Intelligent Control Systems: Integration of Process Control and Predictive Models in a Combined GUI-Based Application

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Context

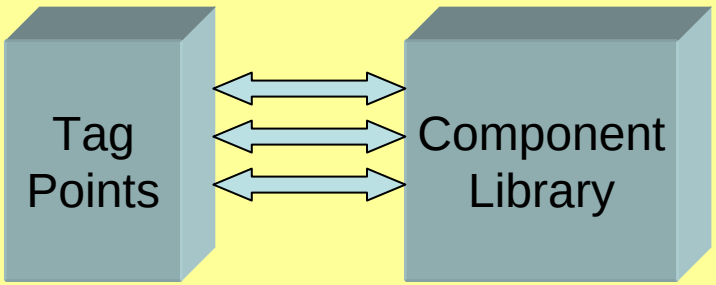
- Process Control
  - PLCs – Programmable Logic Controllers
  - SCADA – Supervisory Control and Data Acquisition
  - “Tag Points” – value reading and control setting
- Specific example:
  - West Point co-generation power plant
  - Intelligent Power Plant project
- Some software mechanisms
  - OPC Server – OLE for Process Control
    - OLE – Object Linking and Embedding
  - COM – Component Object Model
    - DCOM – Distributed COM
  - XML – eXtensible Markup Language

Some Issues and Opportunities

- Existing Interfaces often:
  - are locked-in and inflexible for the operators
  - don't provide dynamic facilities to support modeling, optimization, and control
- Sensor suites – thinking ahead
  - Beyond monitoring - need the right data points for modeling, prediction, optimization, and control
  - May require installation of additional sensors
- Opportunity to create a useful and flexible GUI
  - Provide visualization of what the operators want to see
  - Provide simple mechanisms for what the operators want to do
  - Make it easier for the modelers to build predictors and optimizers
  - Determine how to make it extensible to any process

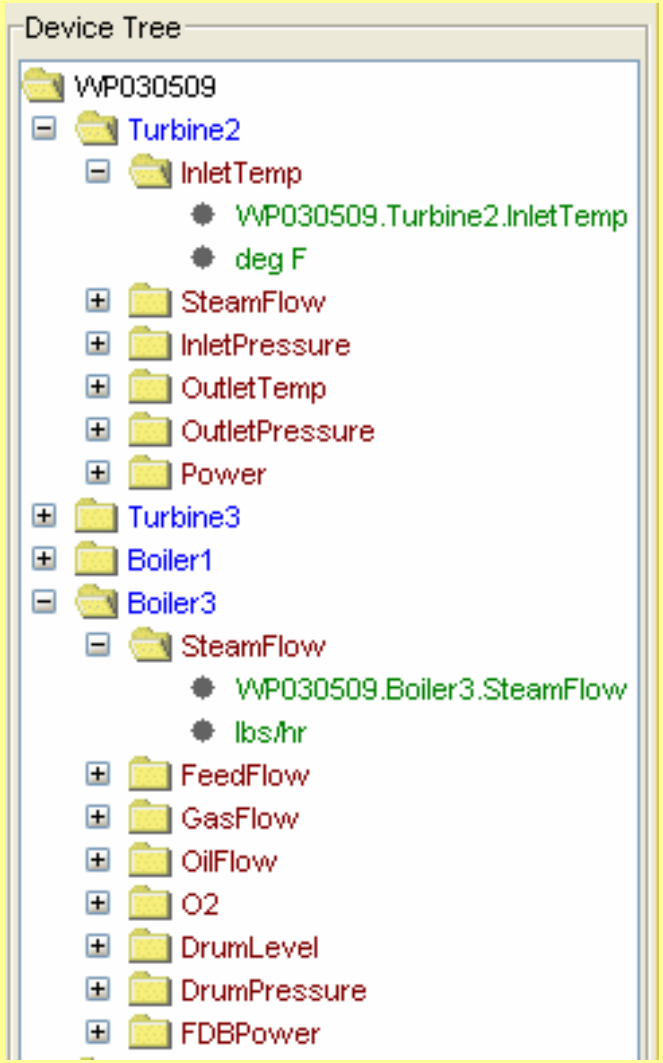
Discovery and Organization

- Discovery
  - Need a mechanism for exploring the exposed data points
  - Need input from the process engineer
- Organization
  - Re-name the data points without losing access to them
  - Hierarchical organization in agreement with intuition
  - Create read and write ability for each tag point
  - Consolidate all of this in a component library



