SimCenter NHERI

Center for Computational Modeling and Simulation

EE-UQ

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Outline

Common SimCenter Applications Features

EE-UQ

Common Features

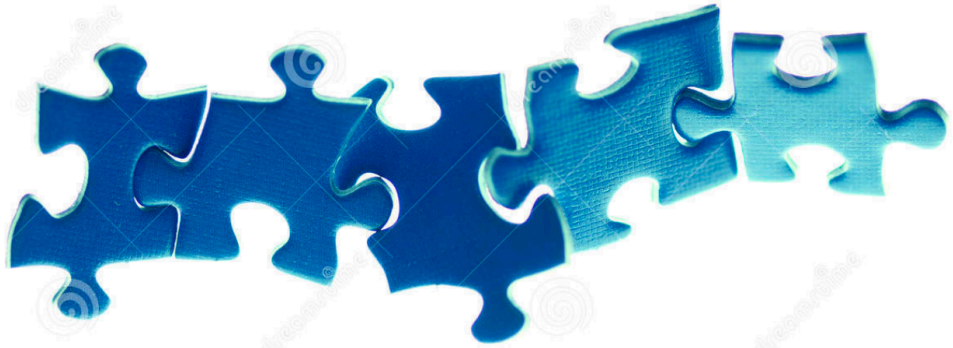
1. Workflows
2. UQ
3. Run in The Clouds

Business Workflow: “Progression of steps (tasks, events, interactions) that move something from an initial state to a final state. In a sequential workflow, each step is dependent on occurrence of the previous step; in a parallel workflow, two or more steps can occur concurrently.“

Implementation Details

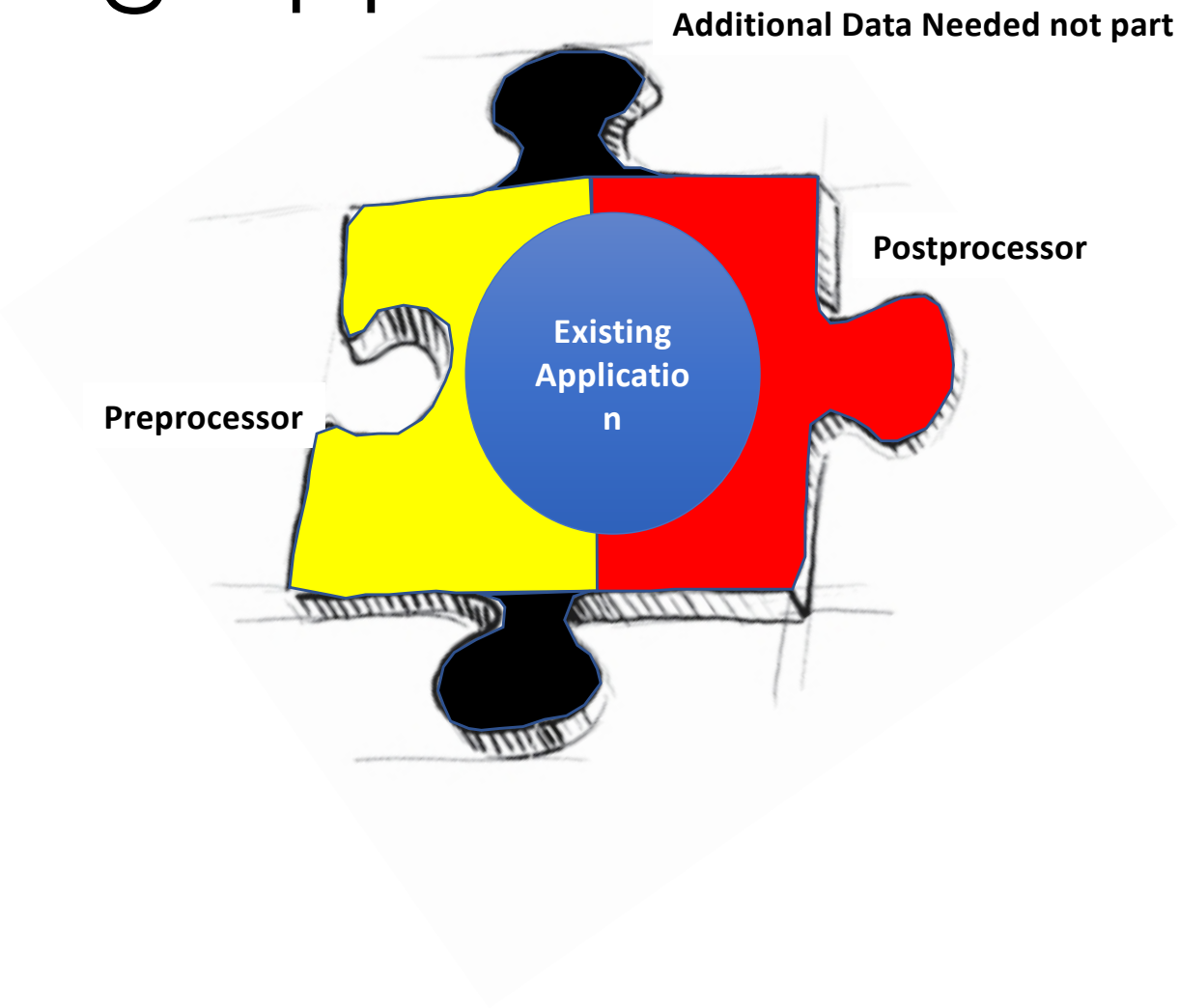
The SimCenter is providing a **framework** that will enable workflow applications to be built that will enable research in Natural Hazards engineering. The framework will allowing researchers with different applications to work together to build more powerful applications.

