Analysis Software Developer Productivity Based On Work Schedule Scheme With Git Commit Metric And Deployment With CI/CD

Darren Kent Jeremy[1], Sfenrianto[2]

[1,2] Information Systems Management Department, Binus Graduate Program – Master of Information System Management, Bina Nusantara University, Jakarta, Indonesia

Email : darren.jeremy@binus.ac.id[1], sfenrianto@binus.ac.id[2]

Abstrak

Pada bulan Desember 2019, terjadi pandemi COVID-19 sehingga membuat PT. XYZ mewajibkan karyawannya untuk bekerja dari rumah dan bekerja dari kantor secara bergantian berdasarkan skema jadwal kerja yang ditentukan oleh PT. XYZ secara acak berdasarkan tim yang ada. Produktivitas bagi Pengembang Perangkat Lunak saat ini masih belum memiliki nilai yang pasti tentang bagaimana menilai produktivitas seorang Pengembang Perangkat Lunak. Hal inilah yang membuat penelitian ini dilakukan untuk mengkaji lebih lanjut produktivitas pengembang perangkat lunak di PT. XYZ berada di antara skema jadwal kerja tersebut. Dalam penelitian ini kami melakukan investigasi terhadap produktivitas pengembang perangkat lunak berdasarkan skema jadwal kerja yang telah ditentukan dari perusahaan, PT.XYZ menerapkan 3 skema untuk jadwal karyawan, yang kemudian disesuaikan dengan kondisi pandemi COVID yang terjadi agar sesuai dengan peraturan pemerintah , skemanya adalah, 2 hari WFO 3 hari WFH, 3 hari WFO 2 hari WFH, 4 hari WFO 1 hari WFH untuk menghindari banyaknya karyawan yang bekerja dari kantor pusat PT. XYZ, kemudian kumpulan data yang dikumpulkan dari aktivitas kontribusi pada repositori PT.XYZ GitHub berdasarkan git commit dan bergabung ke cabang master, kemudian akan di-deploy menggunakan CI/CD. sesuai dengan skema jadwal kerja. Dalam penelitian ini ditemukan bahwa skema jadwal kerja 3 WFH dan 2 WFO memiliki tingkat produktivitas yang lebih tinggi dibandingkan dengan skema lainnya. Dari jenis proyek, Back-end memiliki kontribusi lebih dibandingkan dengan Front-end serta bahasa pemrograman.

Kata Kunci: *Pengembang Perangkat Lunak Produktivitas, Pandemi COVID-19, GitHub, WFO, WFH, CI/CD*

Abstract

In December 2019, the COVID-19 pandemic occurred thus making PT. XYZ requires its employees to work from home and work from office alternately based on the work schedule scheme determined by PT. XYZ randomly based on existing teams. Productivity for Software Developers currently still does not have a definite value on how to assess the productivity of a Software Developers. This is what makes this research conducted to further review the productivity of software developers at PT. XYZ is between those work schedule scheme. In this study, we investigate the productivity of software developers based on a predetermined work schedule scheme from the company, PT.XYZ implements 3 schemes for employee schedules, which are then adjusted to the conditions of the COVID pandemic that occur to comply with government regulations, the schemes are, 2 days WFO 3 days WFH, 3 days WFO 2 days WFH, 4 days WFO 1 day WFH to avoid the number of employees being working from the head office of PT. XYZ, then the data set collected from contribution activity on PT.XYZ repository GitHub based on git commit and merge to master branch, then will be deploy using CI/CD. according to the work schedule scheme. In this study found that the work schedule scheme 3 WFH and 2 WFO have a higher level of productivity compared to other schemes. From the type of project, Back-end has more contribution compared to Front-end as well as the programming language.

Keywords: *Productivity Software Developer, COVID-19 Pandemic, GitHub, WFO, WFH, CI/C*

INTRODUCTION

The COVID-19 pandemic in Indonesia resulted in lifestyle changes known as the new normal. New normal required everyone to limit their activities outside of the house while also changing their behavior patterns. To maintain their ability to carry out regular tasks by modifying their behavior patterns with the help of technological advancements. Many companies are embracing digital changes because of the COVID-19 Pandemic, including pharmaceutical companies, which must remain operational throughout the COVID-19 Pandemic in order to continue serving the public and fulfilling medical demands.

Basically, work from home is nothing new. There are several advantages and disadvantages in implementing work from home. For example, not wasting time which is usually used to travel from home to work especially if you have to face traffic jams on the way. Working from home has some disadvantages, such as being disturbed by the surroundings around the house, such as interference from family members, and even having to care for pets.

