
# femML:
# Finite Element Modeling Markup Language

**Presented by**

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# Overview

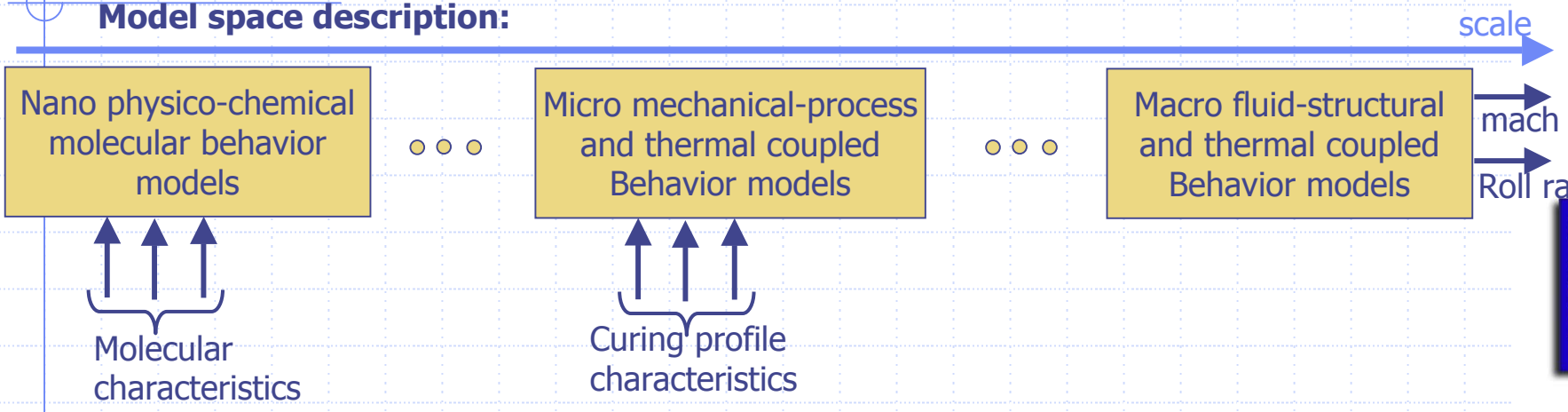
- Vision
- Where we Are (CMS Space)
- Motivation
- Background
- Problem and Issues
- Usage and Definition of XML
- Objectives and Approach
- Progress
- Open call for collaboration

# A Vision for Computational Material/Structural Science

Be able to answer Questions like this:

***What the curing profile of a composite laminate, and macromolecular characteristics of a resin should be in order to be able to sustain a given roll rate for a given time in a Mach 3 mission?***

