Role of NIST in Realizing OKN

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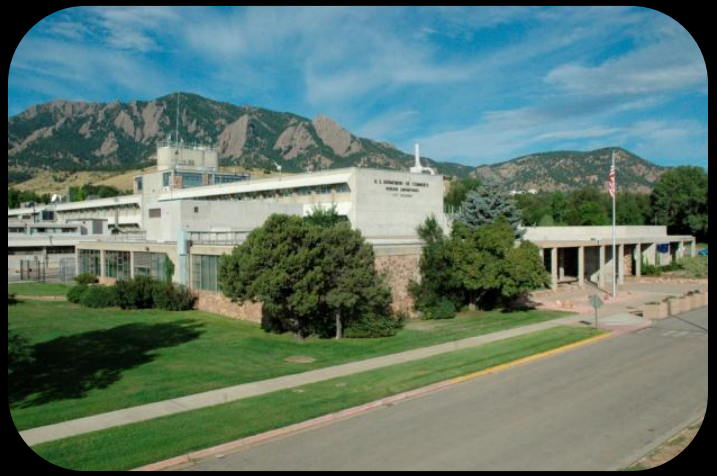
Outline

- NIST Background
- OKN Related Projects
- Expectations

NIST – Bird's eye view

The National Institute of Standards and Technology (NIST) is where Nobel Prize-winning science meets real-world engineering.

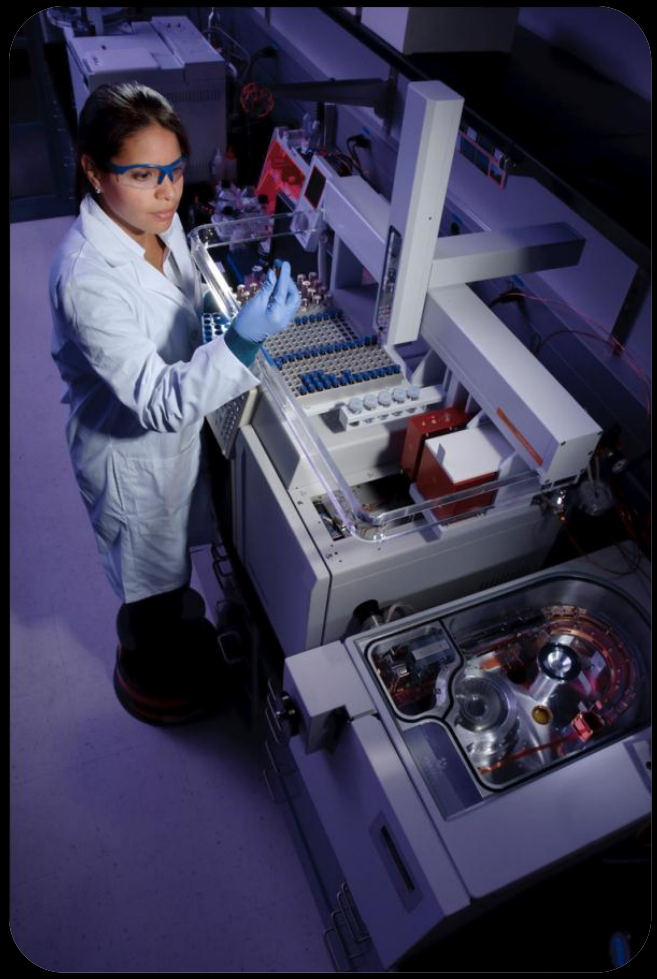
Courtesy HDR Architecture, Inc./Steve Hall © Hedrich Blessing



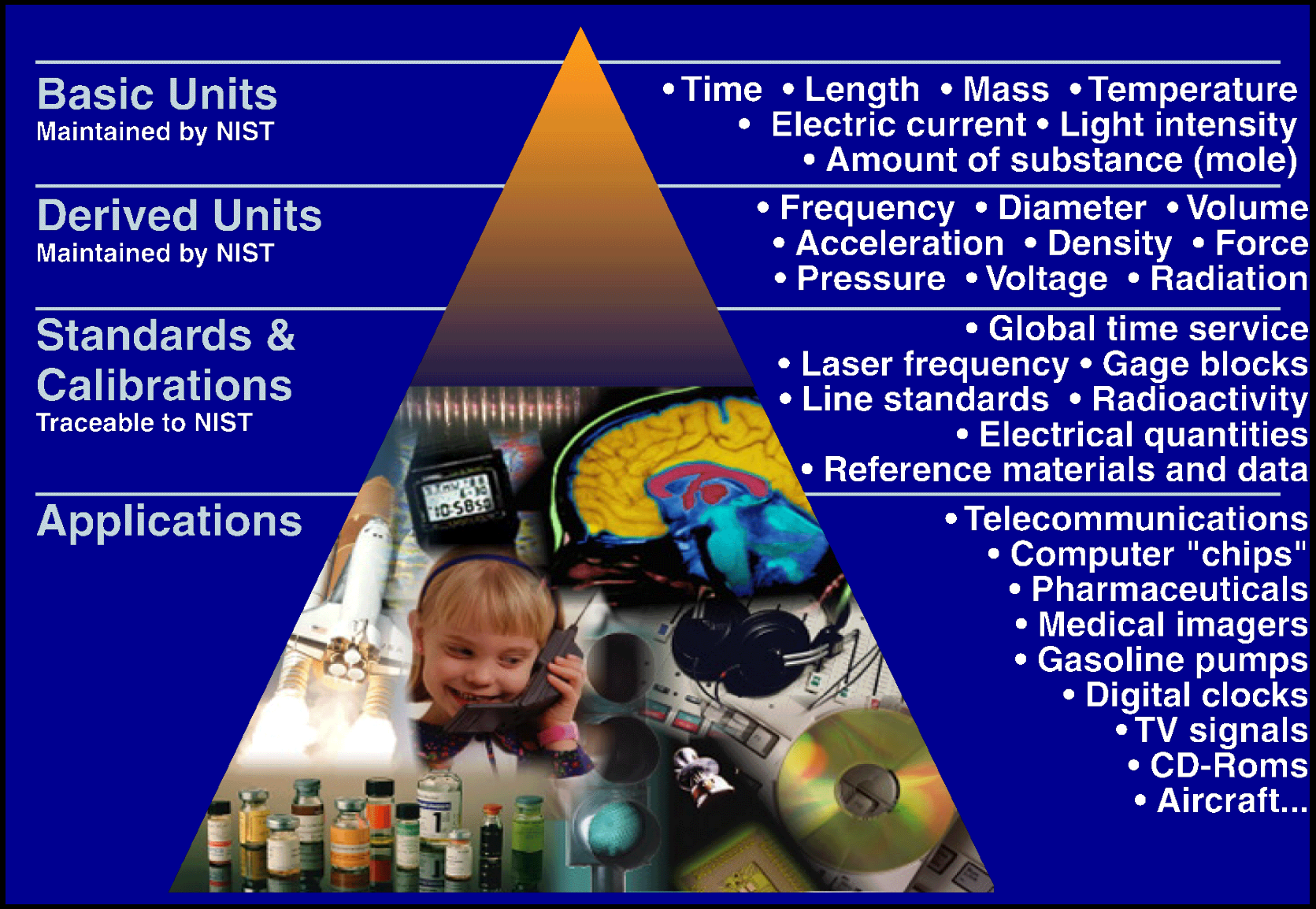
With an extremely broad research portfolio, world-class facilities, national networks, and an international reach, NIST works to support industry innovation – our central mission.

NIST's Mission

- To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.



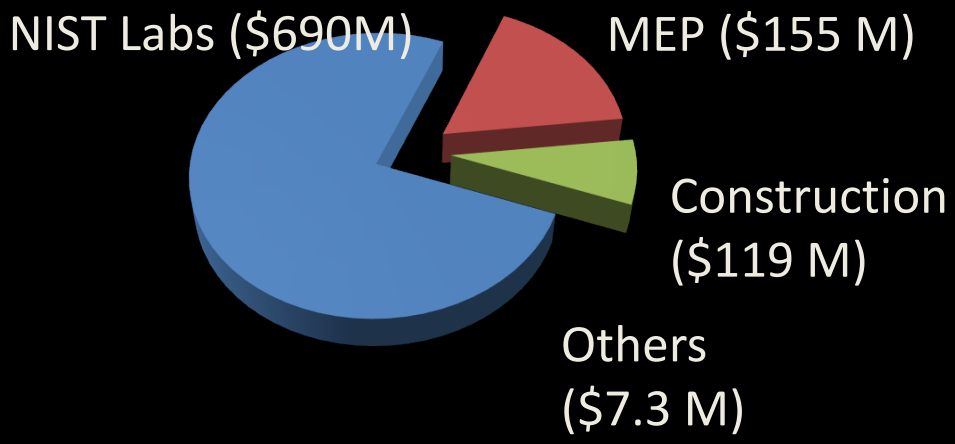
U.S. Economy Depends on NIST Measurements

