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Optimizing Heating and Cooling of Buildings

Capstone Exam MSSE

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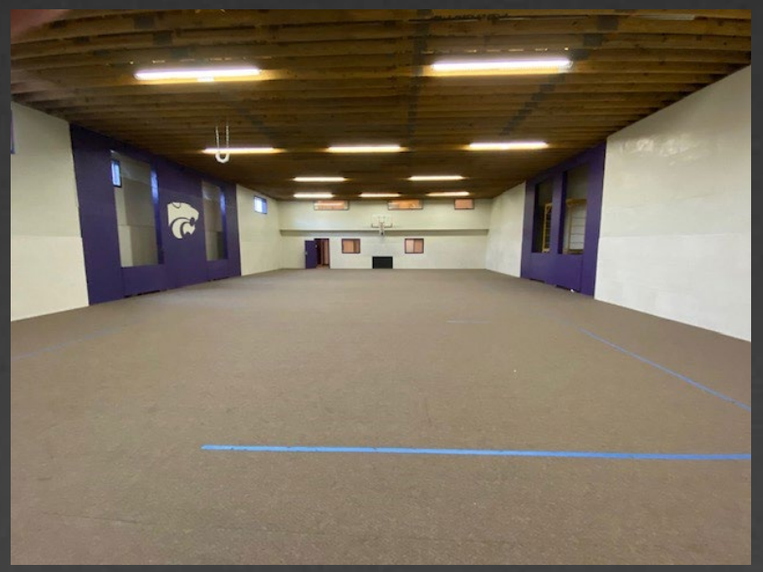
Todd Easton

- B.S. BYU Math, MSOR Stanford, Ph.D ISYE Georgia Tech
- Associate Professor and University Distinguished Teaching Scholar, Industrial and Manufacturing Systems Engineering, Kansas State University
- 2021- Professor (Lecturer) ME U of U
- Wife and four kids
- Enjoy the outdoors, sports, home improvement



Program of Study (30 hours)

SIME 6460 Model-Based Systems Engineering

SIME 6400 Fundamentals of Systems Engineering

ME EN 6183 Discrete Event Systems Simulation

SIME 6430 Requirements Engineering and Management

SIME 6410 System Engineering and Integration

ME EN 6035 Design of Experiments

SIME 6000 Analytics for Systems Management

SIME 6530 Project Management for Engineers

SIME 6050 Operations Research for Systems

SIME 6450 Design of Production and Service Systems

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Can you heat and cool buildings better?

- HVAC is a significant cost.
- Why not precool buildings and avoid the 6.3 cents of electricity cost?

SIME 6430

- Create a set of requirements that are well stated and testable?
  - The building temperatures should stay between 70 and 75 degrees Fahrenheit during the occupied hours.
  - The number of complaints to the manager related to the building's temperature should be less than 4 per week average over a month. (Currently there are on average 3 complaints per week).
  - The new cooling strategy should reduce the energy costs by at least 10% when compared to the energy cost from the prior year. Only applied during the first year.