**Model space description:**




**Approach space description: Design Optimization**

**Design Variables:** Molecular Characteristics, Curing Profile Characteristics

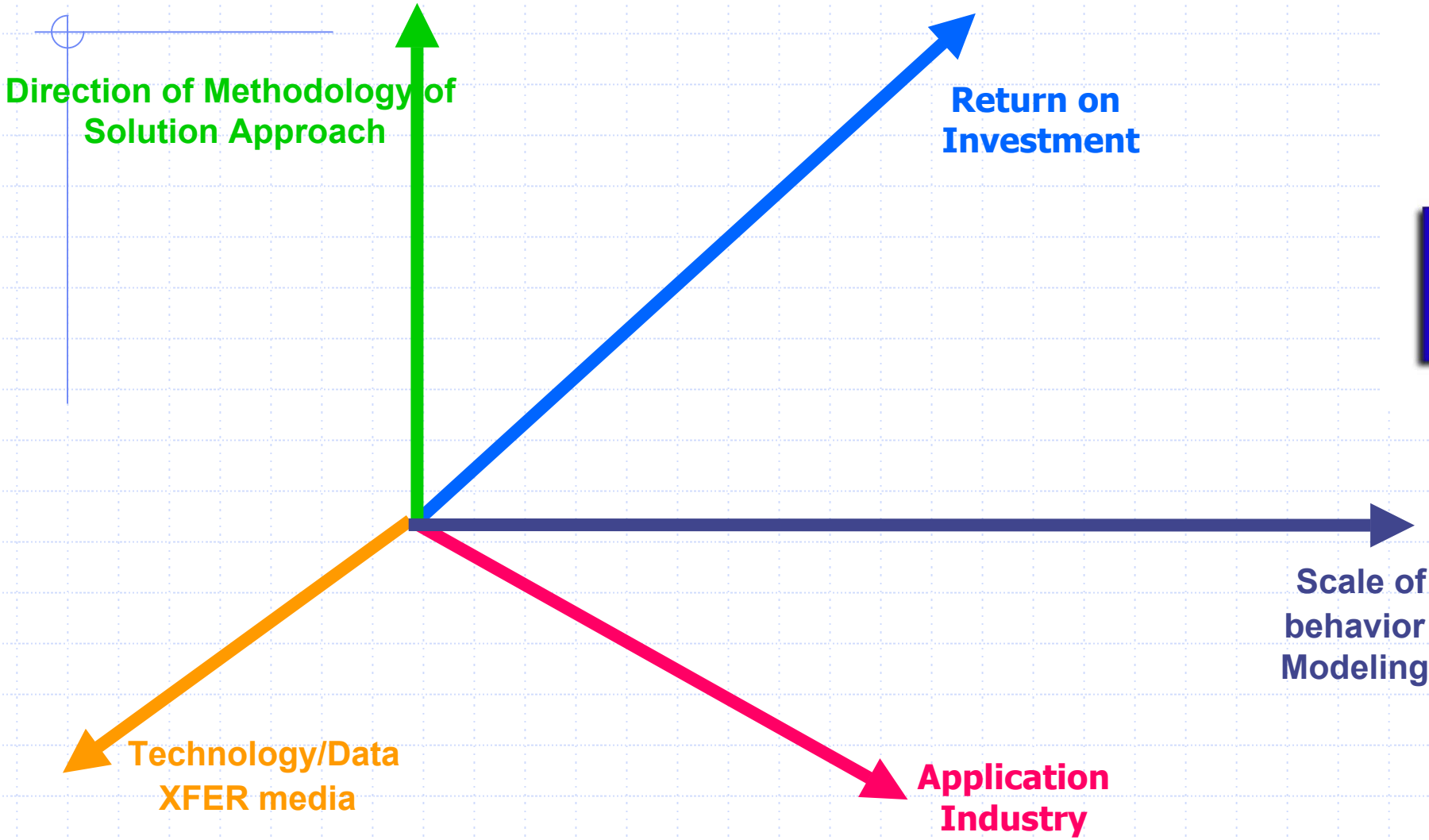
**State Variables:** Mach, Roll rate

**Objective Function:** Dissipated energy, Cost

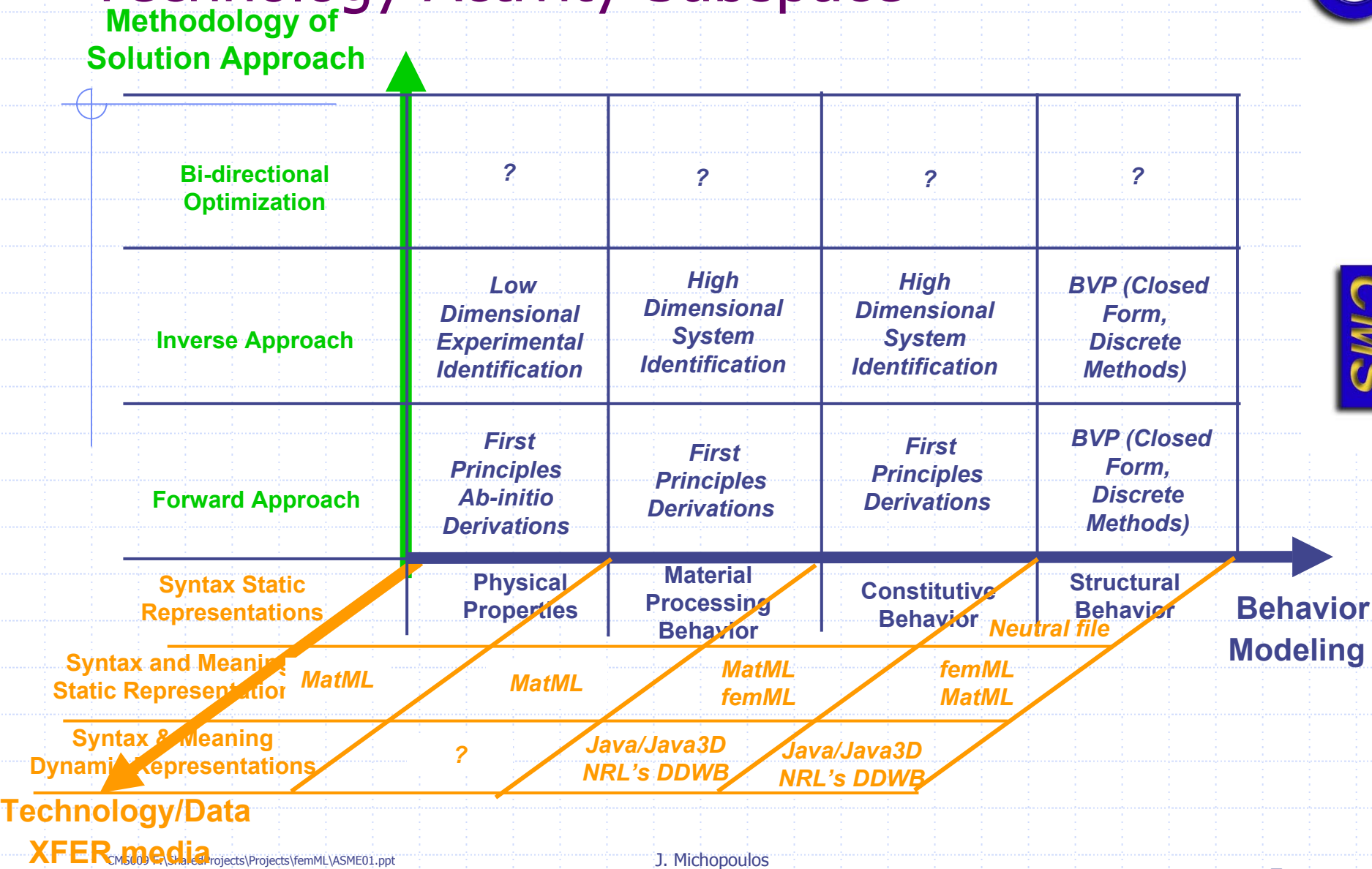
**Nonlinear Constrains:** Positive definite dissipated energy and cost etc.

