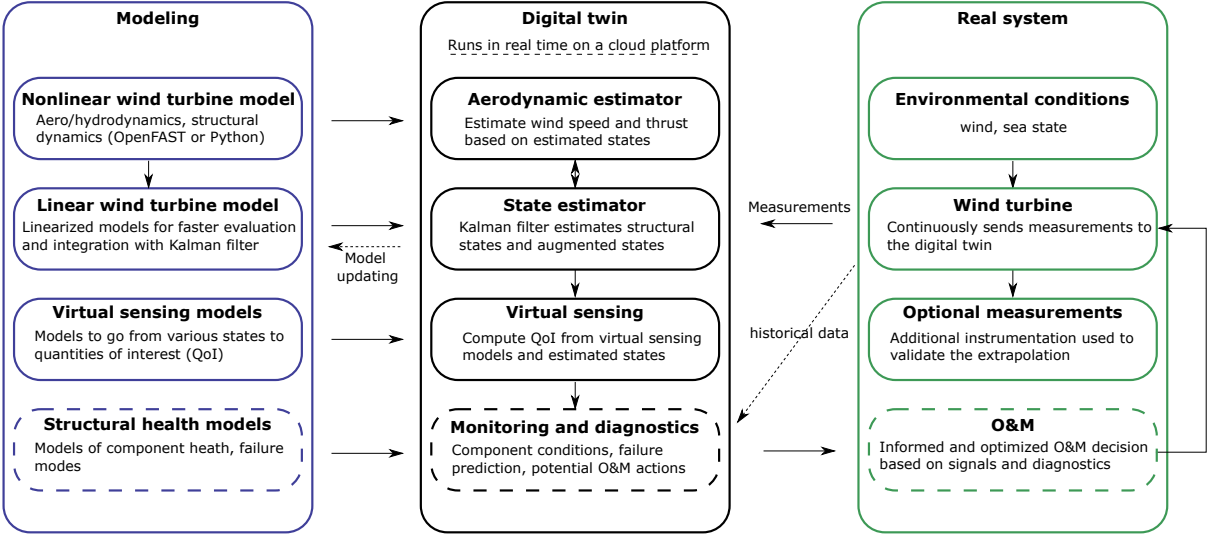
Modeling
Nonlinear wind turbine model
Aero/hydrodynamics, structural dynamics (OpenFAST or Python)
Linear wind turbine model
Linearized models for faster evaluation and integration with Kalman filter
Virtual sensing models
Models to go from various states to quantities of interest (QoI)
Structural health models
Models of component heath, failure modes
Model updating
Digital twin
Runs in real time on a cloud platform
Aerodynamic estimator
Estimate wind speed and thrust based on estimated states
State estimator
Kalman filter estimates structural states and augmented states
Virtual sensing
Compute QoI from virtual sensing models and estimated states
Monitoring and diagnostics
Component conditions, failure prediction, potential O&M actions
Measurements
historical data
Real system
Environmental conditions
wind, sea state
Wind turbine
Continuously sends measurements to the digital twin
Optional measurements
Additional instrumentation used to validate the extrapolation
O&M
Informed and optimized O&M decision based on signals and diagnostics