

Integrated System Modeling for Handling Big Data in Electric Utility Systems

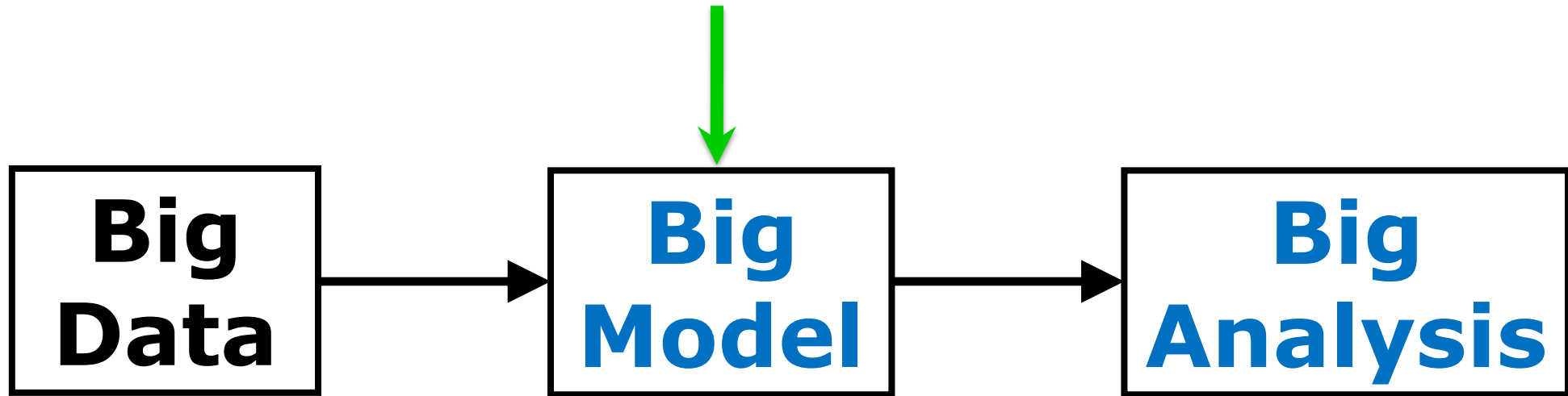
Stephanie Hamilton
Brookhaven National Laboratory

Robert Broadwater
EDD
dew@edd-us.com



Finding Good Solutions for the Hard Problems

Physical System Model



Questions

- How can we determine if investments in smart grid were (are) worthwhile?
- Why are we just storing all of this data?
- How can we determine the effects of renewable generation at the distribution level on the transmission system?
- How can we find bad model data and failed measurement devices?
- How can we move from a manually operated system to an automatically operated system, a self-healing system?
- How can we better manage power restoration for major storms?

Model-Centric Smart Grid

- Terabyte sized data sets are being generated by the smart grid
- A few utilities are using a new approach to the analysis of smart grid - “*model-centric smart grid*”
- The model-centric approach employs a holistic, *construction detail*, model of the physical system – “Integrated System Model (ISM)”
- All measurement data, including weather data, is related to the ISM
 - Changes paradigm of “*pushing data to algorithms*” to “*pushing algorithms to data*”