**Implementation space description: Dynamic Distributed Virtual Environments**

# Computational Materials Science & Technology Activity Space



# Computational Materials Science & Technology Activity Subspace



# Motivation

## Science Applications push

- Distribution of static digital information through the WWW
  - ✓ Multiplicity of custom & commercial applications
  - ✓ Manufacturer Data Sheets
  - ✓ Materials Databases
  - ✓ R & D Publications
  - ✓ etc.
- Collaborative dynamic computing through the WWW
  - ✓ Distributed Applications
  - ✓ Problem Solving Environments
  - ✓ Virtual Design & Prototyping
  - ✓ Agent-based Applications

## Technology Pull

- Multi-industry XMLware proliferation
- XML-Java Integration
- XML-Data Base Technology Integration
- XML-middleware plethora

# Background: Current state

- FILE FORMATS
  - Lots of custom CAD exchange formats (ACIS, Parasolid, IGES (flavored & standard), STEP, STL, VDAFS, CATIA, CADDS5 etc.)
  - Very few custom FEM model exchange file formats (STEP 209)
  - Very few EDI file formats (ANSI X12, EDIFACT)
- DATA exchange and interchange tools
  - Custom applications (FEMAP)
  - Custom translators

# Background (2): state of the art

- TECHNICAL RESOURCES
  - AP209 ISO/DIS 1030-209 Composite and Metallic Structural Analysis and Related Design
    - Satisfies the need for the exchange of computer-interpretable composite and metallic structural product definitions, including product shape, associated FEA models, material properties and analysis results.
    - Currently has a Non-XML markup description.
    - Ongoing efforts for developing XML translation and DTD
  - XSIL: Extensible Scientific Interchange Language
    - Satisfies the need for flexible, hierarchical, extensible, transport of scientific data objects (vectors, arrays, tables, etc.
    - XML-based with existing DTD.
    - Non application specific/optimized.

# Background (3): other efforts

- Business Industry Resources
  - ANSI X12 and UN/EDIFACT efforts for Electronic Data Interchange (EDI)
    - Heavy industry support
    - Plethora of EDI/XML resources and examples
    - Object facilitation layers allowing OMG, NOF and UML technologies to be used with XML repositories

# Problems

- Integration of FEM models encoded in multiple data formats from multiple data sources, with current end-user applications and future data exchange systems between applications.
- Data interpretation varies from data source to data source and therefore introduces semantic correctness uncertainty that destroys robustness of interoperability between applications and data receptacles.

# Bigger problem of the moment

- We want to use the Internet as the Network for everything
  - moving
  - publishing
  - **engineering**
  - finding
  - processing
  - commerce
  - business
  - inter/intra/extra

- This requires standards
  - for the network (TCP/IP)
  - for delivery (HTTP)
  - for programs (Java)
  - for security (Public Key)
  - for content w. meaning (…)

**Oh yes – and we still want to be able to use our old systems and content!**

# Interpretation Problem

- **Neutral/Custom file format case:**
  - **FACT: The majority of custom codes can import and export into non generic highly custom file formats**
  - **PROBLEM: custom formats describe syntax of the data. Meaning is defined in the manuals.**
- **WWW case:**
  - **FACT:The majority of Web-based documents are prepared using the Hyper-Text Markup Language (HTML).**
  - **PROBLEM: HTML describes the presentation/typesetting of data but not their meaning.**

**Custom formats and HTML require that users have detailed knowledge of:**

- **the data meaning**
- **the underlying document structure**

**before using the data in "downstream" or "upstream" applications**

# Interoperability Problem


Data interpretation varies from data source to data source and therefore introduces semantic correctness uncertainty that destroys robustness of interoperability between applications and data receptacles.