However, many companies are not ready to face these terms of working from home. This can have an impact on employee's productivity when implement working from home. For example, manufacturing employees still have to carry out the manufacturing process, and also meet the supply demand.In the other hand, software developers do not need to be in their office environment to do their job, such as writing code, debugging a code and others.

IT department at PT. XYZ also runs work from home and work from office. This work schedule schemes carried out alternately for each team according to the schedule determined by PT. XYZ to avoid the number of employees being too many for one workspace. Each team will still get 5 working days for 1 week, to continue to follow government regulations to break the chain of the spread of COVID-19.

During the COVID -19 pandemic, 72.7% of the top managerial IT divisions at PT.XYZ felt that there were problems in working on projects related to the productivity of software developer at PT.XYZ. Thus, the top managerial IT division of PT. XYZ feels that the productivity of PT. XYZ's software developers need to be reviewed on each work schedule scheme.

In measuring software developer productivity, there are several methods used to measure software developer productivity. Lines of code is one of the methods commonly used to measure software developer productivity. However, this approach method is claimed to be an inaccurate method in measuring software developer productivity.

What is created is connected to software developer productivity (output). This output might be considered to carry out the deployment of a newly created system. Software developer can utilize the Jenkins pipeline CI/CD capability to automate this deployment when performing it.

At PT.XYZ software developers utilize automation deployment, so when code is committed to the master branch it will be directly deployed on staging, which will then be promoted to production so that it can be used by users.
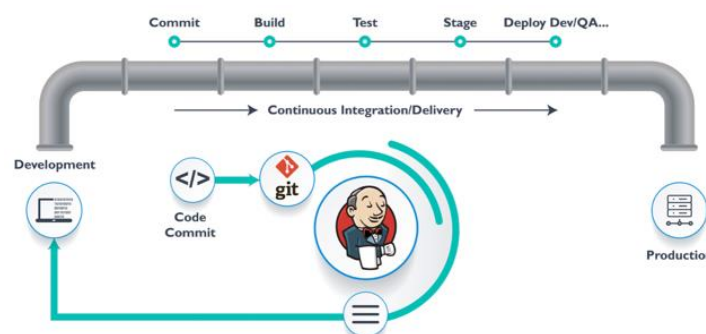

Figure 1. Jenkins Pipeline (CI/CD)

The productivity of software developers can be shown by how the system they create can be used by their potential users. How quickly the features they develop can be used by the users. By looking at the speed in producing a feature that can be used by users, software productivity can be measured. The method in this measurement can be seen from the results of the commits made by software developers in their project repository.

According conduct a survey approach to software developers to see what makes software developers feel productive. In this study found that software developers feel themselves productive if they can complete many tasks or can complete large tasks (output).

The COVID-19 pandemic has raised concerns about software engineers' productivity. According to this study aims to determine is there a correlation between the high productivity of software developers using hybrid work systems (WFH and WFO) and the COVID-19 pandemic. Several metrics, including build/commits/code review, programming language, and the type/age/size of a project. This research discovered that WFH affects software developers' productivity both favorably and unfavorably.

In this study conducts calculations by considering several variables that can affect the productivity of software developers, including work from home and work from office analysis, programming language analysis, project type/age/size analysis, and individual software developer productivity when working from home and also from office.

COVID-19 Pandemic

In December 2019, there was an outbreak of unknown origin that was reported from Wuhan, Hubei Province, China. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or known as the Corona virus is a new type of corona virus that can be transmitted from human to human quickly. It causes to become a global pandemic when the corona virus spreads throughout the world in May 2020 and has infected 4,806,299 populations worldwide.

On March 15, 2020, the President of Indonesia, Joko Widodo, made an appeal to the Indonesian people to minimize the spread of the corona virus by carrying out activities such as working, studying, worshiping from home. Considering the spread of the corona virus is very fast so socializing activities must be reduced with social distancing, but if only we all participate.

Current corona viruses have a predisposition to neuron invasion, olfactory neurons are currently the portal of entry for neuronal invasion and spread of coronaviruses after infection of nerve cells. A quarter of COVID patients who are treated report a disturbance in their sense of smell or commonly known as anosmia.

