Case Study

Dagstuhl Seminar June 1999
"Requirements Capture / Documentation / Validation"

Embedded software is found in video tape recorders, airplanes, pace makers and other electro-mechanical systems. Correctness and reliability are paramount for those systems. Failures in safety-critical systems, like an airplane's computer system, can put human life at risk. But even in mass-market products, such as consumer electronics, reliability is important. Defects in a product's embedded software can lead to delays of market introduction or even to costly product recalls.

Rigorous and systematic methods for elicitation, specification, inspection, and testing of requirements can help to produce high-quality embedded software. A wide spectrum of methods for these activities has been proposed in recent years. The goal of the workshop is to understand commonalities of and differences among methods better, and to estimate the leverage of methods on the development of large industrial embedded software.

The informal requirements for a light control system should be used by the participants to illustrate their contribution to the seminar. Each participant should become acquainted with the case study. All participants who would like to present aspects of a specification technique should use the case study to develop a specification. To get comparable results about which can be discussed in the working groups at the seminar the following procedure is recommended:

Each participant should:

(i) state her/his objectives. The features of the technique in comparison with other techniques should be described. *Example: A specification developed with specification technique xyz allows an easy communication with the customer.*

(ii) describe the context and procedure of specifying. *Example: university environment, two persons specify, they were low-experienced = students. Following steps were performed...*

(iii) describe the results concerning her/his objective and discuss the results under consideration of her/his experience.

At the Dagstuhl seminar, each participant should be able to talk about the different aspects described above. Certain properties of a technique should be illustrated with examples. Strengths and weaknesses of the technique applied should be demonstrated. In advance, each participant should send a proposal (not more than one page) that describes her/his work by the end of January to `kamsties@iese.fhg.de`. Based on the proposals, working groups at the seminar will be established.

The informal requirements are taken from a project conducted within the SFB501 (a Special Research Institute) at the University of Kaiserslautern. This project started at the beginning of 1998. Its aim is to set up and execute a sequence of experiments to demonstrate the benefits of state-of-the-art software engineering techniques and methods.

The following document consists of three parts: Part one contains the informal requirements for a new light control system for the fourth floor of building 32 of the University of Kaiserslautern. Defects (e.g., inaccuracies) in the informal requirements are intended and could be used to demonstrate the effectivity of a method applied. Part two gives additional information on the informal requirements. It describes the architecture of the fourth floor of building 32, the installation of the hallways, and the rooms of this floor. Part three gives an explanation of terms used in the document.

If any questions occur, please do not hesitate to send an email to kamsties@iese.fhg.de or vknethen@informatik.uni-kl.de.

Part 1: Informal Requirements

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

2 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.

3 Paragraphs are numbered for easier reference.

1 Needs

4 In this section, the needs for the new light control system are presented. In 1.1, functional needs are listed and in 1.2 non-functional needs.

1.1 Functional Needs

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

1.1.1 User Needs

6 The user needs are numbered by *U<number>*.

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

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.

U2 As long as the room is occupied, the actual 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 last 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 standard light scene has to be established.

U5 The wall switches for the window- and the wall-ceiling light group in a room should show the following behavior:
- (i) if the corresponding ceiling light is completely on, then the light will be switched off
- (ii) otherwise the ceiling light will be switched on completely

U6 The light scenes can be determined by using the control panel.

U7 For each room, the actual ambient light level can be set by the user using the control panel.

U8 For each room, a default light scene can be set (not by using the control panel).

U9 For each room, a default ambient light level can be set (not by using the control panel).

U10 The value T1 can be set for each room separately (not by using the control panel).

U11 If the outdoor light sensor or the motion detector of a room does not work correctly, the user has to be informed.

8 The user needs concerning the offices are:

U12 The ceiling lights and the task light should be maintained by the control system depending on different light scenes.

U13 The control panel should be movable in the offices, like a telephone.
U14 The control panel should contain at least:
(i) a switch to set the task light (on/off)
(ii) a switch to set the ceiling lights (on/off/ambient)
(iii) a possibility to set the actual ambient light level

9 The user needs for the remaining rooms are:

U15 In all other rooms the control panel should be installed near a door to the hallway.
U16 The control panel should contain at least:
(i) a switch to set the ceiling lights (on/off/ambient)
(ii) a possibility to set the actual ambient light level

10 The user needs for the hallway sections are:

U17 When a hallway section is occupied by a person, the light in this hallway section has to be sufficient to move safely.
U18 Before a person enters one hallway section from another one, the light in the section being entered is turned on if necessary.
U19 The wall switches for lights in the hallway section have to show the following behavior:
(i) if the light is on, then the light will be switched off
(ii) otherwise the light will be switched on.

