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Using Goal Models to Understand and Prioritize Requirements for E-learning Management Systems

Bachelor of Science Thesis in Software Engineering and Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2017

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***Abstract*—Learning management systems are software applications which attempt to handle all aspects of the learning process, they are a crucial part of educational technology. This study investigates and models the functional and non-functional requirements of two academic and one industrial learning management system. Through the use of goal modelling the systems are modelled to provide a visual presentation of the functional and non-functional requirements present. In order to prioritize these requirements and establish which are deemed as most important a survey was sent out, which obtained 63 responses from students and professionals. The models created were validated through two interviews. The prioritized requirements are then used to create a general learning management system requirements model, which can be utilized by developers when creating learning management systems.**

***Keywords*-Learning management system; manual reverse engineering; functional requirements; non-functional requirements; goal modelling**

I. Introduction

Educational technology is defined as "the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources" [1]. One of the technological systems of educational technology is the Learning Management System (LMS). A LMS is a software application for delivering, tracking and managing courses or training programs both in academic and industrial settings [2]. Considering that students are growing up in a digital age [3], educational technology is becoming exceedingly sought-after. As these learning platforms continue to evolve, focus needs to be put on creating "Software requirements specifications (SRS) which are the foundation of the pillars of software. They drive design, development, user experience and support documentation" [4]. It is important for all systems to have accurate and relevant requirements. This is especially true for LMS's and each requirement should express a need of the user which should be fulfilled by the system. "The necessity for new requirements can be instigated by legal triggers (regulations, law or standards) economic and strategic causes (product change, profit or organizational change) or technical reasons (new technology, technological problems)" [5]. In systems engineering, functional requirements define the functionality of the system [6], while non-functional requirements are often defined as quality attributes [7] which help to better the overall performance of the system.

LMS's differentiate themselves from other computer learning systems due to the fact that they attempt to handle all aspects of the learning process. Watson and Watson suggest that society has moved from an industrial age to an informational age and the learning process also needs to follow this paradigm shift [8]. The systems should facilitate the need for "assessment of learners' current knowledge and skill level, work with teachers and learners to identify appropriate learning goals, identify and sequence instruction appropriate for the individual learner, assess learner performance products, store evidence of attainments, support collaboration and generate reports to provide information to maximize the effectiveness of the entire learning organization." [8]. Therefore, the technology platform needs to evolve in order to fully facilitate the needs of the learners. LMSes are the tool by which this change can be actualized. In order for this to be possible, investigating which requirements are present in current LMSes and prioritizing them from a user perspective helps to determine the most important aspects of the system. This can be done through the use of reverse engineering, which is the process of "extracting knowledge or design information from anything man-made" [9].

Faxén investigates the most important aspects of LMS's in order to improve learning outcomes. He classifies requirements into categories which are ranked by importance depending on how often they occur in literature. He suggests that the most occurring requirements within a LMS are communication, course content management and evaluation [10]. There are a number of papers which provide requirements which are present in LMS's however there is limited user prioritization and visualization of these requirements [2] [10] [11] [12] [5]. Developers need to decide which parts of the system they should spend the most time on, hence, the prioritization and visualization of requirements is important because it allows for the important aspects of the system to receive more attention. A process which can help developers achieve this is goal-modelling. Goal-modelling is typically used during early requirements engineering to give rationale for requirements,

identify stable information and guide requirement elaboration [13].

Therefore, a visual goal model which is based on the users wants and needs can be utilized by a developer in order to create a LMS with the relevant functional and non-functional requirements to meet the users desires.

A. Purpose of the study

The purpose of this case study is to create a general LMS requirements model. Initially, requirements were elicited through the analysis of three LMS's and through the research of relevant literature. The elicited requirements were used to create models for each respective LMS and then prioritized by users and developers in order to create a list of the most important requirements. These prioritized requirements were then used to generate the general model. The purpose of the general model is to capture the prioritized requirements and visually present them so that developers have a clear visual representation of which functional and non-functional requirements are important to include.

The three modeled LMS's are:

- Göteborgs Universitet Lärplatform (GUL)
- Luleå Tekniska Universitet (LTU)
- Volvo Group University (VGU)

The elements and agents which will be analyzed and modelled are:

- Non-functional requirements
- Functional requirements
- Actors
- Dependencies between actors

B. Research Questions

RQ: How can requirements be manually reversed engineered and captured in goal models in order to create a general requirements model that supports design of E-learning management systems?

RQ1: How well can we use requirements engineering modelling to capture manually reverse engineered functional and non-functional requirements of three learning management systems?

RQ2: Which requirements are deemed by computer science students and professionals as the most important to include in a learning management system?

RQ3: How well can we use prioritized reverse engineered requirements in order to create a general requirements model for learning management systems?

The ultimate goal of the thesis is to produce a general model which is grounded on manually reverse engineered requirements and user validation of said requirements. The purpose of this model is to create requirements representations which help with the design of future LMS's. However, it is important to note that the design of these systems is outside the scope of the thesis.

II. Related work and Background

The literature review was carried out by searching through digital libraries containing research articles. The search engines Scopus, Google Scholar, Göteborg University library and ScienceDirect were used for browsing through related work. The search terms that have been used in different combinations are "Learning management system", "Functional Requirements", "Non-functional Requirements", "Reverse engineering requirements" and "Modeling requirements". Approximately 150 results have been checked using each search engine and those which fall into similar problem domains have been analyzed closer in order to establish a foundation of research.

1) Functional, non-functional requirements and barriers within LMS's: The design science paper by Richardson [14] proposes how to use available resources to provide a quality, flexible, learning environment for staff and students. The paper describes the process involved in the development of the learning management system. Several factors are taken into account when creating the LMS as reported by this work, flexibility was an important factor. The paper by Chan [14] presents the experience in developing and evaluating a web based learning product. Design considerations are included which focus on the lack of social interaction between students and teachers when using LMS's, lack of motivation and similar pedagogical barriers. The paper also includes pilot tests and post implementation evaluations. The goal of the thesis by Wundenberg [5] is to formulate a general framework for LMS selection based on different types of data to determine the needs of stakeholders. The architecture development and requirement engineering of the framework are based on research of LMS fundamentals. The thesis includes all typical modules, features and elements. It also tests the developed product in a polytechnic school environment. The relevance of these papers to our thesis is that they provide a number of important non-functional requirements when developing a LMS.

The thesis by Faxén [10] has two main objectives: the identification of technology that improves the results of academic e-learning by comparing different LMS's and the establishment of requirements for a LMS in an academic environment. Faxén, through research, establishes thirty requirements arranged in eleven functionality subsets for an academic LMS. These eleven categories were then ranked, the three subsets ranked as most important were course content management, evaluation and communication. The three most important subsets included twelve functional requirements, Faxén then evaluated different LMS's to determine if they supported this functionality. This study does not analyze the LMS's for anything more than the twelve functional requirements established nor does it model these requirements. That is what our thesis will contribute with, the modelling of requirements

and the full analysis of three LMS's. The study by Islam [15] investigates and lists factors that generate satisfaction and dissatisfaction of users in a learning management system. It uses theological assumptions from different theories. The results identify non-functional requirements that produce satisfaction and dissatisfaction for students and educators, it also provides the frequency of these factors. The thesis paper and the study address a similar problem as we do in this thesis. They provide the functional and non-functional requirements in a list whilst our contribution will be a visual general model of prioritized LMS requirements.

2) Solutions to functionality problems within LMS's: The paper by Kunz [16] discusses the requirements of a LMS from a constructivist perspective. The basic elements of constructivist features are described which include active construction of knowledge, social collaboration and negotiations, contextually situated, authentic and meta cognition. It delves into the reasoning behind successful design elements and also what a system needs to provide in order to deliver full functionality. Furthermore, it also investigates a development agenda for the next generation of LMS's which include components that already exist, components that need to be improved and components that have to be developed. The connection that this has to our topic is that it provides us with LMS functionality. They are however not modeled and this will be the gap in the market that our thesis will fill.

3) Guidelines on goal model creation: The paper by Liu and Yu [17] investigates the representation of design knowledge of information systems through the use of goal-oriented requirements language (GRL) and Use Case Maps (UCM). Goals are depicted as functional and non-functional requirements and tasks are the alternative ways to achieve these goals. Furthermore, the relationships between these agents and roles are displayed as dependencies and it is all illustrated through an example web-based training system. The importance of this is that it allows us to see how a similar type of system is being modeled using a goal-oriented language. This provides insights into how requirements are modelled and how the relationships and dependencies between tasks are created.

a) i legend:* i* (eye-star) is a framework used in the software requirements engineering field, it supports goal modelling for systems and organizations. Since it is a goal-oriented modeling framework it offers the usage of actors, dependencies, goals and decomposition [18]. In Figure 1 the i* notations can be viewed.

4) Issues with functional and non-functional requirements elicitation: The paper by Grimshaw and Draper [19] investigates some deficiencies which exist in current system development methods. The problem is that non-functional requirements are often overlooked and that questioning users is not enough when attempting to elicit requirements. A framework is proposed for taking a stakeholder approach to organizational changes in order for effective elicitation of requirements analysis. The problem which is brought up in this paper has significance on our thesis since the majority of data that will be collected concerning requirements will be elicited from users. Hence, the proposed methods in the paper concerning structured development methods will be incorporated in order to elicit requirements in the most effective way.

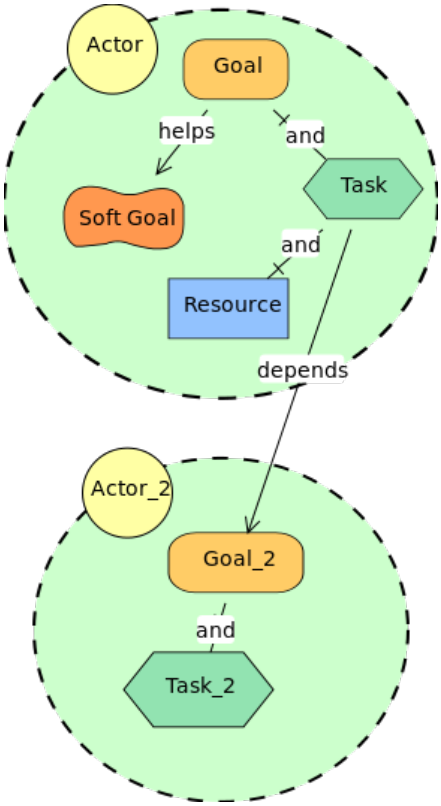

Fig. 1: Illustration of how the i* concepts and dependencies between actors look

III. Methodology

The models based on the three LMSes and the general model were created through the use of a variety of methods: manual reverse engineering, extensive analysis of requirements in documentation, modelling of functional, non-functional requirements and the classification of similar subsets of functional features. This process is visually presented in Figure 2. Note that the interviews and surveys were conducted in parallel due to time constraints.

A. Data Collection

Through research, three subsets concerning the functionality of LMS's were found in literature [10] as well as the criteria of which functionality falls underneath which subset. These subsets were expressed as follows:

- Communication
- Course Content Management
- Additional Services

Communication. This includes functionality and requirements [2] which "Enables communication between administrators and learners" [11], "Search and identify learners and deliver targeted courses, news, references, and other information to continually engage them" [11]. "LMSs give users the possibility to switch between different chat options" [16]. These criteria, amongst others [10], provided guidelines for the placement of functionality within the communication subset.

Course content management. This includes functionality and requirements [20] related to "Assignment upload, uploads of course assignments for the students." [10], "Personal file storage, for the users." [10], "Target content to the correct individuals or groups" [11] and "Course object reuse, possible for the teacher to create courses from existing course objects." [10] These criteria provided guidelines for the placement of functionality within the course content management subset.

Additional services. This contains functionality and requirements [21] which exists in the system but does not fall into the 2 aforementioned subsets. This section was not derived from literature. This includes "ePortfolios which could be used by students as a knowledge construction and reflection space." [16], "Manage user registrations and profiles," [11] and "The system should be compatible with other third party software to simplify integration." [10]. These criteria helped to define which functionality would fit into additional services.

The subsets of functionality were taken from literature. These subsets were chosen since they express the classifications of similar functionality effectively. The data collection procedure began with collecting the documentation of the systems. Product documentation and user documentation was obtained for each system. The documentation was used as a road map when navigating through the systems. The manual reverse engineering followed the listed functionality in [22] for GUL. However, due to the fact that GUL does not utilize all the available functionality that the Ping-Pong framework offers, manual browsing of the system was necessary to establish which functionality was present. The manual reverse engineering of the LTU system followed the listed functionality in [23]. However, just like GUL, the LTU LMS does not utilize all available functionality that Canvas offers, the manual usage and browsing of the system was necessary to establish the functionality present. Navigator is the VGU LMS platform and the data collection for it was conducted in a different way. The Navigator system was inaccessible to us so therefore, visiting Volvo Group to analyze their system was the only alternative. Direct usage of the Navigator system was prohibited to non-employees, however, a long tour of the system was provided as well as a user guide to the system. Detailed notes were taken which could be referred to when creating the model of VGU. The user guide of the system was used as a road map and helped with the manual reverse engineering of the functionality present in the VGU LMS. Once the procedure of analyzing the documentation and manually reverse engineering the requirements was conducted, the modelling phase began.

B. Goal Modelling

Goal-modelling clarifies identified requirements and shows how the abstract goals of the system are analyzed into smaller and more realizable goals. The modelling framework i* was used, since it provides adequate notations to express goals and tasks. The phase included modelling the three LMS's and the three comparable subsets of functional features for the GUL and LTU system.

The subsets and their identified requirements were divided into three separate models for two out of the three systems. This was done for model clarity and to reduce the size of the overall models. The goal models were gradually finalized in iterations. Starting with the creation of the actors then adding the functional requirements and finally creating the dependencies between the actors. The next step was to create the soft goals which represent the non-functional requirements of the system. After the completion of the modelling phase the next step was creating the survey and interviews to prioritize the elicited functional and non-functional requirements in order to be able to create the general LMS model.

C. Survey

Surveys are useful when collecting quantitative data from a large group of individuals without a large amount of time and effort being spent by the questioner. Research done by Kaplan and Saccuzzo which states that if the questions answered by the interviewee are not understood correctly, then the information which is gained is near to useless [24]. Therefore, the survey was constructed and piloted with the help of three students and one teacher. Adhering to survey writing rules [25] helped to make the survey as good as possible. For example, the ordering of questions and using unbiased words in the questions were conscious choices. Feedback was received in

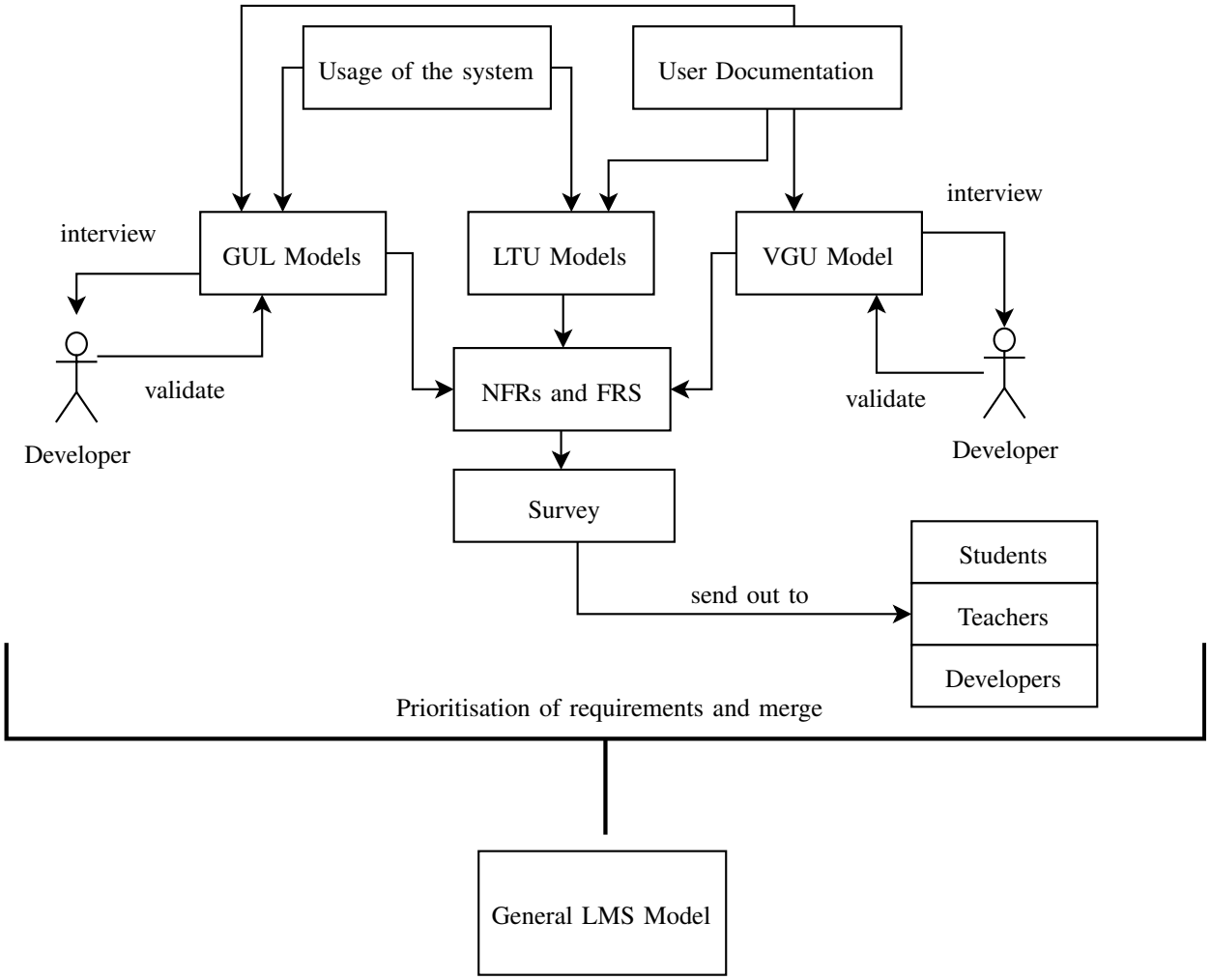

Fig. 2: The steps that lead to the creation of the general model. The NFRs and FRs stand for non-functional and functional requirements.

order to better the survey and make it clearer. The survey was then distributed via e-mail and message boards to a target audience, being the Software Engineering Division within the Computer Science and Engineering Department. This audience was chosen since reliable access could be gained to both students and professors. This helps to ensure that the data received is reliable since the recipients are all experienced with similar software systems and have adequate prerequisite knowledge to accurately answer questions regarding requirements. The ecosystem consisted of three categories of people:

- Students (users)
- Teachers (administrators)
- Developers (creators)

The modelling of the LMS's occurred before the creation of the survey. Due to the large sizes of the models and the substantial amount of requirements which have been identified, the survey could have been extremely long. This would have been counterproductive towards the amount of responses [24]. The initially created models helped to formulate the questions in the survey by providing a collection of most commonly occurring functional and non-functional requirements amongst the three LMS's. Creating a foundation upon which the questions in the survey were constructed. Functionality which appeared in all three or two of the LMS's was included in the survey. However, some functionality only present in one of the systems was also considered due to the fact it could be beneficial to the LMS user.

Due to the division of the models, the survey was divided into different sections. Each section included multiple choice questions which used the agreement scale. The agreement scale questions included the most commonly occurring requirements found within the three LMS's and the answers used the Likert scale [26], where 1 represented "Not important" and 5 represented "Very important", which resulted in the ranking of the functional and non-functional requirements. Certain questions in the survey were open ended, this means that some qualitative data was also been collected through the

survey. These questions were in the format:

- "What is the most important functionality to enhance *specific section* and why?"
- "Do you have any additional functionality which you think that the *specific section* aspect of the LMS would benefit from and why?"

The open ended questions provided the individuals with the possibility of answering questions relating to which of the mentioned requirements are the most important and if there are any additional requirements a LMS would benefit from. These questions were provided at the end of each aforementioned section, ensuring that the respondent was aware that the question refers to this specific section. The purpose of this was to gain insight into the reasoning and solidifying the responses. The qualitative data entered for these questions was analyzed and taken into consideration when carrying out the prioritization. However, these suggestions cannot be prioritized since there is insufficient time to create another iteration of the survey.

D. Interviews

Interviews are discussions with one or more people and the results are typically recorded, video-taped or written down [27] to allow for post analysis. Interviews were another form of data collection which was carried in our LMS investigation. They were semi-structure in order to provide the most relevant and precise data possible. The interviews were conducted in person with individuals that have developed and contributed to the VGU and GUL LMS's. One interview was carried out with a senior management consultant at Volvo. Another interview was carried out with a developer and the owner of Ping-Pong which are the providers of the framework upon which GUL operates. This allowed for a sufficient amount of analysis to be carried out concerning the models and non-functional requirements collected. Two candidates were chosen due to the difficulties which arise when reaching the developers of the systems combined with the limited time frame that exists.

The interviews were conducted once the two LMS's had been modelled. During the interview the participants were presented with the models created. The i* language as well as the models were described to the participants to avoid any misconceptions concerning the language and notations. Afterwards, the participants were questioned whether the models were capturing the LMS's functionality and if the validation of the models was possible. Once these questions were answered, the next phase of the interview included questions regarding the non-functional requirements of the system, validation and the motivation behind them. The data was collected in a text document and then analyzed. The earlier mentioned criteria was used to identify important statements made by the interviewees. The interviews resulted in the validation of the created models, GUL and VGU, as well as the motivation and prioritization of the non-functional requirements.

Interview questions regarding functional requirements:

- Have we modelled your system's functionality correctly? If not, is there any important functionality missing?
- Could you validate the models we have shown?

Interview questions regarding non-functional requirements:

- Have we included most of the non-functional requirements of your system?
- Have we included non-functional requirements your system does not contain? What is the reason for not including them into your system?
- Are there any additional non-functional requirements your system prioritizes? Why do you deem these non-functional requirements to be important for the system?

E. Validation of Models

The three LMS models were created with a variety of methods, such as reverse engineering and analysis of documentation, which is why the validation of the models was necessary. Through the validation, affirmation can be obtained leading to the conclusion that the requirements modeled are consistent with the actual systems and can be therefore re-used in the general model. The LTU model was not validated due to the constraint of being unable to contact the developers of the system.

The validation of the general model is out of the thesis scope. The reason for this is that the most conclusive way to validate the general model would be to create a LMS based upon the identified requirements. However, this is not feasible within the given time frame. The functional and non-functional requirements which are present in the general model have been validated from a user perspective. Therefore, the content of the general model can be considered partly validated. The possibility of creating an LMS based on the general model could be a potential future development research contribution.

F. Analysis Method

The analysis of the data differed depending on the kind of data acquired.

Interviews. The interviews were recorded and then manually transcribed. The transcribed interviews were scrutinized for relevant information. The process of coding the transcribed interviews followed the Constant Comparison Method [28], it helped with labelling relevant data. The relevant data included things related to the validation of the models and the non-functional requirements.

