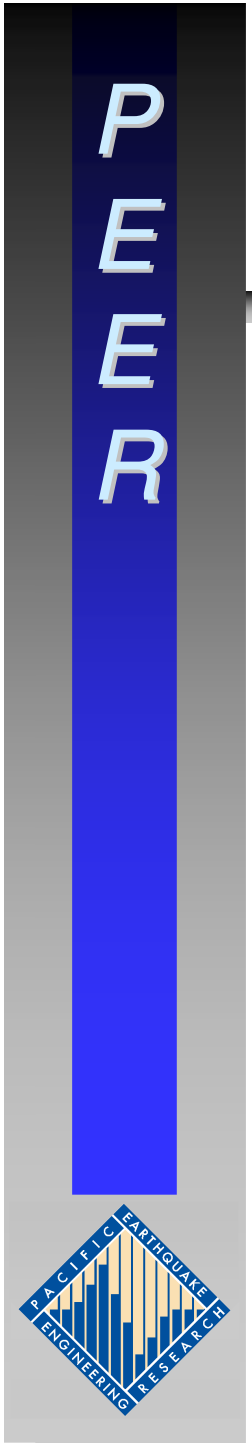

OpenSees User Workshop

Presented by the OpenSees Community

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January 26, 2004

Sponsored by the National Science Foundation
through the Pacific Earthquake Engineering Research Center

Context

- PEER Research Program in Performance-Based Earthquake Engineering.
- Development of enabling technology is expected of NSF research centers.
- Many researchers and students for PEER Thrust Area “Simulation and Information Technology” are contributing to technology development and application.
- New initiatives such as NEES and MBS are encouraging new simulation methods and technology.

