



Getting started with deal.II

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Aims for this module

- Gain familiarity with two core classes
 - Triangulation
 - DoFHandler
- Create and interrogate meshes
- Create and interrogate sparsity patterns

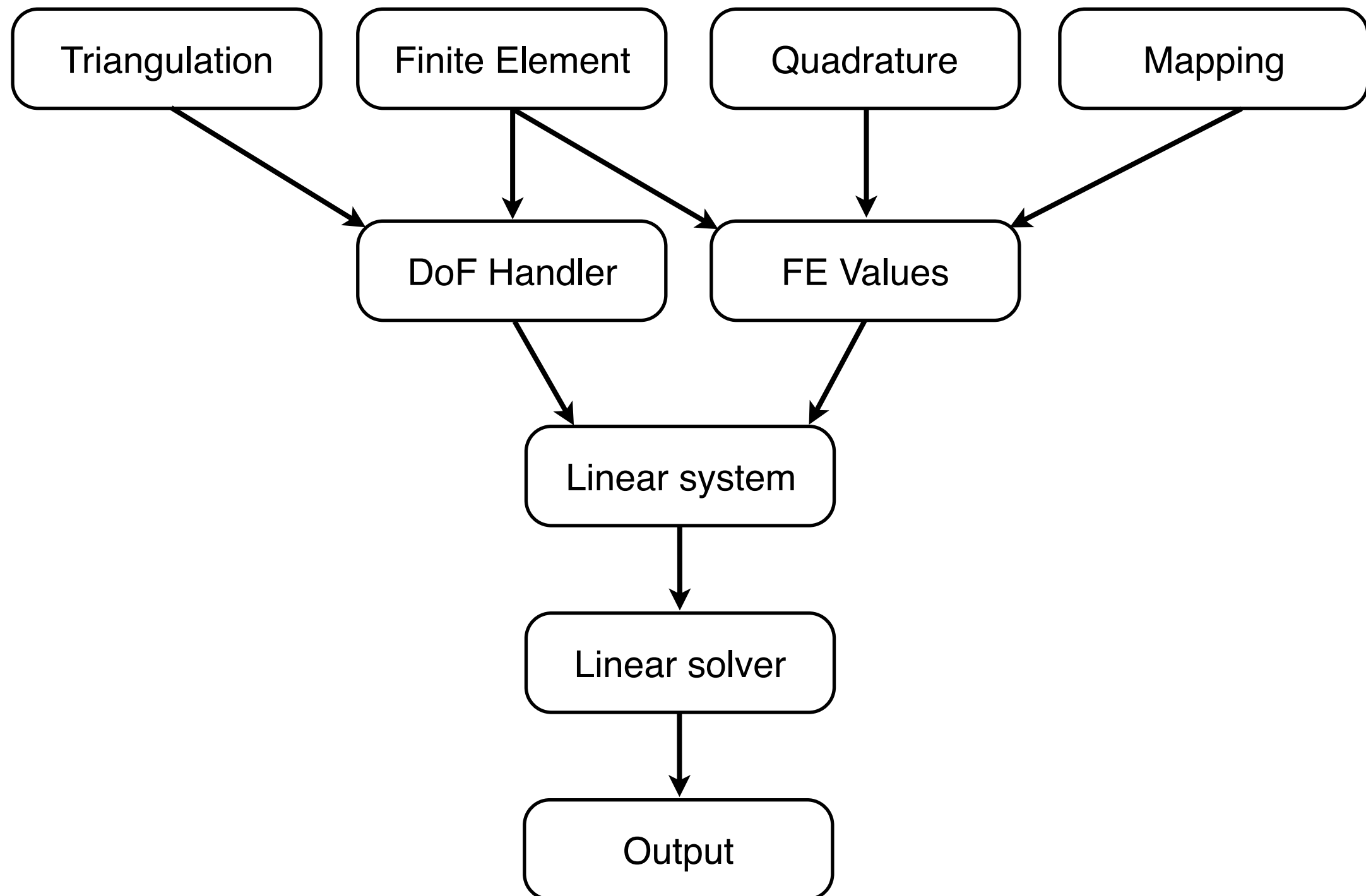
Reference material

- Main page
<https://dealii.org/8.5.1/doxygen/deal.II/index.html>
- Tutorials
 - Step-1
https://dealii.org/8.5.1/doxygen/deal.II/step_1.html
 - Step-49
https://dealii.org/8.5.1/doxygen/deal.II/step_49.html
 - Step-2
https://dealii.org/8.5.1/doxygen/deal.II/step_2.html