Work From Home

Work From Home is a term that we often hear lately, especially during the COVID 19 pandemic. The COVID 19 pandemic caused by the Coronavirus began in Wuhan, China at the end of 2019. It is causing companies in Indonesia to implement policies for their employees. Work from home or remote work is carried out during this pandemic to reduce the risk of spreading the COVID 19 virus to employees in every company. Work from home has finally become a new normal for organizations and employees. This is done with the aim of implementing social distancing between each other in order to stop the spread of the COVID-19 virus.

Work From Home itself has its own challenges for employees in doing each of their work. They need to focus on work, especially for those who are not used to this kind of remote work. This is because employees must do work where there may be distractions such as interference from their children or pets. With the implementation of work from home, companies need to provide facilities and infrastructure for employees to work from home. Companies can take advantage of digital communication when working from home. Technological advances can also make it easier for

employees to communicate with each other when implementing work from home, by doing their job using laptop and internet.

In May 2020 35.2% of the United States workforce worked entirely from their respective homes, these workers prefer to work from home and maintain their current job after the COVID -19 pandemic. Before implementing work from home, employees carried out their work activities directly at the office where they usually do work or what we now often hear with the term work from office.

Work From Office

Work from office is an activity that is usually carried out by workers before the COVID-19 pandemic. The employees must go to where the company they work and complete all their tasks there. The COVID-19 pandemic has forced the workforce to minimize their activities in their workplaces. Work from office activities during the COVID-19 pandemic period were very few compared to before.

Work from office itself has a positive impact on employee performance. The presence of components that represent the environment and behavior when doing office work. Interaction is one of the important components in influencing the productivity of workers who carry out work activities in the office. Even though work from office has negative impact, such as interruption and distractions from colleagues.

Software Developers Productivity

Productivity has several factors that influence software development, ranging from technical factors to environmental factors when developing software. In general, productivity is the relationship between what is produced (output) and the resources used to produce it (input), productivity is an important factor in the success of software projects.

Software created by software developers can support the business of an organization. Software developers will of course face constant innovations that are designed. At some point, software developers are faced with stress or tension so that their productivity is often questioned.

Work environment is one of the important factors in influencing the productivity of a software developers . The work environment is the surrounding environment where a developer can do his work to achieve the target. So that the place of work is one of the important things where in this study it is work from home and work from office in seeing the productivity of a developer in doing his work so that it can be said to be productive.

Mayer et al found that a developer feels productive when he can complete a large task without significant distraction. The task or work of a developer can be described by the number of commits from GitHub generated by each developer. The higher the commits made by a developer, the higher the productivity.

One metric that is often used to see a developer's productivity is lines of code. Lines of code do not give satisfactory results to show whether a developer has a satisfactory level of productivity. In lines of code-based metrics, a skilled developer can code with fewer lines of code to produce the same program than a less skilled developer. The productivity of a developer can be seen from a software developers if he can complete a task, the time spent writing code, and improving previous work.

To measure software developers productivity, there are several things that need to be analyzed, namely: (1). Analysis of productivity differences between work from home and working onsite (2). Analysis of programming language differences in influencing productivity during the COVID-19 pandemic (3). Analysis of several types of projects in influencing productivity during the COVID-19 pandemic (4). Analysis of differences in the productivity of each individual during the COVID-19 pandemic.

GitHub

GitHub is also a platform that is widely used in software development for software developers. GitHub uses git as version control software, where version control is a way to save changes over time without overwriting the previous version. The ability to use a version control system is one of the skills needed in an industry that requires workers to create code. Git is a tool that is widely used for version control in sharing code with fellow software developers. GitHub can be used to support the activities of software developers and also keep the code up to date.

On the Git there are several terms that are often used in its use. Here are some of those terms:

1. **Repository:** Repository is a project folder that will accommodate files related to the project being built, files that can be accommodated such as code files, images, and audio.
2. **Init:** Git-Init is used to initialize the repository. Git will create a hidden directory, where this directory stores all objects and references used and created by Git.
3. **Add:** Git-Add is an important command used in running git, where git-add is not done then it cannot do git commits.
4. **Commit:** Git-commit is creating a comic or a snapshot to a project's repository. By committing means making a record or history to the repository at a specific time.
5. **Pull:** Git pull is a way to update the currently active local branch. To pull changes made to a branch in the repository.
6. **Push:** Git push is a way to upload commits from a local branch to the destination branch.

Lines of Codes Metric

Lines of code is one of the methods used in analyzing the productivity of software developers. The greater the number of rows produced by the software developer, the greater the productivity generated by the software developer.