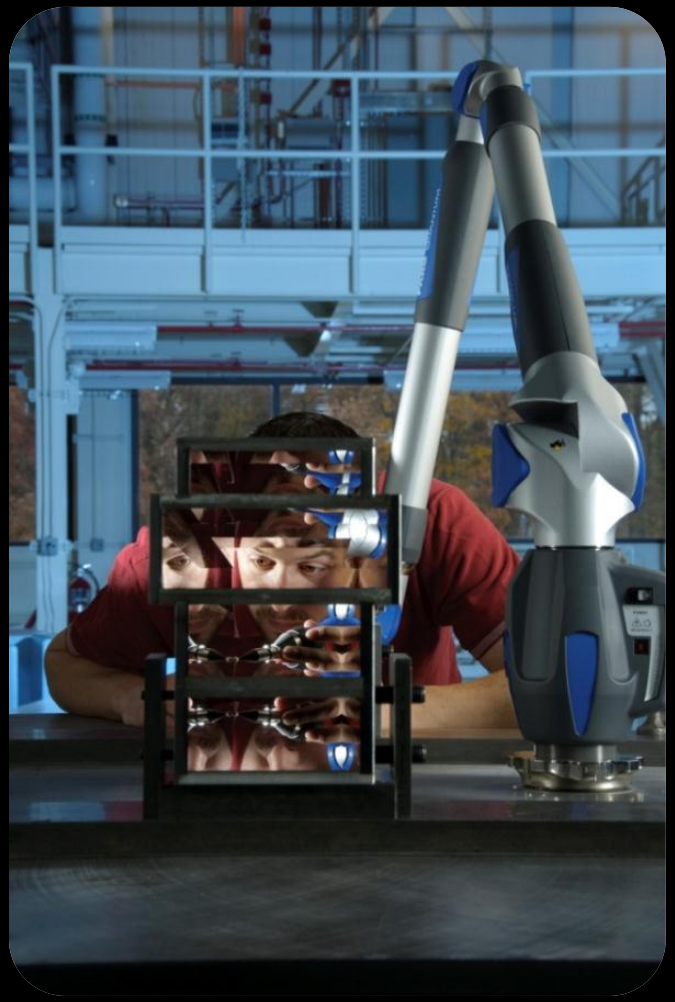


NIST: Basic Stats and Facts

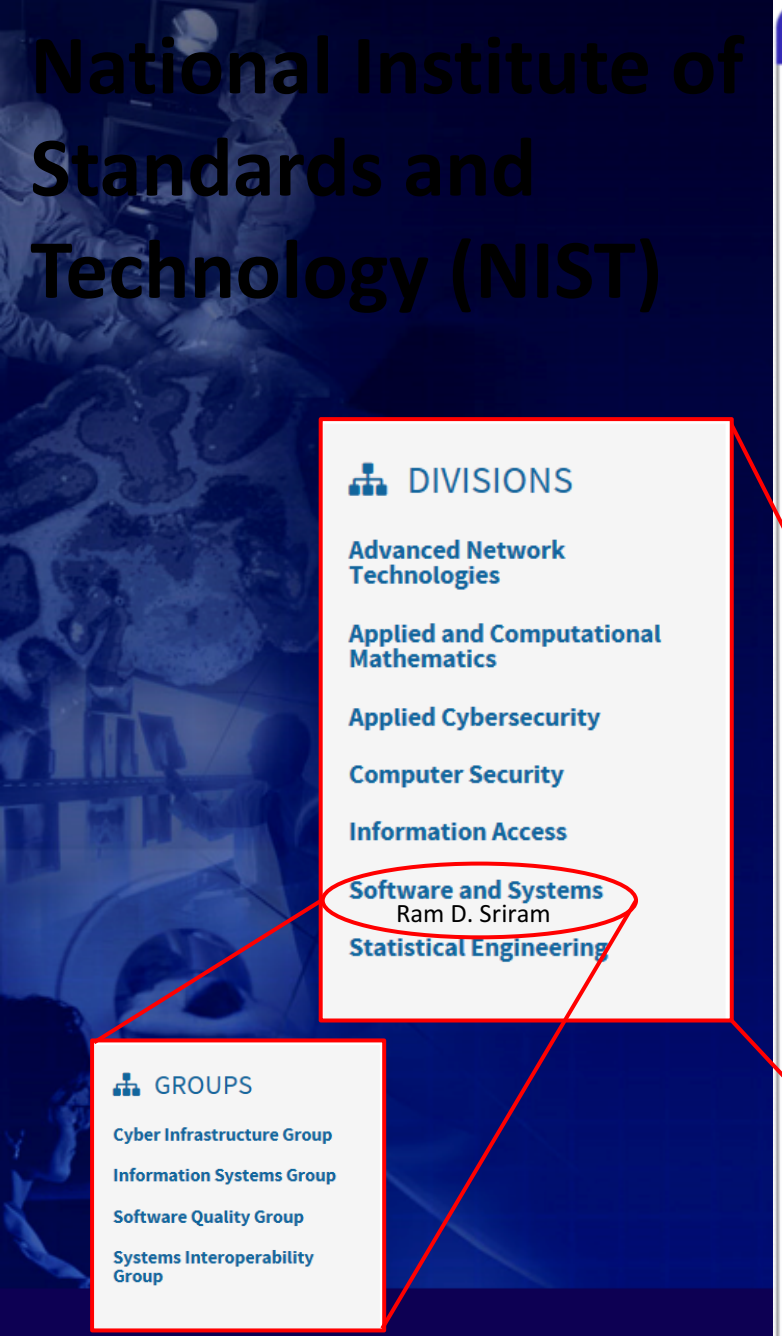
- Major assets
  - ~ 3,000 employees
  - ~ 2,800 associates and facilities users
  - ~ 1,300 field staff in partner organizations
  - Two main locations: Gaithersburg, Md., and Boulder, Colo.
  - Four external collaborative institutes: basic physics, biotech, quantum, and marine science
  - Nobel Prize Winners: 1997,2001,2005,2007

FY 2016 Appropriations $971.3 M





National Institute of Standards and Technology (NIST)



DIVISIONS

- Advanced Network Technologies
- Applied and Computational Mathematics
- Applied Cybersecurity
- Computer Security
- Information Access
- Software and Systems
  Ram D. Sriram
- Statistical Engineering

GROUPS

- Cyber Infrastructure Group
- Information Systems Group
- Software Quality Group
- Systems Interoperability Group

Information Technology Laborat

NIST Organizational Structure

Acting Director
Acting Under Secretary of Commerce for Standards and Technology
Kent Rochford

Chief of Staff
Kevin Kimball

- Executive Officer for Administration
- Management and Organization
- Program Coordination
- Public Affairs Office
- International and Academic Affairs
- Congressional and Legislative Affairs
- Human Subjects Protection

Acting Associate Director for Laboratory Programs/ Principal Deputy
Laurie Locascio

Staff Offices
- Standards Coordination
- Special Programs

Associate Director for Innovation & Industry Services
Phillip Singerman

Staff Offices
- Advanced Manufacturing
- Technology Partnerships

Associate Director for Management Resources
Mary Saunders

Staff Offices
- Civil Rights and Diversity
- Information Services
- Fabrication Technology

RESEARCH COMPONENTS

- Material Measurement Laboratory
  Michael Fasolka (acting)
- Communications Technology Laboratory
  Dereck Orr (acting)
- Physical Measurement Laboratory
  James Olthoff
- Engineering Laboratory
  Howard Harary
- Information Technology Laboratory
  Charles Romine
- Center for Nanoscale Science and Technology
  Robert Celotta
- NIST Center for Neutron Research
  Robert Dimeo

- Baldrige Performance Excellence Program
  Robert Fangmeyer
- Hollings Manufacturing Extension Partnership
  Carroll Thomas

- Office of Acquisition and Agreements Management
  Cecelia Royster
- Office of Safety, Health and Environment
  Richard Kayser
- Office of Financial Resource Management
  George Jenkins
- Office of Human Resources Management
  Susanne Porch
- Office of Information Systems Management
  Delwin Brockett
- Office of Facilities and Property Management
  Skip Vaughn

Interacting with NIST

- Guest Researchers/Faculty Associates
- Grants and Contracts
- IPA
- Summer Students
- NRC Post Doctoral Program
- Collaborative Proposals

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OKN Related Projects

- Core Product Model & Beyond (EL & ITL)
- Ontologies & Category Theory (ITL & EL)
- Extracting Domain Specific Terms From Documents (ITL & MML)
- TREC (ITL)

Generic Information Modeling Requirements

- Model construction
- Representation across scales
- Broad accommodation for multiple formalisms
- Separation of domain-specific concerns
- Integration and aggregation across models
- Model evolution
- Flexibility and modularity
- Scalability