The data extracted was used in order to validate the models created as well as the validation and motivation behind the non-functional requirements.

Survey. The survey consists of 46 questions. The agreement scale questions use the Likert scale which allowed the ranking of different functional and non-functional system requirements

from 1 to 5. It also allowed for ease of statistical calculation when comparing the prioritization level of each question. The statistical evaluation of the responses included a weighted average value, the median value and the modal value. Through the use of a weighted average, a score from 1 to 5 was generated for each question in the survey which signifies the importance of the functionality from the users perspective. The weighted averages assisted when deciding on which requirements were important enough to be included in the general model.

$$\text{WeightedAveragex} = \frac{\sum Wx}{\sum W}$$

w = relative weight

x = value

There is a debate whether the average value should be used when statistically analyzing ordinal data [29] [30] [31]. It is suggested to also use the mode and the median in combination with the weighted average value in order to evaluate ordinal data. Therefore, the mode [32] and the median [33] were also calculated.

The collected data was compared to see which are the most commonly occurring requirements in related literature and which requirements have been evaluated as important through the interviews and the survey. These requirements formed the basis for the general model. The prioritization of the requirements identified was done through excluding the requirements that had a weighted average ranked as low, < 3.4, and including data ranked as high, $>= 3.5$. The requirements which received a weighted average value over a certain limit in the survey were inserted in the general model. Furthermore, additional views of the general model was created where the weighted average value boundary was increased which decreases the size of the model whilst increasing the level of importance. The information obtained from the survey and the interviews will be analyzed and compared to see if elements which were considered important by users, would also be considered important by developers. This helps to finalize the requirements considered in the general model.

G. Threats to Validity

There are a number of issues which arose and acted as threats to the validity of the results from the strategic resource collection methods. The criteria for the threats of validity listed are based on the article by Easterbrook [34]

Construct Validity. The goal models are a possible construct validity threat to the study. The fact is, the models were created based on documentation read and without much background when it came to how the LMS's functioned. Our interpretation of the systems functionality and what was important could have been biased. The mitigation of this threat was done through the help of the interview subjects who also validated the models.

Internal Validity. The subjects interviewed had software engineering backgrounds and an understanding of modelling languages, however, they were unfamiliar with the i* framework. To mitigate this internal threat to validity, a short introduction about the framework was given which provided basic understanding of the notations and the logic of i*. The introduction helped the subjects when examining the models for correctness.

Another potential threat was the design of the survey and the questions. To mitigate this threat we conducted 4 pilot tests for the survey in order to ensure that the questions were not misleading.

External Validity. The fact that only 3 systems are analyzed and modelled is a limitation to the accuracy of the final model. It's difficult to say that these 3 systems which we have analyzed are encompassing enough to contain the most important requirements of LMS's. Optimally, the analysis should by carried out on more than 3 systems. However, due to time constraints, eliciting and modelling requirements for additional systems would not be feasible.

Another threat is that this thesis focuses on students and professors who are active within the field of computer science and software engineering. This could be a limitation on the type of results gathered since IT students may not be representative of the entire LMS user population. Reaching other populations effectively is not possible within the given time frame and the decision was therefore made to focus on a population where sufficient data could be collected.

There were two subjects for the interviews. Having only two subjects is not a large sample. However, since each subject represented their respective company, there was no need to interview more than one candidate at each company.

Reliability. This threat focuses on the likelihood for other researchers to replicate our study and obtain the same results. If they were to follow our methodology, we believe it would be possible. However, if they were to distribute their survey to a different audience, the prioritization of requirements might be different and therefore the final model would not be exactly the same.

IV. Results

In this section the gathered results are presented.

A. Modelling Results for Three LMSes

1) Göteborgs Universitet Lärplatform (GUL): Through the analysis of the documentation and manual reverse engineering of the requirements, the GUL models resulted in three different subsets of a LMS. The three subsets are communication, course content management and additional services. The list of functional and non-functional requirements for all three

subsets can be seen in Tables I, II, III as well as a larger and clearer view of the models in the Appendix Figures 16, 17, 18.

A zoomed in sample of the communication model can be seen in Figures 3 and 4. These figures will be explained to provide the general structure of how the GUL models can be understood. The models include two main actors that represent the user and the system, however in some models there are additional actors which play a role when it comes to achieving a certain task or a goal.

The models are presented by providing a hierarchy of goals, these goals are represented by an orange oval. The user's highest goal is to be able to "Communicate with students and course representatives", this goal is connected to sub goals.

The goals are decomposed to tasks that achieve them, the tasks are represented by a green hexagon. For example, the goal "Use PIM" is decomposed to different tasks that are "Send PIM to teacher" and "Send PIM to group". The darker orange ovals are the soft goals which represent the non-functional requirements. The soft goals "helps"tasks and goals to be achieved. In this case, having "Privacy" helps to achieve the goal "Use PIM". The system's highest goal is to "Provide users with reliable ways of communication", this goal is decomposed into sub goals.

The user's goal "Use PIM" and its tasks "Send PIM to teacher" and "Send PIM to group" are dependent on the goals in the system: "PIMs can be Sent/Received" and "PIMS can be sent/received to group". These goals are decomposed in the system to a task and a resource. The connected tasks are the green hexagons "Display member list email" and "Display group member list emails".

These tasks require resources, resources are represented by a blue rectangle, and provide the necessary information which in this case is "Member List Emails" and "Group List Email". The system contains soft goals just like the user, in this case "High responsiveness for effective messaging" and "Performance" help these goals to be achieved.

2) Luleå Tekniska Universitet (LTU): The analysis and the manual reverse engineering of the requirements lead to the creation of three models. The LTU models contain three subsets of a LMS, communication, course content management and additional services. The list of functional and non-functional requirements for all three subsets are listed in Tables I, II, III as well as larger and clearer view of the models in the Appendix Figures 19, 20, 21.

A zoomed in sample of the additional services model can be seen in Figures 5 and 6. These figures will be explained to provide the general structure of how the LTU models can be understood.

In this case, user's highest goal is to be able to "Allow user to access additional services", this goal is connected to sub goals.

Like in the GUL model, goals are decomposed into tasks, the goal "User can be connected to third party services for personal usage" is decomposed to different tasks, one of them being "Connect Skype service". The task "Connect Skype services" depends on a third actor being "Skype".

The soft goals "helps" tasks and goals to be achieved. In this case, having "Interoperability" helps to achieve the goal "User account can be connected to third party services for personal usage". The system's highest goal is to "Provide additional services", this goal is connected to sub goals.

The user's goal "User account can be personalized" and its task "Edit the user profile" is dependent on a goal in the system "The user profile should be editable". This goal is decomposed in the system to a task and a resource. The connected task is the green hexagons "Profiles should have modifiable data". The resource connected to this task is "Profile information". The system contains soft goals just like the user, in this case "Manageability" helps these goals to be achieved.

3) Volvo Group University (VGU): Once the documentation of the Navigator system had been obtained, the analysis and manual reverse engineering of the requirements was possible. Because of the condensed functionality of the system only one model was created. The focus of the system was the course content management subset of a LMS as listed in Table III and in the large Appendix Figure 22. The VGU LMS documentation did not include third party service or means to communicate within the system.

A zoomed in sample of the VGU Navigator model can be seen in Figures 7 and 8. These figures will be explained to provide the general structure of how the VGU model can be understood.

In this case, the user's highest goal is to be able to "Access training and task information", this goal is connected to sub goals.

Like in the GUL and LTU model, goals are decomposed to tasks, the goal "Personal information can be viewed" is decomposed to a task, the task being "View my page".

The soft goals "helps" tasks and goals to be achieved. In this case, having "Manageability" helps to achieve the goal "Personal information can be viewed". The system's highest goal is to "Provide user with training and task information", this goal is connected to sub goals.

The user's goal "Personal information can be viewed" and its task "View my page" is dependent on a goal in the system "My page is available". This goal is decomposed in the system to a task and a resource. The connected task is the green hexagons "Personal information is displayed". The resource connected to this task is "Personal Profile". The system contains soft goals just like the user, in this case "Privacy" helps these goals to be achieved.

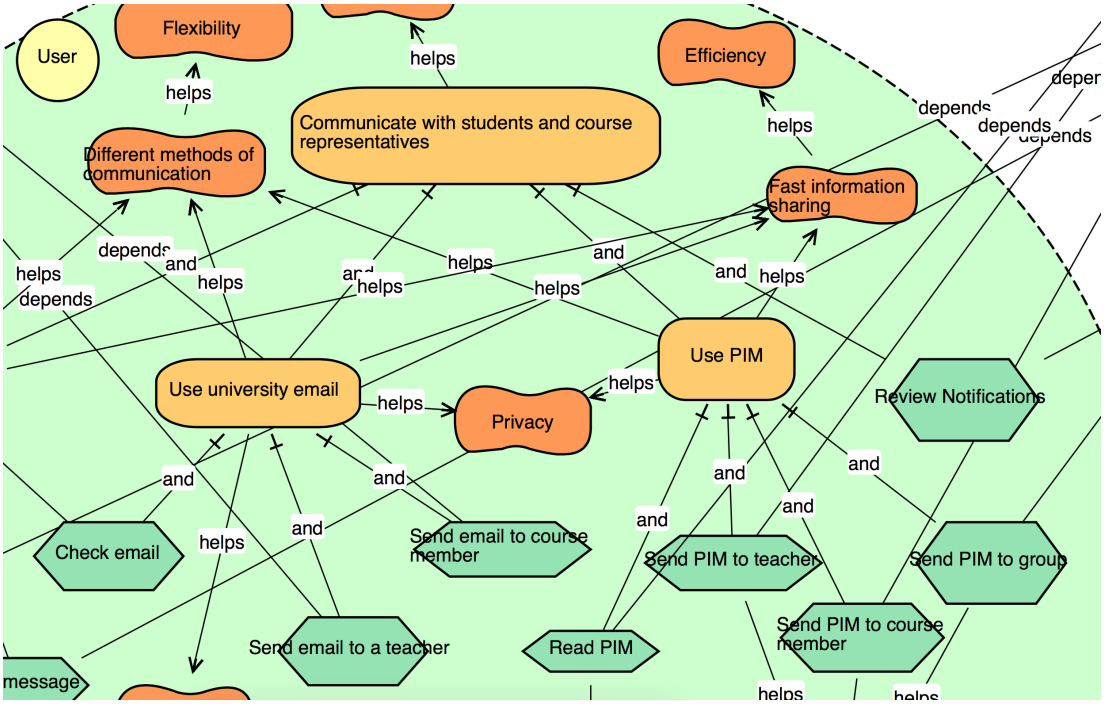

Fig. 3: A zoomed in sample of the User actor in the GUL communication model

Fig. 4: A zoomed in sample of the Systems actor in the GUL communication model

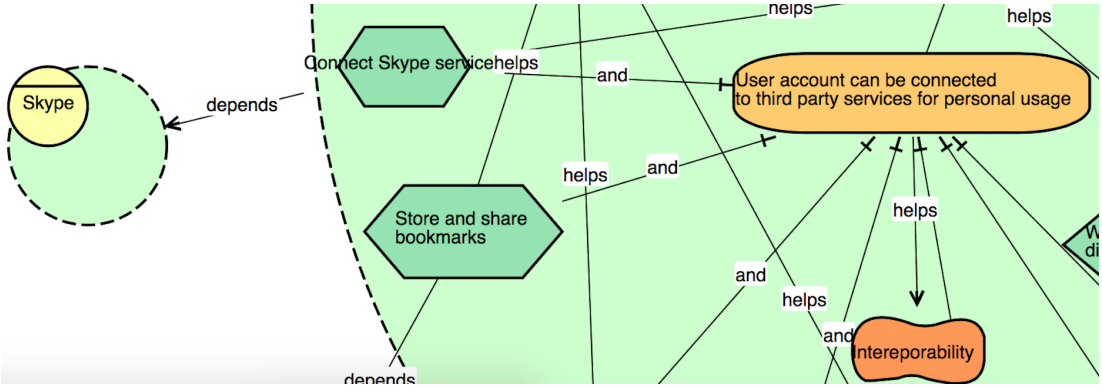

Fig. 5: A zoomed in sample of the User actor in the LTU additional services model

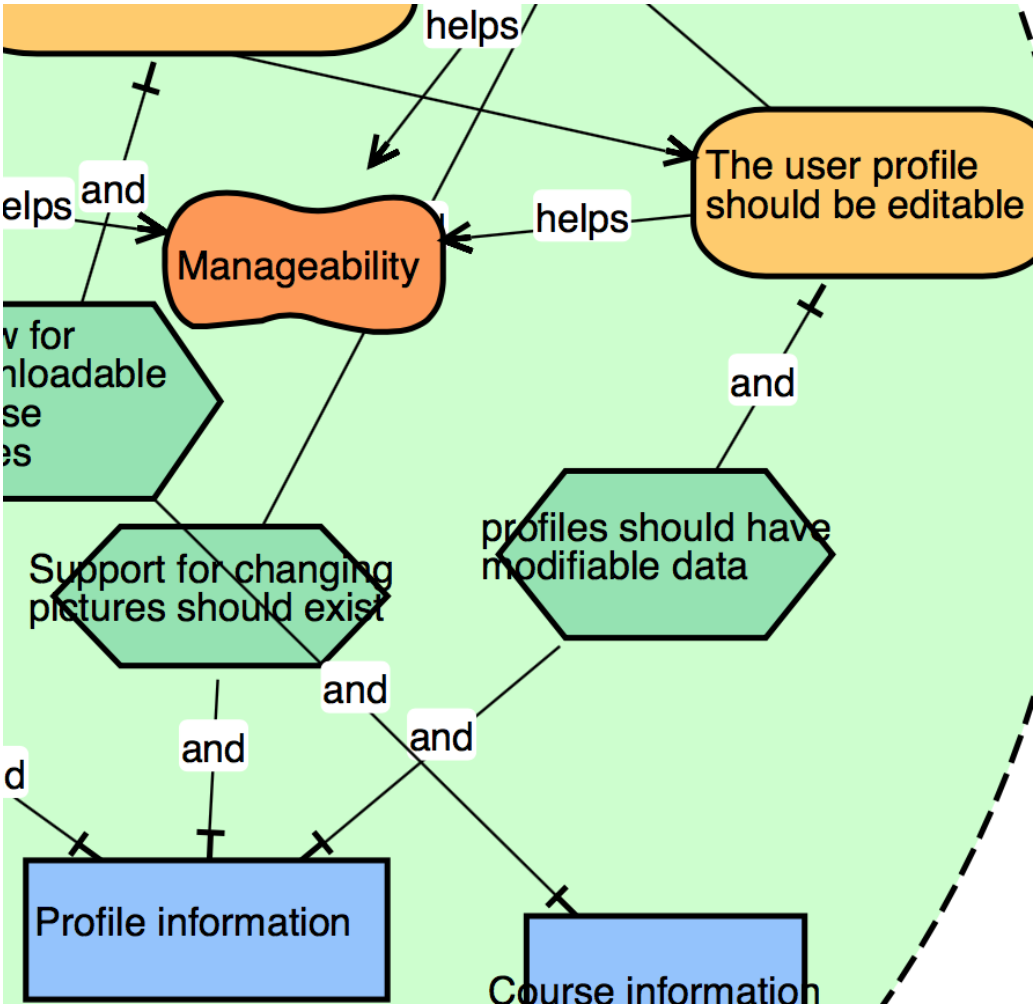

Fig. 6: A zoomed in sample of the Systems actor in the LTU additional services model

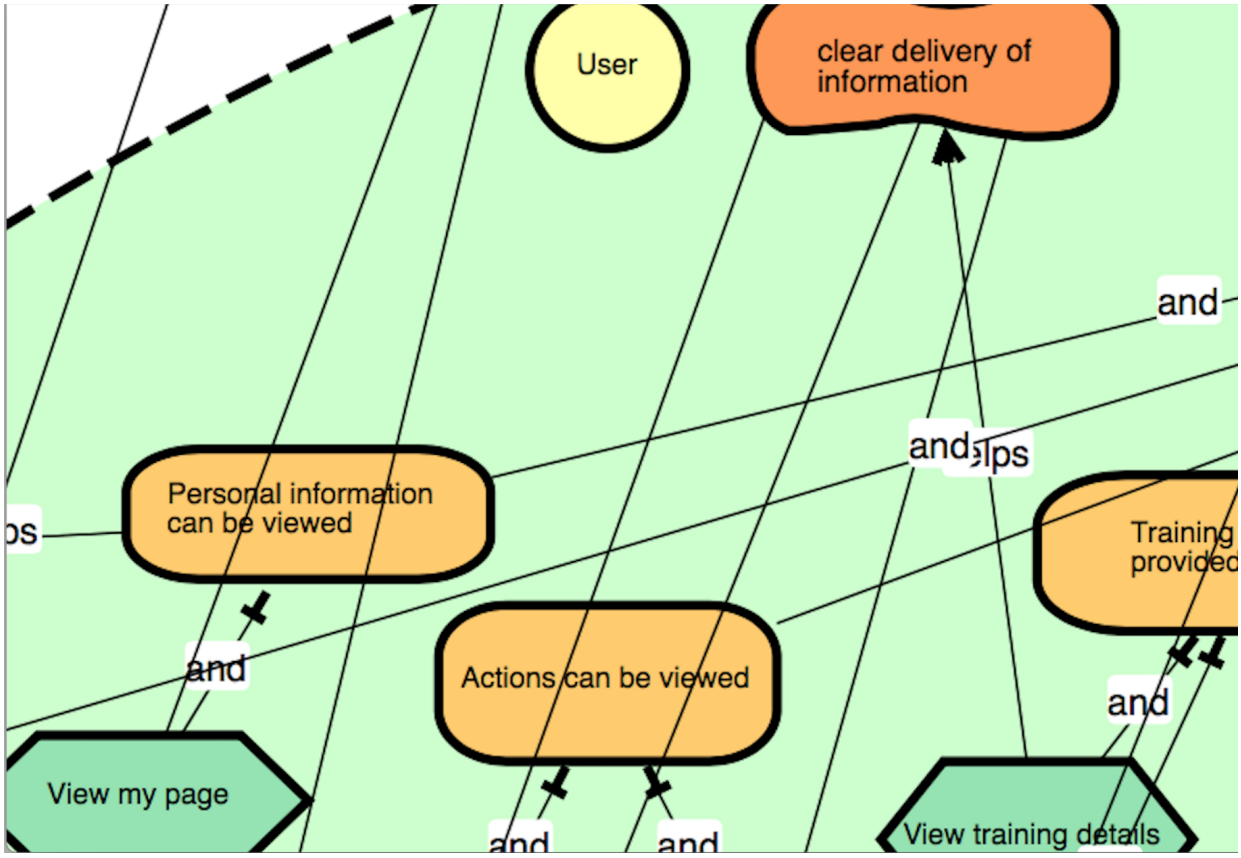

Fig. 7: A zoomed in sample of the User actor in the VGU Navigator model

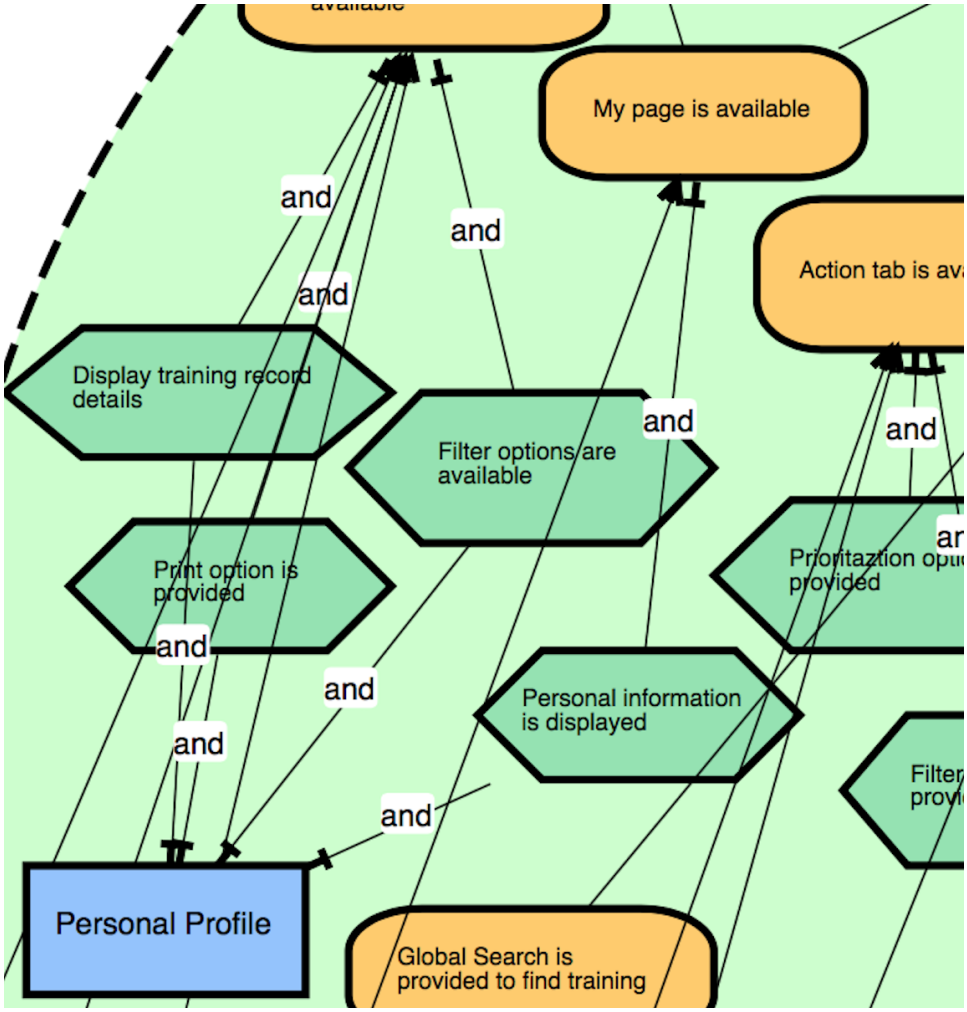

Fig. 8: A zoomed in sample of the Systems actor in the VGU Navigator model

Functional requirements			
	GUL	LTU	VGU
Instant messages	x	x	-
Ask question service	x	-	-
Discussion forums	x	x	-
Notification	x	x	-
University email	x	-	-
Member list	x	x	-
Conference	-	x	-
Course announcements	x	x	-
Course conversations	-	x	-
Student group page	-	x	-
SMS notifications	-	x	-
Real-time course chat	-	x	-
Non-Functional requirements			
	GUL	LTU	VGU
Availability	x	x	-
Flexibility	x	-	-
Usability	x	x	-
Efficiency	x	-	-
Privacy	x	x	-
Interoperability	x	x	-
Performance	x	x	-
Accessibility	-	x	-
Manageability	-	x	-
Reliability	-	x	-
Maintainability	-	x	-
Scalability	-	x	-
Re-usability	-	x	-

TABLE I: List of the requirements included in the Communication subset of each LMS. (x = included) (- = not included)

Functional requirements			
	GUL	LTU	VGU
Contact support	x	-	-
Access Ladok	x	x	-
Access university information	x	x	-
Change profile information	x	x	-
Access video portal	x	-	-
Connect account to third party services	-	x	-
Download course page for offline usage	-	x	-
ePortofilio	-	x	-
Non-Functional requirements			
	GUL	LTU	VGU
Availability	x	x	-
Usability	x	x	-
Efficiency	x	x	-
Interoperability	x	x	-
Modifiability	x	x	-
Security	x	-	-
Accessibility	x	x	-
Privacy	-	x	-
Documentation	-	x	-
Manageability	x	x	-

TABLE II: List of the requirements included in the Additional Services subset of each LMS. (x = included) (- = not included)

Functional requirements			
	GUL	LTU	VGU
Submission of assignments	x	x	x
Review of assignments	x	x	-
Assignment feedback	x	x	-
Grade checking	x	x	-
Prediction of grades	-	x	-
Personal file storage	x	x	-
Personal calendar	x	x	x
Course schedule	x	x	x
Course information	x	x	x
Course evaluation	x	-	x
Course object reuse	x	-	-
Collaboration with peers	-	x	-
Quiz online	-	x	-
Exam online	-	x	x
Course online	-	-	x
Training record	-	-	x
View personal information	x	x	x
Actions	-	-	x
Search for training	-	-	x
Add external training	-	-	x
Withdraw from training	-	-	x
Non-Functional requirements			
	GUL	LTU	VGU
Availability	x	x	x
Usability	x	x	x
Privacy	x	-	x
Performance	x	-	-
Accessibility	x	x	x
Scalability	x	x	-
Manageability	x	x	x
Reuseability	x	x	-
Interoperability	-	x	x
Certifiability	-	-	x
Maintainability	-	-	x
Responsiveness	-	-	x
Modifability/Configurabiliy	-	-	x
Target-ability	-	-	x

TABLE III: List of the requirements included in the Course Content Management subset of each LMS. (x = included) (- = not included)

B. Survey Results

The survey was divided into 5 sections, excluding the introductory section as seen in Appendix J. The division ensures that each section would refer to a specific subset of functionality like they were represented in the models, which were as follow:

- General information : 4 questions
- Communication : 12 questions
- Course content management : 13 questions
- Additional services : 9 questions
- Overall system attributes : 8 questions

The section division allows for increased understanding of the questions context for the respondent and easier analysis of the responses for the researchers. This section is used to present the data acquired. The survey received 63 responses. The division of the respondents were 43 students, 18 teachers and 2 developers. The assumption is made that these respondents are from the software engineering division, because the survey was distributed to the Software Engineering Division within the Computer Science and Engineering Department. The answers to the survey questions can been seen in Appendix K.