Model-Centric Smart Grid Equation

Reliability, Efficiency, Capacity, Protection, Controllability

Performance Analysis +

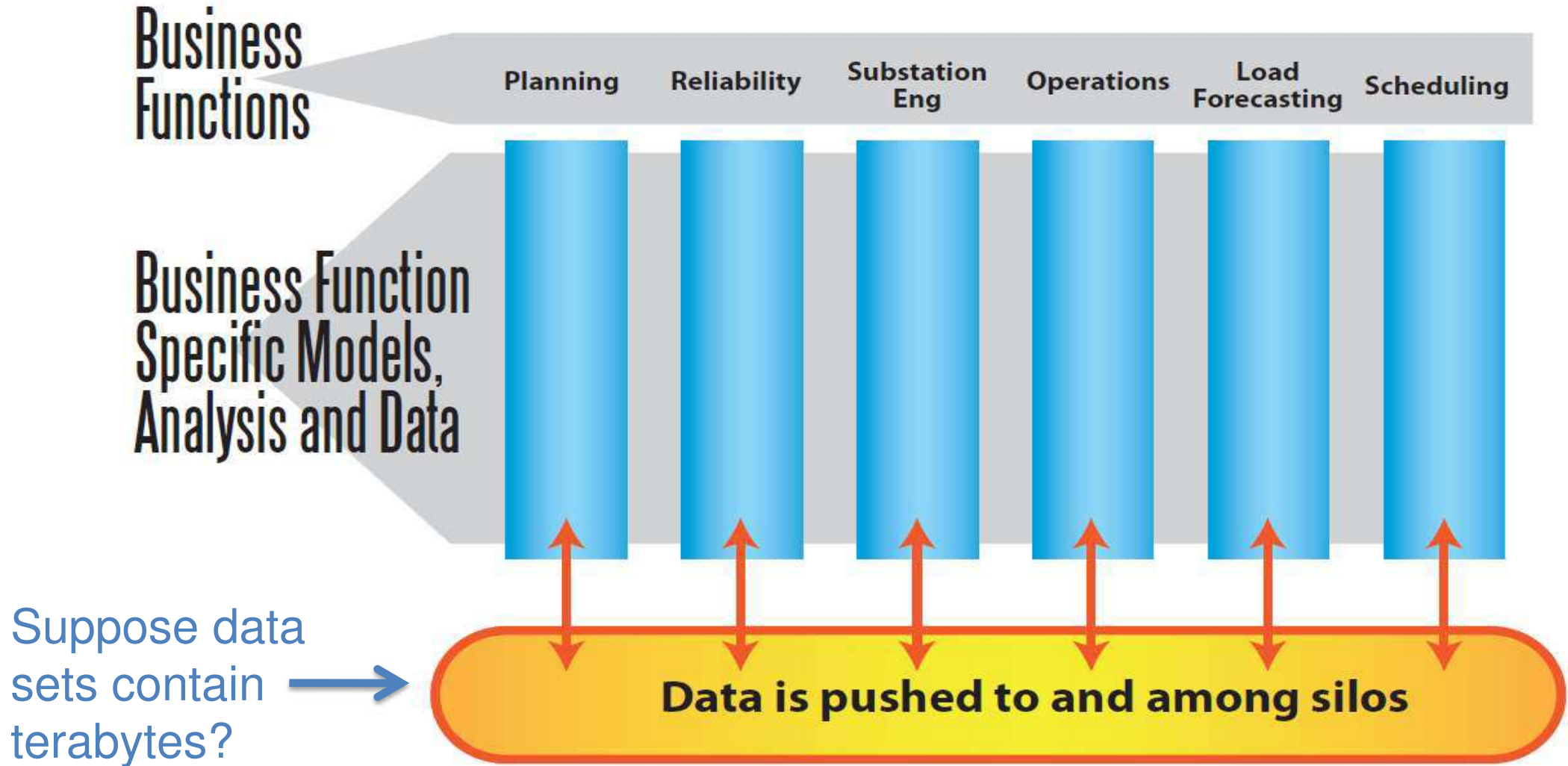
Economic Analysis +

Lab Testing +

Field Validation =

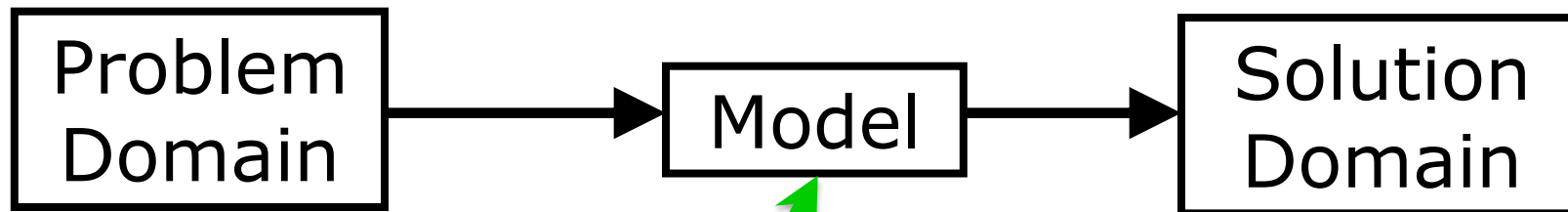
Model-Centric Smart Grid

Silo'ed Organizations with Many, Disjoint Models



Model-Based Decisions

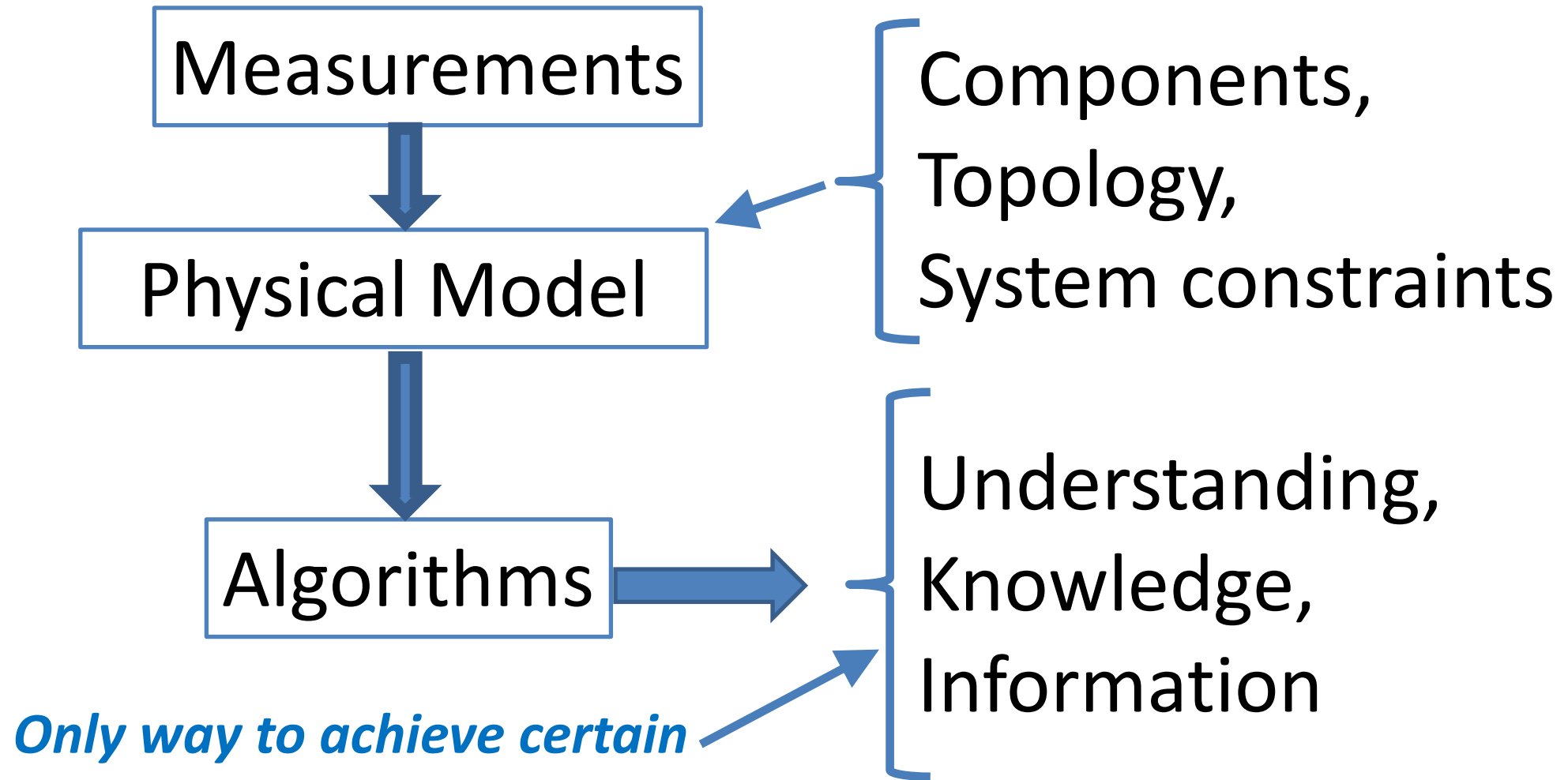
Our ability to solve a problem depends upon the model we have to solve the problem