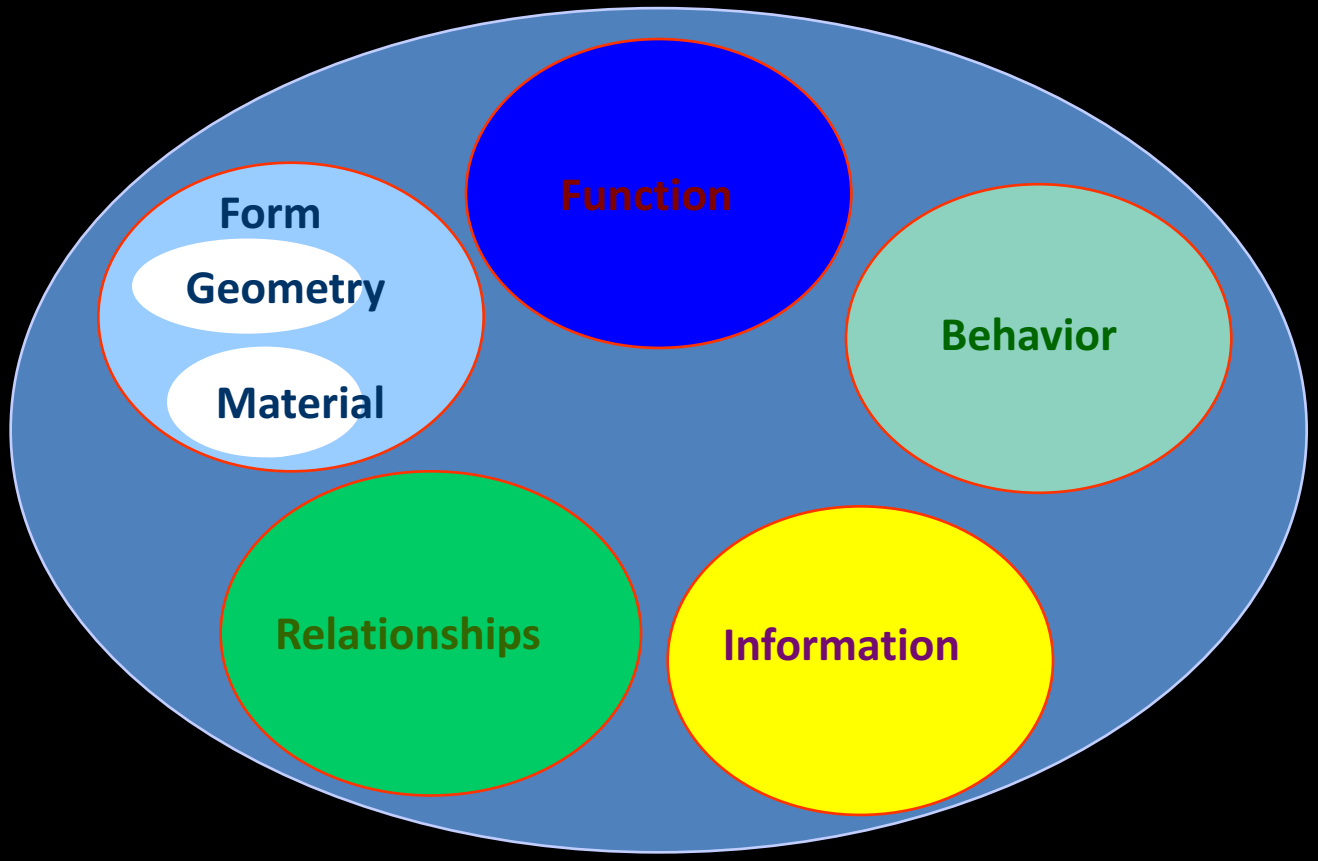
Core Product Model (1994-2010)

- Objective: base-level product model that is:
  - generic
  - extensible
  - independent of any one product development process
  - capable of capturing full engineering context
- Key feature: explicit representation of

  Function – Form - Behavior

  (in contrast to STEP AP 203 that essentially represents only form)

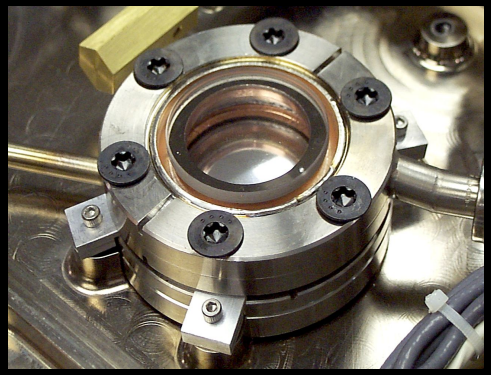
Knowledge Representation



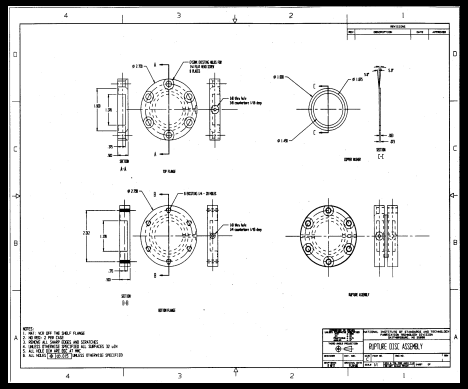
A product is represented by a hierarchy of entities of the class Artifact, which is an aggregation of Function, Form and Behavior. Function represents what the artifact is supposed to do; Form represents the proposed design solution for the design problem specified by the Function; and Behavior represents the evaluation of how the artifact implements its function.

