Problem Description *“Light Control”*

Part 1: Introduction

1 The main motivation for the development of a new light control system are the disadvantages of the currently existing system. Since all lights are controlled manually, electrical energy is wasted by lighting rooms which are not occupied and by little possibilities to adjust light sources relative to need and daylight.

2 In the following document, *keywords* are marked at their first occurrence and listed in the additional dictionary (Part 4).

3 Words written in *emphasis* are names of physical sensors/actuators.

4 Paragraphs are numbered for easier reference.

Part 2: *Floor* Description

5 In this part, the *architecture* and the *installation* of the given *sensor*s and *actuator*s of Building 32, 4th floor is described.

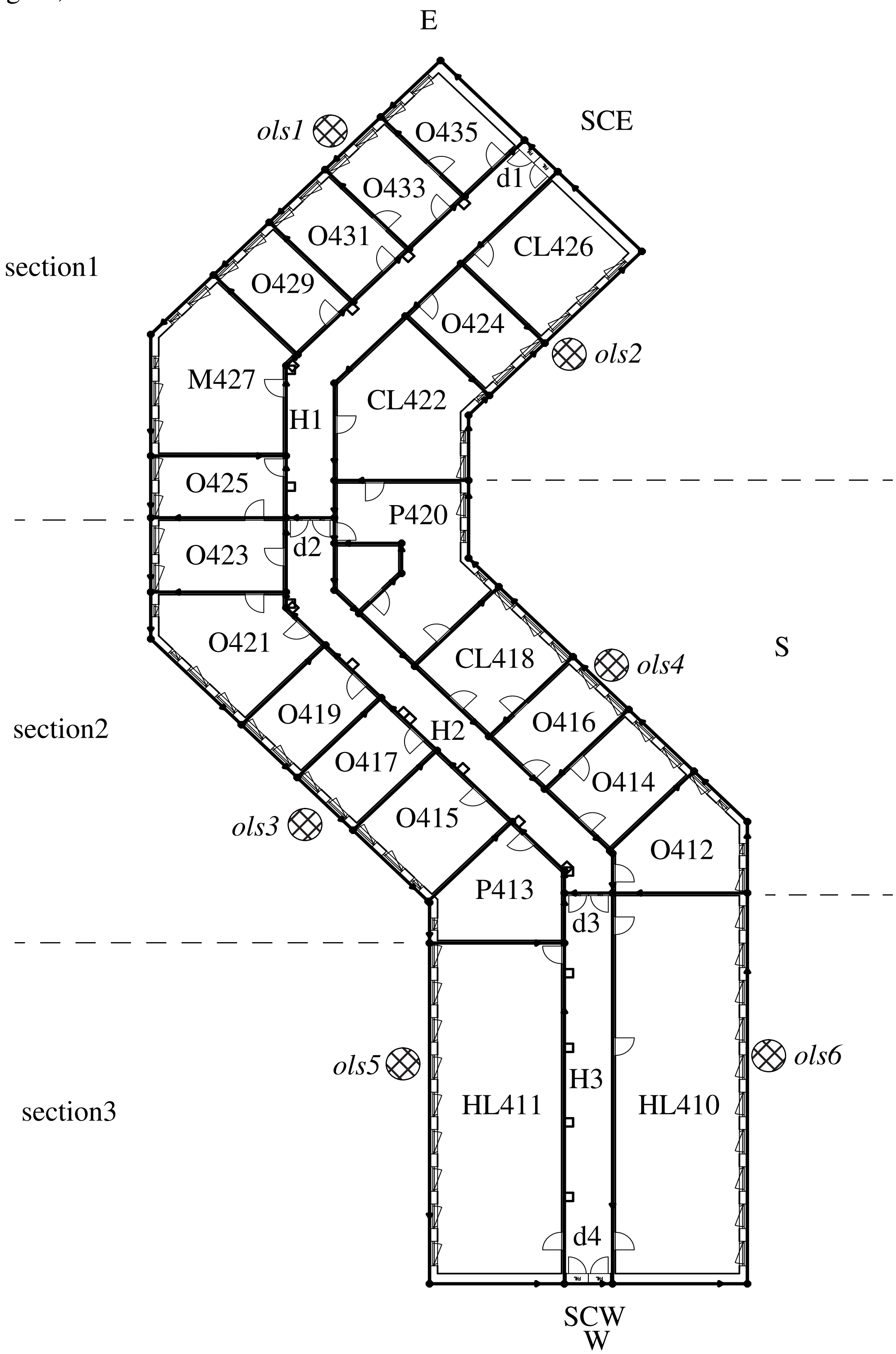

Figure 1: Architecture of the 4th Floor of Building 32

6 The fourth floor of Building 32 consists of three *section*s and shares two *staircase*s SCE and SCW with other floors of the building, as shown in Figure 1. Each section is divided into some *hallway section*s (H) and *room*s, each of which may be an *office* (O), a *computer lab* (CL), a *hardware lab* (HL), a *peripheral room* (P), *or a meeting room* (M). All rooms