Can make it easy or difficult to find a good solution to the problem

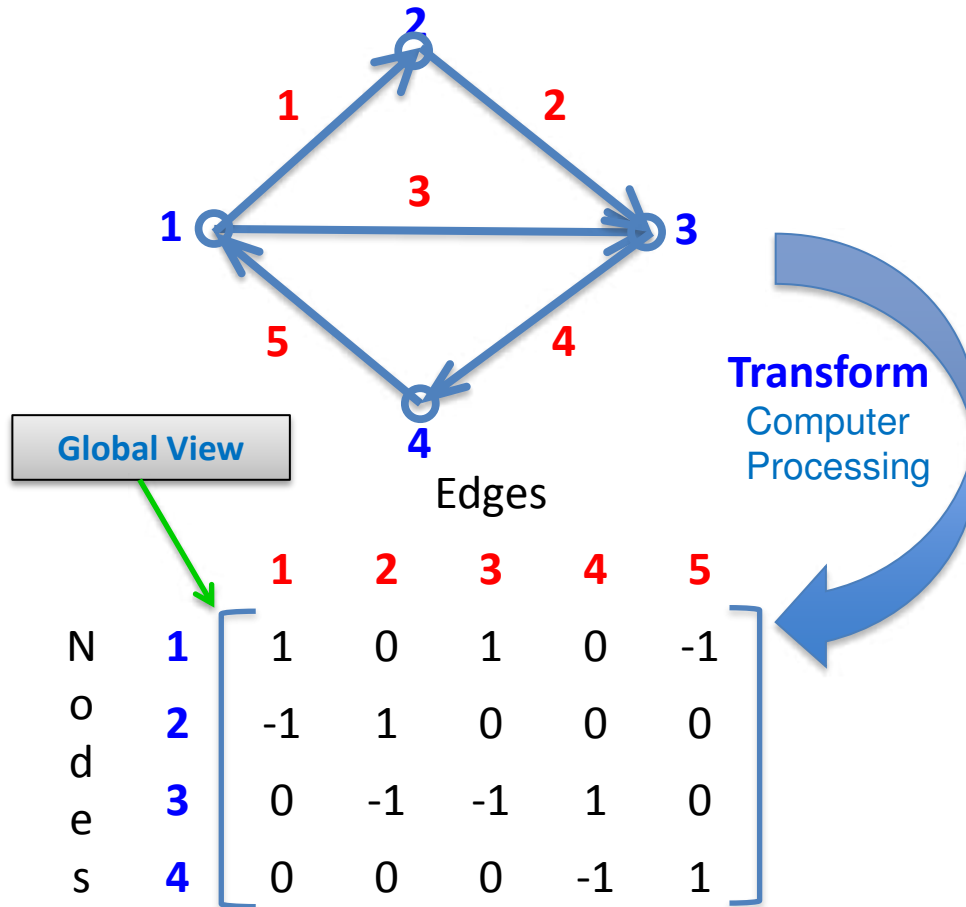
Point solutions or scenario based solutions