There is considerable disagreement on whether the lines of code metric is sufficient to assess software developer productivity. The number of lines of code produced by the software developer themselves will undoubtedly depend on how complicated the software is to develop. Of course, the lines of code are also affected by how efficiently code is written.

Commit Metric

One of the metrics that may be used to evaluate a software developer's performance is the number of commits. We determined the productivity of the software developer at PT.XYZ based on commit. This commit was based on the commit and merge to the git master branch. Which means that after being built, this commit will be deployed to the staging stage by utilize CI/CD.

CI/CD

Continuous integration / continuous deployment is an automation in deploying a system to the staging / production stage. The purposes of CI/CD are to make it easier for software developers to test their new features and therefore ensure the new features can be used by users. CI/CD can be done by adding a script to the code created by the software developer and making the settings needed to be able to automate deployment [31].

At PT.XYZ the branch used is the master branch for this automated deployment. Therefore, this study takes the number of commits from the master branch of each project repository at PT.XYZ.

Related Research

In this study, we want to try to identify, obtain information about the advantages and disadvantages of working from home during the COVID-19 pandemic. This study used qualitative research methods. Data were taken from six respondents who are elementary school teachers in Tangerang. The questions were compiled and developed based on the results of the literature study. The results of this study are that there are several advantages and disadvantages of working from

home, the advantages of working from home are activities that are more flexible in completing work, do not need to follow office hours, do not incur costs for transportation, can minimize the level of stress that can be experienced from congestion, and have more free time. The disadvantages of working from home are, loss of motivation to work, bear the cost of internet and electricity which is more expensive, data security

In this study, we want to investigate the difference in developer productivity between working at home and at work (office). This study uses a quantitative method based on daily activity data from developer Baidu Inc, one of the largest IT companies in China. In total there are about four thousand records from 139 developer activities on 138 working days of the total 1103 records recorded during work from home due to the COVID-19 pandemic. This study found that there are positive and negative impacts on developer productivity in terms of different metrics, for example, builds/commit/code reviews. The study also noticed that working from home has different impacts on projects with different characteristics including programming language, project type/age/size. For example, working from home has a negative impact on developer productivity for large projects

This study aims to see the perception of software developers regarding the productivity of software development. The method used in this study consisted of two surveys to 379 software developers to obtain themes and studies, and the second was to conduct an observational study of 11 professional software developers to investigate the themes obtained in more depth. The results of this study show that software developers feel that their day is a productive day when they can complete many large tasks without significant disturbances, but during the observations made, it shows that respondents carry out significant tasks and activities and still feel productive.

This study aims to see how the influence of work from home on the ability of software developers in presenting software. This research was conducted by monitoring the situation of software companies with software developers in Sweden, the United States and England. This study analyzes several aspects such as productivity, satisfaction, software developers welfare, activities, communication, collaboration, and calendar invitations. In addition, this study also conducted 18 interviews. The study found that software developers continued to code and carry out their daily tasks without significant distractions while their routines were gradually adjusted to the "new normal". This study says that the experience gained during working from home on a large scale will make significant changes in the future in the software industry, such as software developers can do their work anywhere (WFX).

This study investigates the impact of the COVID-19 pandemic on the productivity and well-being of software developers. The methodology used in this research is a survey questionnaire which is translated into 12 languages and gets responses that can be used as many as 2225 from 53 countries, then the data is analyzed using non-parametric inferential statistics and structural equation modeling. The results of this study are (1) the pandemic has a negative effect on the welfare and productivity of software developers, (2) productivity and welfare have a fairly close relationship, (3) disaster preparedness, fear of pandemics, and ergonomics of the home as an office also affect productivity and well-being of software developers
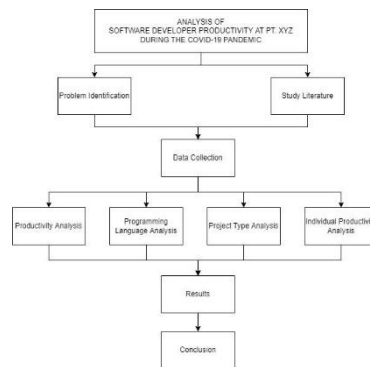
METHOD

Figure 2. Research Model

This research framework is a reference in this research as can be seen from Figure 2. Start from problem identification to conclusion. From the problems raised, a more in-depth problem identification was carried out and a literature study was also carried out to support the research. Then, we gathered the data from GitHub repository owned by PT. XYZ.