The Tables V, VII, IX, XI include the number of respondents that chose a specific answer for each section, the weighted average, the mode and the median for each question. The survey included open ended questions, specifically, each LMS subset section included two open ended questions. However, the section regarding the overall system attributes had only one open ended question. The survey questions can be seen in the Appendix J. The complete survey responses for the open ended questions can be seen in detail in Appendix L.

1) Communication: The communication section of the survey refers to the communication aspect of a LMS and its functional requirements. 12 Questions were asked, whereby the first 10 of them utilized the Likert scale. The number of responses for each response category, the weighted average, the mode and the median can be seen in Table V. The full questions can be seen in Appendix J.

The last two questions were open ended, the full responses to these questions can be seen in Appendix L. They were as follows:

- "In regard to the overall communication functionality of a LMS, what is the most important functionality to enhance communication and why?"
- "Do you have any additional functionality which you think that the communication aspect of the LMS would benefit from and why?"

A few quotes have been included which express what many of the respondents are saying. Many of the responses mentioned functionality already present in the model's. Furthermore, the responses solidified the need to include certain requirements in the general model and are discussed further in the discussion section of the thesis. The first of the open ended question in the communication section of the survey, regarding which is the most important functionality to enhance communication, received responses such as:

Communication Survey Questions	
Question Number	Question
5	How important is being able to privately communicate with students through a LMS?
6	How important is it to be able to privately communicate with a group of students through a LMS?
7	How important is being able to privately communicate with teachers of a course through a LMS?
8	How important is a discussion forum in which you can contact students and teachers within the course through a LMS?
9	How important is being able to receive notifications through a LMS?
10	How important is receiving notifications on different platforms such as text messages?
11	How important is a chat tool?
12	How important is a conference tool?
13	How important is a list of contact information for members of a course and teachers?
14	How important is being able to ask questions anonymously through a LMS?

TABLE IV: Question numbers and corresponding questions for communication

Communication Survey Responses								
Question Number	1	2	3	4	5	Weighted Average	Mode	Median
5	7	13	9	16	18	3.4	5	4
6	3	7	13	23	17	3.7	4	4
7	5	5	7	19	27	3.9	5	4
8	4	7	20	16	16	3.5	3	4
9	2	1	5	17	38	4.4	5	5
10	9	9	16	18	11	3.2	4	3
11	17	11	20	9	6	2.6	3	3
12	16	7	17	14	9	2.9	3	3
13	0	0	10	17	36	4.4	5	5
14	8	10	12	15	18	3.4	5	4

TABLE V: List of the number of respondents that chose a specific survey answer corresponding to the communication subsection questions, the weighted average, mode and median

A student responded with: "*An open discussion forum is always important. Furthermore, being able to contact the teacher anonymously(or not) is an extremely important feature.*"

A teacher responded with: "*The communication functionally is important to replace e-mail exchange and concentrate discussion regarding the course on the course context (i.e. the LMS). However, there are more efficient/effective alternatives for that functionality that can be linked to a LMS and then used primarily to foster communication and discussion (e.g. Slack). The communication should be facilitate by the LMS but not its main feature, since it is, in my personal opinion, a secondary contribution to the Management part of the acronym.*"

The answer regarding the question about additional functionality received a response from a student: "*The ability to*

view content from previous years. That includes discussions and material, such as old exams, assignments and articles."

2) Course Content Management: The course content management section of the survey refers to the course content aspect of a LMS and its functional requirements. 13 questions were asked, whereby the first 11 of them utilized the Likert scale. The number of responses for each response category, the weighted average, the mode and the median can be seen in TableVII. The full questions can be seen in Appendix J.

Course Content Management Survey Questions	
Question Number	Question
17	How important is it for the LMS to support the accessing of course information? (e.g., syllabaus, schedule, summary)
18	How important is it to be able to evaluate a course through a LMS?
19	How important is having a personal storage?
20	How important is having a personal calendar?
21	How important is accessing content from previous years through a LMS?
22	How important is being able to review another students assignment and for your assignment to be evaluated by another student through a LMS?
23	How important is being able to obtain feedback from a teacher?
24	How important is being able to view your grade through a LMS?
25	How important is being able to calculate how your grades would be affected?
26	How important is being able to complete quizzes and exams through a LMS?
27	How important is being able to collaborate with students when using the LMS?

TABLE VI: Question numbers and corresponding questions for course content management

Course Content Management Survey Responses								
Question Number	1	2	3	4	5	Weighted Average	Mode	Median
17	0	0	2	5	56	4.9	5	5
18	4	3	13	18	25	3.9	5	4
19	20	10	11	11	11	2.7	1	3
20	15	8	12	15	13	3.0	1	3
21	3	6	14	16	24	3.8	5	4
22	10	10	23	12	8	3.0	3	3
23	0	0	0	13	50	4.8	5	5
24	4	0	7	10	42	4.2	5	5
25	10	4	17	14	18	3.4	5	4
26	4	3	14	23	19	3.8	4	4
27	4	12	15	16	16	3.4	5	4

TABLE VII: List of the number of respondents that chose a specific survey answer corresponding to the course content management subsection questions, the weighted average, mode and median

The last two questions were open ended, the full responses to these questions can be seen in Appendix L. These were as follows:

- "Concerning the overall capabilities of the course content management, what do you find as the most important functionality and why?"
- "Can you think of any additional functionality that you think that the Course content management aspect of the LMS could benefit from and why?"

We also provide a few quotes from the respondents regarding this section. The first open ended question received a response from a teacher: "*Easy access to information and proper organization of specific content (gather similar purpose files in folders, etc.) The main goal, personally, in a CCM relies on quickly searching and finding the intended piece of information (attendance, grades, announcements, report submissions, etc.). Extra functionalities (e.g. collaborative environments) are welcome, but only if not disrupting current usability or how intuitive is to use the system.*"

The open ended question regarding additional functionality which course content management would benefit from received a response from a student which was: "*Integration with other systems (Ladok, TimeEdit, Google Docs).*"

3) Additional Services: The additional services section of the survey refers to the additional service aspect of a LMS and its functional requirements. 9 Questions were asked, whereby the first 7 of them utilized the Likert scale. The number of responses for each response category, the weighted average, the mode and the median can be seen in Table IX. The full questions can be seen in Appendix J.

Additional Services Survey Questions	
Question Number	Question
30	How important is being able to edit your personal information?
31	How important is being able to link your account to third party applications and websites?
32	How important is it be able to contact support, for information about the LMS?
33	How important is being able to access general university information through the LMS?
34	How important is having multimedia content present in the LMS?
35	How important is being able to download course content for offline usage?
36	How important is having an ePortfolio?

TABLE VIII: Question numbers and corresponding questions for additional services

Additional Services Survey Responses								
Question Number	1	2	3	4	5	Weighted Average	Mode	Median
30	15	6	13	15	14	3.1	4	3
31	17	9	13	19	5	2.8	4	3
32	7	5	14	15	22	3.6	5	4
33	9	5	14	17	13	3.2	4	3
34	9	7	17	16	14	3.3	3	3
35	5	4	6	13	35	4.1	5	5
36	12	10	19	13	9	3.0	3	3

TABLE IX: List of the number of respondents that chose a specific survey answer corresponding to the additional services subsection questions the weighted average, mode and median

The last two questions were open ended, the full responses

to these questions can be seen in Appendix L. These were as follows:

- "Concerning the overall capabilities of the additional services section, which functionality do you find the most important and why?"
- "Do you have any additional functionality that you think the additional services could benefit from and why?"

Similarly to communication and course content management sections, quotes addressing additional services are included. The first of the open ended question in the additional services section of the survey received responses from students such as: "*The ability to download course content for offline usage is by far the most important service. This way the student can study whenever wherever.*"

The second question regarding any additional functionality did not receive many responses due to the fact that many of the respondents felt that additional functionality would not be beneficial.

A student responded with: "*I don't find any of these additional services to be important since students and teachers can survive without them.*"

4) Overall System Attributes: The overall system attributes section of the survey refers to the non-functional aspects of the system. 8 Questions were asked, whereby the first 7 of them utilized the Likert scale. The number of responses for each response category, the weighted average, the mode and the median can be seen in Table IX. The full questions can be seen in Appendix J.

Overall System Attributes Survey Questions	
Question Number	Question
39	How important is the availability of the system?
40	How important is the usability of the system?
41	How important is the manageability of the system?
42	How important is the accessibility of the system?
43	How important is the performance of the system?
44	How important is documentation of the system?
45	How important is the security of the system?

TABLE X: Question numbers and corresponding questions for Overall System Attributes

Overal System Attribues Survey Responses								
Question Number	1	2	3	4	5	Weighted Average	Mode	Median
39	0	0	3	8	52	4.8	5	5
40	0	0	5	17	41	4.6	5	5
41	0	1	13	24	25	4.2	5	4
42	0	1	5	31	26	4.3	4	4
43	0	5	12	25	21	4.0	4	4
44	3	16	20	15	7	3.0	3	3
45	1	4	7	18	31	4.1	5	5

TABLE XI: List of the number of respondents that chose a specific survey answer corresponding to the overall system attributes subsection questions, the weighted average, mode and median

The last question was open ended, the full responses to the questions can be seen in Appendix L. It was as follows:

- "Do you have any additional quality attributes that you think a LMS could benefit from and why?"

A few quotes exemplify the types of responses received and important functionality which should be present in the general model are provided.

A student responded with: "*Interoperability is important as well, the system to be able to communicate properly with newly added software or to have a solid connection with the initially implemented components.*"

C. Interview Results

The interviews were divided into two sections. The first section aimed to validate the goal models created for each system, without focusing on NFRs. VGU consisted of one model which was validated by Thomas Arnoldsson at Volvo. GUL consisted of three models which were all validated by Palle Girgensohn at Ping-Pong. A developer could not be reached in order to validate LTU. There is therefore no interview to validate the LTU model.

The second section aimed to verify the non-functional requirements which are present in the models. We extracted the non-functional requirements which were present in each relevant model into a document where it was clearly visible in text format. This was done to encourage additional discussion and to ensure that none of the non-functional requirements were missed.

1) Validation of models: The validation of the VGU model was achieved by going through the model with the interviewee. Explaining the goals, tasks and functionality present in order to ensure that they are correct. The following quote is taken from the interview transcript as supporting evidence.

- Course Content Management "*Sara - One of the things we are looking for is the validation of the models. That we have actually done it well enough to include it in our thesis.*"
  "*Thomas - I think as good as it gets.*"

The validation of the GUL models was achieved by going through the models with the interviewee. Explaining the goals, tasks and non-functional requirements present in order to ensure that they are correct. The following quotes are taken from the interview transcript as supporting evidence.

- Communication: "*Viktor - So if you think it is accurate enough (Referring to communication model).*"
  "*Palle - I think it seems quite accurate, definitely. It does look good.*"
- Course Content Management: "*Viktor - Overall you would agree to the way it is modelled as such? (Referring to course content management model)*"
  "*Palle - Yeah*"

- Additional services: "*Viktor - So if you, have anything.. Additional to say about that (Referring to additional services model).*"
  "*Palle - I can't really say you can add anything. Yeah I think it is pretty good, pretty accurate.*"

2) Validation of the non-functional requirements: The validation and the motivation behind the non-functional requirements was carried out in the second part of the interview. The interviewer and interviewee went through the list chronologically to discuss the relevance and importance of each requirement. For illustration, quotes have been included from the transcribed interviews. The discussion of usability was as follows:

"*Palle - It is the most important. That is how you actually understand how to do things, I want to do these tasks, how do I do it? If the information is clear then everything is easy to understand. That is the whole point otherwise go buy some other system.*"

"*Thomas - Usability is of course on the top of the agenda right now. From many different angles. That is of course a critical thing in any system.*"

Another non-functional requirement was modifiability:

"*Palle - I don't think it is as important to be able to change the looks, how the system looks and the user interface. But to be able to modify information, that is of course the whole purpose of the platform, if that wasn't easy then it is rubbish. It has to be easy, modifying information is definitely very important.*"

"*Thomas - Modifiability, I would actually change that wording to configurability. What we are working with is to find ways to configure the system, in a way that works for us. Configurability is of a high importance.*"

They were questioned about the accessibility of their system:

"*Thomas - One of the things that we want to work with to improve the accessibility is to improve the systems mobility, because on a mobile device in Volvo group it is a little bit easier to access things. So accessibility is connected to mobility for us.*"

"*Palle - It is definitely something we prioritized, it has to be easy to understand, it is very connected to usability. I would not say it is sort of the top priority, we would never do anything that is cool but it is not accessible.*"

The requirement availability was important to both interviewees.

"*Palle - Yeah that is very important of course. Students have very weird hours, so definitely. We are quite proud to have high availability. The 99.999999 percent lots of 9's and we are always trying to keep these figures up, and very rarely do we have a problem. That is very important.*"

"*Thomas - That is a requirement for us, what the actual requirement is, I have no clue but I would assume it is 24/7/365*"

D. General Model Result

The general model has two versions which are the high-priority model and the low-priority model. Both models include the three subsets which have been taken from literature. The process of creating the general model began by analyzing the results from the survey as can be seen in Tables V, VII, IX, XI and the interview results. Each question in the survey was directly linked to a goal in the initial LMS goal-models. Hence, If the weighted average for a specific question in the survey exceeded 3.5 or 4.0, this correlated with a specific goal from the GUL, LTU or VGU models. The goal was inserted into the general model. Tasks and resources which made this goal feasible were also transferred into the general model. An example of a goal, task and resource which were included in the general model can been seen in Figure 9. All the functional and non-functional requirements included in the general model were re-used from the previously created models.

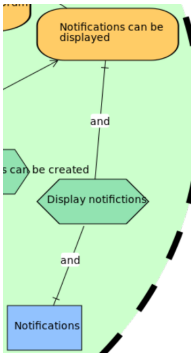

Fig. 9: Notifications Example

The high priority version includes requirements that have scored a weighted average of 4 and above, it represents a more condensed version of the general model. The number 4 was chosen because it includes the requirements that are in the category of important and very important. Furthermore, the weighted average of 4 was chosen because it represents approximately the top quartile of the prioritized requirements. The full model can be seen in Appendix 23.

The low-priority model includes requirements that have a weighted average of 3.5 and above, this view of the general model is substantially bigger than the first version. The number 3.5 has been chosen because it represents the requirements that are in the category of neutral, important and very important. Hence, this represents approximately the top two quartiles of prioritized requirements. The full model can be seen in Appendix 24.

1) Higher prioritization model: The requirements which had a weighted average of 4 and above can be viewed in Table XII. For readability purposes, the full model has been

split up based on the three functionality subsets established previously, they can be viewed in Figures 10, 11, 12.

2) Lower prioritization model: The requirements which had a weighted average of 3.5 can be viewed in Table XI. This model has also been split up for readability purposes based on the three functionality subsets, they can be viewed in Figures 13, 14, 15.

Course Content Management		
	High-Priority Model	Low-Priority Model
View grade	x	x
View course summary	x	x
View course syllabus	x	x
View course schedule	x	x
Upload completed assignment	x	x
Feedback	x	x
Evaluate course	-	x
Complete quiz	-	x
Complete exam	-	x
Performance	x	x
Accessibility	x	x
Usability	x	x
Availability	x	x
Interoperability	x	x
Manageability	x	x
Communication		
Access course member list	x	x
View Notifications	x	x
Privately communicate with teacher	-	x
Privately communicate with group	-	x
Use discussion forum	-	x
Accessibility	x	x
Usability	x	x
Availability	x	x
Interoperability	x	x
Manageability	x	x
Additional Services		
Download course page	x	x
Contact support	-	x
Security	x	x
Performance	x	x
Modifiability	x	x
Accessibility	x	x
Usability	x	x
Availability	x	x
Interoperability	x	x
Manageability	x	x

TABLE XII: The list of requirements included in both High-Priority model and Low-Priority model (x = included) (- = not included)

