Auto-Steered Information-Decision Processes for Electric System Asset Management

Jim McCalley: Electrical Engineering – Power Systems

Vasant Honavar: Comp. Science – Data Integration, ML, Agents

Bill Meeker: Statistics – Reliability, Decision

Daji Qiao: Computer Engineering – Sensor Networks

Ron Roberts: Aerospace Engineering – Nondestructive Evaluation

Sarah Ryan: Industrial Engineering – Stochastic Optimization

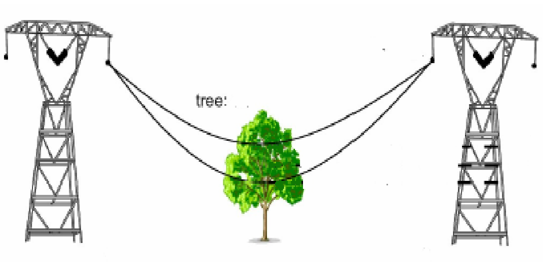
Iowa State University

Power Systems Overview: Transmission

- Commodity market + complex, delicate machine
- Equipment:
  - Ubiquitous, capital-intensive, distributed, failure-prone
  - 150,000 transformers, 600,000 circuit breakers, 254,000 miles of lines. Replacement cost is ~300 billion dollars
- Asset-system management: a decision-science
  - Operate, maintain, expand
- Decision-drivers
  - Equipment health, Failure consequence, Resources

Objective

Develop a hardware-software prototype for auto-steering the information-decision cycles inherent to managing operations, maintenance, & planning of high-voltage electric power transmission systems.



Main Thrusts

- Layer 1: Long-term power system simulation
  - Areva commercial grade simulator (DTS), Iowa/ISU grid
- Layer 2: Sensing and communications
  - One or two field installations on campus, wireless sensors
- Layer 3: Data integration
  - Ontology-based, query-centric, federated
- Layer 4: Converting condition data into failure predictors
  - Steady-state & transient failure probabilities
- Layer 5: Integrated decision algorithms
  - Interacting, rolling, multiobjective, stochastic optimization
  - Two stage info valuation for uncertainty reduction to decide new sensor deployment

