Problem Description

DocName	*Project*	*Version*	*FullName*	*ShortDescriptio*
		<< >>		

Description

The total system is composed of a section within an university building (namely section building 32, 4th floor of Univ. of Kaiserslautern) with installation (including sensors and actuators), users, one facility manager, and the control system. The control system is composed of hardware and software components. The building is influenced by its environment, mainly the weather.

Starting with a given lighting control system, a control system for heating should be developed. Additionally the control system should drive automatically sun blinds.

Two calendar time periods are distinguished:

- ***heating period*** = from autumn to spring during winter time.
- ***non heating period*** = from spring to autumn during summer time.

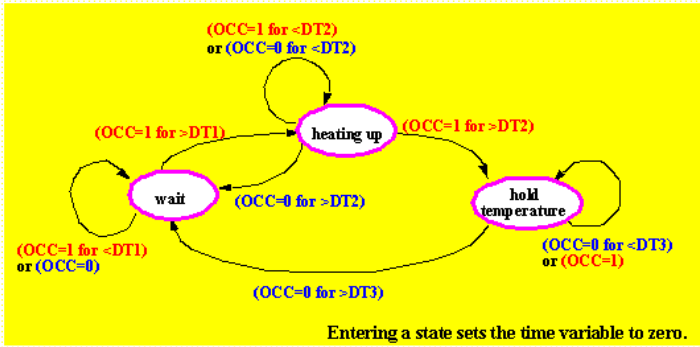
During two time periods four different subordinated operating modes are distinguished:

- ***off time*** = no occupancy expected, typical operation mode at night time
- ***standby time*** = occupancy expected but room not occupied, typical operation mode of empty room at daytime
- ***comfort time*** = room occupied, typical operation mode at daytime or night time if room is occupied
- ***non freeze auto***= only non freeze safety should be maintained, typical operation mode during holidays.

For simplicity we assume that each room has one responsible person that determines the requirements for this room. The identity of this person is not checked. Each actual user, who actually occupies the room can act as the responsible person that determines the requirements of this room.

One facility manager (FM) is responsible to run the building. He is responsible to adjust the settings for the public rooms like hallways and meeting rooms. He enters the default values and range of acceptance of the user choices for the individual rooms owned by different user.

Proposed functionality of the heating control system for detection of occupancy:



Graphical representation of different modes

- For example: DT1=1min, DT2=10min, DT3=30 min

We distinguish three time spans for detecting occupancy for temperature control. If a person is in a room shorter than DT1 minutes, the control system does not try to reach the comfort temperature (***state wait***, stand-by or off time temperature applied, depending on the time period).
If the person occupies the room for a time longer than DT1, the system goes into the ***state heating up*** and starts to reach the comfort temperature. If the person leaves the room before DT2 minutes for a time longer than DT2 minutes, the system returns to the ***state wait***. If the person still occupies the room longer than DT2 minutes, the system enters the ***state hold temperature***, where the comfort temperature should be held, until this person leaves the room for at least DT3 minutes.
Different settings for DT1, DT2, DT3 may exist for each room, depending on the expected usage (day, night, vacation etc.). The default values and ranges of acceptance of individual user choices are given by the facility manager, individual values are given by each user. The data sets (DT1, DT2, DT2) can be chosen as adaptive. The systems learns in this case typical user behaviour and enlarges or diminishes the delay times suitable, to avoid unnecessary energy consumption for heating up respectively to reduce unnecessary long decision intervals.

Example of proposed functionality to adapt the delay times:

- *If during a certain time interval less than 'xmin' transitions from **heating up state** to **wait state** occur, DT1 is decreased by 10 %.*
  *If during a certain time interval more than 'xmax' transitions from **heating up state** to **wait state** occur, DT1 is increased by 10 %.*

- *DT2 shall be adapted to the actual time difference of reaching the desired comfort temperature.*
  If the system does not reach the desired comfort temperature approximately during DT2, it enlarges DT2, otherwise it increases DT2.