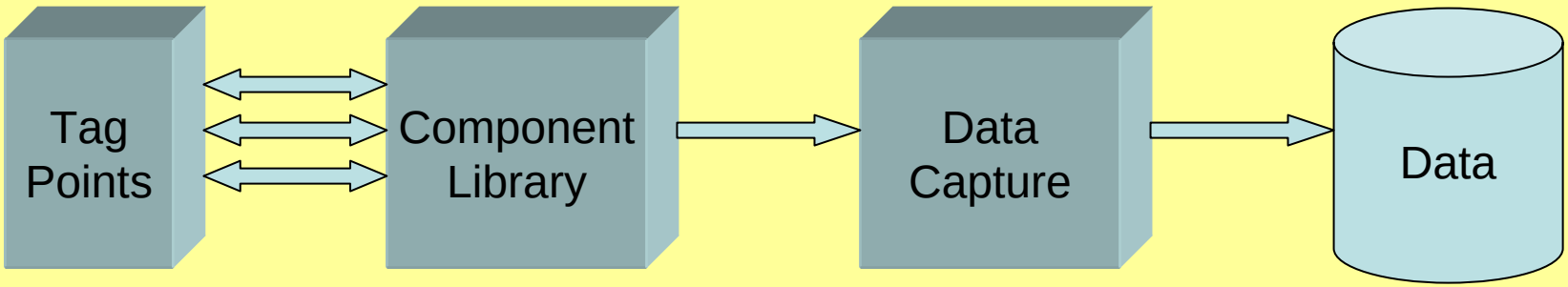
Discovery and Organization

- Model-Based Controller provides this mechanism
  - Component library available for access by other programs
  - Component library also saved in xml
  - *More on this from Nat Frampton*
- What can we do with it?
  - Use it as the sole mechanism for interactions with the process
  - Create a visualization of the component library, such as the hierarchical tree shown here.



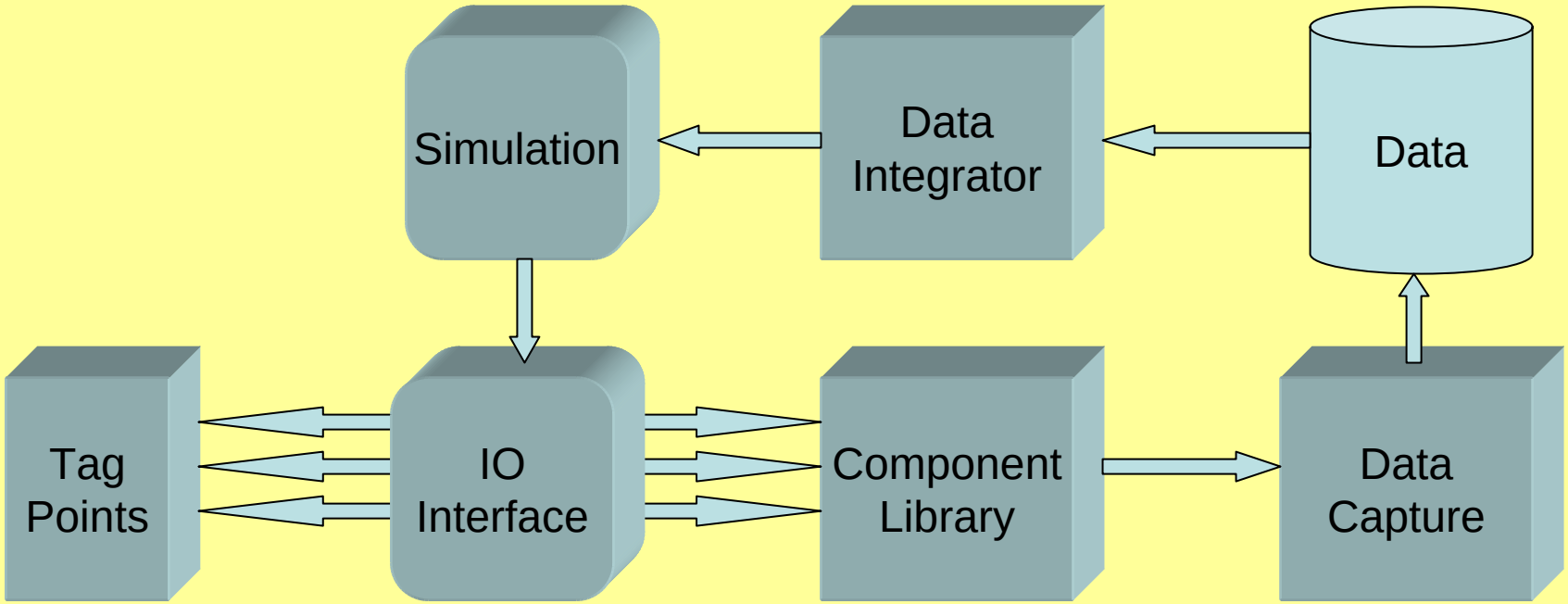
Data Capture

- Data Capture Module
  - Select single tag points or entire hierarchies to capture
    - The operator knows the data that is desired
    - Provide a standard mechanisms that computer users understand
      - Double-click, appear in list
      - Drag from tree, drop into list
  - Select time interval, and record timestamps
  - Save recorded data to the database
  - Can use *any* component library – don't have to create a new data capture mechanism for each process



