Emergent Enterprise Models

Peter Denno

National Institute of Standards and Technology

Gaithersburg, Maryland, USA

peter.denno@nist.gov

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

Overview

- Part 1: Definitions

- Part 2: Model composition
  - Review prior work
  - Viewpoint communication
  - Software requirements engineering

- Part 3: Systems integration
  - What is communicated in interfaces?
  - Dimensions of reconciliation

- Part 4: Exploratory project, Summary

Peter Denno, NIST

Part 1
Definitions

Peter Denno, NIST

Definitions

- enterprise model: a representation of purpose, processes, resources, information, and organization of an enterprise, used in its re-engineering.

- emergent enterprise model: an enterprise model that comes into being through the accretion and interrelation of the various models generated in the course of the development of the enterprise's infrastructure, and through its evolution.
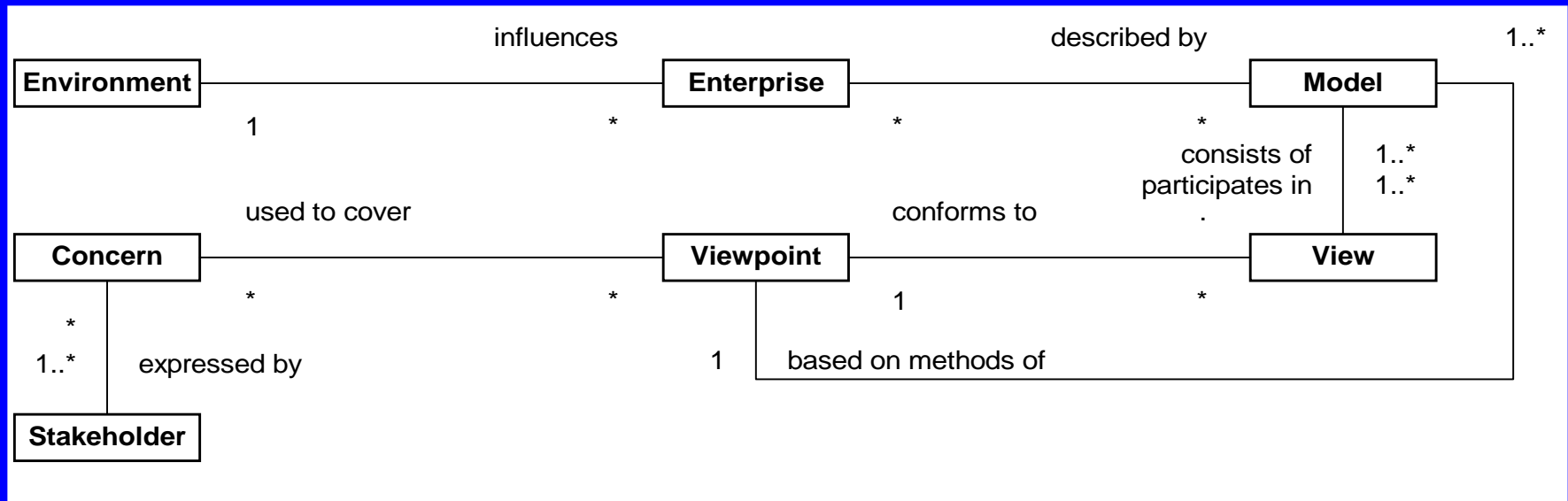
Presentation scope

- This presentation describes requirements and characteristics of a modeling environment supporting emergent enterprise models.

  – to enable efficient enterprise modeling
  – to facilitate systems integration

Peter Denno, NIST

Definitions

Similar to usage in IEEE P1471
"Recommended Practice for Architectural Description"...

