REAL TIME SIMULATION IN BUILDING AUTOMATION SYSTEMS

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ABTRACT - In this paper we speculate on the utility of including "real time". simulation capability in building automation systems, define the terminology, explore the possible methodology that could be used and the research and development necessary to make simulation a useful "on line" tool to the building operating staff.

DEFINITION OF REAL TIME SIMULATION

Real time simulation, as we will use it in this paper, means that the results of the simulation will be available in time to influence the events being simulated. In other words, if we are determining the optimum start time (the latest time at which we can start the system and still achieve specified space conditions by the time the building occupants arrive) for a building heating system, we must have the results of the simulation before the start time passes, otherwise, we cannot obtain the "optimum" start required. In buildings this, generally, will mean that the results must be available at least one building time constant in advance of the event simulated. We use the definition of "time constant" as the period during which an action taken now will still be effecting the conditions within the building. Most buildings have time constants of less than 24 hours while lightly constructed buildings may have time constants of less than one hour.

Our definition of real time simulation also means that the simulation must be iterative in nature. That is, upon completion of a periodic simulation of a building or component, the implementation of an action must be incorporated into the next simulation. For example, if the simulation is run to predict the effect of lowering morning space temperatures through the use of nocturnal cooling by outside air and determine the demand reduction in the afternoon, the next pass through the simulation must include the decision on the use of nocturnal cooling, if it is to predict accurately the building condition resulting from the next control action.

PURPOSES OF REAL TIME SIMULATION IN BUILDING AUTOMATION SYSTEMS

Real time simulation of building operations may offer the building operator the opportunity to determine more optimum energy use strategies by showing him/her the results of his/her control decisions in advance. He/she may also be able to explore the results of complicated interactions of controls, building occuppancy, outside conditions and fan system responses. The objective of such information would be, of course, decreasing the energy use of the building while maintaining or increasing the comfort for the occupants.

Some of the building operations opportunities that real time simulation may be able to increase the efficiency of include:

- Use of nocturnal cooling through the use of outside air
- Optimize use of storage, either hot or cold
- Optimize morning start up time for building systems
- Determine minimum energy (cost) strategies for buildings using complex heat recovery systems i.e., for a given predicted weather condition will it be better to utilize heat recovery from double bundle chiller or utilize outside air cooling and heat from a boiler
- Verify that proposed equipment modifications, control strategies etc. will result in the expected energy reduction or occuppancy conditions

REQUIRED INFORMATION AND ALGORITHIMS

Effective use of real time simulation in building automation will require additional information from the building automation system and the development of improved simulation algorithims. For effective use of real time simulation, engineering judgement indicates the simulation results should be within three to five percent of actual conditions, perhaps even more accurate. The major determining factor in the accuracy requirement is that this is generally the expected range of accuracy of building controls. New control systems such as direct digital systems will be more accurate.

Presently building energy analysts are sometimes satisfied when results are within ten to fifteen percent of operating experience, especially on new building simulations. Investigators have shown that the present major simulation codes are capable of producing results well within the five percent control system error mentioned, but the cost of determining the input data to the necessary accuracy outweigh the benefits. To make effective use of simulation in real time control this accuracy will be necessary, therefore, the information will to be made available. Fortunately building automation systems are already providing a great deal of the necessary information and can be extended to gather the necessary additional information. The principal areas where additional information may be required from the building automation system are in the actual occupancy patterns of the building, the utilization of process equipment, utilization of the lighting system and the actual introduction of outside air to the building other than through the fan system.

Simulation algorithims that have heuristic characteristics will be required. That is the simulation algorithim must "learn" the building characteristics and responses. Such factors as the building response to ambient conditions can be learned from sensors in the building and weighting or response factors adjusted from experience. Flow characteristics of outside air dampers may be measued from flow sensors and position sensors on the outside air dampers. Occuppancy and lighting patterns will be learned from historical data.

Algorithims that predict weather data from local weather forecasts and "learn" the micro-climate variations from the general area prediction will be necessary for envelope influenced buildings. Perhaps some method of predicting micro-weather patterns from weather service weather maps produced four times daily and received by digital methods may be developed. Or Hittles method of representing weather as a Fourier series may be used to generate local micro climate data.

The simulation algorithims used for real time simulation will require accuracy at least equal to present hour by hour methods and should be less computationally intensive, although the latter may be less important with the development of more and more capable micro-processors. Each building may require custom written software that accurately reflects the operation of the building mechanical systems and their interaction with the buiding envelope, or at least methods will have to be developed that enable accurate definition of these systems in standard codes. No generic systems allowed! The algorithim must accept on line data from the building automation system and incorporate it automatically into the next simulation.

Real time simulation will probably require the use of a dedicated high end microprocessor. Running in a background mode may be possible on central processors of building automation systems that utilize super minis. Dedicated super micro's such as the Motorola 68000 series and the Intel 80286 or 80386 will probably be more acceptable. Since the simulation period for each run will most likely be for periods of one or two days, the micro-computer will offer acceptable execution times. Execution on the central system processor may result in unacceptable degradation of primary control functions or unaccptable simulation execution times.

CONCLUSIONS

Simulation can be a useful 'real time' tool in the building automation systems. Utilization of simulation in this environment will require the development of improved heuristic simulation algorithims, additional sensors in the building

automation system, development of weather projection techniques, and the dedication of a super-micro processor. Benefits will include:

- o Eenergy use reduction
- o Increased building comfort
- o Improved building operation

Additional benefits may accrue at the time of building commissioning and/or major modifications. The principal problem areas will be:

- o Training of operators
- o Increased cost
- o Custom pro-gramming
- o Cost effectiveness