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Comparison of Welch-Powell and Recursive Largest First Algorithm Implementation in Course Scheduling

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ABSTRACT

One of the important things to make for the continuity of a good activity is to create schedules, with the creation of a schedule, the activities carried out can be more organized or organized. However, if in putting together a scheduling need to be considered to avoid collisions between activities, this can be prevented by using algorithms in the creation of schedules such as welch-Powell algorithms and recursive largest first. Between the two algorithms, the author wants to compare which algorithms are appropriate to be used in the preparation of a schedule such as for lectures in the Informatics Study Program of Darma Cendika Catholic University for semester 2 and semester 4 where two courses have the same time in one day. From the research conducted obtained the results of welch-Powell algorithm faster in terms of time and more concise in terms of complexity compared to the algorithm recursive largest first and from the coloring of graphs conducted obtained chromatic numbers worth 2, which means in one day used 2 lecture halls based on the similarity of time between courses in semester 2 and semester 4, to prevent the impact of classroom time at the same time.

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1. Introduction

Scheduling is an activity that is carried out to allocate existing resources with the aim of carrying out tasks within a certain period of time(Sunarni et al., 2017). Scheduling can also mean one of the activities that organize an activity so that the activities carried out become more organized or organized so that the expected goals can be achieved properly as well. If there is no scheduling then automatically an activity that is carried out will be less than optimal. One example of scheduling is the scheduling of courses at a university.

There are some problems in making a schedule that often also make obstacles to making a schedule, such as a clash between the time of one activity with the time of another activity, so it takes a way to be able to make a good schedule without any clash between one activity with another.

One way that can be used is to use graph coloring which is one of the methods in graph theory, where there are three types of graph coloring, namely the coloring of knots / points, sides, and regions, but what is widely used in making a good schedule is using point coloring. According to the Goddess coloring points / knots that give a different color at each neighboring point, so that there are no two neighboring points with the same color (Novian Riskiana Dewi, 2020).

There are several algorithms that can be used to solve graph node coloring problems, for example with *welch-powell* algorithm, *backtracking* algorithm, and (Sianipar, 2014). From the application of the algorithm on the graph color obtained some results from research that has been done, including research conducted by Bustan and Salim which concludes that point coloring using *the welch-powell* algorithm can be used in determining student guidance schedules so as not to clash with other students and do not need to wait in line for long to be able to guide with lecturers (Bustan & Salim, 2019) . The same statement was also given

by (Mahmudah & Irawati, 2018) in his research on the coloring of the node/point on the graph stating that the coloring of the graph node could be applied to assist the semester exam schedule.

Research related to scheduling problems was also conducted by Saeful and Taufik, namely the application of *coloring graph* on poor scheduling problems in one of the posyandu in Sukabumi Regency, by using *vertex coloring graph* algorithm and SMS *gateway,* obtained the results of errors in scheduling such as immunisation schedules can be prevented, and can make a good and fast (Bahri, Saeful; Hidayatulloh, 2018). Then other research related to scheduling that uses *welch-powell* algorithm to help in solving problems, such as solving problems in scheduling thesis exams at STMIK Amik Riau, which then after the use of *the welch-powell* algorithm, obtained the results of the exam schedule followed by 10 participants with examiner lecturers did not overlap (Harianto & Eiva Fatdha, 2016) , furthermore, there is research to solve problems in scheduling student council pickets in SMP Negeri 2 Kemrajen, which then after the use of *the welch-powell* algorithm, obtained the results of the picket schedule that is divided into 7 days with no overlapping schedules (Muflikhudin & Pratama, 2021). Then the next research conducted related to solving the problem of student guidance schedule held by the Elementary School Education Study Program of The University of The Pacific, then after the use of *the welch-powell* algorithm, obtained the results of 8 divided groups for guidance schedules that do not overlap (Bustan & Salim, 2019). Then further research conducted for optimization of scheduling system on scheduling *customer service* at Indosat Ooredoo kuta branch, and by using *welch-powell* algorithm, obtained the results of formed 3 teams with members of 4 to 5 people with work schedules that do not overlap each other (Hignasari, 2020) . Then there is further research conducted for the preparation of thesis proposal schedules in the UIN Raden Intan Lampung Mathematics Education Study Program which is still done manually and overlapping, then after the use of *the welch-powell* algorithm, the results can be formed that 4 groups can be formed with lecturers examiners, chairmen, different secretaries and with schedules that do not overlap (Novian Riskiana Dewi, 2020). Aside from the use of *the welch-powell* algorithm, there are also studies that use *the largest first recursive* algorithm as done for scheduling courses at makassar State University department of mathematics that overlap, and after the use of this *largest first recursive* algorithm , obtained results in the form of a schedule of courses that do not overlap (Syam et al., 2020).

