Promoting Sustainability and Transferability of Community Question Answering

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Abstract

Community Question Answering (CQA) provides people with a possibility to ask various questions and, at the same time, provide answers on questions of other users (e.g. Yahoo! Answers). Our thesis concerns with two open emerging problems closely related to the CQA concept: (1) a long-term sustainability of CQA ecosystems, and (2) their transferability to educational and organizational environments.

At first, we conducted a case study on recent negative development of Stack Overflow's community which is reflected in increasing amount of low-quality content created by undesired groups of users. Consequently, we suggested to preserve a long-term sustainability of CQA communities by means of robust reputation mechanisms and answerer-oriented adaptive support methods that in addition involve the whole community. We put these suggestions into practice by means of two novel methods: (1) for reputation calculation focused on quality of users' contributions, and (2) for recommendation of new questions to potential answerers with utilization of non-QA data.

Our main contribution to the second open problem lies in introduction of a novel organization-wide educational CQA system Askalot, which takes educational as well as organizational specifics into consideration.

Categories and Subject Descriptors

H.3.2 [**Information Storage and Retrieval**]: Information Search and Retrieval; K.3.1 [**Computers and Education**]: Computer Uses in Education

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Keywords

Community question answering, knowledge sharing, sustainability, educational domain, adaptive collaboration support

1. Introduction

Standard information retrieval tools, such as Google Search, represent the most popular way how to search for required information on the Web. However, successfulness of these tools decrease when a user wants to find information, which is highly context-specific, subjective (e.g. a recommendation), scattered across many sources or which cannot be easily described by keywords. In these cases, Internet users have a possibility to utilize alternative tools that are based on knowledge sharing in great online communities of people. One of the most successful examples of these community-based knowledge sharing systems is Community Question Answering (CQA).

Knowledge sharing in CQA systems take place in four main steps (see Figure 1):

1. **Question Creation**. Any member of community is able to post a new question by providing its name, detailed description and usually it is also necessary to assign it into a hierarchy of categories or tags. In contrast to standard information retrieval tools, the description of question is not limited to keywords and thus an asker can define his/her information need more precisely.

2. **Question Answering**. As soon as the question is posted, all other members of the community have a possibility to provide their answer candidates, vote for the best answer, vote for the question (if they consider it as an interesting one) or provide additional comments.

3. **Question Closing**. In the case of obtaining correct answer, the asker can mark one of the provided answers as accepted one.

4. **Question Search**. After best answer acceptance, the corresponding question is moved to the archive of solved questions, where it can be retrieved if additional users will seek for the same information in the future.

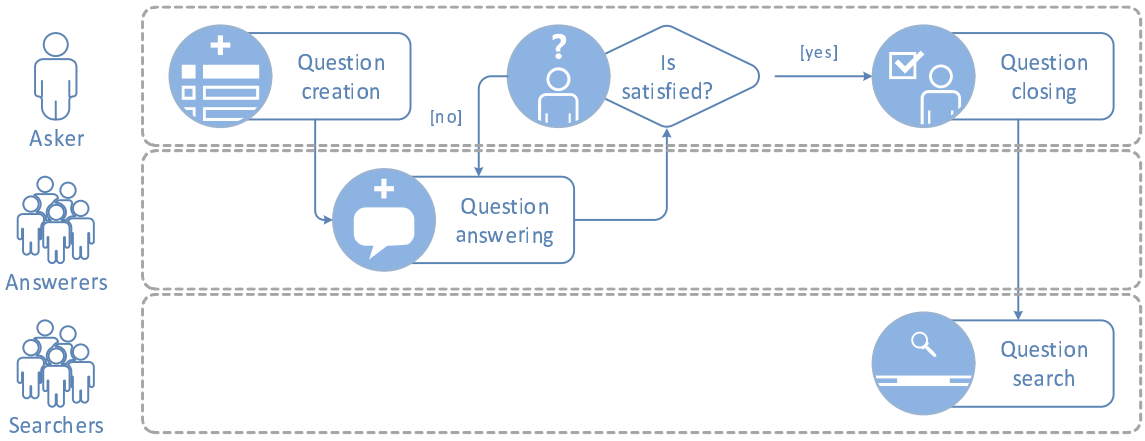

Figure 1: Standard question lifecycle in CQA systems.