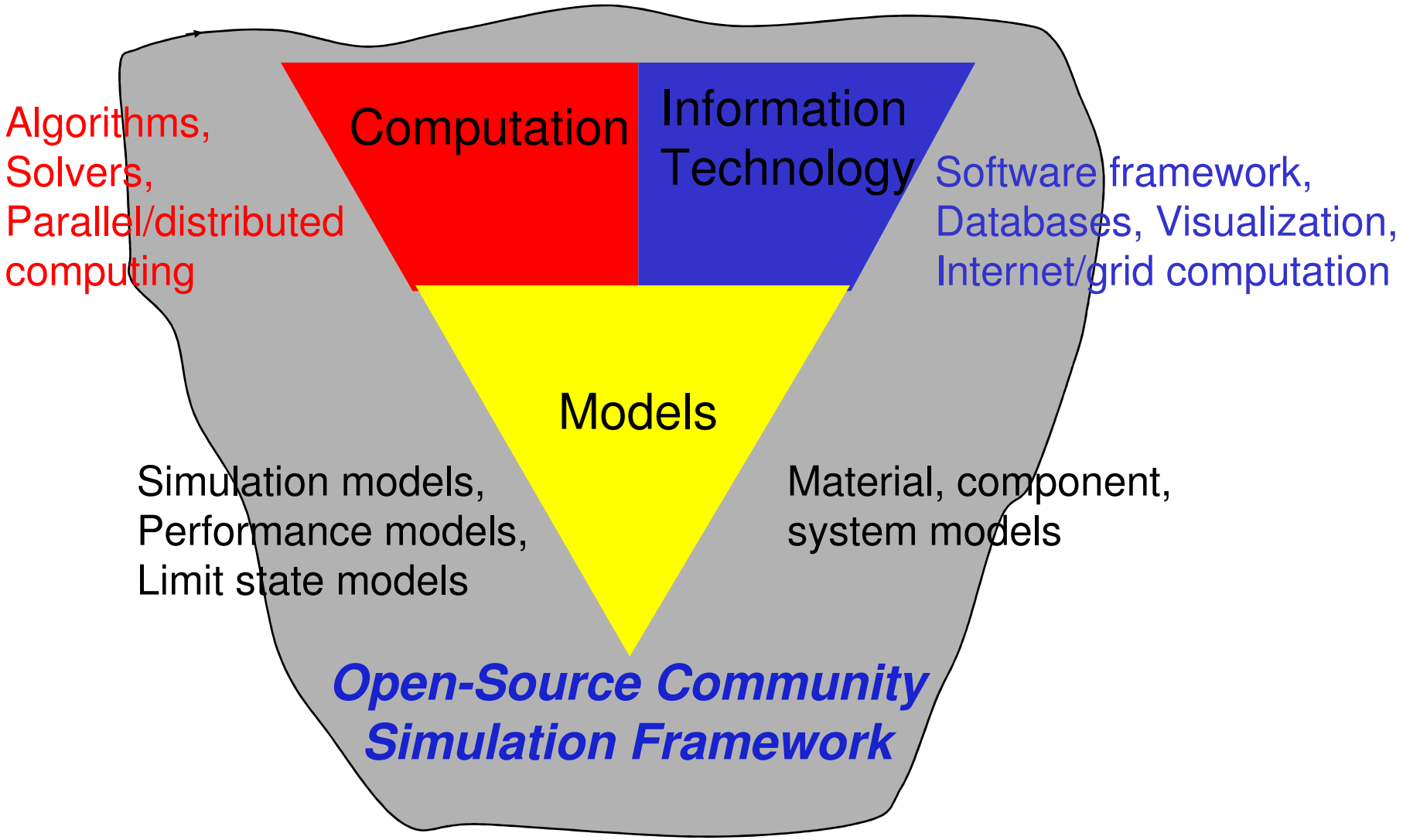
Observations on Current Situation

- Tight binding of models in research and commercial codes is an impediment to new research and implementation of models for professional practice.
- Embedding of computational procedures in codes makes it difficult to experiment and take advantage of computing technology:
  - Parallel and distributed computers
  - Computational grids
- “Closed-source” is the norm, whereas other fields have adopted “open-source” software for communities users.

What is OpenSees?

- A software *framework* for simulation applications in earthquake engineering using finite element methods. OpenSees is not a code.
- A communication mechanism within PEER, and beyond, for exchanging and building upon research accomplishments.
- As open-source software, it has the potential for a community code for earthquake engineering.