Each of these algorithms has its advantages and disadvantages, but in this study the authors wanted to compare between *the welch-powell* algorithm and the *largest first recursive* algorithm in terms of completion time and complexity of the algorithm in the c++ programming language to get an appropriate and optimal algorithm when used to make a good schedule, and use the scheduling of lectures in the Science Study Program. Informatics Of Darma Cendika Catholic University, Surabaya as a test sample.

2. Method

The research is conducted using a comparative method in which(Sugiyono, 2013) the comparative method aims to compare the existence of variables through two or more samples. The comparative method of this study was used to determine the difference between *welch-powell* algorithm and *largest first recursive* algorithm in forming a schedule of study space expansion in the Informatics Study Program of Darma Cendika Catholic University, Surabaya.

Stages of research conducted:

a. Conducting data collection and observation of any course schedule in the Informatics Study Program of Darma Cendika Catholic University Surabaya
b. Mapping data that has been obtained in the form of tables, graphs, and *adjacency matrices*.
c. Apply in a program created to compare speed and complexity between the two algorithms.
d. Collects comparison results from *welch-powell* and *recursive largest first* algorithms in table form.
e. Make conclusions from the research that has been done.

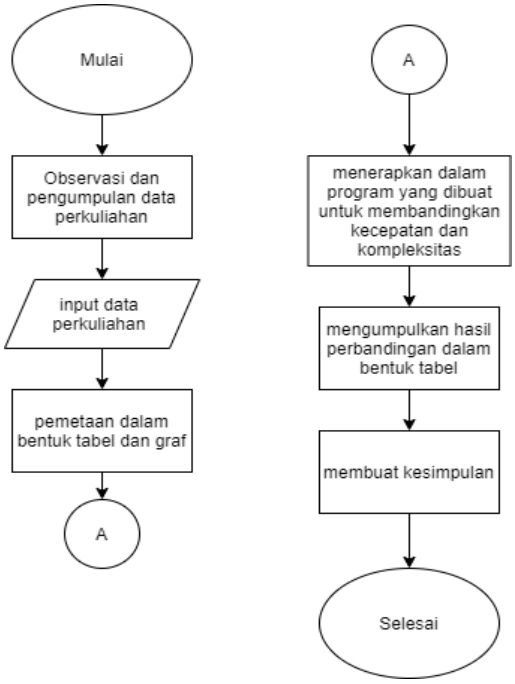

Figure 1. Research Stage Flow Diagram

From the results of the data that has been done obtained a schedule of courses in the Informatics Study Program of Darma Cendika Catholic University for semester 2 (two) and semester 4 (four). In total there are 14 (fourteen) courses with 7 (seven) courses each for semester 2 (two) and semester 4 (four).

Tabel 1
Schedule of Informatics Study Program Semester 2

Kode	Courses	Master Lecturer	Hour	Day
IF19206	Sistem Operasi	Stephanus Surijadarma Tandjung, M.T, Ph.D	10.30 s.d. 13.00	Thursday
IF19207	Algoritma Pemrograman 2	Ryan Putranda Kristianto, M.Kom	13.00 s.d. 15.30	Tuesday
IF19208	Matematika Diskrit	Yosefina Finsensia Riti, S.Kom, M.Eng	09.40 s.d. 12.10	Monday
IF19209	Pemrograman Visual	Edwin Alexander, S.Kom, M.Kom	13.00 s.d. 15.30	Monday
IF19210	Bahasa Inggris	Rindrah Kartiningsih, S.S., M.Si.	11.20 s.d. 13.00	Friday
UN18003	Kepemimpinan Pribadi	Ir. Gunawan Sukianto, S.M., M.M.	09.40 s.d. 11.20	Tuesday
UN19006	Bahasa Indonesia	Dra. Yuliana Sri Purbiyati, M.Pd.	09.40 s.d. 11.20	Rabu

Tabel 2.
Schedule of Informatics Study Program Semester 4

Code	Courses	Master Lecturer	Hour	Day
IF19417	Teori Graf	Yosefina Finsensia Riti, S.Kom, M.Eng	10.30 s.d. 13.00	Tuesday
IF19418	Pemrograman Web	Andre Hartanto, S.Kom, M.Kom	08.00 s.d. 10.30	Wednesday
IF19419	Interaksi Manusia dan Komputer	Yulia Wahyuningsih, S.Pd, M.Kom	13.00 s.d. 15.30	Monday
IF19420	Metode Numerik	Yulia Wahyuningsih, S.Pd, M.Kom	10.30 s.d. 13.00	Thursday
IF19421	Grafika Komputer dan Pengolahan Citra	Stephanus Surijadarma Tandjung, M.T, Ph.D	11.20 s.d. 13.50	Wednesday
IF19422	Sistem Multimedia	Edwin Alexander, S.Kom, M.Kom	09.40 s.d. 12.10	Monday
IF19423	Dinamika Kelompok	Ir. Gunawan Sukianto, S.M., M.M.	08.50 s.d. 10.30	Thursday