Some of the existing CQA systems provide a possibility to ask questions without any topic restriction, such as Yahoo! Answers or Wiki Answers. On the hand, there are CQA systems focused on specific topic areas, for example Stack Overflow, which concerns only with questions related to programming.

The first CQA systems (e.g. Yahoo! Answers established in 2005) emerged as a result of rapid Web 2.0 development. Since then, they have gained a great popularity and nowadays, they contain communities with millions of users who collaborate together to provide answers on thousands of new questions asked each day.

1.1 Two Perspectives on Community Question Answering[1]

In order to understand principles and concepts of CQA systems better, we can describe the question answering process from two perspectives. In the first perspective, CQA systems can be characterized as information systems fundamentally based on knowledge sharing, more specifically they utilize a number of modern theories how online communities work, such as communities of practice, collective intelligence, wisdom of the crowd, social interaction, crowdsourcing or human computation.

At the same time, we recognized that the question answering process is actually a specific type of informal learning. Therefore, CQA systems can be also perceived from more alternative perspective of community-based collaborative learning. In this second perspective, we can characterize CQA systems by means of theories related to technology enhanced learning, such as computer-supported collaborative learning, peer-learning or knowledge building communities.

1.2 Collaboration Support in CQA Systems[1]

Overall successfulness and popularity of CQA systems attracts researchers from many areas, mainly from computer science, psychology and sociology. As the result, CQA systems became the subject of many research publications, which also comprise the bases for our thesis.

[1]The results summarized in this section have been published in I. Srba, M. Bieliková, *A Comprehensive Survey and Classification of Approaches for Community Question Answering*.

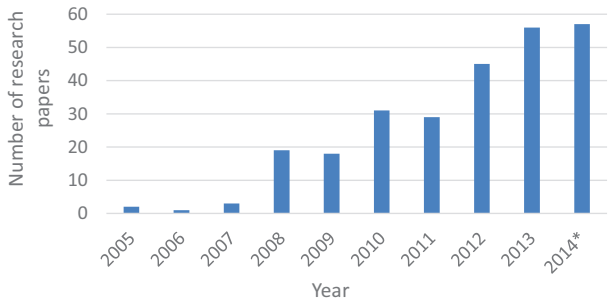

Figure 2: A number of research papers tackling with CQA systems covered by our survey. The last year 2014 covers all papers that were available in digital libraries before February 2015.

However, in spite of a great number of research papers published during the 10-years-long history of research on CQA systems, this area lacks the comprehensive survey which reflects the state of the art. Absence of this kind of survey have caused many negative consequences (e.g. missing established terminology, difficult orientation in the area especially for novices). In order to face these drawbacks, we proposed the first complex classification and survey of research problems solved in CQA systems.

To achieve the best possible coverage of our survey, we looked up papers explicitly aimed at CQA systems in digital libraries (ACM DL, IEEE Xplore, Springer Link and Science Direct). Consequently, we supplemented the list of found papers also with additional publications referenced in the related work. Finally, we obtained the list consisting of 265 papers created before the end of year 2014 (see Figure 2).

Among obtained research papers, we identified also a few surveys, however, they were published several years ago and thus they did not reflect the state-of-the-art approaches (e.g. [7]) or they were focused only one specific problem (e.g. question routing in [2]).

In order to prepare solid foundations for our survey, we proposed a description framework at first. Following the analyses of 265 obtained papers, we identified a set of attributes that characterize research papers and their con-

tributions (i.e. category of approach, subject of research, type of solved problem, input information, gold standard, algorithm, evaluation metrics and dataset). Consequently, we utilized this descriptive framework to propose a complex three-level hierarchy of tasks solved in CQA systems. On the first level, we divided the approaches according to category of approach into three groups: (1) exploratory studies, (2) content and user modelling; and finally (3) adaptive support. On the second and the third level, we categorized approaches according to subject of research and type of solved problem respectively. In each of these groups of approaches, we described several representative approaches with utilization of remaining attributes from the descriptive framework.

