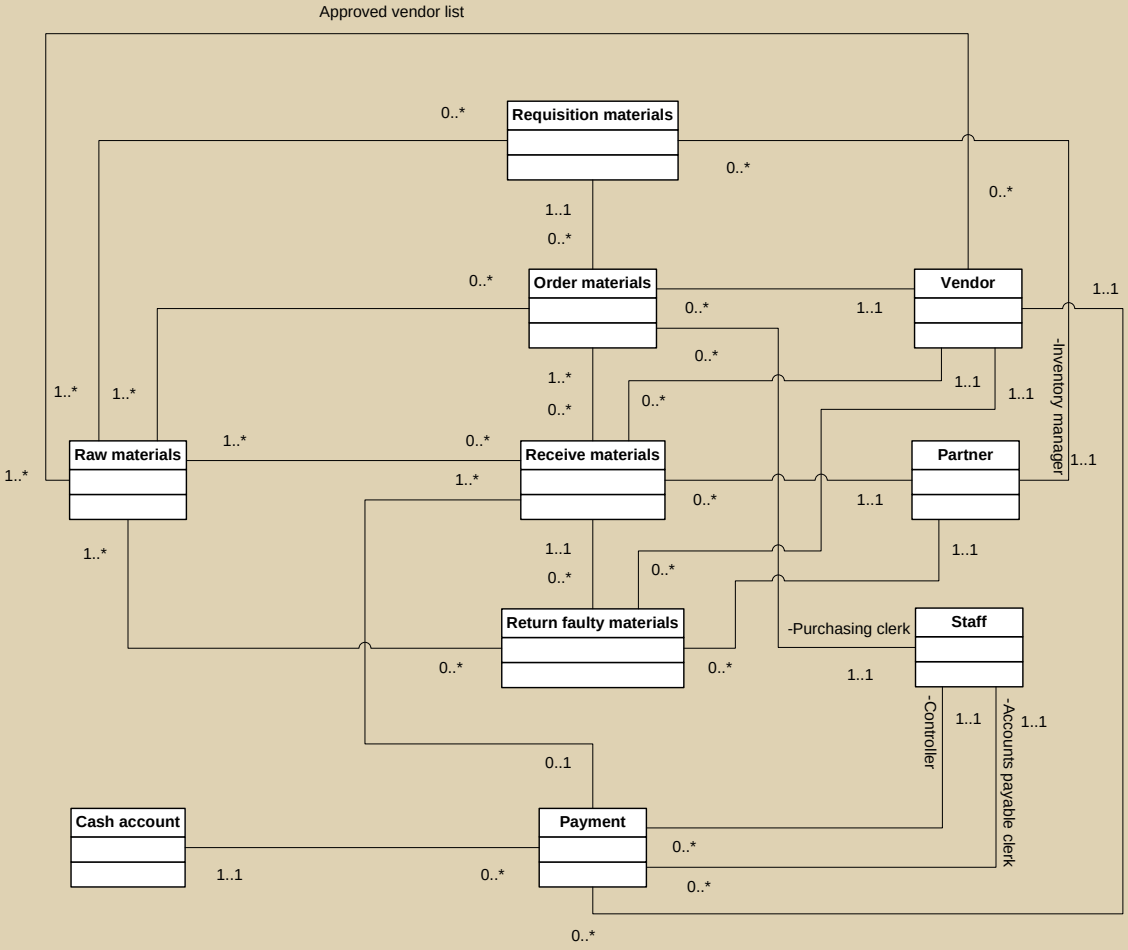
Basic REA Pattern



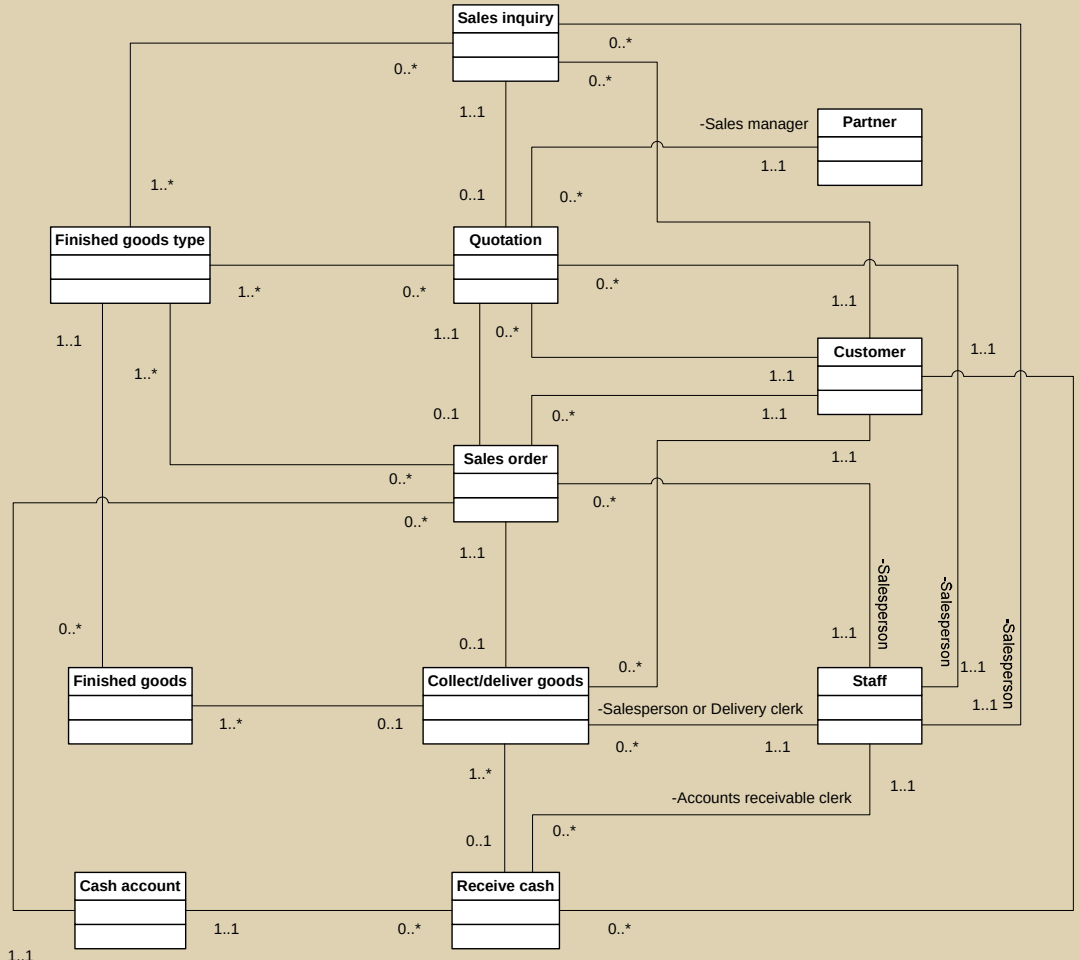
McCarthy 2003

- REA as a unifying theme for teaching Accounting Information Systems
- Skill set
  - Systems analysis
  - Systems design and implemention
  - System use
- REA courses at Michigan State
- Available REA resources