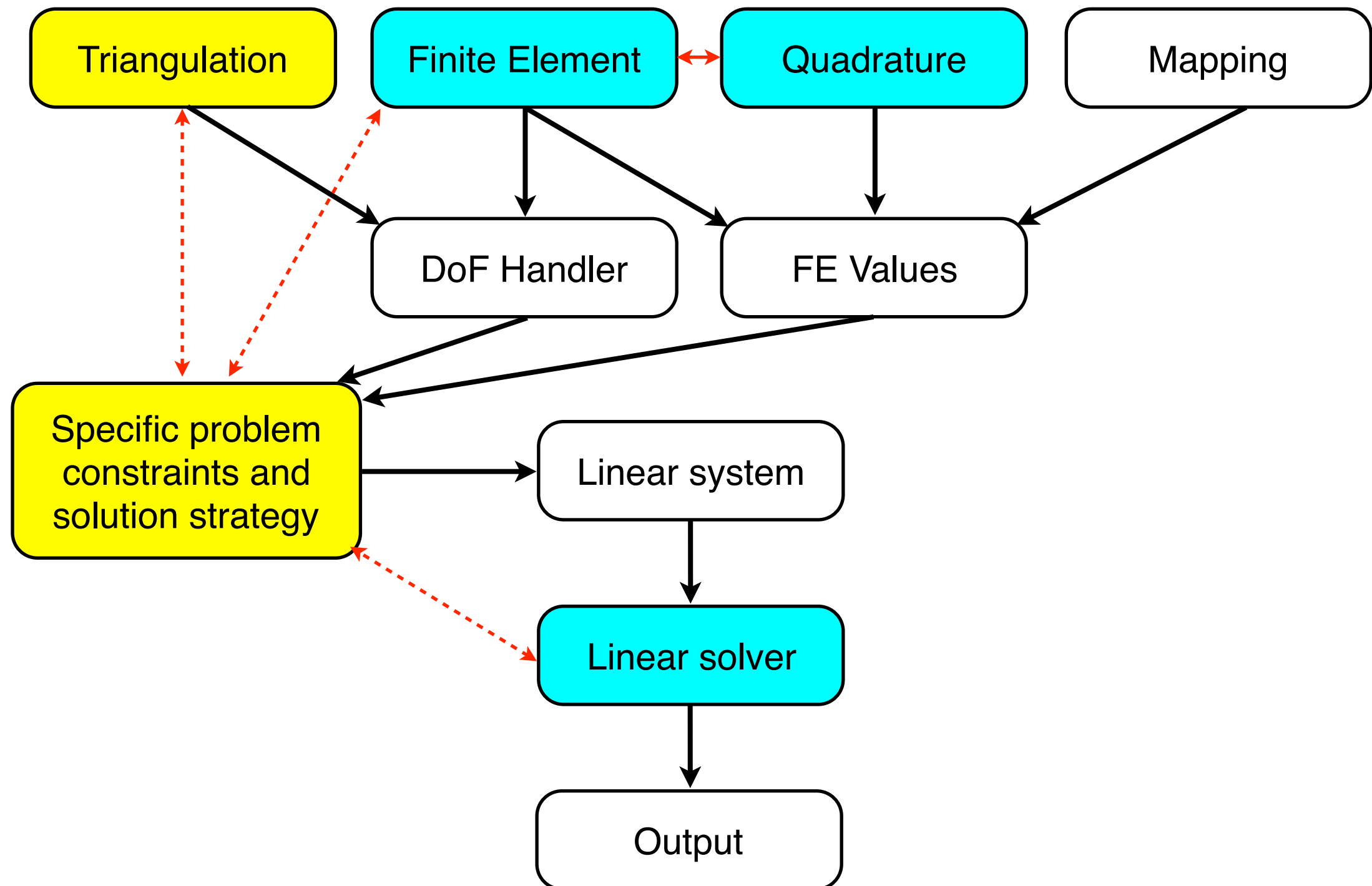
First and biggest tip

- Program defensively
 - Program and test in debug mode
 - Additional compiler warnings
 - Add assertions
- Perform studies in release mode