# Solution: Utilize XML Technology

## Advantages of XML

- Universal Standard format for data interchange/ exchange
- Simultaneous Semantic and Syntactic encapsulation
- Human-readable
- Machine-readable (easy to parse)
- Possible to validate
- Extensible
  - can represent any data
  - can add new tags for new data formats
- Hierarchical structure (nesting)
- *Great amount of tools that facilitates understanding, usage and implementation*

# What is XML? - Core idea

```
<bold>Apple</bold>
<fruit>Apple</fruit>
<computer>Apple</computer>
<computerManuf>Apple</computerManuf>
<structure>Apple</structure>
<materialSys>Apple</materialSys>
<FEMmodel>Apple</FEMmodel>
```

- Does not drop or infer meaning from syntax but it embeds meaning together with syntax

# What is XML?

- Extensible Markup Language
- XML is a meta-language for developing an unlimited number of special-purpose data languages
- A W3C standard approved as "Recommendation" in February 1998
- Core of a family of generic standards
- A simplified form (subset) of SGML
- A standard framework for encoding agreements about communication

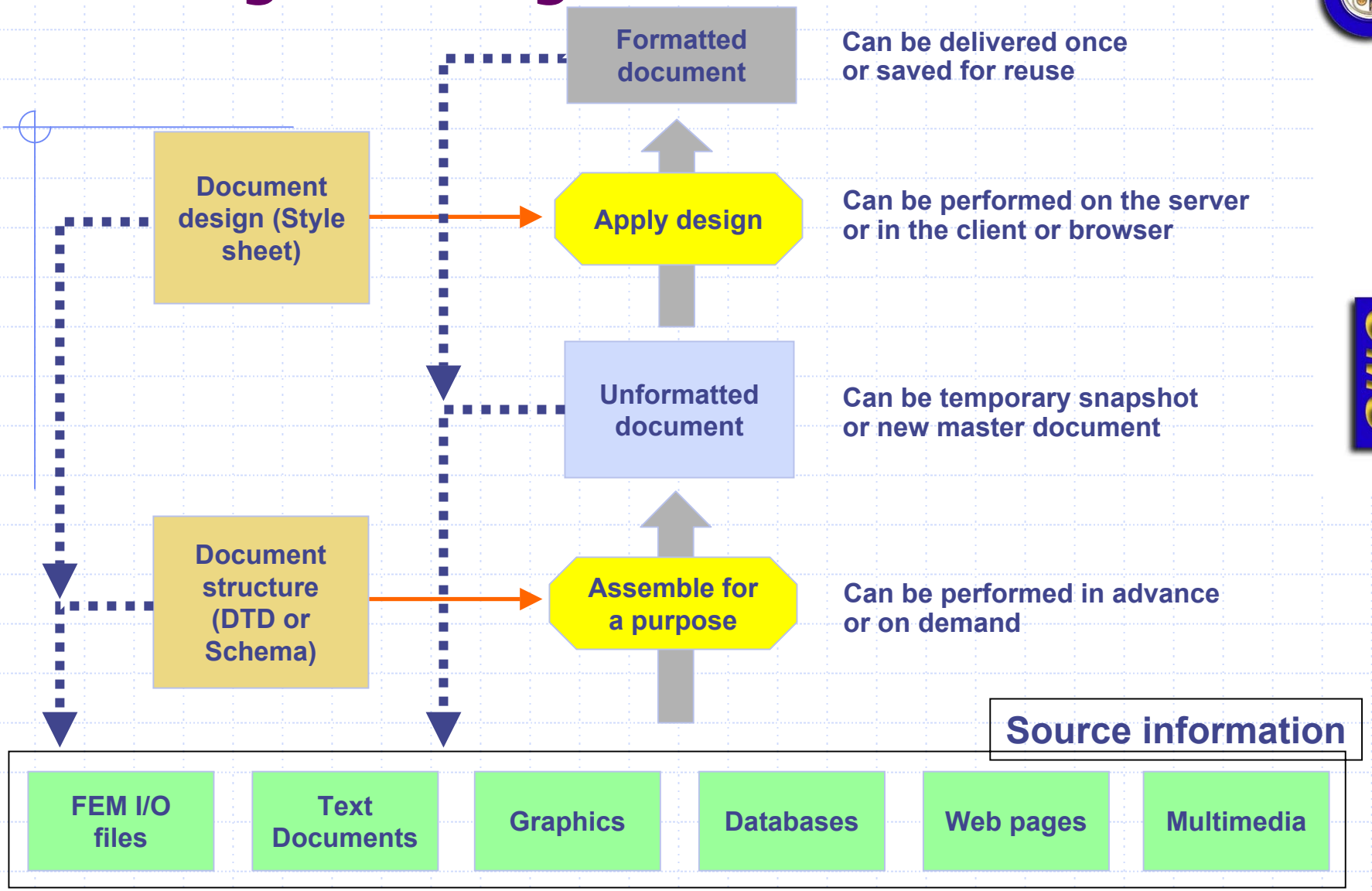
# Examples of S&T related efforts

- MatML Extensible Markup Language (XML) for Materials Property Data is a DTD with examples under development for the exchange of material properties information. It's spearheaded by Dr. Ed. Begley at NIST and a working group.
- CML Chemical Markup Language 1.0 Reference with examples of Chemical Markup Language
- GAME DTD (Genome Annotation Markup Elements) is a syntax for the exchange of genomic annotation.
- GEML The Gene Expression Markup Language is a file format for storing DNA microarray and gene expression data.
- GXL - Graph Exchange Language is an XML language designed to be a standard exchange format for graphs, and to support interoperability between graph-based tools.
- Mathematical Markup Language (MathML) Version 2.0 MathML is an XML application for describing mathematical notation and capturing both its structure and content.
- MODL Molecular Dynamics Markup Language is used to help make sense of the huge amounts of data typical of chemical simulations.
- Systems Biology Markup Language (SBML) is an XML-based language for describing simulations in systems biology.
- XGMML (eXtensible Graph Markup and Modeling Language) is an XML application based upon Graph Modeling Language (GML) that uses XML to describe graphs rather than GML's text format.