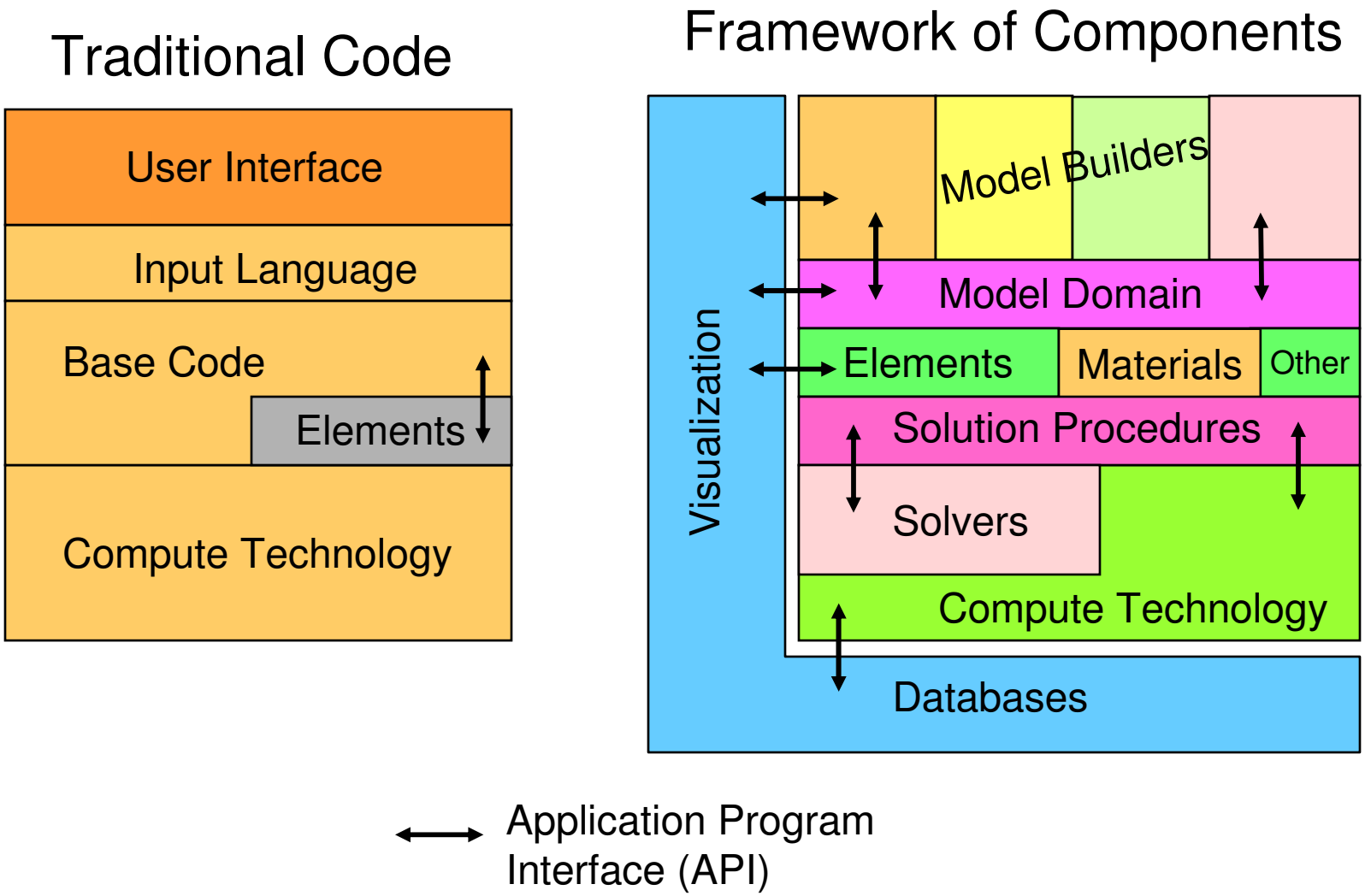
Conceptual Approach for Simulation



Software Framework

- A *framework* is a set of cooperating software components for building applications in a specific domain.
- A framework dictates the architecture of the application. It must represent the design decisions common to the application domain.
- A frameworks is based on the assumption that an architecture will work for most applications within the domain.
- Loose-coupling of components within the framework is essential for extensibility and re-useability for applications.
- Examples: Visualization (GLUT), MS Office, compilers ...
- *A framework is not a "code"*

Simulation Software Alternatives



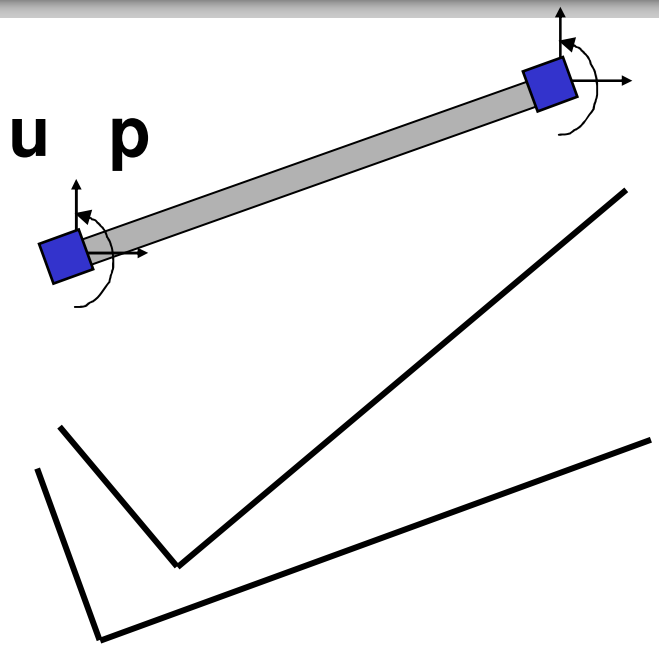
What Should be Your Expectations?

- OpenSees is a research tool at this time, but fairly stable for regular use
- As with any nonlinear analysis, it requires careful consideration of model and interpretation of results
- It is under continual development by students, faculty and other researchers
- User interface development lags behind computational technology
- It is not bullet-proof
- An investment of time and learning is required