in a section are accessible via a connected hallway section. There are three hallway sections and 22 rooms to control. Figure 1 shows also the six *outdoor light sensor*s (*ols1 - ols6*) and the major compass directions. The sensors cover the six directions of the different walls. The label in a room indicates the type of the room and gives a unique number, see Figure 1.

2.1 Office Description

7 Each office (shown in Figure 2) has one *door* (d1) to the hallway section and can have up to two doors (d2, d3) leading to its adjacent rooms. Each door is equipped with a *door closed contact*, named *dcc<n>*, where n is the number of the door in the room.

8 Each office is equipped with

1. one *motion detector* (*imd*), so that the room is fully covered.
2. two *ceiling light group*s (window and wall). The luminaires in a ceiling light group in any room are turned on or off only as a group.
   Each ceiling light group is controlled by one *push button* (*pb1* and *pb2*, respectively), which toggles the ceiling light group if switched to the other position.
   Each ceiling light group can be dimmed with its own *dimmer-actuator.*
3. two *status line*s (*sll1 and sll2*) each of which shows the status of one ceiling light group.

2.2 Computer Lab Description

9 Same as office.

2.3 Hardware Lab Description

10 Same as office, but with more than one door leading to the hallway section.

2.4 Meeting Room Description

11 Same as office.

2.5 Peripheral Room Description

12 The peripheral rooms will not be controlled by the *control system*, and thus they are not described here!

2.6 Hallway Section Description

13 Each hallway section is limited by two doors, each of which is leading to an adjacent hallway section or to an adjacent staircase. The associated names of the doors (d1, d2, d3, d4) are shown in Figure 1. Each door is equipped with a door closed contact, named *dcc<n>*, where n is derived from the name of the door.

14 Each hallway section is equipped with

1. two motion detectors (*imd1* and *imd2*), placed above the doors at each end of the hallway section to determine the presence of a person near a door,
2. one motion detector to cover the whole section (*imd3*),
3. one *hallway section ceiling light group.* The luminaires in a hallway section ceiling light group are turned on or off only as a group.
   Each ceiling light group is controlled by several push buttons (*pb<i>*) each of which toggles the ceiling light group if switched to the other position.

4. one status line (*sll1*) that shows the status of the hallway section ceiling light group.

2.7 Staircase Description

15 Each staircase connects several floors.

16 At the landing of each staircase at each floor, the staircase is equipped with

1. one motion detector (*imd1*) above the door of the landing that leads to the adjacent hallway section to detect motion in the staircase near the door.

