PEER

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OpenSees: Analysis

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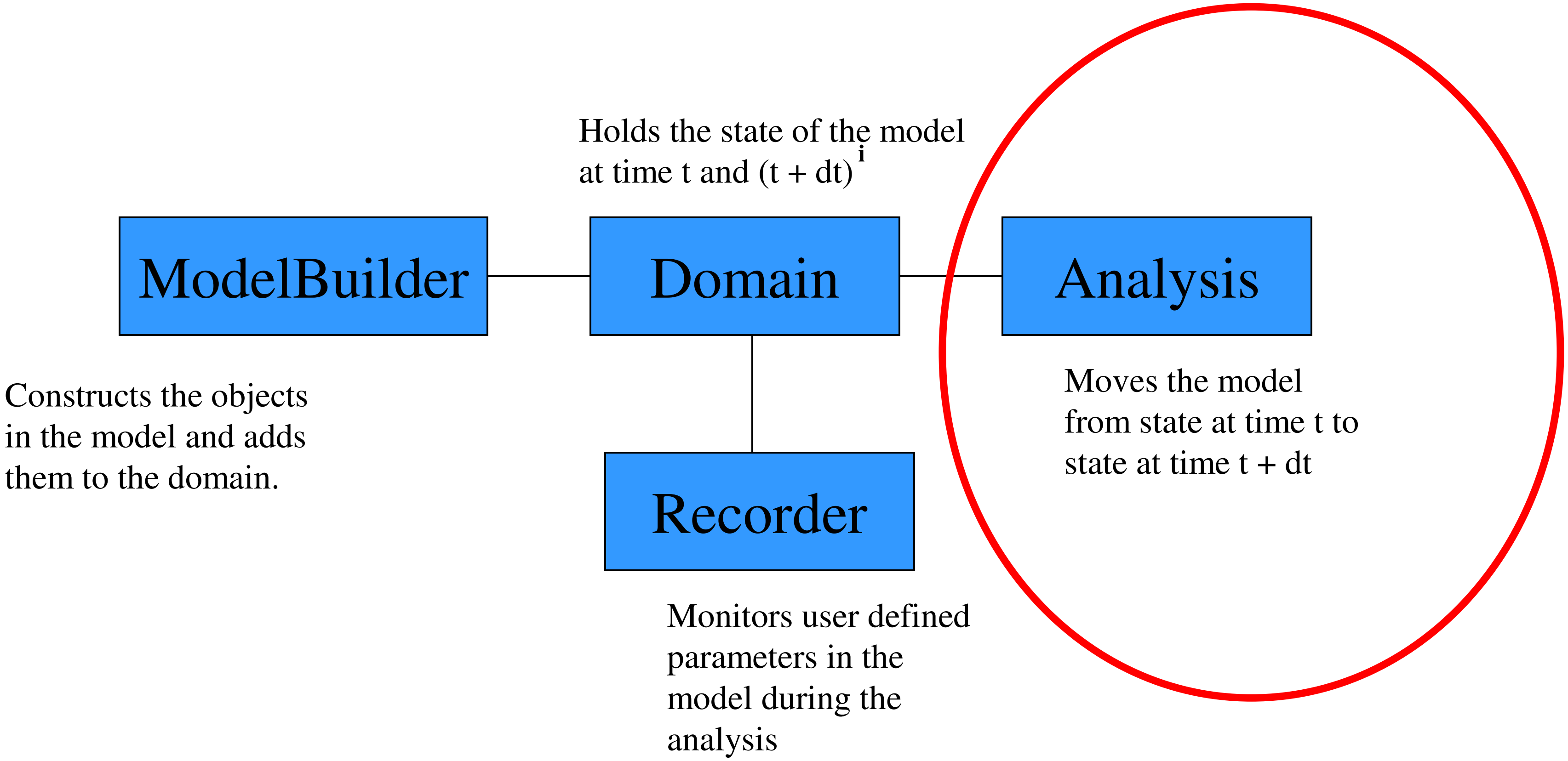
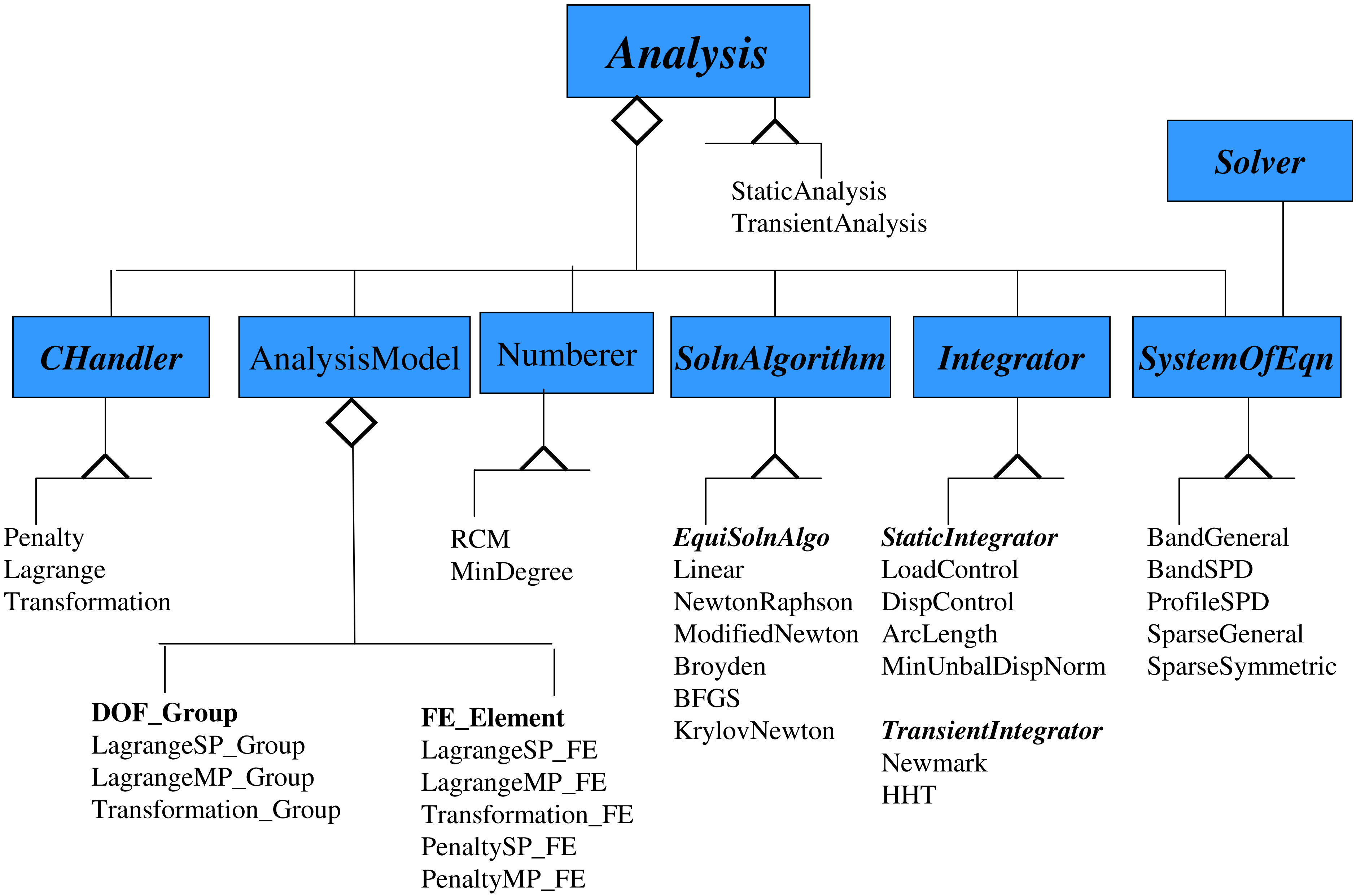
Main Abstractions in OpenSees