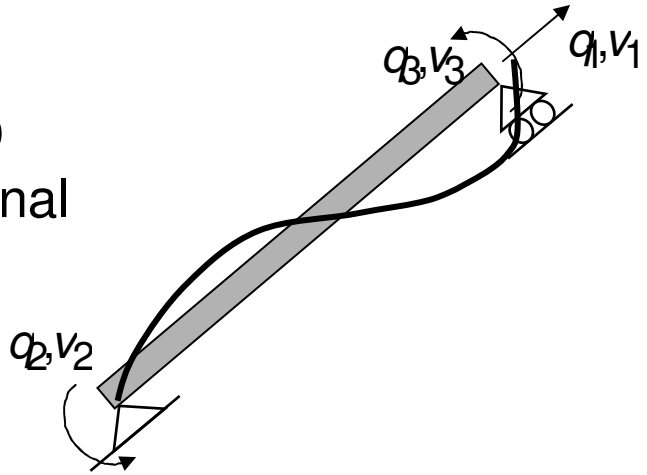
Objective of Workshop

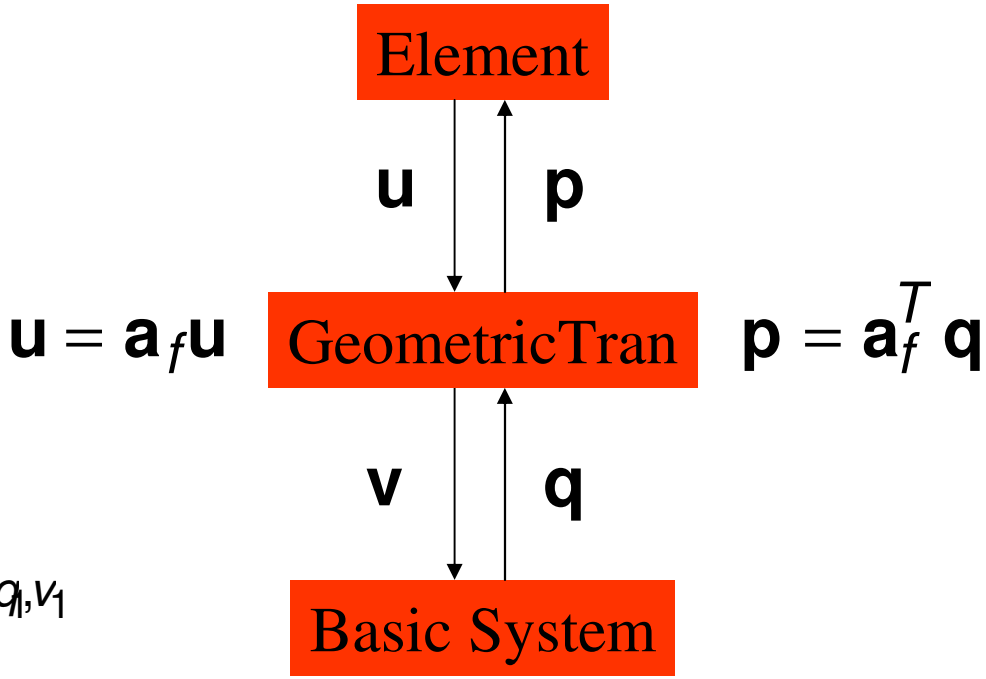
- Describe modeling and analysis capability, including hierarchy of system, element, section, material
- Overview of applications, structural and geotechnical
- Provide specific examples of nonlinear analysis as a starting point
- Introduction to user interfaces under development
- Pointers to more information and user support