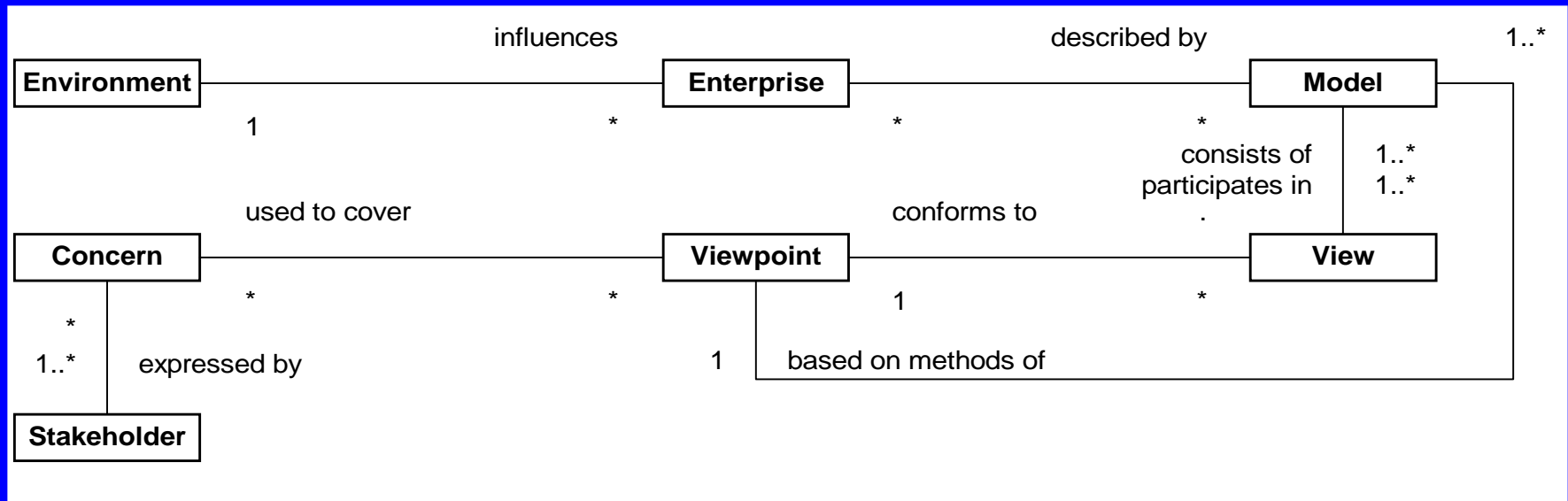|	influences		described by		1..*
Environment		**Enterprise**		**Model**	
1		*	*	*	
			consists of	1..*	
			participates in	1..*	
	used to cover		conforms to	.	
Concern		**Viewpoint**		**View**	
*	*	*	1	*	
1..*	expressed by	1	based on methods of		
Stakeholder					

Viewpoint: a reusable template from which to construct views; it defines well-formedness conditions on views.

Definitions

Similar to usage in IEEE P1471
"Recommended Practice for Architectural Description"...

	influences		described by	1..*
Environment		**Enterprise**		**Model**
1	*	*	*	

consists of — participates in

1..*
1..*

used to cover — conforms to

Concern		**Viewpoint**	1	**View**
*	*		*	

*
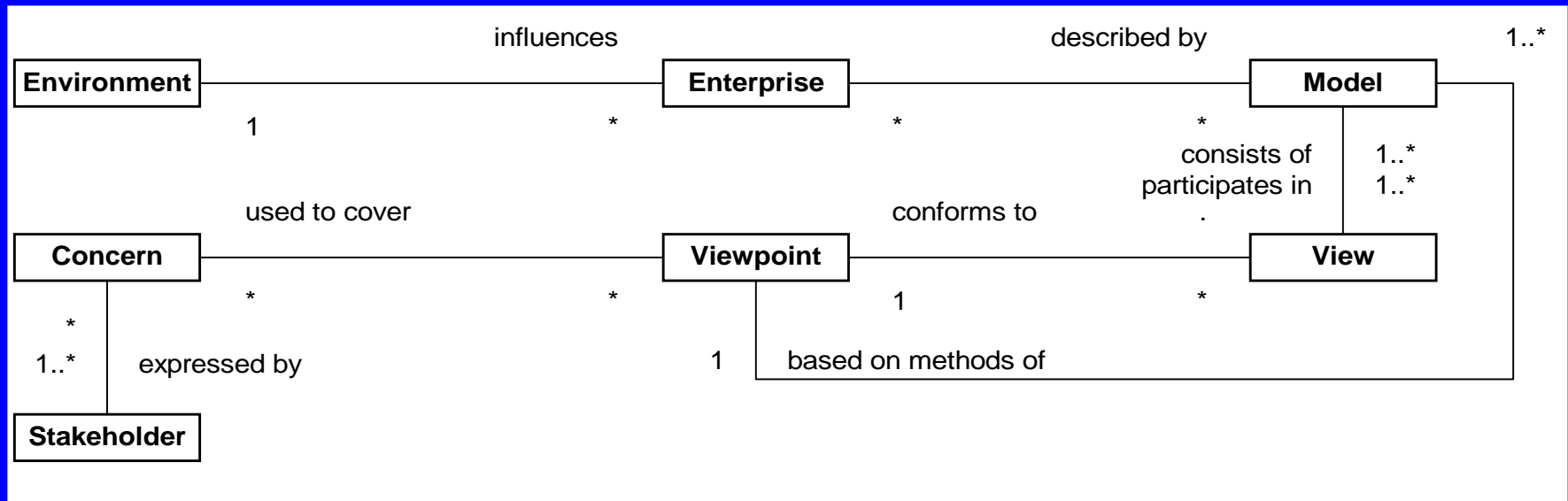1..* expressed by

1 based on methods of

Stakeholder

View: a representation of the whole enterprise from the perspective of a related set of concerns

