EPRI's HEATXPRT™ Heat Rate Improvement Advisor

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Abstract

HEATXPRT is a software tool EPRI has been developing to help utility personnel improve heat rate by diagnosing heat rate problems on-line in fossil power plants. When implemented in a plant, HEATXPRT will apply expert system methods to on-line plant data and calculated performance parameters to provide continuous advice to operators and engineers on causes of heat rate problems. HEATXPRT is PC-based and operates on Microsoft Windows software; it uses plant data input directly from existing performance monitors.

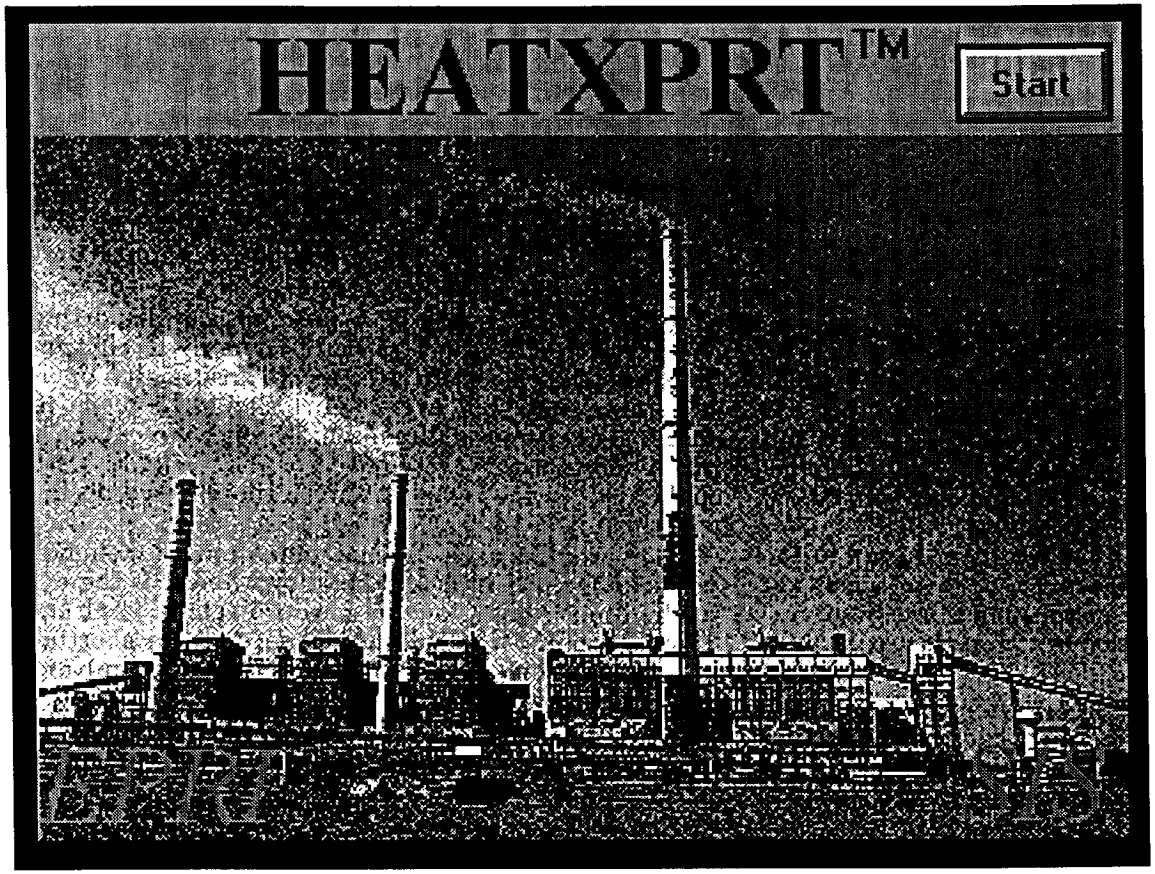
Influence diagrams and probability tables are the cornerstones of HEATXPRT's reasoning powers. This approach makes it easier to represent how plant parameters related to one another. It's simpler to capture and modify expert knowledge with influence diagrams and probability tables than it is with a conventional rules-based approach. This in turn makes it easier to customize HEATXPRT for individual units.