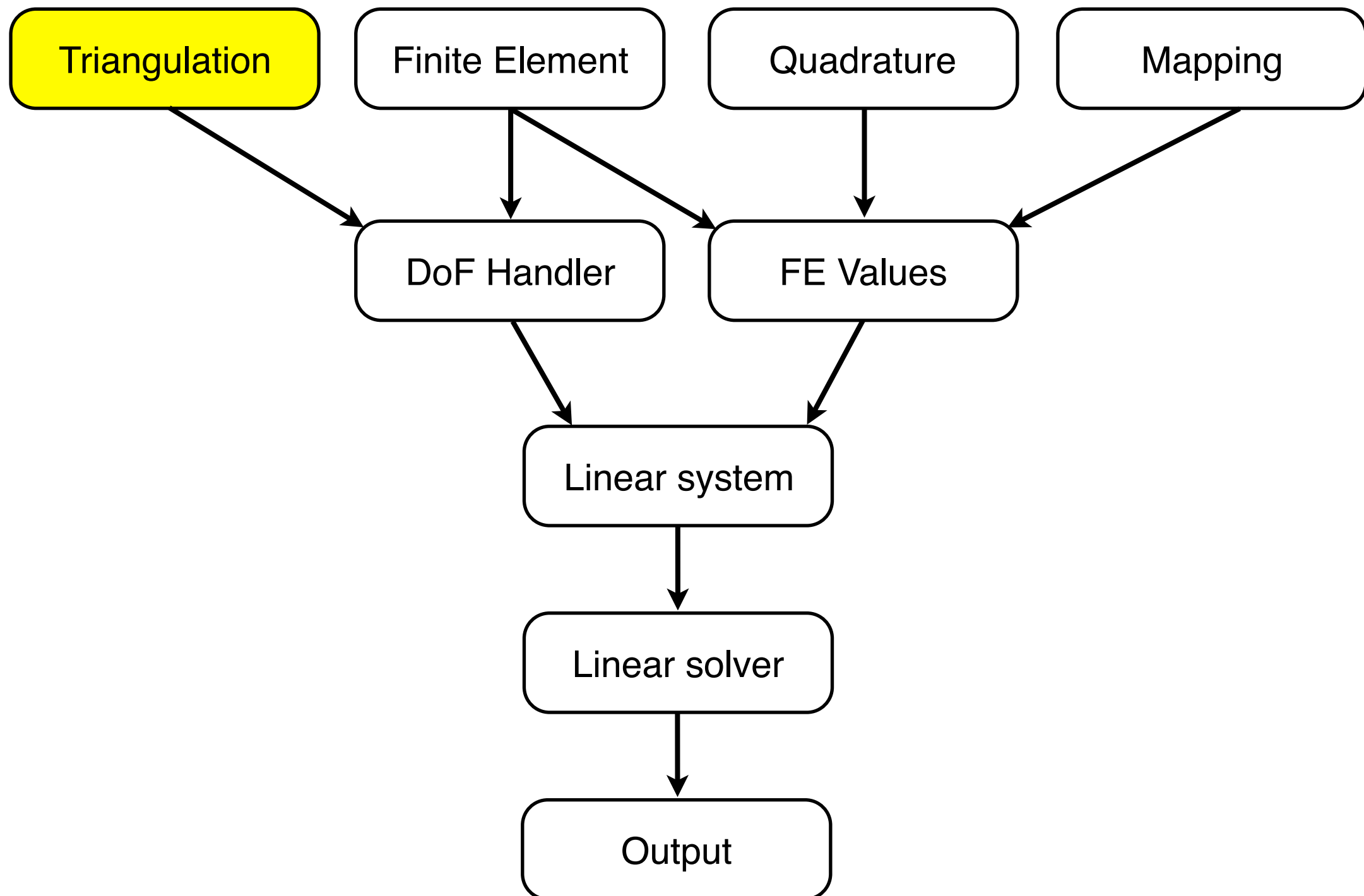
Structure of a prototypical FE problem



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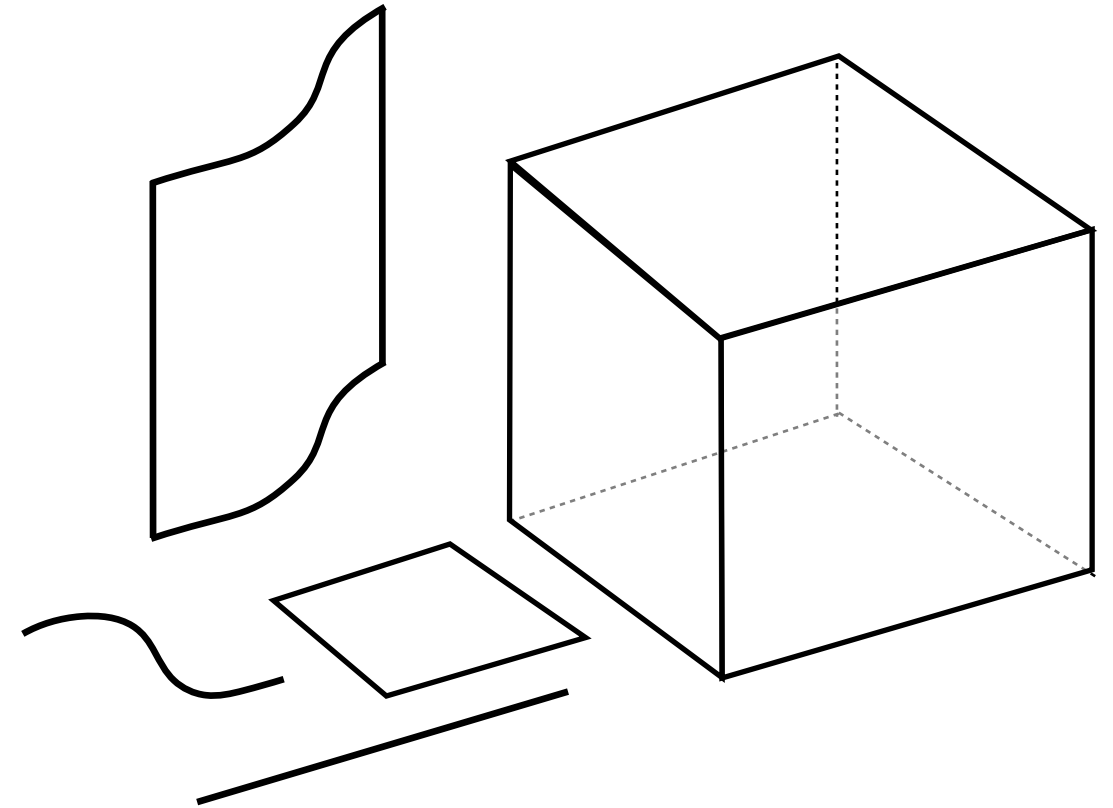


Structure of a prototypical FE problem



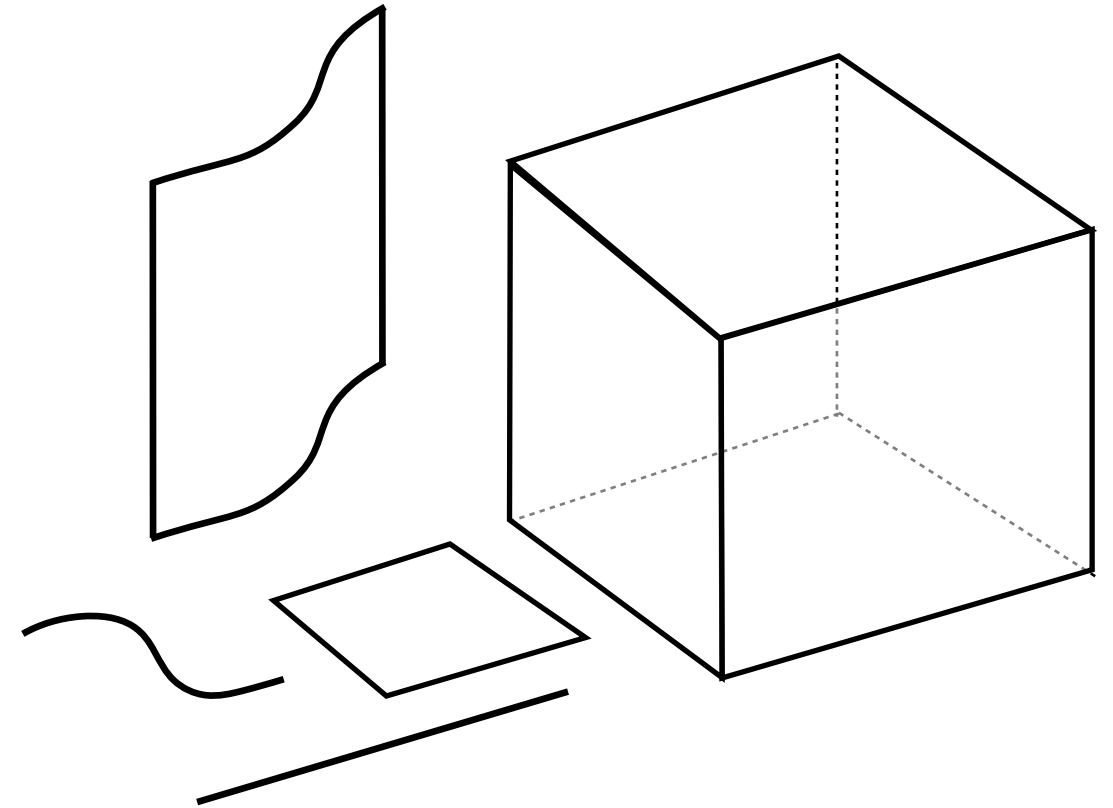
Interaction with geometry: the Triangulation class