Layer 2: Sensing and Communications

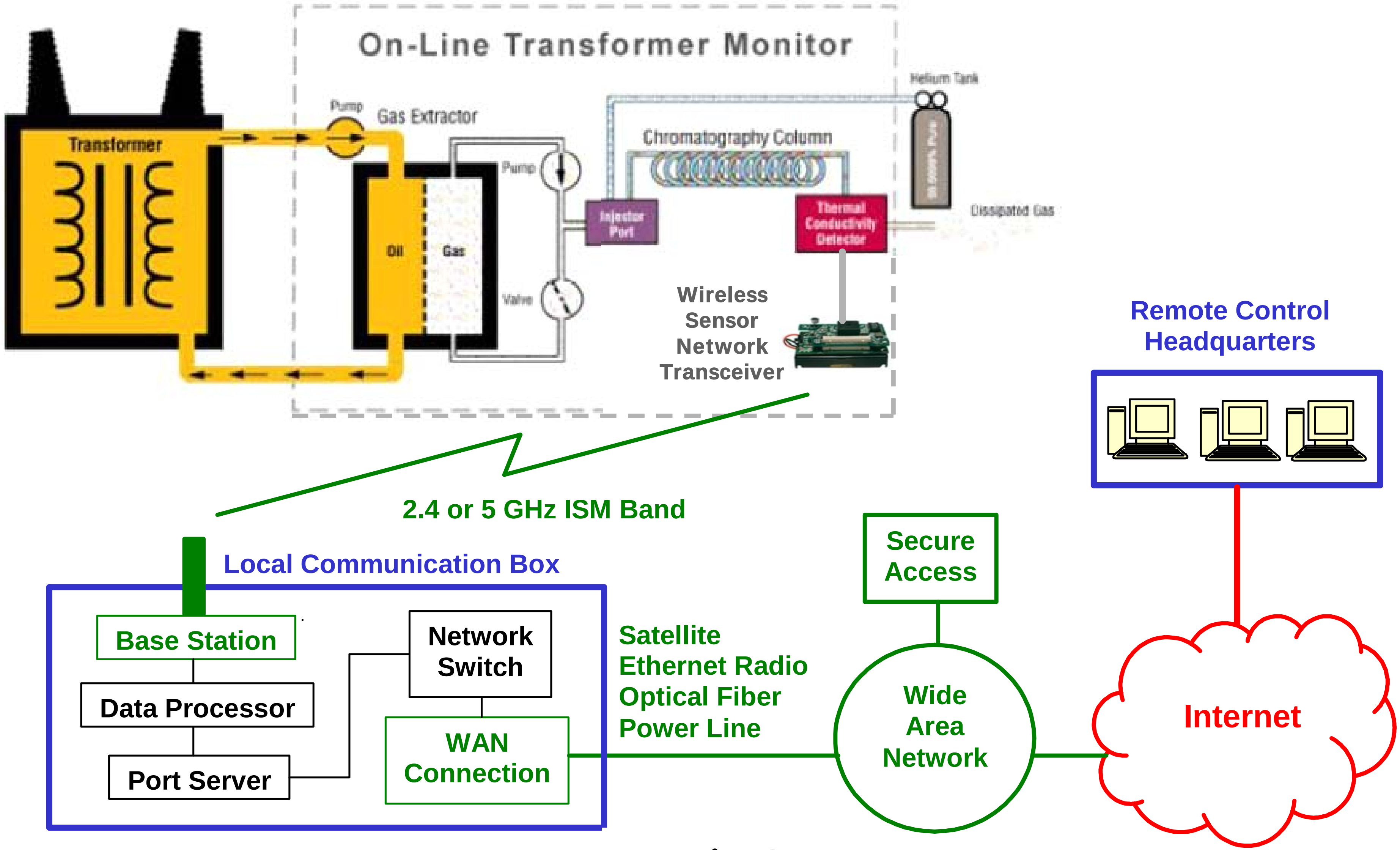