Definitions

Similar to usage in IEEE P1471
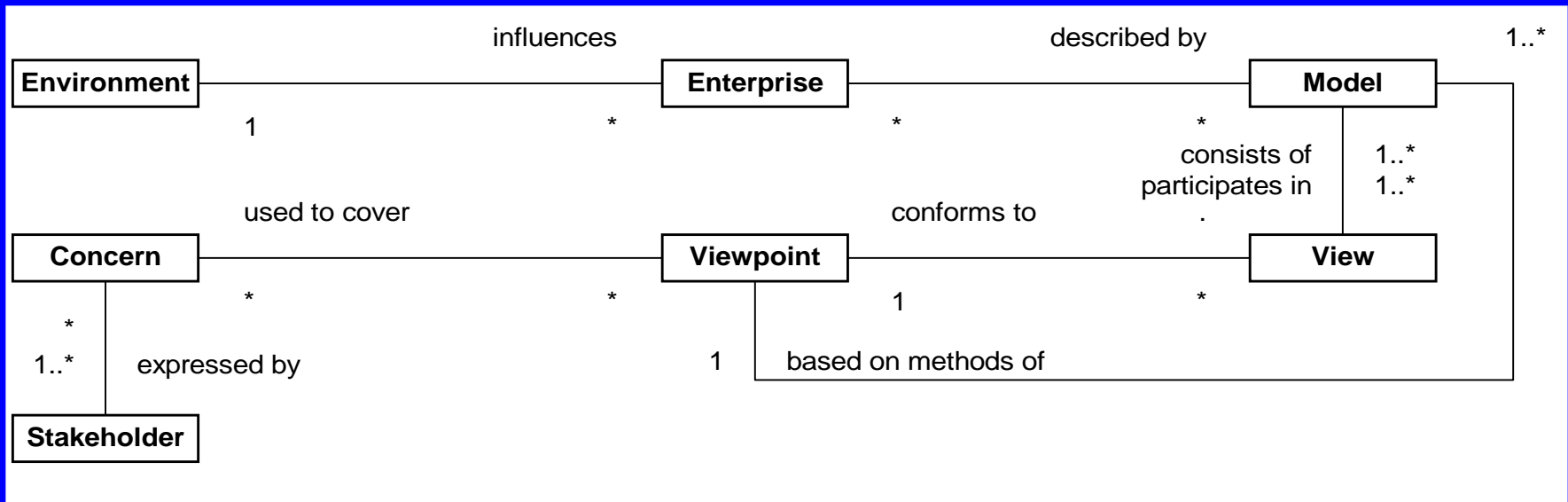"Recommended Practice for Architectural Description"...

	influences	described by	1..*
Environment	**Enterprise**	**Model**	
1	*	*	*
		consists of	1..*
		participates in	1..*
	used to cover	conforms to	.
Concern	**Viewpoint**	**View**	
*	*	1	*
1..*	expressed by	1 based on methods of	
Stakeholder			

Concern: those stakeholders' interests that pertain to the development, operation or other key characteristics of the enterprise

Peter Denno, NIST

Definitions

Similar to usage in ISO 14258 CD
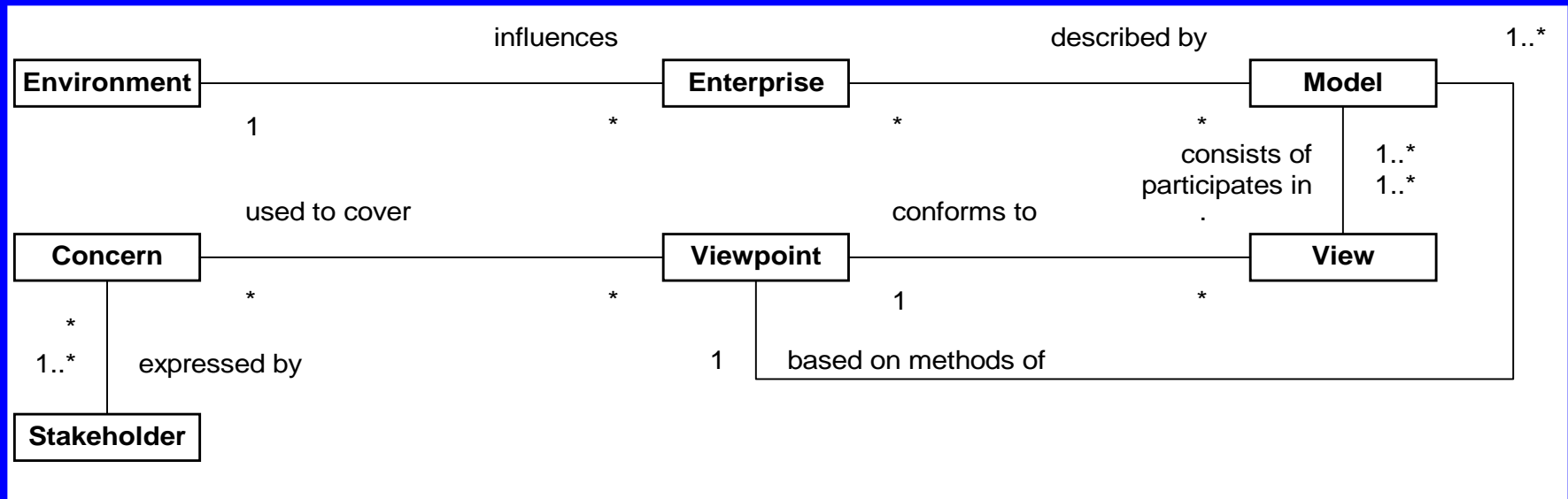"Concepts and Rules for Enterprise Models"...