Measurements, Models, Algorithms, Information

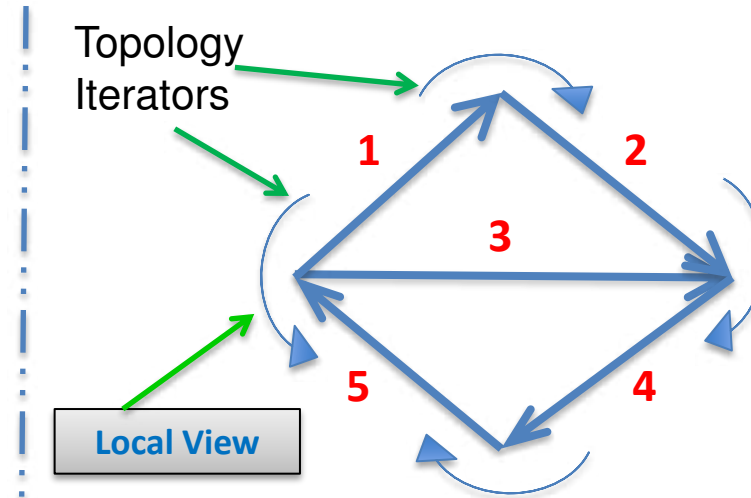


Graph Trace Analysis for the Big Model

Matrix Analysis with Edge-Node Graph



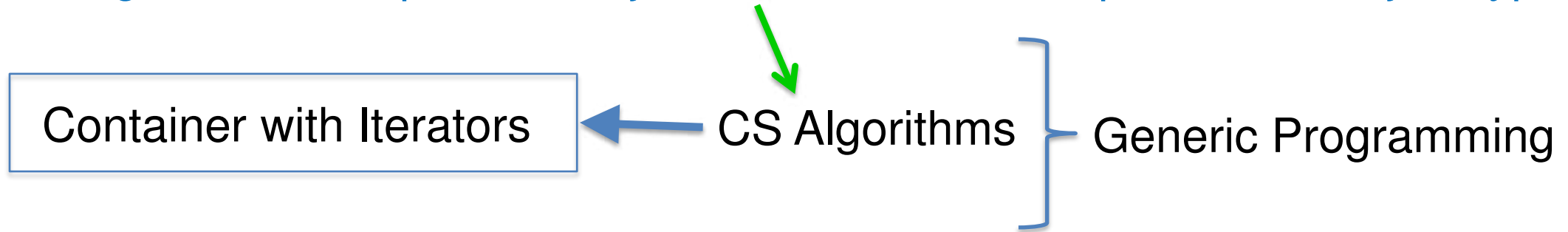
Graph Trace Analysis with Edge-Edge Graph



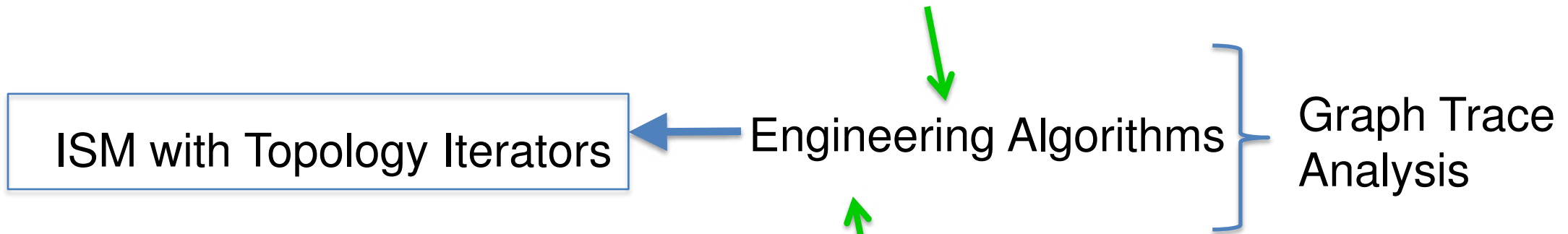
- Edge knows neighbors
- Topology continuously maintained
- Algorithms with topology iterators

Generic Programming Roots for GTA

Algorithms that process objects in container, independent of object type

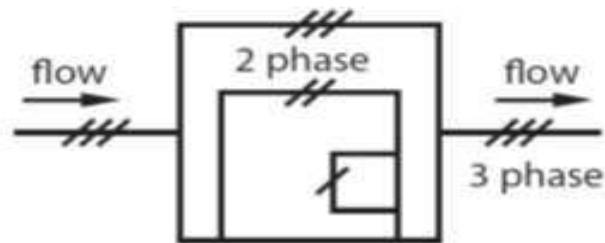
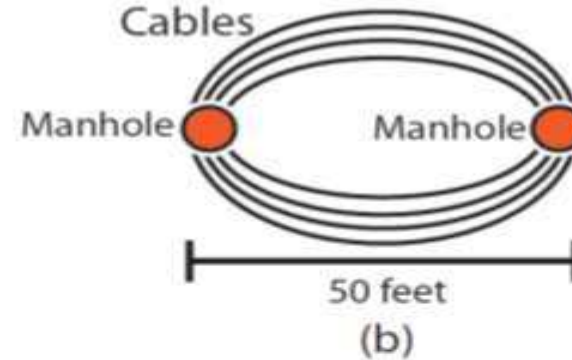
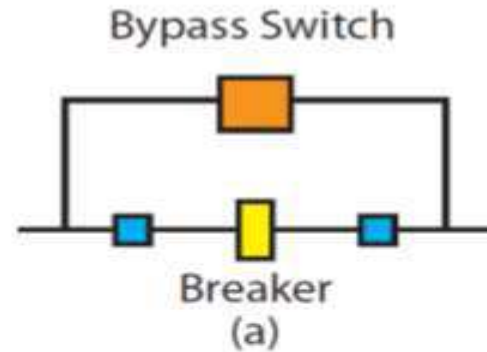


Algorithms that process edges or components of graph



Generic analysis independent of system type - electric, gas, fluid, etc.