Existing Applications of course do not of Course work together



SimCenter defining interfaces they must meet!

And Writing Code to incorporate Existing Applications into Workflow



Input File for Regional Earthquake Simulation

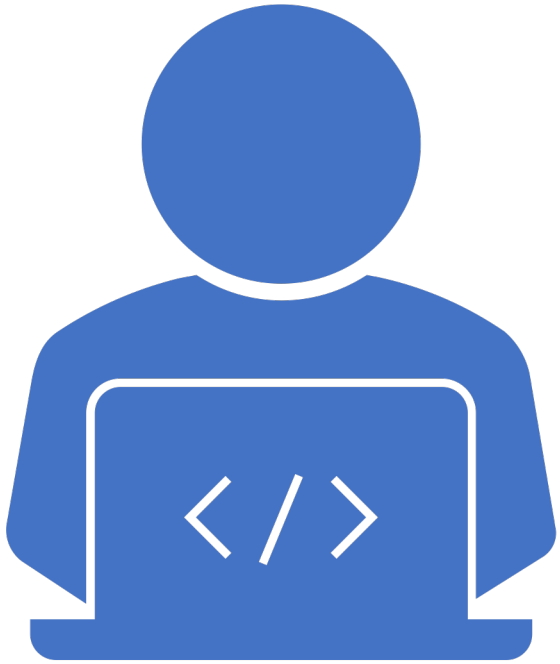
Untitled — Edited

Workflow — emacs Workflow1.json — 137×55

```
{
   "Name": "Workflow 1",
   "Author": "fmk",
   "WorkflowType": "Regional Simulation",
   "buildingFile":"buildings.json",
   "Applications": {
      "Buildings": {
         "BuildingApplication": "UrbanSimDatabase",
         "ApplicationData": {
            "Min": "1",
            "Max":"1856000",
            "parcelsFile":"/Users/fmckenna/NHERI/parcels.csv",
            "buildingsFile":"/Users/fmckenna/NHERI/buildings2010.csv"
         }
      },
      "Events": [
         {
            "EventClassification": "Earthquake",
            "EventApplication": "LLNL-SW4",
            "ApplicationData": {
               "pathSW4results": "/Users/fmckenna/NHERI/Hayward7.0/",
               "filenameHFmeta":"/Users/fmckenna/NHERI/Workflow1.1/createEVENT/HFmeta"
            }
         }
      ],
      "Modeling": {
            "ModelingApplication": "MDOF-LU",
            "ApplicationData": {
               "hazusData":"/Users/fmckenna/NHERI/Workflow1.1/createSAM/data/HazusData.txt"
            }
      },
      "EDP": {
            "EDPApplication": "StandardEarthquakeEDP",
            "ApplicationData": {}
      },
      "Simulation": {
         "SimulationApplication": "OpenSees",
         "ApplicationData": {}
      },
      "UQ-Simulation": {
         "UQApplication": "Dakota-FEM",
         "ApplicationData": {}
      },
      "Damage&Loss": {
         "Damage&LossApplication": "FemaP58-LU",
         "ApplicationData": {
            "filenameSettings":"/Users/fmckenna/NHERI/Workflow1.1/createLOSS/data/settings.ini",
            "pathCurves":"/Users/fmckenna/NHERI/Workflow1.1/createLOSS/data/ATCCurves/",
            "pathNormative":"/Users/fmckenna/NHERI/Workflow1.1/createLOSS/data/normative/"
         }
      }
   }
}
-uu-:**-F1  Workflow1.json   Top L11    (Fundamental)----------
Auto-saving...done
```