Based on the framework in Figure 2, the analysis will be carried out based on four research question that can affect the productivity of software developers while implementing work schedule schemes.

Productivity analysis

In this research question, we want to analyze the differences between work from home and work from office in each work schedule scheme on software developers productivity during the COVID-19 pandemic. To compare software developers productivity in each work schedule scheme, the datasets are first grouped per day on each existing project to see the number of contributions each day. The data compared is the data on the number of contributions each day on each work schedule scheme by comparing work from home and work from office on the GitHub repository. To compare daily activity data records in the GitHub repository by comparing the contribution using mean, median, max, and min when working from home and working from office each work schedule schemes.

Programming Language Analysis

We want to analyze whether programming language have an impact in influencing software developers productivity when working from home and working from office on each work schedule scheme. The programming languages will be divided into two groups of programming languages: ReactJS, and Golang. The data will be gathered from an existing GitHub repository and analyzed based on the amount of contributions made by the software developers in each programming language.

Project Type Analysis

Based on project type, we want to analyze the project type in influencing the productivity of software developers when working from home and working from office on each work schedule scheme. The type of project taken is divided into two which is Back-end and Front-end. To evaluate the contribution of the two types of projects, we calculate the p-value to see how significant the difference between work from home and work from office is.

Individual Productivity Analysis

It is important to analyze the differences in productivity of each individual software developers when working from home and working from office. To see the productivity of each software developers we analyze from the number of contributions made by each individual software developers to the taken GitHub repository. The data will gather based on the existing work schedule scheme. Then the p-value is calculated between work from home and work from office for each work schedule schemes to see the significant difference in the productivity of each software developers.

By analyzing the factors above, companies can make decision in implementing work from home and work from office to improve the performance of software developers.

Research Data

Table I. Work Schedule Scheme

Skema	WFO (days)	WFH (days)	Start Date	End Date
SK1	2	3	13-Apr-20	19-Jul-20
SK2	3	2	08-Feb-21	16-May-21
SK3	4	1	17-May-21	22-Aug-21

In this study, data collection methods will be used by recording GitHub activity records on each project repository. Then the GitHub activity will be adjusted to the work schedule scheme of each software developers between work from home and work from office on a predetermined scheme. During the COVID-19 pandemic in 2020 to 2021 PT. XYZ has several workday schemes out of a total of 5 working days in 1 week, which are divided into 3, as can be seen from Table 1.

Then the data taken is data from 6 GitHub repositories owned by PT. XYZ, which include 3 Front-End projects with ReactJS programming language, and 3 Back-End projects with Golang programming language from GitHub Repository that owned by PT. XYZ. This Repository were selected based on the projects currently running on PT. XYZ. We can see at Table II.

Table II. Project Information

Project	Project Type	Programming Language
P1	Front-End	ReactJS
P2	Front-End	ReactJS
P3	Front-End	ReactJS
P4	Back-End	Golang
P5	Back-End	Golang
P6	Back-End	Golang

RESULTS

From the results of data collection and processing. In this chapter, the research questions of this study will be discussed.

Productivity Analysis

Table III. Overall Productivity

	WFH	WFO	Mean	Median	Max	Min
SK1	19	21	3.34	0	19	0
SK2	160	491	54.25	25	294	5
SK3	169	475	53.67	19.5	197	2

The results in the Table III show that productivity SK2 has higher average, median, max, and min of the software developers PT.XYZ when compared to SK1 and SK3. Whereas SK2 has an average contribution of 54.25, SK3 has an average of 53.67, and SK1 has an average of 3.34. This demonstrates that the productivity of PT.XYZ software developers is higher while using SK2.

From Table III that contains overall productivity from the software developers PT. XYZ. The following section will discuss about the impact of programming languages on the productivity of software developers at PT. XYZ.

Programming Language Analysis

The impact of programming languages on the productivity of software developers at PT. XYZ.
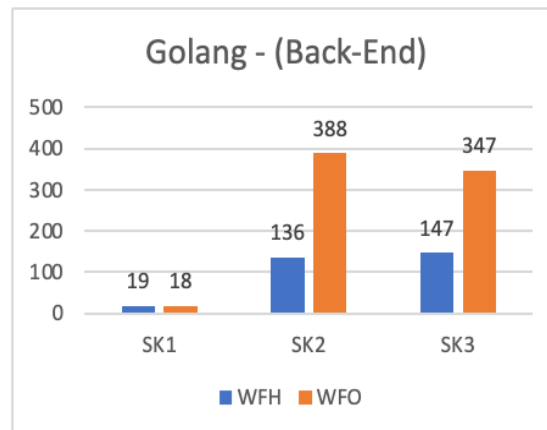