- *If during a certain (long) time interval less than 'ymin' transitions from **hold temperature state** to **wait state** occur, DT3 is decreased by 10 %.*
  *If during a certain (long) time interval more than 'ymax' transitions from **hold temperature state** to **wait state** occur, DT3 is increased by 10 %.*
  Important: During adaptation of DT3 has to be DT3>DT2 !

User Needs (U), Facility Manager Needs (FM) and Non-functional Needs (NF) for light control

- In U1-U11 **general** user needs are listed which are demanded for each kind of **room.**
- In U12-U14 the user needs for the **offices** are listed**.**
- In U15-U16 the user needs for the **remaining rooms** are listed**.**
- In U17-U19 the user needs for the **hallway sections** are listed.
- In FM 1 -FM 11 the facility manager needs are described.

The nonfunctional needs NF1-NF9 are split in several groups depending on the aspect they are dealing with.

- NF1-NF3: Needs in the case of a **malfunction** of the **outdoor light sensor**
- NF4: Need in a **worst case failure** of the **control system**
- NF5: Need in the case of a malfunction of the motion detector:
- NF6-NF7: **Safety and Legal Aspects**
- NF8-NF9: **User Interface**

User Needs (U), Facility Manager Needs (FM) and Non-functional Needs (NF) for heating control

- In UH1-UH15 user needs are listed.
- In FMH 1 -FMH 17 the facility manager needs are described.
- In NFH1-NFH9 non functional needs are described.

Attributes

FullName	*ModelName*	*Type*	*Value*	*Description*

User Needs (U), Facility Manager Needs (FM) and

Non-functional Needs (NF) for light control

Name	*ModelName*	*Description*	*ObjectTypes*
sufficient room light	U1	If a person occupies a room, the light has to be sufficient to move safely, if nothing else is desired by a chosen light scene.	
occupied light scene	U2	As long as the room is occupied the actual chosen light scene has to be maintained.	
re-established light scene	U3	If the room is reoccupied within T1 minutes after the last person has left the room, the last chosen light scene has to be re-established.	
reoccupied light scene	U4	If the room is reoccupied after more than T1 minutes since the last person has left the room, the standard light scene has to be established.	
wall switch behaviour	U5	The wall switches for the window- and the wall ceiling light group in a room should show the following behaviour: • if the corresponding ceiling light is completely on then the light will be switched off • otherwise the ceiling light will be switched on completely	
light scenes by control panel	U6	The light scenes can be determined by using the control panel.	
ambient light level	U7	For each room the actual ambient light level can be set by the user using the control panel.	
default light scene	U8	For each room a default light scene can be set (not by using the control panel).	
default ambient light level	U9	For each room a default ambient light level can be set (not by using the control panel).	
Time T1	U10	The value T1 can be set for each room separately (not by using the control panel).	
Deficiency of light sensor or motion detector	U11	If the outdoor light sensor or the motion detector of a room does not work correctly, the user has to be informed.	
ceiling lights and the task light	U12	The ceiling lights and the task light should be maintained by the control system depending on different light scenes.	
Mobility of control panel	U13	The control panel should be installed movably like a telephone in the offices.	