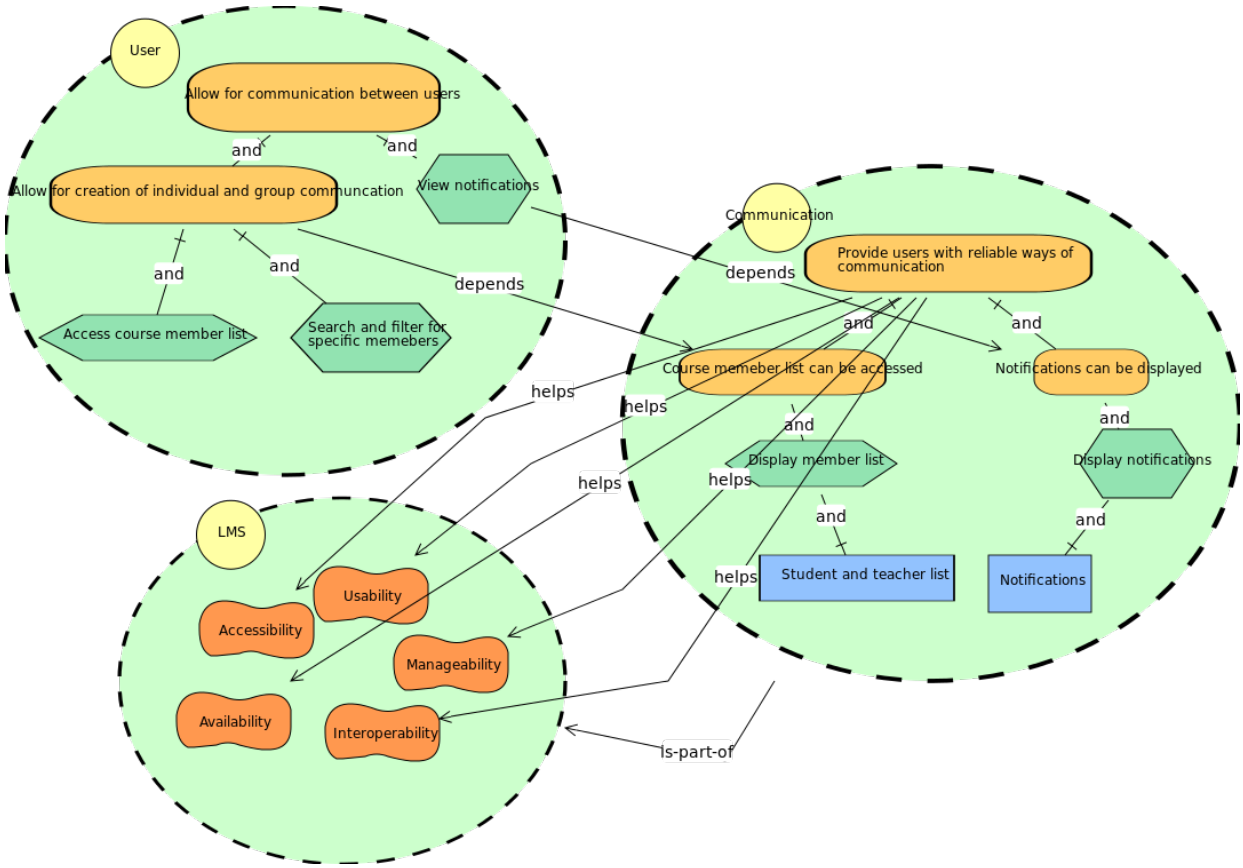

Fig. 10: Communication High Priority

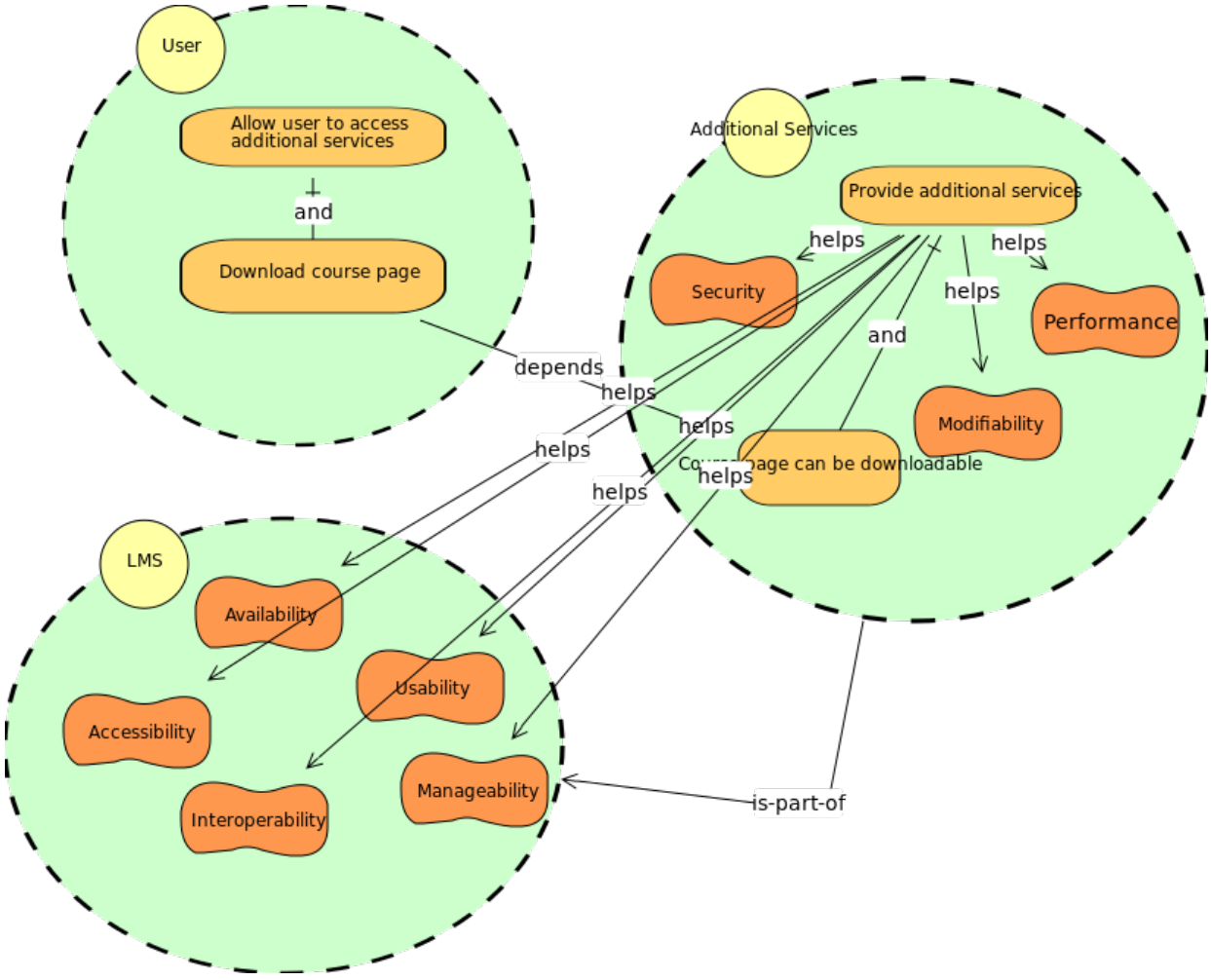

Fig. 11: Additional Services High Priority

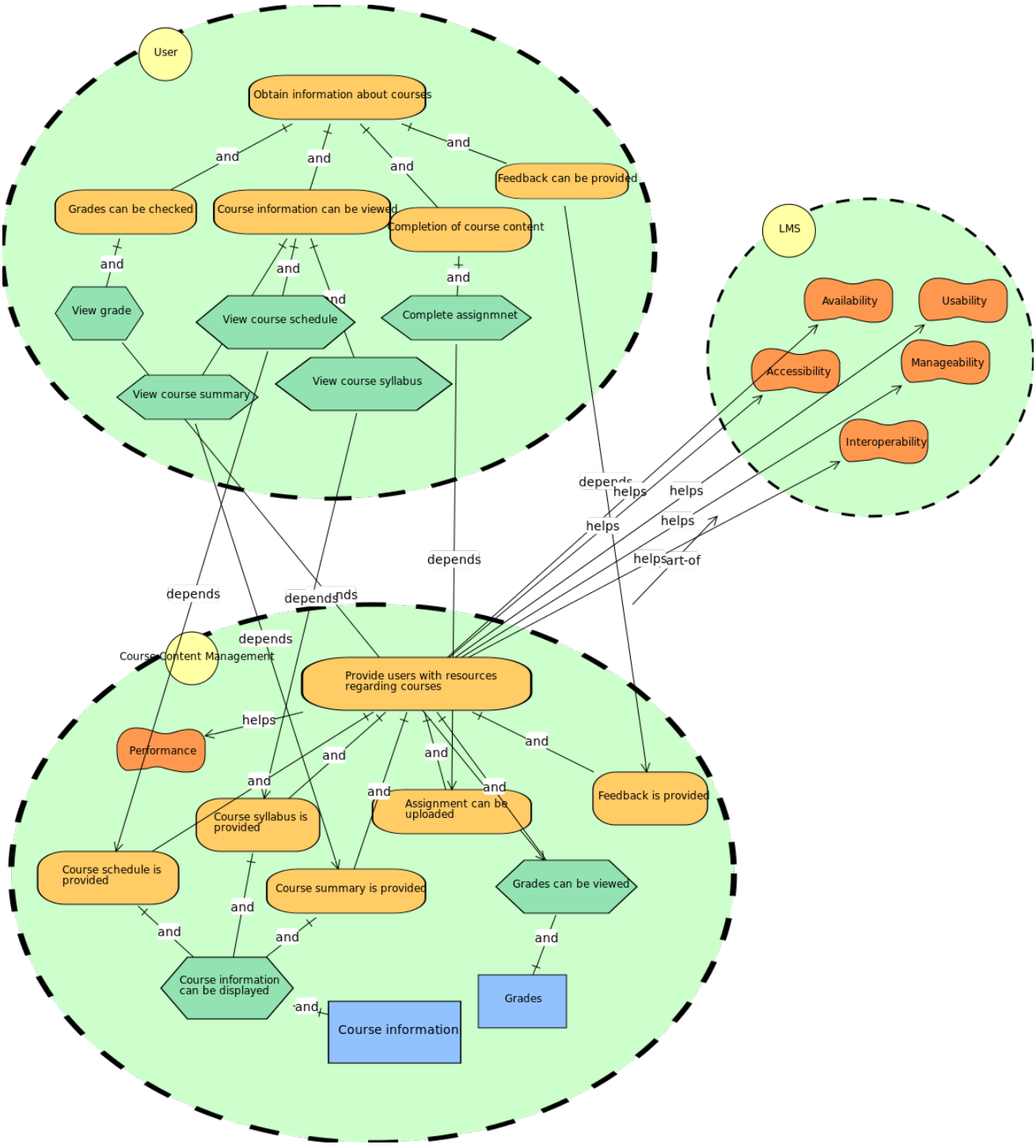

Fig. 12: Course Content Management High Priority

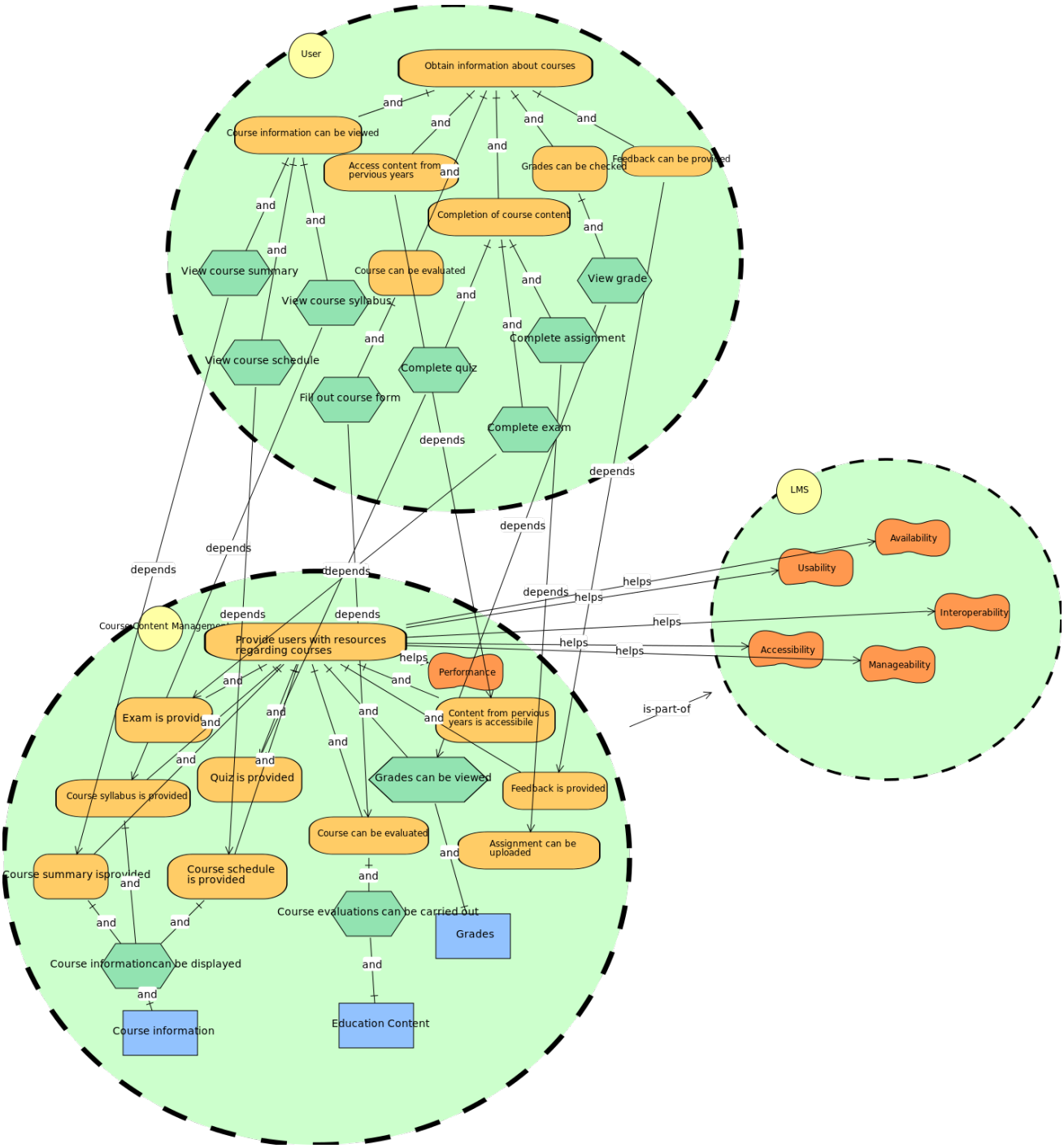

Fig. 13: Course Content Management Low Priority

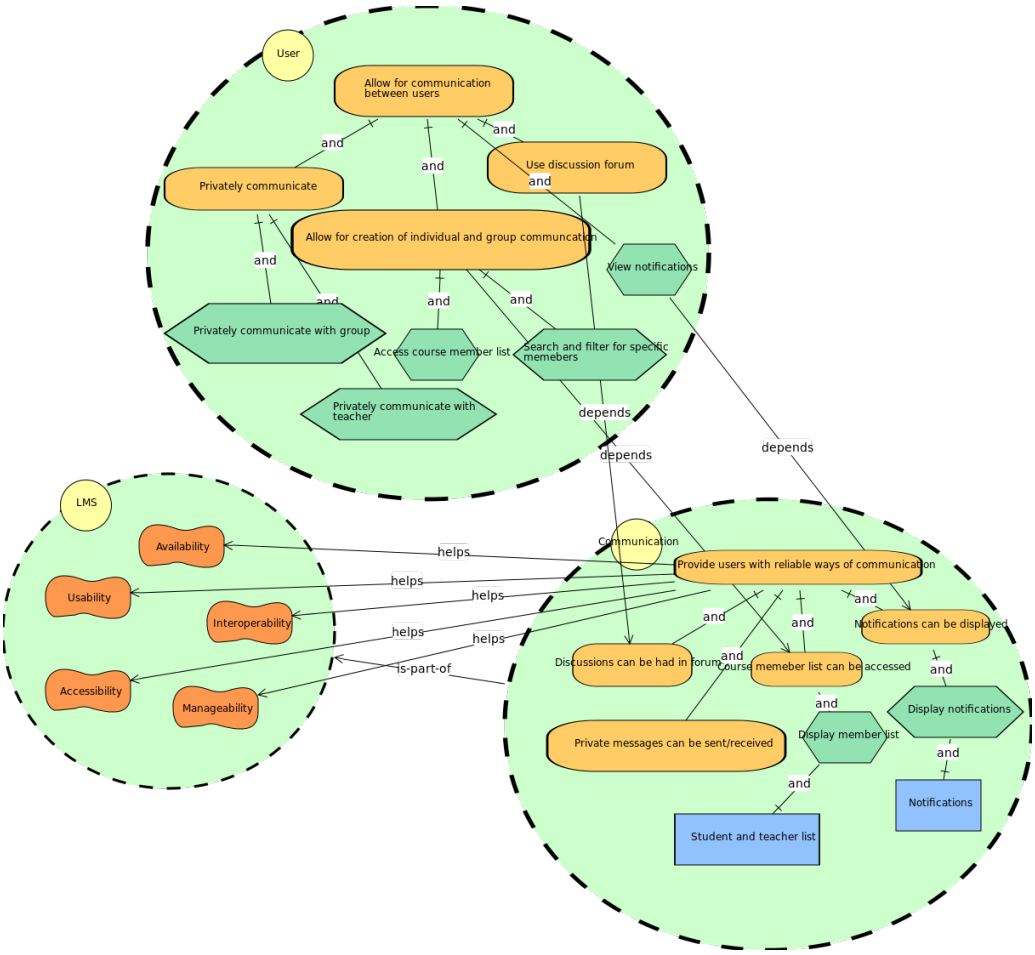

Fig. 14: Communication Low Priority

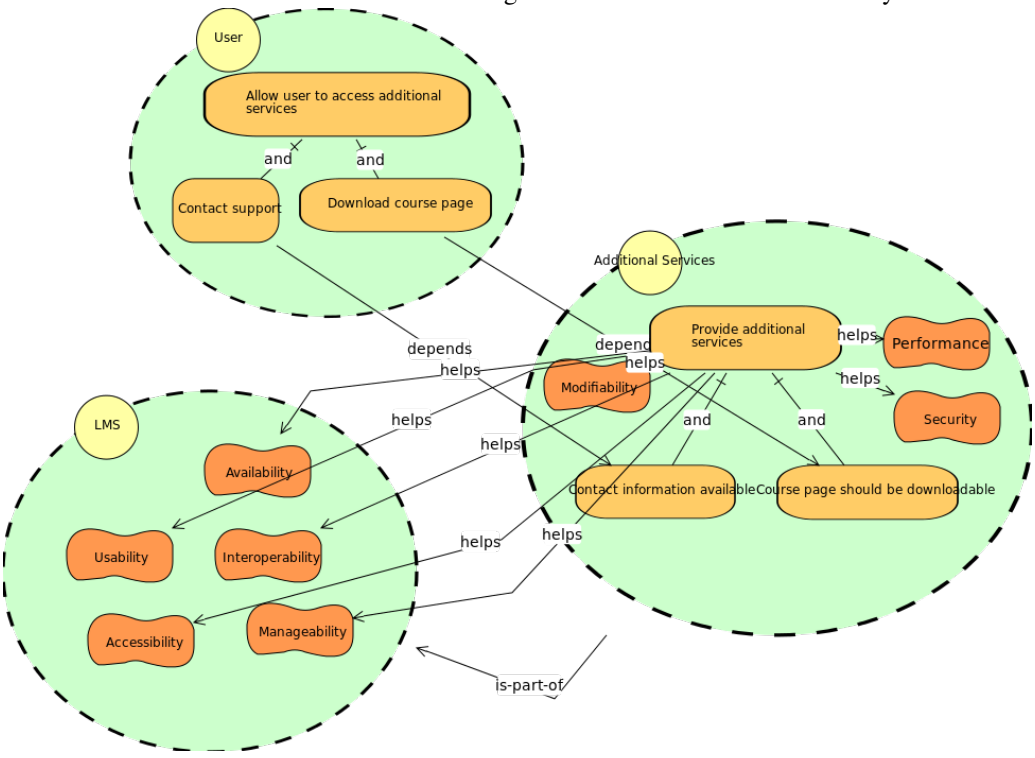

Fig. 15: Additional Services Low Priority

V. Discussion

The following section will answer the research questions stated in the introduction and discuss the results presented in the results section.

A. RQ: How can requirements be manually reversed engineered and captured in goal models in order to create a general requirements model that supports design of E-learning management systems?:

The steps taken in order to create the general requirements model for LMS's were as follows:

- Obtaining the user documentation of the systems
- Manual reverse engineering of requirements
- Modelling of the reverse engineered requirements
- Use of survey in order to prioritize requirements
- Use of interviews in order to validate the models created
- Creation of the general requirements model based on the prioritized requirements

We believe this method can also be utilized for the modelling of other software systems and it is not just limited to LMS's.

B. RQ1: How well can we use requirements engineering modelling to capture manually reverse engineered functional and non-functional requirements of three learning management systems?:

RQ1 concerns the process of capturing the relevant functional and non-functional requirements of the LMS systems. Based on the modelling results and the interview results which can be seen in the previous section, requirements engineering can indeed capture reversed engineered functional and non-functional requirements. In total, there were 7 models created of the systems, 3 for GUL, 3 for LTU and 1 for VGU. Each of the models were gradually finalized in iterations. We believe that we were able to capture the relevant reverse engineered requirements and this was verified through the interviews with the developers of the GUL and VGU systems. We were unable to validate the LTU model which means that the functional and non-functional requirements present in Figures 19, 20, 21 may not be correct. This is a limitation of the modelling process since being unable to get into contact with experienced users or developers of the LTU system prohibits the validation of the model.

As can be seen in the results, the functionality present in the 2 academic models is similar to each other. For example, in the communication Figure 16,19 "Allow for communication through discussion forums" and in the course content management Figure 17, 20 "Reviews can be submitted" are present in both systems. This was expected since they were created for the same purpose and were targeted at the same type of audience. This means that they share a lot of common functionality and goals. The VGU platform, which is the industrial LMS, can be seen in Figure 22, differs from the two academic models. This is interesting, we believed that there would be a difference but not such a significant one. The VGU navigator platform focuses mainly on course content management because communication and other additional services are not handled through the navigator but rather done through other applications. As Thomas mentioned in the interview "The learning management system is very very small part of the everyday working life of the employees. We have other solutions, team place, outlook, messenger and all these things". This is the reason as to why VGU only consists of one model. Academic LMS's are vital to the daily life of most student and teacher users, therefore it makes sense that it requires more functionality, enabling it carry out a wider spectrum of tasks.

There are certain aspects of the modelling phase which were easier to perform than others. Firstly, we had to familiarize ourselves with the i* framework and how to correctly represent elicited requirements. With the help of our supervisor Jennifer, we were able to surpass that obstacle.

The functionality and requirements of the LMS's were identified through the user documentation which was obtained. Functional requirements were easy to identify through user documentation and manual reverse engineering, they were also simple to capture within the models. The dependencies were logical and did not cause any issues.

On the other hand, the non-functional requirements were much harder to identify. These requirements are not obviously deducible when analyzing a system and are not stated in the user documentation. Therefore, further research was needed to identify these non-functional requirements. Firstly, to identify which requirements were relevant and correct quality attributes of the system. Secondly, to identify which of the models that they apply to and thirdly, to identify which specific goals that were 'helped' by these requirements. This was the largest difficulty when creating the models.

Another negative aspect of the goal modelling was encountered when we started using the i* framework to model and that was the size of the models. We did not anticipate for the models to become extremely large and difficult to read. Having all of the functionality in one model lead to a lot of disorganization, therefore we decided to divide the functionality up into three subcategories and into different views for readability.

To answer the question "How well can we use requirements engineering modelling to capture reverse engineered functional and non-functional requirements of three learning management systems?", we believe that requirements engineering modelling can be used to capture reverse engineered requirements.

C. RQ2: Which requirements are deemed by computer science students and professionals as the most important to include in a learning management system?:

The prioritization of the requirements relate to the answering of RQ2. The data gathered through the survey and

the interviews leads to answering this research question. The results gathered can be seen in Tables V, VII, IX, XI and in the Appendix K and L. The analysis of the survey provided us with the insight of what students, teachers and developers found important within a LMS. A majority of the multiple choice survey questions respondents deemed the course content management and communication subsets of the LMS and their functionality as the most important. The additional services aspect of the LMS was found useful, although unnecessary. The open ended questions in the survey included answers from the participants, it helped us discover their opinions which resulted in solidifying the results we obtained from the multiple choice questions with almost no contradictions.

Participants found the communication aspect of a LMS beneficial, having a list of contact information for members of a course and teachers as well as the functionality of receiving notification concerning a course were noted as most important with an average of 4.4 and medians and modes of 5 as seen in Table V. Next on that list was being able to privately communicate with students and teachers through the LMS as well as through a discussion forum with respectively an average of 3.7, 3.9, 3.5, medians of 4,5,3 and modes of 4 as seen in Table V. The first open ended question regarding the communication aspect received similar results "In regard to the overall communication functionality of a LMS, what is the most important functionality to enhance communication and why?", most comments regarded notifications, being able to contact teachers and students, a list of contact information and discussion forums as most important. Although, some participants noted that there are better alternatives than being able to communicate through a LMS and that shouldn't be its main functionality. This is exemplified in the following comments: "There are other means of reaching people that are faster, and have a better chance of getting a response (e.g. email, Facebook, face-to-face meeting)." as seen in Appendix L. We do agree that the main functionality of a LMS is not the communication aspect of it. However, since one of its functionality is to deliver content and reporting of student work, we believe there should be an open line of communication between the deliverer of content and the receiver of content.

The second open ended question "Do you have any additional functionality which you think that the communication aspect of the LMS would benefit from and why?" didn't include any useful data that could have been considered, although we did receive comments which simply state "No." as well as "No, and it would turn the LMS more cumbersome to use, when it should be primarily (in my personal opinion) a main landing page/gateway to gather information about the course (grade, schedule, submissions, and similar management aspects, etc.)" as seen in Appendix K. A possible reason for the large amount of no or blank responses could be that participants could not express their requests or simply did not want to spend the effort writing the responses. Another reason could be that the survey was too long and therefore discouraged participants to provide extensive answers.

The course content management aspect of the LMS received very clear results. The functionality deemed as most important was the accessing course information (e.g., syllabus, schedule, summary) with a weighted average of 4.9 and modes and medians of 5 as seen in Table VII, followed by being able to obtain feedback from a teacher as well as being able to view your grade through the LMS with an acquired weighted average of 4.8 and 4.5, modes and medians of 5 as seen in Table VII. Next on the list of important functionality was being able to evaluate a course, access content from previous years and being able to complete quizzes and exams through the LMS. The weighted averages obtained for the functionalities respectively were 3.9, 3.8 and 3.8, with modes of 4 and medians of 5 as seen in Table VII.