Environment: the uncontrollable part of a system which is widened to the extent that a decision-making procedure cannot be conceived for its control.

Peter Denno, NIST

Definitions

Similar to usage in IEEE P1471
"Recommended Practice for Architectural Description"...

Environment	influences	Enterprise	described by	Model	1..*

- Environment — 1
- Enterprise — *
- * (Enterprise to Model)
- Model — *
- consists of / participates in — 1..* / 1..*

used to cover

conforms to

Concern		Viewpoint	conforms to	View

- Concern — *
- Viewpoint — *
- Viewpoint — 1
- View — *
- Concern — * / 1..*
- expressed by
- Stakeholder
- based on methods of — 1

Model: the expression of a view based on the well-formedness rules of a viewpoint. Also called a "partial specification".

Part 2
Viewpoint composition

Peter Denno, NIST

Two senses of composition

- Viewpoint composition: leading to a more complete specification of the system
  - a concern for modelers
  - this part of presentation

- Systems integration: leading to a more efficient, agile and comprehensible business process
  - a concern for business managers and system integrators
  - next part of presentation

- The modeling environment should address both of these.

Peter Denno, NIST

The Enterprise Modeling Problems

- Enterprise Modeling's (EM) return on investment is quite low:
  - Characterizations of the environment are often thrown away.
  - Stakeholders' concerns are rarely explicitly encoded and materially used in subsequent models (traceability is lacking).
  - The abundance of viewpoints makes it difficult to…
    - …see the big picture
    - …identify conflicting assertions
    - …determine whether all concerns are being addressed

- We'd like to change that.
  - Viewpoint composition is key to the solution.

Peter Denno, NIST

Notations

- Notation: the "technology" used to express a viewpoint.

- Many viewpoints, many notations, many models...
  - Management, Engineering Disciplines, Systems Engineering, Resource Planning, Scheduling, IT personnel, IT consultants, *etc.*
  - *Not all object-oriented!*
  - *Not all about software!*

- There is value in diversity:
  - Each notation offers a different set of expressive capabilities
  - …and a different set of analytic capabilities

2001 11 19   Peter Denno, NIST

Notations

- There are challenges in diversity:
  - Consistency:
    Do the concerns expressed in the various notations used contradict each other?

  - Overlap:
    Do the viewpoints tend to emphasize equivalent concerns?

  - Traceability:
    Do I know whether a concern is being addressed, amid the diversity of viewpoints and notations?

  - Composition:
    Do the various viewpoints complement each other?

Viewpoints on the notion of viewpoint

- The challenges of diversity of viewpoints
  are being explored and addressed in various ways:

  - A "Family of Languages" sharing a common semantics
    [Zave and Jackson, Steve Cook et al., UML 2.0 RFPs]

  - Information Models to express relationships among views
    [Nuseibeh, et al.]

  - Technology and tools to encapsulate concerns ad hoc
    [Ossher and Tarr, Kiczales et al.]

  - Work towards a better understanding of refinement
    [UML 2.0 RFPs, D'Souza, Denno]

Family of Modeling Languages

- Goal: provide a common semantics through which partial specifications in related notations (e.g. the various notations of UML) can "communicate"

- Benefits of communication:
  – consistency checking across viewpoints
  – traceability from requirements

- Benefits of common semantics:
  – more concise definition of a modeling language
  – more orderly extensions to 'the family'

Family of Modeling Languages (UML™)

- Since it conception, UML has been a very loosely-related, overlapping, 'mixed bag' of modeling notions.

- Currently 2 UML extension techniques :

  – Profiles: Specialize existing UML meta-model elements
    - But cannot introduce new ones.

  – Meta-model Extension: Introduce new meta-model elements
    - Demonstrated in OMG's Common Warehouse Meta-model

Family of Modeling Languages (UML™)

- The UML Meta-Model is the focus of both extending UML's reach to new viewpoints as well as addressing the lack of coherence among notations.

- Not a silver bullet:
  - Modeling 'as a domain itself' can be described formally, most other interesting domains cannot.