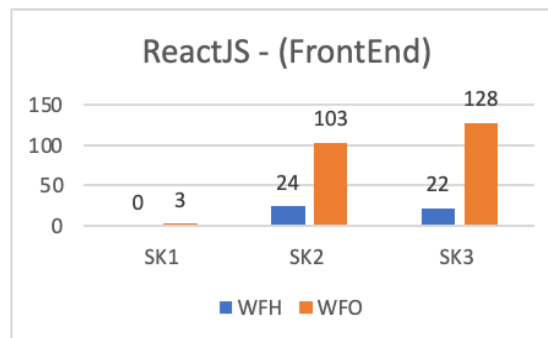*Figure 3. Contribution on Golang (Back-End)*

Figure 4. Contribution on ReactJS (Front-End)

Figure 3 shows that when software developers implement work from the office, the Golang programming language has the highest number of contributions in SK2. However, when working from home SK3 has the highest contribution. Nevertheless, the ReactJS programming language in the Table VI has a higher number of contributions during WFO in SK3 and WFH in SK2.

Project Type Analysis

The impact of type of project on the productivity of a software developers, it is the same with the programming language used by the project type has a considerable impact. Overall, the Back-End project type has the highest contribution value in SK2. While the Front-End project type has the highest contribution value in SK3. From the data in Table V, there are 524 contributions for back-end projects on SK2, and 494 for SK3. As a result, SK2 is 5.72% better than SK3 in terms of productivity. The p-value between Back-End and Front-End is 0.016 it shows that the contributions to Back-End and Front-End has a significant difference.

Individual Productivity Analysis

In this section we will see the productivity of each individual when running work schedule schemes.

Table IV. P-value for individual productivity

	SK1	SK2	SK3
D1	**0.01***	0.195**	**0.028***
D2	NA	0.187**	0.172**
D3	NA	**0.013***	**0.039***
D4	NA	0.25**	0.052**
D5	NA	**0.047***	0.446**
D6	NA	**0.045***	0.084**
D7	NA	**0.045***	0.25**
D8	NA	0.25**	**0.028***
D9	NA	**0.028***	**0.018***
D10	NA	**0.045***	0.084**
D11	NA	**0.008***	**0.041***
D12	NA	0.333**	NA
D13	NA	**0.026***	**0.002***
D14	NA	**0.027***	0.231**
D15	NA	**0.032***	0.157**
D16	NA	**0.032***	**0.002***
D17	NA	0.25**	0.056**
D18	**0.037***	**0.016***	**0.018***

*significant, **not significant

Table VII shows the p-value of the contribution of productivity software developers between work from home and work from office in each work schedule scheme. From a total of 18 software developers, there are 2 software developers in SK1 who have significant differences between work from home and work from office. In SK2 productivity 12 software developers (66%) have a significant difference between work from home and work from office. On the other hand, in SK3 there are 8 software developers (44%) differences between work from home and work from office.

DISCUSSION

In the discussion section, will be present the feedback from PT.XYZ about the overall productivity, programming languages, project types and individual productivity of their software developers. After doing quantitative research, we conducted a survey to software developers and also high-ranking officials at PT. XYZ to ask about factors that might influence the findings from previous quantitative studies, higher productivity in SK2, Golang programming language as Back-End programming language has a higher productivity compared to ReactJS as a Front-End programming language, and also the individual productivity of each software developers where there is a more significant comparison between work from home and work from office in SK2.

Overall software developers productivity on the SK1 did not go well because the early stages of software developers were working from home, as well as the early stages of project development. However, the amount of work from home that is too much makes communication more difficult, even though with WFH software developers can use more time to focus on doing their work (not wasting time on trips to the office and vice versa). Software developers feels that SK2 is less distractions from the work environment.

The Golang programming language for Back-End project types has higher productivity than ReactJS for Front-End project types due to the Back-End project type contains the business logic, which

frequently evolves to meet PT. XYZ business objectives. According to the software developers at PT. XYZ, SK2 provides a work-life balance so that software developers are more willing to complete their work faster. With SK2 software developers can make better use of their time at home and at the office. In the office they can have discussions and develop at home to be more focused (not disturbed by office environment activities). WFH has a different impact for each individual, some have a positive impact, and some have a negative impact. This negative impact can come from home disturbances such as pets, as well as other home activities.