Parts of control panel (1)	U14	The control panel should contain at least: ● a switch to set the task light (on/off) ● a switch to set the ceiling lights (on/off/ambient) ● a possibility to set the actual ambient light level	
Installation of control panel	U15	In all other rooms the control panel should be installed near a door to the hallway.	
Parts of control panel (2)	U16	The control panel should contain at least: ● a switch to set the ceiling lights (on/off/ambient) ● a possibility to set the actual ambient light level	
Sufficient hallway light	U17	When a hallway section is occupied by a person, the light in this hallway section has to be sufficient to move safely.	
entered_section light	U18	Before a person enters a hallway section from another one, the light in the entered section has been turned on if necessary.	
Hallway wall switches	U19	The wall switches for lights in the hallway section have to show the following behaviour: ● if the light is on then the light will be switched off ● otherwise the light will be switched on	
Desired light by use of daylight	FM1	Use daylight to achieve the desired light whenever possible.	
Hallway light off by T2	FM2	Lights in a hallway section have to be switched off when the section has been unoccupied for T2 min.	
Room light off by T3	FM3	If a room is unoccupied for more than T3 minutes, all lights must be switched off.	
Time T2	FM4	The value T2 can be set for each hallway section separately.	
Time T3	FM5	The value T3 can be set for each room separately.	
Light off by FM	FM6	The facility manager can turn off any light in a room or hallway section that is not occupied.	
Malfunction for FM	FM7	If a malfunction occurs the facility manager has to be informed.	
Control system support for FM	FM8	If a malfunction occurs the control system supports the facility manager by finding the reason.	
Reports and consumption	FM9	The system provides reports on current and past energy consumption.	
Store and request	FM10	All malfunctions and unusual conditions are stored and reported on request.	
Malfunction manually	FM11	Malfunctions that the system cannot detect, can be entered manually.	
Failure degradation	NF1	In any case of failure the system shall provide a stepwise degradation of functionality down to manual operability.	
Outdoor light sensor damage_1	NF2	If the outdoor light sensor does not work correctly, for rooms the control system should behave as if the outdoor light sensor submits the last correct measurement of the outdoor light constantly.	
Outdoor light sensor damage_2	NF3	If the outdoor light sensor does not work correctly the standard light scene for all rooms is that all ceiling lights are on.	
Outdoor light sensor damage_3	NF4	If the outdoor light sensor does not work correctly and a hallway section is occupied the lights in this hallway section has to be on.	
Motion detector damage	NF5	If the motion detector of a room or a hallway section does not work correctly, the control system should behave as if the room or the hallway section is occupied.	
Hallway light not controllable	NF6	If the lights in a hallway section are neither controllable automatically nor manually the lights have to be on.	
Hardware connections	NF7	All hardware connections have to be made according to DIN standards.	
Hazardous conditions	NF8	No hazardous conditions for persons, inventory, or building is allowed.	
Use of control panel	NF9	The control panel should be easy and intuitive to use.	

System warning	NF10	The system warns about unreasonable inputs.	

User Needs (U), Facility Manager Needs (FM) and Non-functional Needs (NF) for heating control

Name	*ModelName*	*Description*	*ObjectTypes*
enter the desired value of comfort temperature	UH1	The user can enter manually the ***desired value of comfort temperature***. This value holds only if it is element of a preselected interval given by the facility manager, otherwise the nearest possible value of this interval is used. The default value given by the facility manager can be overridden.	
comfort temperature	UH2	In comfort temperature shall be reached as fast as possible during the ***heating up state***, and maintained during the ***hold temperature state*** as good as possible. During the ***states wait*** and ***heating up*** appropriate actions have to be taken. (A schema of functionality is proposed above.).	
interruption of ***non freeze auto operation mode***	UH3	The user can interrupt and re-establish ***non freeze auto operation mode*** for his actual room. The control system shall go to regular operation mode according the actual daytime, taking into account its previous settings. Without an user instruction to continue ***non freeze auto operation mode*** the system re-establishes this mode after a longer time period in which the room is not occupied.	
individual working times	UH4	The user can enter manually his preferred working time. During this time the systems waits in ***stand by operation mode*** until an user enters his room. The remaining time ***off time operation mode*** is applied. These values hold only if they are elements of preselected intervals given by the facility manager, otherwise the nearest possible values of this intervals are used. Default values given by the facility manager are overridden manually.	
user holidays	UH5	The user can enter manually his individual holiday start and end times valid for his room in advance of 1 year. During this intervals only ***off time operation mode*** is applied. The default holiday start and end values given by the facility manager are valid additionally.	
manually operation of sun blinds	UH6	The user can enter manually for each sun blind the instruction to move up or down. This instruction holds until he leaves the room for a longer time period.	
energy save	FMH1	Energy consumption should be reduced as far as possible during maintaining of comfortable working conditions for all users.	
solar radiation and heating storage	FMH2	The use of solar radiation for heating during all times if heating is required or not disallowed, and the use of storage capacity of the building should always be preferred against the usage of the central heating unit.	
defaults	FMH3	The facility manager sets all default values and the ranges of acceptance of all variables, which can be entered by the users (see ***User Needs*** above). De distinguishes only between rooms of a different kind. The user can override this values for his room, if his settings are element of the range of acceptance, otherwise the nearest possible values element of this range are used.	