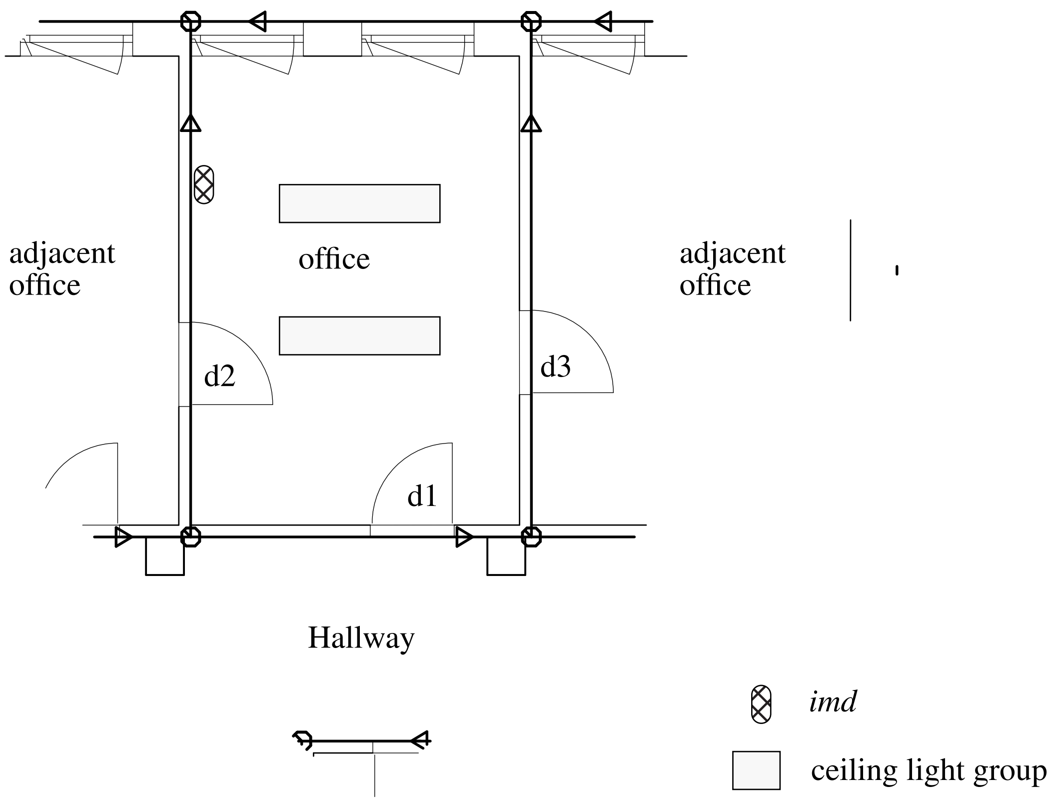

Figure 2: Office Architecture

2.8 Sensor Description

17 *Analog sensor*s typically have an exponential time response. Reaction time is the time from a change of the sensed property to the time when the sensor has reached 90% of the change, excluding conversion time. Conversion time is the time to convert the analog value to a digital one that can be accessed by the control system.

Table 1: Sensors

Type	Resolution	Range	Reaction / Conversion Time	Description
door closed contact		0, 1	10 ms	It is placed above the door and is 1 if the door is fully closed.
motion detector		0, 1	1 s	1 means a person is moving, even very slowly, in the range of the detector. Transition to 0 can be delayed.
outdoor light sensor	1 lux	1 - 10000 lux	10 ms / 1 s	Mounted perpendicular to facade, measures the *illumination* of the facade for the calculation of light flow through a window.
status line		0,1	10 ms	Senses if the light has the voltage turned on or off.

2.9 Actuator Description

18 Actuators have a linear time response. Reaction time is therefore defined as the time to change from 0 to 100% / 100 to 0%, if different.

Table 2: Actuators

Type	Range	Control	Reaction Time	Description
control system active		0, 1	10 ms	Even if the CS sends an 1 within every 60 s, the CS is still alive.
dimmer	0 - 100%		10 ms	Controls light between 0 (off) and 10-100% (on).
pulse	1, 0		10 ms	
push button		0, 1	10 ms	1 as long as pushed

19 The structure of a *dimmable light* is shown in the next picture. Inputs to the dimmable light are the *pulse line* to toggle the light, a *dim value* to set the current dim value and the signal *control system is active* to show the status of the control system. If this signal is not sent every 60 s, the dimmable light switches to fail safe mode, i.e. dim value is assumed to be 100%. The output is a status line to show the current state (on or off) of the light.