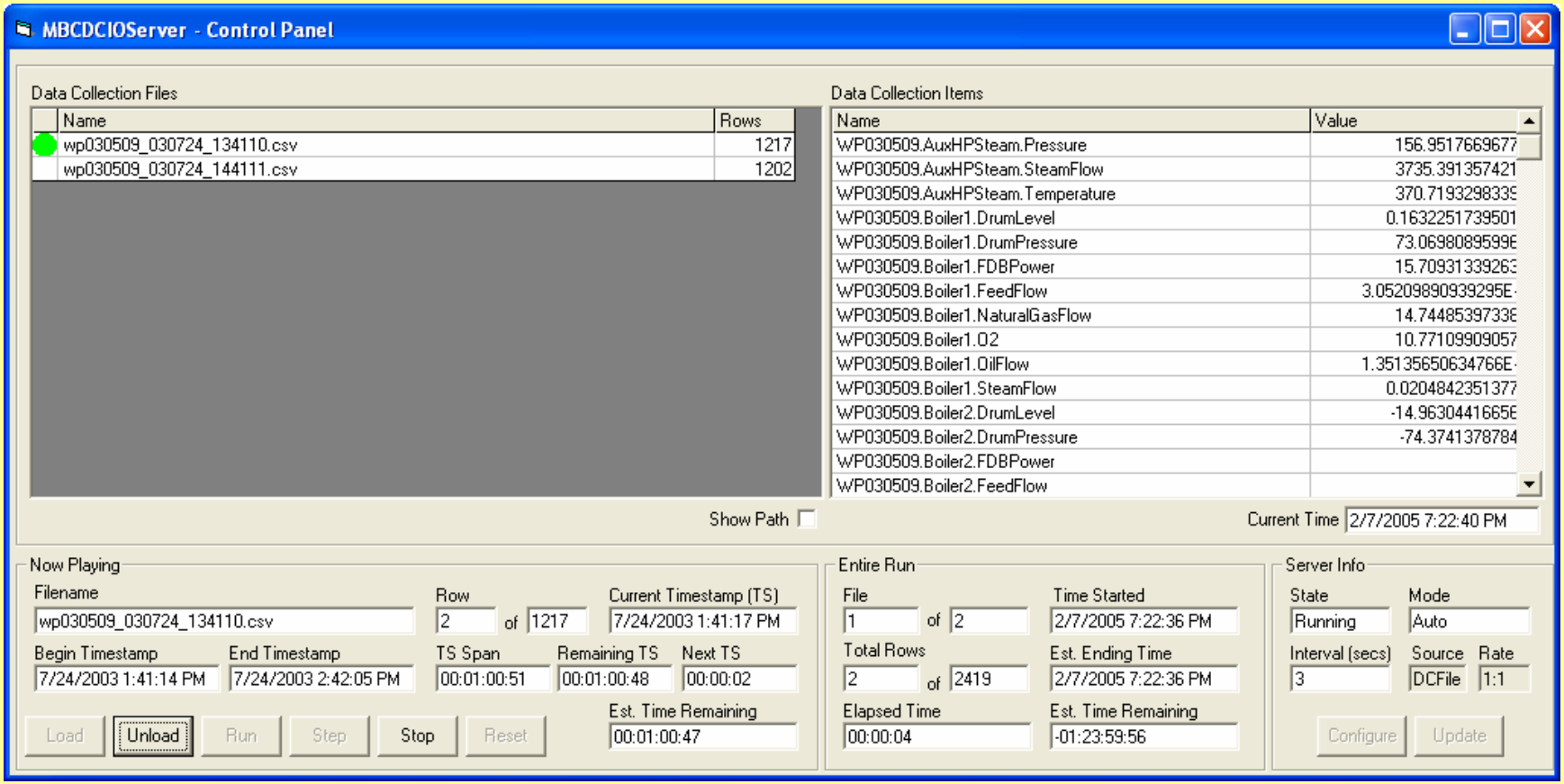
Simulation

- Simple mechanism for incorporating simulation
  - Insert an IO Interface module before the Component library
  - Switch it to read data directly, or from the simulation
  - Simulation pulls the data through a Data Integrator
  - Data source is transparent to users of the Component Library