1.1.2 Facility Manager Needs

11 The facility manager needs are numbered by *FM<number>*.

FM1 Use daylight to achieve the desired light whenever possible.
FM2 Lights in a hallway section have to be switched off when the section has been unoccupied for T2 min.
FM3 If a room is unoccupied for more than T3 minutes, all lights must be switched off.
FM4 The value T2 can be set for each hallway section separately.
FM5 The value T3 can be set for each room separately.
FM6 The facility manager can turn off any light 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 by 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.

1.2 Non-Functional Needs

12 The non-functional needs are split into several groups depending on the aspect they are dealing with. They are numbered by *NF<number>*.

1.2.1 Fault Tolerance

13 In any case of failure the system shall provide a stepwise degradation of functionality down

to manual operability.

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

NF1 If the 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 the outdoor light sensor does not work correctly, the standard light scene for all rooms is that all ceiling lights are on.

NF3 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.

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

NF4 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 mere occupied.

16 Needs in a worst case failure of the control system:

NF5 If the lights in a hallway section are neither controllable automatically nor manually, the lights have to be on.

1.2.2 Safety and Legal Aspects

NF6 All hardware connections have to be made according to DIN standards.

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

1.2.3 User Interface

NF8 The control panel should be easy and intuitive to use.

NF9 The system issues warnings on unreasonable inputs.

Part 2: Building Architecture

17 In this part, the architecture and the installation of the given sensors and actuators of Building 32, 4th floor is described.

18 In the following document, *keywords* are marked at their first occurrence and listed in the additional dictionary (Part 3).