Form

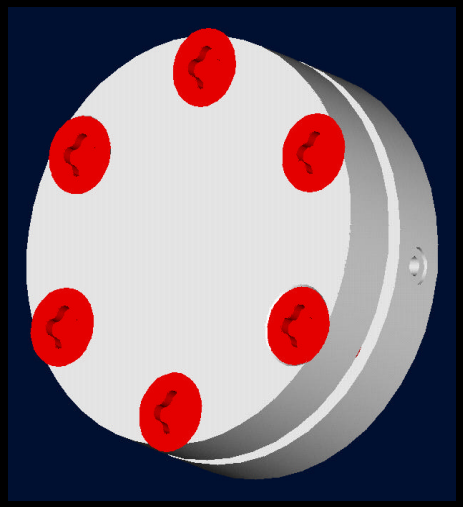
Rupture Disc



Digital Picture

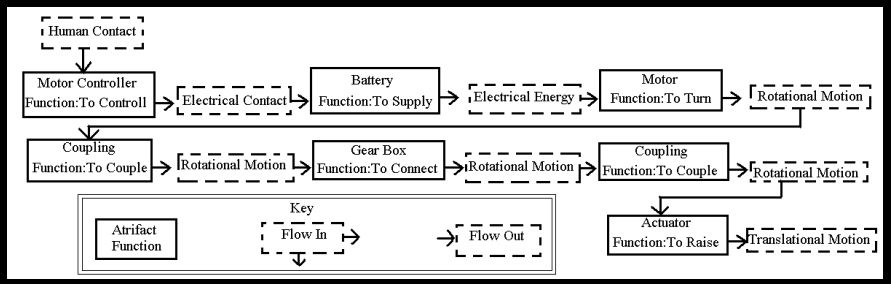


Detailed Design

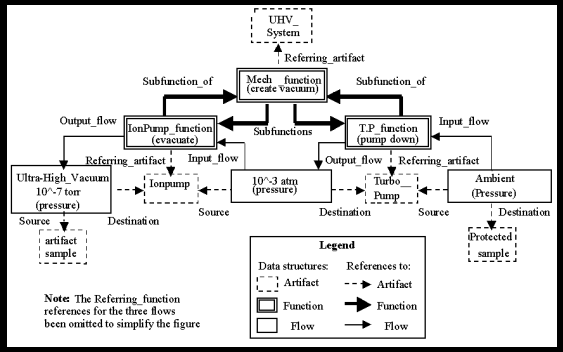


3D Model

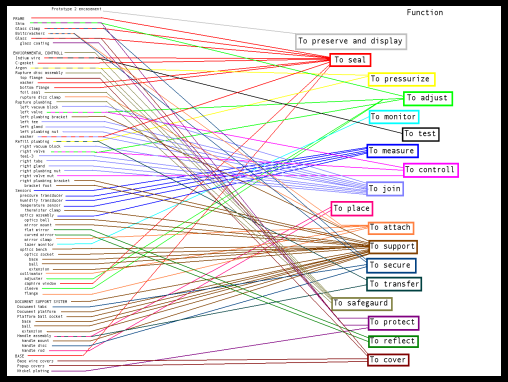
Function



Simplified Function Flow

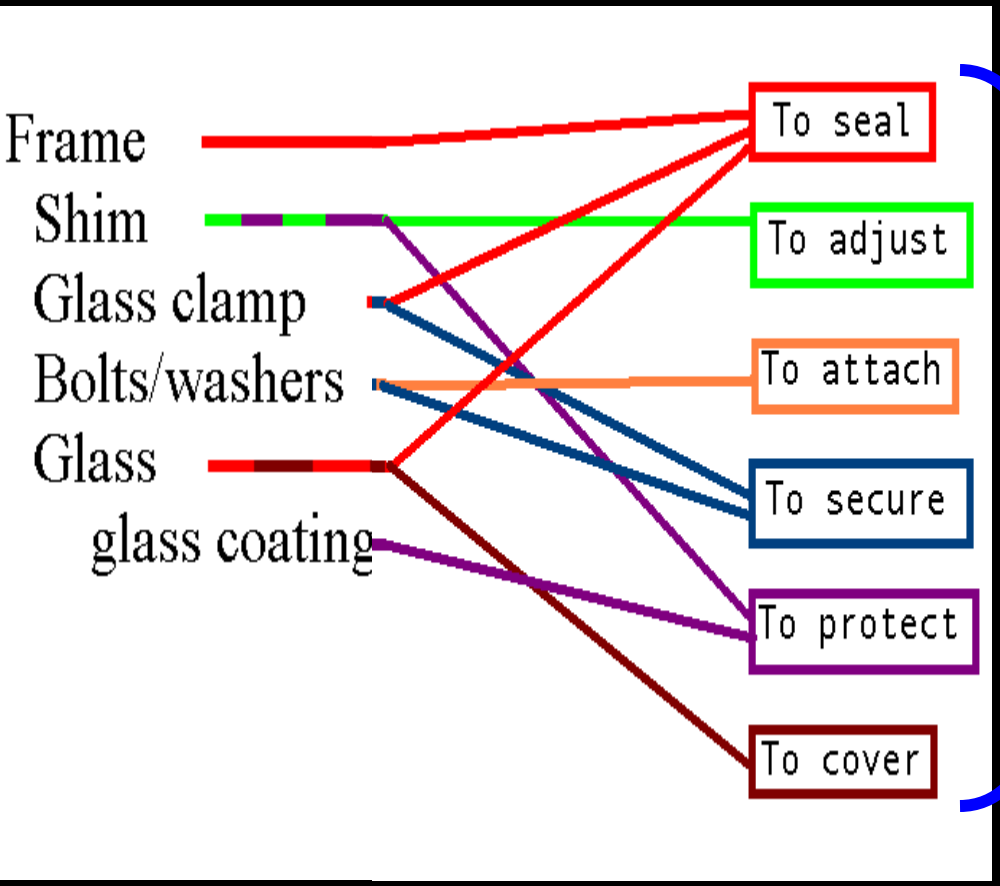


Detailed Function Flow



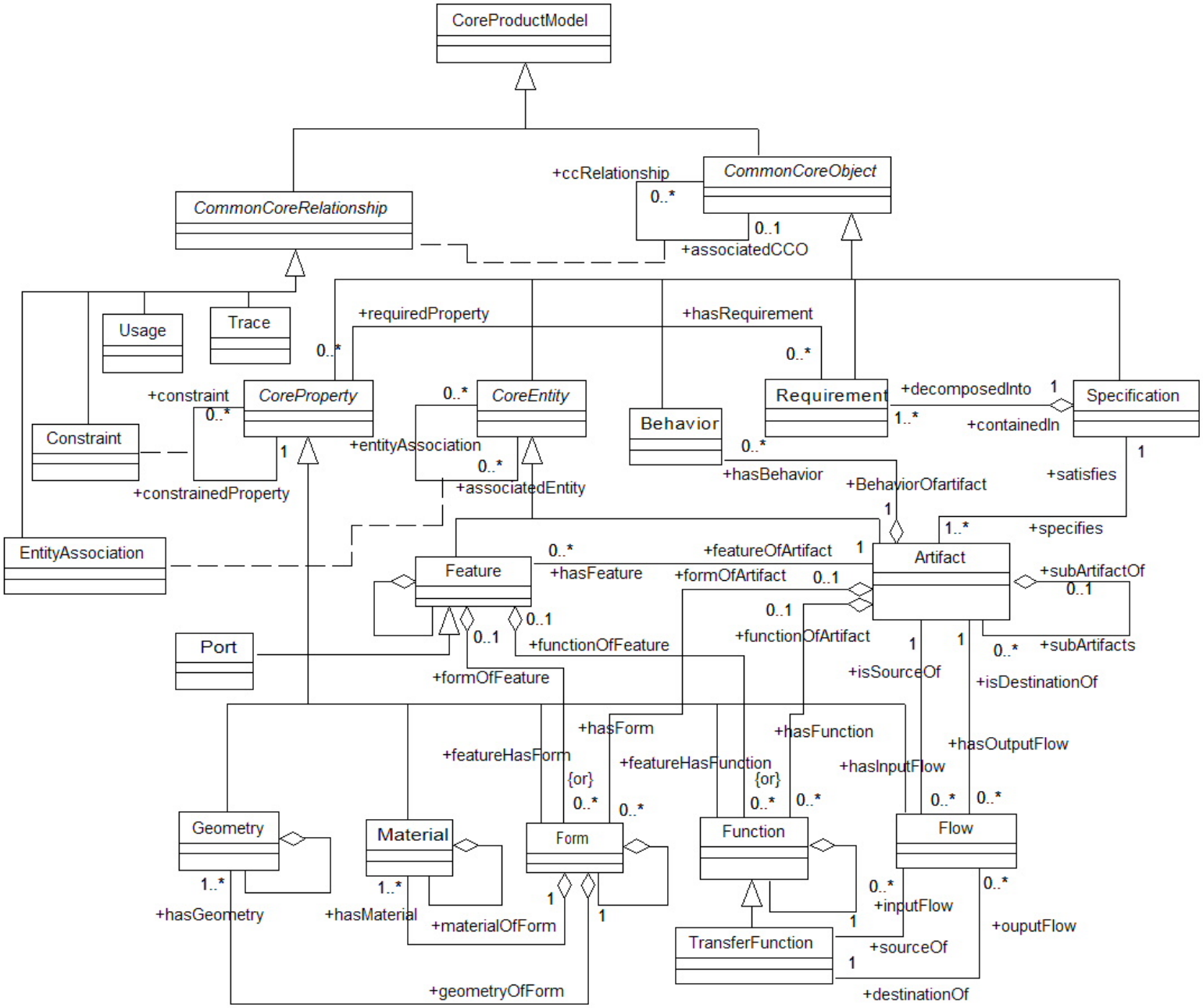
Function Links

Links between Function and Artifact



Function
- **Usage-function**
  - Sink
    - Absorb
    - Consume
    - Destroy
    - Dissipate
    - Eliminate
    - Empty
    - Export
    - Remove
  - Source
    - Add
    - Create
    - Emit
    - Extract
    - Generate
    - Import
    - Supply
  - Storage
    - Accumulate
    - Collect
    - Store
- **Combination/ distribution-function**
  - Branch
  - Combine
  - Connect
  - Couple
  - Distribute
  - Divide-flow
  - . . .
- **Conveyance-function**
  - Advance
  - Channel
  - Conduct
  - Convey
  - Direct
  - Divert
  - Guide
  - Generic-move
  - Rotate
  - Transfer
  - Translate
  - Transmit
  - Transport
- **Signal/Control-function**
  - Actuate
  - Adjust
  - Close
  - Decrease
  - Delay
  - Detect
  - Display
  - Equalize
  - Enhance
  - Generic-control
  - Identify
  - Increase
  - Indicate
  - Inhibit
  - Limit
  - . . .

Design Objects | Function types | Function Taxonomy


CoreProductModel
CommonCoreObject
+ccRelationship
0..*
0..1
+associatedCCO
CommonCoreRelationship
Usage
Trace
+requiredProperty
+hasRequirement
0..*
0..*
+constraint
0..*
CoreProperty
0..*
CoreEntity
Behavior
Requirement
+decomposedInto
1
1..*
Specification
+containedIn
Constraint
1
+entityAssociation
0..*
+hasBehavior
+BehaviorOfartifact
+satisfies
1
+constrainedProperty
+associatedEntity
1
1..*
+specifies
EntityAssociation
0..*
+hasFeature
+featureOfArtifact
1
Artifact
+subArtifactOf
0..1
Feature
+formOfArtifact
0..1
0..1
0..1
+functionOfArtifact
1
1
0..*
+subArtifacts
Port
0..1
+functionOfFeature
+isSourceOf
+isDestinationOf
+formOfFeature
+hasForm
+hasFunction
+hasOutputFlow
+featureHasForm
{or}
+featureHasFunction
{or}
+hasInputFlow
0..*
0..*
0..*
0..*
0..*
0..*
Geometry
Material
Form
Function
Flow
1..*
1..*
1
1
0..*
+inputFlow
0..*
+ouputFlow
+hasGeometry
+hasMaterial
+materialOfForm
1
TransferFunction
+sourceOf
1
+geometryOfForm
+destinationOf

CPM : Four Categories of Classes

1. Classes that provide supporting information for the objects (abstract classes) for storing common information
   - CoreProductModel, CommonCoreObject, CommonCoreRelationship
   - CoreEntity, CoreProperty
2. Classes of physical or conceptual objects
   - Artifact, Feature, Port, Specification, Requirement
   - Function, TransferFunction, Flow, Behavior
   - From, Geometry, Material
3. Classes that describe relationships among objects, they are derived from CommonCoreRelationship
   - Constraint, Usage, Trace, EntityAssociation
4. Classes that are commonly used by other classes.
   - Information, ProcessInformation, Rational

CPM : Three Kinds of Associations

All object classes have their own separate, independent decomposition hierarchies by attributes such as subArtifacts/subArtifactOf for the Artifact class.

There are associations between:

- a Specification and the Artifact that results from it
- a Flow and its source and destination Artifacts and its input and output Functions
- an Artifact and its Features.

Four aggregations are fundamental to the CPM:

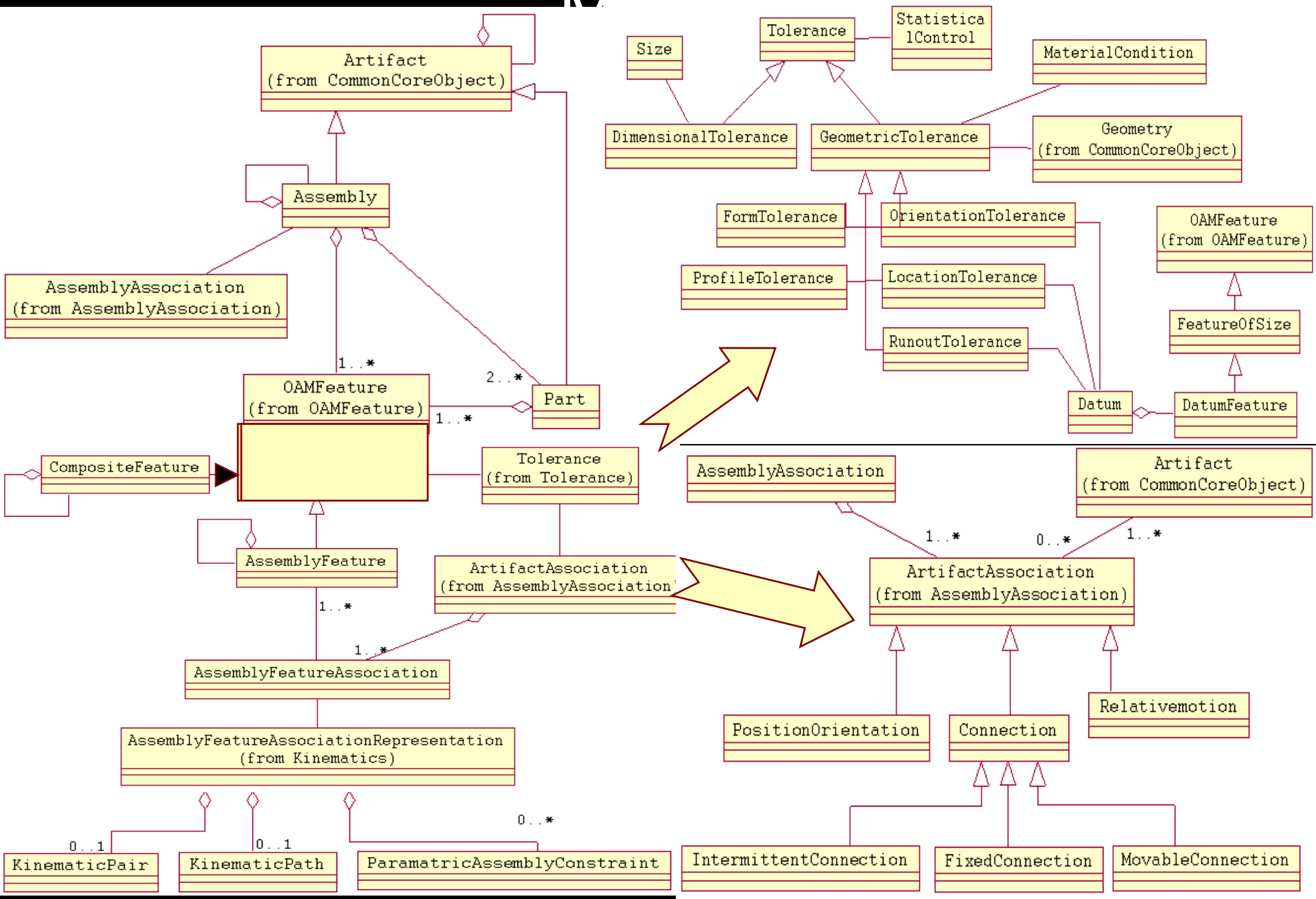
- Function, Form and Behavior aggregate into Artifact
- Function and Form aggregate into Feature
- Geometry and Material aggregate into Form
- Requirement aggregates into Specification.

Open Assembly Model

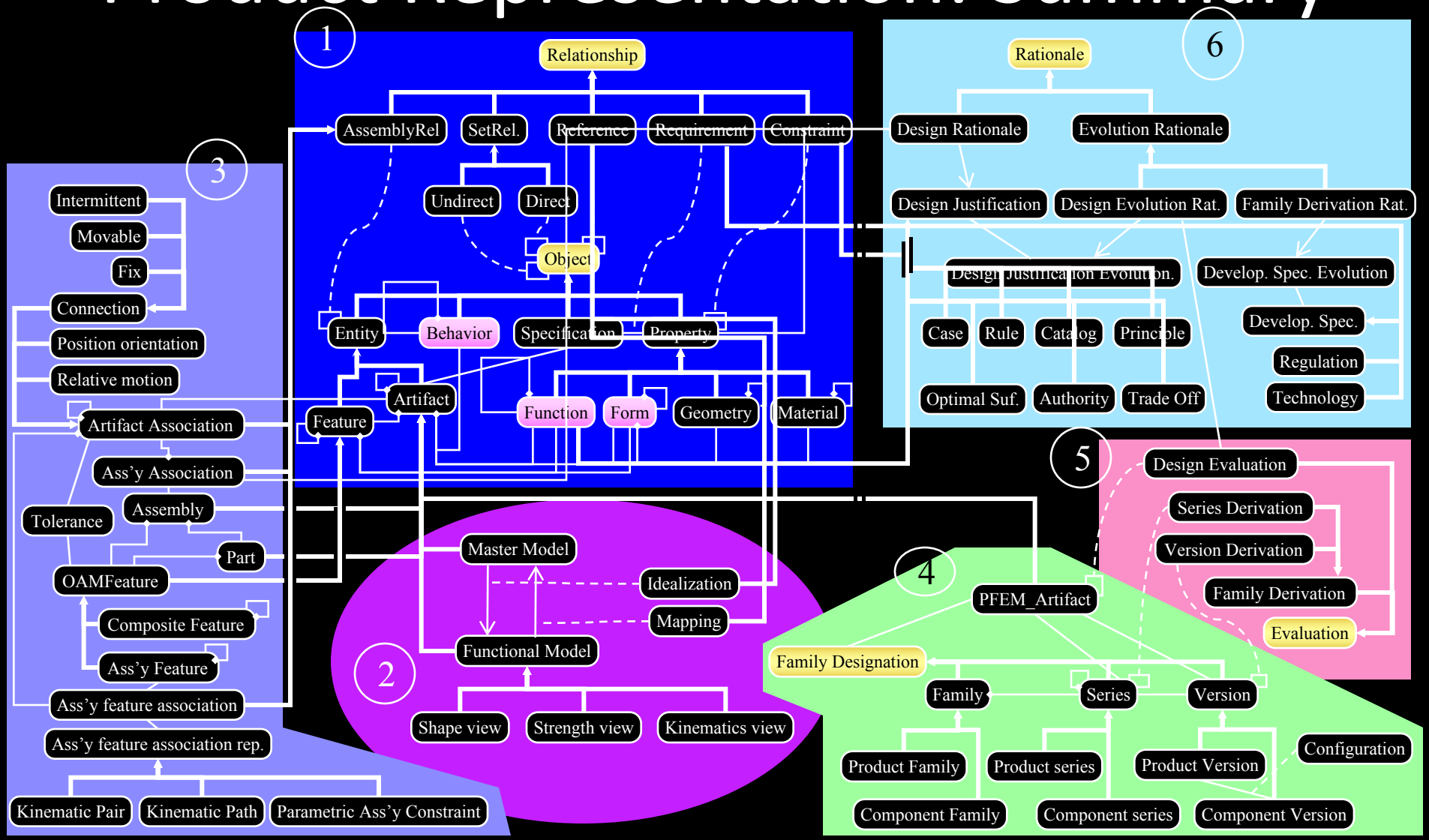
- Objectives:
  - standard representation for assembly and system-level tolerance information
  - extensible
- Key features:
  - emphasizes information requirements for part features and assembly relationships
  - ***assembly as a concept and assembly as a data structure***

CPM&OPM leads: Fenves & Sudarsan

Extension to CPM: Open Assembly Model



Product Representation: Summary



Impacts of NIST's Product Modeling Work

- Major portions of CPM/OAM was included in STEP Part 109
- CPM/OAM is being used by several organizations
- Portions of CPM/OAM was used in CAD vendor software (EU)
- OntoSTEP released as open source software
- Extensions to CPM/OAM
  - Georgia Inst. of Tech: *Design/Analysis integration*
    - Creates complex analysis models faster
    - Being integrated into work with Lockheed Martin
  - University of Wisconsin Madison: *Heterogeneous material modeling*
    - Supports a new approach to mesh-free analysis
  - Arizona State University: *Extended features*
    - Being used in a project for US Army
  - Syracuse University: *Tolerance, kinematics, and assembly analysis*
    - Provides greater support for integrating product specifications with manufacturing and inspection.
  - University of Maryland, College Park: *Assembly-based search*
    - Allows organizations to use existing designs
    - Currently in negotiations with an industrial partner