1.3 Open Problems and Thesis Goals

Following the state of the art in the area of CQA systems, we identified open problems, which resulted from constant development of these systems.

- **Absence of approaches addressing emerging problems of CQA ecosystems**. In spite of overall popularity and successfulness, some of the most popular CQA systems have recently experienced negative development of their content and community. The most eminent problems, which significantly hinder the question answering process, are a rapidly increasing amount of low-quality content and a growing number of undesired groups of users who purposefully abuse CQA systems (e.g. in order to quickly solve their problems without returning the received help back to the community). In spite of the great effort in supporting collaboration of users, the existing state-of-the-art approaches do not sufficiently address these negative trends. Moreover, some of the approaches for providing users with collaboration support even indirectly support these undesired groups of users. The main reasons for this discrepancy is that collaboration support is primarily aimed at askers and their goals to receive answers in the shortest possible time. On the other hand, answerers and their expectations are not taken into consideration sufficiently. In addition, existing approaches involve in the question answering process only a small subset of highly active and expert users, while the rest of the community is usually left unutilized.

- **Undiscovered potential of educational CQA systems**. In addition, in spite of many positive results of CQA systems on the open Web, their beneficial effects have not been fully discovered in other environments yet. Nowadays, we witness initial efforts on taking advance of their concepts in business context. Question answering in CQA systems can be perceived, however, not only as a process of knowledge sharing, but also as a specific kind of informal collaborative learning. Therefore, CQA systems incorporate also interesting and undiscovered learning potential that can be utilized especially in educational domain. This potential is obvious particularly at organizational level, as students are quite often struggling with various problems related to a learning process or learning materials that cannot be answered easily in CQA systems outside their educational organization.

We aim to address these open problems by exploring sustainability and transferability of community question answering. In particular, our thesis goals are:

- **Goal 1: Proposal and evaluation of new methods to preservation of CQA sustainability**. In order to suppress the negative consequences of the current development in the most popular CQA systems and to maintain the long-term sustainability of their ecosystems, our first goal is to investigate the emerging problems in more details. Consequently, we aim to propose novel methods that can support the collaboration between users and at the same time contribute to the long-term sustainability of CQA systems. For example, the recommendation of questions to potential answerers represents a possibility to motivate and involve all kinds of answerers (not only active and expert ones) with respect to their interests in particular topics, question difficulty etc.

- **Goal 2: Adapting successful concepts of CQA systems for specifics of organization-wide and educational environment**. Our second goal is to examine how verified CQA systems can be adapted in two transitions: (1) from a non-educational to an educational context; and (2) from the open Web to an organizational environment. Consequently, we introduce the novel organization-wide educational CQA system Askalot that is specifically designed to support the question answering process while taking organizational as well as educational specifics into consideration.

2. Proposed Solutions for Preservation of CQA Sustainability[2]

With the aim to describe the emerging problems in CQA communities more precisely, we conducted a case study on CQA system Stack Overflow. At first, we evaluated a community perception in Meta Stack Overflow (a specific part of Stack Overflow, which is dedicated to questions about system itself). Starting from year 2014, it is possible to witness an increasing trend of questions that point out a negative development of the community. The community identified three main groups of undesired users:

1. **Help vampires**, who create a great number of questions without any effort to find the required information by means of standard information retrieval tools, while they are interested only in getting their questions answered and they do not return any received help back to the community.

2. **Noobs** who create trivial and low-quality questions.

3. **Reputation collectors** who purposefully answer mainly low-quality and uninteresting questions (mostly created by the previous two groups of users) in order to gain as much reputation as possible.

[2]The results summarized in this section have been published in I. Srba, M. Bieliková, *Why Is Stack Overflow Failing? Preserving Sustainability in Community Question Answering*, 2016.

Consequently, we supported and statistically confirmed the community perception by easily reproducible quantitative analyses, which are also suitable for monitoring the community evolution in the future.

As the solution to this negative trend, we proposed to change the standard reputation mechanisms and to research new methods for adaptive collaboration support, which are primarily answer-oriented (since the most of the existing methods are asker-oriented) and which involve the whole community (since the most of the existing methods involve only small part of highly active experts).