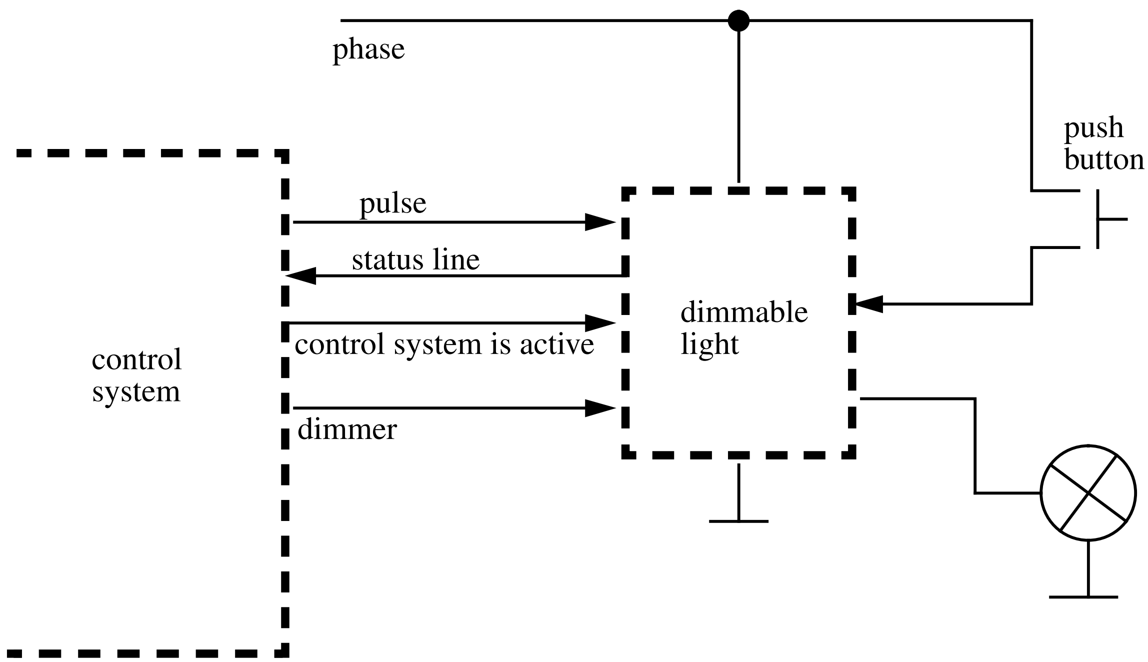

Figure 3: Dimmable Light

Part 3: Informal Needs

20 This part contains the needs for a new light control system for the fourth floor of Building 32 of the University of Kaiserslautern.

21 In Section 3.1, functional needs are listed and in Section 3.2 non-functional needs are listed.

3.1 Functional Needs

22 The functional needs are split into two groups, *user* needs and *facility manager* needs, depending on the person who has expressed them.

3.1.1 User Needs

23 The user needs are labelled by U<number>.

24 At first, general user needs are listed, which are demanded for each kind of room:

- U1 If a person occupies a room, there has to be *safe illumination*, if nothing else is desired by the *chosen light scene*.
- U2 As long as the room is occupied, the chosen light scene has to be maintained.
- U3 If the room is reoccupied within *T1* minutes after the last person has left the room, the chosen light scene has to be reestablished.
- U4 If the room is reoccupied after more than T1 minutes since the last person has left the room, the *default light scene* has to be established.
- U5 The push buttons for the window- and the wall-ceiling light group in a room should show the following behavior:
  - (i) if the corresponding ceiling light group is completely on, it will be switched off
  - (ii) otherwise it will be switched on completely.
- U6 For each room, the chosen light scene can be set by using the *room control panel*.
- U7 For each room, the *ambient light level* can be set by using the room control panel.
- U8 For each room, the default light scene can be set by using the room control panel.
- U9 For each room, a *default ambient light level* can be set by using the room control panel.
- U10 For each room, the value T1 can be set by using the room control panel.
- U11 If any outdoor light sensor or the motion detector of a room does not work correctly, the user of this room has to be informed.

25 The user needs concerning the offices are:

- U12 The ceiling light groups should be maintained by the control system depending on the *current light scene*.
- U13 A room control panel in an office should be movable as is a telephone.
- U14 The room control panel for an office should contain at least:
  - (i) a possibility to set each ceiling light group (on/off)
  - (ii) a possibility to set the ambient light level

26 The user needs for the remaining rooms are:

- U15 In all other rooms, the room control panel should be installed near a door leading to the hallway section.
- U16 The room control panel should contain at least:
  - (i) a possibility to set each ceiling light group (on/off)
  - (ii) a possibility to set the ambient light level

27 The user needs for the hallway sections are:

- U17 When a hallway section is occupied by a person, there has to be safe illumination.
- U18 Before a person enters one hallway section from another one, the hallway section ceiling light group in the section being entered has to be on.
- U19 The push buttons for the ceiling light group of each hallway section have to show the following behavior:
  - (i) if the hallway section ceiling light group is on, then it will be switched off
  - (ii) otherwise it will be switched on.

3.1.2 Facility Manager Needs

28 The facility manager needs are labelled by FM<number>.

- FM1 Use daylight to achieve the *desired light setting* of each room and each hallway section whenever possible.
- FM2 The ceiling light group in each hallway section has to be off when the hallway section has been unoccupied for at least *T2* minutes.
- FM3 The ceiling light groups in a room have to be off when the room is unoccupied for at least *T3* minutes.
- FM4 For each hallway section, the value T2 can be set by using the *facility manager control panel*.
- FM5 For each room, the value T3 can be set by using the facility manager control panel.
- FM6 The facility manager can turn off the ceiling light groups in a room or hallway section that is not occupied.
- FM7 If a *malfunction* occurs, the facility manager has to be informed.
- FM8 If a malfunction occurs, the control system supports the facility manager in finding the reason.
- FM9 The system provides reports on current and past energy consumption.
- FM10 All malfunctions and unusual conditions are stored and reported on request.
- FM11 Malfunctions that the system cannot detect can be entered manually.