Peter Denno, NIST

Challenge of Extension (example)

- What in the UML meta-model might correspond to the EXPRESS notion of entity?

- Class?
  - "A class is a description of a set of objects that share the same attributes, operations, methods, relationships and semantics."... "A class may implement an interface."

- Classifier?
  - "A classifier is an element that describes behavioral and structural features; it comes in several specific forms, including class, data type, interface, component, artifact, and others that are defined in other meta-model packages."

Challenge of Extension (example)

- The Class model element is close, but EXPRESS entities do not define methods nor implement an interface.

- The Classifier model element conflates items whose instances have identity (*e.g.* classes) with those that do not (*e.g.* datatypes).

- These and other definitions are strongly biased to modeling implementation languages
  (especially C++ / Java).

Peter Denno, NIST

Conjunction as Composition [Zave & Jackson]

- Addresses composition of partial specs from diverse viewpoints.

- Partial specs are translated into common set of FOPL predicates (constrained differently for each viewpoint).

- Studies requirements on "composition style":
  - Nature of common semantics and composition style
    - The less redundancy in viewpoints, the better

Conjunction as Composition
[Similar to Zave & Jackson, "Conjunction as Composition"]

- Communication among partial specifications
  (for enterprise views, consistency checking, traceability)...

  - ...through common set of M3 modeling predicates
    (constrained differently in each notation)

  - ...through export of additional, defined predicates
    - These exported, defined predicates are equivalent to
      reified refinement relationships.

Refinement Relationships

- Refinement: a relationship among model elements of distinct models; the elements refer to the same thing or have some parts in common.

    – The 'direction' is roughly from abstract to more concrete

    – Model elements of a refinement relationship may differ with respect to the conceptual, behavioral and technical commitments of their viewpoint

      (side remark: Software development methodologies differ principally in the path through "refinement space" that they prescribe.)

Relationships among model elements
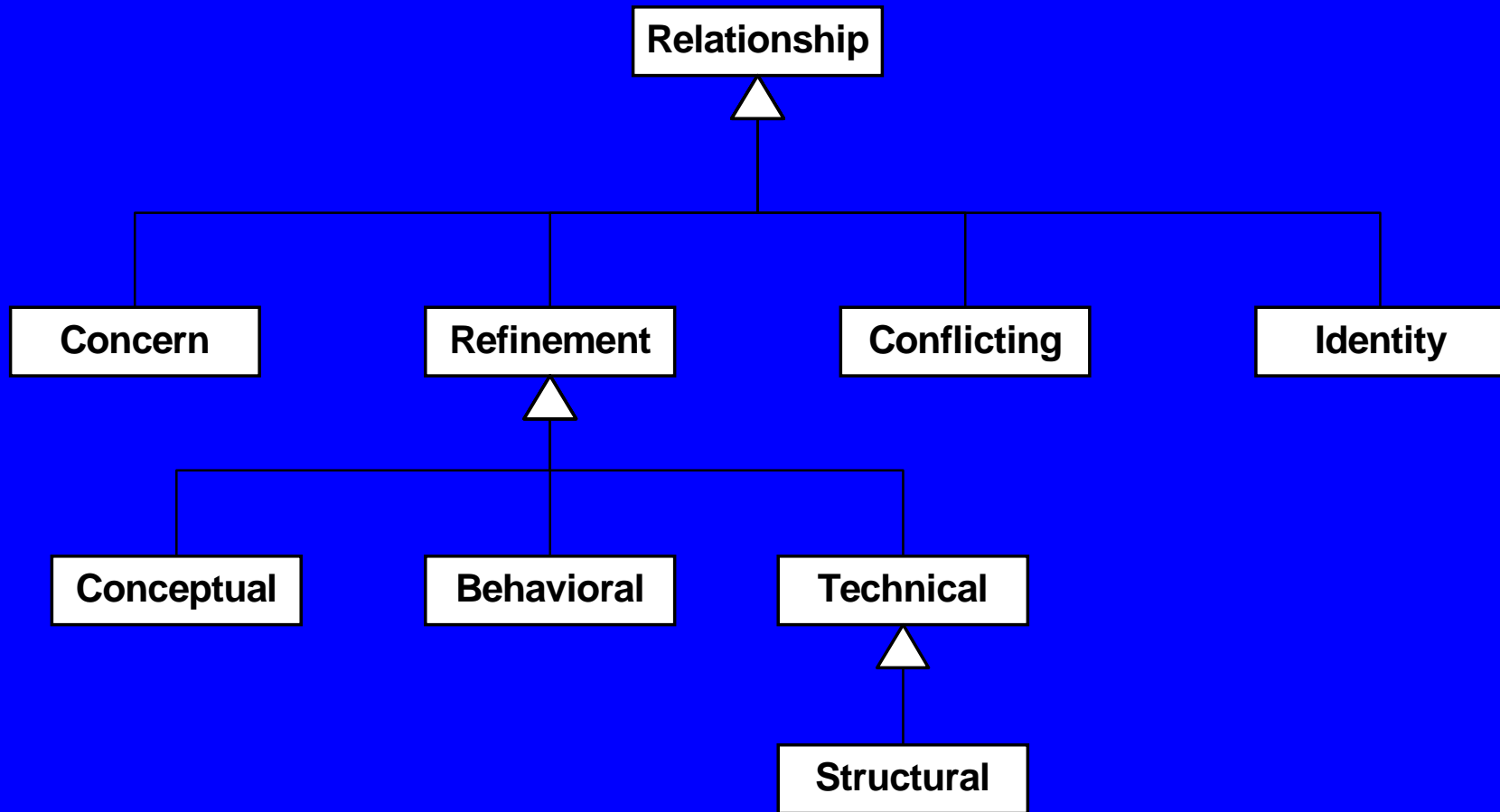
This taxonomy is likely to need further elaboration...