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

2.1 Building Structure

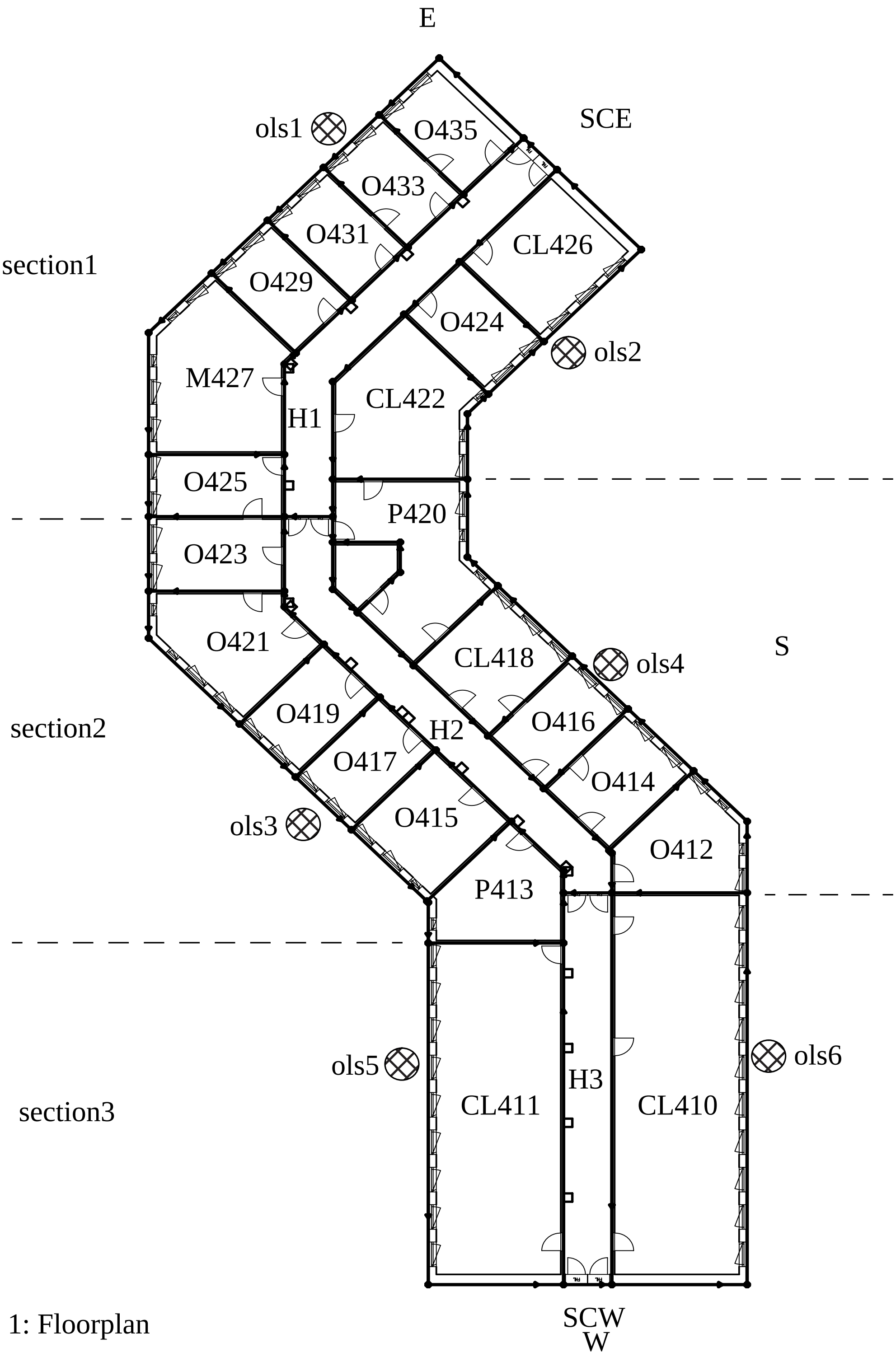


Figure 1: Floorplan

20 The fourth *floor* of building 32 consists of three *sections* and shares two *staircases* SCE and SCW with other floors of the building, as shown in figure 1. Sections are divided into *offices*(O), *computer labs(*CL), *hardware labs*(HL), *peripheral rooms*(P), *meeting rooms(M),* and *hallways(H).* All rooms in a section are accessible via connected hallways. There are three hallways and 22 rooms to control. Figure 1 also shows the six outdoor *light sensors* (ols1 - ols6) and the major compass directions. The sensors cover the six directions of the different walls. The number in the rooms indicate the type of room plus a unique number.

2.2 Current Installation

21 Currently, ceiling light groups in all rooms can only be turned on or off in groups.

22 In all rooms, each ceiling light group is controlled by one or more push-buttons, that toggle the light if switched to the other position.

23 Task lights are controlled manually by one push-button.

24 In the hallways, several push-buttons can toggle the ceiling light group on and off. All push-buttons are connected in parallel.

2.3 Planned Installation

2.3.1 Offices

25 An office (shown in Figure 2) has one door (d1) to the hallway and can have doors to the adjacent rooms (d2, d3). Only those doors are part of a room that open into the room. Therefore, d3 is not an object of the shown room, but the name can be used as a reference. Each door is equipped with a door closed contact, named *dcc<n>*, where n is the number of the door in the room.

26 Each office is equipped with

1. one *motion detector*, so that the room is fully covered (*imd1*). Actually several motion detectors can be connected in parallel to achieve the coverage.
2. two *ceiling light* groups (window and wall), that can be dimmed individually with *dimmer-actuators lle1* (window) and *lle2* (wall)
3. a panel to control the light groups directly or select *light scenes*,
4. a desk with a movable *task light* on it.The task light can be manually turned on and off *(pb3*).
5. two push-buttons (*pb1* (window) and *pb2* (wall)) for the control of the ceiling lights.
6. three status lines (*sll1..3*) that show the status of the three light sources.