3.2 Non-Functional Needs

29 The non-functional needs are split into several groups according to the aspect they are dealing with. They are labelled by NF<number>.

3.2.1 Fault Tolerance

30 In any case of failure, the system shall provide a stepwise degradation of functionality down to manual operability.

31 Needs in the case of a malfunction of the outdoor light sensor:

- NF1 If any outdoor light sensor does not work correctly, the control system for rooms should behave as if the outdoor light sensor had been submitting the last correct measurement of the outdoor light constantly.
- NF2 If any outdoor light sensor does not work correctly, the default light scene for all rooms is that all ceiling light groups are on.
- NF3 If the outdoor light sensor does not work correctly and a hallway section is occupied, the ceiling light group in this hallway section has to be on.

32 Needs in the case of a malfunction of the motion detector:

NF4 If any 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 were occupied.

33 Needs in a worst-case failure of the control system:

NF5 If the ceiling light group in a hallway section is controllable neither automatically nor manually, the ceiling light group of this hallway section has to be on.

3.2.2 Safety and Legal Aspects

NF6 All hardware connections are made according to DIN standards.

NF7 No hazardous conditions for persons, inventory, or building are allowed.

3.2.3 User Interface

NF8 The control panels are easy and intuitive to use.

NF9 The system issues warnings on unreasonable inputs.

Part 4: Dictionary of Terms

Table 3: Dictionary of keywords of the application domain

Keyword	Description
actuator	device that can be controlled by the control system
ambient light level	light intensity in a room
analog sensor	a sensor that measures an analog value
architecture	structure of a building, floor, or room
ceiling light group	luminaire under or in the ceiling,
chosen light scene	a *light scene* chosen by a user using the room control panel for the case that a room is occupied
computer lab	room with many terminals, workstations, open to all group members and temporarily to students of a class
control panel	small device with a keyboard, LEDs for important states, and a simple display for textual messages
control system	hard- and software system that controls indoor climate, lighting, safety and security
current light scene	the light scene currently established by the control system
default light scene	a light scene for the case that a room is not occupied
default ambient light level	an ambient light level that is established if no other ambient light level is chosen
desired light setting	the setting of a ceiling light group in a room or a hallway section desired by the control system
dimmable light	luminaire that can be dimmed
dimmer-actuator	actuator controlling the output of a luminaire
door	connection between rooms and hallway sections
door closed contact	electrical or magnetic gadget to determine the state of a door
facility manager	person responsible for running a building on a daily basis
facility manager control panel	a control panel for the facility manager
floor	part of a building
hallway section	part of a section between several rooms to connect them to each other
hallway sections ceiling light group	ceiling light group in a hallway section
hardware lab	room with terminals and other electronic stuff

Table 3: Dictionary of keywords of the application domain

Keyword	Description
illumination	amount of light incident on a surface, measured in lux
installation	equipment belonging to a building
light scene	light scenes are predefined settings of the ambient light level and an ordered list of ceiling light groups which should be used to achieve them. One light scene consists of 3 parameters: 1. name of the light scene 2. the desired ambient light level in the room 3. an ordered list, which consists of the installed luminaires. The order of the list is the order, in which the control system has to use the luminaires to reach the desired ambient light level.
malfunction	incorrect behavior of a device
meeting room	a room open to all group members
motion detector	sensor detecting motion of a person or animal in its range, state is on during positive detection
office	room for one or two group members with terminals and/or workstations
outdoor light sensor	sensor measuring the illumination in a half sphere perpendicular to it's flat bottom
peripheral room	room for computer peripherals, copy machines, general group access
push button	an actuator for switching on and off a ceiling light group, it is on, as long as pushed manually
room	part of a section
room control panel	a control panel in a room
safe illumination	illumination greater than 14 lux
section	part of a floor
sensor	device that can sense something
staircase	part of a building connecting several floors
status line	wire that has the status of a device as value
T1	time span used to decide which light scene has to be established in a room
T2	time span used to determine the settings of the ceiling light group in a hallway section
T3	time span used to determine the settings of the ceiling light group in a room
user	person occupying a room or a hallway section