Beam-Column Models I

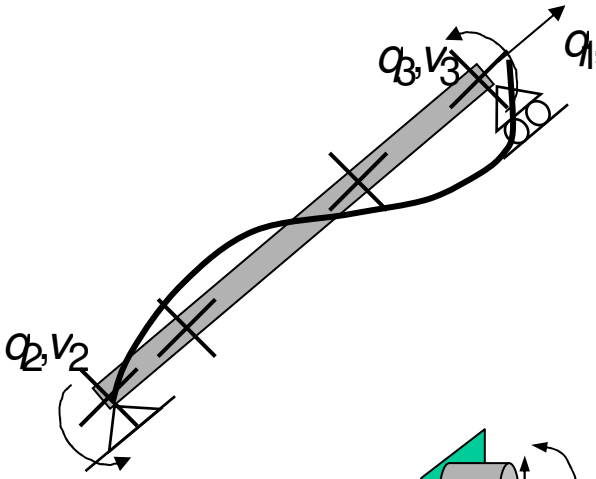


Linear
LinearPD
Corotational





Beam-Column Models II



Displacement

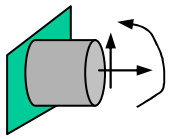
$$\mathbf{e} = \mathbf{a}\mathbf{v}$$

$$\mathbf{q} = \int_0^L \mathbf{a}^T \mathbf{s}\, dx$$

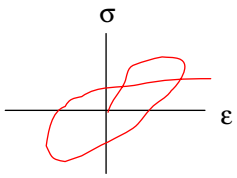
Force

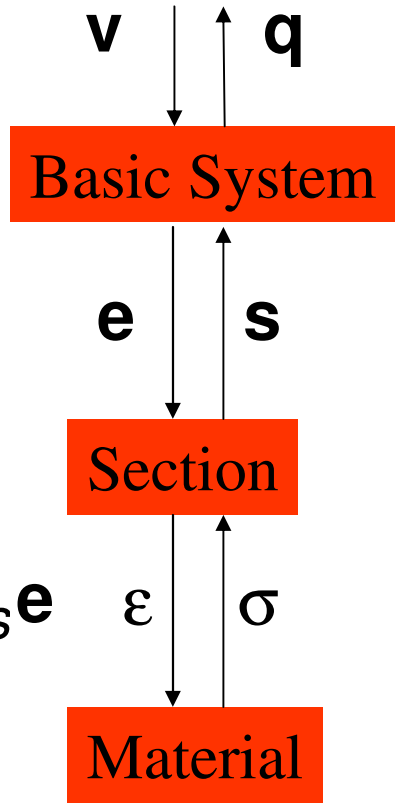
$$\mathbf{s} = \mathbf{b}\mathbf{q}$$

$$\mathbf{v} = \int_0^L \mathbf{b}^T \mathbf{e}\, dx$$



e, s





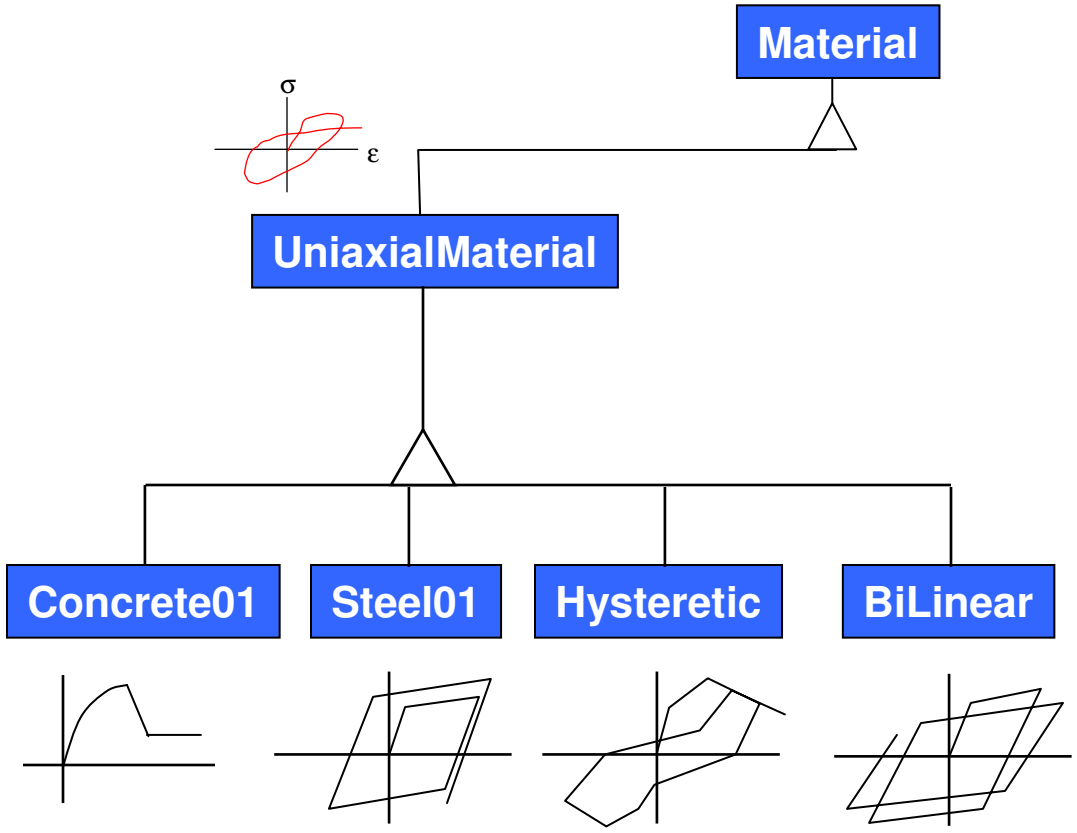
$$\varepsilon = \mathbf{a}_s \mathbf{e}$$