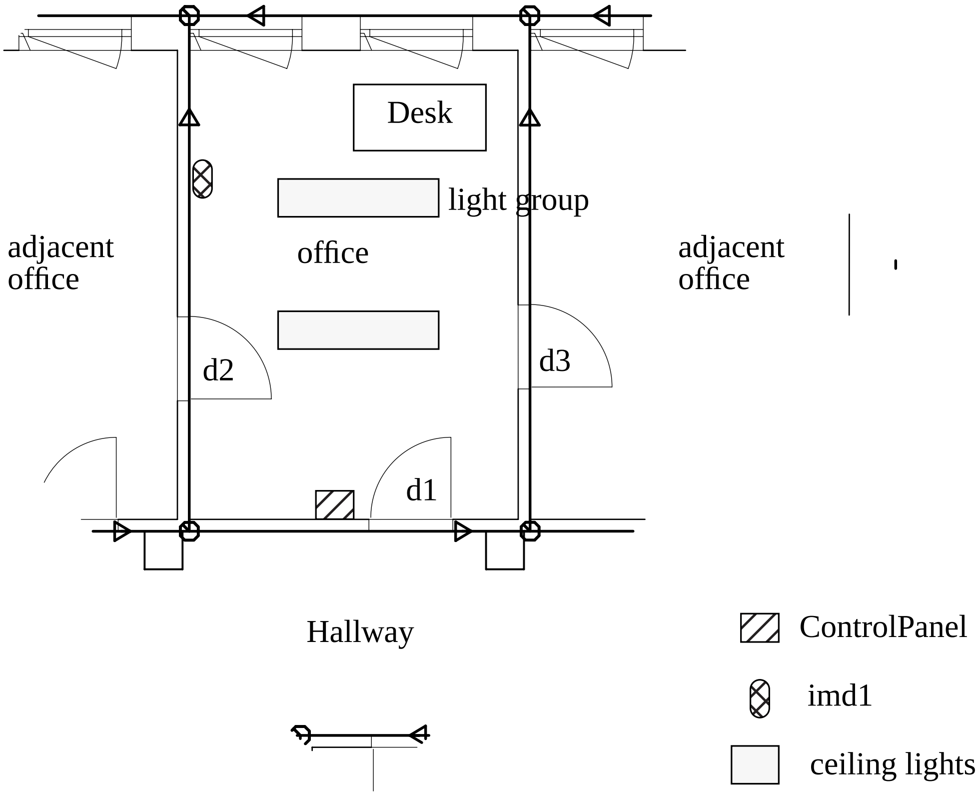


Figure 2: Office

2.4 Hallway

27 Each hallway is limited by two doors, leading to the adjacent hallways. Each door is assigned to only one hallway. Therefore, in the given floor with 3 hallways and 4 doors, there exists one hallway with two doors and two hallways with only one door. The assignment of the doors and their associated names are shown in Figure 3. Each door is equipped with a door closed contact, named *dcc<n>*, where n is derived from the name of the door.

28 Each hallway is equipped with

1. two motion detectors (*imd1* and *imd2*), placed above the doors at each end of the hallway to determine the presence of a person near a door,
2. one motion detector to cover the whole section (*imd3*), can be several connected in parallel for coverage.
3. one ceiling light group that can be turned on and off,
4. several wall push-buttons *(pb)* to toggle the light, an impulse relay, which controls the ceiling light group, and normal relays in parallel to push-buttons.
5. one *status line* (*sll1*) that determines if the light is on or off (*sl1*)

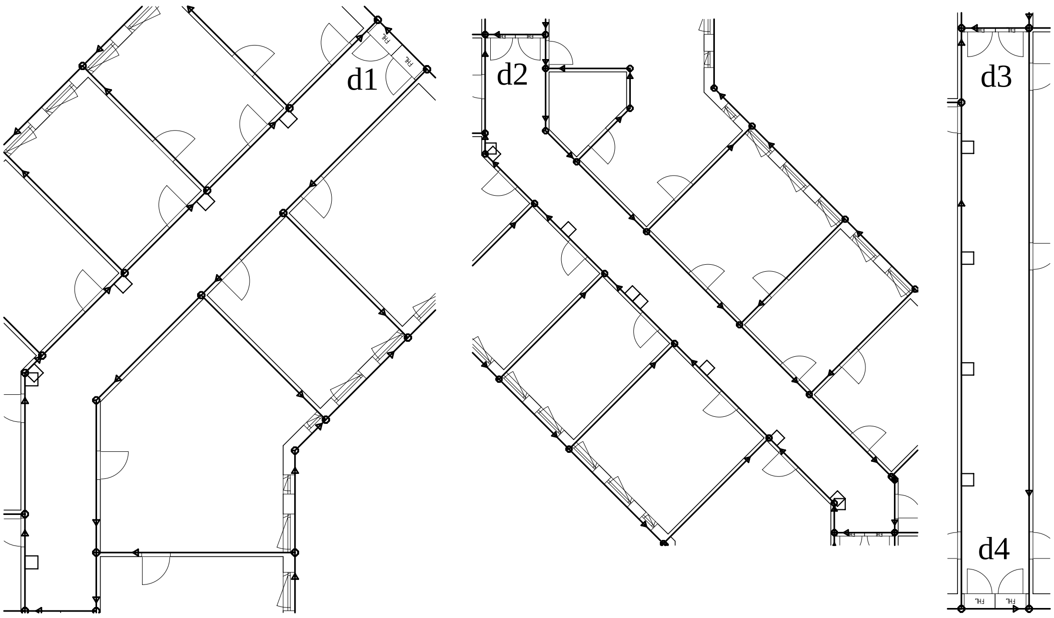


Figure 3: Three hallways

2.4.1 Staircase

29 Staircases connect several floors.

30 At the floor level, a staircase is equipped with

1. one motion detector *imd1* above the door to the adjacent hallway to detect motion near the door.