The first open ended question "Concerning the overall capabilities of the course content management, what do you find as the most important functionality and why?" received similar answers which solidified the results obtained previously. Many of the respondents commented that being able to find relevant course information and for it to be accessible was most important, followed by being able to receive feedback, evaluate a course and view your grade as seen in Appendix L.

The second question "Can you think of any additional functionality that you think that the Course content management aspect of the LMS could benefit from and why?", similarly to the communication answers mostly received a "No." response. However, other comments included integrating the LMS with third party services, for us that meant increasing the interoperability of the system, comments like these were received "Integration with other systems (TimeEdit and Google Docs)" and "Connecting the schedule to your own(Google calendar for instance)." as seen in Appendix K. Which lead us to the conclusion that students and professionals deem the interoperability functionality of a LMS as important.

The section regarding the additional services aspect of a LMS received overwhelmingly different results. Only two functional requirements were deemed as important which were the ability to download course content for offline usage and contact support through the LMS. They received a weighted average of 4.1 and 3.6, modes of 5 and medians of 4 and 5 as seen in Table IX. The open ended question "Concerning the overall capabilities of the additional services section, which functionality do you find the most important and why?" answers found being able to download course content for offline usage as most important as can be seen in Appendix L. Other comments regarded this aspect of a LMS as not that important "I don't find any of these additional services to be important since students and teachers can survive without them" as seen in Appendix L. The second question "Do you have any additional functionality that you think the additional services could benefit from and why?" did not receive many responses, however, the responses received were almost all "No." as can be seen in Appendix K.

The section regarding the non-functional requirements of the

system in the survey received high responses and were quite clear to interpret. Almost all the non-functional requirements were deemed as important: availability, usability, manageability, accessibility, performance and security receiving a weighted average between 4.8 and 4.1 and modes and medians of 4 and 5 as seen in Table XI. The only non-functional requirement not found as important was documentation. The open ended question "Do you have any additional quality attributes that you think a LMS could benefit from and why?" did not received many responses, as seen in Appendix L. However, there was one comment which addressed interoperability: "Interoperability is important as well, the system to be able to communicate properly with newly added software or to have a solid connection with the initially implemented components." as seen in Appendix L, we had already identified interoperability as important receiving comments addressing it solidified that it is indeed important for the respondents as well.

Research was done to acquire the non-functional requirements present in the goal models, therefore the interviews were used to validate these requirements. A list was created which included the non-functional requirements from the models. During the interview the interviewees went through the list and were questioned whether the non-functional requirements present in the models are correct. The interviews carried out with the Volvo employee Thomas Arnoldsson and the Ping-Pong developer Palle Girgensohn were very enlightening and helpful. The answers we acquired through out the interviews concerning the quality attributes we had identified were only positive, they were all important to the industrial contacts. We had not included non-functional requirements which are not part of their LMS systems. This result was expected since the list included general attributes present in almost every system, however, the reassurance and motivation behind why these requirements are necessary was helpful when it came to the creation of the general model.

D. RQ3: How well can we use prioritized reverse engineered requirements in order to create a general requirements model for learning management systems?

The purpose of the general model is to capture the prioritized requirements and provide developers with a clear visual representation of the requirements needed to be included in a LMS. We believe that we were able to do so as can be seen in Appendix 23 and 24, however, as previously mentioned the validation of the general models is outside the scope of our thesis.

The prioritization of requirements was done through the use of a formula to calculate the weighted average. The median and the mode were also analyzed to ensure that choosing to use the weighted average did not result with an entirely different ordering of priorities. They also helped with evaluating which requirements should be included in the general model. We made the choice to include requirements which scored above a 3.5 weighted average in one version of the general model which is defined as the low-priority model. If we had chosen to use the mode and the median, the resulting model would have looked very similar. It would, however, have included slightly more functionality which were on the verge of being included. For example "How important is being able to calculate how your grades would be affected?" which had a weighted average of 3.4, a median value of 4 and a mode value of 5. This functionality was excluded from the low-priority general model due to the weighted average being below 3.5. Whilst if we had utilized the median or the mode value, it would have most likely been included in the low-priority general model. The low-priority model represents the full general model with all prioritized functionality and requirements and can be seen in Appendix 24.

The second version of the general model is defined as the high-priority model. The high-priority model contains functionality and requirements which have scored a weighted average of 4 and above and with minimum modal and median values of 4 and 5. This model represents the most vital requirements to include, according to computer science students and professionals. All of the calculated values have been examined in order to create this model. The reason for this is to ensure that all of the functionality which is present in the high-priority model is highly valued by the majority of users. The full high-priority model can be seen in Appendix 23. The high and low priority versions represent different importance models.

A developer wanting a more condensed visual representation of the most fundamental and vital requirements could consult the high-priority model whilst the low-priority model provides a more comprehensive view of functionality which includes the second level of important requirements.

The creation of the general model was not difficult since we had familiarized ourselves with the i* framework and the goals, soft-goals and tasks which were included were directly taken from the previously created models. The general model was divided up into three subcategories and into different views for readability. The decision of which requirements were prioritized highly enough to be included in their respective models was an extensive discussion. The decision for choosing the weighted average value of > 3.5 for the low-priority model and > 4 for the high-priority model was due to the percentages of requirements which would therefore be included. These percentages can be seen in Table XIII.

The end result of the model represented functionality and requirements previously identified as important through research and user validation which leads to the conclusion that the general model created can indeed be used as a guideline for the creation of a LMS.

Percentage of requirements included in General Model		
Section	Low-Priority Model	High-Priority Model
Communication	50%	20%
Course Content Management	55%	27%
Additional Services	29%	14%
Overall System Attributes	86%	86%

TABLE XIII: Percentage of functionality which is included in the general model from each section of the survey

VI. Future Work and Conclusion

Several topics have appeared during the writing of this thesis which have the potential to be future work and research contributions. A larger sample of learning management systems is important in order to fully establish that the functional and non-functional requirements which have been identified are indeed accurate. Therefore, an area of future research would be to expand the scope of this thesis by modelling additional systems in order to gain further evidence that the modelled functionality is representative of the entire field. Furthermore, this thesis builds on the responses of students and professors within the field of computer science. Future research can be carried out to investigate if similar functionality is considered as important within other fields of study. One way to validate the general model would be to create a LMS based on the requirements which have been identified. This is potential future work which is outside the scope of this thesis but could be a design-science object of study.

This paper explores the functional and non-functional requirements which are present in three LMSes: Göteborg Universitet Lärplatform, Luleå Tekniska Universitet and Volvo Group University.

The requirements were extracted through the use of manual reverse engineering of the systems, analysis of user documentation and the research of relevant literature. The functional and non-functional requirements were modelled using the i* modelling language in order to create overviews of the functionality of each independent system. This was successfully accomplished through answering RQ1 and although there were issues involved with the modelling process, as mentioned in the discussion, requirements engineering modelling is an effective way to capture functional and non-functional requirements.

The initial models provided the necessary information required to construct the survey which acted as the main source of data collection for user validation of requirement importancy. Interviews were conducted in parallel with the survey distribution in order to validate the created models and provide further insight into the non-functional requirements. The data provided from the survey enabled the prioritization of the requirements which was carried out and the discussion around RQ2 delves into this.

Finally the general model was created from the prioritized requirements. This answers the final research question. The prioritized requirements from the survey can indeed be utilized to create a general model which has the potential to be used for the creation of learning management system.

In conclusion, the process of requirements engineering modelling is an effective way to capture the functional and non-functional requirements of a learning management system. We believe that the process which is proposed in this thesis could also be applied when attempting to capture the requirements of other software systems. The general model, although unvalidated, provides functionality which is deemed as important by users and would therefore be of use to developers when creating a system.

Acknowledgment

We would like to thank Palle Girgensohn at Ping-Pong and Thomas Arnoldsson at Volvo for taking the time to participate in our interviews. We would also like to thank our supervisor Jennifer Horkoff for the continued support and invaluable feedback which we have received during the time of writing.