Peter Denno, NIST

Refinement Relationships

- Conceptual refinement: the model elements are terms from the universe of discourse and the refinement is a constraint concerning their usage.

- Behavioral refinement: the model elements represent actors and the relationship concern synchronization, triggering, conditions, composition, or factoring of an activity.

- Technical refinement: a relationship in which an implementation commitment is made.

Peter Denno, NIST

Relationships among model elements

- Zave & Jackson [in *Conjunction as Composition*] report experience showing that enabling viewpoint communication requires more than just constraining the same set of core predicates, it requires additional defined predicates shared among viewpoints.

  – In our work, refinements and concern predicates serve as those "additional predicates"

- Identifying refinements is additional work for modelers

- Some "tool support" is possible. The M2 provides hints...

Tool support for refinement identification

- Modelers identify refinements across M1 models. However, the nature of the M2 technology can provide indication that a refinement exists.

- Example:
  - The IDEF0 notion of "control" does not distinguish between triggering events and pre-conditions.
  - The UML State Machine does
    - ==>
  - A behavioral refinement exists between the IDEF0 model element and the UML State Machine element.

Mid-talk: Confluence of Ideas

- Family-of-specification-languages (with formal semantics)
- Improved understanding of the notions of refinement and viewpoint
- Formal foundations for viewpoint / model composition
- Modeling tools and implementation languages for management of concerns

→

- Traceability to requirements
- Viewpoint consistency
- Viewpoint composition   } Inter-model Coherence
- Enterprise model composition
- New approach to systems integration

- New approach to standards-making ?

Peter Denno, NIST

Part 3
Systems Integration

2001 11 19

Peter Denno, NIST

The Systems Integration Problems

- It remains costly.

- Results are sometimes not satisfactory.

- We'd like to change that.
  - Inter-model coherence can help
    (the EM and VI problems are interrelated)
    - Inter-model coherence helps establish what, in each instance of interface, must be resolved for subsystems to cooperate.

Definitions

- **Integrate**: to establish meaningful communication among software entities so that they may act jointly and together.

- **Integration**: a design activity that identifies how joint action enabled by particular communications can satisfy needs.

- **Design activity**: an activity that produces the specification of a system addressing stated needs.

Why Communicate?

- The sole purpose of communication is to achieve a desired behavior in the recipient.

    - "Preservation of semantics" across interfaces isn't the issue.
    - "meaning" is not nearly as important as equivalence of meaning

Peter Denno, NIST

3 Dimensions of Integration

- Integration requires reconciliation of interfaces along 3 dimensions:
    - Functional: what purpose the component serves
    - Semantic: agreement WRT what is being referred to
    - Technical: protocols, information and operation factoring