2.4.2 Computer Labs

31 A computer lab has one door (d1) to the hallway and can have doors to the adjacent rooms (d2, d3). The light installation is the same as in the offices. The sensors at the doors are named like the ones at the offices.

32 Each computer lab is equipped with

1. one *motion detector*, so that the room is fully covered (*imd1*). Actually, several motion detectors can be connected in parallel to achieve the coverage.
2. two *ceiling light* groups (window and wall) that can be dimmed individually with *dimmer-actuators lle1* (window) and *lle2* (wall)
3. a panel to control the light groups directly or select *light scenes*,
4. two push-buttons (*pb1* (window) and *pb2* (wall)) for the control of the ceiling lights.
5. two status lines (*sll1*, *sll2*) that show the status of the light sources.

2.4.3 Hardware Labs

33 Same as computer labs, but with more than one door to the hallway.

2.4.4 Meeting Room

34 Same as computer lab.

2.4.5 Peripheral Rooms

35 The peripheral rooms will not be controlled by a computer system, and thus they will not be presented furthermore!

2.5 Sensors

36 This section describes the real physical sensors including converters if necessary.

37 Analog sensors 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.

38 NC means “normally closed”. Closed is coded as 1, open as 0.

Table 1:

Name	Abbrev.	Type	Resolution	Range	Reaction / Conversion Time	Description
door contact	dcc	NC-contact		0, 1	10 ms	It is placed above the door and is 1 if the door is fully closed.
wall switch	lsw	switch		0, 1	10 ms	2 stable positions
push-button	pb	momentary push-button		0, 1	10 ms	1 as long as pushed
motion detector	imd	passive infrared 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	ols	analog light sensor	1 lux	1 - 10000 lux	10 ms / 1 s	Mounted perpendicular to facade, measures the illuminance of the facade for the calculation of light flow through a window.

2.6 Actuators

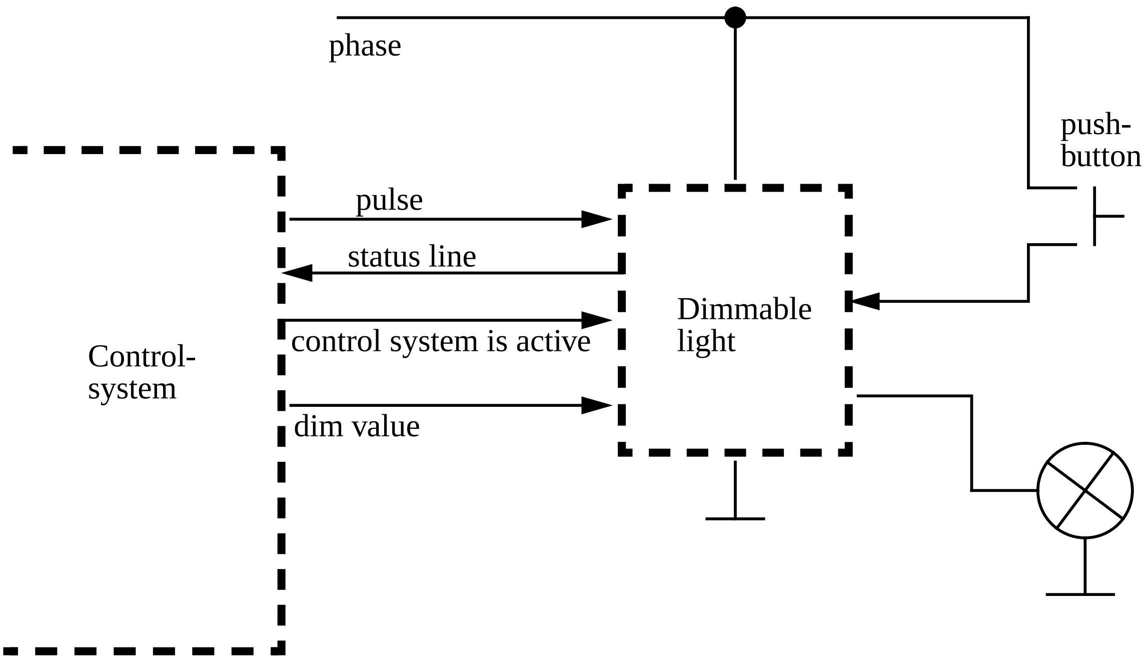
39 Actuators have a linear time response. Reaction time is therefore defined as the time to

change from 0 to 100% / 100 to 0%, if different.