In order to verify our suggestions, we proposed and evaluated (1) a method for reputation calculation with consideration of content quality and question difficulty; (2) a method for question routing with consideration of non-QA data (i.e. data that are not the result of the question answering process itself).

2.1 Reputation Based on Content Quality and Difficulty[3]

User reputation in CQA systems represents the global value of user for the community and it reflects his/her expertise and activity in the system. The existing methods for reputation estimation, however, emphasis mainly user activity and thus they very often give high reputation for very active users (despite the real quality of their contributions). The same problem is also present in rule-based reputation mechanisms employed in CQA systems (e.g. in Stack Overflow).

We proposed a new method for reputation calculation, which puts emphasis on the level of user expertise. In other words, users gain a bigger amount of reputation for asking difficult questions and for providing high-quality answers on difficult questions. The correctness of the proposed method was evaluated on two independent datasets from Stack Exchange platform. Experimental results showed that our method achieved better results in comparison with original method for reputation calculation in Stack Exchange platform as well as in comparison with other metrics proposed in the previous research papers, e.g. Z-score [8]. In addition, in comparison with Stack Exchange reputation, the distribution of reputation calculated by our method follows approximately Gauss normal distribution (what correspond to expectation that the majority of users have average level of expertise).

2.2 Question Routing Based on Non-QA Data[4]

In order to evaluate our remaining suggestions for preservation of CQA sustainability, we proposed a novel method for question routing (i.e. recommendation of new questions to potential answerers). On the basis of the state-of-the-art analyses, we found out that almost all existing question routing methods work solely with QA data (i.e. data that are the result of the question answering process, mainly logs about asked questions and provided answers).

This solution, however, cause that these methods are able to route questions only to a small part of the whole community, which consists of highly active and expert users. On the other hand, the big potential of the rest of the community (mainly newcomers and lurkers) is left unutilized. If it will be possible to recommend questions also to these users, we can motivate them to participate on question answering more actively and thus we can contribute also to long-term sustainability of CQA ecosystems.

In order to achieve this shift, we proposed to consider during question routing not only QA-data but also non-QA data (i.e. user information which are publicly available inside or outside of CQA systems). Non-QA data have been already previously utilized in CQA systems, however, only for determination of social attributes (e.g. [3]) or to determine user expertise, nevertheless only with simple term vectors [4], which have been already in other works outperformed by models based on latent topics.

To fill this gap, we proposed and implemented the method for question routing that connects utilization of non-QA data with verified state-of-the-art user expertise modelling by means of latent topics (LDA). The recommendation is performed in four steps: (1) construction of question profiles; (2) construction of non-QA data profiles; (3) constructions of user profiles; and finally, (4) matching question and user profiles.

We experimentally evaluated the proposed method on a dataset from CQA system Android Enthusiasts. We compared three versions of out method which considers QA data, non-QA data and their combination. The results showed that non-QA data improved precision of recommendation for all kinds of users and not only for those with low level of QA data as we originally hypothesized.

3. Utilization of CQA Systems in Organizational and Educational Environment[5]

In the second part of our dissertation thesis, we investigated transferability of CQA systems to additional domains. In spite of the large number of research paper, just a few of them concern with utilization of CQA systems in organizational environment, e.g. [5]. Specifically, educational organizations represent an interesting area, where CQA systems have a potential to improve knowledge sharing among students as well as communication with a teacher.

Utilization of CQA systems in education is not, however, straightforward. Standard open CQA systems are not appropriate to support learning. Some of them even prohibit asking questions related to homework or assignments (e.g. Stack Overflow). Moreover, organizational environment has many specifics that on one hand make question answering more difficult (e.g. a higher probability of expert overload), and on the other hand, provide new possibilities (e.g. presence of a teacher, a possibility to ask question closely related to the organization).

[3]The results summarized in this section have been published in A. Huňa, I. Srba, M. Bieliková, *Exploiting Content Quality and Question Difficulty in CQA Reputation Systems*, 2016.

[4]The results summarized in this section have been published in I. Srba, M. Grznár, M. Bieliková, *Utilizing Non-QA Data to Improve Questions Routing for Users with Low QA Activity in CQA*, 2015.

