HUST

ĐẠI HỌC BÁCH KHOA HÀ NỘI

HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

ONE LOVE. ONE FUTURE.

ĐẠI HỌC
BÁCH KHOA HÀ NỘI
HANOI UNIVERSITY
OF SCIENCE AND TECHNOLOGY

JOB SHOP SCHEDULING PROBLEM

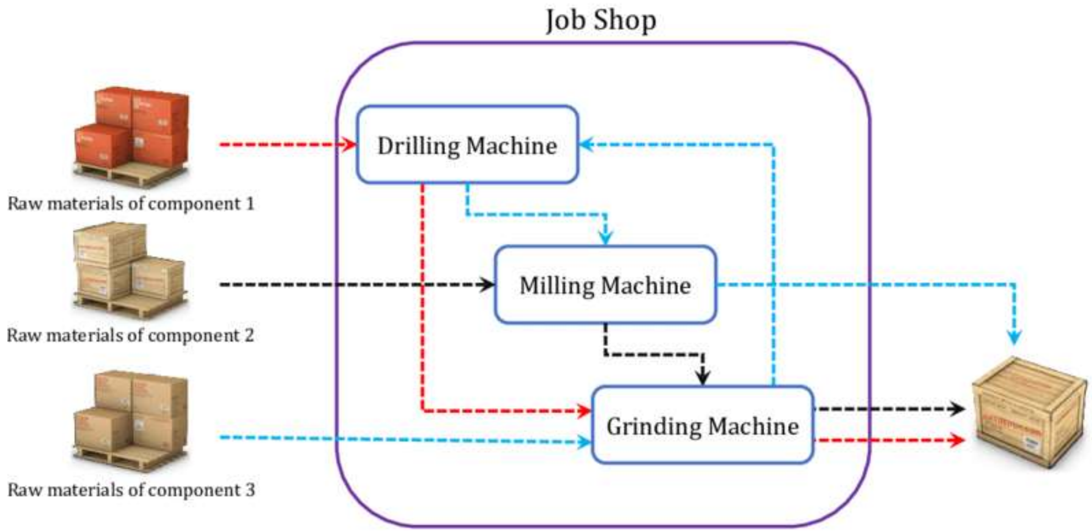
ONE LOVE. ONE FUTURE.

HÀ NỘI, 9/2023

1. MÔ TẢ BÀI TOÁN

Cho **n thao tác** cần được thực hiện trên **m máy**. Mỗi thao tác được thực hiện trên một máy mà mỗi máy chỉ xử lý nhiều nhất một thao tác trong cùng một thời gian. Mỗi công việc có thời gian xử lý và mức độ ưu tiên khác nhau

Yêu cầu đặt ra: Sắp xếp các thao tác làm việc đảm bảo **hợp lý** và tối ưu hóa về **thời gian hoàn thành** bên cạnh đó có thể áp dụng một số yêu cầu khác như tối ưu hóa về năng lượng, ..



1. MÔ TẢ BÀI TOÁN

Notation	Description	Meaning	Interpretation
$C_{\max}$	$\max_j (C_j)$	makespan or maximum completion time	cost of a schedule depends on how long the entire set of jobs has finished processing
$T_{\max}$	$\max_j (T_j)$	maximum tardiness	maximum difference between the completion time and the due date of a single job
T_t	$\sum T_j$	total tardiness	positive difference between the completion time and the due date of all jobs and there is no reward for early jobs and only penalties incurred for late jobs
$\overline{T}$	$(\sum T_j)/n$	mean tardiness	average difference between the completion time and the due date of a single job
$L_{\max}$	$\max_j (L_j)$	maximum lateness	check how well the due dates are respected, and there is a positive reward for completing a job early
I_t	$\sum I_j$	total idle time	difference between running time and processing time of all machines
F_t	$\sum F_j$	total flow time	time that all jobs spent in the shop
$\overline{F}$	$(\sum F_j)/n$	mean flow time	average time a single job spent in the shop
$W_{\max}$	$\max_j (W_j)$	maximum workload	maximum working time among all machines
W_t	$\sum W_j$	total workload	total working time on all machines
O_t	$\sum O_j$	total operation cost	cost value of all operations
E_t	$\sum E_j$	total energy consumption	energy consumption of the whole production process

1. MÔ TẢ BÀI TOÁN

JSP

Exact algorithms

Heuristics
- FIFO
- SPT
- LPT
- MOPR
- Johnson

....