- Describes problem geometry
 - Support for lines, quad, hex elements
 - Conceptually even higher order!
 - Structured/unstructured meshes
 - Co-dimension 1 or 2 case
- Grid creation
 - Built-in basic grid generation and manipulation tools
 - Can read in grids



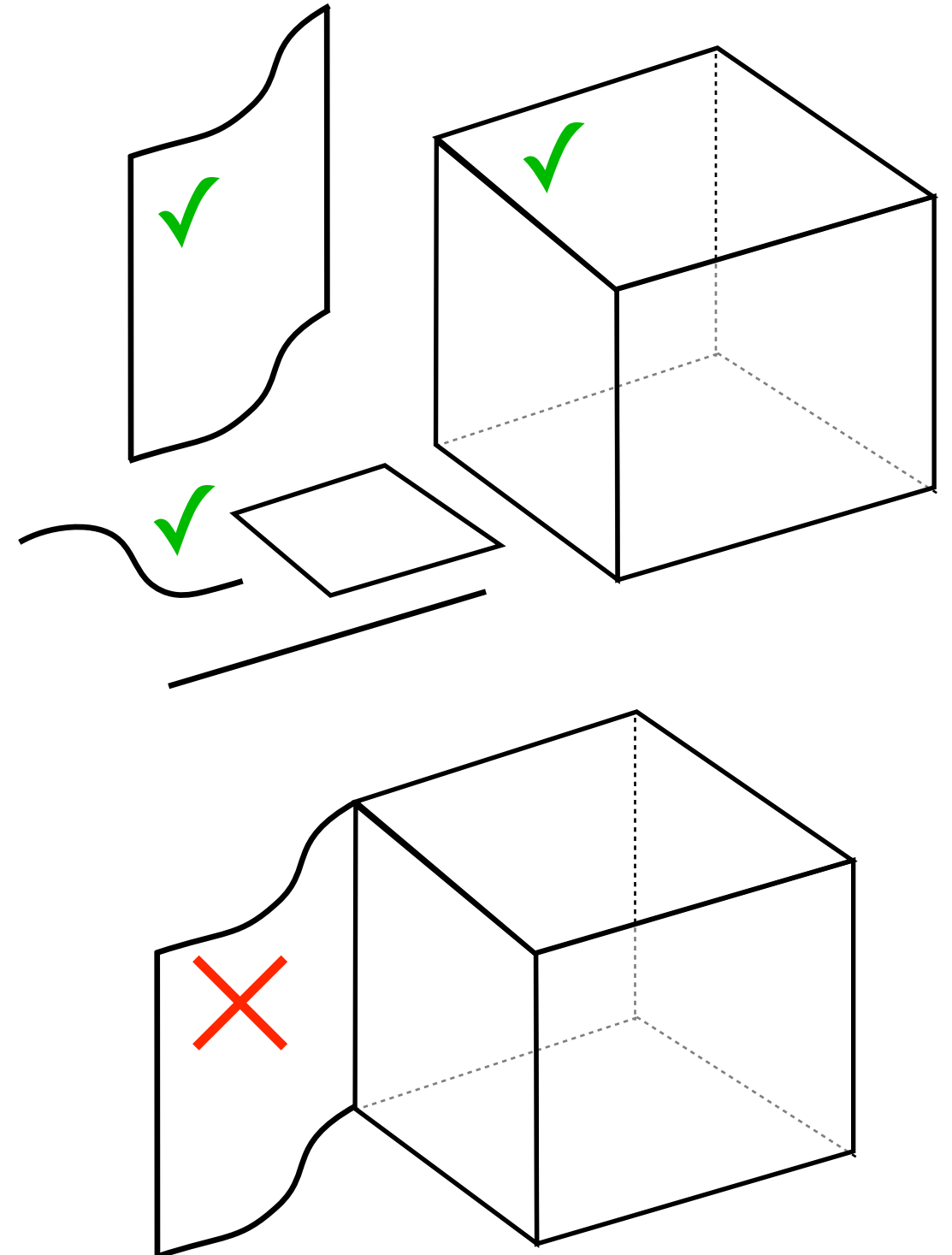
Interaction with geometry: the Triangulation class

- Assign helper ID's
 - Materials
 - Boundaries
 - Manifolds
- Allows storage of custom data-structure attached to each cell/face
- Cells know about neighbour cells
 - Useful for DG methods