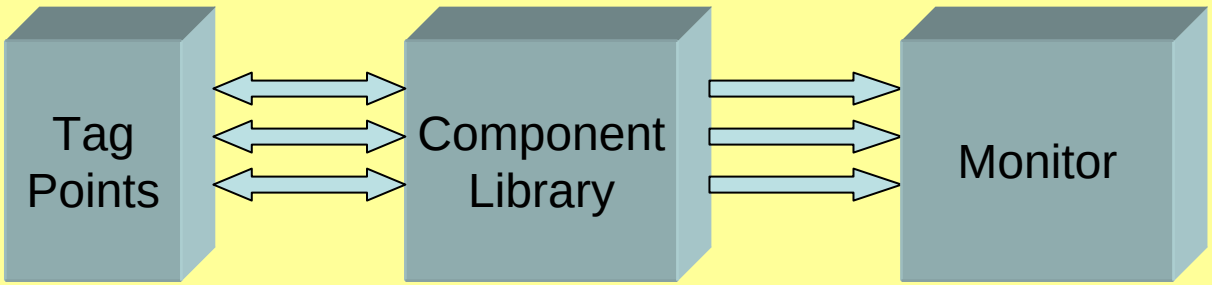
Simulation - Image

- Select and load the data files of interest, then run the simulation



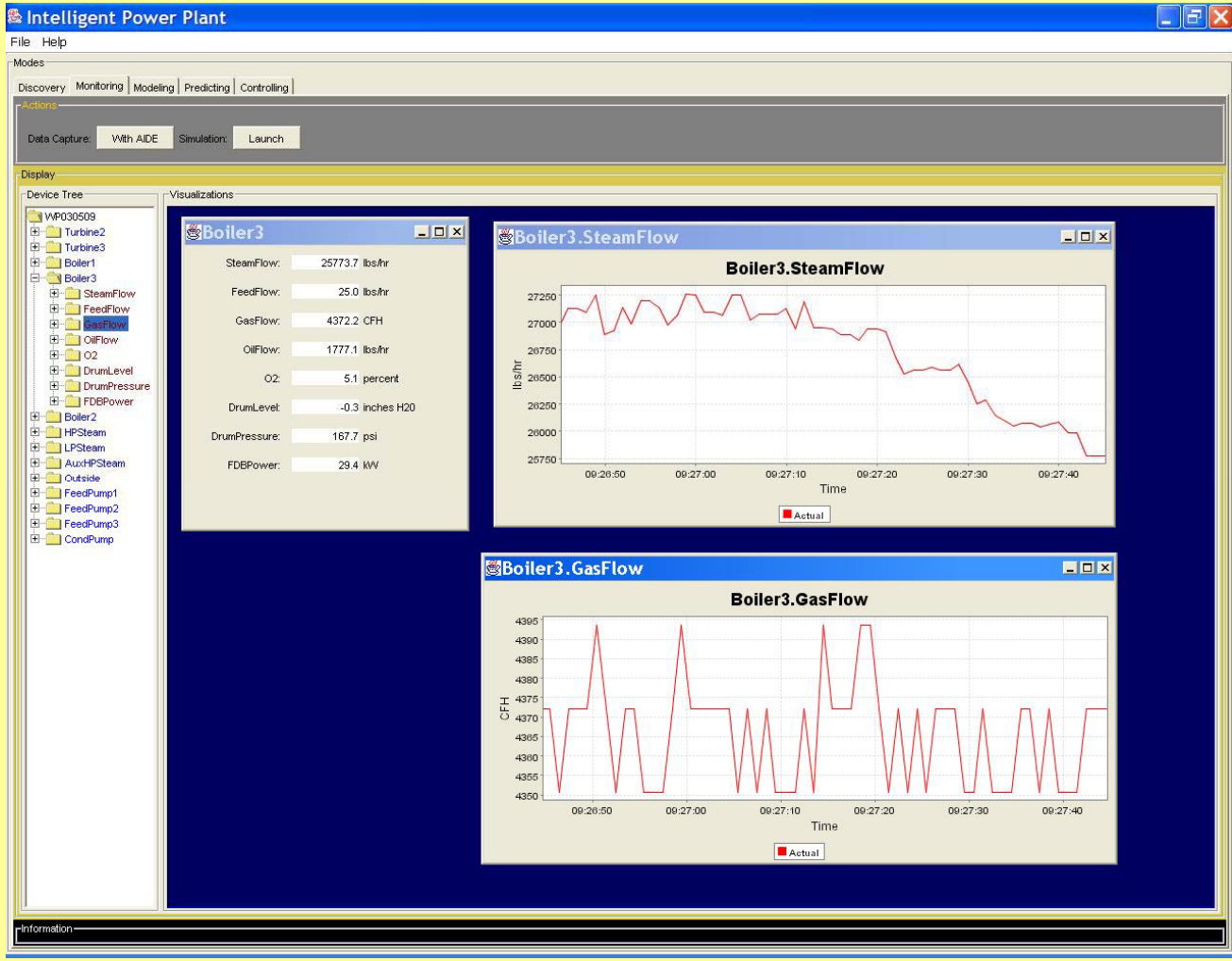
Process Monitoring

- Tag Points of Interest
  - We have a visualization of the (re-named) tag points
  - Behind that, we have the means of reading the tag points
- Methods for Presenting the Readings
  - As text
  - As a graph
- Comparison of Different Tag Points
  - Trend graphs are synchronized in time
  - Snapshots of text and graph displays can be captured