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APPENDIX

A. Communication GUL

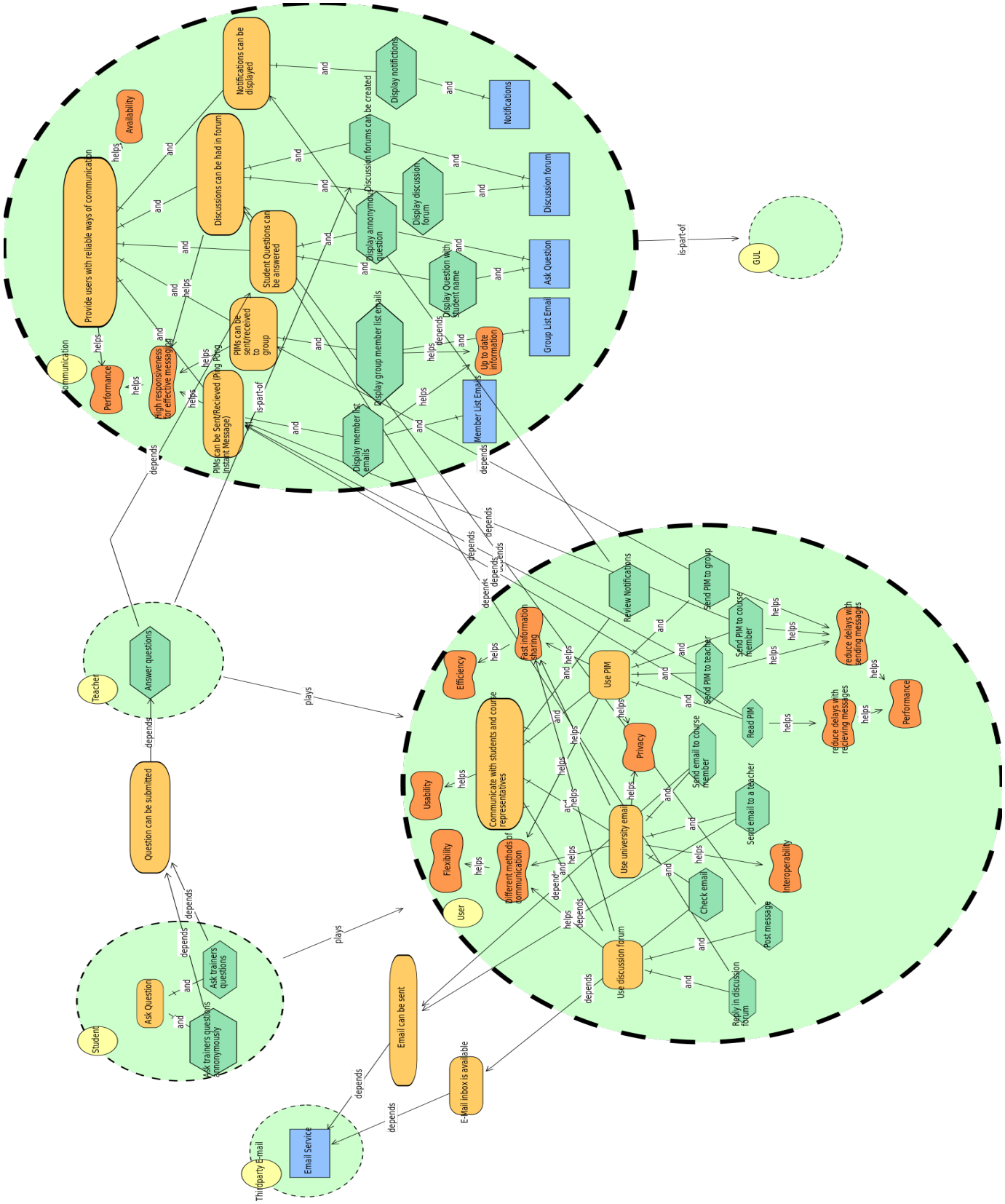


Fig. 16: Communication GUL

B. Course Content Management GUL

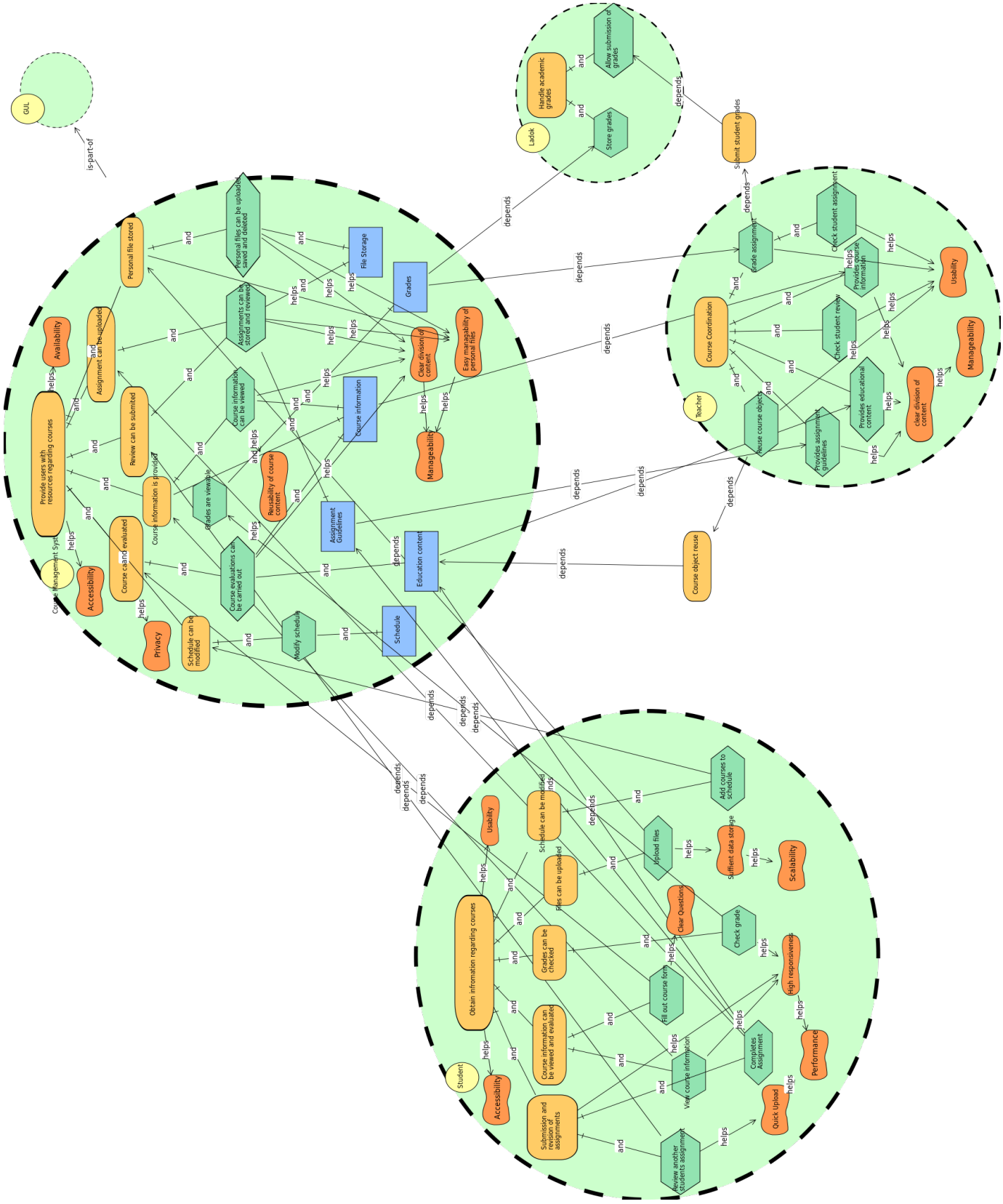


Fig. 17: Course Content Management GUL

C. Additional Services GUL

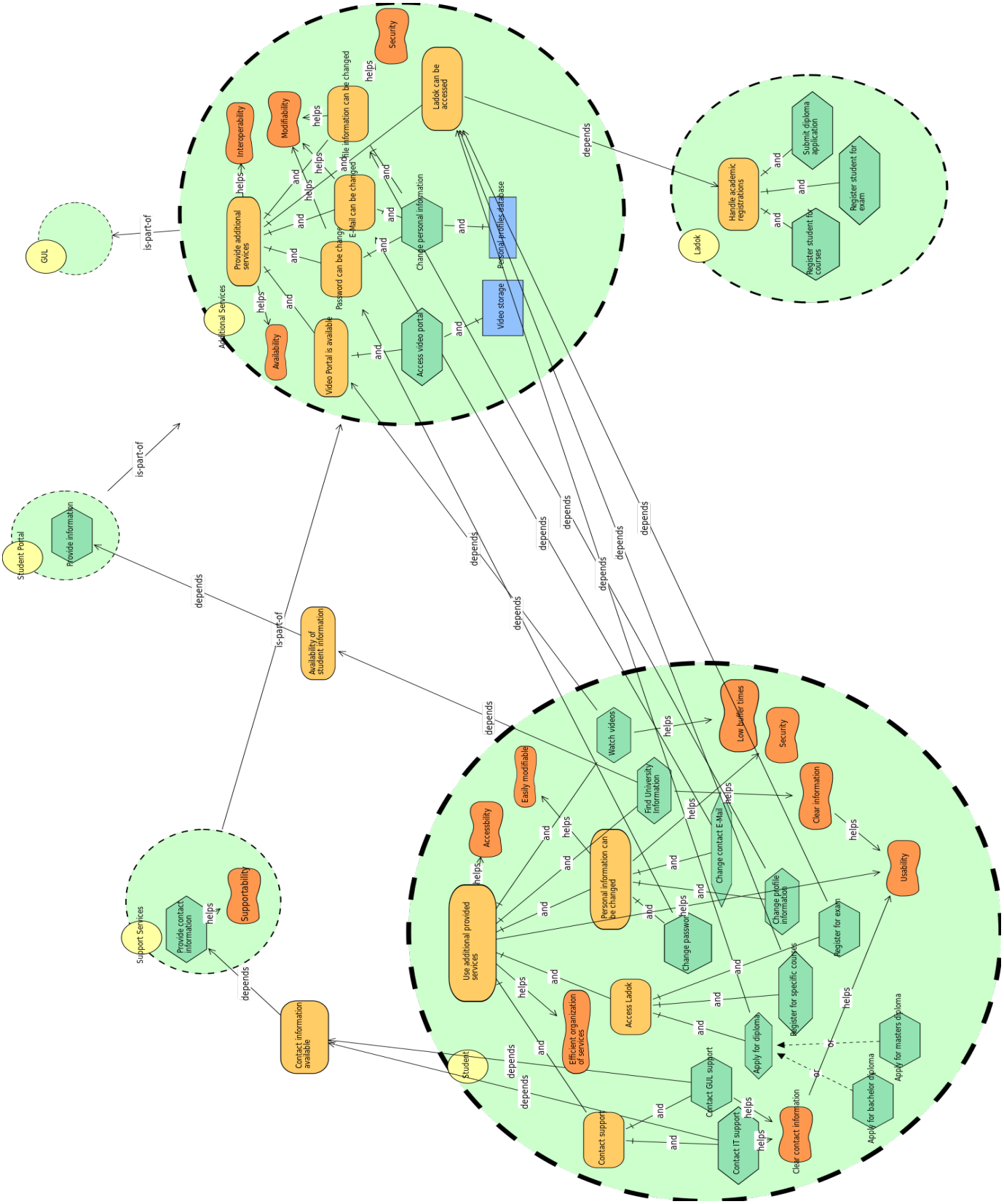


Fig. 18: Additional Services GUL

D. Communication LTU

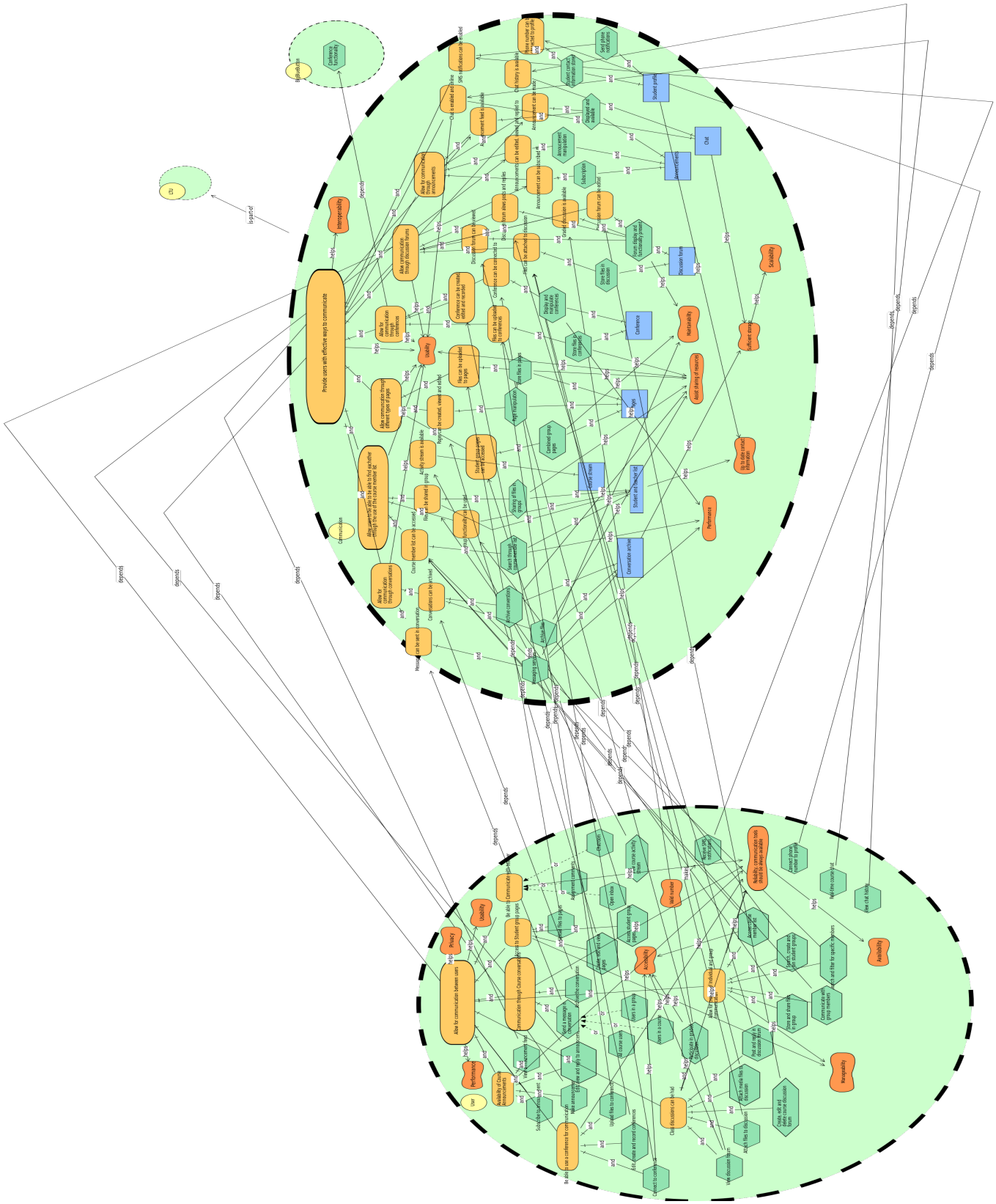


Fig. 19: Communication LTU

E. Course Content Management LTU

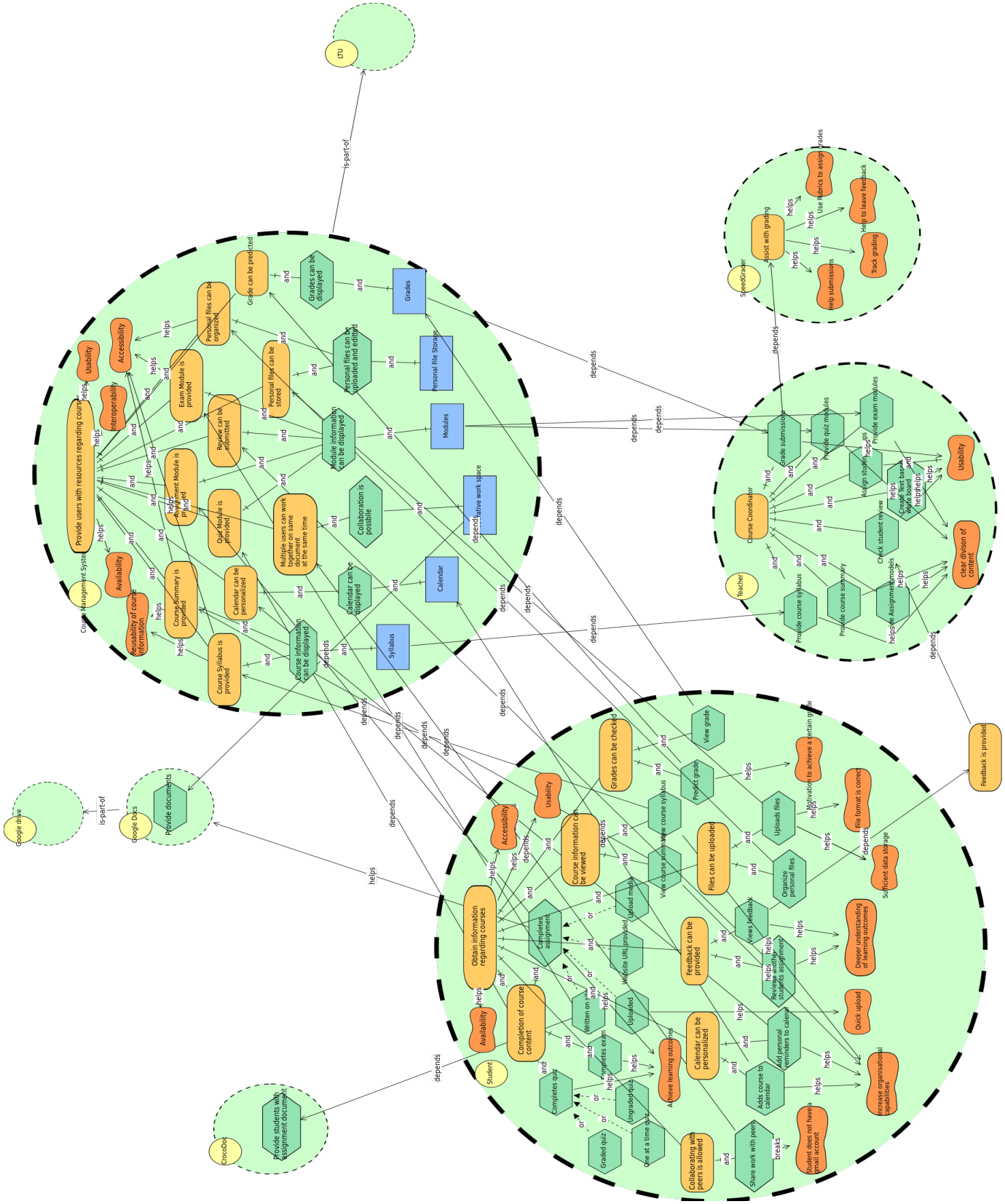


Fig. 20: Course Content Management LTU

F. Additional Services LTU

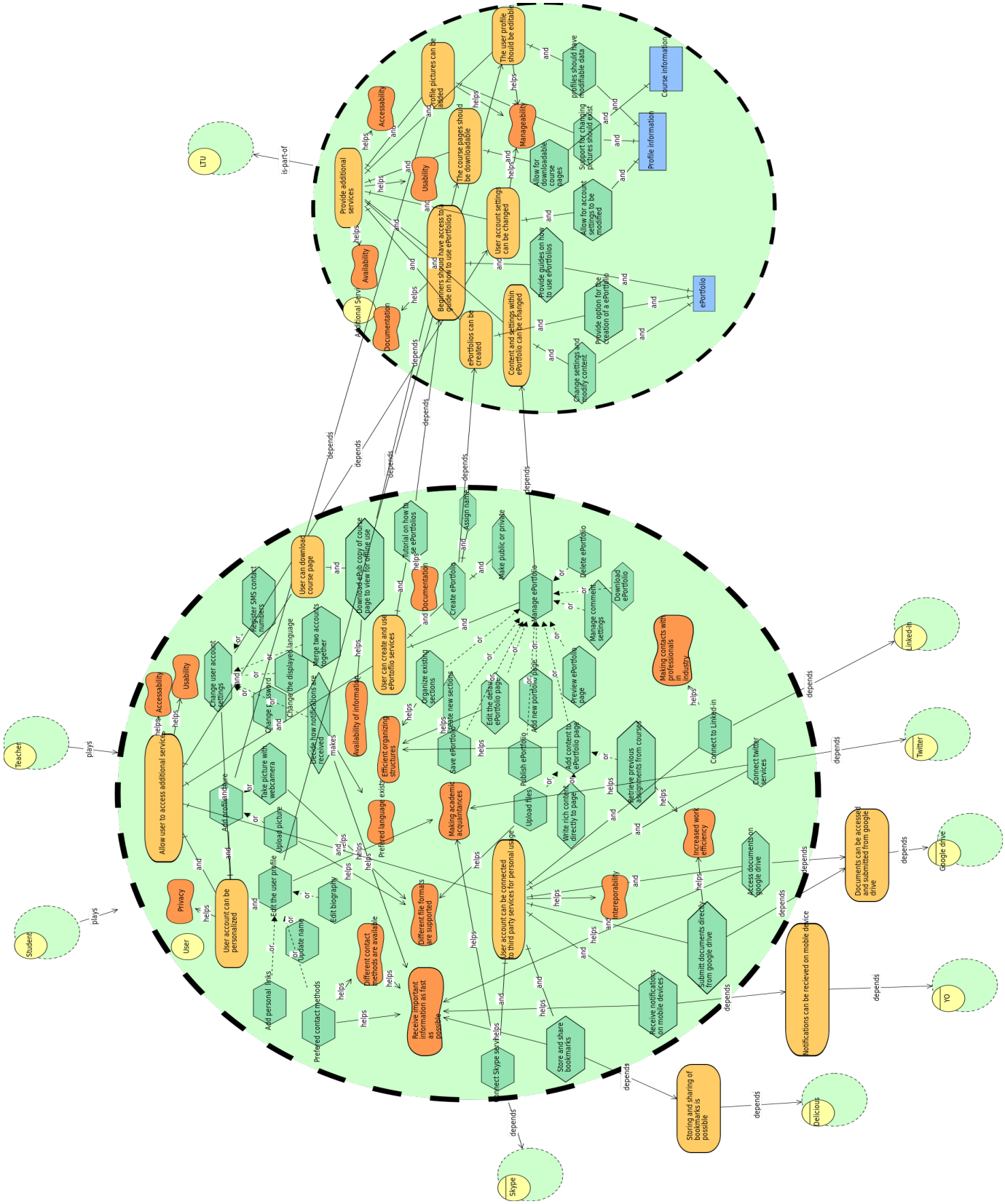


Fig. 21: Additional Services LTU

G. Volvo Navigator

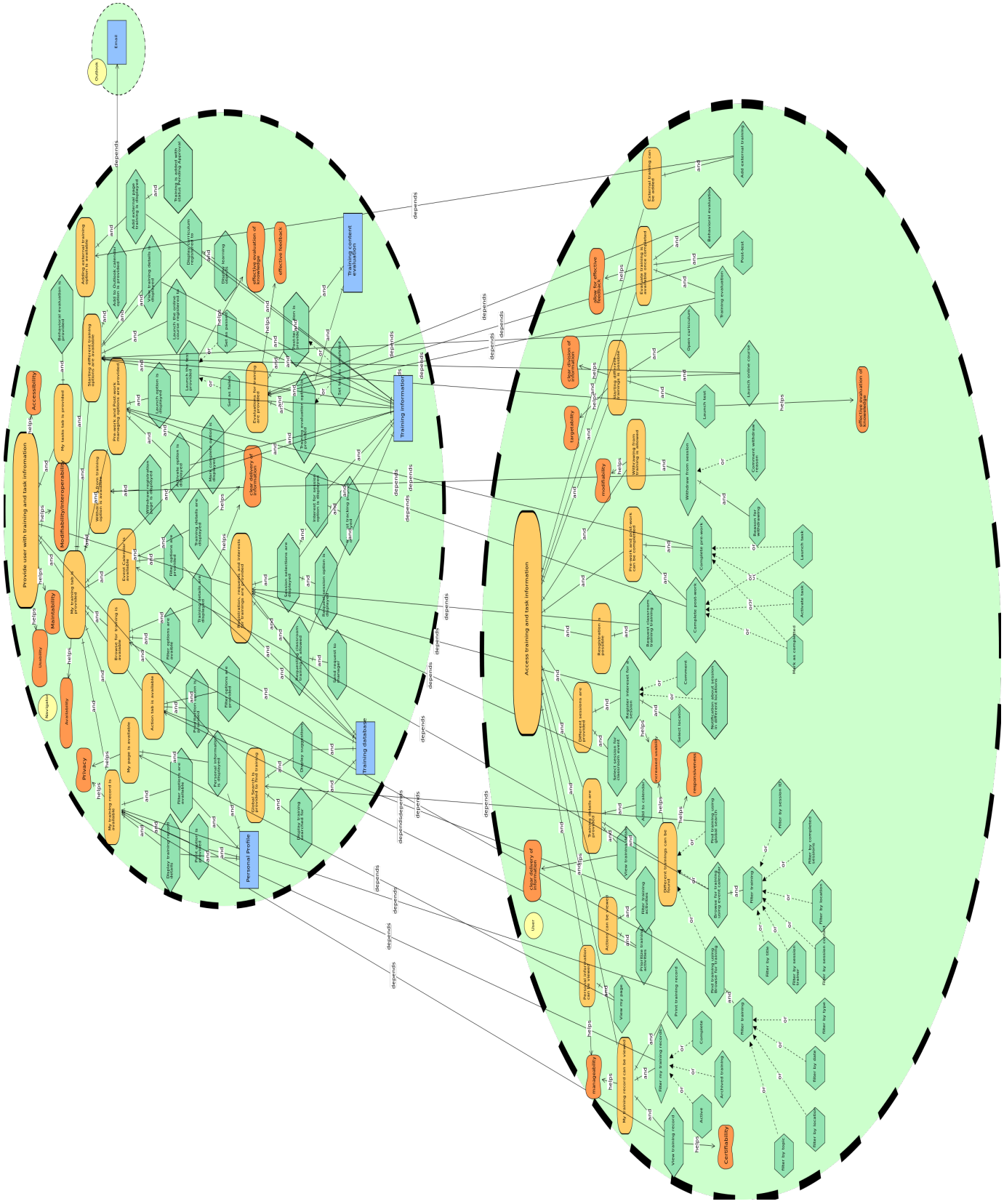


Fig. 22: Volvo Navigator

H. High Priority General Model

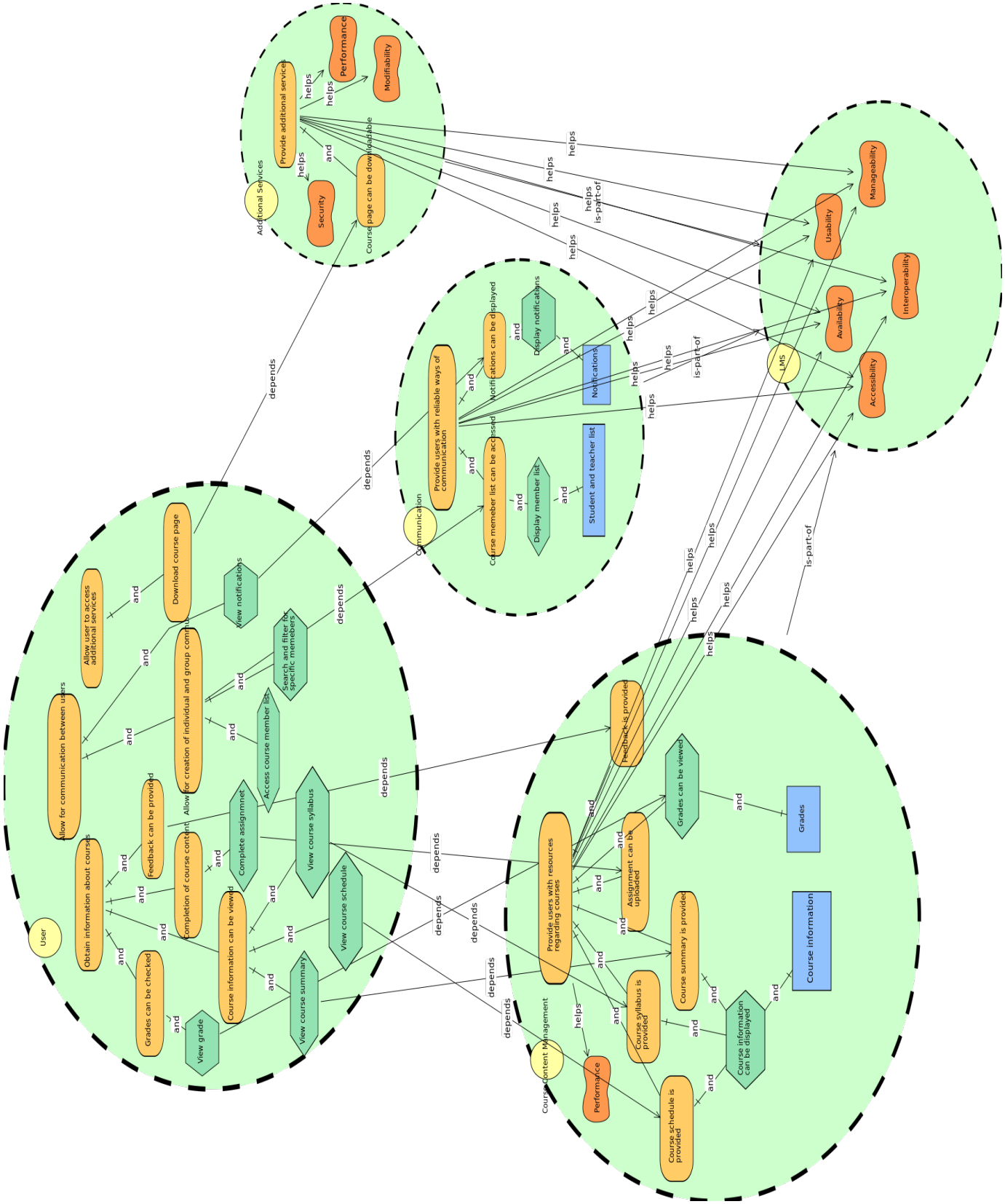


Fig. 23: High Priority Model

I. Low Priority General Model

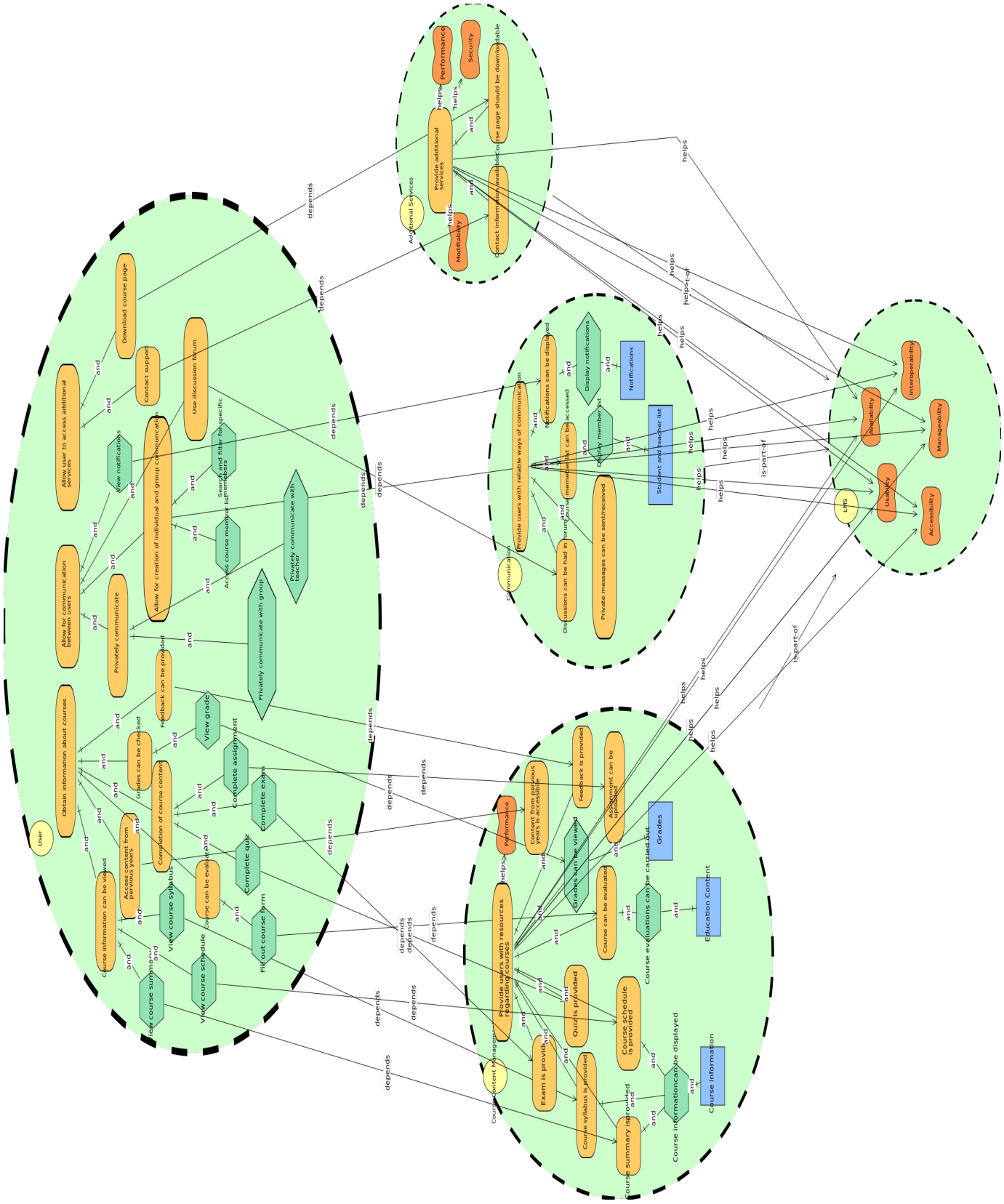


Fig. 24: Low Priority Model

Introduction

Hello, our names are Sara Alibrahim and Viktor Lantz, we are Software Engineering & Management students and this survey functions as data collection for our bachelor thesis.

The survey concerns the functional and non-functional requirements of a Learning Management system(LMS). We are looking for responses which will be used anonymously to help us identify the most important functional and non-functional aspects of a LMS system.

The survey consists of 5 sections, containing approximately 10 questions each. All responses are completely anonymous and the survey takes approximately 10 minutes to complete.

Thank you for taking the time to respond to our survey!

* Required

Learning Management Systems

A Learning Management System (LMS) is a platform upon which individuals are able to browse educational or training based information. It also concerns the organisation of personal files and uploaded assignments and similar documents. The platform is used for communication and other learning related services. An example of a LMS in an academic setting is Gothenburgs University Learning Platform.

1. **Do you use LMS's?** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

2. **Which of these categories do you belong to?** *
   Check all that apply.
   - ☐ Student
   - ☐ Teacher
   - ☐ Developer
   - ☐ Other: _____

3. **How many different LMS's have you used?** *
   Mark only one oval.
   - ◯ 0-2
   - ◯ 2-4
   - ◯ 4-6
   - ◯ 6+

4. **Have you used them in an academic or in an industrial environment?** *
   Mark only one oval.
   - ◯ Academic
   - ◯ Industrial
   - ◯ Both
   - ◯ Other: _____

Communication within a course

Communication within LMS's can take several forms such as direct messaging or open discussion forums. The following questions will explore how important different types of communication functionality are.

5. **How important is being able to privately communicate with students through a LMS?** *
   Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

6. **How important is it to be able to privately communicate with a group of students through a LMS?**
   Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

7. **How important is being able to privately communicate with teachers of a course through a LMS?** *
   Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very Important

8. **How important is a discussion forum in which you can contact students and teachers within the course through a LMS?** *
   Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

9. **How important is being able to receive notifications through a LMS?** *
   Notifications notify the user of important recent activities from all of your courses including announcements, discussions, assignments, etc.
   Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

10. **How important is receiving notifications on different platforms such as text messages?** *
    Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

11. **How important is a chat tool?** *
A chat tool allows students and teachers to interact in real time.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

12. **How important is a conference tool?** *
Conferences makes it easy to conduct synchronous (real-time) discussions within your course with both students and teachers. They allow you to broadcast real-time audio, video, share presentation slides, and share any other online resources.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

13. **How important is a list of contact information for members of a course and teachers?** *
The list of contact information is a sorted list of E-mails or contact information to individual members of a course.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

14. **How important is being able to ask questions anonymously through a LMS?** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

15. **In regard to the overall communication functionality of a LMS, what is the most important functionality to enhance communication and why?**

16. **Do you have any additional functionality which you think that the communication aspect of the LMS would benefit from and why?**

Course Content Management

The course content management (CCM) part of the system handles the browsing and uploading of educational content. The CCM is accessed by students and teachers alike in order to view and provide course information and educational content. It also includes the organisation of schedules and work file structures.
The following questions will explore how important you find different aspects of the Course content management system.