# Classes of Application

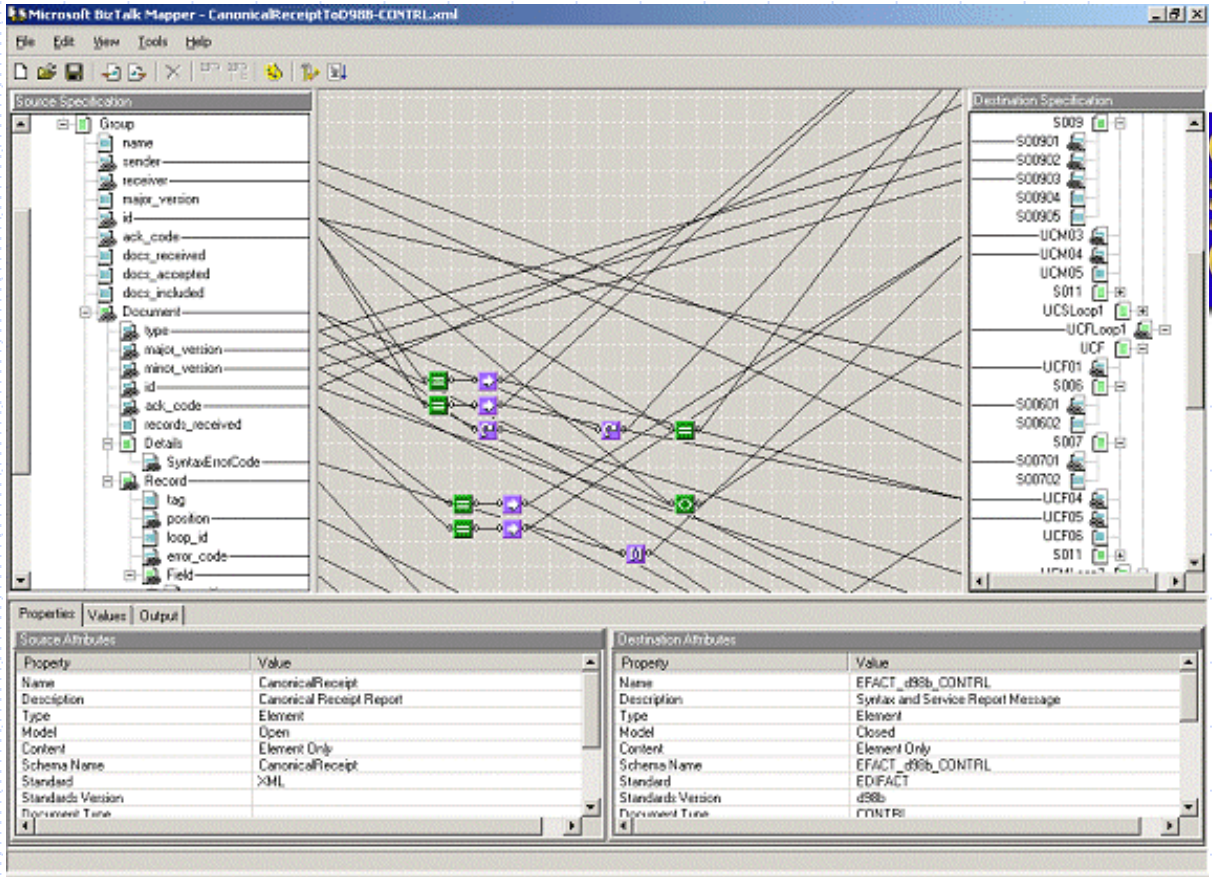
- **information delivery** – enabling information to be assembled from multiple sources to meet individual requirements
- **inter-application messaging** – enabling data transfer within and between organizations to facilitate EDI and system interoperability
- **intra-application messaging** – to supplement or replace such protocols as CORBA, COM/DCOM and Enterprise Java Beans in the development of distributed computing applications

# Putting it all together



# Very Efficient Tools
# i.e. BizTalk Mapper or DataJunction

- Map between DTDs/schemas
- Intuitive GUI
- Extensible
- Produces
  XSLT




# Java Technologies cross leveraging Why Java/XML?


- XML Structures can map *homomorphically* to Java Objects
- XML tags map *well* to Java Objects
  - late binding
  - hierarchical (OO) data model
- Unicode support in Java
- Portability
- Network friendly

# XML and Object Mapping


- Java -> XML
  - Start with Java class definitions
  - Serialize them - write them to an XML stream
  - Deserialize them - read values in from previously serialized file
- XML -> Java
  - Start with XML document type
  - Generate Java classes that correspond to elements
  - Classes can read in data, and write in compatible format (shareable)