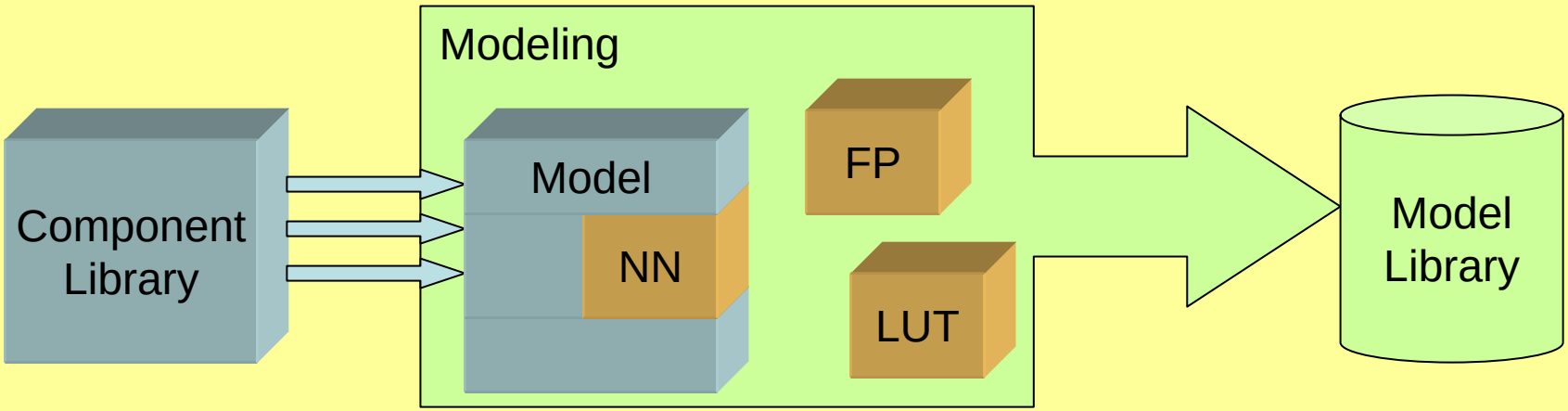
Process Monitoring - Image

- Example
  - Drag and drop from the hierarchical tree
- Features
  - Source independence
  - Flexibility
  - Live or replayed data