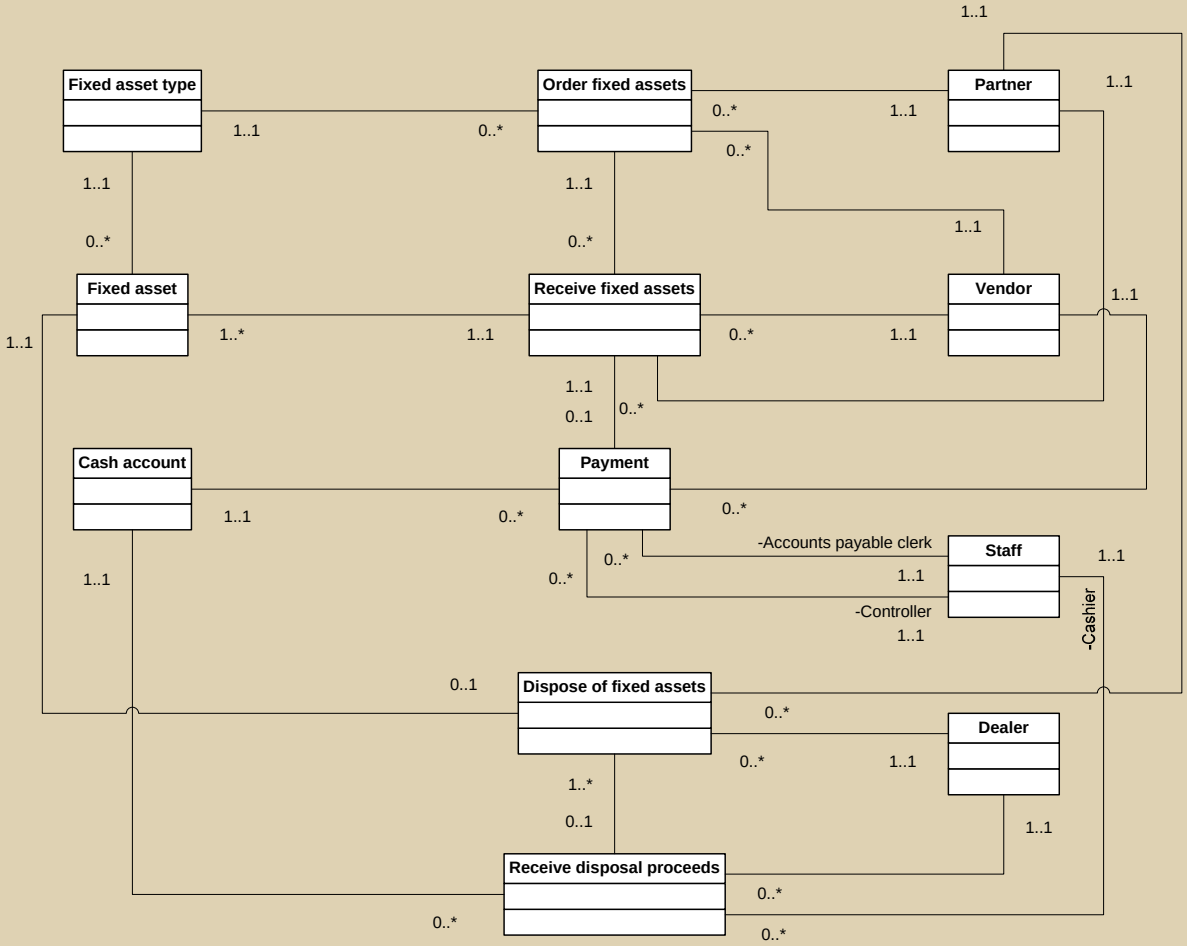
Homework 2 – Materials Acquisition



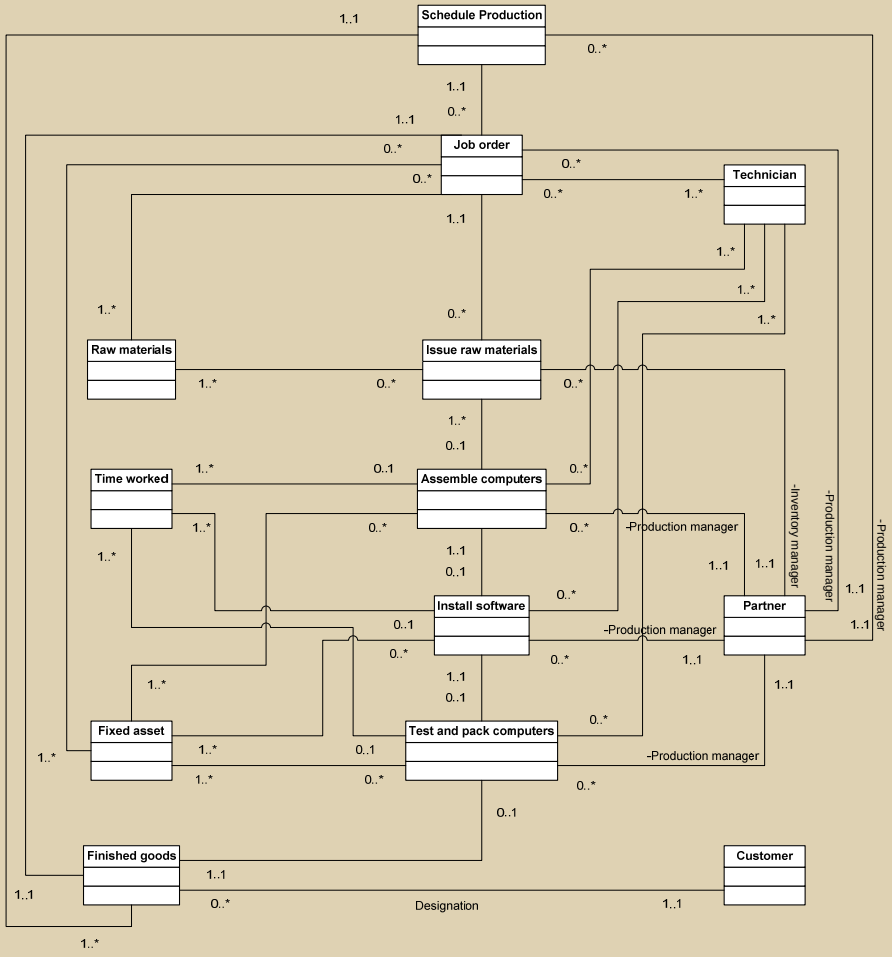
Homework 2 – Sales



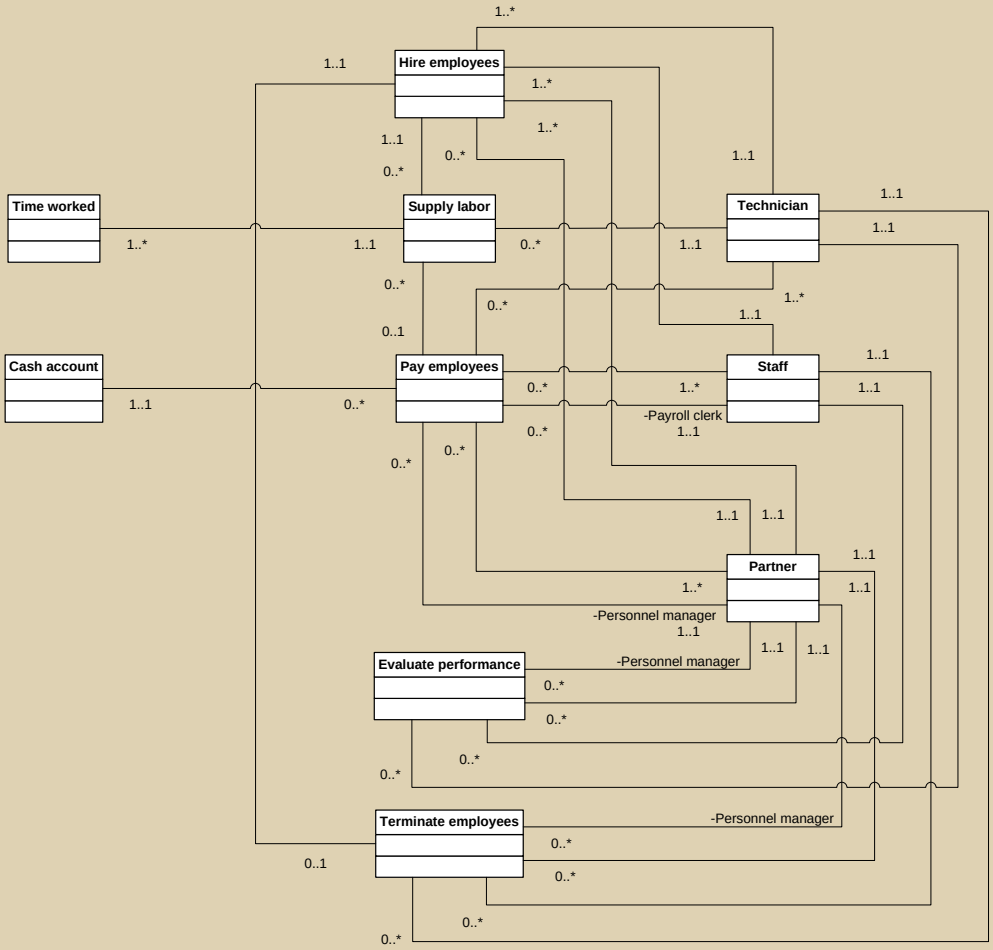
Homework 2 – Fixed Assets



Homework 2 – Production



Homework 2 – Human Resources



REA as an Accounting Ontology

- Geerts, Guido L. and William E. McCarthy. 2002. "An Ontological Analysis of the Economic Primitives of the Extended-REA Enterprise Information Architecture" *International Journal of Accounting Information Systems* (No. 3, 2002): pp. 1-16.
- Lampe, James C. "Discussion of an Ontological Analysis of the Economic Primitives of the Extended-REA Enterprise Information Architecture" *International Journal of Accounting Information Systems* (No. 3, 2002): pp. 17-34.
- Geerts, Guido L. and William E. McCarthy. 2000. "The Ontological Foundation of REA Enterprise Information Systems". *Working Paper*.
- Gruber, Thomas. 1993. "A translation Approach to Portable Ontologies" *Knowledge Acquisition* (Vol. 5, No. 2): pp. 199-220.
- Guarino, Nicola. 1998. "Formal Ontology and Information Systems" *Formal Ontology In Information Systems*. IOS Press: Amsterdam, pp. 3-15.
- Zúñiga, Gloria L. 2001. "Ontology: Its Transformation from Philosophy to Information Systems" *FOIS '01*.
- Smith, Barry. 1998. "The Basic Tools of Formal Ontology". *Formal Ontology in Information Systems* (ed. N. Guarino).