# XML-Java Endless possibilities

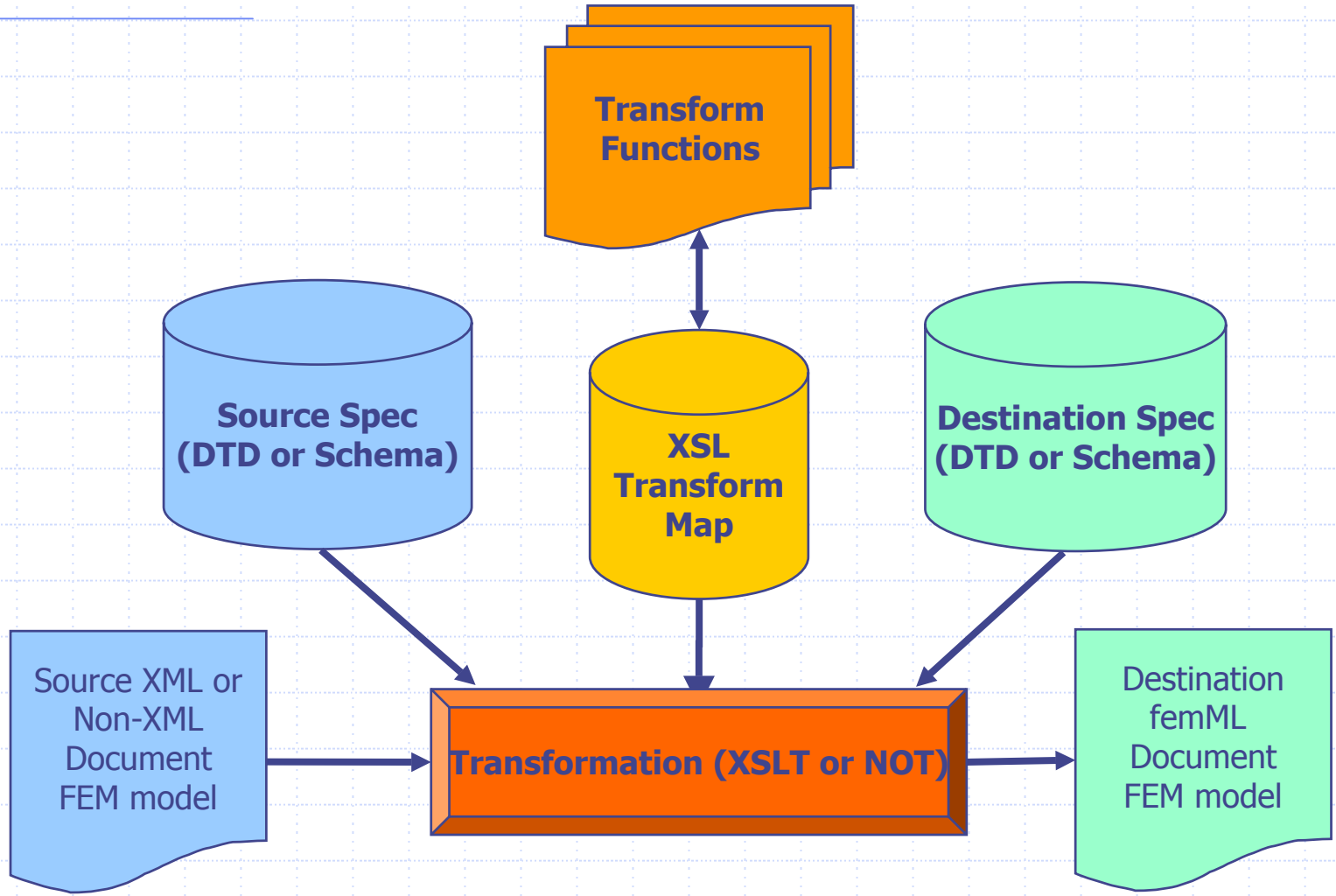
- light-weight asynchronous processes implementation of distributed, migrating, dynamic and intelligent agents for each one of the femML entities
- composition/synthesis of complex models just by simple messaging between dynamic object-ware units automatically produced by XML<->Java toolsets

# femML Objectives

- Define a standard for the exchange of FEM data (including product shape, associated FEM models, material properties and analysis results) that will allow a *person* or a *computer application* to interpret and use the data *regardless of its source or target* and *regardless of the taxonomic order of the FEA model*.
  - Set of XML Tags
  - Document Type Definition (DTD) or/and Schema
- Define and develop a set of examples that follow the standard.
- Define and develop a set of tools for the utilization of this standard from and to other applications.
- Develop examples of using this tools.