$$\mathbf{s} = \int_A \mathbf{a}_s^T \sigma\, dA$$

$$\sigma = \sigma(\varepsilon)$$

No assumptions are made on section or material behavior; each level in the hierarchy can be defined independently of other levels

UniaxialMaterial Behavior

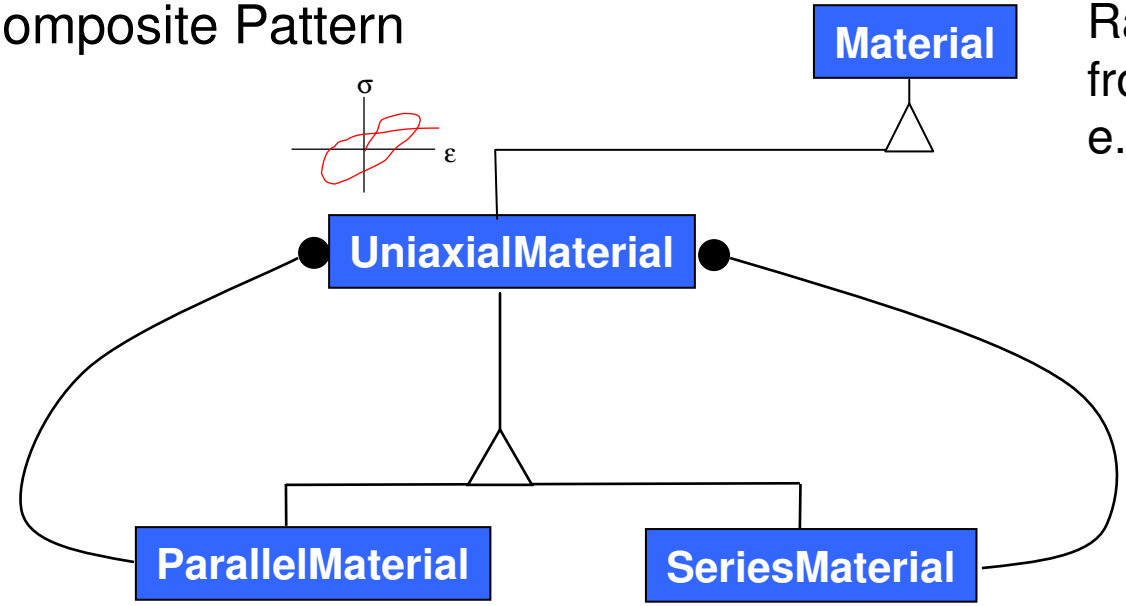


Also:

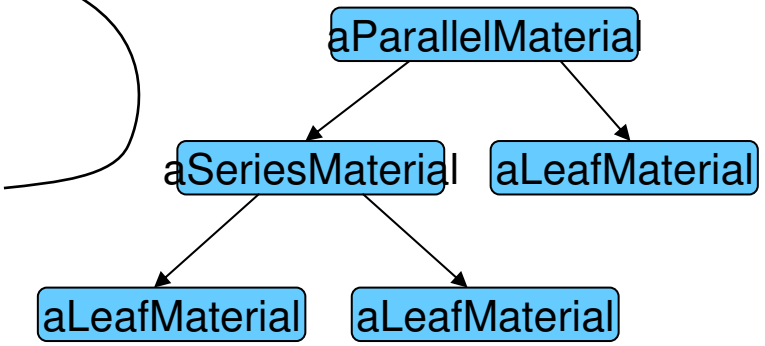
EPP
EPP-Gap
Clough
Pinch
Hardening

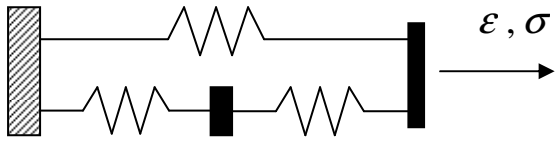
Aggregate UniaxialMaterials

Composite Pattern

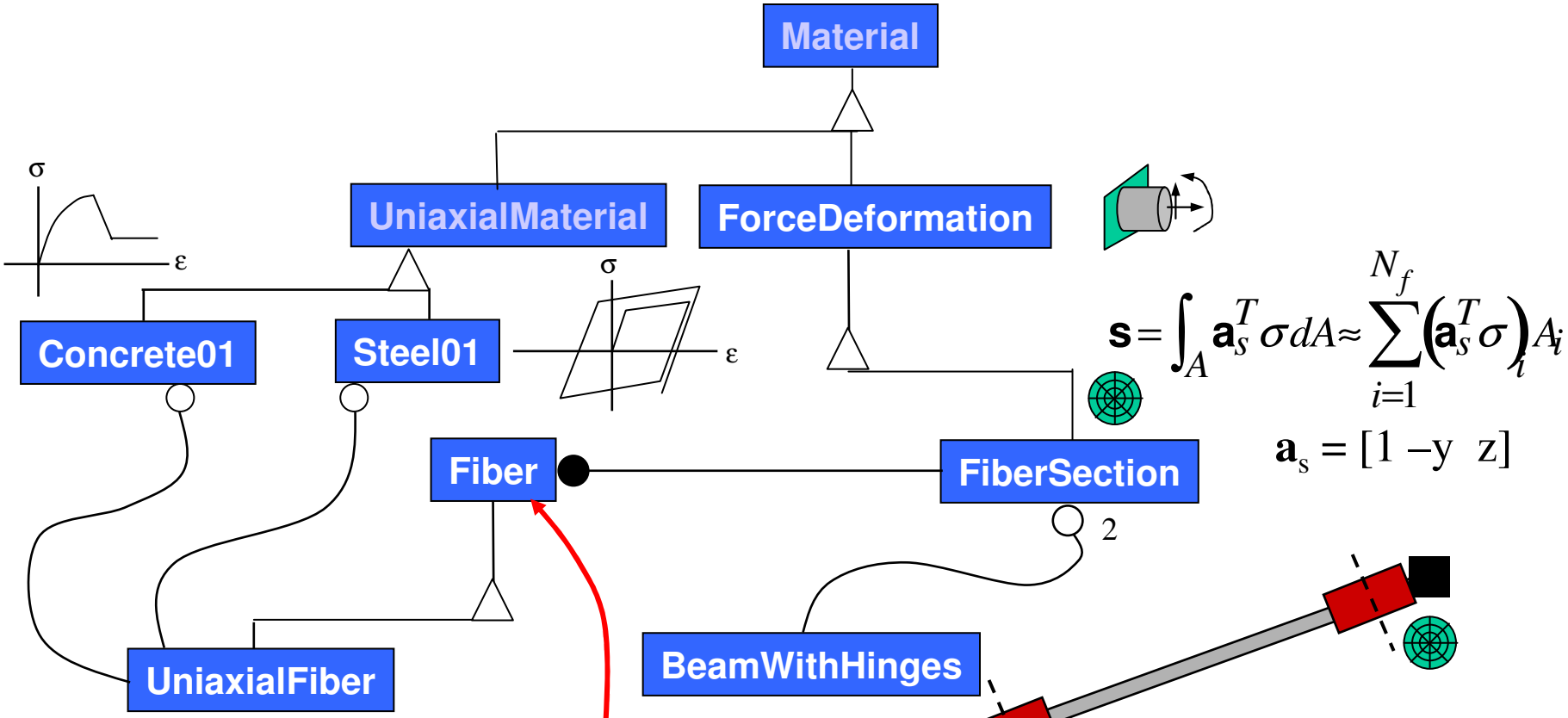


Rapidly develop models
from existing implementations,
e.g., composite gapping material