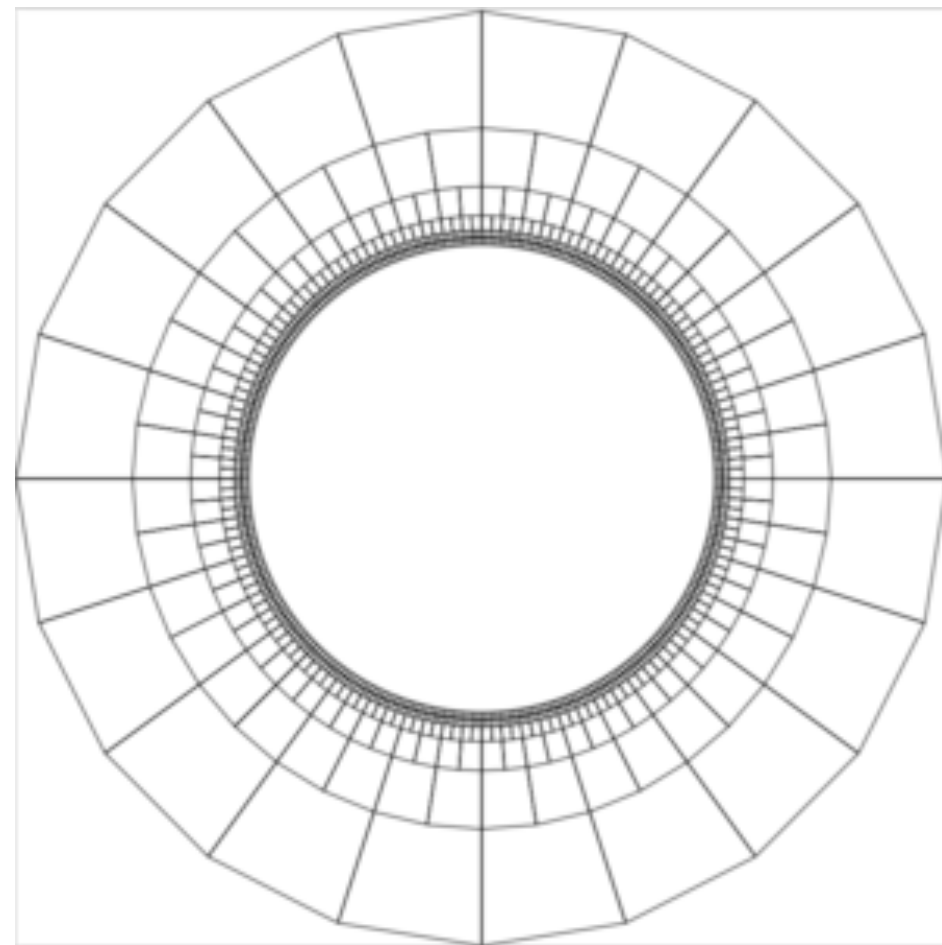
Interaction with geometry: the Triangulation class

- Can enforce topologies
 - Manifolds on boundary
 - Internal manifolds
- Disadvantage
 - Cannot mix triangulation types
 - e.g. Volumetric body with extended manifold surface

