Questionnaire for User Habits of Compute Clusters (QUHCC)

Johanna Renker[1(✉)], Stephan Schlagkamp[2], and Gerhard Rinkenauer[1]

[1] Leibniz Research Centre for Working Environment and Human Factors, Dortmund, Germany
{renker,rinkenauer}@ifado.de
[2] Robotics Research Institute, TU Dortmund University, Dortmund, Germany
stephan.schlagkamp@udo.edu

Abstract. There is an increased interest to improve existing schedulers of compute clusters. Trace data are used to analyze the performance of compute clusters and to develop improved algorithms, but the interaction of the user and the compute cluster is not considered yet. Therefore, the current study investigates user behavior and satisfaction with regard to compute clusters. The resulting data are used to model users and to run a scheduler simulation with these modeled users. A new questionnaire for User Habits of Compute Clusters (QUHCC) with 7 scales and 53 questions was developed for this purpose. Results indicate that there is considerable potential to improve the performance of computer systems, viz. users satisfaction is limited, because different kinds of user strategies are necessary to improve the performance of the system. Future work includes the further validation and improvement of the questionnaire.

Keywords: Questionnaire · High performance computing · User strategies · User satisfaction

1 Introduction

Workload traces can be used to evaluate the performance of computing systems [1], but they represent only one instantiation of the interaction process. The interaction of the user with the computing system is often disregarded. Users submit jobs and receive responses from the computing system, so that a mutual influence occurs. In the current study this mutual influence is investigated by focusing exemplarily on user satisfaction and user strategies with regard to computing systems. To assess the interaction patterns a questionnaire was developed and employed for data collection. Those data provide insights into the dynamic process of users and computing systems and allow to model user behavior in a simulation to test different scheduler algorithms, which might improve the performance of computing systems [2]. Several questionnaires regarding user experience and satisfaction already exist [3–5], but they are not usable in the context of High Performance Computing (HPC), because the interaction with compute

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clusters is rather abstract and the handling specific. Therefore, a need emerged to develop a new questionnaire, which is adapted to the different characteristics of compute clusters. In order to gain deeper insights into the interaction between users and compute clusters, we consulted a focus group with administrators of a compute cluster.

2 Method

The used research method is twofold. First, we interviewed a focus group to get an overview of interaction patterns between users and compute clusters. Based on these information, a questionnaire is developed to get more detailed insights into the interaction process from a larger sample of compute cluster users.

2.1 Focus Group

The employment of a focus group is a common research method to get qualitative information about a certain topic during a moderated discussion. This technique involves in-depth group interviews with a sample of a specific population. Group interviews are resource-efficient and support the dynamic social interaction, so that the achieved data are often richer than from one-to-one interviews [6]. In the current study we used this method in the first explorative phase to gain insights into users interaction with compute clusters and to detect the main issues, which are investigated in the second phase by means of the questionnaire. Our focus group comprises administrators of a compute cluster at TU Dortmund University. We discussed issues concerning user habits, user satisfaction and needs of users with these experts. Finally, the following main research questions resulted from the discussions:

- Which factors determine user satisfaction?
- Which strategies are used to gain results faster?
- What waiting times are acceptable by users?
- How do sparse resources affect users working habits?
- How can different job types be categorized?

During the group interviews, we received information about the work environment and working habits of users of computing systems, e.g., we were informed that users of smaller clusters, like the Linux compute cluster of the Faculty for Physics at the TU Dortmund, often ask for assistance in case that urgent results are needed. Together with the administrators we categorized jobs of compute clusters into small, medium, and large jobs as well as interactive work. Then, we determined definitions: Interactive work is the submission of very short jobs, which are immediately processed to allow continuous work; small jobs last up to four hours, mediums jobs last one to three days and large jobs last longer than three days. This categorization helps to consider user behavior in terms of job submissions in a differentiated way. All information gathered from the focus group are considered in our further work.

2.2 Item Design

To answer the research questions concerning the focus group results we developed a questionnaire - Questionnaire for User Habits of Compute Clusters (QUHCC). We derived seven scales from the questions: Level of Experience, Job Perception, User Behavior, User Strategies, User Satisfaction and Acceptance of Waiting Times (see Table 1).

The scale User Strategies is divided into five subscales to investigate different kinds of strategies: strategies which deal with working time, usage of strategies, general job adjustment, ego job adjustment and job cancelation. After defining these scales, several items in the context of compute clusters are developed. The Big-Five-Inventory-10 [7] as well as questions about the work environment

Table 1. Overview of the seven scales of QUHCC.