Prototype Version 2.0 is an off-line system comprising a sensor validation module, a friendly graphical user interface and all major knowledge elements of a power plant including feedwater heaters, boiler, turbine, cooling water system, pumps, and fans. It was validated last year with data from Basin Electric Cooperative's Antelope Valley Unit 1.

The details of HEATXPRT will be presented.

HEATXPRT™
Heat Rate Improvement Advisor

John Tsou, EPRI Project Manager (415) 855-2220



HEATXPRT

EPRI's On-line Expert System will Help Plant Personnel Improve Power Plant Efficiency by Identifying Causes of Heat Rate Problems and Suggesting Corrective Actions

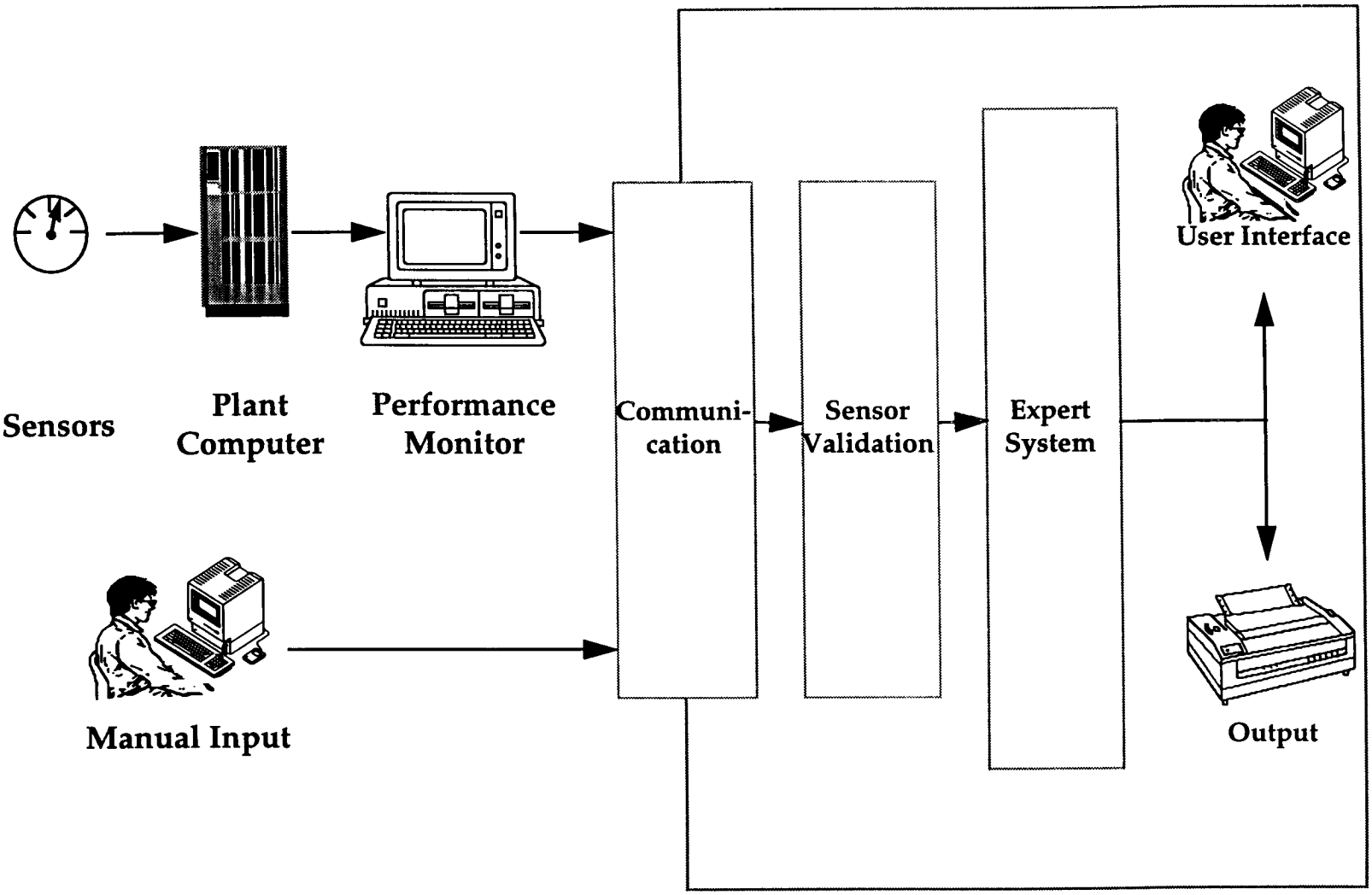
HEATXPRT Description

- **PC-based software links with plant DAS and performance monitor**
- **Continuously analyzes data to**
  - **Validate sensor readings**
  - **Identify abnormal performance**
  - **Pinpoint probable cause**
  - **Suggest corrective actions to operator**

