Distributed Intelligent Automated Demand Response (DIADR)

Test Report

Milestone 2 Demonstration—BMS OpenADR Integration

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Abstract:

This report summarizes the testing results of the CITRIS Building Management System (BMS) OpenADR Integration demonstration for DIADR project as Milestone 2 and Task 4 deliverable. The test was held at Sutardja Dai Hall (or CITRIS Building) at the University of California, Berkeley on Nov. 12, 2010. During the demonstration, Siemens used a standalone device, the Siemens Smart Energy Box, to connect the CITRIS BMS with the LBNL DRAS server based on BACnet and OpenADR protocols. The test result shows that we have successfully enhanced the CITRIS Siemens Building Management System as Open ADR ready and met Milestone 2 (and Task 4) of the DIADR project due on Nov. 17, 2010.

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1 Introduction

This goal of this project is to develop a distributed intelligent automated demand response (DIADR) management system with intelligent optimization and control algorithms for demand management, including demand side management for

- HVAC/lighting
- Plug-loads
- Energy storage

The final objective is to demonstrate DIADR at Sutardja Dai Hall (CITRIS building) at UCB to achieve a 30% demand reduction up to two hours in response to a DR event, based on Siemens technology and the OpenADR communication protocol.

To achieve this goal and meet the objective, we first need to enable the communication between the CITRIS building management system (BMS) and an OpenADR server. The CITRIS building uses a BMS from Siemens called Apogee, and the OpenADR server (DRAS) used for this project is a DRAS server hosted by LBNL. This task was referred to as **BMS OpenADR Integration** (Task 4) in our original proposal and the accomplishment of it was marked as the second milestone of the DIADR project.

This document describes the details of the BMS OpenADR Integration test and reports the demonstration results as performed at the CITRIS building on November 12, 2010.

2 Test Summary

2.1 Key Features

The corresponding milestone for this test is to enable the CITRIS building management system to receive ADR events and respond to the events, e.g., to change a setpoint of an office room. The following are the key features that have been specified and implemented for this milestone

- CITRIS BMS receiving Demand Response Signal issued at LBNL DRAS server and storing as BACnet data on the server
- CITRIS BMS changing Room temperature in response to the Demand Response event
- CITRIS BMS resetting temperature setpoint to the Normal at the end of Demand response event

2.1 DIADR Test Organization

The DIADR test is conducted at the CITRIS building at UCB. The OpenADR enabling hardware and software were developed by Siemens. The test cases and the test data were also designed by Siemens with the support from UCB and LBNL.

2.2 References

This report refers to the report entitled System Architecture delivered to DOE on Oct. 27, 2010.

2.3 Test Execution and Test Objectives

The objective of this test is to use a standalone device, the Siemens Smart Energy Box, to connect the CITRIS BMS with LBNL DRAS server based on BACnet and OpenADR protocols and perform demand response function as specified in the key features.

3 Test Environment

3.1 Test Setup

Figure 1 shows the test setup for the CITRIS BMS OpenADR integration. At one end, the DR events are issued from LBNL DRAS server. At the other end, a physical room, Office 464, will be controlled by the CITRIS BMS Apogee to respond to the DR event. Specifically, the thermostat setpoint of Office 464 will be changed upon Apogee receiving the DR event.