- Interdependencies among the dimensions exist.
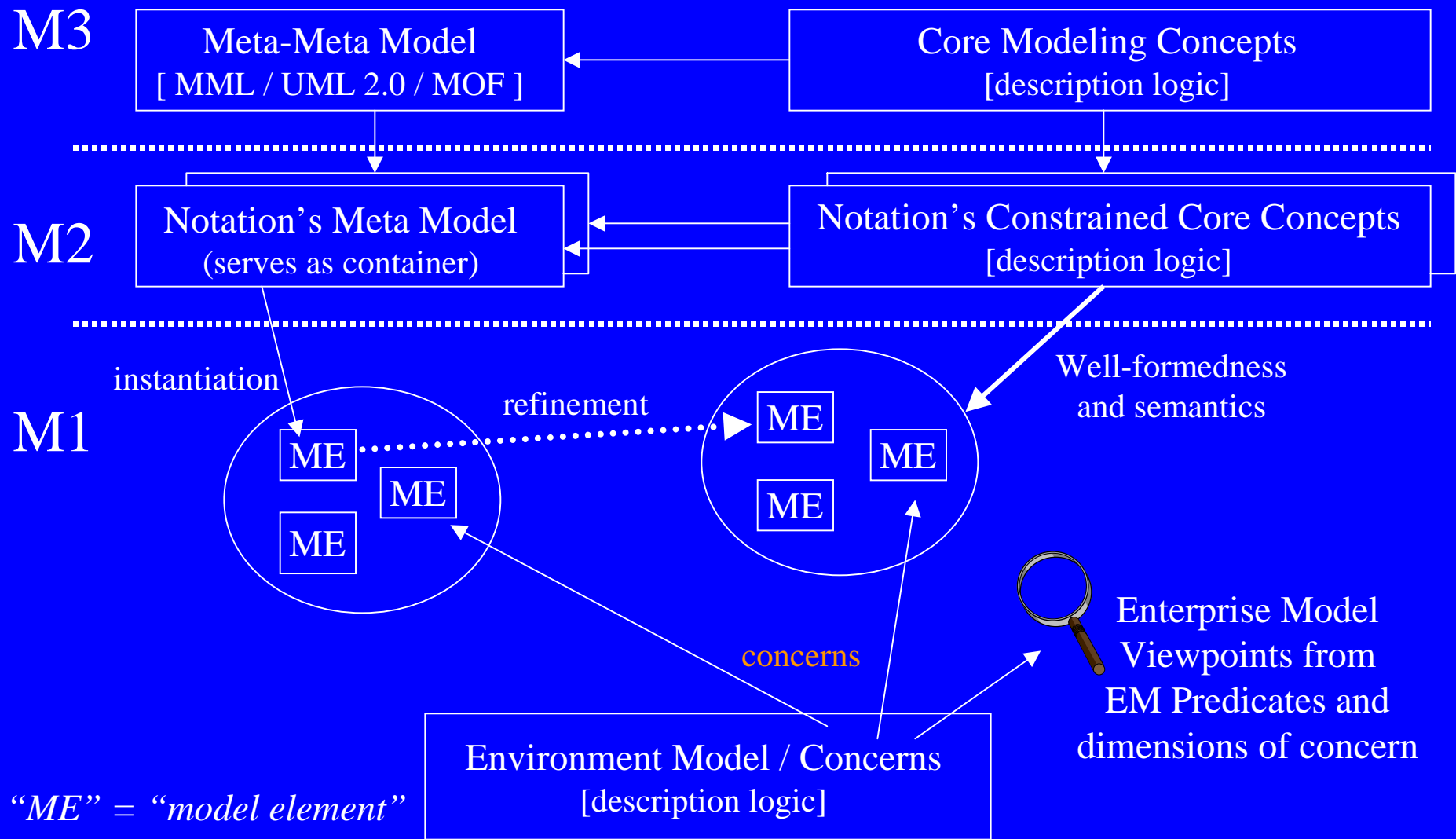- Individual modeling technologies never address the 3 simultaneously.

→

Viewpoint composition is essential.

Peter Denno, NIST

Part 4
Exploratory Project and Summary

Peter Denno, NIST

Project Architecture

M3

Meta-Meta Model
[MML / UML 2.0 / MOF]

Core Modeling Concepts
[description logic]

M2

Notation's Meta Model
(serves as container)

Notation's Constrained Core Concepts
[description logic]

M1

instantiation

refinement

Well-formedness
and semantics

ME

ME

ME

ME

ME

ME

ME

concerns

Environment Model / Concerns
[description logic]

Enterprise Model
Viewpoints from
EM Predicates and
dimensions of concern

"ME" = "model element"