Geerts & McCarthy 2002

- In an effort to build a formal enterprise domain ontology, utilizes Sowa's 12 ontological categories
  - All things are classified as either physical or abstract
    - Physical: positive mass or energy
    - Abstract: no positive mass or energy
  - Further binary categorization as either continuant or occurrent
    - Continuant: No timelike sequence (stable attributes)
    - Occurrent: Depends on timelike sequence (state of flux)
  - Firstness v. Secondness v. Thirdness
    - I.e., individual, relationship, mediation

Lampe 2002

- Lampe indicates that GM2002 uses inconsistent and confusing terminology
- Lampe also accuses GM2002 of erroneous ontological analyses and discussion
- Lampe argues that GM2002 suffers from inadequate and incomplete application of Sowa's taxonomy to the REAC components

Geerts & McCarthy 2000

- Proposes REA as an enterprise domain ontology
- Extends REA vertically by adding *value chains* and *workflow detail*
- Extends REA horizontally by adding *type* and *commitment*
- Provides formal names and definitions for various categories of events and relationships

Geerts & McCarthy 2000

- Commitment
  - Agreement to execute an economic event in a well-defined future that will result in either an increase of resources or a decrease of resources
    - E.g., Sales Order
- Type
  - Abstraction describing a group of actual phenomena
  - Event types, resource types, agent types, etc.
    - E.g., mail order sales, perishable inventory, large customers, etc.

Geerts & McCarthy 2000

- Duality
  - Transfer
  - Transformation
- Stock-flow
  - Inflow
    - Take, production
  - Outflow
    - Give, use, consumption

Geerts & McCarthy 2000

- A three-layered architecture is used to consider enterprise information systems at different levels of granularity:
  - Enterprise scripts
    - Series of processes in a *value chain*
  - Economic exchanges
  - Recipes
    - Orderings of low-level *tasks*

Geerts & McCarthy, Lampe 2002

- Geerts & McCarthy (2002) and Lampe (2002) are flawed in a number of ways:
  - The extensions to the original REA model envisaged in Geerts & McCarthy (2002) are barely comprehensible without reference to other unpublished papers
  - Terminology changes meaning from the early papers without proper explanation
  - Several ideas from the original REA papers are dropped or changed without comment (e.g., ternary control relationships)
  - The value of taxonomizing the extended ontology by reference to Sowa's concepts is not clearly articulated
  - In particular, the importance of the Thirdness dimension in an enterprise domain is not demonstrated

Geerts & McCarthy, Lampe 2002

- The basis for categorizing relationships as physical or abstract is not articulated, and is especially problematic for relationships that relate a physical entity to an abstract entity
- Although GM2002's categorization matrix reveals ontological incompleteness in the sense that there are empty cells, this in itself does not demonstrate that there are missing ontological primitives that have meaning or value in the enterprise domain
- We do, however, identify some missing significant business activities and propose extending the primitives to include ancillary business events beyond economic events and commitments (e.g., Requisitioning, Packing or picking goods for shipping, transferring goods into or out of warehouses)

Geerts & McCarthy, Lampe 2002

- In addition, Gillett & DeBoskey proposed additional relationships between these new events, and between existing entities (e.g., to represent “Approved Vendor lists”)
- Much of Lampe’s discussion is an extended summary of Sowa’s ideas that serves only to argue that the semantic content of Sowa’s categories is properly determined by their factorization (e.g., physical, continuant, firstness) rather than by their labels
- Lampe’s discussion itself is formulated based on an inappropriate and inaccurate distinction between connotation and denotation

Gruber 1993

- An ontology is an explicit specification of a conceptualization
- For knowledge-based systems, what "exists" is exactly that which can be represented
- In a translation approach, ontologies are specified in a standard, system-independent form and translated into specific representation languages
- Ontologies form a basis for knowledge-sharing
- Ontological commitments underlie content-specific agreement
- A common ontology serves as a knowledge-level specification of the ontological commitments of a set of participating agents
- Ontolingua
  - A formal language for ontologies
  - A domain-independent translation tool

Guarino 1998

- Research on ontology is becoming increasingly widespread in the computer science community
- A highly interdisciplinary approach
- This paper aims to clarify the use (as of 1998) of the terms *ontology*, *ontological commitment* and *conceptualization*
- Distinguish Ontology from ontology
- Guarino wants to reserve the word *conceptualization* for the philosophical use of *ontology*
- Given a language **L** with ontological commitment **K**, an ontology for **L** is a set of axioms designed in such a way that the set of its models approximates as best as possible the set of intended models of **L** according to **K**

Guarino 1998

- Coarse v. fine-grained ontologies
- Ontological integration of different systems
- Generality
  - Top-level ontologies
  - Domain ontologies
  - Application ontologies
- Using ontologies to develop information systems