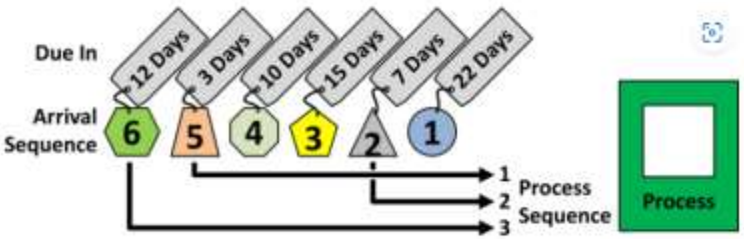
Meta-Heuristics
- GA
- SA
- .....

1. MÔ TẢ BÀI TOÁN

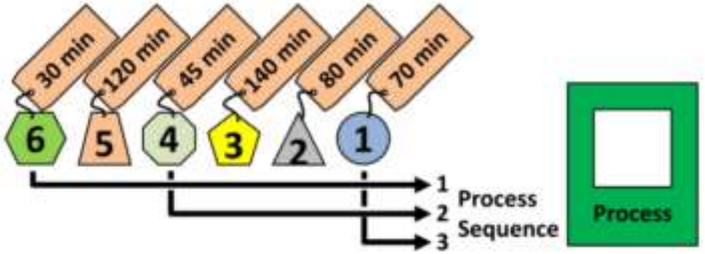
Heuristics

- **FIFO**

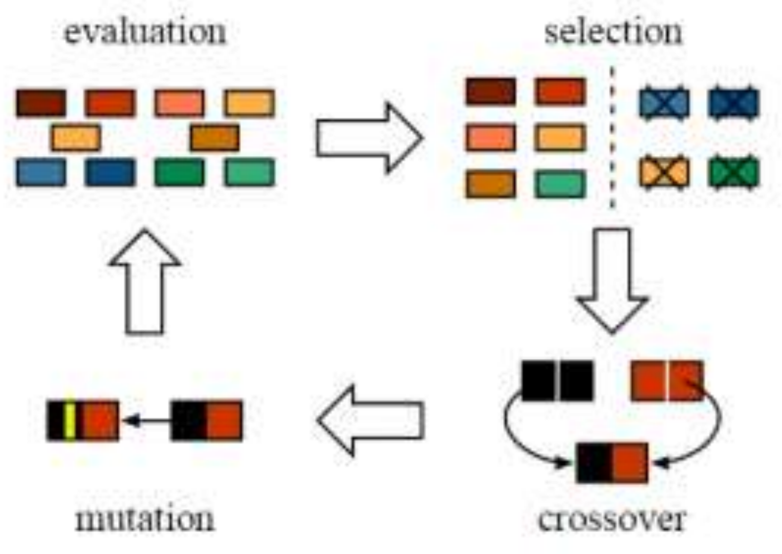
- **EDD**

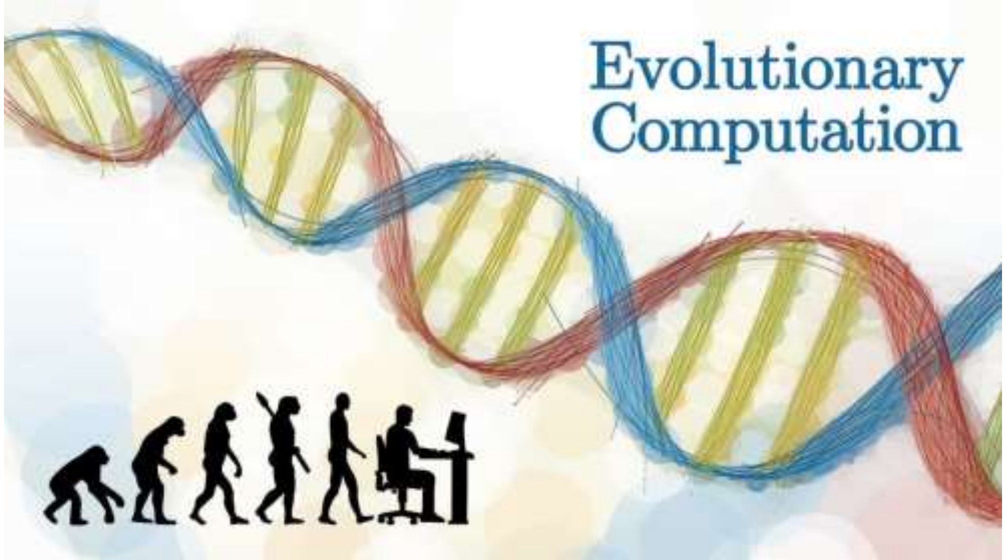


- **SPT**

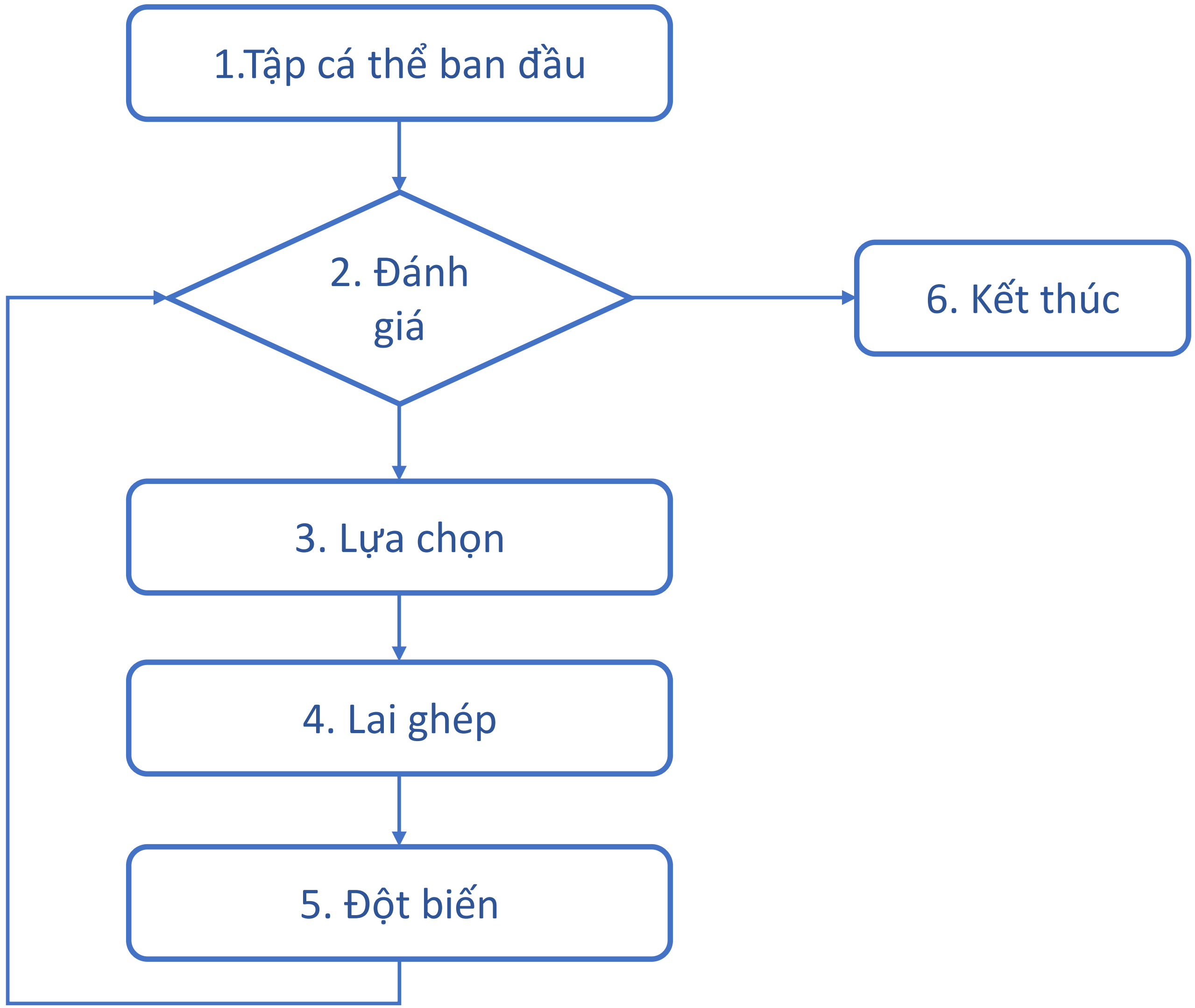


Meta-Heuristics | Genetic Algorithm





2. THUẬT TOÁN DI TRUYỀN



3. VÍ DỤ