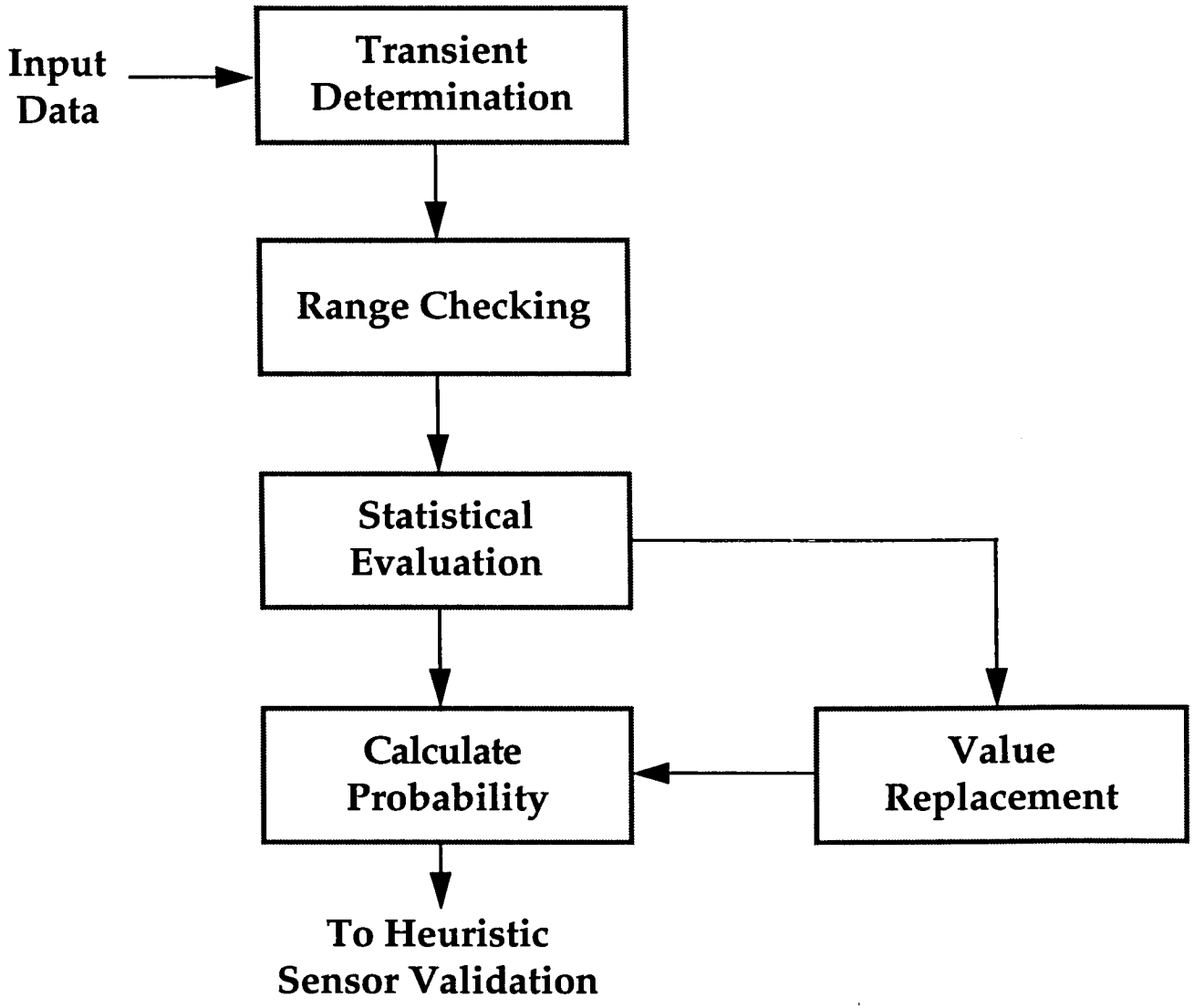
HEATXPRT Objectives

- **To improve plant heat rate by quickly identifying the cause of abnormal performance**
- **To provide a heat rate improvement tool for both plant operators and engineers**
- **To provide information on validity of instrumentation**