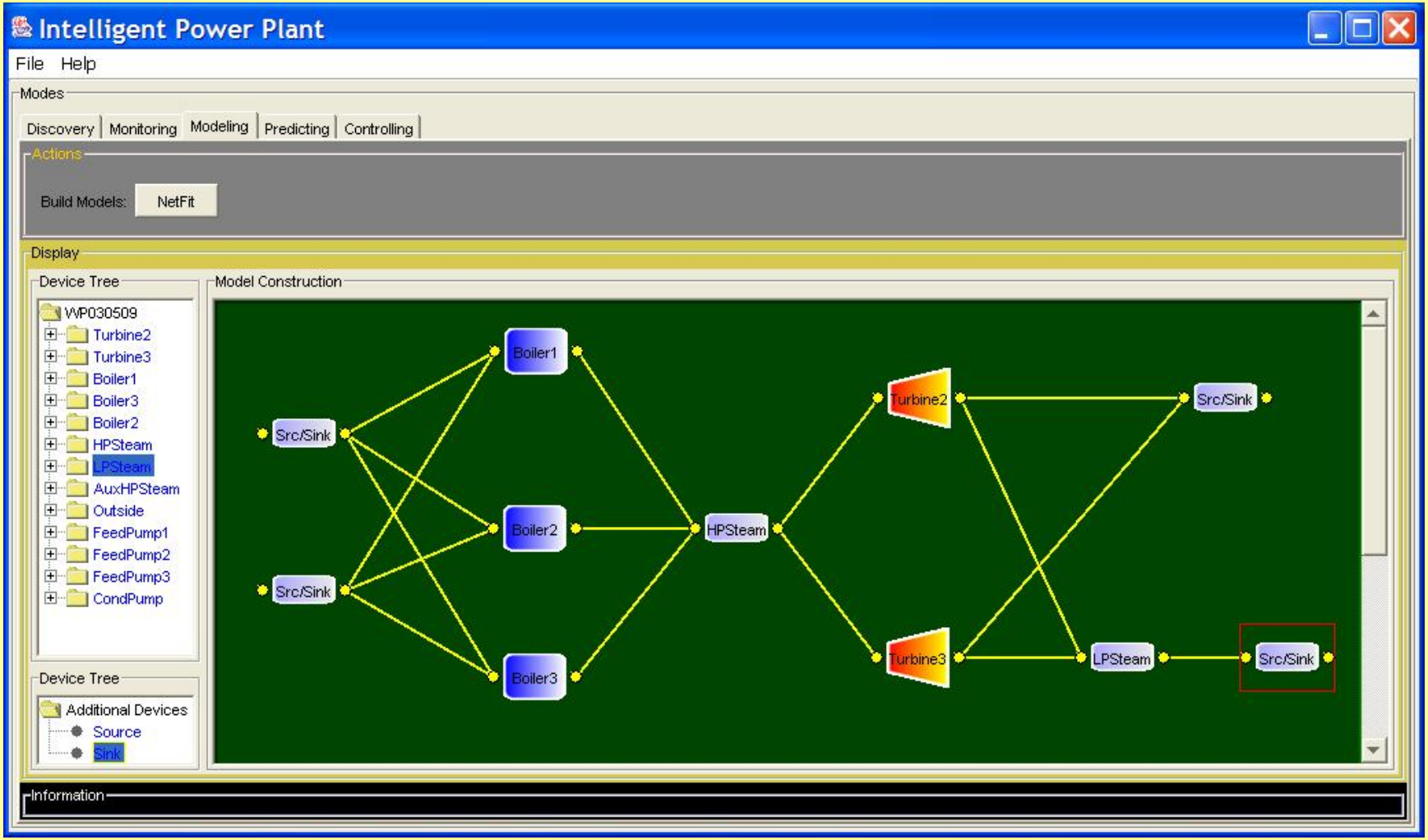
Modeling

- Models based on tag points of interest
  - Select tag points from the component library
  - Remember that the data might be live or simulated
  - Modeling may be counter-intuitive (what follows what?)
- Different model types to “plug in”
  - First principles, look up tables, neural networks, etc.
  - More on model creation and neural networks from Peter Curtiss



Component Modeling

- Model tied to the components from the library

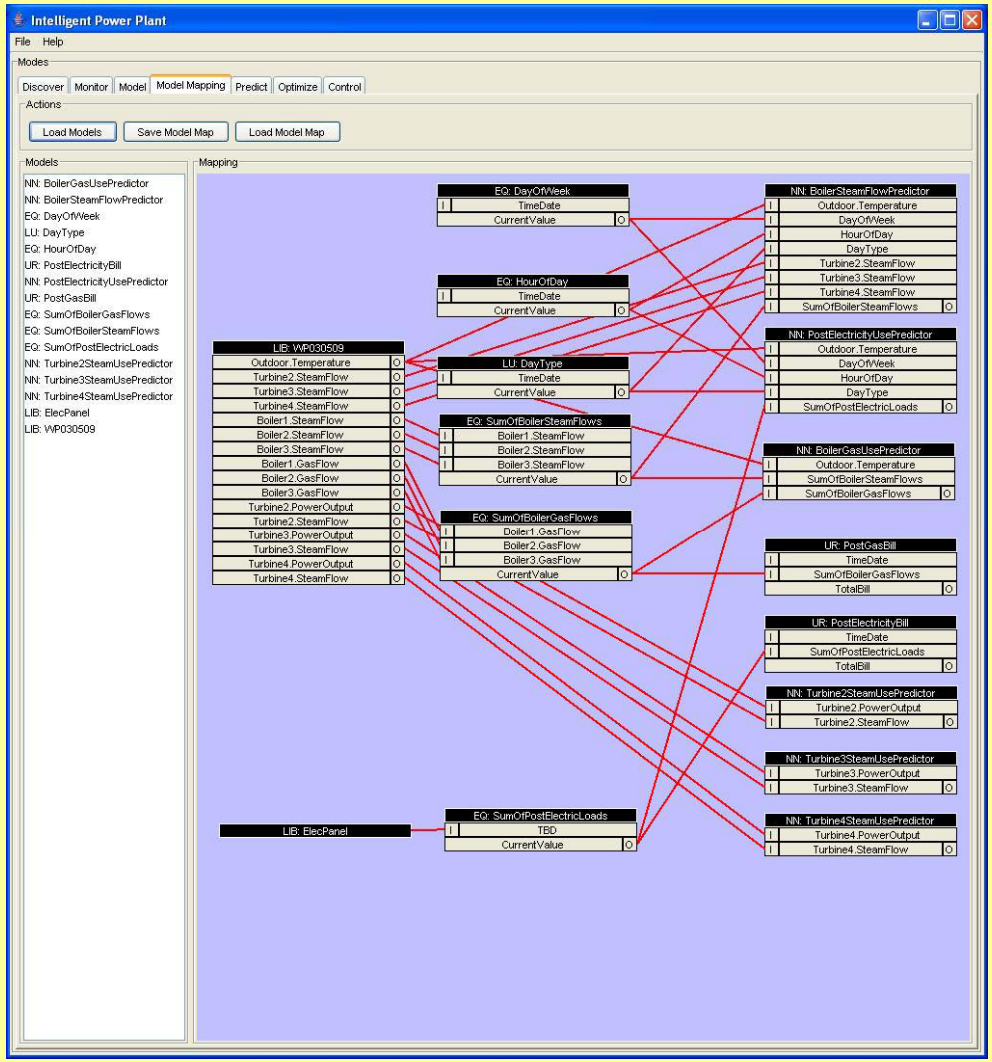


Process Modeling

- Extended Modeling
  - Lots of things that affect the model (and predictions based on it) may not be included in the tag-points.
  - Examples from the USMA Power Plant:
    - Student attendance
    - Weather (trend, not instantaneous)
    - Others already mentioned by Darrell Massie
  - Might need to get these from external sources
    - Security issues! More on this from Scott Lathrop
- More sophisticated modeling
  - Decouple the models from the components
  - The output of some models may be the inputs of other models
    - Need mechanism for composition of the meta-models

