

# IPRO 303

Information Design for  
Plant Management to  
Predict Equipment  
Failure

# Introduction

The goal of IPRO 303 was to design a User Interface (UI) for monitoring and predicting equipment failures in coal fired power plants.



# Project Team Members

- **Instructor:** Edmund C. Feldy PE
- **Sponsors:** SmartSignal ®
- **IPRO Team:** Jacob Dodds, Samad Erogbogbo, Rachel Fleming, Haruko Fujimoto, Nirav Hazariwala, Jihyung Kim, Sangwook Lee, Arthur McAnally, Ray Simons

# SmartSignal®

- SmartSignal® is a corporation that provides applications to increase equipment performance by means of predictive analysis.
- SmartSignal's clients include a number of major power plants nationwide and worldwide.
- The mission of SmartSignal is to provide a solution which analyzes information and identifies the level of contingencies.

# Specifications from SmartSignal®

- SmartSignal® preferred to keep the problem open ended and unbiased
- Without many explicit problems to solve, the team had the latitude to develop a fresh approach
- A successful design must resolve technical, graphical, and personnel issues

# Problems Addressed

- Unmanageable number of errors displayed
- False errors
- Ineffective communication of error information
- Steep learning curve for new employees

# Goals

Team Goal was to design a User Interface (UI) with the following characteristics:

- Makes information manageable
- Integrate all decision-makers at the power plant
- Easily accessible and understandable information

# Methodology

- Research how warning information is handled by power plants
- Develop multiple UI's to be reviewed by SmartSignal®
- Revise and develop best proposed UI and present it to SmartSignal®

# Team Organization

## Primary Subteam structures:

- High-level Design Team
  - Design the structure of the user interface
- Communication Team
  - Research end-users/ communicate with Smart Signal
- Fault Analysis Team
  - Design appropriate fault level system

# Team Organization (Cont.)

## Secondary Subteam structures:

- The Design Content Team
  - Defined the content of the UI and its functionality
- The Screen Shots Team
  - Developed Web-based prototype of the UI
- The Requirements Document Team
  - Created a document that lists all of the design requirements
- Additional Teams were created to complete IPRO deliverables

# Team Ethics

- The team's Ethics Plan stresses respecting the non-disclosure agreement with SmartSignal®
- Disclosing information about SmartSignal® could cause the team to acquire biased information



# Final Design (Error Screen)

The screenshot displays the 'SS Alert' web application in a Microsoft Internet Explorer browser window. The interface includes a navigation menu with buttons for 'ERROR LIST', 'WHITE-LIST LOG', and 'GENERAL INFO'. A search bar contains the name 'Nirav Hazariwala' and a 'Submit' button. Below the navigation is a control panel with buttons for 'DELETE', 'WHITE-LIST', 'ADD ERROR LOG', and 'VIEW ERROR LOG', along with a filter section for 'MIN' and 'MAX' values (set to 1 and 5 respectively) and 'OK' and 'Refresh' buttons. The main area is a table of error records, sorted by date. The table has columns for 'PRI', 'DATE/TIME', 'ASSET', 'TAGNAME', 'STATE', 'STATE', 'AREA', and 'OPERATOR'. The rows are color-coded: green for 'ABNRML', yellow for 'FAILED', red for 'HIGH', and cyan for 'LOW'. A vertical sidebar on the left is labeled 'ERROR LIST BY DATE'. On the right, there is a vertical menu with categories like 'COAL', 'BOILER', 'STACK', 'TURBINE', 'COOLING', 'WATER', 'HIGH PRSR HTR', 'LOW PRSR HTR', 'FEED PUMP', 'CONDENSATE PUMP', 'CONDENSER', 'ECONOMIZER', and 'MILL'. The browser's address bar shows 'Thursday 24.04.2008 15:14'.

PRI	DATE/TIME	ASSET	TAGNAME	STATE	STATE	AREA	OPERATOR
2	4/14 12:20	CONDENSER	CDWF13-B19	INLET FLOW RATE	ABNRML	SECTOR 6	SAMAD
3	4/14 12:19	COAL FEEDER	RTINTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	RACHEL
4	4/14 12:10	STEAM	CARD21-W11	B AIR HEATER GAS OUT TEMP	HIGH	SECTOR 7	NIRAV
1	4/14 12:08	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	ARTHUR
2	4/14 12:05	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	SAMAD
1	4/14 12:04	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	ARTHUR
2	4/14 12:04	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	SAMAD
1	4/14 12:03	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	ARTHUR
1	4/14 11:58	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	ARTHUR
1	4/14 11:50	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	ARTHUR
3	4/14 11:43	COAL FEEDER	RTINTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	RACHEL
2	4/14 11:38	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	SAMAD
2	4/14 11:38	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	SAMAD
1	4/14 11:31	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	ARTHUR
5	4/14 11:30	COMPRESSOR	ARCADA-M1	AIR/OIL PUMP PRESSURE	HIGH	SECTOR 7	NIRAV
4	4/14 11:29	STEAM	CARD21-W11	B AIR HEATER GAS OUT TEMP	HIGH	SECTOR 7	NIRAV
3	4/14 11:28	COAL FEEDER	RTINTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	RACHEL
2	4/14 11:22	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	SAMAD
1	4/14 11:18	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	ARTHUR