Table 2: Actuators

Name	Abbrev.	Type	Range	Control	Reaction Time	Description
dimmable light	sll	status line		0, 1	10 ms	Senses if the light has the voltage turned on or off.
	cia	status line		0, 1	10 ms	Even if the CS sends an 1 within every 60 s, the CS is still alive.
	dll	dimmer	0 - 100%		10 ms	Controls light between 0 (off) and 10-100% (on).
relays			1, 0		10 ms	

40 The structure of the dimmable lights 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 light switches to fail safe mode and dim value changes to 100%. The output is a status line to show the current state (on or off) of the light.



Part 3: Dictionary of Terms

Table 3: Dictionary of keywords of the application domain

Keyword	Abbre-viation	Description	German Translation
actual user		current user of a room	aktueller Benutzer
actuator		device that can be controlled by control system	Aktuator
ambient light			Umgebungslicht
blind		used to shade window from the outside	Jalousie
ceiling light		luminaire under or in the ceiling,	Deckenbeleuchtung
comfort time		time period in which full room climate comfort is expected	Benutzungszeit
computer lab		room with many terminals, workstations, open to all group members and temporarily to students of a class	Terminalraum
contact		electrical or magnetic gadget to determine the state of a door, window etc.	Kontakt
control panel		small panel, typically on the wall, with a keyboard, LEDs for important states, and a simple display for textual messages	Bedienungsfeld
control system		hard- and software system that controls indoor climate, lighting, safety and security	Kontrollsystem
dimmer-actuator		controls the output of a luminaire	Dimmer
door			Tür
environment		surrounding of section of the building, indoor and outdoor	Umgebung
facility manager	FM	person responsible for running a building on a daily basis	Hausmeister
hallway		part of a building between several rooms to connect them to each other	Flur
hardware lab		room in which experiments with hardware are performed	Hardware-Praktikumsraum
illuminance		amount of light incident on a surface, measured in lux	Beleuchtungsstärke
impulse relays		changes state (on, off) with each signal	Stromstoßrelais

Table 3: Dictionary of keywords of the application domain

Keyword	Abbre-viation	Description	German Transla-tion
installation		equipment belonging to the building and that can be operated, like radiators, windows openers, light fixtures,...	Installation
light scene		light scenes are predefined settings of the light levels and an ordered list of luminaires which should be used to achieve them. One light scene consists of 4 parameters: 1. name of light scene 2. illuminance of the ambient light of the room 3. illuminance for the desk 4. 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 given light values.	Lichtszene
light sensor		measures the illuminance in a half sphere perpendicular to it's flat bottom	Lichtsensor
luminaire	light		Leuchte
member		persons in research group	Gruppenmit-glieder
motion detec-tor	imd	detects motion of a person or animal in its range, state is on during positive detection	Bewegungs-melder
office		room for one or two group members with terminals and/or workstations	Büro
off-time		time in which no usage is expected	
peripheral room		room for computer peripherals, copy machines, general group access	Peripherieraum
public room		accessible to all group members and the public at all times	öffentlich zugänglicher Raum
push-button		is on, as long as pushed manually	Taste
responsible person		person responsible for individual settings of one room	verantwortliche Person
room			Raum
sensor		device that can sense state of the building, users or environment	Sensor

Table 3: Dictionary of keywords of the application domain

Keyword	Abbre-viation	Description	German Transla-tion
stand-by time		time in which a person is expected in a room	
status line		A wire that has the status of a device as value	
switch		Can be turned on or off manually	Schalter
system			System
task light		luminaire on desk	Arbeitsleuchte
temperature sensor			Temperatursensor
user			Benutzer
weather		outdoor temperature, wind, radiation, humidity	Wetter
window			Fenster
workshop		Room with tools and special machines for electronic and metal work, access for techni-cians	Werkstatt