Introduction
The goal of our project was to develop a complex diagnostic model of the HVAC (Heating, Ventilation and Air Conditioning) system for the University's Information Technology and Engineering Building (ITEB) and diagnose problems in real-time. We used a program designed by Qualtech Systems Inc. (QSI) called TEAMS™ to create the model and run diagnostics to isolate failures in the ITEB HVAC system by using values from temperature and humidity sensors located throughout the building. Increasingly complex systems mean failures can be more difficult to isolate. Isolating a single failure in a system consisting of hundreds of components could be time consuming and cost inefficient. TEAMS™ uses a logical reasoner to diagnose the problem and provide the most cost and time efficient method of checking and repairing the suspect components.

TEAMS™ - Testability Engineering And Maintenance System
TEAMS™ Designer: A modeling tool used to create any physical complex system. It can be something as simple as a flashlight or as complex as a rocket engine. The system is modeled by assigning failure modes to each element and linking results of each component with other affected components.

TEAMS-RT: Software that combines real-time data and the model to determine suspect components when faced with an observed failure.

TEAMS-RDS: An online server that combines the model and test code to determine probabilities of suspect components failing. By associating time and cost to each component, TEAMS-RDS will determine which components to check first when running diagnostics on the system.

HVAC System
HVAC is an acronym for heating, ventilation and air conditioning. ITEB's HVAC system has three main components: the basement, penthouse and VAV (Variable Air Volume) system for each floor. The basement contains the heat exchanger, which regulates temperature of the water in the building. The penthouse holds the two air handlers that regulate air flow in the building. Air is then sent to each floor and is distributed to every room by a number of VAVs. The VAVs compare the set temperature with the actual temperature, which is read from a sensor in each room. They modify the incoming air to meet the desired temperature and humidity for the rooms assigned to them.

Figure 1: Schematics for the air handling unit in the West penthouse.
Figure 2: ITEB third floor schematic showing VAVs and associated sensors.

Obtain schematics and research HVAC
Obtain sensor data from facilities
Determine failures in system
Add real-time results to model and send to TEAMS-RDS

Figure 3: Flow chart describing implementation process. Schematics of ITEB HVAC system were used to design a model in TEAMS Designer. Generated test results from sensor values were processed to determine failures and sent through TEAMS-RT to the user interface TEAMS-RDS. The model and the sensor results were combined in TEAMS-RDS to provide an interactive diagnostic solution.

Figure 4: ITEB HVAC system in TEAMS-Designer.

TEAMS™ DESIGNER HVAC MODEL
TEAMS™ Designer is set up as a hierarchical model of the overall system. By using possible failures associated with each component and connecting the components together, a complex system can be made completely based on how each component can fail. Time and cost of tests for each component can be used to help a technician most efficiently isolate the error and repair the system. The HVAC model that we developed in TEAMS™ only has test points associated with the VAVs.

The reason for this is that sensors are only located in rooms, which are directly connected to a VAV.

TEAMS-RT is a sub-component of TEAMS-RDS that runs code we developed in real-time with the TEAMS™ Designer model. TEAMS-RT takes any component associated with the failed test point and relays that component suspect to failure. If real time data is implemented into the system, TEAMS-RT will use the real-time information to help isolate the failure or failures in the system.

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Figure 5: Second floor view of ITEB office wing consisting of multiple VAVs and their associated temperature and humidity sensors.

Figure 6: Third floor view of a single VAV's components.

Figure 7: Final floor within control damper of a single VAV showing possible failure modes.

Figure 8: Suggested results associated with one sensor failure in TEAMS-RT.

Figure 9: Test analysis from TEAMS-RDS. RDS uses logic reasoning to determine the percent probability of each component failing.

Conclusions
This project required us to use our knowledge and technical skills as engineers to solve a real-world problem. With the help of UConn facilities and our technical liaison, Moises Soto, we created a working and accurate model for the ITEB HVAC Designer that is capable of checking for, and isolating faults based on sensor value results.

During the development of this project, we learned that using TEAMS™ to its highest capability requires an expert technical background with the system. We were unable to obtain actual sensor results from facilities, however, our code can parse data from a test file that we created and evaluate failures results into our model to check for failures. If real-time data were to be obtained, it would be trivial to implement.

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