- Errors randomly recorded by the system
- Colors and numbers show the degree of intensity
- After an error is resolved a message may be submitted for future reference

# Final Design (Errors by Priority)

SS Alert - Microsoft Internet Explorer

File Edit View Favorites Tools Help

ERROR LIST WHITE-LIST LOG GENERAL INFO Nirav Hazariwala Submit

Thursday 24.04.2008 15:14

DELETE X WHITE-LIST ADD ERROR LOG VIEW ERROR LOG FILTER: MIN 1 MAX 5 OK Refresh

PRI	DATE/TIME	ASSET	TAGNAME	STATE	STATE	AREA	OPERATOR
5	4/14 11:30	TURBINE	ARCADA-M1	AIR OIL PUMP PRESSURE	HIGH	SECTOR 7	NIRAV
5	4/14 10:15	TURBINE	ARCADA-M1	AIR OIL PUMP PRESSURE	HIGH	SECTOR 7	NIRAV
4	4/14 12:10	STEAM	CARD21-W11	B AIR HEATER GAS OUT TEMP	HIGH	SECTOR 7	RAY
4	4/14 11:29	STEAM	CARD21-W11	B AIR HEATER GAS OUT TEMP	HIGH	SECTOR 7	RAY
4	4/14 10:10	STEAM	CARD21-W11	B AIR HEATER GAS OUT TEMP	HIGH	SECTOR 7	RAY
4	4/14 9:07	STEAM	CARD21-W11	B AIR HEATER GAS OUT TEMP	HIGH	SECTOR 7	RAY
3	4/14 12:19	COAL FEEDER	RTTNTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	RACHEL
3	4/14 11:43	COAL FEEDER	RTTNTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	RACHEL
3	4/14 11:28	COAL FEEDER	RTTNTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	JHYUNG
3	4/14 11:02	COAL FEEDER	RTTNTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	RACHEL
3	4/14 10:28	COAL FEEDER	RTTNTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	JACOB
3	4/14 9:32	COAL FEEDER	RTTNTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	RACHEL
3	4/14 9:32	COAL FEEDER	RTTNTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	RACHEL
3	4/14 8:30	COAL FEEDER	RTTNTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	RACHEL
2	4/14 12:20	COMPRESSOR	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	SAMAD
2	4/14 12:05	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	SAMAD
2	4/14 12:04	COMPRESSOR	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	SAMAD
2	4/14 11:38	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	SAMAD
2	4/14 11:38	COMPRESSOR	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	HARUKO

ERROR LIST BY PRIORITY

COAL  
BOILER  
STACK  
TURBINE  
COOLING  
WATER  
HIGH PRSR HTR  
LOW PRSR HTR  
FEED PUMP  
CONDENSATE PUMP  
CONDENSER  
ECONOMIZER  
MILL

- Errors may be sorted by
  - Priority
  - Time
  - Asset
  - Tagname
  - State
  - Area
  - Operator

# Final Design (Whitelisting)

SS Alert - Microsoft Internet Explorer

File Edit View Favorites Tools Help

ERROR LIST WHITE-LIST LOG GENERAL INFO Nirav Hazariwala Submit

Thursday 24.04.2008 15:14

DELETE X REVERT PERSONAL LOG PLANT-WIDE LOG

PRI	DATE/TIME	ASSET	TAGNAME	STATE	STATE	AREA	INSTANCES
2	4/14 12:05	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	3
1	4/14 11:58	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	6
1	4/14 11:50	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	1
2	4/14 11:38	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	2
1	4/14 11:31	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	6
3	4/14 11:28	COAL FEEDER	RTTNTD-DP	D FEEDER RUNNING AND TRIPPED	FAILED	SECTOR 7	3
2	4/14 11:01	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	4
1	4/14 10:28	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	2
2	4/14 10:22	TURBINE	CARD21-W11	EN FW HEATER LEVEL	ABNRML	SECTOR 7	2
1	4/14 9:21	SCRUBBER	WMF-SAT45	EXHAUST HOOD TEMPERATURE	LOW	SECTOR 7	9