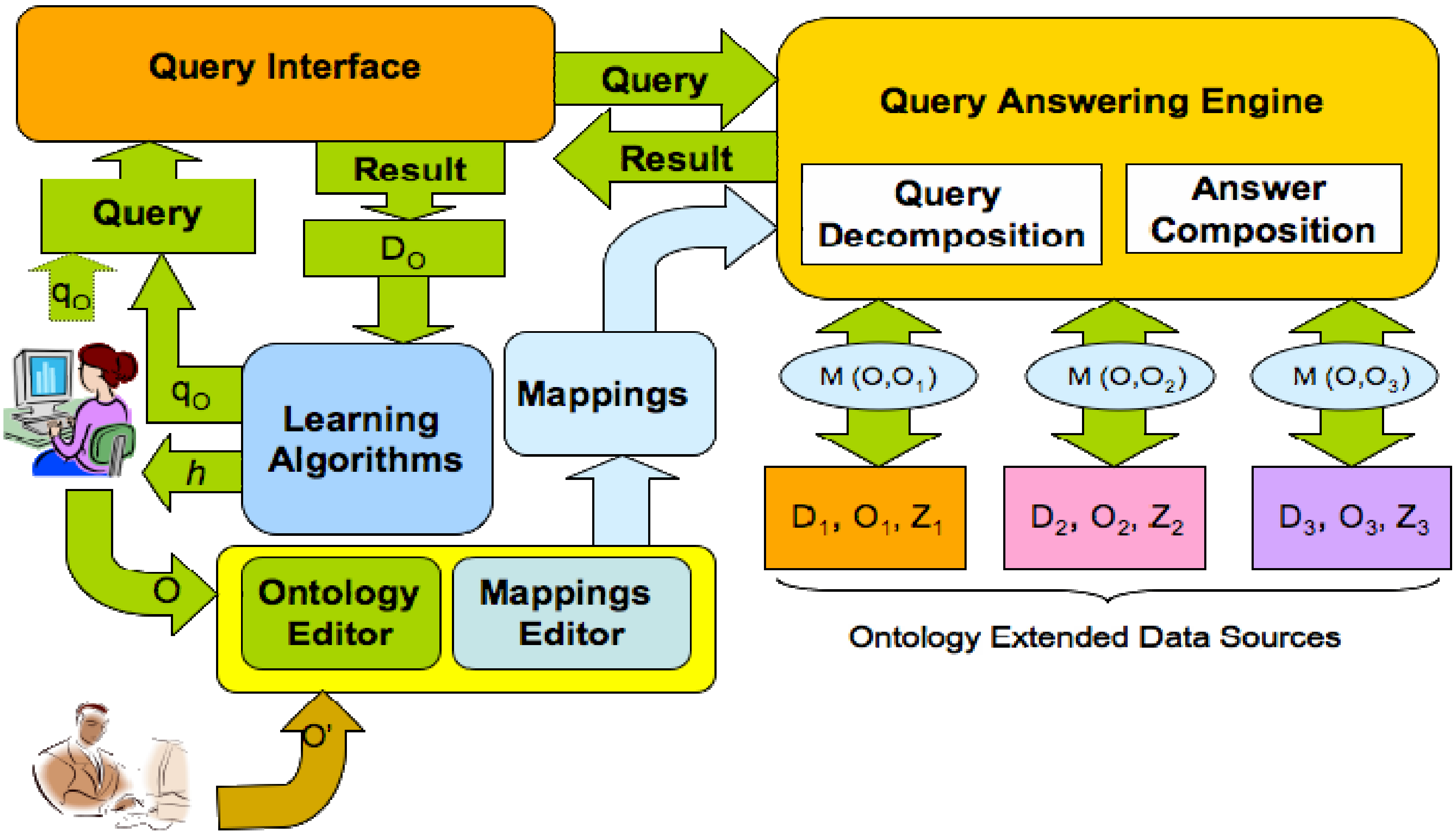