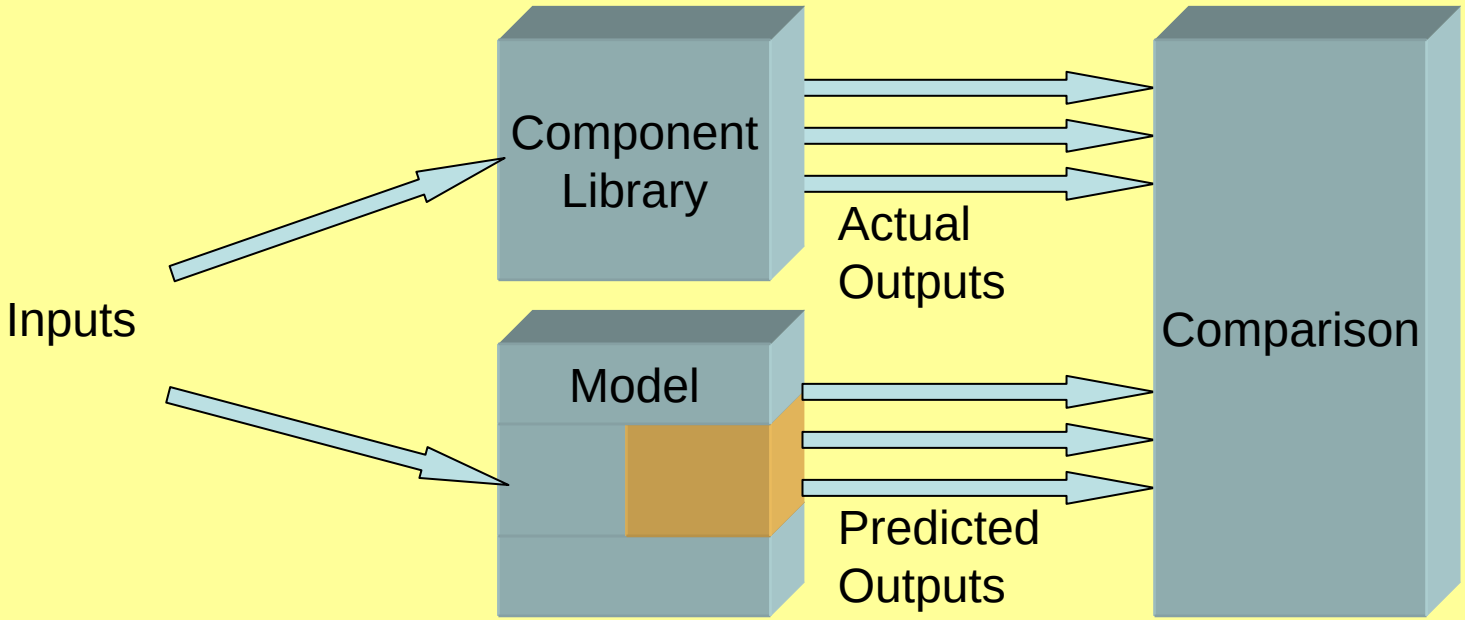
Model Visualization and Mapping

- Visualizing the models
  - Name, Inputs, Outputs
- Making the connection
  - List the models from the model library
  - Drag them onto the mapping field
  - Drag the output from one model to the input of another
  - Collapse/expand models for clarity
- Works for any model



Modeling Validation and Verification

- Validation
  - modeling the correct objects (input from the process engineer)
- Verification
  - modeling the objects correctly
- Statistical measures of accuracy

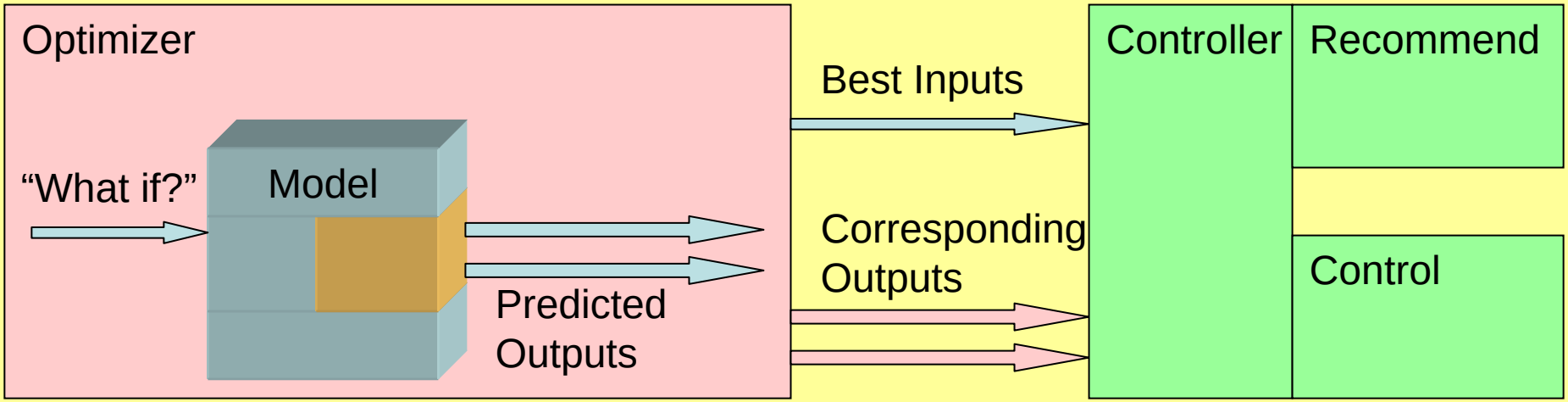


Prediction - Image

- Correct models
  - can be used for making predictions
- Visualization
  - of predictions by themselves
  - of predictions versus actual data
  - helps people see the accuracy (or inaccuracy)