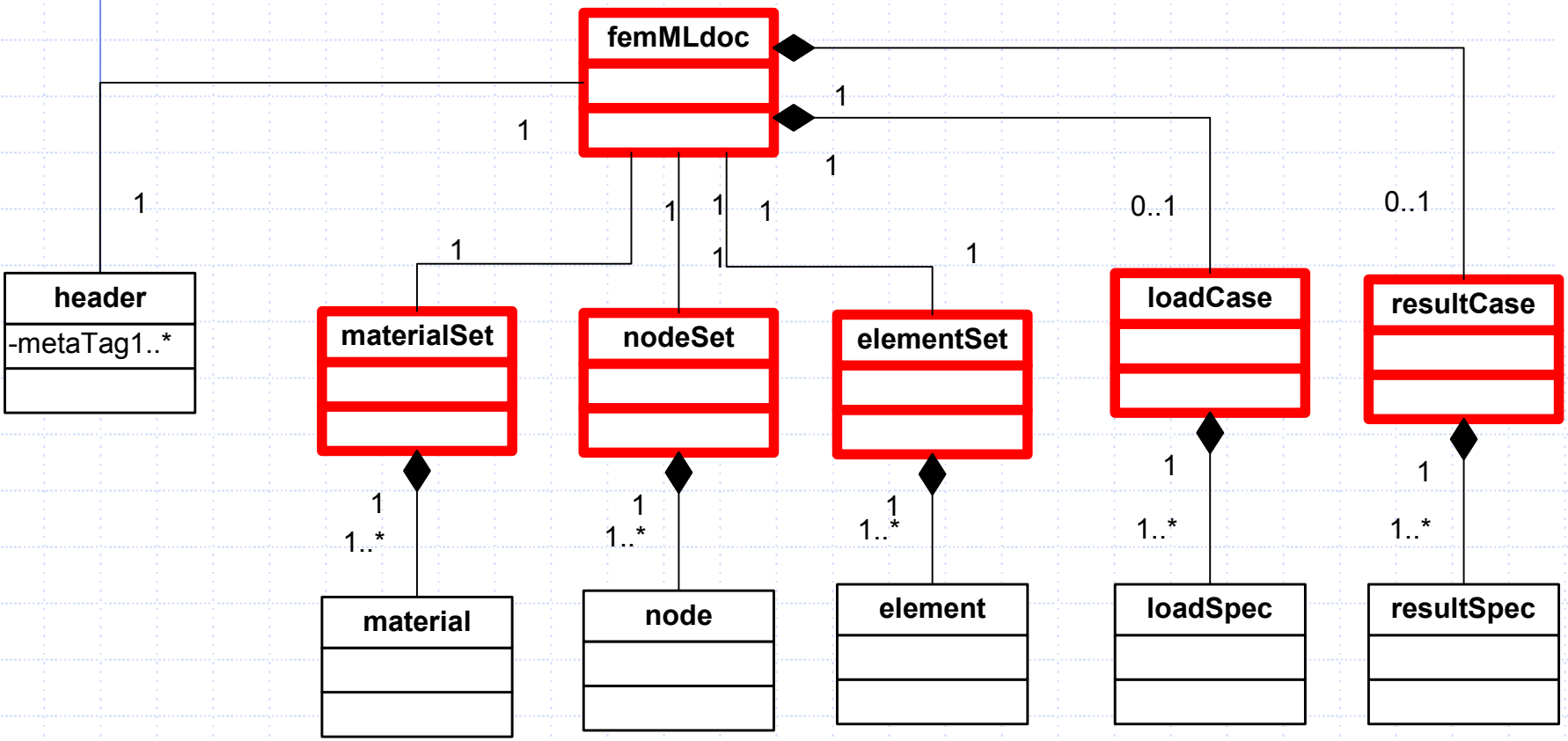
# Approach: The XML S2S exchange

**Employ a Station to Station (S2S) exchange based on XML technology**



# Current femML document structure

## UML representation of femML DTD



# Issues to be resolved

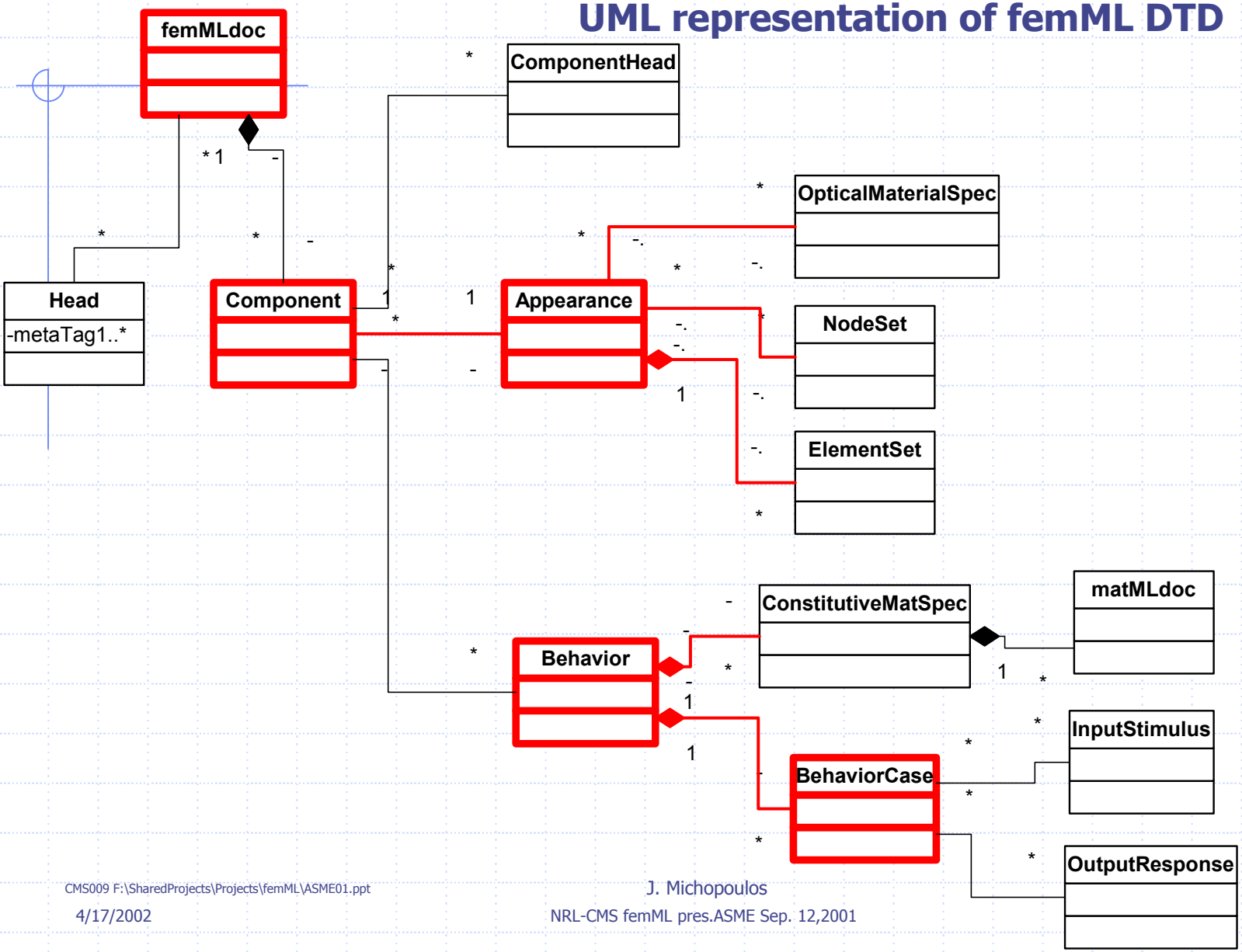
- **Accommodate the entire set of possible system representations:**
  - **Finite Element**
    - **Structured**
    - **Unstructured**
    - **Blocked**
    - **Hierarchical**
    - **Spectral**
    - **Stochastic**
  - **Finite differences**
    - **Structured**
    - **Unstructured**
    - **Blocked**
  - **Boundary elements**
  - **Hybrid elements**
  - **Non-Discrete Model Representations**
    - **Analytic BVP Symbolic Solutions**
    - **Continuous**

# Issues to be resolved (cont.)

- Separation between Appearance and Behavior
- Utilize/Leverage existing XML representations for XML substructures when available through namespace uniqueness (i.e. MatML for material properties specification)
- Maintain transformability to other Data exchange formats (i.e. thing isomorphically to existing DTDs like XSIL, X3D etc.)
- Maintain View-ability of implicit or explicit scene graph representations of the appearance components of datasets through providing transformation capability by appropriate DTD/Schema Factorability
- Maintain factoring and composition homomorphism between femML documents and structural models