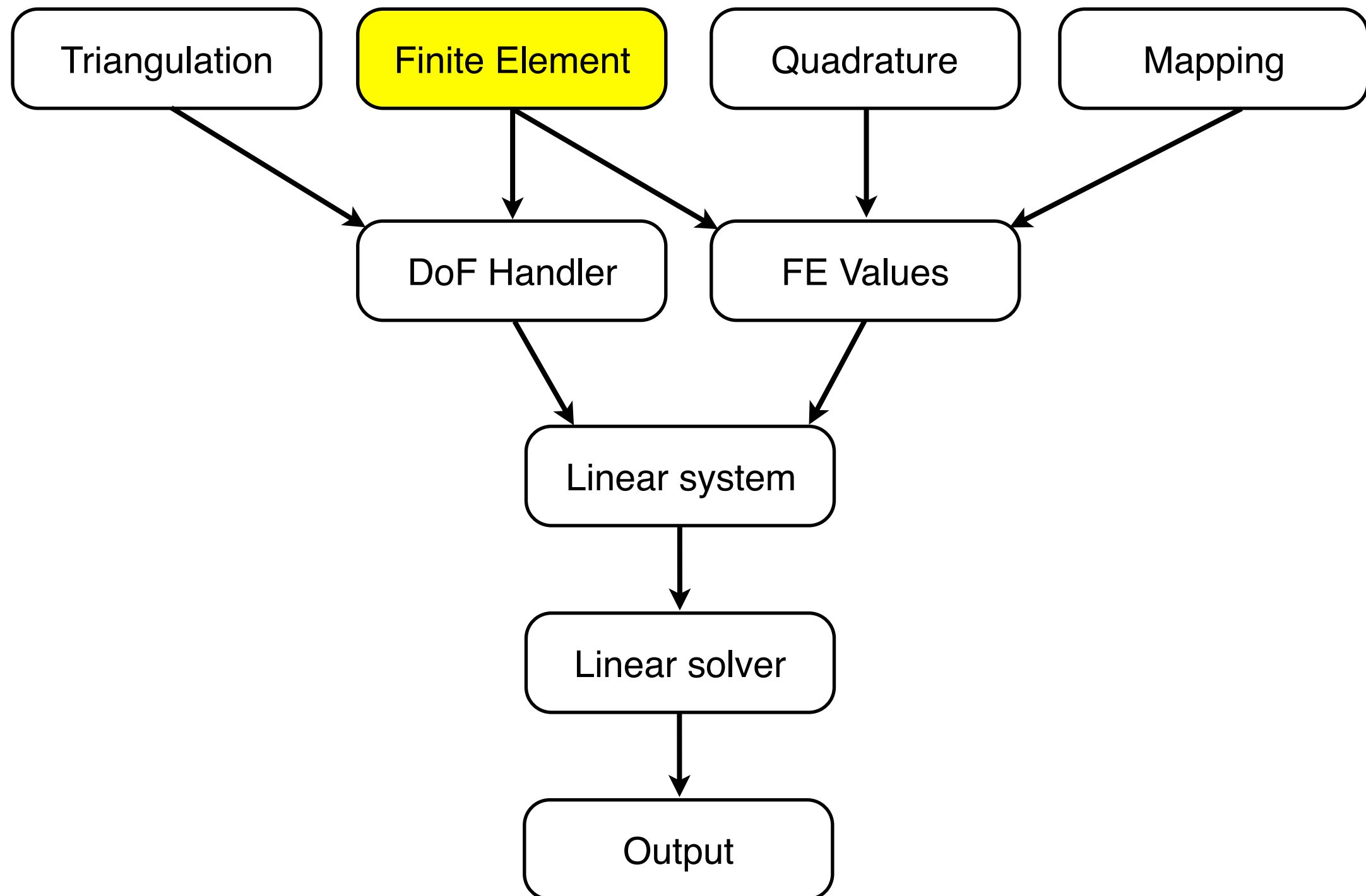


Interaction with geometry: the Triangulation class

- Demonstration: Step-1, step-49
https://www.dealii.org/8.5.1/doxygen/deal.II/step_1.html
https://www.dealii.org/8.5.1/doxygen/deal.II/step_49.html
<http://www.math.colostate.edu/~bangerth/videos.676.5.html>
<http://www.math.colostate.edu/~bangerth/videos.676.6.html>
- Key points
 - deal.II headers
 - Creating a triangulation
 - Boundary topology
 - Traversing a triangulation
 - Querying geometric information
 - Manipulating a triangulation
 - Aspects of grid refinement
 - Visualising a triangulation



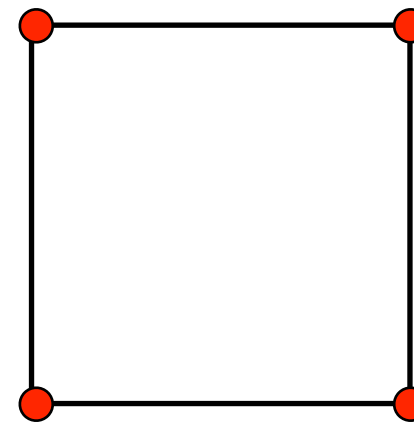
Structure of a prototypical FE problem



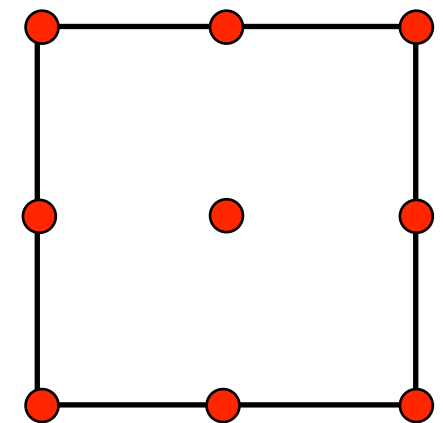
Assigning degrees-of-freedom: the FiniteElement classes

- Built in Finite Elements
 - Continuous
 - Piecewise Lagrange polynomials
 - Discontinuous
 - Monomials
 - Legendre polynomials
 - Vector-valued
 - Nedelec (H^{curl} , C/Dc)
 - Raviart-Thomas (H^{div} , C/Dc)
- A few more...
- Can develop finite elements from scratch
 - Specialisation for FE's derived by polynomial expansions
 - Enhanced/bubble elements

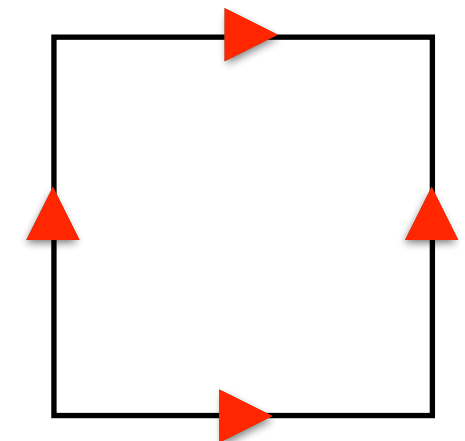
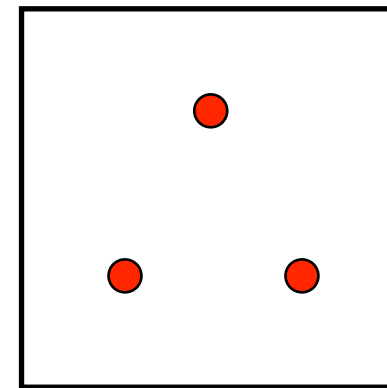
FE_Q<2>(1)