From the tables that have been made there are several courses at the same time, and there is no room description that can be used to prevent the use time of the same room in one study program, so that the minimum classroom scheduling is needed that can be used. Then from the table is represented in the form of a graph like the picture below. The code of each course represents a point or *vertex* in the graph, then the same hours and days between one course and another representing the line or *edge* in the graph.

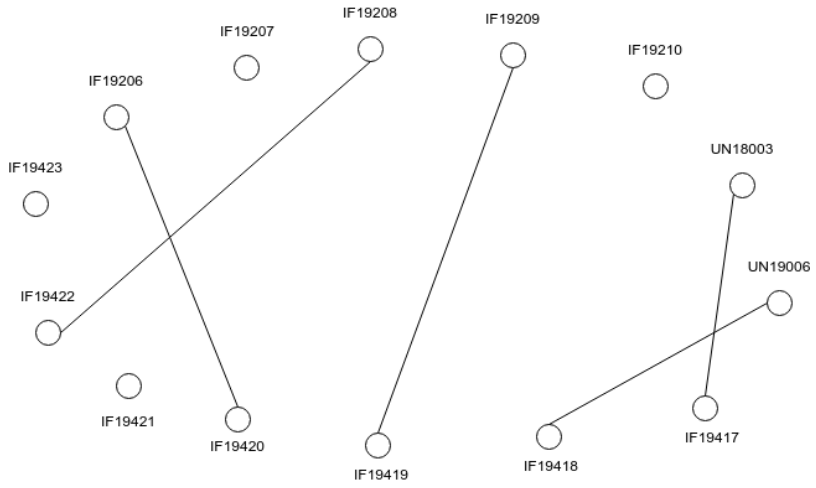

Figure 2. Graph Lecture Schedule Informatics Science Study Program

Then when it is used as *an adjacency* matrix or the determination matrix becomes as follows.

	IF19206	IF19207	IF19208	IF19209	IF19210	UN18003	UN19006	IF19417	IF19418	IF19419	IF19420	IF19421	IF19422	IF19423
IF19206	0	0	0	0	0	0	0	0	0	0	1	0	0	0
IF19207	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IF19208	0	0	0	0	0	0	0	0	0	0	0	0	1	0
IF19209	0	0	0	0	0	0	0	0	0	1	0	0	0	0
IF19210	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UN18003	0	0	0	0	0	0	0	1	0	0	0	0	0	0
UN19006	0	0	0	0	0	0	0	0	1	0	0	0	0	0
IF19417	0	0	0	0	0	1	0	0	0	0	0	0	0	0
IF19418	0	0	0	0	0	0	1	0	0	0	0	0	0	0
IF19419	0	0	0	1	0	0	0	0	0	0	0	0	0	0
IF19420	1	0	0	0	0	0	0	0	0	0	0	0	0	0
IF19421	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IF19422	0	0	1	0	0	0	0	0	0	0	0	0	0	0
IF19423	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3. Matrix Adjacency Lecture Schedule Informatics Study Program

The *welch-powell* algorithm is an algorithm used in graph coloring by coloring the knots of the highest degrees, the steps contained in *the welch-powell* algorithm are as follows:

a. Sorting nodes of G with degrees decreased.
b. Uses one color to color the first tallest knots and nodes that do not neighbor these knots.
c. Start again by coloring the second highest node with other colors based on a list of sequences of nodes that have been made.
d. Repeat coloring on the knot until all the knots have been colored (Setia, 2011)

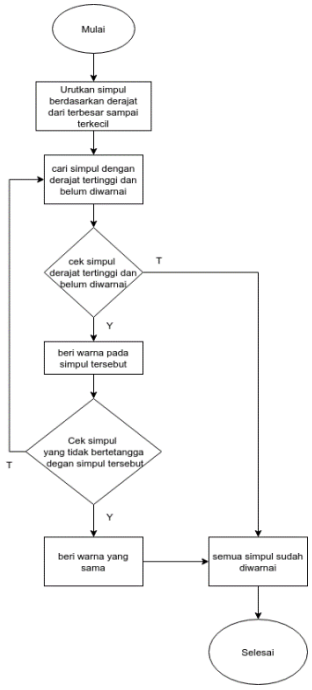

Figure 4. Welch-powell Algorithm Flow Diagram

The *Largest First Recursive* algorithm is an algorithm that can be used to solve problems with scheduling by implementing them on graph coloring. This algorithm is suitable for graphs that have large orders. The steps contained in this algorithm are as follows:

a. Register all degrees of nodes and sort in *descending or descending*.
b. Selected the node with the largest degree, then given a color
c. Looking for nodes that are not neighboring to the initial node so that the knots become prospective nodes that will be colored equal to the initial node.
d. Selection of prospective nodes so that the knot can be colored equal to the color of the initial node.