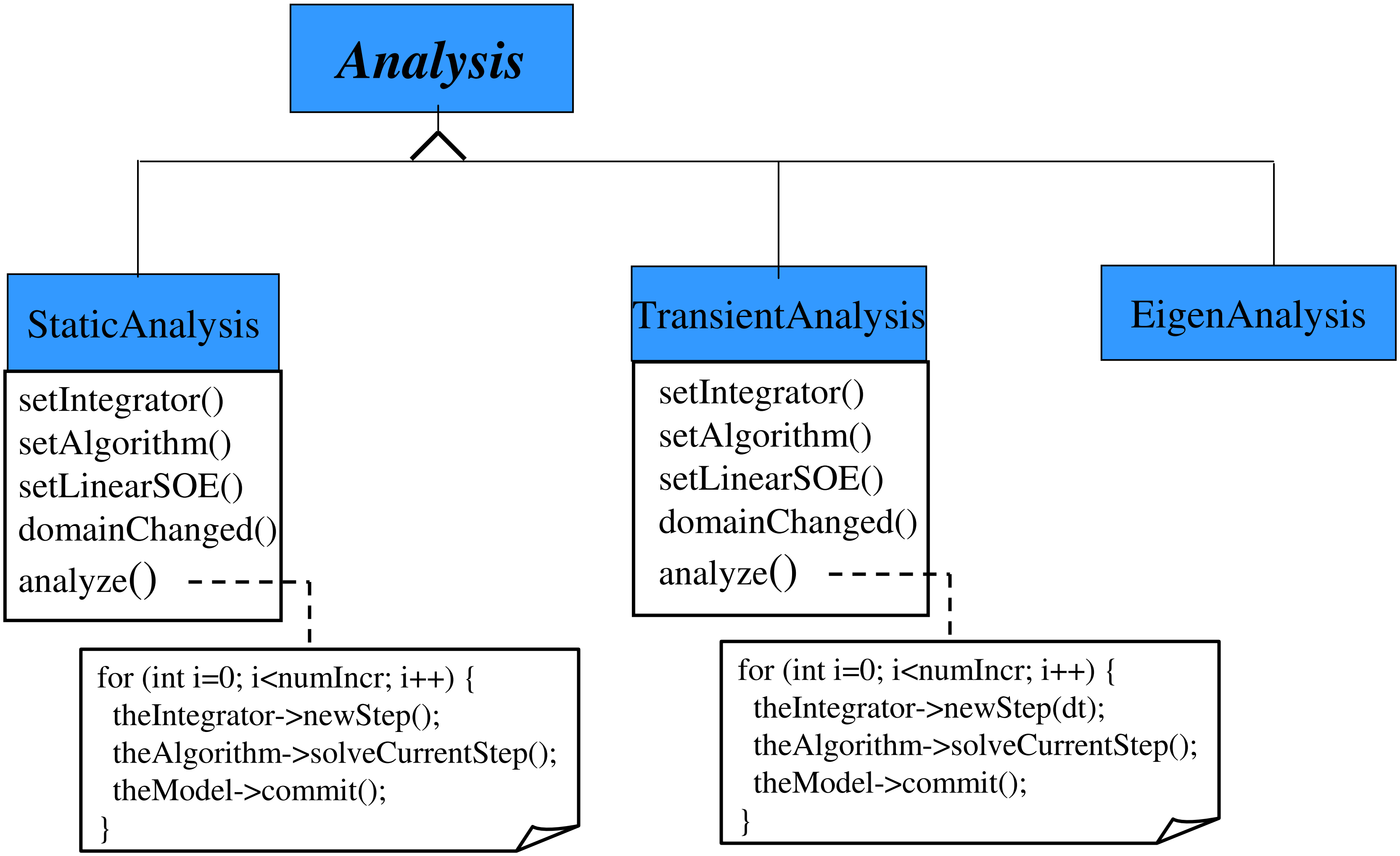
In this presentation we focus on the ANALYSIS