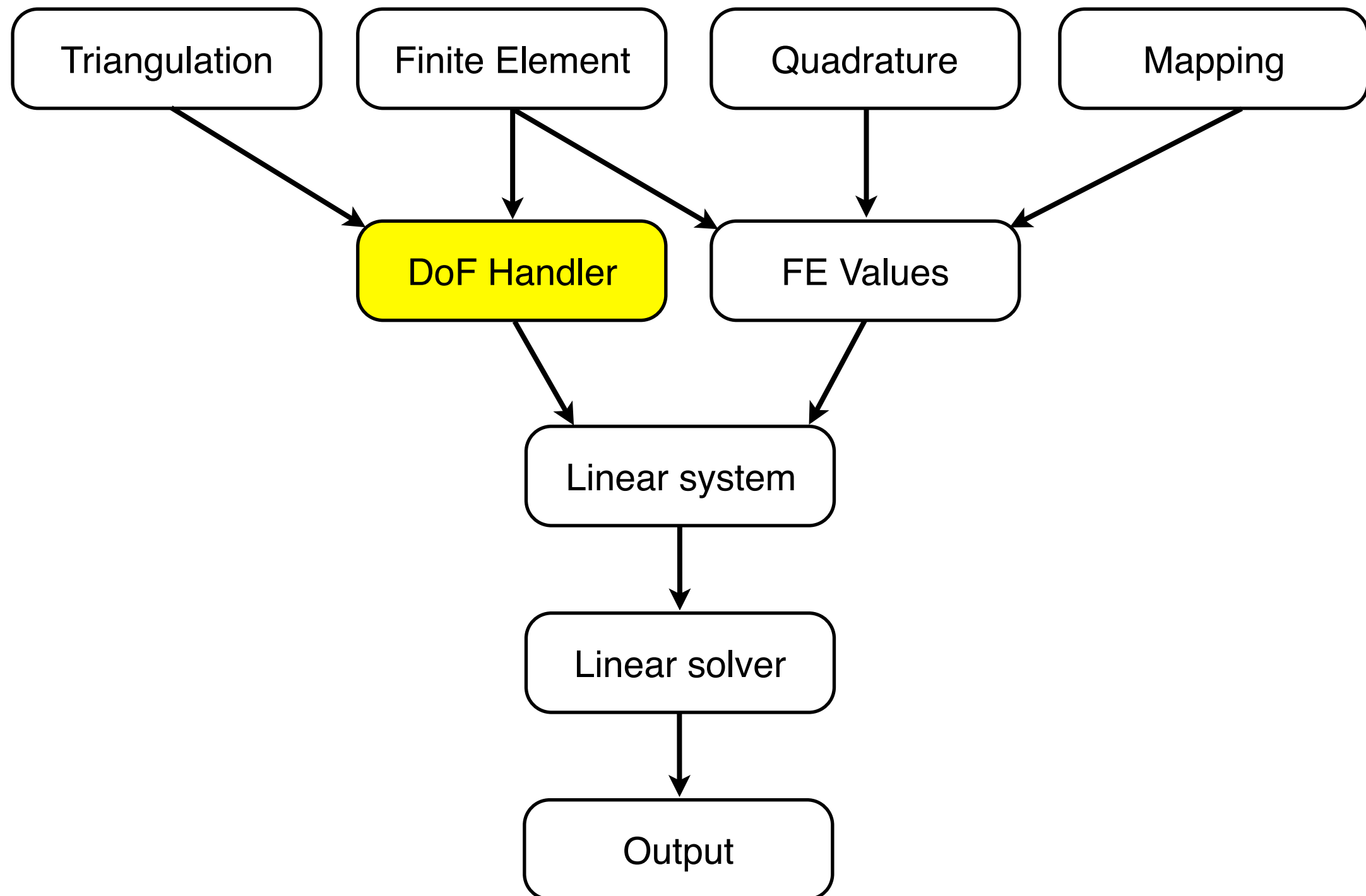
FE_Q<2>(2)



FE_DGPMonomial<2>(1) FE_Nedelec<2>(0)