Peter Denno, NIST
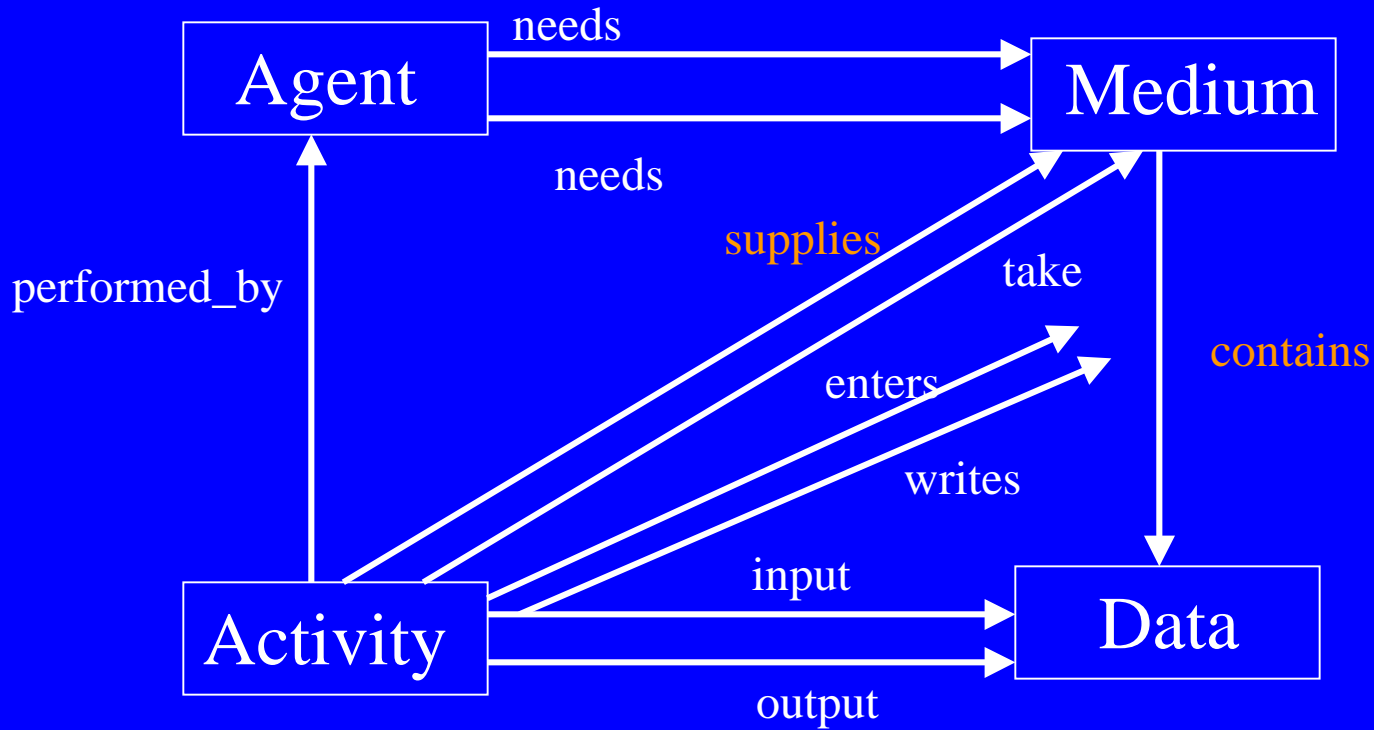
What are concern predicates?

- Recall that viewpoint composition may require more than just common M3 modeling predicates...

- To provide enterprise modeling viewpoints, concern predicates are defined that reflect a pattern that the modeler finds useful to his perspective.

- Example:
  - Nissen et al. Describe an abstract model involving four concepts and several relations between these.

Nissan's ad hoc Enterprise Meta-Model

Peter Denno, NIST

Concern predicates for EM

- Example:

    - Concern "The BOM shall reflect Effectivity" is an instance of
      (contains <medium> <data>) , that is
      (contains BOM effectivity)

    - Concern "Engineering Change may affect BOM" is an instance
      (supplies <activity> <data>), that is
      (supplies Engineering-change BOM)

Peter Denno, NIST

How is EM viewpoint composition performed?

- One may select predicates and model elements in various ways to compose EM viewpoints to meet needs.

- There need not be a dominant collection of predicates
  - Different in character than predicates defining model element semantics
    - Distinction analogous to that of "interface" vs. "use of interface" in ADL
    - More than needed for any single EM viewpoint is OK?
    - Orthogonality only an issue among those selected for view?

- The quality of the work performed tagging model elements with predicates may be crucial.

Peter Denno, NIST

Summary(1)

- Models of an enterprise may be composed, in the sense that a core semantics is assigned to the M3 model and specialized for the various notations at M2.

- Additional coherence provided by refinement and concern predicates between model elements (some user-placed).

Peter Denno, NIST

Summary (2)

- Result:
    - Detect inconsistencies between viewpoints

    - Improve traceability from / to requirements (concerns)

    - Identify characteristics of interfaces in all 3 dimensions

    - Holy Grail: Increase rigor in industrial consensus standards-making

    - (reduce cost)

Challenges?

- Communication among viewpoints by constraining common predicates, refinement relationships, and concern predicates...
  - Is that enough?
- Can dimensions of concerns really be made to correspond to enterprise model viewpoints?
  - Is that useful?
- Will the management of model elements 'tagged' with concerns and refinements going to be cumbersome?

- Is the discipline of an environment model unbiased wrt implementation reasonable?

References

- *Four Dark Corners in Requirements Engineering*,
  Zave & Jackson, ACM Trans. Soft. Eng and Meth. 1/97

- *Requirements Analysis from Multiple Perspectives: Experiences with Conceptual Modeling Technology,* H. W. Nissen, et al. ConceptBase web site.

- *Conjunction as Composition*,
  Zave & Jackson, ACM Trans. Soft. Eng and Meth. 10/93

- *Modeling Technology for a Model-intensive Enterprise*,
  Denno, Flater & Gruninger, SSGRR 2001

- *From a Logical Point of View*,
  Willard Van Orman Quine, 1953

Peter Denno, NIST