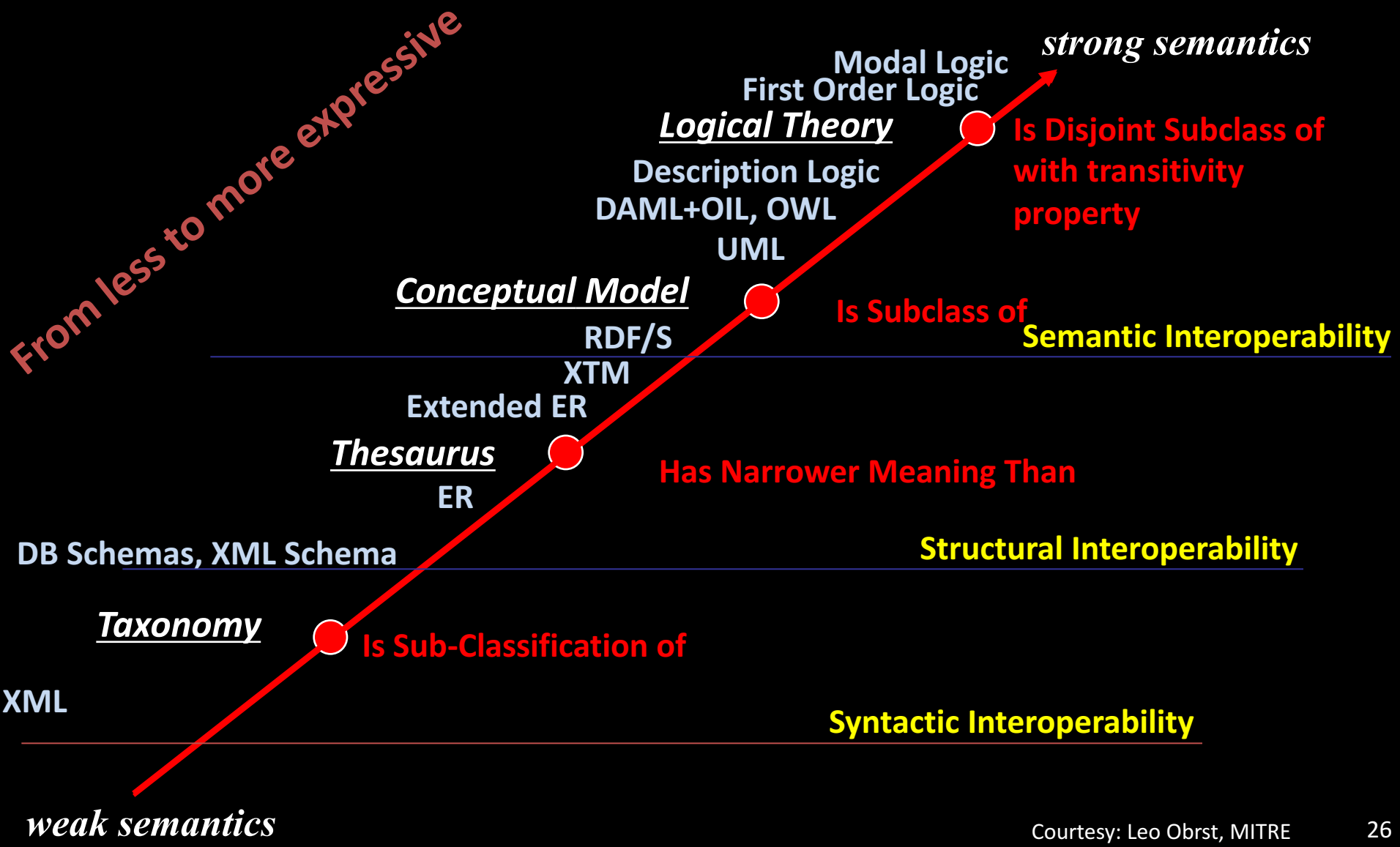
The Next Steps

- Engineering Laboratory is currently involved in the Industry Ontologies Foundry

OKN Related Projects

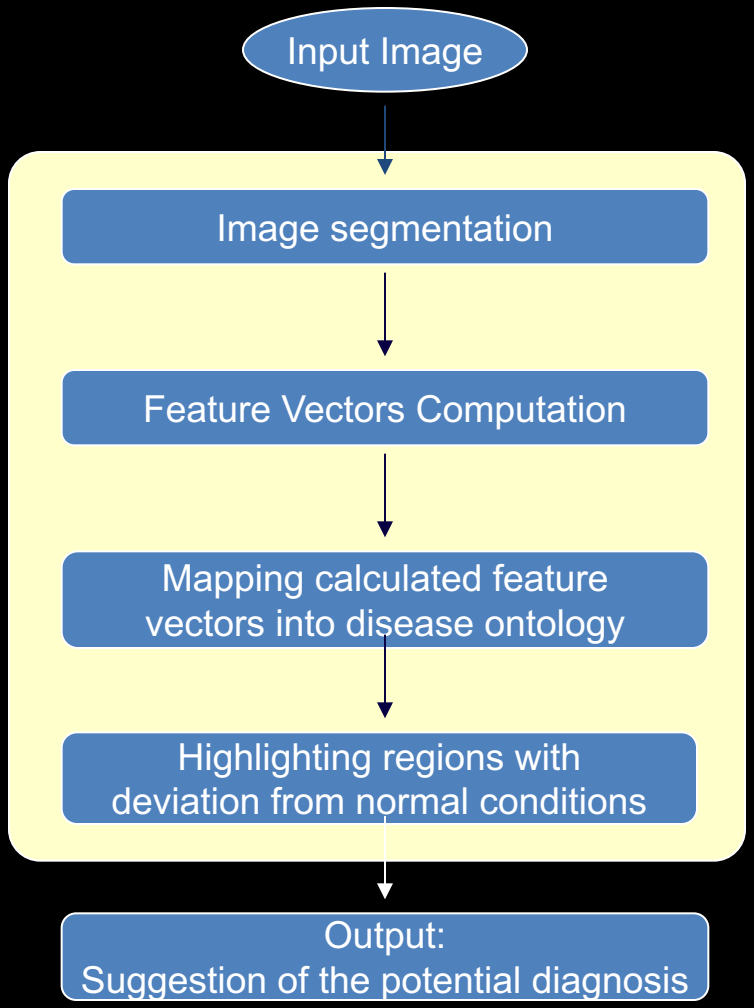
- Core Product Model & Beyond (EL & ITL)
- Ontologies & Category Theory (ITL & EL)
- Extracting Domain Specific Terms From Documents (ITL & MML)
- TREC (ITL)