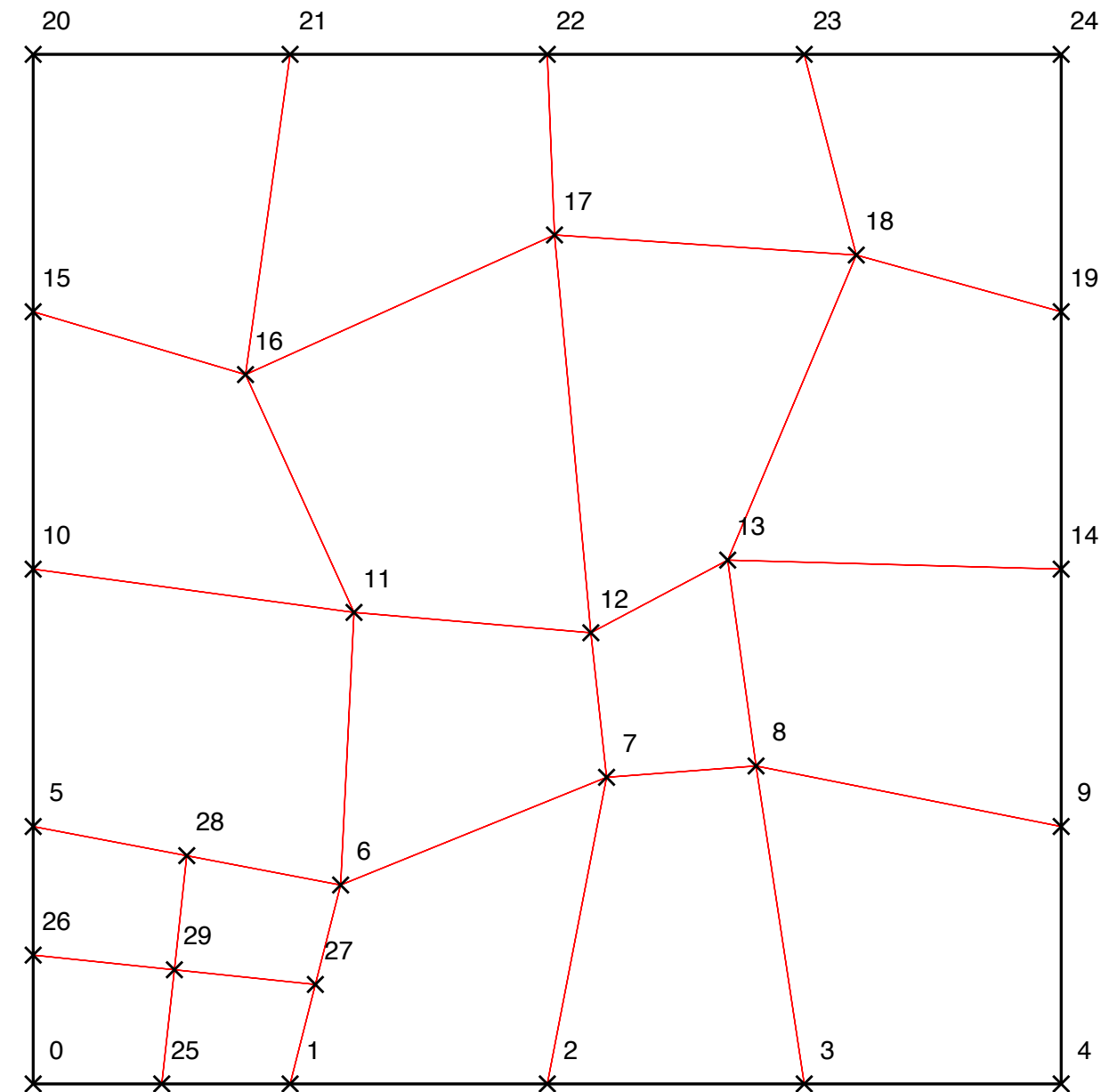


Structure of a prototypical FE problem



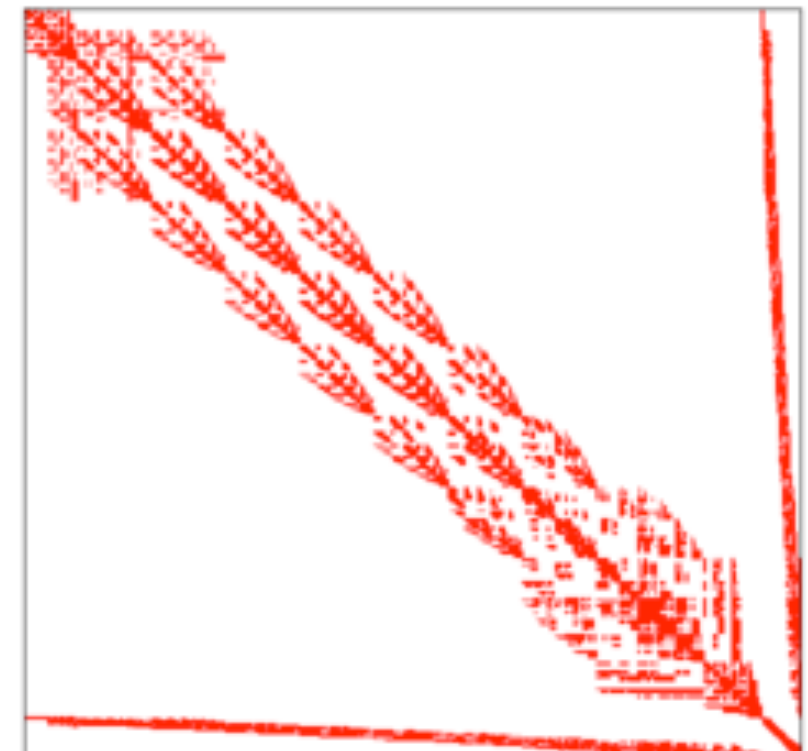
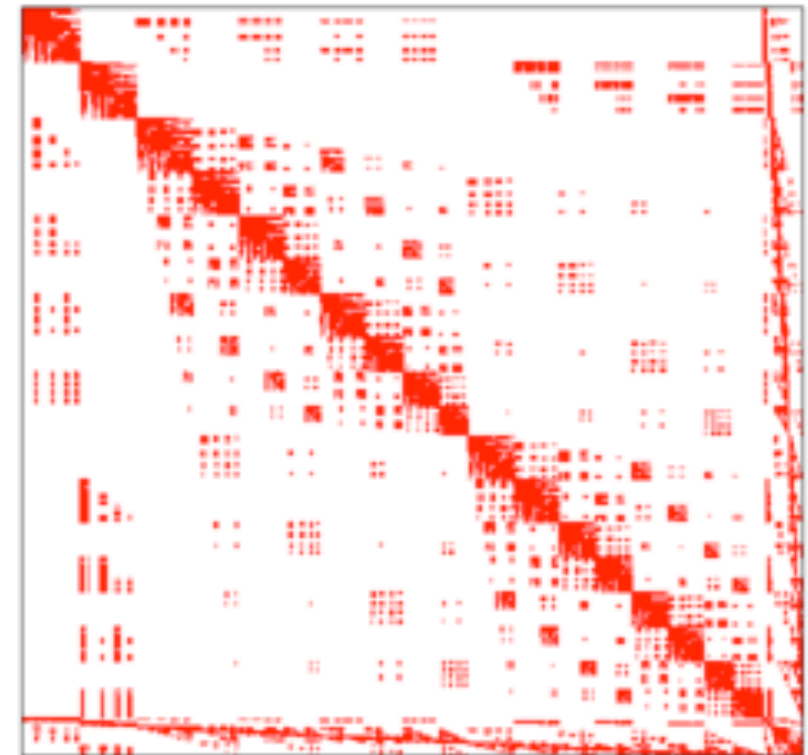
Assigning degrees-of-freedom: the DoFHandler class

- DoFHandler assigns DoF's to grid
 - Important: separate to Triangulation!
- Unified way to access DoF's, regardless of FE used
 - e.g. Discontinuous elements: support points not necessarily at vertices
- Fast access and grid traversal
 - STL-type cell iterators
 - Access to faces, edges through these
- Disadvantage
 - All cells must have same types of finite-elements*



Assigning degrees-of-freedom: the DoFRenumbering namespace

- Renumbering schemes
 - Cuthill McKee
 - King
 - Downwind
- Reduce bandwidth
- Collect like-components
- Induce block-structure
- Directional (fluid flow)
- MPI subdomain



Assigning degrees-of-freedom: the FiniteElement and DoFHandler classes

- Demonstration: Step-2
https://www.dealii.org/8.5.1/doxygen/deal.II/step_2.html
<http://www.math.colostate.edu/~bangerth/videos.676.9.html>
- Key points
 - Choosing a Finite Element
 - Distributing degrees-of-freedom on a mesh
 - Renumbering degrees-of-freedom
 - Visualising sparsity patterns