OpenSees Analysis



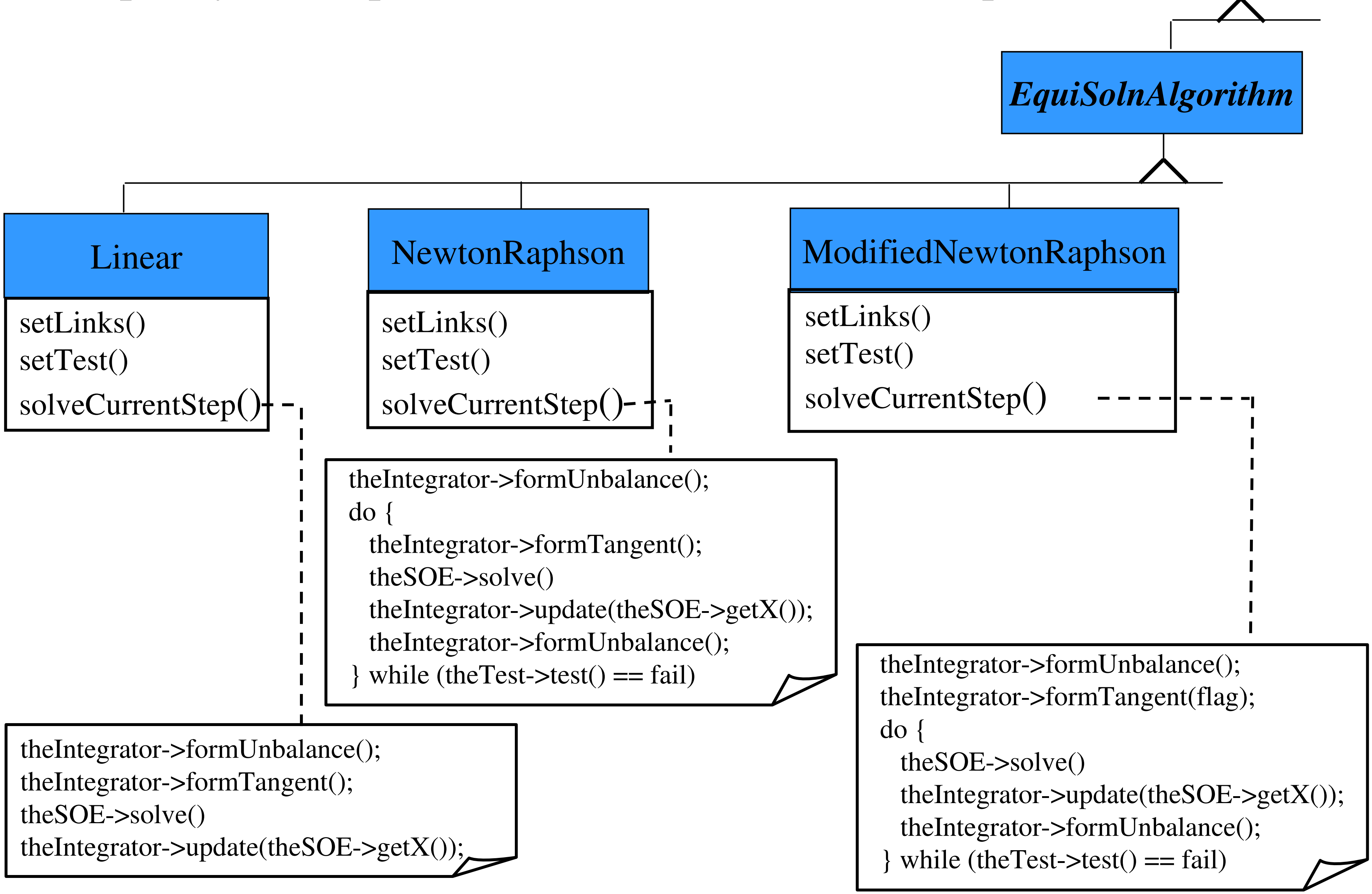
Analysis Classes:

- to update the state of the Domain



Algorithm Classes:

- to specify the steps taken to solve the nonlinear equation



Integrator Classes:

-determines the predictive step for time $t+\Delta t$
-specifies the tangent matrix and residual vector at any iteration
-determines the corrective step based on ΔU

- Transient Integrator for Use in Transient Analysis

  Nonlinear equation of the form:

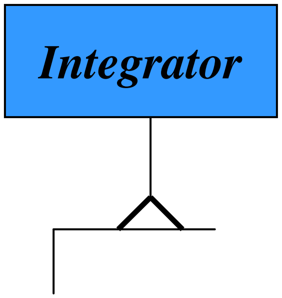
  $$\mathbf{R}(U, \dot{U}, \ddot{U}) = \mathbf{P}(t) - \mathbf{F_I}(\ddot{U}) - \mathbf{F_R}(U, \dot{U})$$

- Static Integrators for Use in Static Analysis

  Nonlinear equation of the form:

  $$\mathbf{R}(U,\lambda) = \lambda \mathbf{P}^* - \mathbf{F_R}(U)$$

  - Load Control $\lambda_n = \lambda_{n-1} + \Delta\lambda$
  - Displacement Control $Uj_n = Uj_{n-1} + \Delta Uj$
  - Arc Length $\Delta U_n \wedge \Delta U_n + \alpha^2 \Delta\lambda_n = \Delta s^2$