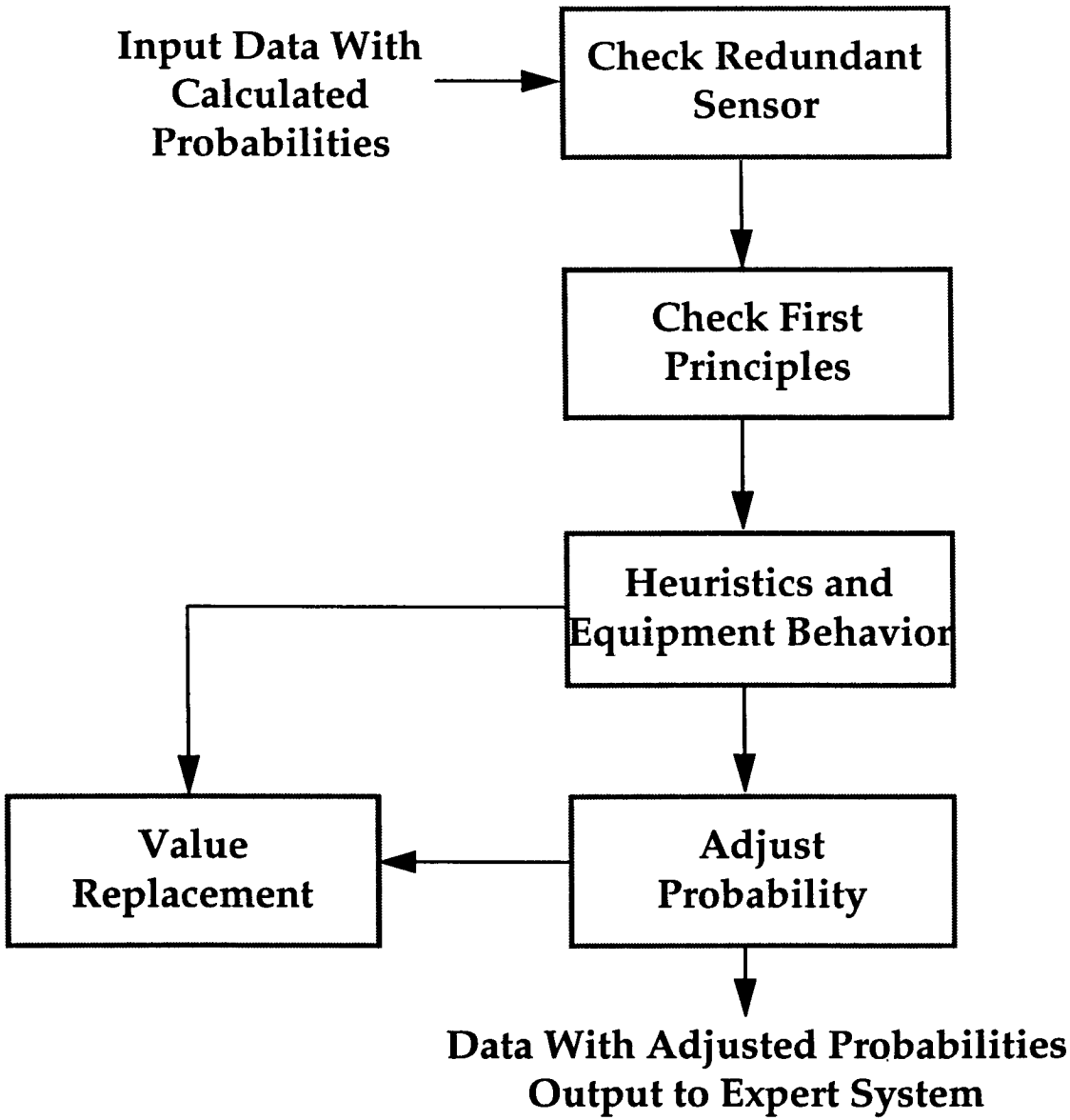
HEATXPRT Architecture



Algorithmic Sensor Validation



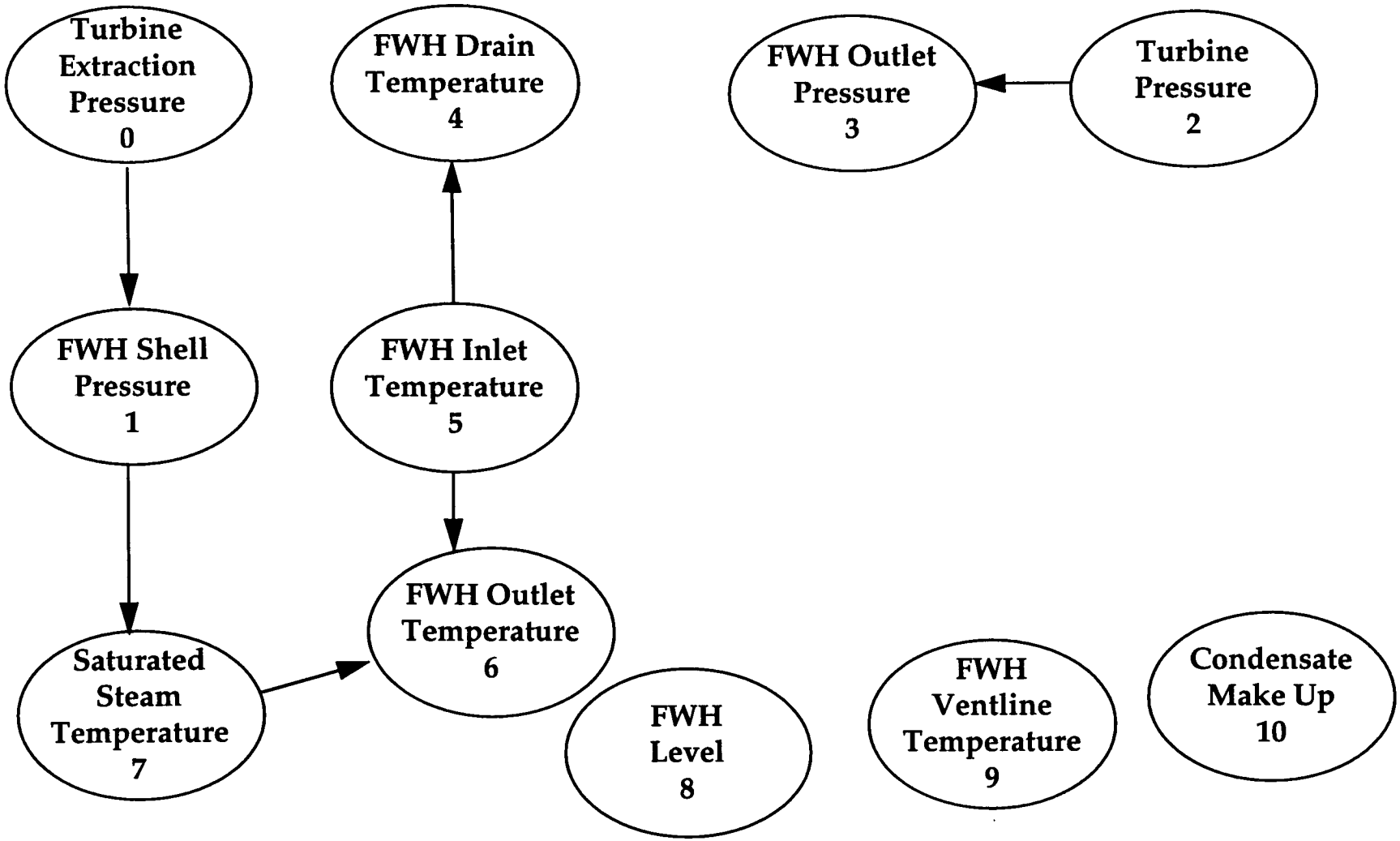
Heuristic Sensor Validation



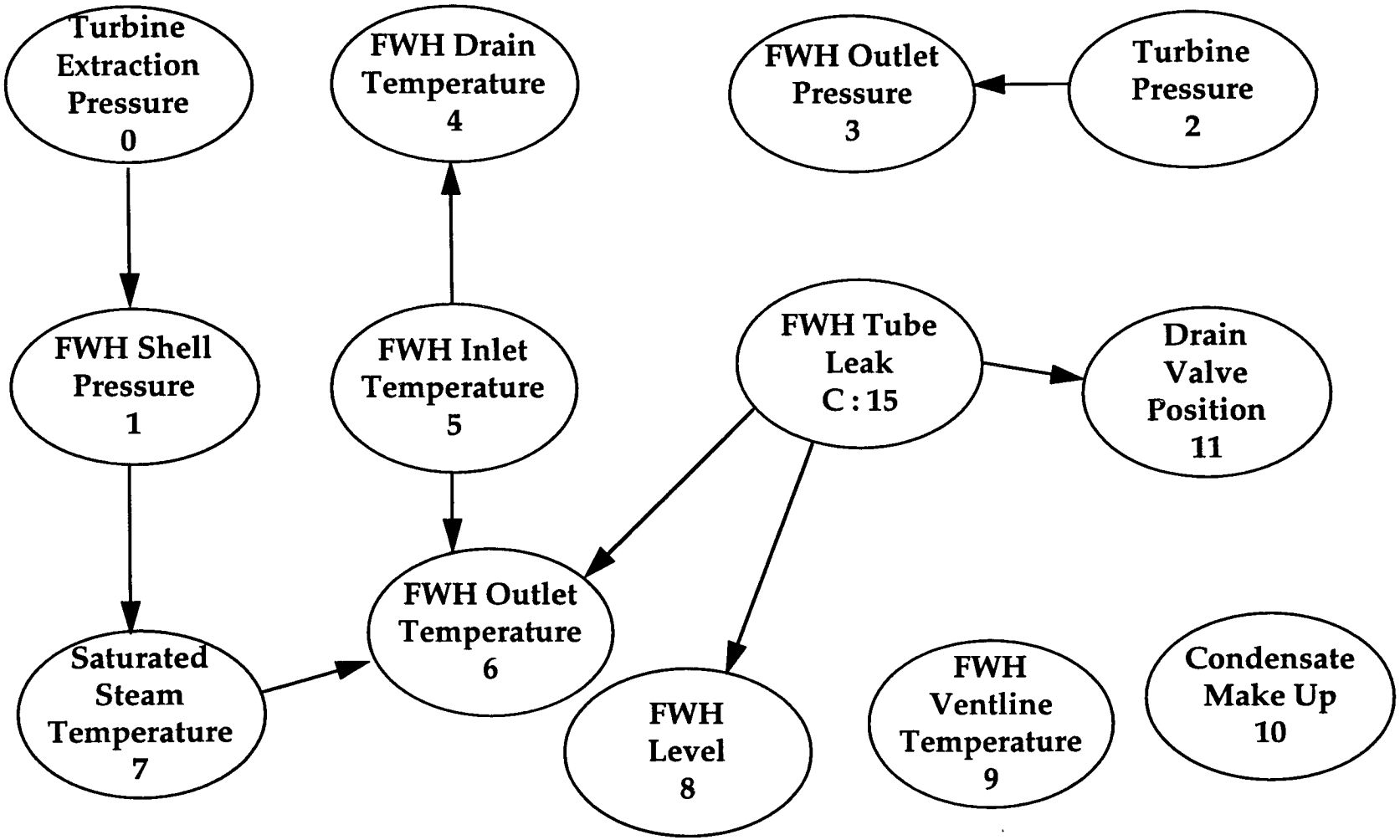
Expert System Approach

- Knowledge is represented by influence diagrams
- Influence diagrams are easy to develop in generic form
  1. Link parameter-to-parameter dependencies
  2. Then map cause-to-parameter influences
- Probabilities are assigned, customized for each plant
- Validated data sets are processed through the probability tables