calendar time	FMH4	The facility manager can set the calendar time of heating and non heating period	
non freeze auto operation mode	FMH5	The facility manager can set the operating mode of the hole building, or of single rooms to ***non freeze auto operating mode*** during both heating periods. This means that the desired value of room temperature is set to a preselected ***non freeze temperature***, and no change in occupancy will influence this. The actual user settings are stored and reestablished after end of ***non freeze auto operation mode***. ***Non freeze auto operation modes*** can be ordered in advance of 1 year with defined start and end or begin immediately with unknown end.	
adaptive occupancy detection for heating	FMH6	The delay times for detecting occupancy can be chosen by the facility manager as adaptive. In this operation mode the systems *'learns the typical user behaviour'* and tries to adapt the delay times DT1, DT2, DT3 appropriate. A proposed functionality is shown above.	
malfunction information	FMH7	Important informations should be send to the facility manager. The facility manager is supported by the system in checking the reason before he goes to the location or take other actions.	
spy information	FMH8	The facility manager is informed about repeated unreasonable user behaviour, which contradicts aspects of energy saving.	
comfortable use	FMH9	The control system provides basic energy saving procedures automatically for control comfort. If the facility manager deviates from such settings, the system provides a report on expected results.	
unreasonable inputs	FMH10	The system warns against unreasonable inputs (input consistency).	
report on energy consumption	FMH11	The system provides reports on current and past energy consumption (cost reporting).	

storage of malfunctions	FMH12	All malfunctions, alarms and unusual conditions are stored and reported on request.	
manually entered malfunctions	FMH13	Malfunction of components that the system cannot detect, can be entered manually.	
malfunction of single sensors	NFH1	If only one single sensor of a group is damaged, the other ones shall provide makeshift operation, otherwise default values respectively manually entered values shall be used.	
serious malfunction	NFH2	If the whole control system has a serious malfunction, complete manually operation should be possible.	
malfunction indoor temp. sensor	NFH3	If only one sensor does not work correctly, the other ones shall be used to get an estimation. If all temperature sensors of a room do not work correctly, the valves are set directly to appropriate positions, according the outdoor temperature and settings of neighbour rooms.	
malfunction of indoor mot. det.	NFH4	In the case of a serious malfunction of the motion detectors, the user can enter manually the occupancy. Default is ***occupied*** during daytime and ***not occupied*** during night time. The entered occupancy is valid until the malfunction is removed, or the occupancy is manually changed by a user command, or the next change between daytime and night time (respectively vice versa) occurs . ***Important:*** In the case of a malfunction of the motion detectors the *occupancy for temperature control (manually entered)* differs from the *occupancy for light control (default = occupied)*.	
hardware connections	NFH5	All hardware connections have to be made according to DIN standards.	
hazardous conditions	NFH6	No hazardous conditions for persons, inventory, or building is allowed.	
control panel	NFH7	The control panel should be easy and intuitive to use.	

flexibility	NFH8	The control system shall be designed such that it can be easily changed and expanded.	
makeshift operation	NFH9	In the case of malfunctions the system shall provide stepwise degradation of functionality. The use of manually entered or default values should provide makeshift operation.	

User Needs (UC),
concerning conflicts between illuminance control and temperature control

Name	*Model Name*	*Description*	*Object Types*
Effect of sun blinds on indoor illuminance	UC1	The light control system has to consider the actual linear position and angular position of sun blinds when controlling the indoor illuminance from outdoor light. Adjusting of the room temperature by sun blinds has priority.	
use of solar radiation for lighting	UC2	Solar radiation is used for room lighting as far as possible, but temperature control and the user can override this rule.	