Zúñiga 2001

- An attempt to compare and reconcile conflicting definitions of ontology from philosophy and information systems
- Philosophical ontology is neither reducible to nor identical with language or its formalism
- The goal of philosophical ontology is truth
- Examines both Gruber's definition and Guarino's, and contrasts them with philosophical ontology
- In particular, she notes that the distinction is generally known in information system circles, but that confusion arises in interdisciplinary discussions
- In contrast to Guarino, she proposes to keep philosophical language and to define *IS ontology* and *conceptualization*

Smith 1998

- Relates formal ontology to Husserl's *Logical Investigations*, based on
  - Mereology (part-whole relations)
    - Distinguish mereology from set theory
  - Dependence
  - Topology (boundary, continuity and contact)
- Substances and accidents (c.f. Aristotle)
- Axioms for mereology (Simons 1987)
- Specific dependence (relates substance and accident)
- Separability
- Topology
  - Boundary
  - Closure
  - Connectedness

Some Ontological Issues

- Ontology is the main component of metaphysical philosophy
- It deals with questions of the nature of being, of what there is in the world, of the nature, constitution, and structure of reality
- W.V.O. Quine has summarized this philosophical enterprise succinctly as:
  - Q. What is there?
  - A. Everything!
- Information systems researchers have co-opted the term, and speak of "ontologies"
- E.g., Tom Gruber (1993): "An ontology is an explicit specification of a conceptualization"

Some Ontological Issues

- Ontologies can be conceived at many levels: general, domain, application, etc.
- Thus a domain ontology specifies what there is said to be in a particular application domain
- Domain ontologies specify the structure of the relevant categories of reality in some domain – and the semantic modeling principle tells us that this is precisely what should be represented by the data in an information system for that domain
- In recent years, McCarthy and his followers have extended REA to become a formal domain ontology

Some Ontological Issues

- From a philosophical perspective, there is surely more to ontology than taxonomy
- Philosophical ontology is different from information systems ontology (Zúñiga, 2001)
  - The goal of philosophical ontology is truth
  - She analyzes Gruber's and Guarino's definitions
  - Guarino's proposed solution is to rename philosophical ontology . . .
  - Information systems ontology is about what our terms mean and what we can represent

Some Ontological Issues

- Barry Smith (1998) defines formal ontology based on:
  - Mereology (part-whole relations)
  - Dependence
  - Topology (boundary, continuity and contact)

Some Ontological Issues

- Partridge (2002) points out that neither Bunge's not Sowa's work (on which the Wand/Weber and REA ontologies, respectively, are based) is in the philosophical mainstream
- There is no significant focus on key philosophical concerns such as identity and mereology
- The distinction between internal and external agents fails to be objective (because it takes a specific party's point of view – related to the focus on epistemology rather than ontology)

Some Ontological Issues

- Considered as a taxonomy, the REA Ontology has already proved extremely fruitful as a pedagogical tool
- However, if we want the REA Ontology to provide a theoretical underpinning for our work, it needs:
  - Contain more than mere taxonomy
  - Be consistent with a wider philosophical approach
    - But which?

Some Ontological Issues

- Traditionally, ontology has considered the things to whose existence a given theory commits us
  - W.V.O. Quine's notion of "ontological commitment"
- They are not only taxonomized, but include at the top level the "major categories of existence"
  - An idea introduced by Aristotle
- Sowa's approach is categorical in this sense

Some Ontological Issues

- Aristotle's categories included:
  - Substance
  - Quantity
  - Quality
  - Relation
  - Place
  - Time
  - Position
  - State
  - Action
  - Affection

Some Ontological Issues

- There have been many attempts to update this. For example, Grossmann (1983):
  - Individuals
  - Properties
  - Relations
  - Classes
  - Structures
  - Quantifiers
  - Facts
  - Negatives

Some Ontological Issues

- Of particular interest in such a categorical analysis is the definition of facts
- In 20th century philosophy, facts have often been identified with 'states of affairs' – insofar as they are distinguished, there is dispute as to whether there can be states of affairs that are not the case
- Armstrong (1997), for example, considers states of affairs to be the fundamental category of reality
- Other contemporary approaches (e.g., Bacon, 1995) suggest that the fundamental category of reality is 'tropes': instances or bits of a property or relation, such as 'Peter's confusion'
- On the other hand, some philosophers identify 'events' as states of affairs of a certain sort
  - Kim and Goldman treats events as time-referenced states-of affairs
  - Davidson considers events as spatio-temporally located singular entities
  - Chishlom considers events as contingent basic states-of affairs (not individuated by time)
  - Bennett treats events as tropes
- Can there be negative events (the dog not barking in the night, for example)?