17. **How important is it for the LMS to support the accessing of course information? (e.g., syllabus, schedule, summary)** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

18. **How important is it to be able to evaluate a course through a LMS?** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

19. **How important is having a personal storage?** *
Personal storage allows you to upload personal files and organise them.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

20. **How important is having a personal calendar?** *
A calendar helps students and teachers see what assignments and events are coming up in the course. Personal events can also be added.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

21. **How important is accessing content from previous years through a LMS?** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

22. **How important is being able to review another students assignment and for your assignment to be evaluated by another student through a LMS?** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

23. **How important is being able to obtain feedback from a teacher?** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

24. **How important is being able to view your grade through a LMS?** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

25. **How important is being able to calculate how your grades would be affected?** *
A functionality in which you can know how your grades would be affected by upcoming assignment or exams by inserting predictive numbers.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

26. **How important is being able to complete quizzes and exams through a LMS?** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

27. **How important is being able to collaborate with students when using the LMS?** *
Collaborative technology allows for multiple users to work together on the same document at the same time, on Google Documents for example.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

28. **Concerning the overall capabilities of the course content management, what do you find as the most important functionality and why?**

29. **Can you think of any additional functionality that you think that the Course content management aspect of the LMS could benefit from and why?**

Additional Services

Additional services encompass additional tasks which can be carried out by the users. These services include contact support information, personal pages (which contain information about yourself and similar data) and third party connections to the platform. Examples of the third party connections are applications such as Skype, LinkedIn or Google Drive.
The following questions will explore how important you find the services which are present in the additional services.

30. **How important is being able to edit your personal information?** *
    Being able to add contact information, profile pictures and similar information.
    Mark only one oval.

	1	2	3	4	5	
Not important						Very important

31. **How important is being able to link your account to third party applications and websites?** *
    Connecting your account to Skype, LinkedIn, Twitter, Google Drive, etc.
    Mark only one oval.

	1	2	3	4	5	
Not important						Very important

32. **How important is it be able to contact support, for information about the LMS?** *
    Mark only one oval.

	1	2	3	4	5	
Not important						Very important

33. **How important is being able to access general university information through the LMS?** *
    Mark only one oval.

	1	2	3	4	5	
Not important						Very important

34. **How important is having multimedia content present in the LMS?** *
    Multimedia content includes elements such as videos, pictures and other visual content.
    Mark only one oval.

	1	2	3	4	5	
Not important						Very important

35. **How important is being able to download course content for offline usage?** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

36. **How important is having an ePortfolio?** *
An ePortfolio is a place for you to showcase your good work from a course or academic program. ePortfolios can be used for course projects, but they can also be used by student organisations to create a simple web presence.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

37. **Concerning the overall capabilities of the additional services section, which functionality do you find the most important and why?**

38. **Do you have any additional functionality that you think the additional services could benefit from and why?**

Overall System Attributes

Quality attributes are realized non-functional requirements used to evaluate the performance of a system. This section explores attributes which relate to the entire LMS in order to see which are more important to the user.

39. **How important is the availability of the system?** *
Availability is the proportion of time a system is in a functioning condition. So if the system is not available then it is not working as expected for a period of time.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

40. **How important is the usability of the system?** *

Usability is the systems perceived efficiency or elegance. Usability encompasses the style and clarity with which the interaction with the system is designed. Basically, how easy is the system to use, for example the readability of elements in the system.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

41. **How important is the manageability of the system?** *

In general, manageability is the ease, speed, and competence with which a system can be discovered, configured, controlled, and supervised. Basically, how easy is it to manage items of interest within the LMS system.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

42. **How important is the accessibility of the system?** *

This is about making things accessible to all people. Can be viewed as the "ability to access" and benefit from some system. This can also relate to the design of the system to accommodate for disabilities.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

43. **How important is the performance of the system?** *

Performance refers to the specific ability of a system to complete assigned tasks within a given time.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

44. **How important is documentation of the system?** *

Documentation of the system includes user guides and information about how the functionality of the system can be utilized.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

45. **How important is the security of the system?** *

Security is the degree of resistance or protection from external harm. The safety aspect ensures that files and documents are kept private.
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

46. **Do you have any additional quality attributes that you think a LMS could benefit from and why?**

_____

_____

_____

_____

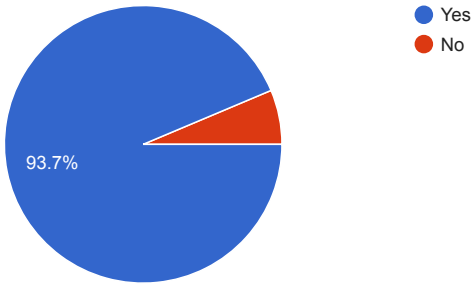
_____

Introduction

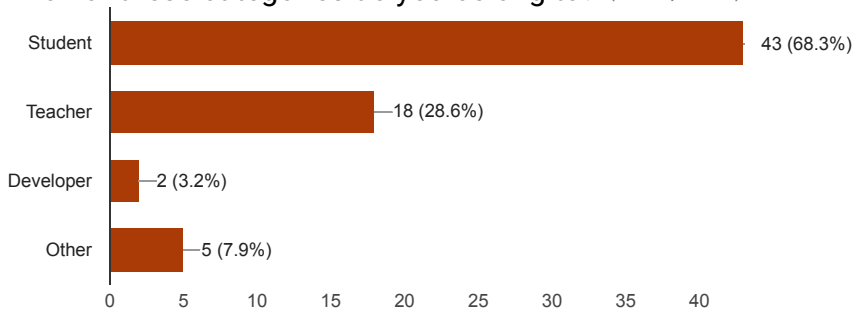
63 responses

Learning Management Systems

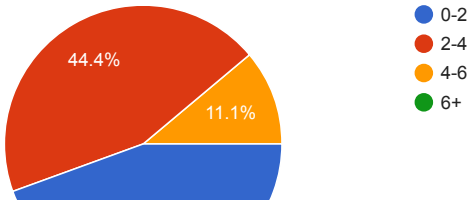
Do you use LMS's? (63 responses)



Which of these categories do you belong to? (63 responses)

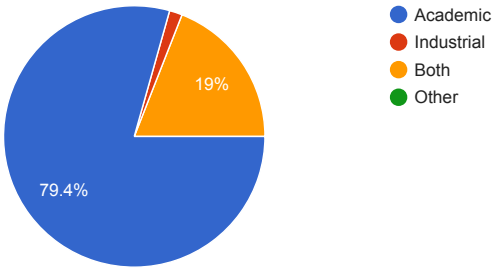


How many different LMS's have you used? (63 responses)



Have you used them in an academic or in an industrial environment?

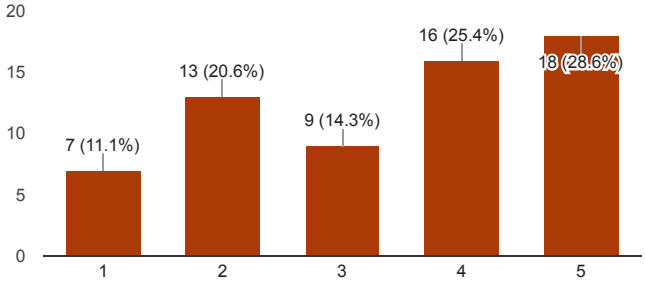
(63 responses)



Communication within a course

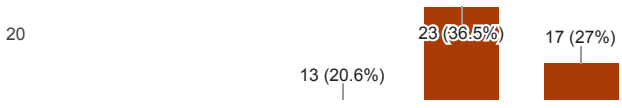
How important is being able to privately communicate with students through a LMS?

(63 responses)



How important is it to be able to privately communicate with a group of students through a LMS?

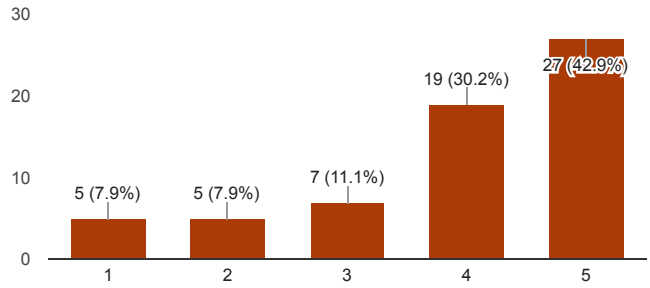
(63 responses)



How important is being able to privately communicate with teachers of a

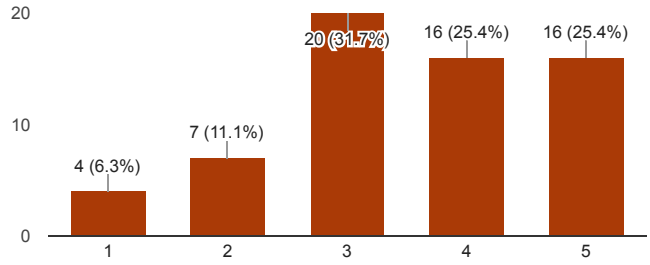
How important is being able to privately communicate with teachers of a course through a LMS?

(63 responses)



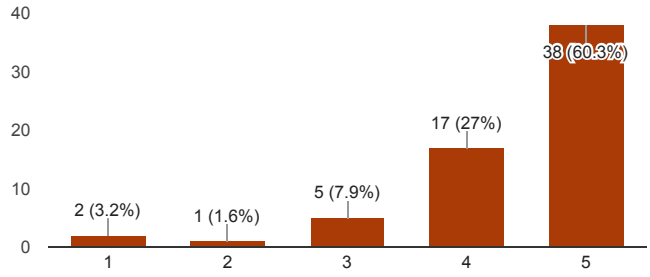
How important is a discussion forum in which you can contact students and teachers within the course through a LMS?

(63 responses)



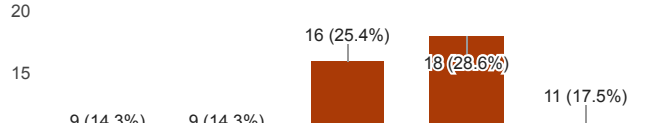
How important is being able to receive notifications through a LMS?

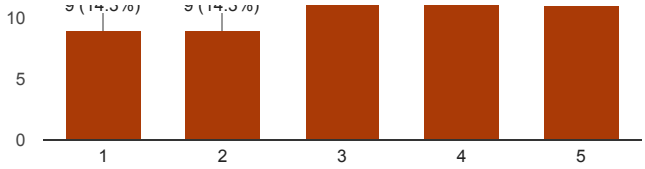
(63 responses)



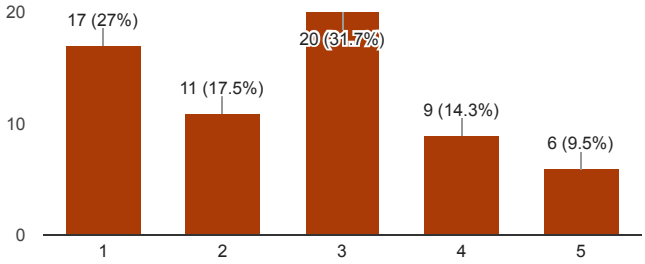
How important is receiving notifications on different platforms such as text messages?

(63 responses)

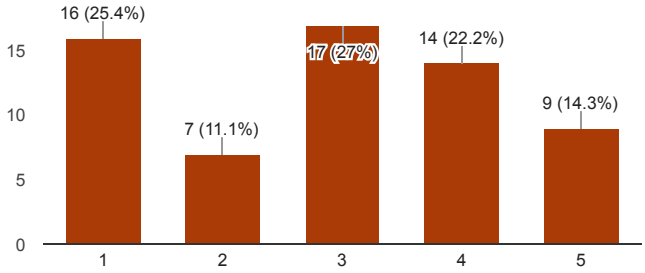




How important is a chat tool? (63 responses)



How important is a conference tool? (63 responses)

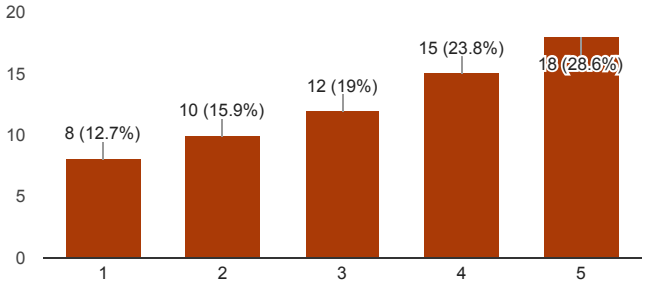


How important is a list of contact information for members of a course and teachers?
(63 responses)

How important is being able to ask questions anonymously through a

LMS?

(63 responses)



In regard to the overall communication functionality of a LMS, what is the most important functionality to enhance communication and why?

(43 responses)

Organised files and folders so the students could easily access the material. Also Keeping the students up-to-date with the latest news.

An open discussion forum is always important. Furthermore, being able to contact the teacher anonymously(or not) is an extremely important feature.

Efficiency and usability so that it is actually faster and simpler than emailing or in other ways contact course participants or teachers.

no idea

Anonymous features

make announcements, book meetings

Receiving notifications on time and alerts because it is the essence of communication.

Forums, they are asynchronous therefore convinient for both teachers and students

Simplicity and usability. Finding where to communicate and having a centralised part of the LMS for communication.

Notifications in terms of hand-ins, new uploaded documents and being able to discuss matters in groups.

Do you have any additional functionality which you think that the communication aspect of the LMS would benefit from and why?

(27 responses)

No

No

No

Being able to create word (editing) files within the LMS platform, in this way the students could work through the LMS platform.

The ability to view content from previous years. That includes discussions and material, such as old exams, assignments and articles.

don't know

When using github as a LMS, I loved the option that students could send me pull requests to improve material.

-

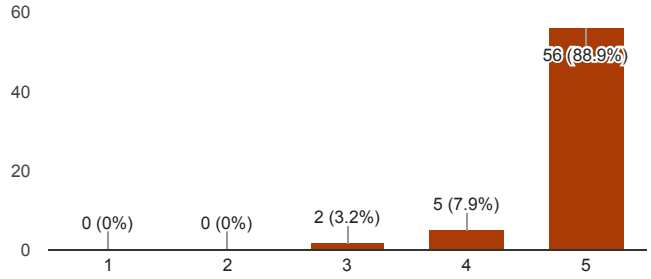
If there is a chat system that is live on the side of the application (live feed with the online statuses of teachers and students) it will be easier to communicate with the people. - Copyright Raze :D

No, and it would turn the LMS more cumbersome to use, when it should be primarily (in my personal opinion) a main landing page/gateway to gather information about the course (grade, schedule

Course Content Management

How important is it for the LMS to support the accessing of course information? (e.g., syllabus, schedule, summary)

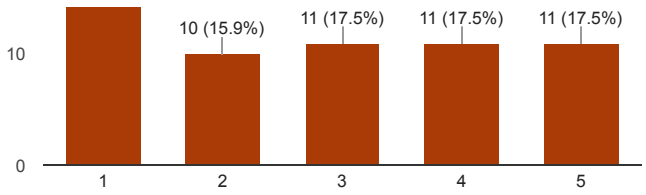
(63 responses)



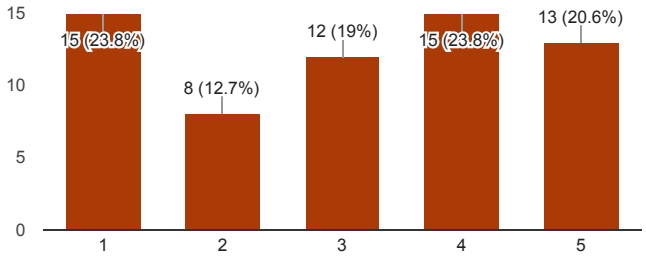
How important is it to be able to evaluate a course through a LMS?

(63 responses)

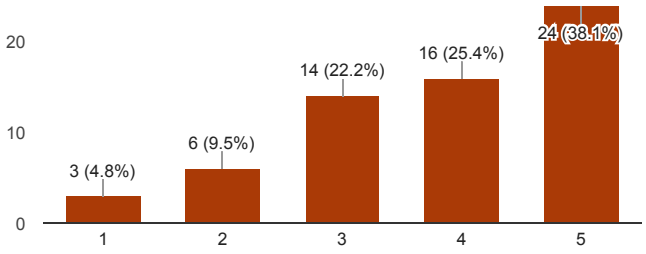
How important is having a personal storage? (63 responses)



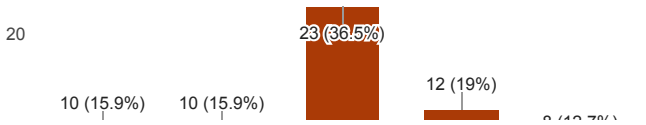
How important is having a personal calendar? (63 responses)



How important is accessing content from previous years through a LMS?
(63 responses)

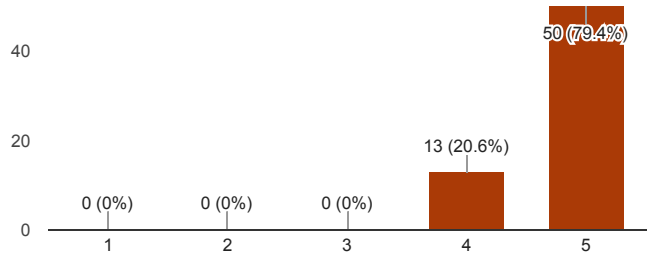


How important is being able to review another students assignment and for your assignment to be evaluated by another student through a LMS?
(63 responses)



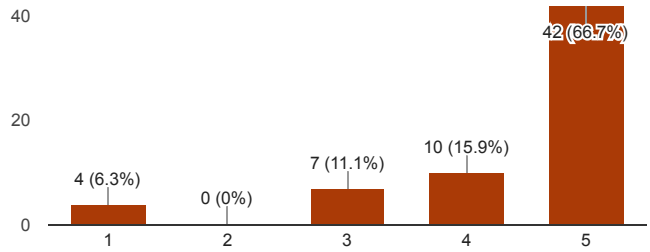
How important is being able to obtain feedback from a teacher?

(63 responses)



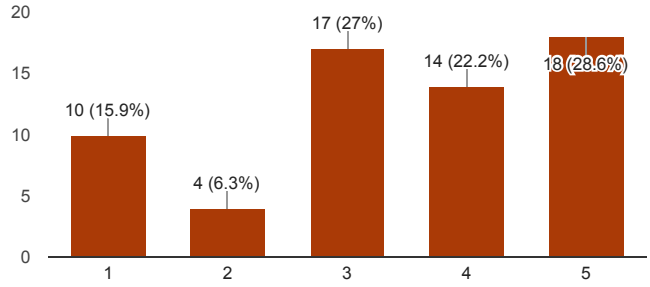
How important is being able to view your grade through a LMS?

(63 responses)



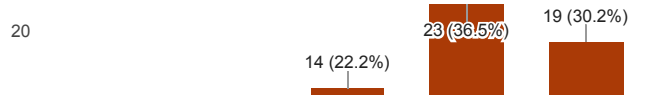
How important is being able to calculate how your grades would be affected?

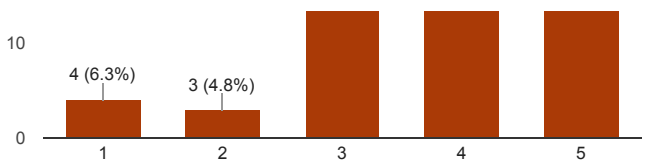
(63 responses)



How important is being able to complete quizzes and exams through a LMS?

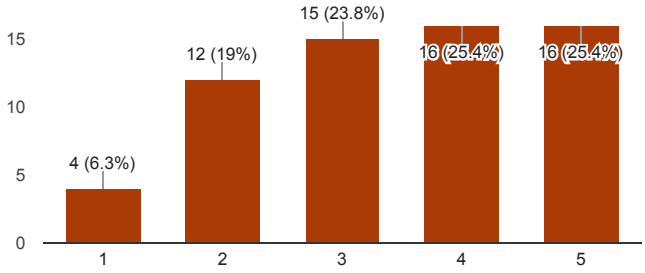
(63 responses)





How important is being able to collaborate with students when using the LMS?

(63 responses)



Concerning the overall capabilities of the course content management, what do you find as the most important functionality and why?

(37 responses)

Being able to submit homework and check the results/feedback - also check up on the latest course news

The basic possibilities of handing in assignments, creating groups, receiving feedback from teachers and viewing course information(schedule, material, pm etc).

Accessible from different platforms in order to be able to check your schedule etc from example your phone.

no idea

These are a lot of questions and they are hard to answer. Calendar is not important, but I should be able to export it into my Outlook or Google Calendar. Evaluation should be done seperately. Old files I keep myself, but I would like to copy last year's course setup and edit it from there.

Progress metering -- gives students an indication of their learning and teachers an indication of where issues are
Objectives -- related to progress metering, allows defining clear learning objectives and exercises/tasks to achieve them

Having a centralised template for the course responsible to follow, in order to be able to easily find information from different courses.

Download and share course material

Can you think of any additional functionality that you think that the Course content management aspect of the LMS could benefit from and why?

(20 responses)

No

No

No

-

-

no :D

Connecting the schedule to your own(Google calendar for instance).

no

Sync with computer like Dropbox style

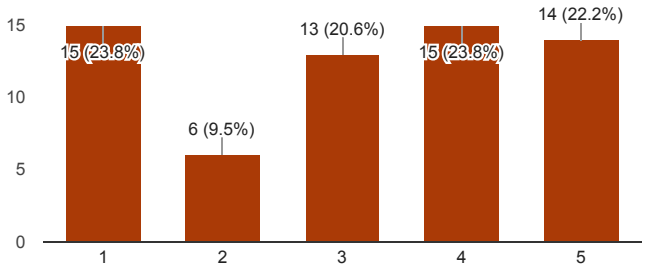
Be able to receive information via email or text messages. And being able to receive notifications.

(i) Analytics on students activities (percentage of participation in forum discussions, progression of grades from different assignment submissions), compatibility in content to allow easy (ii) Import and (iii) export features, in order to reuse information when designing similar courses (or the same course across different terms)

Additional Services

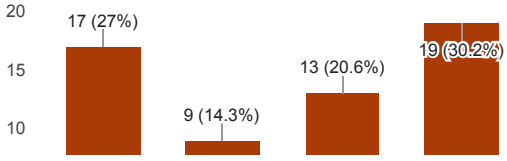
How important is being able to edit your personal information?

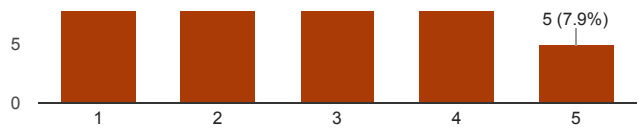
(63 responses)



How important is being able to link your account to third party applications and websites?