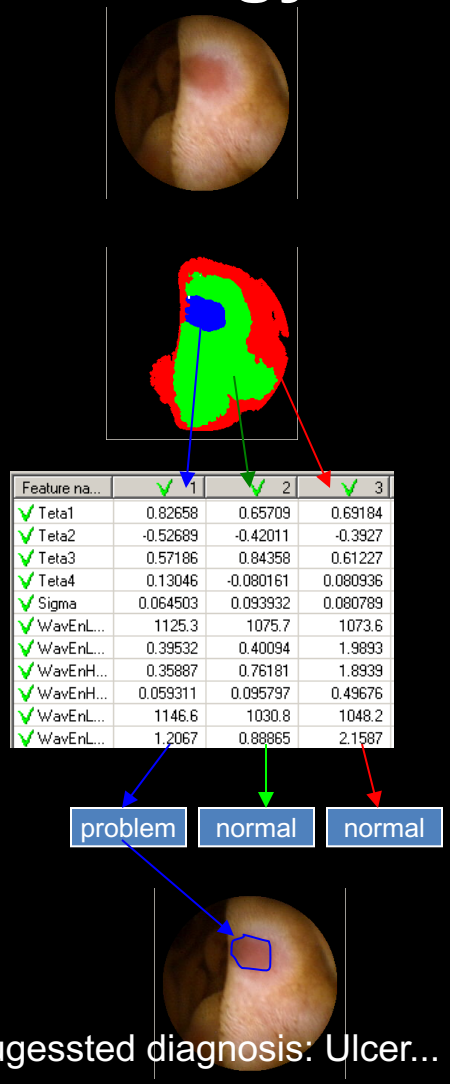
Ontology Spectrum



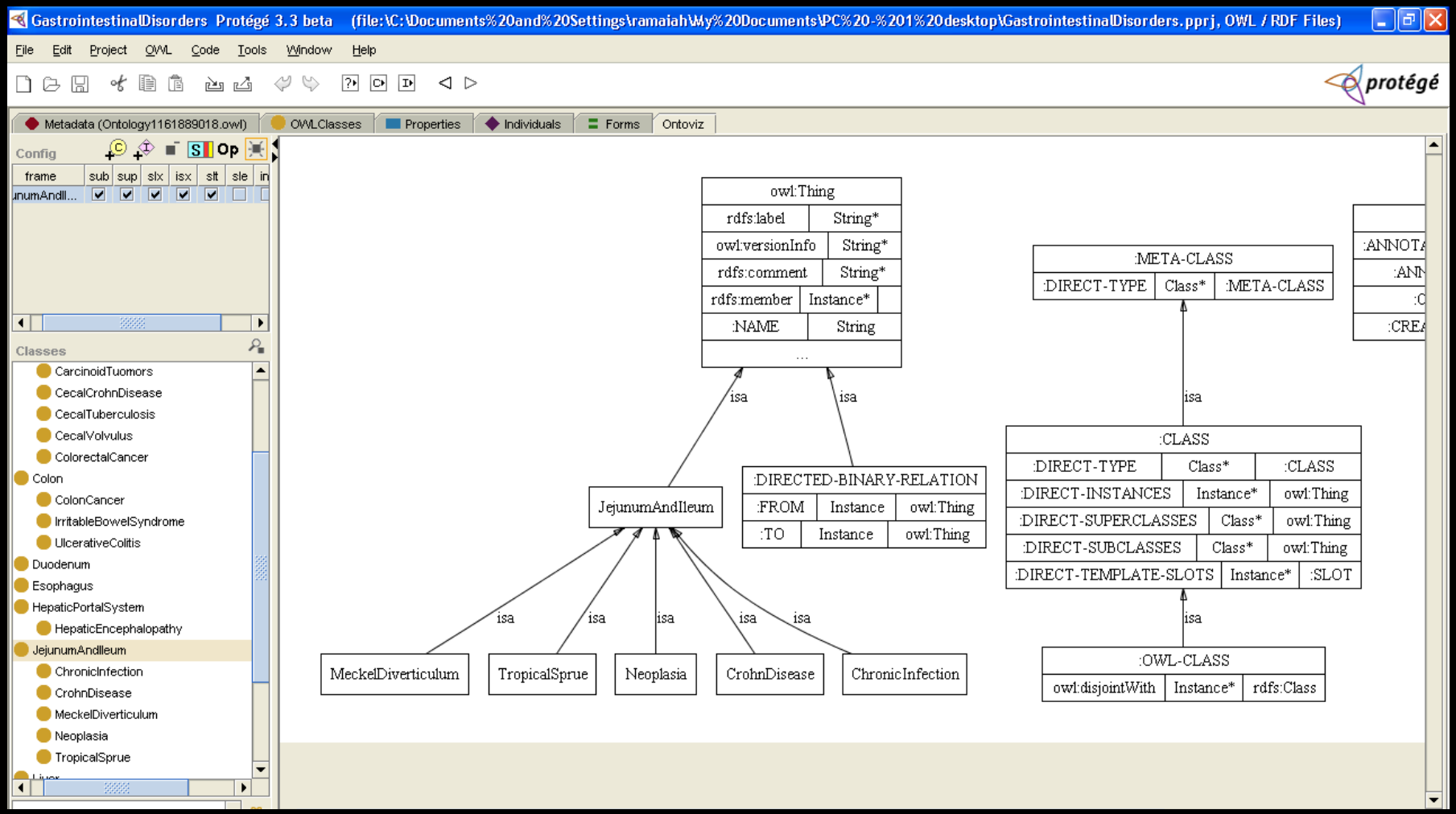
Courtesy: Leo Obrst, MITRE

Methodology for Image to Diagnosis Through Disease Ontology

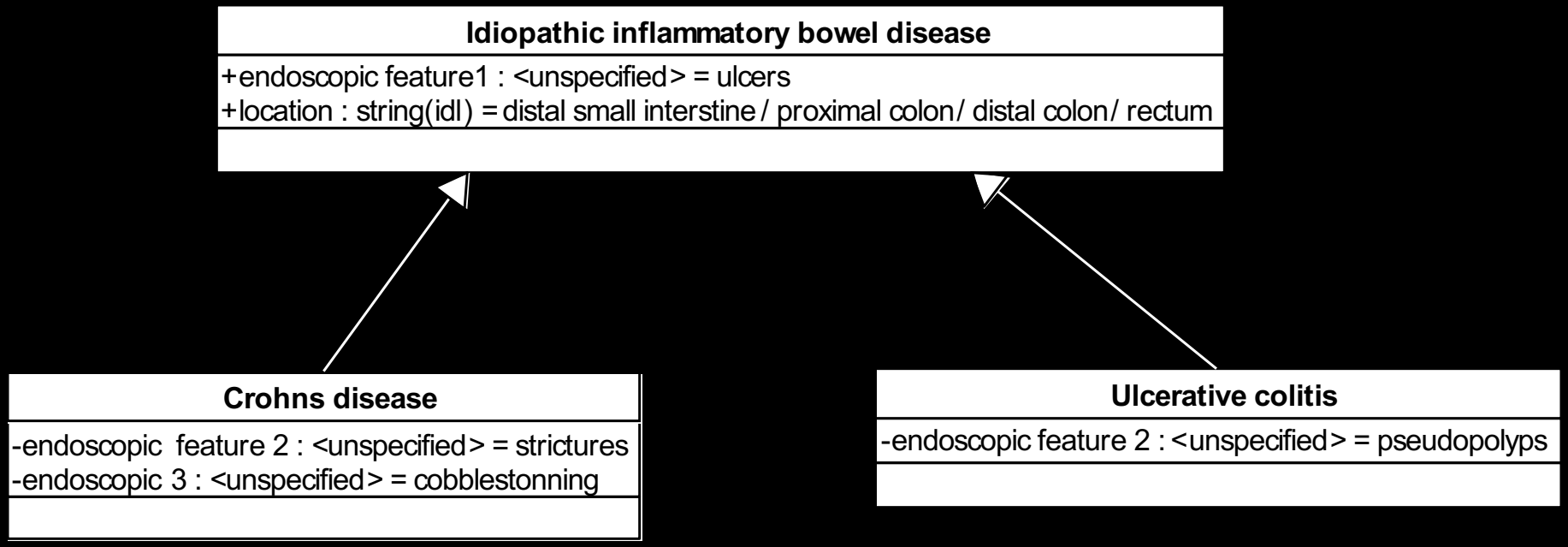




Fragment of Disease Ontology in Protege'-Ontoviz



UML Representation of Inflammatory Bowel Disease



For more about Ontologies: See Ontology Summit Web Pages

- The Ontology Summit is an annual series of events that started in 2006 with the joint sponsorship of Ontolog and NIST
- The summit is largely a self-organizing, bottom-up, volunteer driven effort, that solicits contributions from participants around the world in both industry and academia
- Each year's Summit (different theme every year) consists of a series events and continued discourse spanning three months, culminating in a free, two-day face-to-face workshop and symposium
- URL: http://ontologforum.org/index.php/OntologySummit

Toward Category Theory

- Most semantic models (e.g., OWL) are based on formal logic and set theory. This is usually sufficient for enabling information interoperability between systems.
- Logical models are usually less relevant in system analysis and behavior.
- Other relevant classes of semantics include stochastic, dynamical systems, geometric and computational models.

- We are exploring the use of category theory (CT) as a flexible foundation for representing, analyzing and interlinking this broader class of semantic models.

A Calculus of Information

In mechanical engineering, Newton's calculus provides:

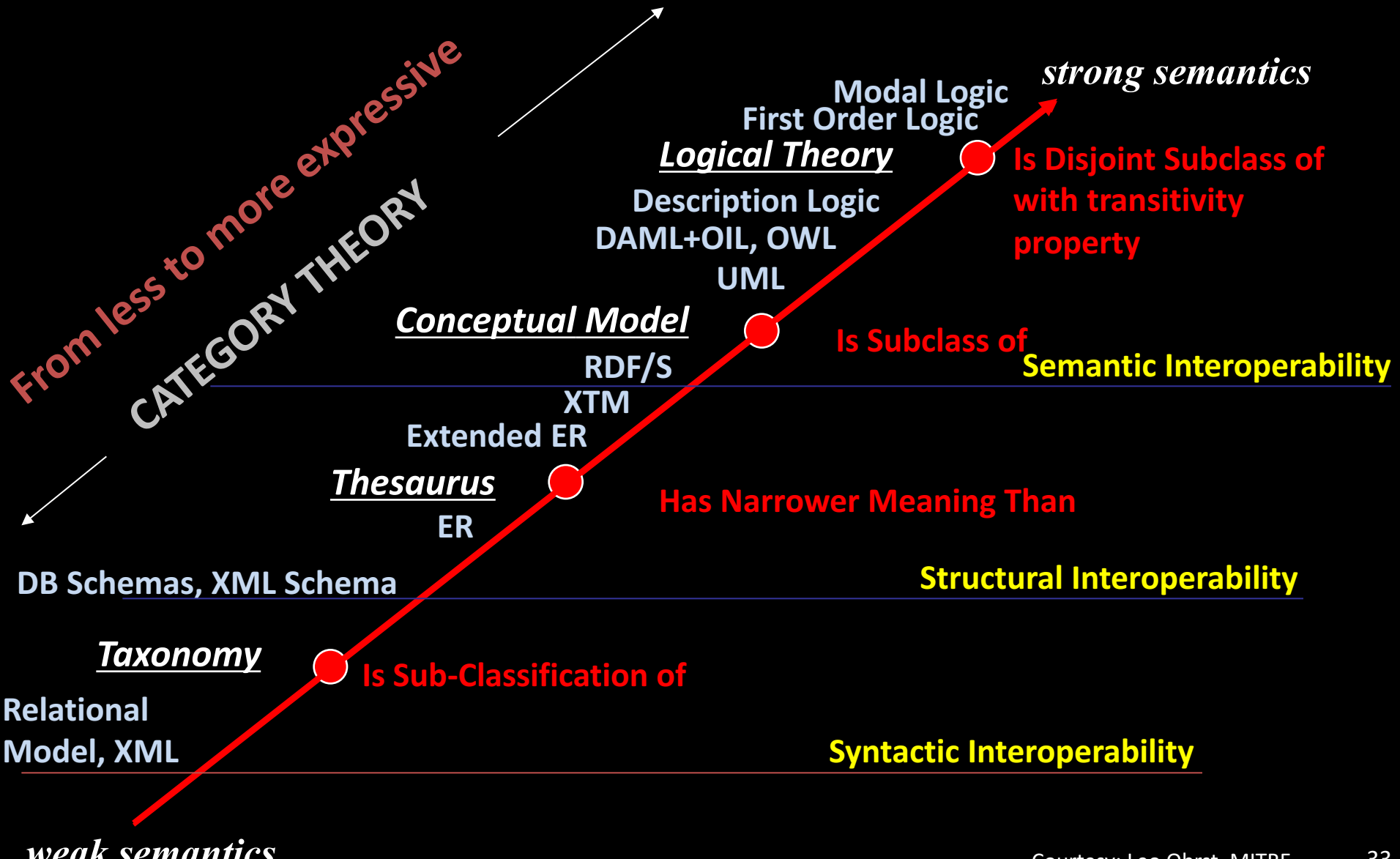
- A language for representing mechanical states, processes and behavior.
- A collection of standard techniques and algorithms for analyzing mechanical systems expressed in this language.

The predicate calculus plays similar roles for logic, and the λ-calculus for computation.

CT is a calculus of abstract processes which generalizes all three of these contexts.

Formal representation in CT provides "hygiene", helping to guide our thinking and to avoid errors and misrepresentation.

