**Motivation and Challenges**

- Real-time protection and control to steer power system to a safe state and restoring the system after breakup is vital to future system reliability.
- The risk of a wide-area outage can be significantly reduced or even completely eliminated with faster than real-time simulations.
- Simulation requirement will need to be 4 orders magnitude faster than that of conventional software. Seconds of dynamic simulation need to be computed in milliseconds.

**Technical Approach – Parareal in Time**

- Parallelism across the time domain, which consists in dividing the integration interval into sub-intervals and solve concurrently over each sub-intervals.
- The Parareal in Time algorithm is used in this project which provides the initial seeds in each sub-interval by using a coarse approximation of the trajectory.
- The coarse approximation can be obtained by a fast, simple, and less accurate numerical approach or by using simplified system equations.

**Application to Power System Dynamic Simulations**

**Power System Classical Model**

- **Constant** $K_e$
- **Constant** $T_m$

- **Rotor Mechanical Equations**
  
  \[
  \frac{d\delta}{dt} = w_B S_m \\
  \frac{dS_m}{dt} = \frac{1}{2H} [-DS_m + T_m - T_e] 
  \]

- **Rotor Electrical Equations**
  
  \[
  i_q = \frac{1}{(R_a + x_d^2)} [R_a X_d' - V_q] \\
  T_e = E' q I_q 
  \]

- **Network Algebraic Equations**

  \[
  V_{PQ} = V_{0}Q V_{DQ} \\
  \]