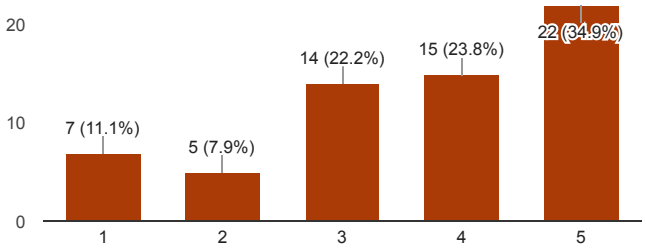
(63 responses)





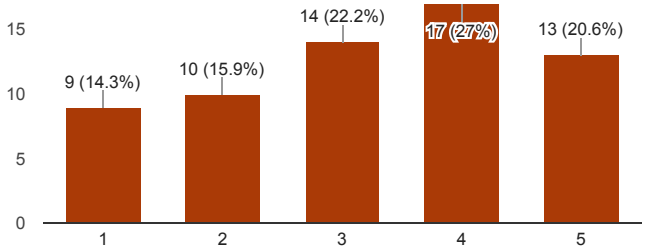
How important is it be able to contact support, for information about the LMS?

(63 responses)



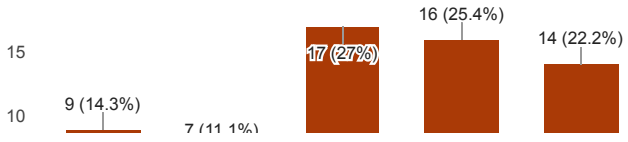
How important is being able to access general university information through the LMS?

(63 responses)



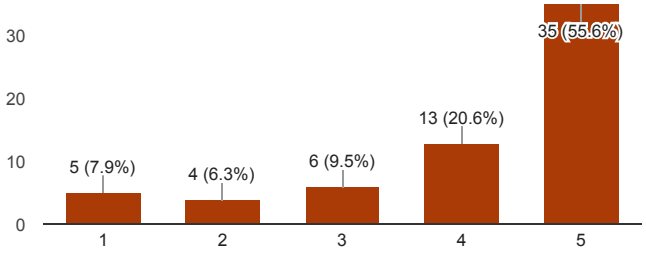
How important is having multimedia content present in the LMS?

(63 responses)

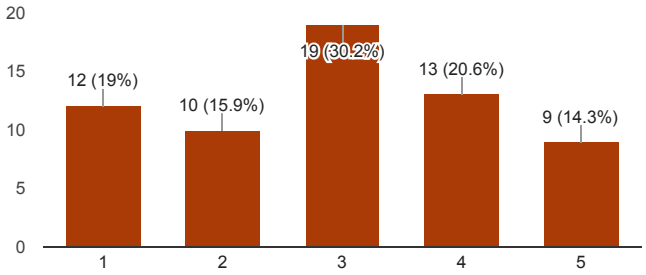


How important is being able to download course content for offline usage?

(63 responses)



How important is having an ePortfolio? (63 responses)



Concerning the overall capabilities of the additional services section, which functionality do you find the most important and why?

(24 responses)

Being able to download documents offline, could be beneficial at some times.

Being able to download the content and contacting support.

To be able to get overall information about how the LMS works and how to get help if you are unsure of how to use it to its potential.

no idea

I can always link to youtube for videos...

Able to view multimedia content directly from the LMS and not though external applications. Also, ePortfolio seems pretty interesting in order to showcase yourself and your work (for potential jobs)

The more Freedom the user has the better the use of the platform. If the user can do all of the mentioned above it will be a perfect LMS

I don't think that connecting different services is "important" but I think it is a stepping stone to optimize the benefits of LMS. By integrating them, a student develop the mindset of service availability and integration of systems that is vital for technology users and students in general. It also allows teachers to switch between environments easily (lectures already uploaded in Google Drive and then connected with the LMS, or gathering the course schedule to trigger Slack notifications for students). That being said, that is perceived as EXTRA content, thus not important for the main functioning of an LMS, but essencial for

Do you have any additional functionality that you think the additional services could benefit from and why?

(14 responses)

-

-

-

No

No

No

As mentioned connecting a calendar might be beneficial.

no

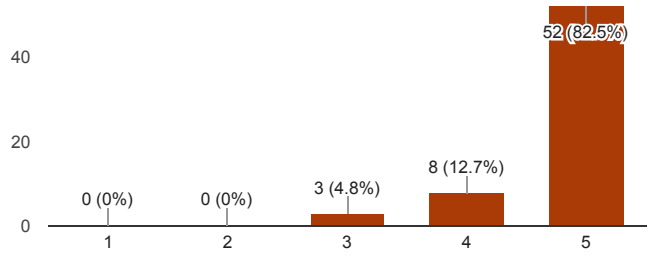
No, I perceive it as an activity of collecting the additional functionality in existing services, and then connecting to the LMS. That is more related to (i) the availability of those services, (ii) effort in create and maintain the integration between platforms.

Easy ways to connect third part programs like Google docs.

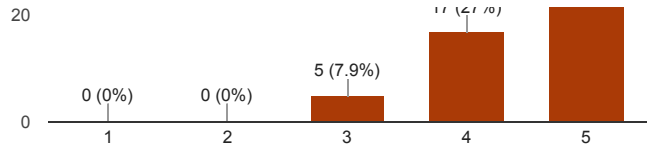
allow to draw diagrams or to interact with other kinds of artifacts (e.g. SW development specific)

Overall System Attributes

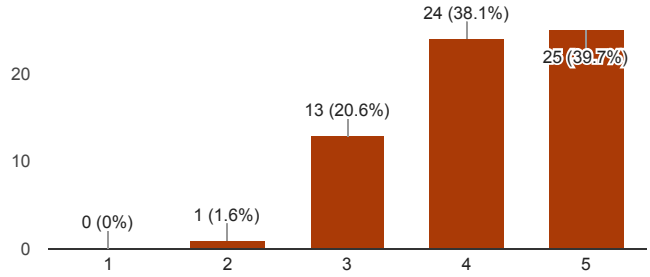
How important is the availability of the system? (63 responses)



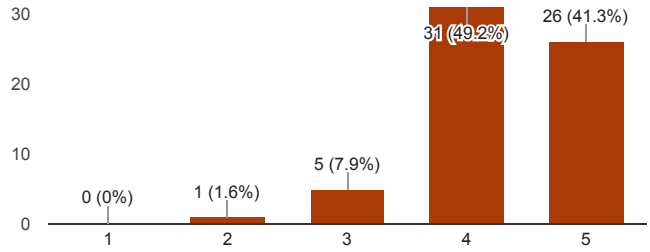
How important is the usability of the system? (63 responses)



How important is the manageability of the system? (63 responses)

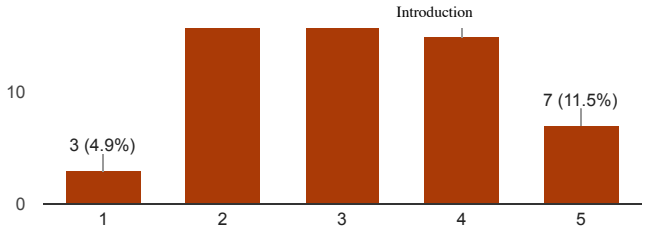


How important is the accessibility of the system? (63 responses)

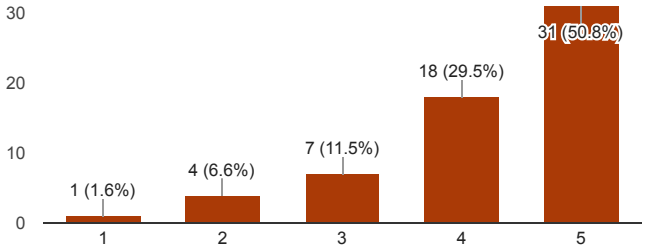


How important is the performance of the system? (63 responses)

How important is documentation of the system? (61 responses)



How important is the security of the system? (61 responses)



Do you have any additional quality attributes that you think a LMS could benefit from and why?

(15 responses)

No

No

It needs to be consistent with other University systems, e.g. room bookings.

Please just improve GUL.

Interoperability is important as well, the system to be able to communicate properly with newly added software or to have a solid connection with the initually implemented components.

Perhaps the format of the documentation, by providing short videos with examples on different features. Or interface elements that you can enable/disable to provide tips as you access different features.

But I would like to raise awareness on the cofounding aspects of the questions above (which comes with the non-functional nature of them). For instance, documentation becomes less important, as usability of the system (intuitive, memorability, etc.) becomes better, so you can try to use the system rather than searching for the feature in a documentation. Security and other aspects are also related to the nature of the course and the University's policies on transparency of material (e.g. private universities/courses and public universities have different needs in that level perhaps).

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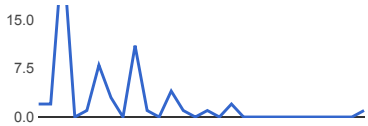
Number of daily responses



In regard to the overall communication functionality of a LMS, what is the most important functionality to enhance communication and why?
Organised files and folders so the students could easily access the material. Also Keeping the students up-to-date with the latest news.
An open discussion forum is always important. Furthermore, being able to contact the teacher anonymously(or not) is an extremely important feature.
Efficiency and usability so that it is actually faster and simpler than emailing or in other ways contact course participants or teachers.
Anonymous features
Make announcements, book meetings
Receiving notifications on time and alerts because it is the essence of communication.
Forums, they are asynchronous therefore convinient for both teachers and students
Simplicity and usability. Finding where to communicate and having a centralised part of the LMS for communication.
Notifications in terms of hand-ins, new uploaded documents and being able to discuss matters in groups.
Retrieve emails and contact information easily. Notifications in other platforms that don't require the web browser to be open
Have it always available and interoperable with different platforms.
Being able to send messages with the people in the application.
The communication functionally is important to replace e-mail exchange and concentrate discussion regarding the course on the course context (i.e. the LMS). However, there are more efficient/effective alternatives for that functionality that can be linked to a LMS and then used primarily to foster communication and discussion (e.g. Slack). The communication should be facilitate by the LMS but not its main feature, since it is, in my personal opinion, a secondary contribution to the Management part of the acronym.
One question: what do you mean by writing "privately communicate"? To send directed messages to individual students or groups? I am asking because the term "private" has a different meaning to me. Student-teacher communication should rarely have a private character. However, there are the important means of privacy and confidentiality concerning

the student-teacher communication. Please, check how far these can be guaranteed for an electronic communication platform within the legal constraints in Sweden.
Students get notifications of updates in the course
Instant messaging with teachers.
Both private and public messaging possibilities between both individuals and groups.
Intuitive design - user sees the page and knows where to click (contact a teacher, view a group page, etc).
I believe the UX and that the LMS is user-friendly, since if it is difficult to use makes no sense to have all the functionalities.
Receiving notifications via email or text since you can't expect the student/teacher to be online all the time
Email information connected to a course representative as that is the quickest way to establish a line of communication. At least in my experience as email is usually checked more frequently
Get email lists and easier live chat would increase the communication in a constructive way. However, could also imply more admin time from the teachers.
The most important communication functionality is to receive notifications, so that you e.g. know when new material have been added to the content and thus makes the student able to keep up to speed with the course.
private and group messages
Biggest issue usually is the lack of user friendliness towards the communication functionality
To message privately
Direct messaging, because that is pretty much all you need.
In my opinion being able to obtain contact information and discussion are the most important functionalities
I think that the most profitable way of communicating via a LMS is via asynchronous communication, i.e. not all the party are online at the same time. It is therefore important to have optimal features that allow communicating this way. For example, maybe it's better to record a video rather than having interacting conference session imho.

receiving notifications, because this helps to be aware of possible updates, news, decisions, etc.
assignments, mails
Conference tool is very important, since a student can ask questions when something they don't understand occurs.
Discussion forum and private messages
I think a good discussion forum is very important. If students are willing to use it and discuss among each other it can both reduce workload of the teacher and achieve better learning experiences.
Notifications for sure, especially if it is connected to a mail or message service.
Being able to contact your teacher is a key functionality
Visibility of notifications are vital as all the participants need to be aware of what happens on the platform (such as new assignments , material or updates) so that they can be acted upon in due time.
Teacher communication and platform notifications. So you do not miss anything and can get help needed with very little waiting time.
Notifications/dashboard - something that clearly shows recent activity so that the user doesn't have to seek out what has happened on their own. It could be very easy to miss important info or events without this function.
Being able to find a contact list of students and teachers and send them messages (emails). That way, you can fast and easy get in touch with the person you want.
I would say that it is important in particular with the availability of a teacher or other responsible person of a LMS. If one have any questions, or if something unpredicted occurs etc.
To be able to communicate anonymously with teachers

Do you have any additional functionality which you think that the communication aspect of the LMS would benefit from and why?
Being able to create word (editing) files within the LMS platform, in this way the students could work through the LMS platform.

The ability to view content from previous years. That includes discussions and material, such as old exams, assignments and articles.
When using github as a LMS, I loved the option that students could send me pull requests to improve material.
If there is a chat system that is live on the side of the application (live feed with the online statuses of teachers and students) it will be easier to communicate with the people.
No, and it would turn the LMS more cumbersome to use, when it should be primarily (in my personal opinion) a main landing page/gateway to gather information about the course (grade, schedule, submissions, and similar management aspects, etc.)
Facebook like feed were updates are displayed.
To create your own schedule based on the courses you have and the meetings. And when you make a change all the involved receive a notification.
The ability to easily be able to switch groups (for seminars or practicals) with other students would be useful. Like adding a request to switch groups that pops up on the LMS that another student can agree to which would result in a schedule change for both students
Well, I've never tried Feedback Fruits but having the slides for the presentations inside the platform to be shown in class with live clickers' voting etc. would be great. The more everything could be integrated into one platform, the better. If done nicely with intuitive navigation.
Ability to create groups and communication tools for it.
Send prioritized (i.e. 'HIGH PRIO, LOW PRIO') mesasges
feedback on assignments/exercises
connection to mooc
A real time drawing tool will benefit LMS communication in case a teacher or student cannot describe their problem in words (a picture tells a thousand words).
feedback on assignments
Maybe a connection to twitter/facebook/etc.. It is easier to reach some of the students this way.
A function that allows you to play VR videos, so that in the teacher has the possibility to upload VR videos while giving a lecture.

That poke feature facebook has would be nice so you can get attention of teachers.
I rarely use an LMS for communication as there are other means of reaching people that are faster, and have a better chance of getting a response (e.g. email, Facebook, face-to-face meeting). If notifications from an LMS could extend to other platforms such as email I might use it more.
An easy-to-use mobile app. All of the LMS I have been using don't have a mobile version. Instead, they have their usual web interface which is often very bulky and not pleasant to use in a smartphone.
Maybe a chat bot that you can ask questions about courses

Concerning the overall capabilities of the course content management, what do you find as the most important functionality and why?
Being able to submit homework and check the results/feedback - also check up on the latest course newsfX
The basic possibilities of handing in assignments, creating groups, receiving feedback from teachers and viewing course information(schedule, material, pm etc).
Accessible from different platforms in order to be able to check your schedule etc from example your phone.
These are a lot of questions and they are hard to answer. Calendar is not important, but I should be able to export it into my Outlook or Google Calendar. Evaluation should be done seperately. Old files I keep myself, but I would like to copy last year's course setup and edit it from there.
Progress metering -- gives students an indication of their learning and teachers an indication of where issues are Objectives -- related to progress metering, allows defining clear learning objectives and exercises/tasks to achieve them
Having a centralised template for the course responsible to follow, in order to be able to easily find information from different courses.
Download and share course material
Ability to view grades, contact people, access documents, etc.
Getting proper feedback and being able to access old information from past courses. You can improve your work and keep never forget what was done in the past.

Easy access to information and proper organization of specific content (gather similar purpose files in folders, etc.) The main goal, personally, in a CCM relies on quickly searching and finding the intended piece of information (attendance, grades, announcements, report submissions, etc.). Extra functionalities (e.g. collaborative environments) are welcome, but only if not disrupting current usability or how intuitive is to use the system.
FAQs, Management of communication, communication of teaching material
Finding information about the course, course material.
Being able to view course content.
I believe the last one cited - collaborative platform. If the LMS can have all that is needed we as a student will not get with a lot of windows opens when doing an assignment or an exam.
The ability to receive feedback from the teachers is important because you can view it whenever and not lose the feedback rather than receiving the feedback in paper form
The ability to access course content is by far the most important functionality. As I see it, this is the main purpose of even having an LMS.
In terms of what a LMS should do, more content should be available for the students. Content such as previous documents, literature, grades etc etc.
Able to quickly organize active courses, assignments or workshops.
Being able to easily find required documents (i.e. assignments, lectures, etc)
The functionality for managing hand-in assignments and their deadlines.
Evaluation of a course, provides teachers with feedback
It's important that collaboration and coordination would be supported by the LMS. Also important that students and teachers could see the progress
obtain feedback from teachers, I think this is a core functionality in LMS. The students often have doubts, ask questions and want to receive feedback.
sharing documents assignment management
Obtaining feedback from teacher is very important so that a student can understand or correct the work that they have done.
Collaboration and feedback on assignments

The most important feature is the support the accessing of course information. It has to work at any time for anyone. It's so important for me because it's the most basic thing that I expect to work no matter what.
A smart calendar is always greatly appreciated.
Accessing content from previous years is important as you might want to access a previous course to at least get the name of the book referred.
The content needs to be very accessible - the navigation should be simple and intuitive.
Grade viewing and course information. The most relevant and most used platforms since this is something directly helping your studies. The other stuff like peer grading hasnt the same impact.
A good scheduling system that is properly used by the teachers is really important. This can save everyone from a lot of confusion about lectures and deadlines.
Having everything at the same spot, because it's convenient.
Being able to find course information, reading materials and assignments specifications. This helps in the preparation and learning for the course.
To be able to access information about courses

Can you think of any additional functionality that you think that the Course content management aspect of the LMS could benefit from and why?
Connecting the schedule to your own(Google calendar for instance). **(Not in models)**
Sync with computer like Dropbox style.
Be able to receive information via email or text messages. And being able to receive notifications.
(i) Analytics on students activities (percentage of participation in forum discussions, progression of grades from different assignment submissions), compatibility in content to allow easy (ii) Import and (iii) export features, in order to reuse information when designing similar courses (or the same course across different terms).
The own calendar I cited before, page that contains an interactive tool with the connection between the courses (like which course depends on another) and each of this courses the student can input manually or the system can bring the info from Ladok (if fail or passed) in order to see the courses we can register or not (good for planning).

Able to connect your schedule with the information from the course content management
Functionality for managing student groups within a course, including options for generating random groupings, and dynamically adding and removing members to them.
Plug-ins and add-ons to allow specific kinds of exercises to be used by students and to allow the teachers to understand if there are gaps.
Integration with other systems (Ladok, TimeEdit, Google Docs)
Perhaps embedded video could be useful rather than posting links.
Integrating a system that records and stores the lectures from a course would be really beneficial. Being able to go back and re-watch/listen to previous lectures can be incredibly helpful when studying for exams, for example.

Concerning the overall capabilities of the additional services section, which functionality do you find the most important and why?
Being able to download documents offline, could be beneficial at some times.
Being able to download the content and contacting support.
To be able to get overall information about how the LMS works and how to get help if you are unsure of how to use it to its potential.
I can always link to youtube for videos...
Able to view multimedia content directly from the LMS and not though external applications. Also, ePortfolio seems pretty interesting in order to showcase yourself and your work (for potential jobs)
The more Freedom the user has the better the use of the platform. If the user can do all of the mentioned above it will be a perfect LMS
I don't think that connecting different services is "important" but I think it is a stepping stone to optimize the benefits of LMS. By integrating them, a student develop the mindset of service availability and integration of systems that is vital for technology users and students in general. It also allows teachers to switch between environments easily (lectures already uploaded in Google Drive and then connected with the LMS, or gathering the course schedule to trigger Slack notifications for students). That being said, that is perceived as EXTRA content, thus not important for the main functioning of an LMS, but essencial for exploiting its optimised benefit, without making the LMS itself a cumbersome platform (as opposed if you were to implement all those existing extra feature in the LMS platform itself, for instance)

Organisation - info should be organised and thus easy to find
I don't find any of these additional services to be important since students and teachers can survive without them
Being able to download course content
The ability to download course content for offline usage is by far the most important service. This way the student can study whenever wherever.
Easy accessible university-related information displayed
Accessing general uni information, as that is not available elsewhere
ePortfolio, because you may want to fetch some good work that you did in last years. Even when you finish a course or leave academia, you may want to have access to some certain works which may be useful for your current work/position.
Having an ePortfolio is important, since many organisations would like to view previous work and projects.
Getting help with the system in case something goes wrong, for both, teacher and student. This get's critical in case deadlines or important tasks are handled through the system.
Having multimedia content available is important. Depending on the situation, a picture can explain some things so much better than a text.
The general news section of our system is useful; events around campus as well as guest speakers and workshops get posted regularly which helps students stay up-to-date.
Download course content, will be used, rest are already better developed by other companies.
I think having multimedia content is very important for learning. People have different ways in which they learn best so students should be provided with various media options.
Being able to download materials for offline usage. That way I can study anytime, anywhere.
To be able to edit my information and link other sites

Do you have any additional functionality that you think the additional services could benefit from and why?
As mentioned connecting a calendar might be beneficial.

No, I perceive it as an activity of collecting the additional functionality in existing services, and then connecting to the LMS. That is more related to (i) the availability of those services, (ii) effort in create and maintain the integration between platforms.
Easy ways to connect third party programs like Google docs.
Allow to draw diagrams or to interact with other kinds of artifacts (e.g. SW development specific)
An app/mobile friendly version.
The LMS I use has hardly any of the additional content mentioned above so I think any of these would be a good addition, especially multimedia and third-party websites.

Do you have any additional quality attributes that you think a LMS could benefit from and why?
It needs to be consistent with other University systems, e.g. room bookings.
Interoperability is important as well, the system to be able to communicate properly with newly added software or to have a solid connection with the initially implemented components.
Perhaps the format of the documentation, by providing short videos with examples on different features. Or interface elements that you can enable/disable to provide tips as you access different features. But I would like to raise awareness on the co-founding aspects of the questions above (which comes with the non-functional nature of them). For instance, documentation becomes less important, as usability of the system (intuitive, memorability, etc.) becomes better, so you can try to use the system rather than searching for the feature in a documentation. Security and other aspects are also related to the nature of the course and the University's policies on transparency of material (e.g. private universities/courses and public universities have different needs in that level perhaps).
Intuitive design is the backbone else a LMS not that useful - like most today
Simplicity, because a complex system takes a lot of effort to learn.
The LMS could benefit of maintainability, making life easier for the developers of the system.
It should be kept as simple as possible. A LMS is no replacement for human contact.
In addition to usability, I find it also important to design LMS for user experience.

"Robustness". Users (likely students) may use functions not as they are intended or "tinker" with the system. It should not break if that is the case.
To be able to modify the interface of the system. Meaning, to be able to organize the front-page, etc., according to how you want it and not just have the default look. For example, I don't use many of the features of a LMS so I would like to be able to arrange the UI in such a way that the things I used are only visible.