Some Ontological Issues

- If we define 'significant events' within the REA ontology in accordance with an established view of events in a more general ontology, we can take advantage of whatever principles of identity, mereology, etc. come with it
- If we adopt 'significant events' as primitive within our domain ontology, then it is our responsibility to explain how two descriptions can be determined to refer to the same event, how events are individuated, what it means for one event to be part of another, and so on
  - Other relations between events may also be valuable: for example, what can we say about an event preceding another, or causing another?
- Of course, my focus here on events is not meant to suggest that there are not also philosophical issued to be resolved with regard to economic resources, and agents
- In addition, REA reifies certain relations between business entities, such as stock-flows, etc., and this introduces a new set of issues
- Another view of the particular events that we are interest in suggest that they may be identified with changes of states

Some Ontological Issues

- How will we reconcile our theoretical (ontological) approach with our pedagogical practice?
- 'Significant event'
  - Significant
    - We want to plan, execute, control or evaluate
  - Event
    - Step in a business process
- Epistemologically, it makes sense to *discover* 'significant events' in this way
- But ontologically, it may be preferable to define a business process as a sort of sequence of regulated linked events

Some Ontological Issues

- All this may seem both abstract an abstruse – and considered purely as an intended theoretical underpinning, perhaps it is
- At a very practical level, however, many of us are familiar with the difficulties students face when first trying to determine from a narrative what 'significant' events have taken place – and their distress on being told that while it may be correct to say that three significant events have occurred, it would not be incorrect to say there were five, or two – but perhaps less useful for our purposes of planning, executing, controlling or evaluating

Some Ontological Issues

- Unrelated to REA, Shafer, Gillett and Scherl (2000) proposed a Logic of Events, a mathematical theory that incorporates axioms for both refinement of events and a temporal ordering of events (and their interaction)
- Among other things, such a theory explicitly specifies how events can be created from other events

Some Ontological Issues

- Consider, for example:
  - Ship Goods

  - Pick goods
  - Pack boxes
  - Hand boxes off to shipping agent

- Which is correct?
  - Both!

- Pick goods, Pack boxes, Hand off: each *refines* Ship goods
- Pack boxes *requires* Pick goods

- Etc.

Some Ontological Issues

- An issue that should be addressed in an ontological analysis is whether or not our ‘significant events’ are to be considered extended in time, or as instantaneous events that ‘occur’, consistently with how we record them at a particular moment

Some Ontological Issues

- Finally, we should consider whether or not we prefer a parsimonious or a profligate ontology:
  - If we admit ancillary events into our ontology, typification will give us instigation events, facilitation events, and termination events
  - Conversely, if we admit instigation events, facilitation events, and termination events into our ontology, generalization will give us 'business' events
  - Alternatively, we may prefer to assert that our ontology includes all types of significant events we are able to identify
    - In this case, typification and generalization will not be principles for generating 'defined types' but a kind of relation between existing types

Some Ontological Issues

- Philosophically, there is a great deal more work to be done . . .
- Practically, we propose extensions to the REA ontology, based on the widely accepted concept of significant business events and experience of using the REA methodology as a pedagogical tool to teach the design of accounting information systems:
  - A significant event is any step in a business process that management wants to plan, execute, control or evaluate