CONCLUSION

From the results obtained, it can be concluded that the software developers PT.XYZ has a higher overall productivity value in running the work from office scheme for 3 days and working from home for 2 days compared to other schemes. In addition, the project type and programming language also have a significant influence where the Back-End project type with the Golang programming language has a greater contribution value when compared to the Front-End project type with the ReactJS programming language. The productivity of individual software developers also has a significant difference in SK2 (3 days work from office, 2 days work from home) This shows that the number of works from home has a different impact on each software developers at PT.XYZ.

Since SK1 happened during the start of the COVID-19 pandemic in Indonesia, there is a limited quantity of data that can be retrieved, future study should have a number of data work schedule schemes with more data and a larger number of projects, so that it can compare the work schedule scheme with more adequate data for each work schedule scheme.

REFERENCES
Pragholapati, "New Normal ' Indonesia ' After Covid-19 Pandemic," Nurs. Dep. Fac. Sport Educ. Heal. Sci. Univ. Pendidik. Indones., vol. 2019, pp. 1–6, 2020.

R. Sparrow, T. Dartanto, and R. Hartwig, "Indonesia Under the New Normal: Challenges and the Way Ahead," Bull. Indones. Econ. Stud., vol. 56, no. 3, pp. 269–299, 2020, doi: 10.1080/00074918.2020.1854079.

B. S. Utami and P. I. Aliyansah, "COVID-19: Challenges and opportunities in Indonesia health sector," E3S Web Conf., vol. 202, pp. 1–7, 2020, doi: 10.1051/e3sconf/202020201008.

P. Ralph et al., "Pandemic programming," Empir. Softw. Eng., vol. 25, no. 6, pp. 4927–4961, 2020, doi: 10.1007/s10664-020-09875-y.

A. V. Putri and I. Irwansyah, "Communication Patterns and Media Technology Role in Organization and Society During Pandemic," J. Soc. Media, vol. 4, no. 2, p. 228, 2020, doi: 10.26740/jsm.v4n2.p228-261.

A. Purwanto et al., "Impact of Work From Home (WFH) on Indonesian Teachers Performance During the Covid-19 Pandemic : An Exploratory Study," Int. J. Adv. Sci. Technol., vol. 29, no. 5, pp. 6235–6244, 2020.

I. Lane, M. Mullen, and D. Logan, "Working from Home During the COVID-19 Pandemic: Tips and Strategies to Maintain Productivity & Connectedness," Psychiatry Inf. Br., vol. 17, no. 5, Apr. 2020, doi: 10.7191/PIB.1145.

O. Okorie, R. Subramoniam, F. Charnley, J. Patsavellas, D. Widdifield, and K. Salonitis, "Manufacturing in the Time of COVID-19: An Assessment of Barriers and Enablers," IEEE Eng. Manag. Rev., vol. 48, no. 3, pp. 167–175, Jul. 2020, doi: 10.1109/EMR.2020.3012112.

D. Russo, P. H. P. Hanel, S. Altnickel, and N. Van Berkel, "The daily life of software engineers during the covid-19 pandemic," Proc. - Int. Conf. Softw. Eng., pp. 364–373, May 2021, doi: 10.1109/ICSE-SEIP52600.2021.00048.

E. Oliveira, E. Fernandes, I. Steinmacher, M. Cristo, T. Conte, and A. Garcia, "Code and commit metrics of developer productivity: a study on team leaders perceptions," Empir. Softw. Eng., vol. 25, no. 4, pp. 2519–2549, 2020, doi: 10.1007/s10664-020-09820-z.

B. M. Y. Parareda, "Measuring Productivity Using the Infamous Lines of Code Metric," 2007.

S. Mysari and V. Bejgam, "Continuous Integration and Continuous Deployment Pipeline Automation Using Jenkins Ansible," Int. Conf. Emerg. Trends Inf. Technol. Eng. ic-ETITE 2020, pp. 1–4, 2020, doi: 10.1109/ic-ETITE47903.2020.239.

A. N. Meyer, T. Fritz, G. C. Murphy, and T. Zimmermann, "Software developers' perceptions of productivity," Proc. ACM SIGSOFT Symp. Found. Softw. Eng., vol. 16-21-Nove, pp. 19–29, 2014, doi: 10.1145/2635868.2635892.