Repeat these steps until all the knots are colored (Sari et al., 2013)

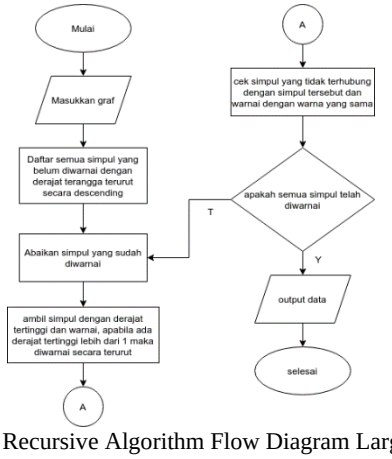

Figure 5. Recursive Algorithm Flow Diagram Largest First

The parameters used in this study are two:

a. Program Execution Time
   The execution time of the program determines how fast the program is running related to the use of the operator's function in the program. When testing an algorithm, the shorter the time required by the program the better the program is created and the better the implementation of the algorithm used in the program.

b. Program Complexity
The complexity of the program shows how complex or level of complexity a program can be seen from the number of lines of program code used.

3. Results and Discussion

From research activities conducted using the c++ programming language :
Program code link: https://github.com/yehezkielermanto/comparisonalgorithm

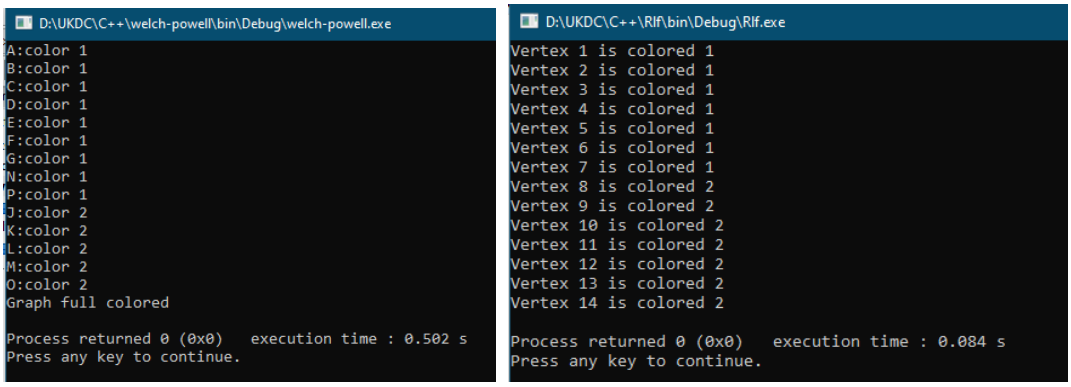

Figure 6. ***Welch-Powell algorithm execution and largest first recursive***

Table 3
Welch-Powell algorithm test results and *largest first recursive*

Algorithm	Parmeter Tester				Complexity
	Execution Time (seconds)				
	Test 1	Test 2	Test 3	Average	
Welch-Powell	0,055	0,071	0,122	0,083	98 line
Recursive Largest First	0,162	0,110	0,049	0,107	168 line

Based on the test table, *welch-powell's* algorithm is faster in program execution time to solve scheduling problems by 0.083 seconds and has a low level of complexity that produces as many as 98 lines of code, compared to *the largest first recursive algorithm.* Which has a program execution time of 0.107 seconds and produces a fairly high program complexity of 168 lines of code, so the conclusion of the test table that has been done that programs with low complexity or have concise lines of code affect the execution time, and programs with algorithm implementation in it that require a shorter time than the comparison program shows that The algorithm is more efficient. Graph coloring that can be shaped using *the welch-powell* algorithm:

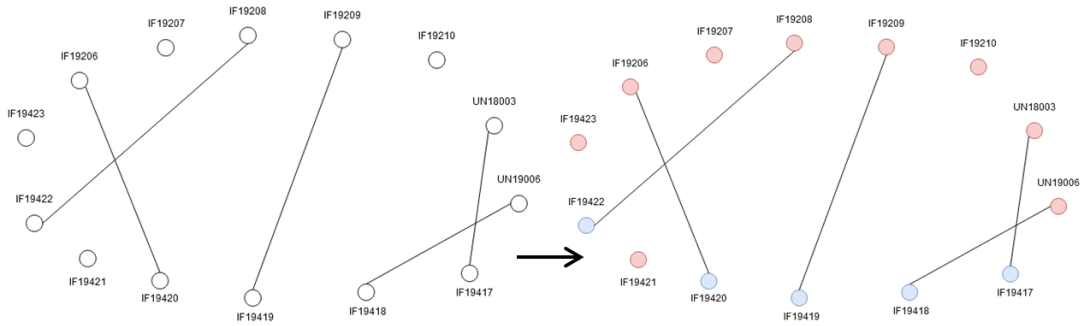

Figure 7. Welch-Powell algorithm graph coloring results

Graph coloring that can be formed using the *largest first recursive* algorithm:

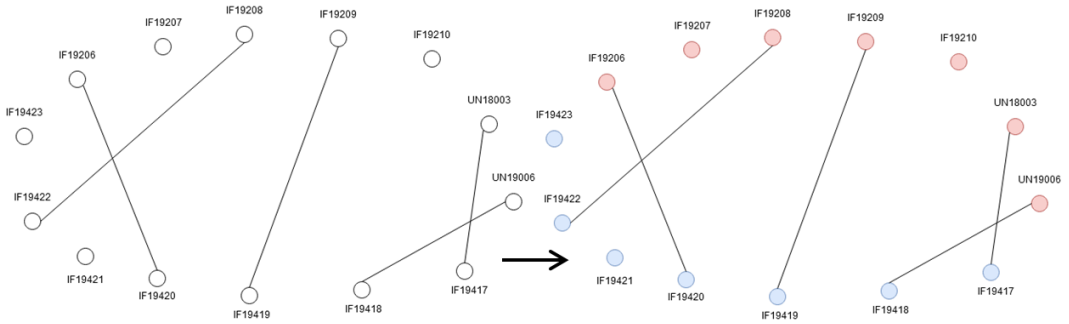

Figure 8. Graph coloring results of largest first recursive algorithm

Then based on the results of the coloring graph obtained chromatic numbers that are 2 (two) which means that in a day there are 2 course schedules at the same time get their respective classrooms so that there is no clash in the use of classrooms, as in the lecture schedule table that can be formed below.

Table 4
Schedule of Lecture Room Informatics Study Program Semester 2 and 4

Semester 2				Semester 4			
Code	**Day**	**Hour**	**Room**	**Code**	**Day**	**Hour**	**Room**
IF19208	Monday	09.40 s/d 12.10	R01	IF19422	Monday	09.40 s/d 12.10	R02
IF19209	Monday	13.00 s/d 15.30	R01	IF19419	Monday	13.00 s/d 15.30	R02
UN18003	Tuesday	09.40 s/d 11/20	R01	IF19417	Tuesday	10.30 s/d 13.00	R02
IF19207	Tuesday	13.00 s/d 15.30	R01	IF19418	Wednesday	08.00 s/d 10.30	R02
UN19006	Wednesday	09.40 s/d 11.20	R01	IF19421	Wednesday	11.20 s/d 13.50	R01
IF19206	Thursday	10.30 s/d 13.00	R01	IF19423	Thursday	08.50 s/d 10.30	R01
IF19210	Friday	11.20 s/d 13.00	R01	IF19420	Thursday	10.30 s/d 13.00	R02

Information:

IF19206 = Sistem Operasi
IF19207 = Algoritma Pemrograman 2
IF19208 = Matematika Diskrit
IF19209 = Pemrograman Visual
IF19210 = Bahasa Inggris
UN18003 = Kepemimpinan Pribadi
UN19006 = Bahasa Indonesia
IF19417 = Teori Graf
IF19418 = Pemrograman Web
IF19419 = Interaksi Manusia dan Komputer
IF19420 = Metode Numerik
IF19421 = Grafika Komputer dan Pengolahan Citra
IF19422 = Sistem Multimedia
IF19423 = Dinamika Kelompok

4. Conclusion

Welch-Powell's algorithm and *largest first recursive* algorithm are algorithms that can be used and effective in creating a lecture scheduling. Based on research that has been done *welch-powell* algorithm faster in terms of time and more concise in complexity compared to *the largest first recursive* algorithm, because on the graph the results of representation of the lecture schedule still have a small order. In the research conducted found chromatic numbers worth 2 (two) which means that 2 (two) classes can be formed for courses that have a clashing time or the same time.

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