Some Ontological Issues

- Armstrong, D.M. 1997. "A World of States of Affairs". Cambridge University Press: Cambridge.
- Bubenko, J., "The Temporal Dimension in Information Modeling," Research Report RC 6187 (IBM Research Laboratories, Yorktown Heights, NY, November 1976)
- Chen, P.P. "The Entity-Relationship Model—Toward a Unified View of Data," ACM TRANSACTIONS ON DATABASE SYSTEMS (March 1976), pp 9-36.
- Codd, E.F., "A Relational Model of Data for Large Share Data Banks," COMMUNICATIONS OF THE ACM (June 1970), pp. 377-87.
- ,----- "Further Normalization of the Data Base Relational Model," in R. Rustin, ed., Data Base Systems (Prentice Hall 1972), pp. 33-64.
- Everest, G.C., and R. Weber (1977), "A Relational Approach to Accounting Models," THE ACCOUNTING REVIEW (April 1977), pp. 340-59.
- Geerts, G.L. and W.E. McCarthy. 2002. "An ontological analysis of the economic primitives of the extended-REA enterprise information architecture". *International Journal of Accounting Information Systems*. 3 (March): 1-16.
- Geerts, G.L. and W.E. McCarthy. 2000. "The ontological foundation of REA enterprise information systems". *Working paper*.
- Grossmann, R. 1983. "The Categorial Structure of the World". Indiana University Press: Bloomington.
- Gruber, T. 1993. "A Translation Approach to Portable Ontologies," Knowledge Acquisition, pp. 199-220.
- Ijiri,Y. 1975. *Theory of Accounting Measurement,* American Accounting Association.
- Kroenke, D.M., *Database Processing*, Prentice Hall: Upper Saddle River, NJ, 1998.
- Lampe, J.C. 2002. "A discussion of an ontological analysis of the economic primitives of the extended-REA enterprise information architecture". *International Journal of Accounting Information Systems*. 3 (March): 17-34.
- Mattessich, R. (1964), Accounting and Analytical Methods (Richard D. Irwin, 1964).
- McCarthy, W.E. 1979. "An entity-relationship view of accounting models". *The Accounting Review*. 54 (Spring): 667-686.
- McCarthy, W.E. 1982. "The REA accounting model: a generalized framework for accounting systems in a shared data environment". *The Accounting Review*. 57 (July): 554-578.
- Partridge, C. 2002. "Shifting the ontological foundations of accounting's conceptual scheme".
- Simon, P. 1987. *Parts: A Study in Ontology*. Clarendon Press: Oxford.
- Smith, A.J., and D.C.P. Smith (1977b),"Database Abstractions: Aggregation and Generalization," ACM Transactions on Database Systems (June 1977), pp. 105-33.8
- Smith, B. 1998. "The Basic tools of formal ontology". *Formal Ontology in Information Systems (ed. N. Guarino).*
- Sorter, G.H. (1969). "An 'Events' Approach to Basic Accounting Theory," The Accounting Review (January 1969), pp. 35-49.
- Sowa, J. 1984. *Conceptual structures: information processing in mind and machine*. Addison Wesley: Reading, MA.
- Sowa, J. 1999. *Knowledge representation: logical, philosophical, and computational foundations*. Brooks/Cole Publishing: Pacific Grove, CA.
- Yu, S.C. (1976), The Structure of Accounting Theory (The University Press of Florida, 1976) (p. 256).
- Zúñiga, G.L. (2001). "Ontology: Its Transformation from Philosophy to Information Systems" FOIS '01.

Literature Review

- Two “teams”
- Format paper and bibliography for The Accounting Review
- Use EndNote for bibliography
- Identify all papers relating to Ethics in Accounting, including Auditing, Accounting Education, etc.
- Analyze and Summarize

Assignments for Week 4

- **Amy**: ISO/IEC 15944-4:2006 Information Technology - Business Agreement Semantic Descriptive Techniques -- Part 4: Business Transaction Scenarios – Accounting and Economic Ontology.
- **Fang-chun**: Partridge, Christopher. 2002. “Shifting the Ontological Foundations of Accounting’s Conceptual Scheme”.
- **Amy**: Wand, Yair and Ron Weber. 1990. "An Ontological Model of an Information System" IEEE Transactions on Software Engineering (Vol. 16, No. 11): pp. 1282-1292.
- **Deirdre**: Weber, Ron. 2002. "Ontological Issues in Accounting Information Systems." In *Researching Accounting as an Information Systems Discipline*. American Accounting Association, pp. 13-33.
- **Pyungkyung**: Vandenbossche, P. E. A. and J. C. Wortmann. 2006. "Why Accounting Data Models from Research are not Incorporated in ERP Systems". Paper presented at the 2nd International REA Technology Workshop, June 25, 2006.
- **Yongbum**: March, S.T. and G. F. Smith. 1995. "Design and Natural Science Research on Information Technology" *Decision Support Systems* (Vol. 15): pp. 251-266.
- **Pyungkyung**: David, Julie S., G. Gerard, and William E. McCarthy. 2002. "Design Science: An REA Perspective on the Future of AIS." In *Researching Accounting as an Information Systems Discipline*. American Accounting Association, pp. 35-63.
- **Fang-chun** : 2007. Design Research in Information Systems. Web Site.
- **Deirdre**: Dunn, Cheryl and Sev Grabski. 2002. Empirical Research in Semantically Modeled Accounting Systems" In *Researching Accounting as an Information Systems Discipline*. American Accounting Association, pp. 157-180.
- **Yongbum**: Hruby, Pavel. 2002. "Universal Enterprise Model: Business Pattern Language." Microsoft Business Solutions, Denmark.

Homework 3

- Prepare UML diagrams, and Data Repository Structures for:
  - Cash Transfers
  - Loans
  - Services
  - Production
  - Human Resource Management
- Submit as a WORD document via the Digital Drop Box - I recommend, but do not require, VISIO 2003