StaticIntegrator
LoadControl
DispControl
ArcLength
MinUnbalDispNorm

TransientIntegrator
Newmark
HHT
CentralDifference (X3)

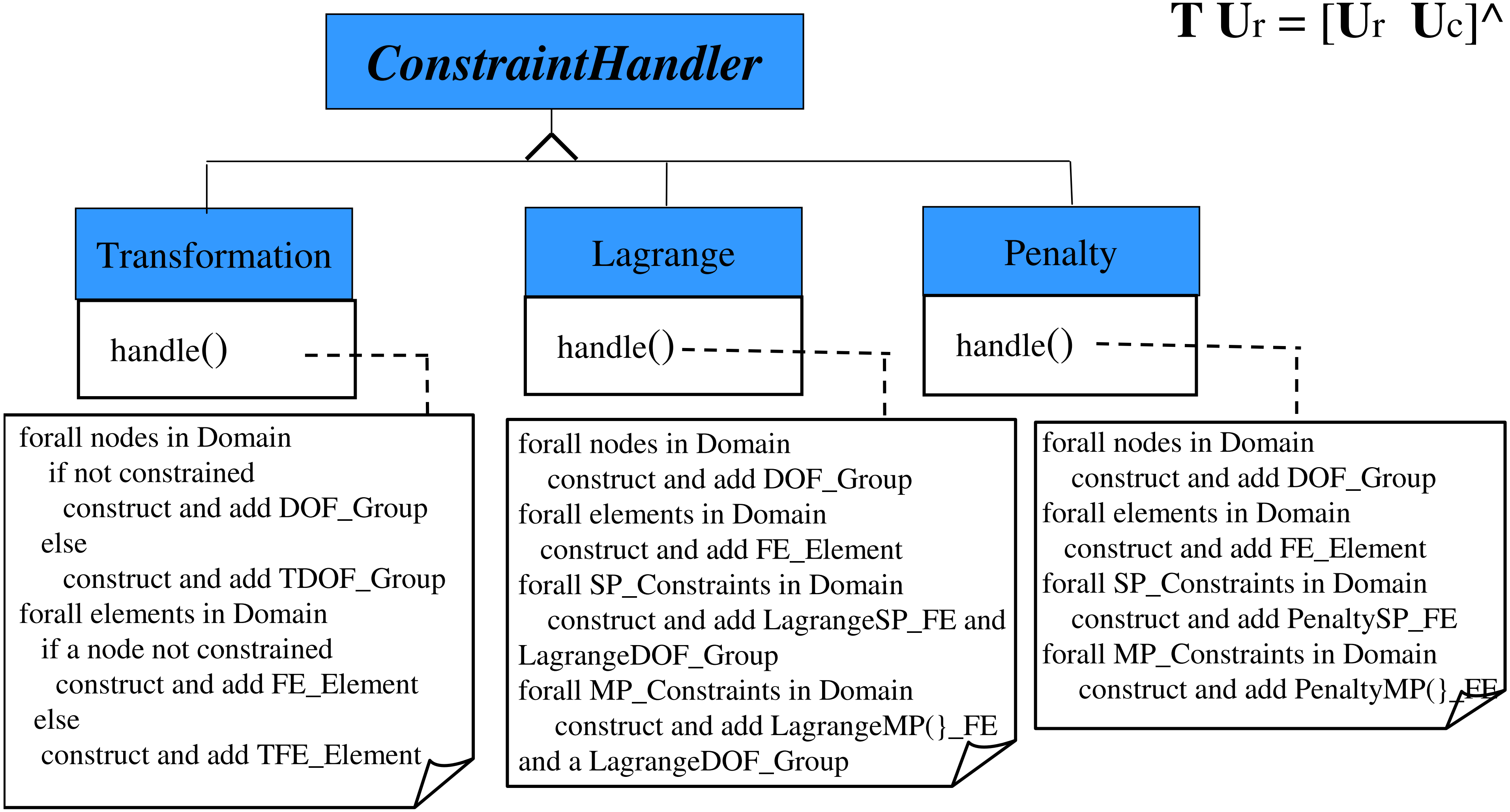
ConstraintHandler Classes:

- to specify how the constraints are enforced

$$\mathbf{U_c = C_{rc}\, U_r}$$

$$\mathbf{C\, U = 0}$$

$$\mathbf{T\, U_r = [U_r \;\; U_c]^\wedge}$$



$$K^*\, U_r = R^*$$

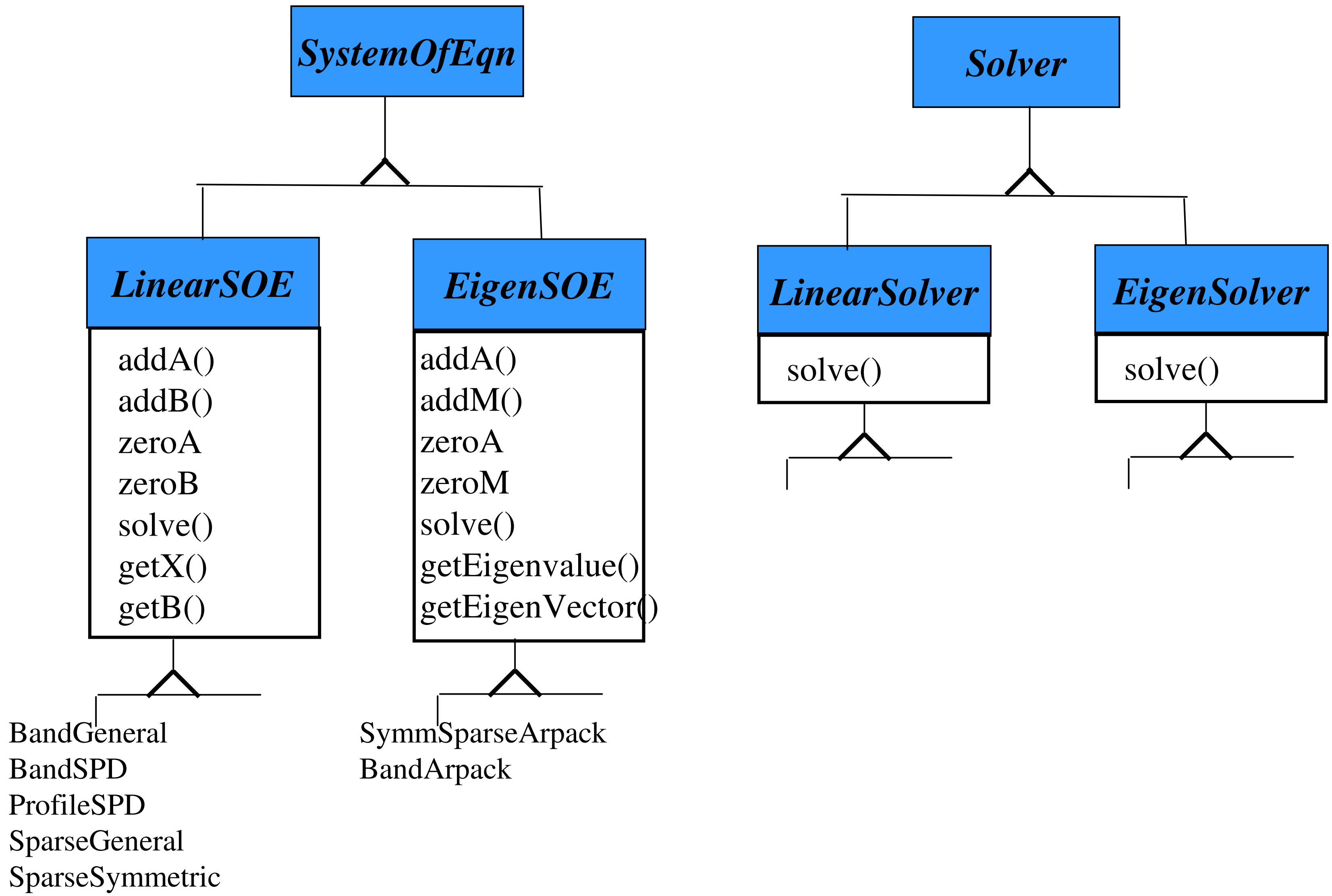
$$\begin{bmatrix} \mathbf{K} & \mathbf{C^\wedge} \\ \mathbf{C} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \mathbf{U} \\ \lambda \end{bmatrix} = \begin{bmatrix} \mathbf{R} \\ \mathbf{Q} \end{bmatrix}$$

$$\mathbf{[K + C^\wedge \alpha C]\, U = [R + C^\wedge \alpha Q]}$$

SystemofEqn and Solver Classes:

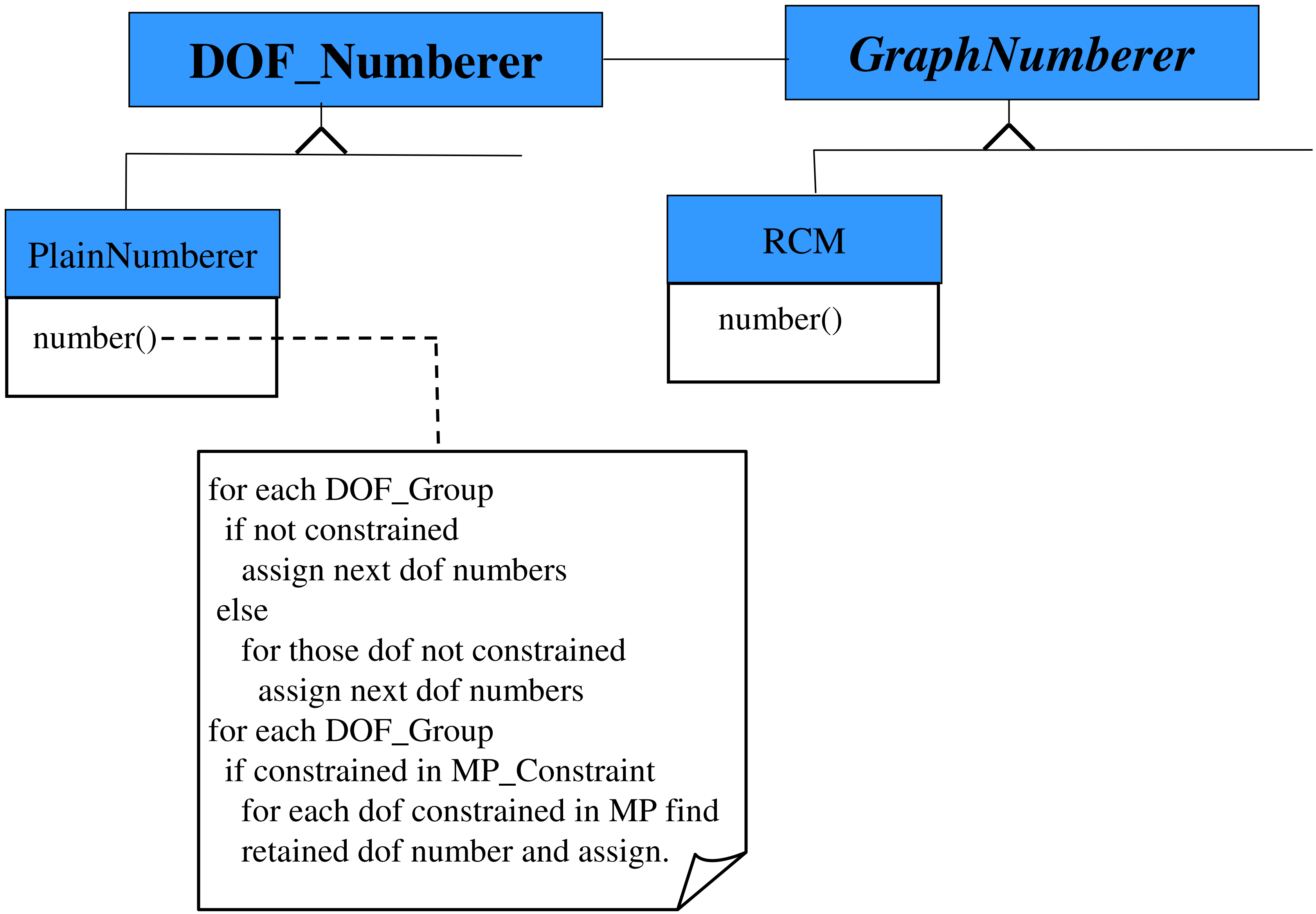
-the SystemOfEqn classes store the matrix equations

-The Solver classes work on the SystemOfEqn classes to solve the eqn.



Numberer command:

- to specify how the degrees of freedom are numbered



ConvergenceTest Classes:

- to determine if convergence has been achieved