L. Bao, T. Li, X. Xia, K. Zhu, H. Li, and X. Yang, "How does Working from Home Affect Developer Productivity? -- A Case Study of Baidu During COVID-19 Pandemic," pp. 1–17, 2020.

M. Ciotti, M. Ciccozzi, A. Terrinoni, W. C. Jiang, C. Bin Wang, and S. Bernardini, "The COVID-19 pandemic," Crit. Rev. Clin. Lab. Sci., vol. 57, no. 6, pp. 365–388, 2020, doi: 10.1080/10408363.2020.1783198.

M. J. Pedersen and N. Favero, "Social Distancing during the COVID-19 Pandemic: Who Are the Present and Future Noncompliers?," Public Adm. Rev., vol. 80, no. 5, pp. 805–814, 2020, doi: 10.1111/puar.13240.

D. Hornuss, B. Lange, N. Schröter, S. Rieg, W. V. Kern, and D. Wagner, "Anosmia in COVID-19 patients," Clin. Microbiol. Infect., vol. 26, no. 10, p. 1426, Oct. 2020, doi: 10.1016/J.CMI.2020.05.017.

M. Dockery and S. Bawa, "Working from home in the COVID-19 lockdown," Bankwest Curtin Econ. Cent. Res. Br. COVID-19, no. May, pp. 1–5, 2020.

D. Šmite, N. B. Moe, E. Klotins, and J. Gonzalez-Huerta, "From Forced Working-From-Home to Working-From-Anywhere: Two Revolutions in Telework," 2021.

S. A. A. W. Sooriyapperuma and C. L. K. Nawarathna, "Determinants of Employees ' Job Satisfaction when Working from Home ; with particular reference to the telecommunication and software companies in Colombo district Sri Lanka," vol. 3, no. 2, pp. 47–61, 2021.

A. Bick, A. Blandin, and K. Mertens, "Work from Home After the COVID-19 Outbreak," Fed. Reserv. Bank Dallas, Work. Pap., vol. 2020, no. 2017, 2020, doi: 10.24149/wp2017r1.

B. P. Haynes, "An evaluation of the impact of the office environment on productivity," Facilities, vol. 26, no. 5–6, pp. 178–195, Apr. 2008, doi: 10.1108/02632770810864970.

D. Ford et al., "A Tale of Two Cities: Software Developers Working from Home during the COVID-19 Pandemic," ACM Trans. Softw. Eng. Methodol., vol. 31, no. 2, pp. 1–37, 2022, doi: 10.1145/3487567.

S. Wagner and E. Murphy-Hill, "Factors That Influence Productivity: A Checklist," Rethink. Product. Softw. Eng., pp. 69–84, 2019, doi: 10.1007/978-1-4842-4221-6_8.

M. A. CHILTON, B. C. HARDGRAVE, and D. J. ARMSTRONG, "Person-Job Cognitive Style Fit for Software Developers: The Effect on Strain and Performance," https://doi.org/10.1080/07421222.2005.11045849, vol. 22, no. 2, pp. 193–226, 2014, doi: 10.1080/07421222.2005.11045849.

E. Paiva, D. Barbosa, R. Lima, and A. Albuquerque, "Factors that influence the productivity of software developers in a developer view," Innov. Comput. Sci. Softw. Eng., pp. 99–104, 2010, doi: 10.1007/978-90-481-9112-3_17.

MockusAudris, F. T., and H. D., "Two case studies of open source software development," ACM Trans. Softw. Eng. Methodol., vol. 11, no. 3, pp. 309–346, Jul. 2002, doi: 10.1145/567793.567795.

M. Parareda, B., & Pizka, "Measuring productivity using the infamous lines of code metric," Proc. Sp. 2007 Work. Nagoya, Japan., 2007.

M. D. Beckman, M. Çetinkaya-Rundel, N. J. Horton, C. W. Rundel, A. J. Sullivan, and M. Tackett, "Implementing Version Control With Git and GitHub as a Learning Objective in Statistics and Data Science Courses," J. Stat. Data Sci. Educ., vol. 29, no. S1, pp. S132–S144, 2021, doi: 10.1080/10691898.2020.1848485.

R. Kallis, A. Di Sorbo, G. Canfora, and S. Panichella, "Predicting issue types on GitHub," Sci. Comput. Program., vol. 205, p. 102598, 2021, doi: 10.1016/j.scico.2020.102598.

A. Poth, M. Werner, and X. Lei, How to Deliver Faster with CI/CD Integrated Testing Services?, vol. 896. Springer International Publishing, 2018.