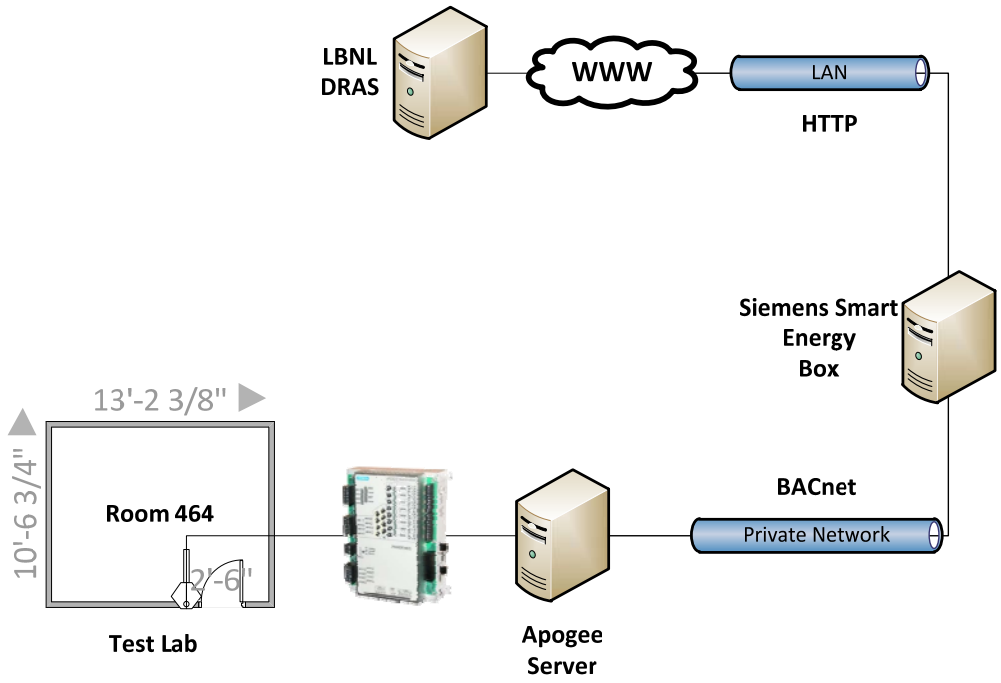

Figure 1. Overall DIADR system setup

Between the LBNL DRAS server and the CITRIS Apogee system, the Siemens Smart Energy Box (SEB) acts as a gateway for a building to grid connection. SEB is a device developed by Siemens that can receive DR signals and send out the message to building automation systems to respond to the DR event. For the DIADR application, it has implemented an OpenADR client to receive the demand response signal from DRAS Server in LBNL and also implemented a BACnet client to send building controls Apogee system to change building energy usage through a BACnet protocol. For this demo, a simple control strategy is implemented in SEB to generate building controls from the DR events. In the future, SEB will also provide an integration platform to host advanced DR strategies to achieve maximal building demand reduction.

3.2 Software Test Environment

The following is the software environment of SEB used for testing

- Windows XP with SP1 and Higher
- .Net Framework 3.5 SP1
- Smart Energy Box Runtime System
- Smart Energy Box Status Viewer
- BACnet communication protocol on TCP/IP
- BACnet Server
-

3.3 Hardware Test Environment

The following PCs have been used:

PC Name	Description / Performance	Component
ART0032 (Smart Energy Box)	SIMATIC Microbox PC Intel Core 2 Duo CPU, 1.2GHZ, 2 GB RAM with two network interfaces. One network interface to connect to the internet and another network interface to communicate with BMS	Smart Energy Box Runtime Smart Energy Box Status Viewer
CITRIS Building Management system Server (BMS)	This is the existing building management server (Apogee) with support of BACnet communication protocol	BACnet Server Apogee Building Management System Software
LBNL Demand Response Server	This machine is accessed via web service from the Smart Energy Box to get the demand response event information. This is a remote machine which does not physically exist at CITRIS, it resides at LBNL.	Demand Response Server

Table 1: Hardware Used for Testing

3.4 Test Scenarios

In order to test the features listed in Section 2, the following detailed test cases were designed for the test.

1) **Establishing connection between LBNL DRAS and Smart Energy Box**
   The goal of this test is to test the connection between LBNL Demand response server and Smart Energy Box. DR events issued by LBNL DRAS should be received by Smart Energy Box.

2) **Establishing connection between the Smart Energy Box and the CITRIS building management system (Apogee)**
   This goal of this test is to test the connectivity between the Smart Energy Box and building management system in response to the DR event. The Smart Energy Box will change the thermostat setpoint of Room 464 in response to the DR event.

4 Test and Results

All tests mentioned in the test scenarios have been executed manually and the test results were recorded in log files using the Smart Energy Box Status viewer. The tests have been verified on CITRIS Building management System

4.1 Test Data

The major test data needed for this test is DR events issued by the DRAS Server at LBNL and the corresponding thermostat setpoint changes of CITRIS Room 464.