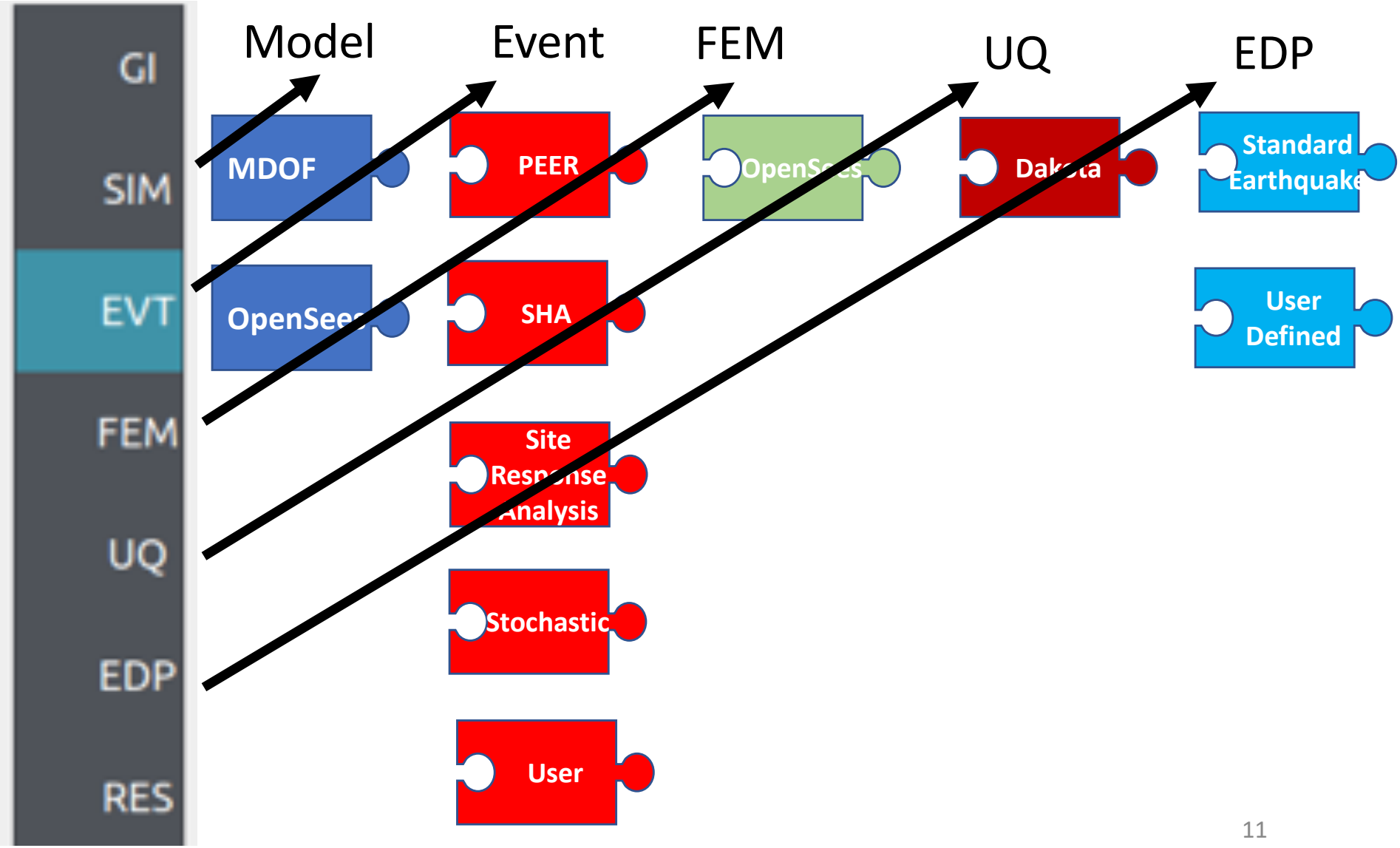
```
"Events": [
   {
      "EventClassification": "Earthquake",
      "EventApplication": "LLNL-SW4",
      "ApplicationData": {
         "pathSW4results": "/Users/fmckenna/NHERI/Hayward7.0/",
         "filenameHFmeta":"/Users/fmckenna/NHERI/Workflow1.1/createEVENT/HFmeta"
      }
   }
],
"Modeling": {


},
"Events": [
   {
      "EventClassification": "Earthquake",
      "EventApplication": "SHA-GM",
      "ApplicationData": {
         "scenarioConfig": "./HayWired7.25.json"
      }
   }
],
"Modeling": {
```