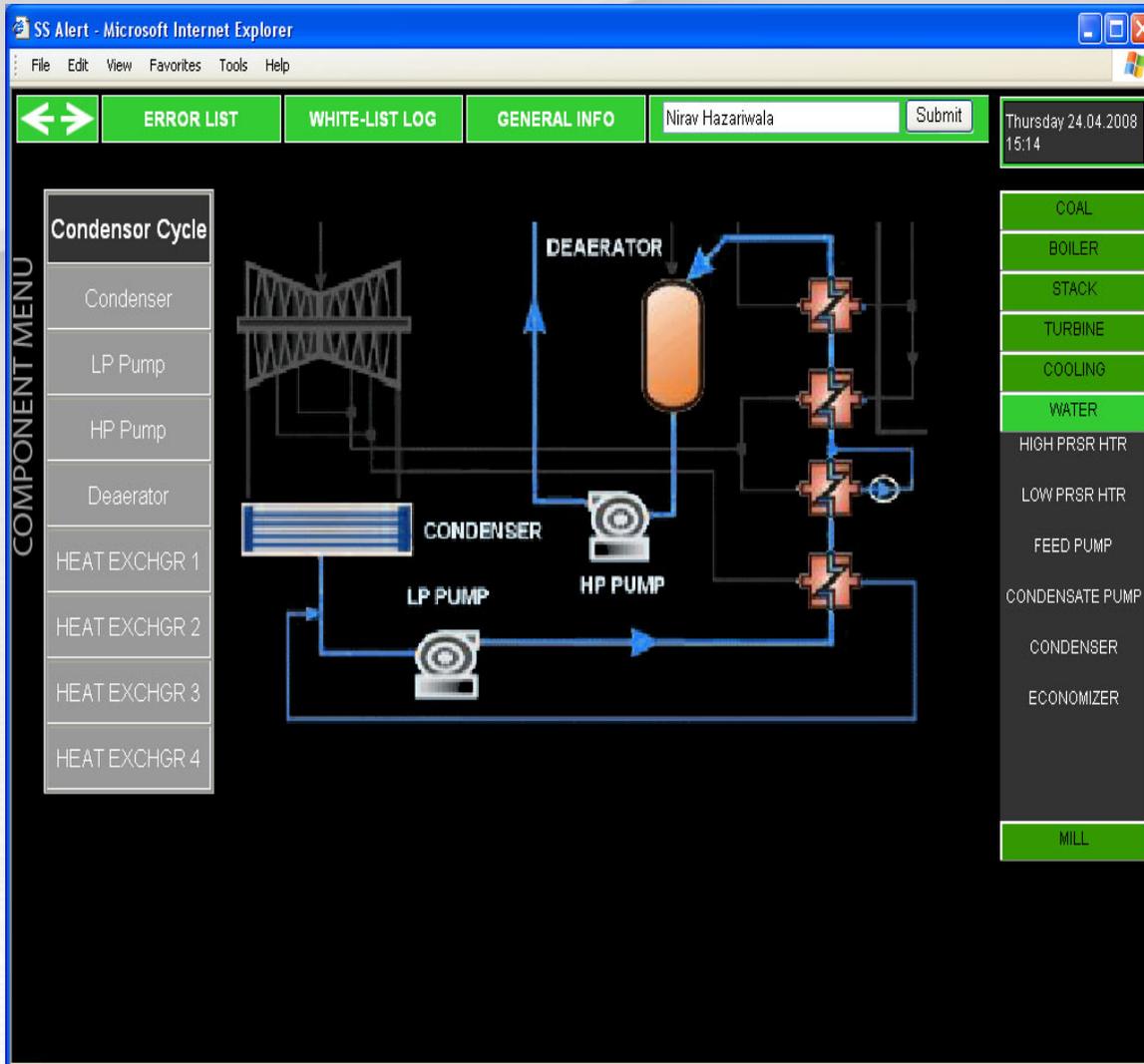
WHITELIST PLANT-WIDE

- COAL
- BOILER
- STACK
- TURBINE
- COOLING
- WATER
- HIGH PRSR HTR
- LOW PRSR HTR
- FEED PUMP
- CONDENSATE PUMP
- CONDENSER
- ECONOMIZER
- MILL

- False errors occur in the system occasionally
- These errors may be whitelisted to remove them from the main error screen
- The delete function will only be accessible to the plant supervisor
- The Personal log shows errors whitelisted by specific employee(s)
- The Plant-wide log shows errors listed by all employees



# Final Design (Component)



- The state of several components may be observed
- This allows the engineer to view information about a schematic of the component and some related parts.
- The user can get more detailed information by clicking the component

# Final Design (Asset)



- Specific information of the component provided
- Operating conditions may be modeled to allow employees to predict output
- Helps to address the steep learning curve
- Historic data available

# Final Design (General Info)



- General information provided
- A graphical gauge shows ideal values for the entire power plant

# Obstacles

- The request for an open-ended approach led to a lack of focus
- Initial lack of team organization
- Lack of applicable information from previous IPRO teams
- Scheduling power plant visits

# Results

- Final User Interface

- Minimizes errors
- Helps eliminate steep learning curve
- Dynamic software structure
- Appropriate Fault Analysis System
- Meets the needs of SmartSignal® and end-users
- Extendable to systems/facilities beyond power plants

# Acknowledgements

- **Donald J. Chmielewski PhD**- Assistant Professor, Illinois Institute of Technology
- **Mr. Gerald Delaney**- Chemical Process Specialist, Midwest Generation
- **Mr. David Farrell**- Product Manager, SmartSignal Corporation
- **Ms. Stacey Kacek**- Vice President of Product Development, SmartSignal Corporation
- **Mr. Scott Lehman**- Lehman Electric Company
- **Mr. Mark Nagel**- Engineering Manager, Midwest Generation
- **Mr. Michael Sedlak**- Chief Electrical Engineer, Midwest Generation,
- **Karl Stolley PhD**- Assistant Professor, Illinois Institute of Technology

# Questions?