Imed Kacem, Slim Hammadi: “*Approach by Localization and Multiobjective Evolutionary Optimization for Flexible Job-Shop Scheduling Problems*”, 2002

TABLE I
TABLE D

		M1	M2	M3	M4
J 1	O 1 ,1	1	3	4	1
	O 2 ,1	3	8	2	1
	O 3 ,1	3	5	4	7
J 2	O 1 ,2	4	1	1	4
	O 2 ,2	2	3	9	3
	O 3 ,2	9	1	2	2
J 3	O 1 ,3	8	6	3	5
	O 2 ,3	4	5	8	1

3. VÍ DỤ

TABLE I
TABLE D

		M1	M2	M3	M4
J1	O1,1	1	3	4	1
	O2,1	3	8	2	1
	O3,1	3	5	4	7
J2	O1,2	4	1	1	4
	O2,2	2	3	9	3
	O3,2	9	1	2	2
J3	O1,3	8	6	3	5
	O2,3	4	5	8	1

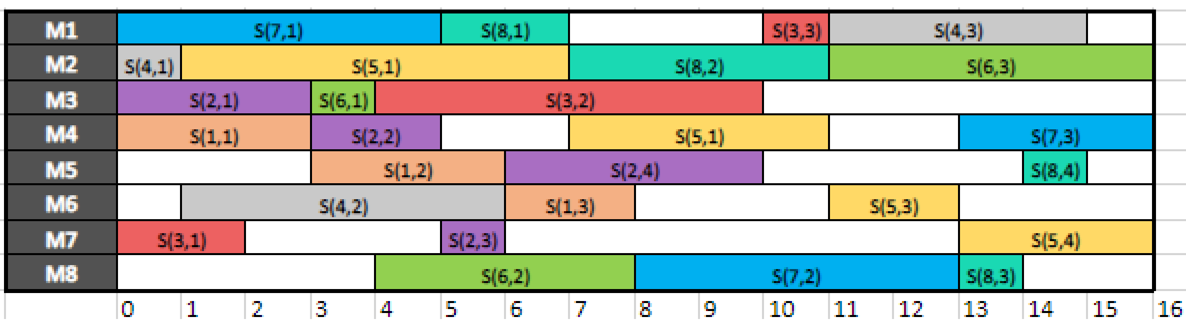
```
S[1][1]: [(0, 1), 0, 0, 0]
S[1][2]: [0, 0, 0, (1, 2)]
S[1][3]: [(2, 5), 0, 0, 0]
S[2][1]: [0, (0, 1), 0, 0]
S[2][2]: [0, 0, 0, (2, 5)]
S[2][3]: [0, (5, 6), 0, 0]
S[3][1]: [0, 0, (0, 3), 0]
S[3][2]: [0, 0, 0, (5, 6)]
S[3][3]: [0, 0, 0, 0]
Tf =  [5, 6, 6]
Wk =  [4, 2, 3, 5]
Cmax =  6
Wmax =  14
```