SImCenter applications are in actuality Scientific Workflow Systems



- They provide an interface to allow user to select from different applications to run in a scientific workflow
- The interface also allows users to specify specific inputs, schedule and run the workflow, and to monitor the progress.
- They allow the user to utilize their own application in the workflow

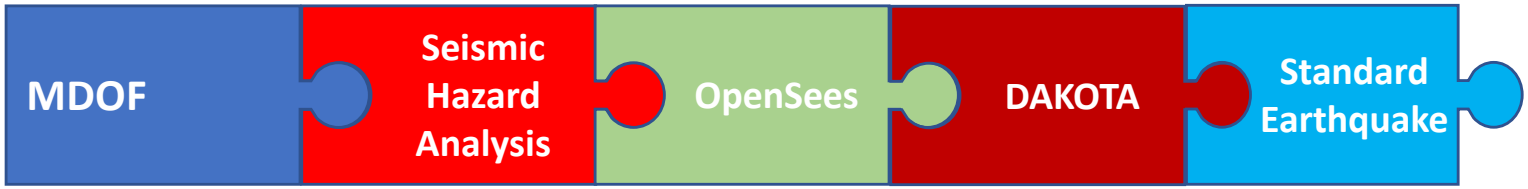
e.g. EE-UQ Presents Users With a Lot of Options



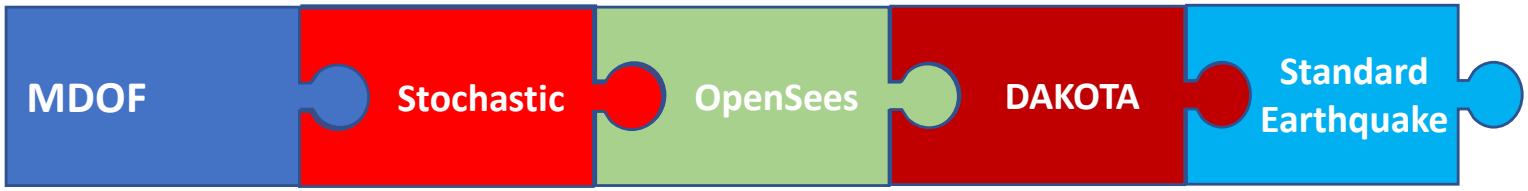
allows User to Mix and Match

Chain a set of applications into a building workflow

Workflow 1



Workflow 2



Workflow 3

Common Features

1. Workflows
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3. Run in The Clouds

“An estimate without a standard error is practically meaningless”

source: “Theory of Probability”, Thomas Jeffers

"Today, however, the phenomena and processes we ask computer models to predict are of enormous importance to critical decisions that affect our welfare and security—concerning, for example, climate change, the performance of energy and defense systems, the biology of diseases, and the outcome of medical procedures. With such high stakes, we must insist that the predictions include concrete, quantifiable measures of uncertainty. In other words, we must know how good the predictions are. "source: "Computer Predictions With Quantified Uncertainty", Tinsley Oden, Robert Moser, and Omar Ghattas

the SimCenter Applications ARE NOT Deterministic Applications

i.e. they not produce a single output result for every response parameter

they ARE UQ Applications

i.e. for each output response they produce information on the response and some measure on the uncertainty in the computed response, e.g. mean and std. dev

Because they are UQ applications

User has to identify certain parameters as being **Random Variables**

User then has to define the **Distribution** associated with these Random Variable

Common Features

1. Workflows
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To generate UQ requires more computation – applications enable cloud based computing

- they can run these computations in parallel using the cores of your local computer;

- they also allow you to run the simulations through the Cloud on the HPC resources provided through **DesignSafe-ci.**

How Do We Do This?

EE-UQ is split into 2 applications:

Front End UI

Backend Workflow

- Front end is an application runs on your desktop
- Backend workflow applications run on either your desktop or HPC at TACC

