A Review of Digital Twin Technology and an Approach for a Robust Digital Twin for Power Systems Applications

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MOTIVATION

- Digital twins are popular in other industries
- Digital twins are a novel way to utilize advanced technology
- Current literature for applications in power systems is very limited
- New capabilities may prove beneficial contextualized with issues relating to renewables and other emerging technology

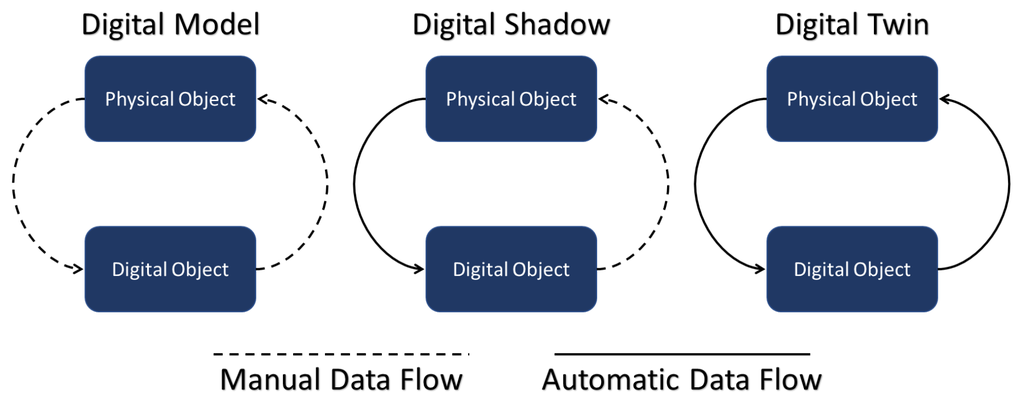
CONCLUSION

- Digital twins are viable in power system applications
- Digital twins enable much greater real-time analysis of power systems
- New technologies will increase the need for real-time analysis
- A robust digital twin platform can take advantage of high-fidelity simulations for a wide variety of applications

DIGITAL TWIN DEFINITION

A digital twin is:

1. A digital model of a physical system, that
2. can receive data from the physical system and
3. create output that supports the operation of the physical system,
4. in real-time.



EXISTING POWER SYSTEM DIGITAL TWINS APPLICATIONS

Scale is a limiting factor for power system digital twins. Real-time simulation is computationally intensive. As a result, existing digital twins primarily cover singular components or small microgrid applications. Transmission and distribution are mainly theory. To the right are existing or theorized applications in current literature.

Singular Component

- Evaluate remaining life
- Estimate unmeasurable values
- Fault detection
- Weather-based PV output estimation
- Maximum power point tracking correction

Microgrid

- Estimated power transfer
- Measurement validation
- False data injection detection
- Denial of service detection
- Control system response estimation

Transmission & Distribution

- Contingency Analysis
- Fault detection
- Hidden failure detection
- Measurement validation
- Cyber-attack detection
- Bad data correction

PROPOSED ROBUST APPROACH TO DIGITAL TWINS

- Digital twins are usually defined in three layers
  - Physical
  - Cyber
  - Application
- The digital twin mirrors the physical twin (i.e. the physical grid)
  - Physical – Electromechanical
  - Cyber – Communications and control
- The application layer is dependent on desired scope
- Possible flow from application layer to physical twin includes (but is not limited to):
  - Automatic control of the physical grid
  - Automatic output for grid operators