4.1.1 DR Events

Here is the list of DR events issued for the test; each category lasted five minutes. Between events the system resumed to normal.

Notification Time	DR Event Start Time	DR Event End Time	Event Category
11/12/10 10:40	11/12/10 10:45	11/12/10 10:50	Moderate
11/12/10 10:50	11/12/10 10:55	11/12/10 11:00	High
11/12/10 11:00	11/12/10 11:05	11/12/10 11:10	Moderate
11/12/10 11:10	11/12/10 11:15	11/12/10 11:20	Moderate
11/12/10 11:20	11/12/10 11:25	11/12/10 11:30	High
11/12/10 11:30	11/12/10 11:35	11/12/10 11:40	Moderate

Table 2: Automated Demand Response Events used for testing

4.1.2 Room 464 Thermostat Setpoints

The current building mode is heating, so the following setpoint changes are designed as a DR strategy to respond to different DR events.

DR Event Category	Set point (°F)
Normal	73 (Or Current Setting)
Moderate	68
High	66

Table 3: Room 464 Thermostat Setpoints used for testing

The BACnet object name of the Room 464 thermostat is 7011.SDH.S4-16:CTL STPT.85 and the BACnet object name of the temperature sensor of that room is 7011.SDH.S4-16:ROOM TEMP.85. We will monitor these two values with the Smart Energy Box Status viewer.

4.2 Test Results

The following are the execution results of the two test cases defined in the test plan.

4.2.1 Test Case 1: Establishing connection between LBNL DRAS and Smart Energy Box

Test Pre-condition: Establish Ethernet connection between the SEB and the CITRIS Apogee System. Smart Energy Box should be able to access internet. Configure SEB to be able to receive DR events from the LBNL DRAS.

Step	Description	Result (Success /Failure)
Step 1	Run Smart Energy Box and Smart Energy Box Status Viewer	**Success**
Step 2	SEB Status Viewer should show the current DR Mode and Next DR mode as Normal (If DR events are not yet issued))	**Success**
Step 3	Issue DR Event from LBNL Demand Response Server according to the schedule as mentioned in 4.1.1	**Success**
Step 4	When the first event is notified by DR server, the SEB should receive the event and set that as the Next event if start time is ahead of current time; else it will be the current time. The same status should reflect in the SEB Status viewer as well.	**Success**
Step 5	Once event start time is Current it should become the current event and the next event should be set to Normal	**Success**
Step 6	Once all events are finished, Current and Next DR modes should be set to Normal	**Success**

Table 4: Test Case 1

4.2.2 Test Case 2: Establish Connection between the Smart Energy Box and the Building Management System

Test Pre-condition: Establish Ethernet connection between the SEB and the CITRIS Apogee System. The Smart Energy Box should be able to access the internet. Configure the SEB to be able to receive DR events from LBNL DRAS. Configure the SEB Status viewer to view the status of Room 464 thermostat setpoint and toom temperature.

Step	Description	Result (Success/Failure)
Step 1	Run Smart Energy Box and Smart Energy Box Status Viewer	**Success**
Step 2	SEB Status Viewer should show the current DR Mode and Next DR mode as Normal	**Success**
Step 3	SEB Status Viewer shows the Room 464 thermostat current setpoint and room temperature	**Success**
Step 4	Issue DR Event from LBNL Demand Response Server according to the schedule as mentioned in 4.1.1	**Success**
Step 5	When the first event is notified by the DR server, the SEB should receive the event and set that as Next event if start time is ahead of current time; else it will be the current time. The same status should reflect in the SEB Status viewer as well.	**Success**
Step 6	If the current mode is High, the Smart Energy Box should set the Room 464 thermostat setpoint to 66 °F (this can be configurable through configuration) and continue the same temperature setpoint until the DR event is finished.	**Success**
Step 7	If the current mode is Moderate, the Smart Energy Box should set the Room 464 thermostat setpoint to 68 °F (this can be configurable through configuration) and continues the same temperature setpoint until the DR Moderate event is finished.	**Success**
Step 8	The changed setpoint in Step 6 should be changed physically for Room 464. Verify Room 464 setpoint at Building management System, which should be same as set at Step 6. Also the SEB status viewer should show the changed setpoint.	**Success**
Step 9	Once the current DR event is finished, the room temperature setpoint should be reset to normal	**Success**
Step 10	Verify Room 464 setpoint at Building Management System, which should be reset to original/Normal i.e. 73 °F Also the SEB status viewer should show the changed setpoint.	**Success**
Step 11	Repeat Step 5 To Step 7 until all issued events are finished.	**Success**
Step 12	The SEB Status viewer will show the trend of Room 464 temperature by selecting View Trend option on the Room temperature point.	**Success**