[5]The results summarized in this section have been published in I. Srba, M. Bieliková, *Askalot: Community Question Answering as a Means for Knowledge Sharing in an Educational Organization*, 2015 and in in I. Srba, M. Bieliková, *Design of CQA Systems for Flexible and Scalable Deployment and Evaluation*, 2016.

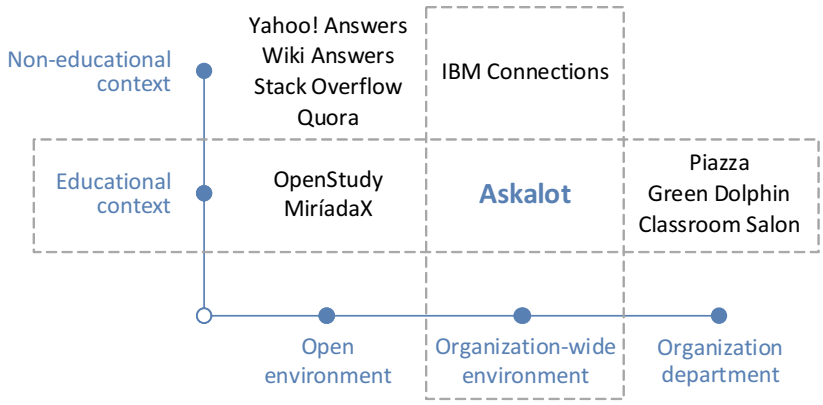

Figure 3: Askalot system in the context of existing CQA systems.

We built on these organizational and educational specifics and we proposed a new concept of university-wide educational CQA system. In order to verify its feasibility, we designed and implemented CQA system Askalot[6], which specifically supports collaborative learning in communities of learners across the whole organization. Existing educational CQA systems (see Figure 3) are focused either on question answering in open communities outside organization, e.g. OpenStudy [6], or inside organizations, however, only at class-level, e.g. Green Dolphin [1].

CQA system Askalot supports specifically two groups of users: students and teachers. At first, it provides them with standard question answering functions (asking a question, posting answers and comments, voting, best answer selection, see Figure 4), but also with more advanced community-features (e.g. community profiles, following, see Figure 5) and workspace awareness (e.g. dashboard, activity feed, complex notification system). Teachers have in addition possibility to see statistics describing how well students are able to perform during question answering.

Besides Askalot's primary goal to support educational question answering, it can be also characterized as an open experimental platform. It is built on an experimental infrastructure, which allows to implement and evaluate any adaptive collaboration support methods in a simple and effective way. The experimental infrastructure can be used in offline experiments with datasets coming from Askalot itself or even with datasets from any system in Stack Exchange platform, or in live experiments with a community of students in Askalot.

Askalot is implemented as an open-source web application[7], which provides responsive user interface so it can be used on personal computers as well as on mobile devices. The development of system is driven by test with test coverage at 90%.

System Askalot was experimentally evaluated at our Faculty of Informatics and Information Technologies, Slovak University of Technology in Bratislava during the summer term of academic year 2015/2014. During the pilot evaluation, 600 bachelor students from four selected courses and their teachers joined the community in Askalot and asked 180 questions and provided 250 answers. Nowadays, students have a possibility to ask questions related to any subject taught at our faculty.

[6]Demo of CQA system Askalot is available at: https://askalot.fiit.stuba.sk/demo

[7]Source code of CQA system Askalot is available at: https://github.com/AskalotCQA/askalot

4. Contributions and Conclusions

Contributions achieved in the dissertation thesis can be divided into three main groups:

1. **Overview of theories and state of the art in CQA systems**. In spite of significant interest in this area in academy as well as in industry, the systematic overview of theories standing behind their success was missing. In our work, we described CQA systems from two perspectives - from the perspective of knowledge sharing and collaborative learning. In each of them we identified the most important theories, which provide an insight how the community-based question answering process works. At the same time, we did an analyses of 265 research publications, which served us as the basis for proposal of descriptive framework, complex three-level categorization hierarchy of approaches as well as for describing representative approaches from each category. This survey should help novice researchers to get better overview of the research domain and to identify optimal techniques in methods' proposal and evaluation.
2. **Supporting long-term sustainability of CQA ecosystems**. We identified the increasing negative trend in development of some CQA systems. In order to describe it in more details, we conducted the case study on CQA system Stack Overflow. In the study, we analysed community perception, which we supplemented with easily executable and reproducible quantitative analyses. These analyses allow any other researchers continue monitoring development of the negative trends not only on Stack Overflow but also on all other CQA systems built on the top of Stack Exchange platform. Following the achieved insight in the case study, we proposed several remedy solutions (e.g. new attitude to reputation calculation or systematic involvement of the whole community). These suggestions were illustrated and verified by means of innovative methods for (1) reputation calculation based on content quality and difficulty; and (2) question routing based on non-QA data.