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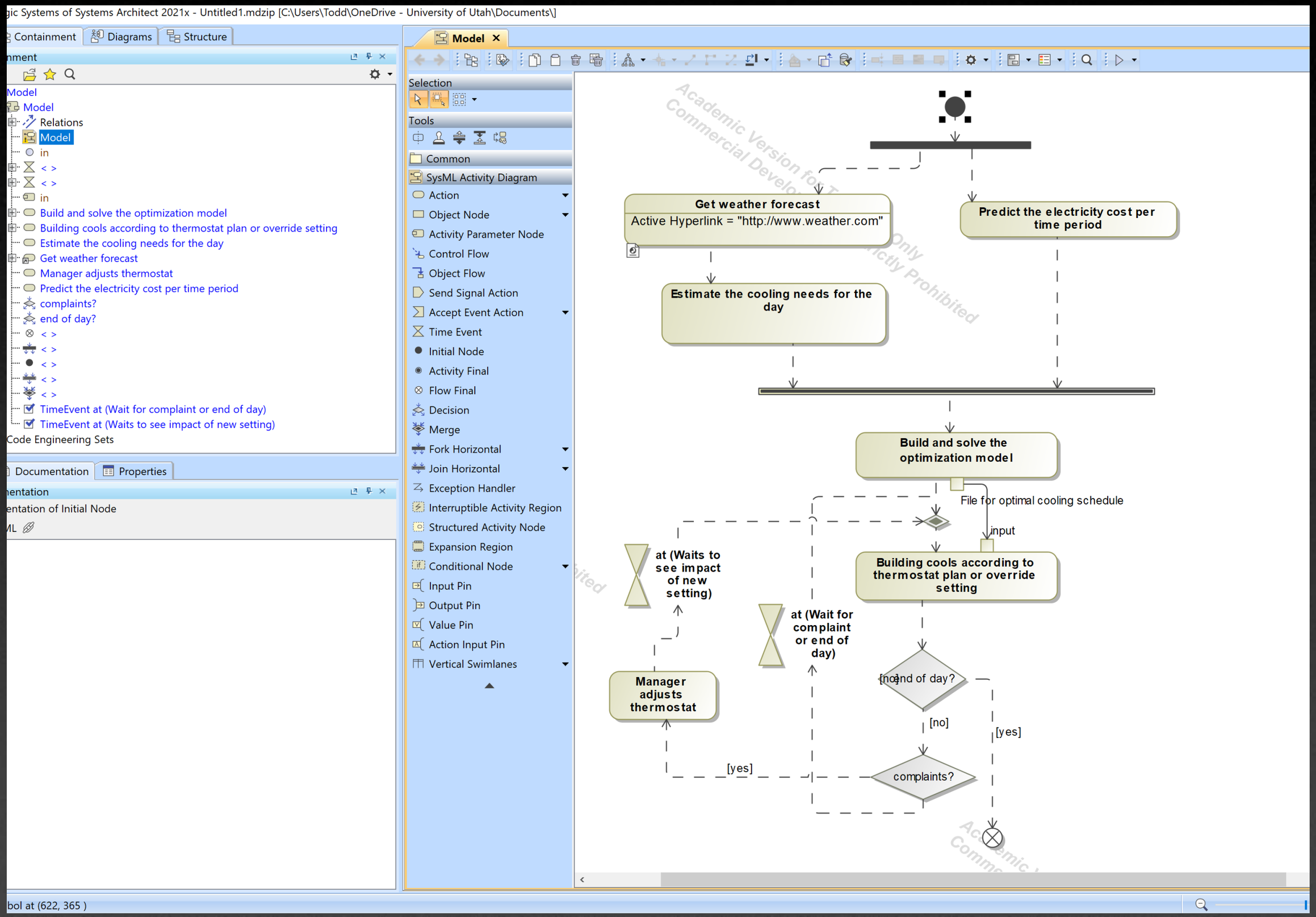
SIME 6460 - Activity Diagram



SIME 6050

- Build an mixed integer program.
- The decision variables are the amount of cooling added per time interval and the current temperature of the building.
- Parameters is an estimate of how much cooling will be needed in the building.
- Some constraints involve maintaining an appropriate temperature in all zones and times

SIME 6050 Continued

- The main constraint follows an inventory model where the next temperature is equal to the buildings current temperature plus the amount of cooling and the natural amount of heat added based on the day's weather and building usage.

$Temp_{t+1} = Temp_t + ACcooled_t + weatherheat_t$ for all $t < T$

- The objective is to minimize the sum of the cost of the electricity used in any given time period.
- Comment for culminating experience: It is sufficient to describe what you would do if you had sufficient time and resources. The full model does not need to be built.

Ethical Considerations

- In changing the heat settings of a building, one has to consider the impact of temperature on people's behavior.
- There is a variety of research about higher temperature and violence. Colder temperatures do not seem to have as big of an impact.
- We should focus more on precooling rather than allowing building to overheat.

Other Considerations

- This project clearly helps with the economic and environmental impact.
- This methodology could be modified to minimize carbon; thereby improving public health, safety and welfare.
- There are also implications relating to cultural and social aspects of changing the temperature of buildings (cheap landlords).

Other courses that were considered

This is not a slide of the Capstone Exam, but provided to see how I could have integrated several other courses too.

SIME 6410 Develop the integration system to have the HVAC automatically create its settings based upon the weather and projected costs

ME EN 6035 Develop surveys to and design the experiments to determine if the new settings are better or worse for occupants. This may include temperature, humidity, barometric pressure, etc.

Questions