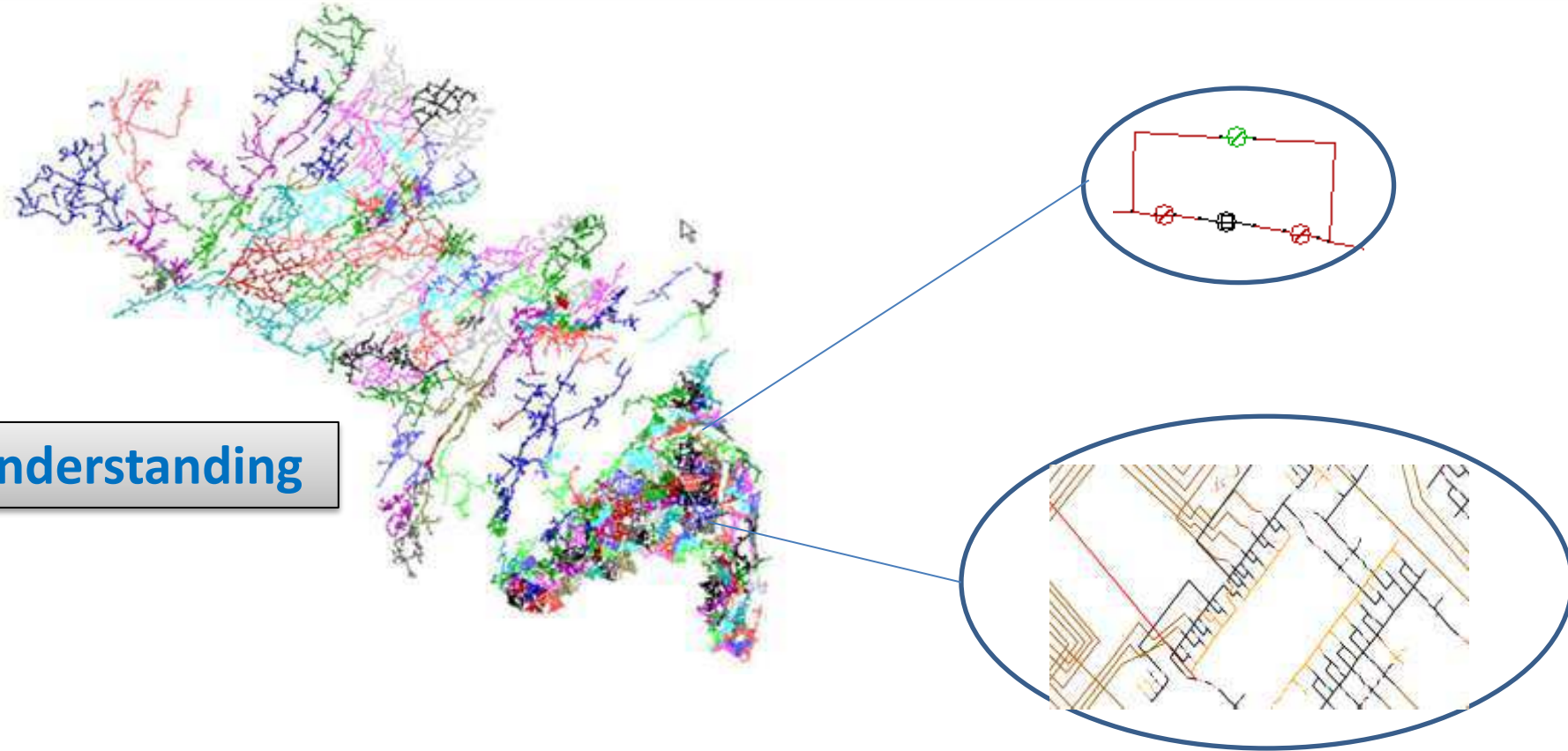
The Best Equivalent Is No Equivalent



Every model simplification leads to elimination of scenarios

Integrated System Model

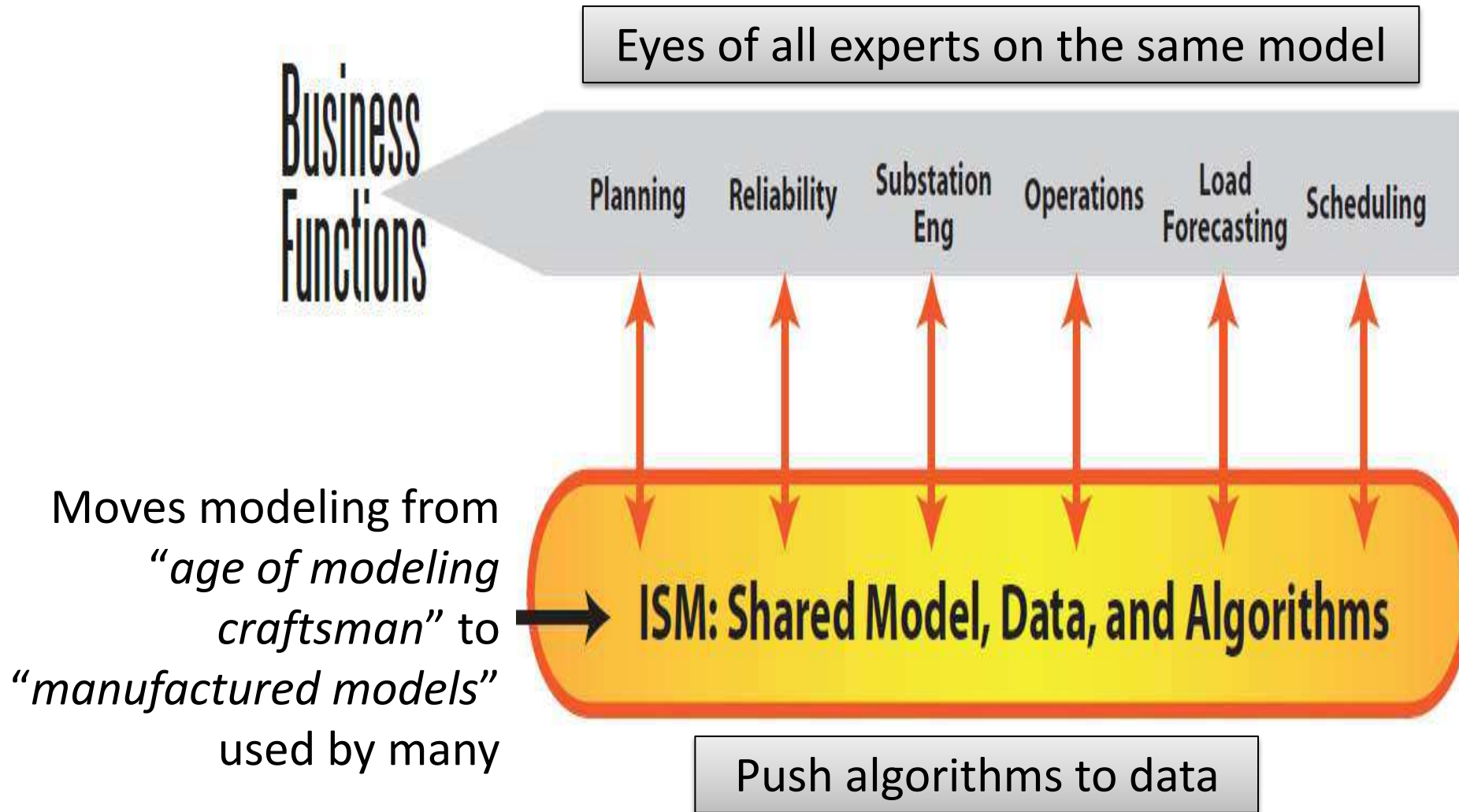
Merge different construction models together, relating all measurements