- DTD or/and SCHEMA
- Incremental vs. Shotgun Approach

# Potential femML document structure

## UML representation of femML DTD



# Desired Approach Methodology

- Form working group with members from Academia, Industry, Government, Professional societies and Standards Organizations
- Identify issues to be resolved and their priority
- Develop and implement strategy for addressing issues
- Utilize "Open Source Development Network" resources like the "SourceForge" http://sourceforge.net/ development and deployment repository for DTD/SCHEMA/Examples/XSLTware and custom format translator components

# Schedule

| Steps | femML | MatML |
|---|---|---|
| Establishment of working group | 2000-01 | 2000 |
| Delineation of the scope and specifications | 1999-02 | 2000-01 |
| Development of the formal Document Type Definition and/or Schema | 2001-… | 2000-01 |
| Development of a catalog of examples | 2000-… | 2000-… |
| Application development and acceptance testing | Future | Future |
| Dissemination | Future | Future |

# Open Call for Participation Contact Info

- femML
  - Contact: J. Michopoulos (**john.michopoulos@nrl.navy.mil**)
  - URL: **http://cms.nrl.navy.mil/pub/femML**
  - e-mail: **femML@cms.nrl.navy.mil**
- MatML
  - Contact: E. Begley (**begley@nist.gov**)
  - URL: **www.ceramics.nist.gov/matml/matml.htm**
  - E-mail: **begley@nist.gov**

***THANK YOU FOR YOUR ATTENTION!***