Scale name	Main subject	Amount of items
Level of Experience (LE)	- Total work experience with the compute cluster (objective measurement) - Confidence while working with compute clusters (subjective measurement)	2 (objective) 4 (subjective)*
	Example: I feel confident in working with Super-/HP-/Cloud-Computing.	
Job Length Perception (JLP)	- Categorization of different job types (interactive work, small, medium and large jobs) - Perception of the length of these job type	3
	Example: How long do you consider a small job to take on average?	
User Behavior (UB)	- Frequency of job submissions per job type on average	7
	Example: How often do you submit small jobs?	
Waiting for Jobs (WJ)	- Estimated waiting times for responses according to the different job types	3
	Example: To continue work, I have to wait for results of small jobs.	
User Strategies (US)	- Usage of strategies to accelerate the computing process	23*
	Example: I often submit bag-of-tasks (=lots of single jobs) to exploit the promised capacities.	
User Satisfaction (USF)	- Satisfaction with the working time of the compute cluster	4*
	Example: I am often frustrated if I have to wait longer than expected for a result.	
Acceptance of Waiting Times (AWT)	- Willingness to wait for results depending on the submitted job type	7
	Example: Imagine you submit a job you expect to run for 10 minutes. How long are you willing to wait for the result on top of the 10 minutes?	

* Items were rated on a 6 point scale from “strongly disagree” to “strongly agree”

(e.g., the name of the compute cluster), personal information (e.g., age) and the comprehensibleness of the items are added to the whole survey.

2.3 Participants

In total, 24 users of three different compute clusters at the TU Dortmund University took part in the study (*mean age* = 33 years; *SD* = 9.52). They work in the fields of mathematics, statistics, chemistry, physics or computer science. On average 34 % of the participants working times deals with HPC. Generally, results from the subjective LE scale show that participants feel quite confident while working with compute cluster (*mean* = 4.92; *SD* = 0.88).

3 Results

In the following we present some exemplary results for the first two main research questions, viz. users satisfaction and usage of strategies. Results from the USF scale show that users satisfaction with the waiting times of their submitted jobs is limited (*mean* = 3.82, *SD* = 0.95). Furthermore, the level of user experience (t = 2.59, p = .02) and working outside the usual working hours (r = -2.59, p = .02) were shown to be statistically significant predictors of user satisfaction (see Table 2).

Regarding the user strategies, most of the users (63 %) submit bags of tasks (=lots of single jobs) to exploit the promised capacities and/or switch to other cluster which are less utilized (42 %). Overall, only 5 out of the 24 participants do not use one of the four mentioned strategies at all (see Table 3).

Table 2. Regression model with User Satisfaction as the criterion variable.

	Unstandardized coefficients	Standardized coefficients	t	Sig
Constant	2.30			
Level of Experience	0.48	0.44	2.59	.017
Strategy Working Time	-0.41	-0.44	-2.59	.017

Adjusted R^2 = 32.9 per cent; $F(2, 21) = 6.64$; $p < .01$

Table 3. Item statistics of subscale "Usage of Strategies (US)".

	Yes	No
I submit bags of tasks (=lots of single jobs)	63 % (15)	37 % (9)
I prioritize jobs by urgency	13 %(3)	87 % (21)
I switch to other clusters, which are less utilized	42 % (10)	58 %(14)
I consult and agree with other users	33 % (8)	67 % (16)
None of the above applies	21 % (5)	79 % (19)

4 Discussion

Purpose of the current study was to elucidate user satisfaction and strategies during the interaction with HPC. For this a questionnaire (QUHCC) was designed. QUHCC seems to be suitable to identify the main factors influencing user satisfaction. Furthermore, QUHCC allows identifying user strategies. Exemplary results are presented for the main topics users satisfaction and strategies. Users satisfaction with HPC seems to be limited and is modulated by users experience and the amount of work outside of the usual working hours. The more experienced the users are and the less they are working outside usual work hours the more satisfied users are with the waiting time of their compute cluster (see also Schlagkamp and Renker [8]). Thus, there seems to be still potential to increase users satisfaction by improving schedulers of compute clusters. Regarding users' strategies, O'Donnell and Draper [9] already showed that users use multiple alternative methods to deal with response delays. In accordance with those authors, we also found that users employ a quantity of strategies to avoid long waiting times. They mostly submit bags of tasks or switch to other clusters, which are less utilized to gain faster responses.

In addition, the information derived from the QUHCC will allow to model relevant aspects of user behavior in scheduler simulations. This may help to get deeper insights in specific patterns of the trace data, so that crucial time intervals can be detected and schedulers improved. However, modeling could be still improved by changing data characteristics. For example the definition of job types is a crucial issue, because every user has another mental representation of short, medium and long jobs. The findings of our study suggests that job types should be not defined as a time interval, but rather as a distribution of points of time to gain more precise data for the modeling.

A limitation of the current study is the small number of participants, which makes it challenging to validate the current data set. Therefore, besides of the improvement of the questionnaire in future studies larger samples will be tested.

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