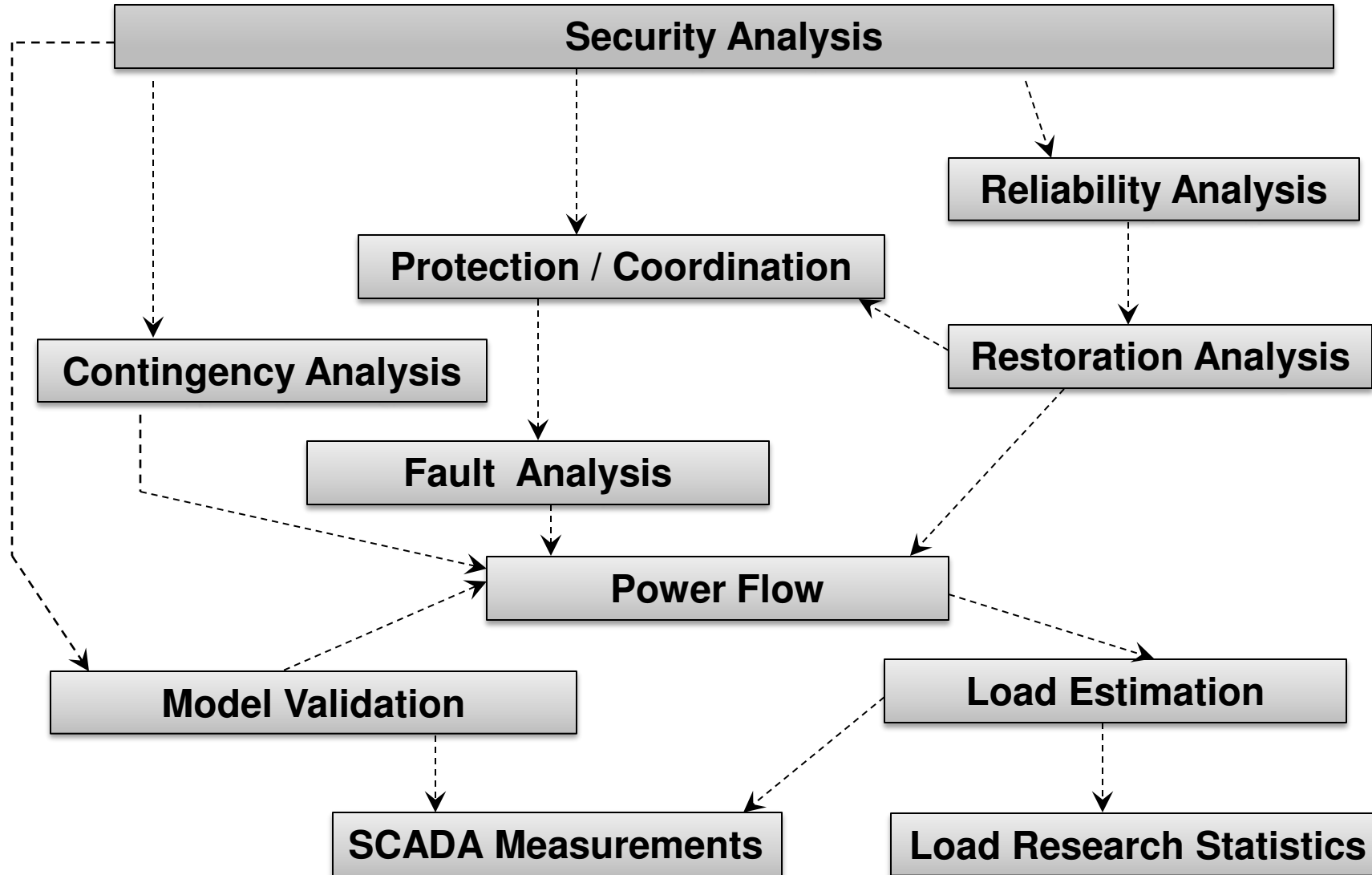
“Aha” understanding

Model for holistic solutions, not point or scenario based solutions