Ontology Spectrum



Integrating Supply Chain Databases: CT Approach

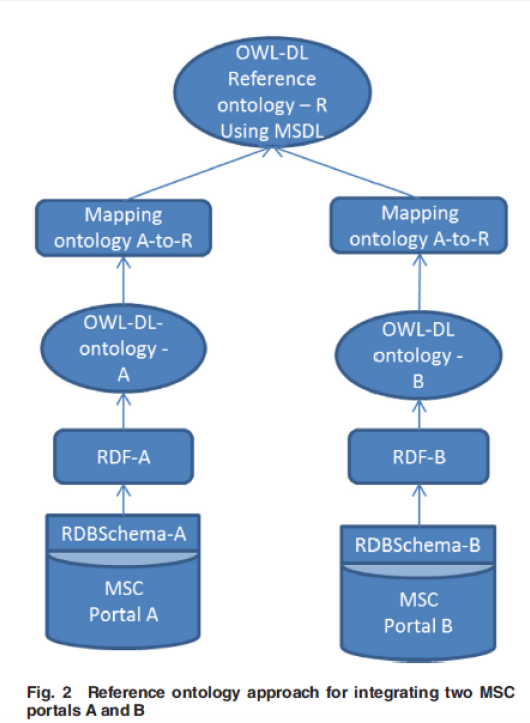
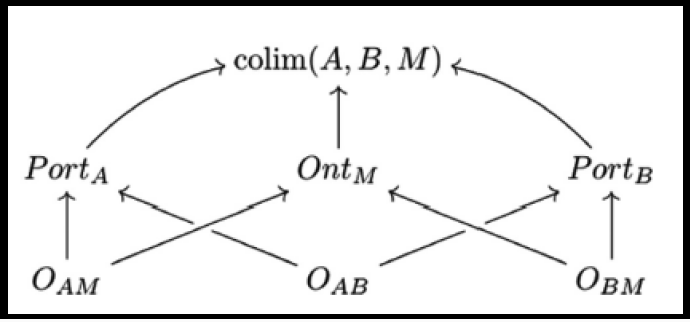


Fig. 2 Reference ontology approach for integrating two MSC portals A and B



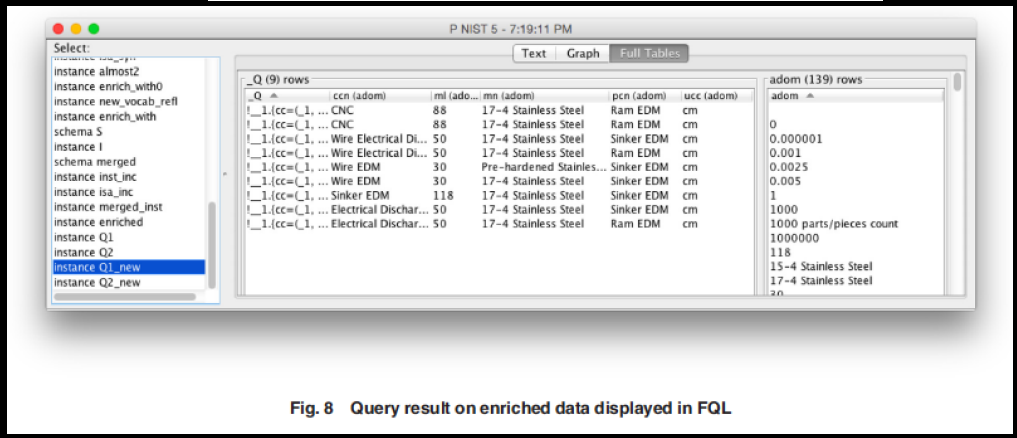


Fig. 8 Query result on enriched data displayed in FQL

Wisnesky R, Breiner S, Jones A, Spivak DI, Subrahmanian E. Using Category Theory to Facilitate Multiple Manufacturing Service Database Integration. ASME. *J. Comput. Inf. Sci. Eng.* 2017;17(2):021011-021011-11. doi:10.1115/1.4034268.

OKN Related Projects

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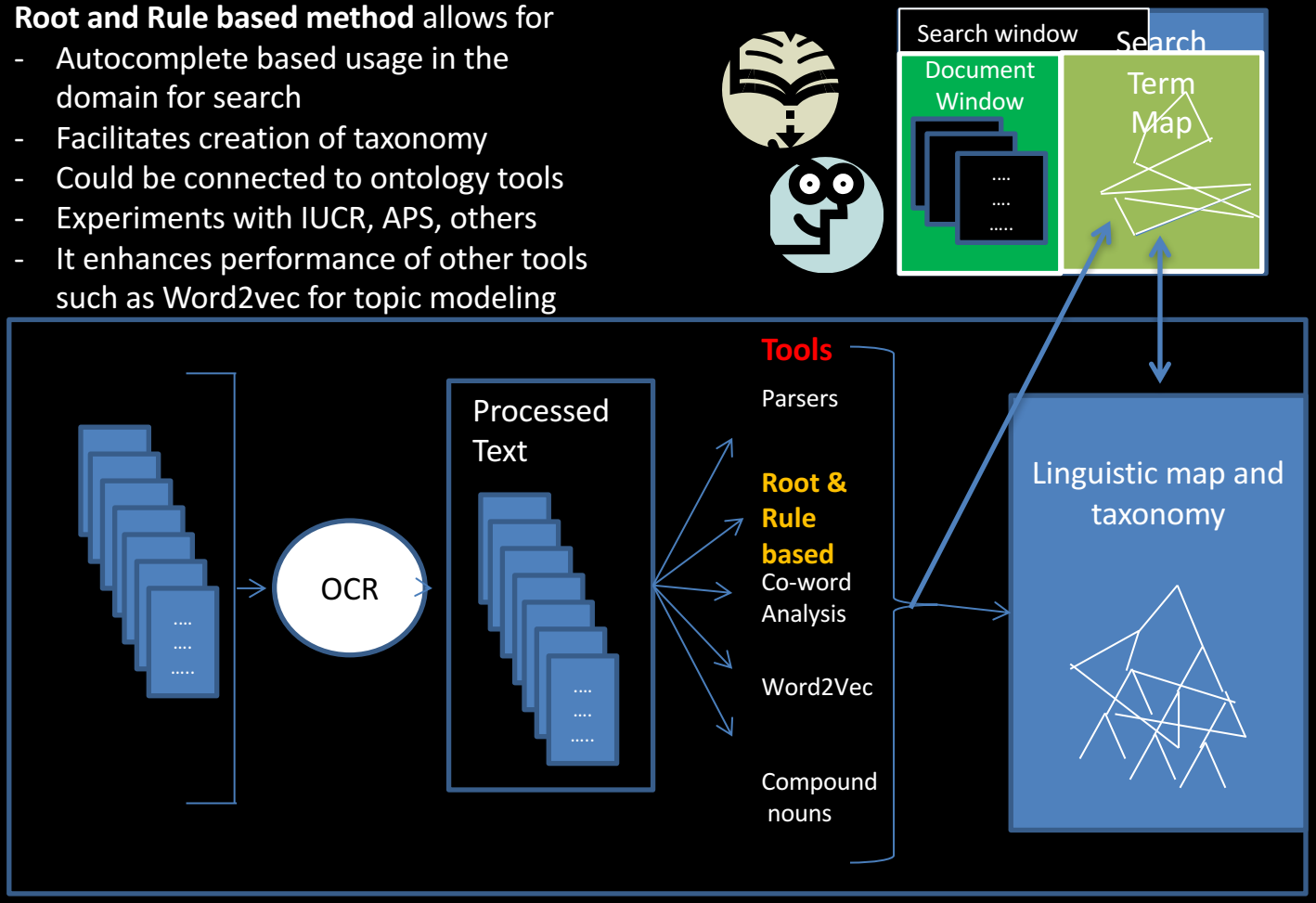
Disciplinary Information Systems

Root and Rule based method allows for
- Autocomplete based usage in the domain for search
- Facilitates creation of taxonomy
- Could be connected to ontology tools
- Experiments with IUCR, APS, others
- It enhances performance of other tools such as Word2vec for topic modeling



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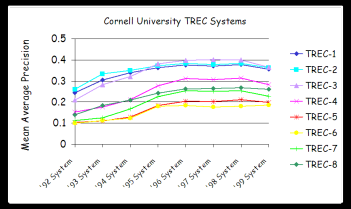
TREC

- A workshop series that provides the infrastructure for large-scale evaluation of (text) retrieval technology
  - realistic test collections
  - uniform, appropriate scoring procedures
  - a forum for the exchange of research ideas and for the discussion of research methodology

Improves the state of the art



The TREC data revitalized research on information retrieval. Having a standard, widely available, and carefully constructed set of data laid the groundwork for further innovation in the field. The yearly TREC conference fostered collaboration, innovation, and a measured dose of competition (and bragging rights) that led to better information retrieval.

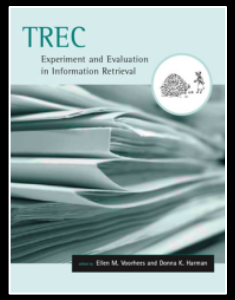
Hal Varian
Google Chief Economist
March 4, 2008

Forms/solidifies a research community

This project [the TREC Legal track] can be expected to identify both cost effective and reliable search and information retrieval methodologies and best practice recommendations, which, if adhered to, certainly would support an argument that the party employing them performed a reasonable ESI search, whether for privilege review or other purposes.

Magistrate Judge Paul Grimm
Victor Stanley v. Creative Pipe

Establishes the research methodology



TREC is an annual benchmarking exercise that has become a de facto standard in Information Retrieval evaluation.

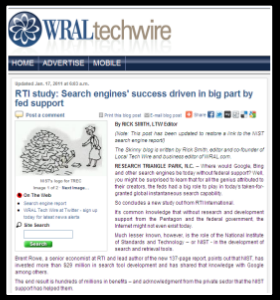
Stephen Robertson
Microsoft
SIGIR 2007

Facilitates technology transfer

TREC has proven to be a valuable forum in which IBM Research has contributed to an improved understanding of search, while at the same time the insights obtained by participating in TREC have helped to improve IBM's products and services.

Alan Marwick, et al.
IBM chapter of the TREC book
2005

Amortizes the costs of infrastructure



In other words, for every $1 NIST and its partners invested in TREC, at least $3.35 to $5.07 in benefits accrued to IR researchers…These responses suggest that the benefits of TREC to both private and academic organizations go well beyond those quantified by this study's economic benefits.

RTI International
Economic Impact Assessment of NIST's TREC Program
December 2010

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Expectations

- Provide a generic template for structuring knowledge
- Develop evaluation and test methodologies
- Explore TREC track for evaluating OKN in various domains
- Leverage funding