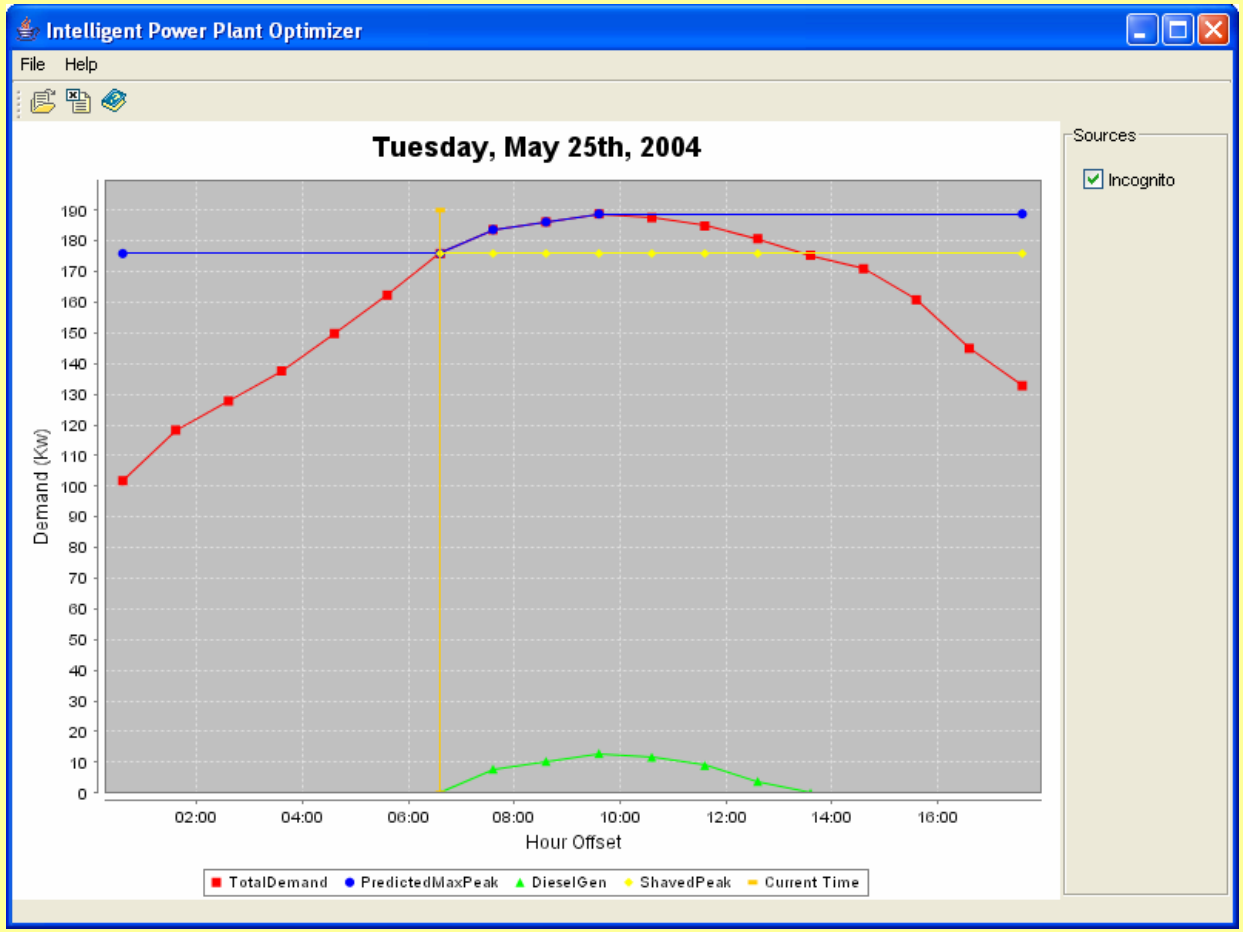
Optimization and Control

- Optimizer
  - Feeds “what if?” inputs to the model(s)
  - Records the best combination
  - Sends the best combination to the controller
- Controller
  - Can recommend control settings to the operator
  - Can control the process directly (through the component library)



Optimization and Control - Image

- Visualization
  - helps the operator believe the recommendation



Conclusions

- The ability to discover, re-name, and organize tag points into an easily understood component library serves as the foundation for the other operations described here.
- Basing the other operations on the component library significantly reduces the amount of custom programming required.
- Graphical interfaces and visualizations:
  - make data capture, monitoring, etc., accessible to the operator.
  - make model creation and mapping easier for the modeler.