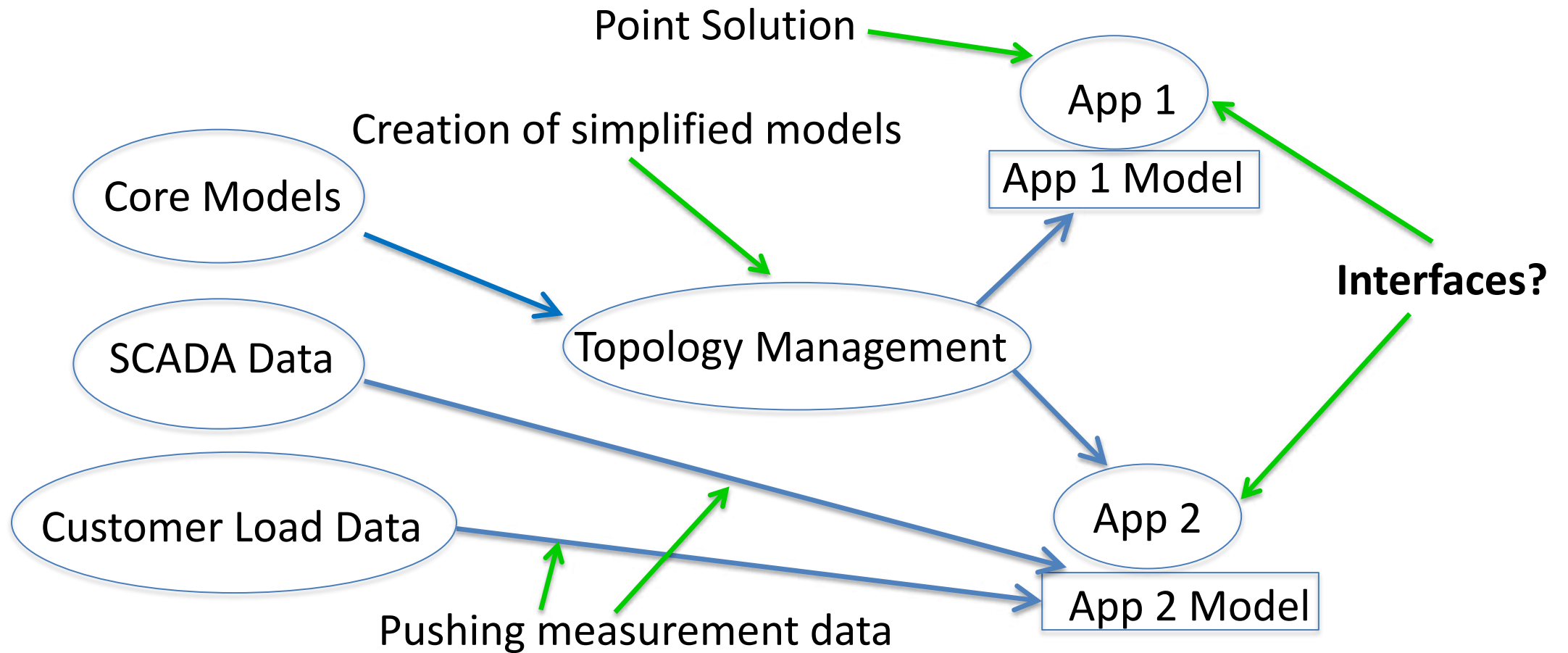
ISM “Living Model” Organization



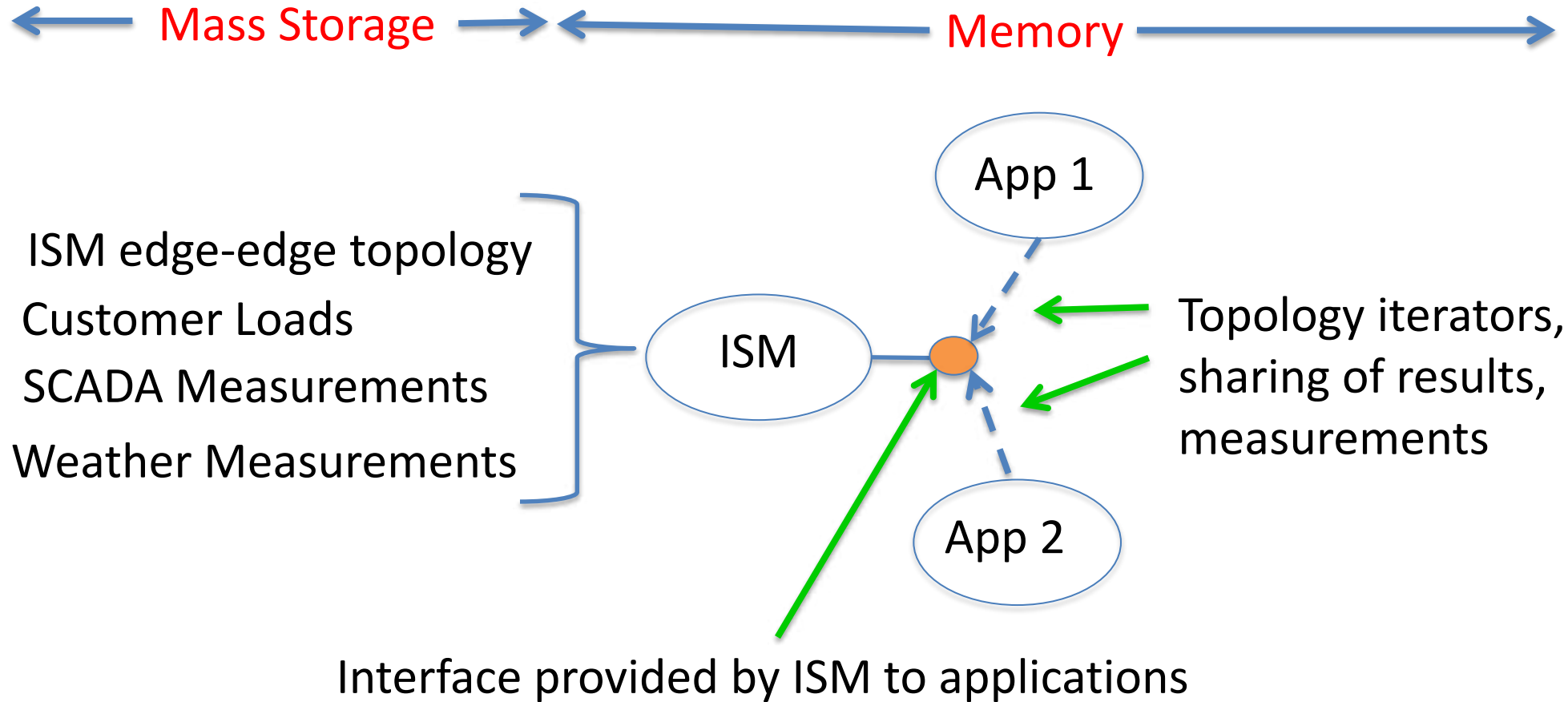
Analysis Collaboration to Build Intelligence