Table 5: Test Case 2

4.2.3 Room 464 Temperature Setpoint trend with respect to DR Event

The following graph shows the thermostat setpoint change corresponding to the demand response event change as scheduled in Table 2.

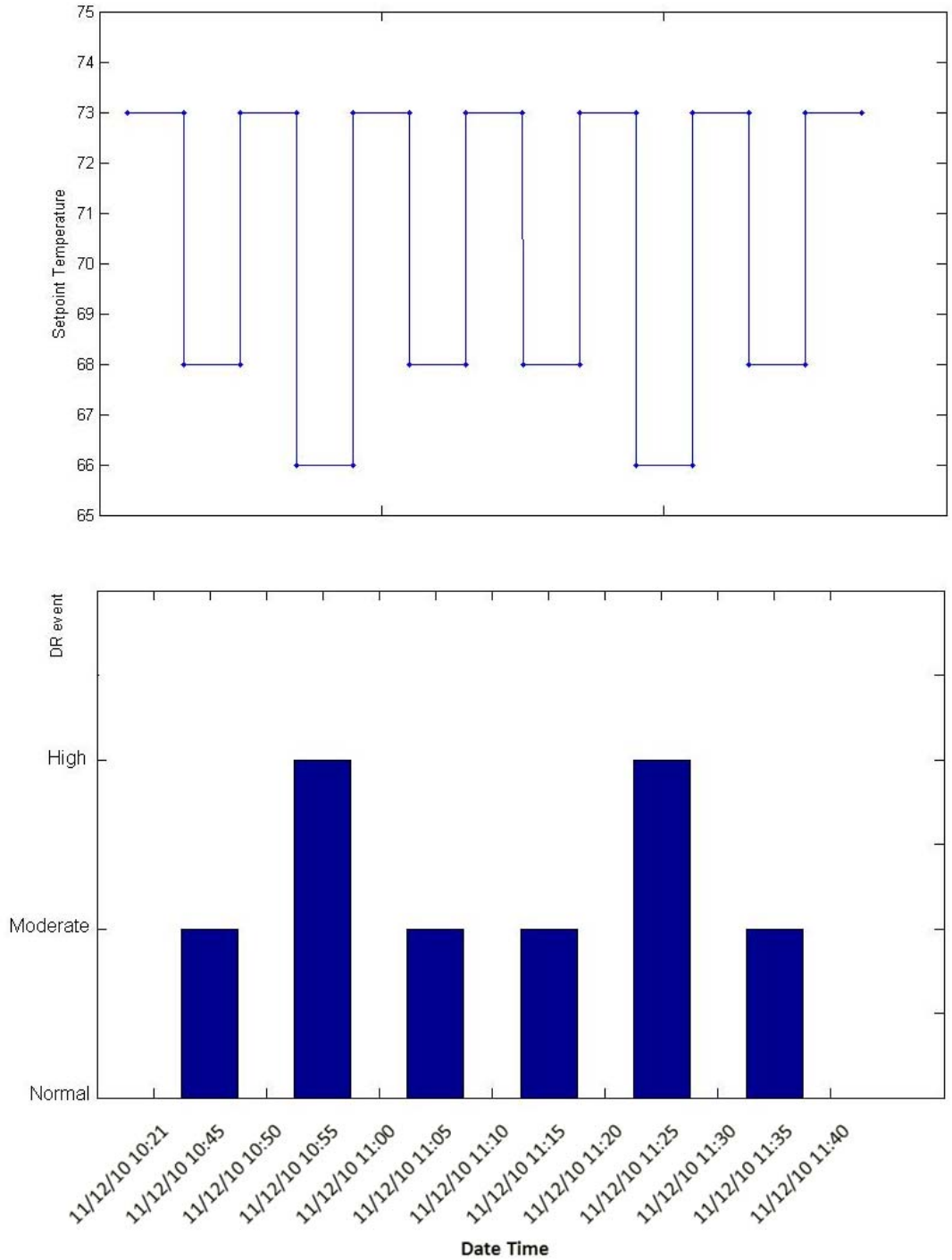

Fig 2: Change of Room 464 thermostat setpoint trend in response to the DR event

Appendix -- Test log file

'SEBHMI.log'

11/12/10 11:44:07 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:42:13 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:41:38 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:40:58 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:40:07 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 73

11/12/10 11:40:03 Current DR Mode is Normal

11/12/10 11:38:13 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:38:07 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:35:06 Next DR Mode is Normal

11/12/10 11:35:05 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 68

11/12/10 11:35:03 Current DR Mode is Moderate starts at 11/12/2010 11:35:00 ends at 11/12/2010 11:40:00

11/12/10 11:33:00 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:32:49 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:32:32 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:32:14 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:31:28 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:31:06 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:30:11 Next DR Mode is Moderate starts at 11/12/2010 11:35:00 ends at 11/12/2010 11:40:00

11/12/10 11:30:09 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 73

11/12/10 11:30:03 Current DR Mode is Normal

11/12/10 11:25:06 Next DR Mode is Normal

11/12/10 11:25:05 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 66

11/12/10 11:25:03 Current DR Mode is High starts at 11/12/2010 11:25:00 ends at 11/12/2010 11:30:00

11/12/10 11:20:09 Next DR Mode is High starts at 11/12/2010 11:25:00 ends at 11/12/2010 11:30:00

11/12/10 11:20:07 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 73

11/12/10 11:20:03 Current DR Mode is Normal

11/12/10 11:20:02 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:19:33 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:19:27 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:19:05 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:18:59 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:18:54 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:15:11 Next DR Mode is Normal

