Teaching Complex Systems based on Microservices

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Abstract. Developing complex systems using microservices is a current challenge. In this paper we present our experience with teaching this subject for more than 80 students at the University of São Paulo, fostering team work and simulating the industry's environment.

Keywords: Complex Systems · Microservices · Computing Education.

1 Introduction

The interest of industry and academia for the microservices architectural style increases yearly. However, its adoption is non-trivial and has many challenges. The teaching-learning process on this subject should cover relevant technical and theoretical contents. It is important to think how universities can prepare students to develop complex systems using microservices. Ideally, it should be interesting, motivating, and offer an experience close to the industry.

This paper presents our approach for teaching the development of complex systems with microservices, as applied in the course "Laboratory of Complex Computational Systems" at the University of São Paulo (USP). Since 2018, it was offered four times as a two-week extension course with 65 students in total. In 2020, it is being offered as a semester-long course with 18 students.

2 About the Course

Our teaching method has three pillars: theoretical, technological and practical. The first includes lectures about complex systems, microservices and agile methodologies. The second is made of talks about Web development. The third is focused on the implementation of an application based on microservices.

In the course, lectures are given by researchers and industry professionals. Students are organized into teams (4-6 members) and have to develop different domains of the system. Our assessment is continuous and incremental. The final grade is calculated based on presence and active participation in class, overtime attendance during development sprints (four extra hours per week), and the fulfillment of simple tests and exercise lists. The course also includes regular warm-up activities to foster team building and to illustrate concepts learned.

For a more detailed summary of the structure of the course, please access: https://uspdigital.usp.br/jupiterweb/obterDisciplina?sgldis=MAC0475.

	Microservices									Web Front-End										Versioning				Methodologies																	
ID	Archtect.			Patterns			Modeling			HTML			CSS			JS			VueJS			Git			GitLab			XP			Scrum			Kanban			DevOps		
1	1	3	4	1	3	3	3	4	3	4	3	4	3	4	4	4	4	1	3	3	4	4	4	4	5	4	1	3	2	4	4	4	2	3	4	1	3	2
2	2	2	3	2	2	3	3	3	4	3	3	3	3	3	3	2	3	3	1	2	2	4	4	4	3	4	3	3	3	3	3	3	3	3	3	3	4	3
3	4	5	4	4	5	4	4	5	4	4	3	4	4	3	4	2	2	3	1	2	2	4	5	4	4	4	4	4	3	4	3	4	4	3	4	4	4	4
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18	2	3	3	1	2	2	3	3	3	4	4	4	4	4	4	3	4	4	3	4	3	3	4	3	3	3	3	3	3	3	4	4	4	4	4	4	1	1	2

Fig. 1. Heatmap with students' self-assessed level of knowledge in 13 of 19 skills the course aims to improve. Each answer follows a Likert scale ranged 1-5, where 1 means "very low" and 5 means "very high". Each topic has answers about three moments: before the course, after the first lecture block, and after the first development sprint (both focused on theory and front-end Web technologies).

3 Lessons Learned

To evaluate the learning process, we surveyed our current 18 students to collect their self-assessed level of knowledge in 19 skills the course focuses on. Since this offering is ongoing, our results describe only the first three of five moments we intend to evaluate: before the course, after the first lecture block, after the first sprint (both focused on theory and Web front-end), after the second lecture block, and after the second sprint (both focused on Web back-end).

Figure 1 shows a heatmap that summarizes their answers for the 13 skills we could evaluate so far. The results are positive: students felt their skills were improving, in particular the ones related to microservices (which few students knew much about before the course). In our understanding, the gain of knowledge between the second and third surveys shows the importance of including a practical project besides the theoretical and technology lectures.

Furthermore, we made a non-structured interview with the students to ask eight questions covering their backgrounds, difficulties on each of pillar of our teaching method (theoretical, technological, practical), and general impressions.

Overall, the course is meeting the students' initial expectations. The biggest challenges reported include: team work, which is not commonly applied in other courses; and remote communication, since the course is being taught online due to the COVID-19 pandemic. The main knowledge gains include: team work, because they feel they are learning how to develop together and are enjoying the collaborative discussions that come from it; and an environment similar to the industry's, since they reported our course was the closest to the challenges they expect to deal with in a full-time job, in particular the use of microservices.