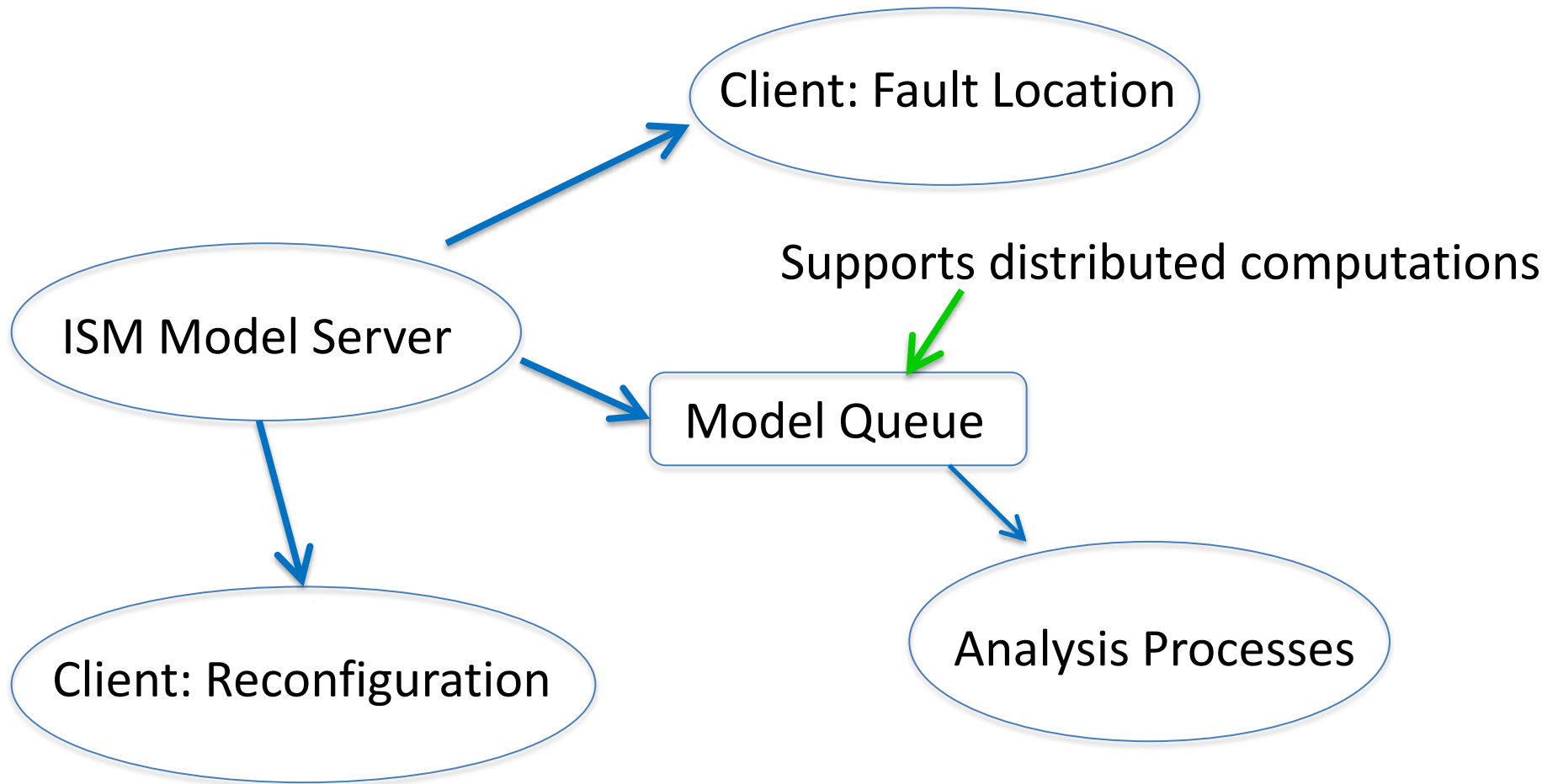
Commonly Used Analysis Architecture



ISM Analysis Architecture



ISM Model Management for Distributed Computation Environment



Wrap Up

- **One model of the entire physical plant that is reused provides**
 - Foundation for solving hard problems
 - Organizational efficiencies and analysis collaborations
 - Automated analysis
- All measurements are related to ISM
- **Building ISM requires significant effort to correct mistakes in existing model data and measurements – “*Living Model*”**
- Graph Trace Analysis is a new approach to topology management and analysis that can be used for algorithms that run on the ISM