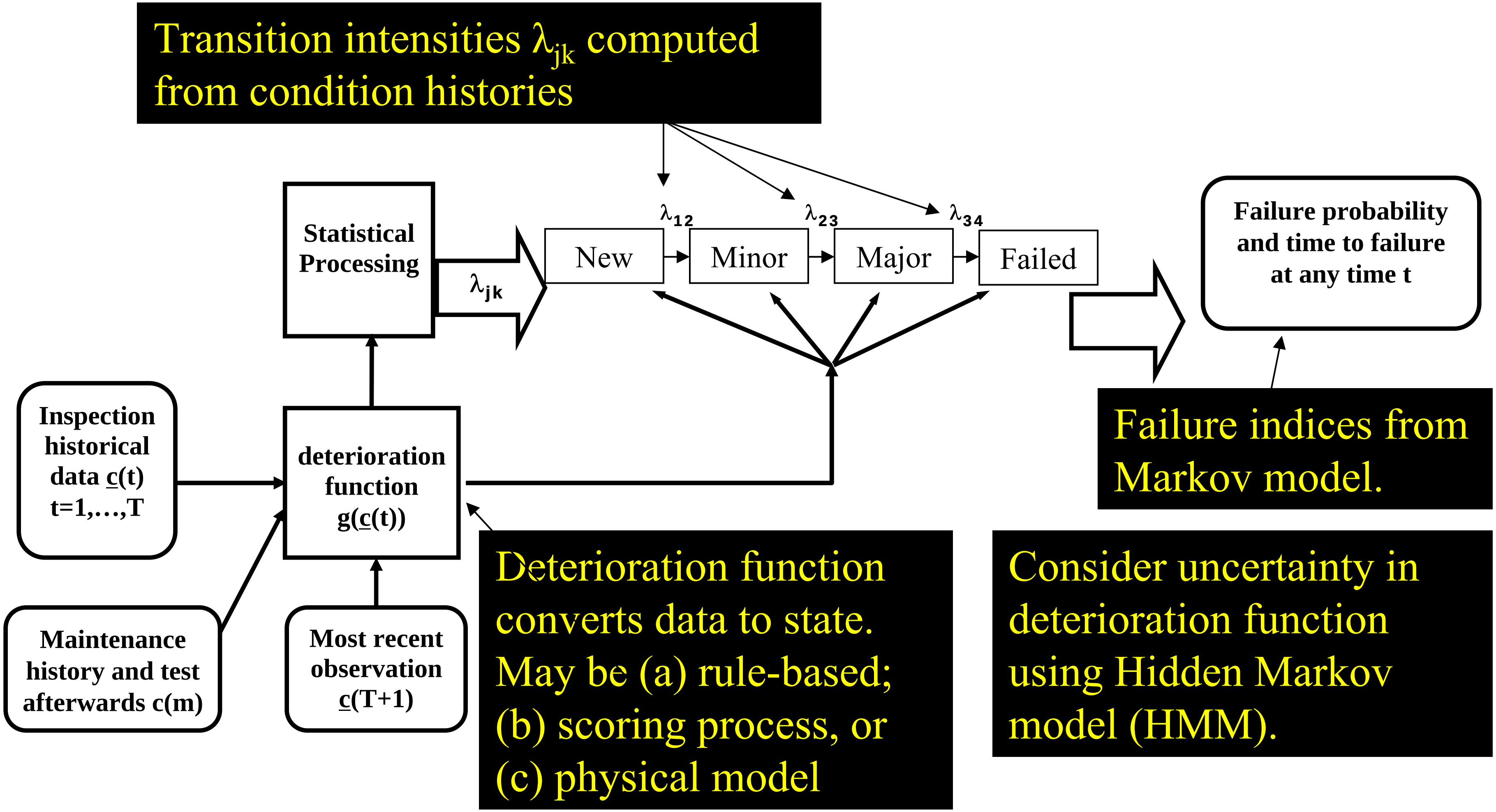
Fig. 2

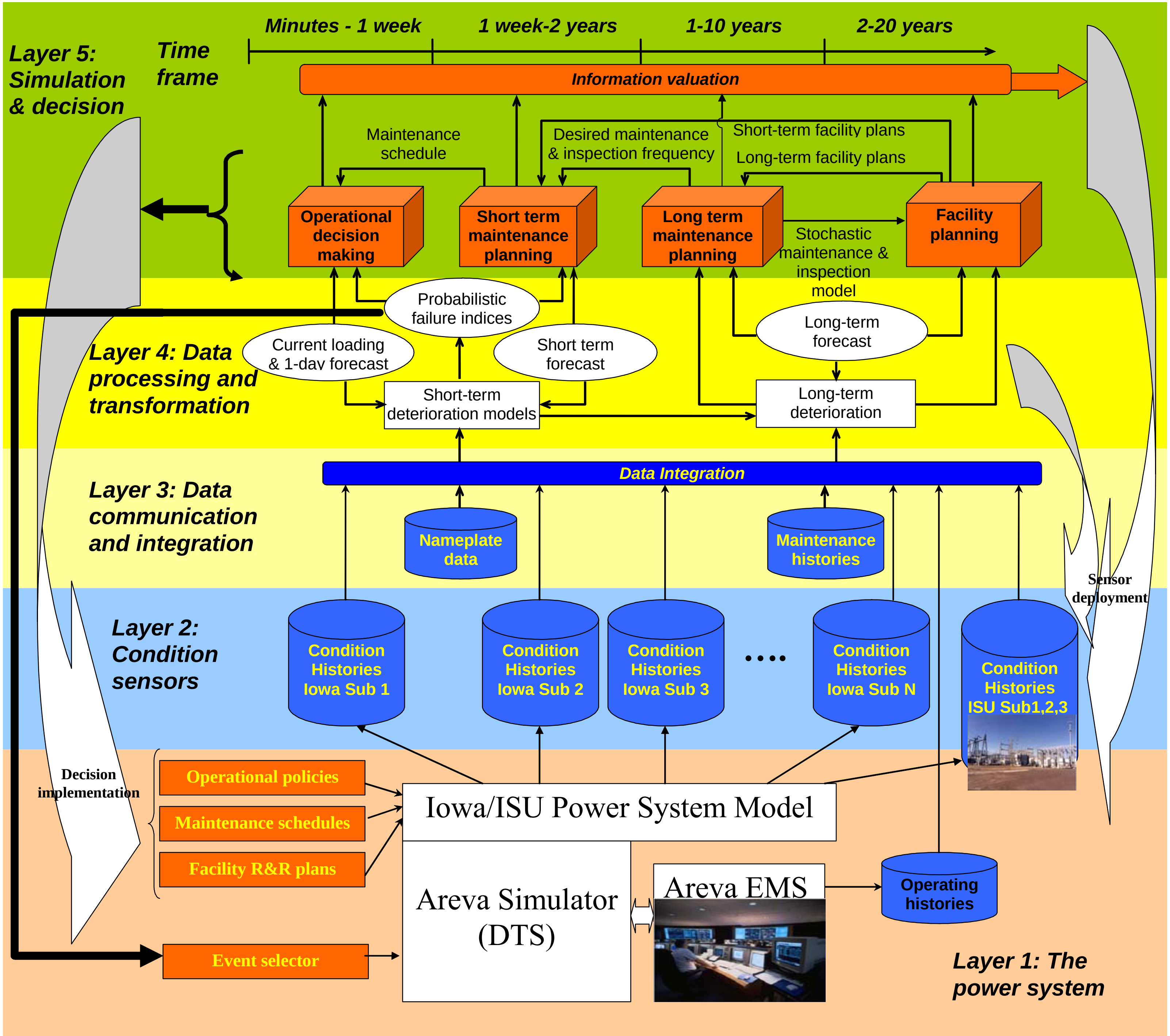
Layer 3: Data Handling and Integration



INDUS: INtelligent Data Understanding System

Layer 4: Data Transformation




Layer 5: Simulation & decision
Time frame
Minutes - 1 week
1 week-2 years
1-10 years
2-20 years
Information valuation
Maintenance schedule
Desired maintenance & inspection frequency
Short-term facility plans
Long-term facility plans
Operational decision making
Short term maintenance planning
Long term maintenance planning
Facility planning
Stochastic maintenance & inspection model
Probabilistic failure indices
Current loading & 1-day forecast
Short term forecast
Long-term forecast
Layer 4: Data processing and transformation
Short-term deterioration models
Long-term deterioration
Data Integration
Layer 3: Data communication and integration
Nameplate data
Maintenance histories
Sensor deployment
Layer 2: Condition sensors
Condition Histories Iowa Sub 1
Condition Histories Iowa Sub 2
Condition Histories Iowa Sub 3
Condition Histories Iowa Sub N
Condition Histories ISU Sub1,2,3
Decision implementation
Operational policies
Maintenance schedules
Facility R&R plans
Iowa/ISU Power System Model
Areva Simulator (DTS)
Areva EMS
Operating histories
Event selector
Layer 1: The power system

Industrial Partners

Cannon Technologies (Mike Cannon) – Sensors, communication networks, & diagnosis from data

TjH2b (Dave Hansen)– Data transformation

ISU Facilities & Management (Randy Larabee) – Access to field installation on campus

Field Installation

Areva T&D (Jay Giri) – Power system simulator; equipment monitoring system.

Field Installation & Simulator

MidAmerican Energy (Ali Chowdhury) – Data

Karen O’connor (Alliant Energy) - Data

Data