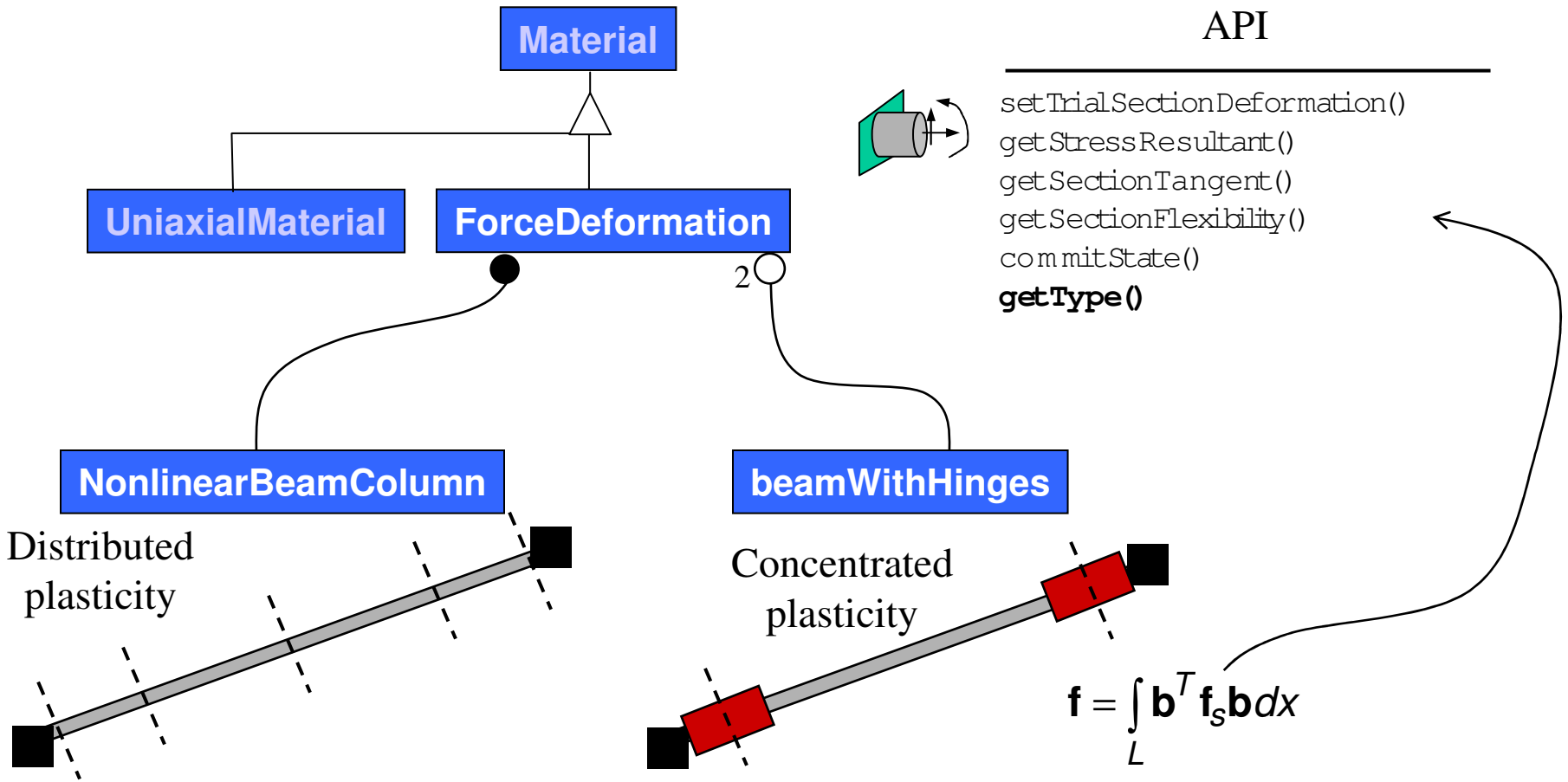


Form Follows Mechanics



The Fiber abstraction keeps the FiberSection class unaware of the response it integrates, making for a flexible design; however, there is a performance penalty associated with flexibility.

Beam-Column Modeling



Organization of Workshop

- Tcl command language; what is Tcl?
- Modeling commands
  - System, element, section, material hierarchy
- Analysis commands
  - Standard and advanced methods
- Basic examples and use of parameters
- Advanced structural and geotechnical applications
- Other user interfaces

Thanks to:

- Silvia Mazzoni
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