Outline

Common SimCenter Applications Features

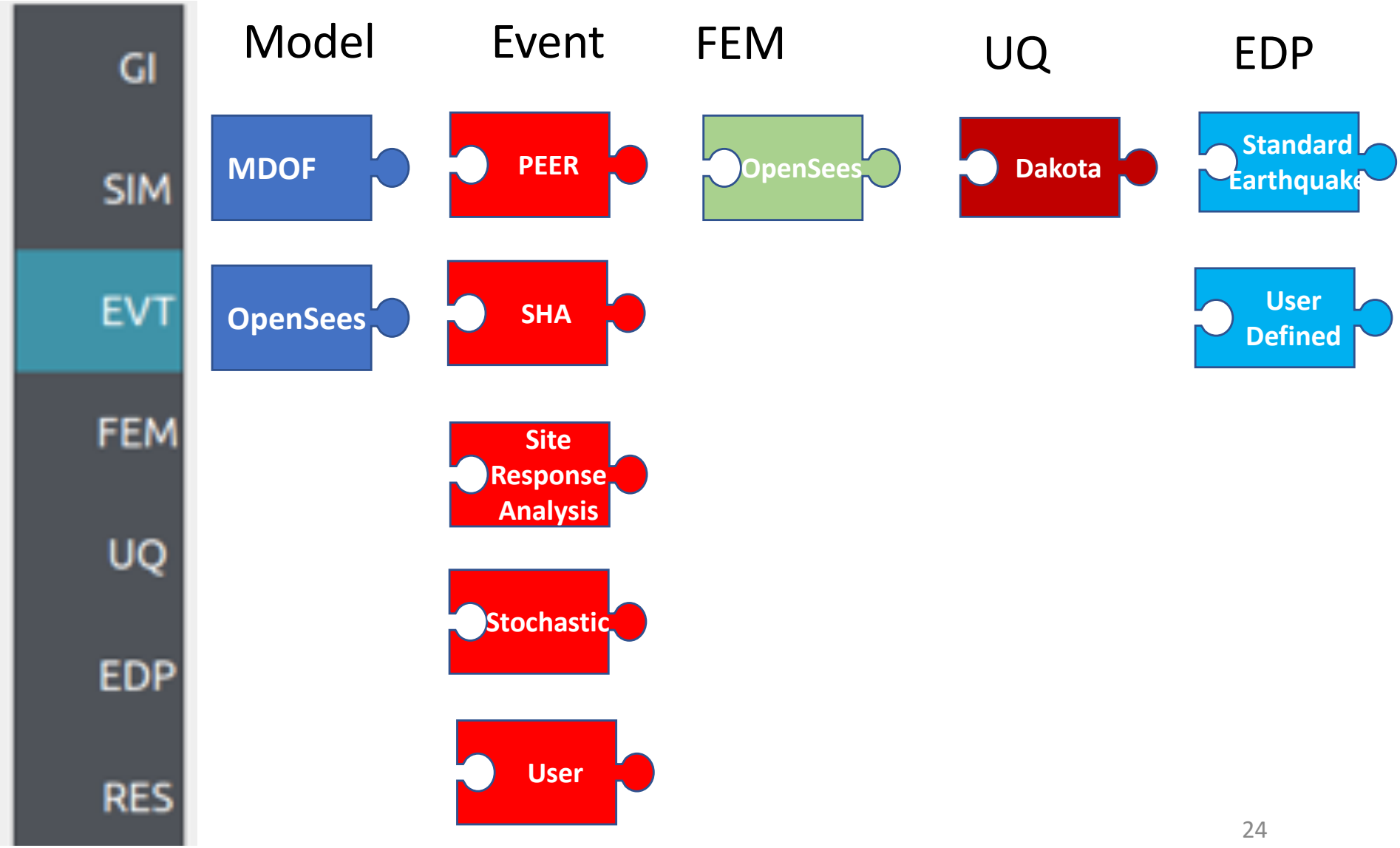
EE-UQ

Purpose:
To Determine Response of a Building subjected to an Earthquake Event

Unique Features

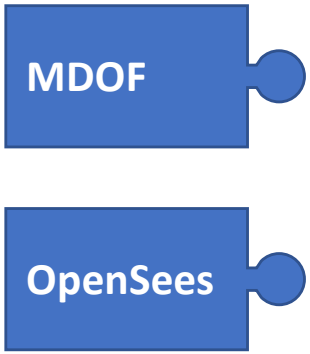
- Uncertainty Quantification
- Local or Remote Execution
- Ground Motion Selection

e.g. EE-UQ Presents Users With a Lot of Options



Models

Model



Shear Building Model

Provide OpenSees input file

Ground Motion Selection

Event

Provide list of PEER ground acceleration (.AT2) files

For specified location obtain ground motions

Given motion at rock, propagate motion to surface to obtain input motion

Given input parameters, generate synthetic ground motions

Provide list of SimCenter Motions

FEM Options – fe code that performs analysis

FEM

specify analysis options (integration scheme, convergence test, ..)

UQ Engine

UQ

1. Specify UQ method (forward propogation of uncertainty_
2. Specify random variable distribution

Engineering Demand Parameters (the Response Quantities of Interest)

EDP