Parameter-to-Parameter Influence Diagram for Feedwater Heater



Cause-to-Parameter Influence Diagram for Feedwater Heater Tube Leak



Parameter-to-Parameter Probability Tables for Feedwater Heater

1: Feedwater heater shell pressure (Subject parameter)
0: Turbine extraction pressure (Influencing parameter)

1/0	Low	Normal	High
Low	0.80	0.20	0.00
Normal	0.05	0.90	0.05
High	0.00	0.20	0.80

3: Feedwater heater outlet pressure
2: Feedwater heater inlet pressure

3/2	Low	Normal	High
Low	0.80	0.20	0.00
Normal	0.05	0.90	0.05
High	0.00	0.20	0.80

Combined Probability Table for Feedwater Heater Tube Leak

15	5	7	6		
			Low	Normal	High
T	Low	Low	0.85	0.10	0.05
T	Low	Normal	0.70	0.20	0.10
T	Low	High	0.35	0.35	0.30
T	Normal	Low	0.70	0.20	0.10
T	Normal	Normal	0.30	0.65	0.05
T	Normal	High	0.20	0.60	0.20
T	High	Low	0.35	0.35	0.30
T	High	Normal	0.20	0.60	0.20
T	High	High	0.15	0.55	0.30
F	Low	Low	0.80	0.20	0.00
F	Low	Normal	0.50	0.45	0.05
F	Low	High	0.20	0.20	0.60
F	Normal	Low	0.78	0.20	0.02
F	Normal	Normal	0.05	0.90	0.05
F	Normal	High	0.02	0.20	0.78
F	High	Low	0.50	0.27	0.23
F	High	Normal	0.05	0.45	0.50
F	High	High	0.00	0.20	0.80

6: Feedwater heater outlet temperature
7: Saturated steam temperature
5: Feedwater heater inlet temperature
15: Feedwater heater tube leak

- Assumed prior probability of the cause is T : 0.02, F: 0.98
- Assumed prior probability of all other parameters is L: 0.05 N: 0.90 H: 0.05

HEATXPRT Status

- HEATXPRT Prototype Version 2.0 available
- EPRI looking for partners for implementation
- Tailored collaboration opportunity
- Contact John Tsou (415) 855-2220