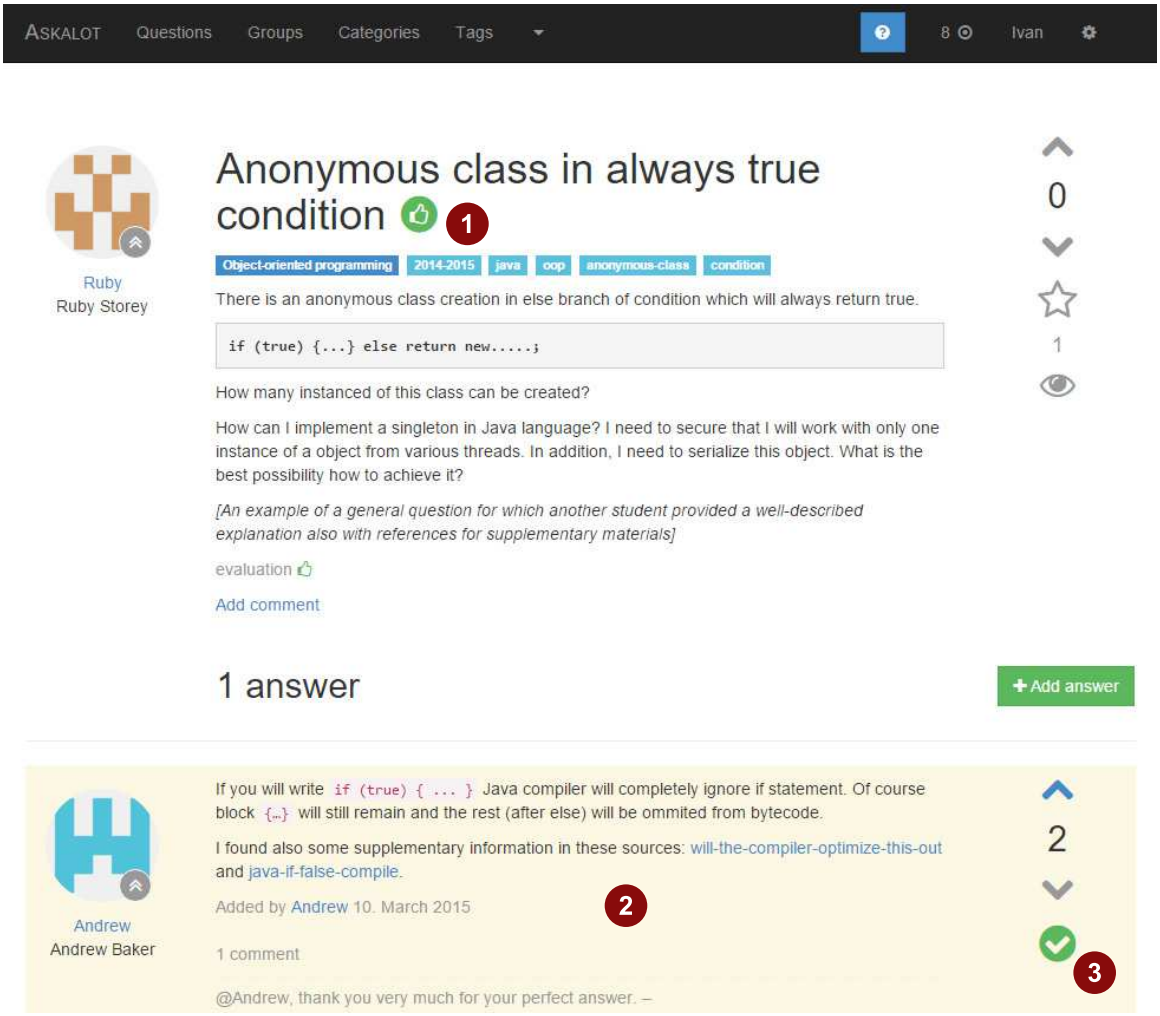

Figure 4: Detail of a question posted in Askalot. (1) Question evaluated by a teacher as a good one. (2) Answer posted by a teacher is highlighted with a different background so it can be easily distinguished from other answers posted by students. (3) Answer is marked by a student as an accepted one.

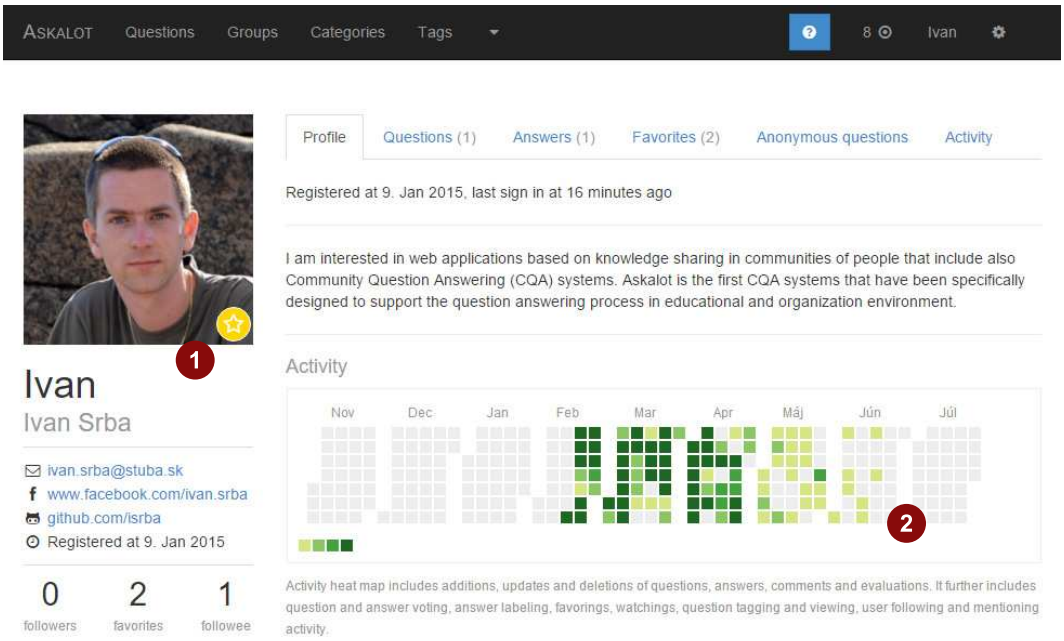

Figure 5: Detail of a user community profile in Askalot. (1) User gravatar with a gold reputation level. (2) User activity heat map.

3. **Investigation of CQA transferability to educational domain**. Last but not least, we identified a potential of CQA systems to be employed not only on the standard open Web, but also in organizational and educational environment. The proposed concept of university-wide educational CQA system has been evaluated by implementation of CQA system Askalot. Askalot has been deployed as a supplementary tool to formal educational process at our faculty. Its community consists of more than 1100 students and teacher. In addition, Askalot provides also the experimental infrastructure, which has been already used in evaluation of several research papers and bachelor or master theses.

The achieved results in the dissertation thesis provides good basis for additional research in the area of CQA systems. At first, it is possible to continue in proposal of additional methods for adaptive collaboration support, which will also contribute to sustainability of CQA community ecosystems. We perceive another potential in further development of educational CQA systems. We plan to deploy Askalot at Lugano University as a part of collaboration project in SCOPES programme. Moreover, we have started a collaboration with Harvard University with the aim to adjust implementation of Askalot so it can be used for question answering in MOOC system edX.

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