11/12/10 11:15:09 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 68

11/12/10 11:15:08 Current DR Mode is Moderate starts at 11/12/2010 11:15:00 ends at 11/12/2010 11:20:00

11/12/10 11:10:17 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:10:11 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:09:54 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 11:01:01 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 11:00:34 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.25

11/12/10 11:00:12 Next DR Mode is Moderate starts at 11/12/2010 11:15:00 ends at 11/12/2010 11:20:00

11/12/10 11:00:12 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 73

11/12/10 11:00:03 Current DR Mode is Normal

11/12/10 10:56:44 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 10:55:23 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 10:55:06 Next DR Mode is Normal

11/12/10 10:55:03 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 66

11/12/10 10:55:02 Current DR Mode is High starts at 11/12/2010 10:55:00 ends at 11/12/2010 11:00:00

11/12/10 10:52:53 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 10:51:51 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 10:51:16 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 10:50:55 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 10:50:49 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 10:50:20 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 10:50:10 Next DR Mode is High starts at 11/12/2010 10:55:00 ends at 11/12/2010 11:00:00

11/12/10 10:50:10 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 73

11/12/10 10:50:04 Current DR Mode is Normal

11/12/10 10:49:45 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.5

11/12/10 10:48:08 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 72.75

11/12/10 10:45:04 Next DR Mode is Normal

11/12/10 10:45:03 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 68

11/12/10 10:45:02 Current DR Mode is Moderate starts at 11/12/2010 10:45:00 ends at 11/12/2010 10:50:00

11/12/10 10:40:05 Next DR Mode is Moderate starts at 11/12/2010 10:45:00 ends at 11/12/2010 10:50:00

11/12/10 10:21:30 Next DR Mode is Normal

11/12/10 10:21:13 Current DR Mode is Normal

11/12/10 10:21:13 Changed value of object 7011.SDH.S4-16:ROOM TEMP.85 is 73

11/12/10 10:21:13 Changed value of object 7011.SDH.S4-16:CTL STPT.85 is 73