M1	J11		J13				
M2	J21					J23	
M3	J31						
M4		J12	J22			J32	
	0	1	2	3	4	5	6

3. VÍ DỤ

Job	Operation	M1	M2	M3	M4	M5	M6	M7	M8
1	S[1][1]	0	0	0	(0,3)	0	0	0	0
	S[1][2]	0	0	0	0	(3,6)	0	0	0
	S[1][3]	0	0	0	0	0	(6,8)	0	0
2	S[2][1]	0	0	(0,3)	0	0	0	0	0
	S[2][2]:	0	0	0	(3,5)	0	0	0	0
	S[2][3]:	0	0	0	0	0	0	(5,6)	0
	S[2][4]:	0	0	0	0	(6,10)	0	0	0
3	S[3][1]:	0	0	0	0	0	0	(0,2)	0
	S[3][2]:	0	0	(4,10)	0	0	0	0	0
	S[3][3]:	(10,11)	0	0	0	0	0	0	0
4	S[4][1]:	0	(0,1)	0	0	0	0	0	0
	S[4][2]:	0	0	0	0	0	(1,6)	0	0
	S[4][3]:	(11,15)	0	0	0	0	0	0	0
5	S[5][1]:	0	(1,7)	0	0	0	0	0	0
	S[5][2]:	0	0	0	(7,11)	0	0	0	0
	S[5][3]:	0	0	0	0	0	(11,13)	0	0
	S[5][4]:	0	0	0	0	0	0	(13,16)	0
6	S[6][1]:	0	0	(3,4)	0	0	0	0	0
	S[6][2]:	0	0	0	0	0	0	0	(4,8)
	S[6][3]:	0	(11,16)	0	0	0	0	0	0
7	S[7][1]:	(0,5)	0	0	0	0	0	0	0
	S[7][2]:	0	0	0	0	0	0	0	(8,13)
	S[7][3]:	0	0	0	(13, 16)	0	0	0	0
8	S[8][1]:	(5, 7)	0	0	0	0	0	0	0
	S[8][2]:	0	(7, 11)	0	0	0	0	0	0
	S[8][3]:	0	0	0	0	0	0	0	(13, 14)
	S[8][4]:	0	0	0	0	(14, 15)	0	0	0

		M1	M2	M3	M4	M5	M6	M7	M8
J1	O1,1	5	3	5	3	3	X	10	9
	O2,1	10	X	5	8	3	9	9	6
	O3,1	X	10	X	5	6	2	4	5
J2	O1,2	5	7	3	9	8	X	9	X
	O2,2	X	8	5	2	6	7	10	9
	O3,2	X	10	X	5	6	4	1	7
	O3,4	10	8	9	6	4	7	X	X
J3	O1,3	10	X	X	7	6	5	2	4
	O2,3	X	10	6	4	8	9	10	X
	O3,3	1	4	5	6	X	10	X	7
J4	O1,4	3	1	6	5	9	7	8	4
	O2,4	12	11	7	8	10	5	6	9
	O3,4	4	6	2	10	3	9	5	7
J5	O1,5	3	6	7	8	9	X	10	X
	O2,5	10	X	7	4	9	8	6	X
	O3,5	X	9	8	7	4	2	7	X
	O4,5	11	9	X	6	7	5	3	6
J6	O1,6	6	7	1	4	6	9	X	10
	O2,6	11	X	9	9	9	7	6	4
	O3,6	10	5	9	10	11	X	10	X
J7	O1,7	5	4	2	6	7	X	10	X
	O2,7	X	9	X	9	11	9	10	5
	O3,7	X	8	9	3	8	6	X	10
J8	O1,8	2	8	5	9	X	4	X	10
	O2,8	7	4	7	8	9	X	10	X
	O3,8	9	9	X	8	5	6	7	1
	O4,8	9	X	3	7	1	5	8	X

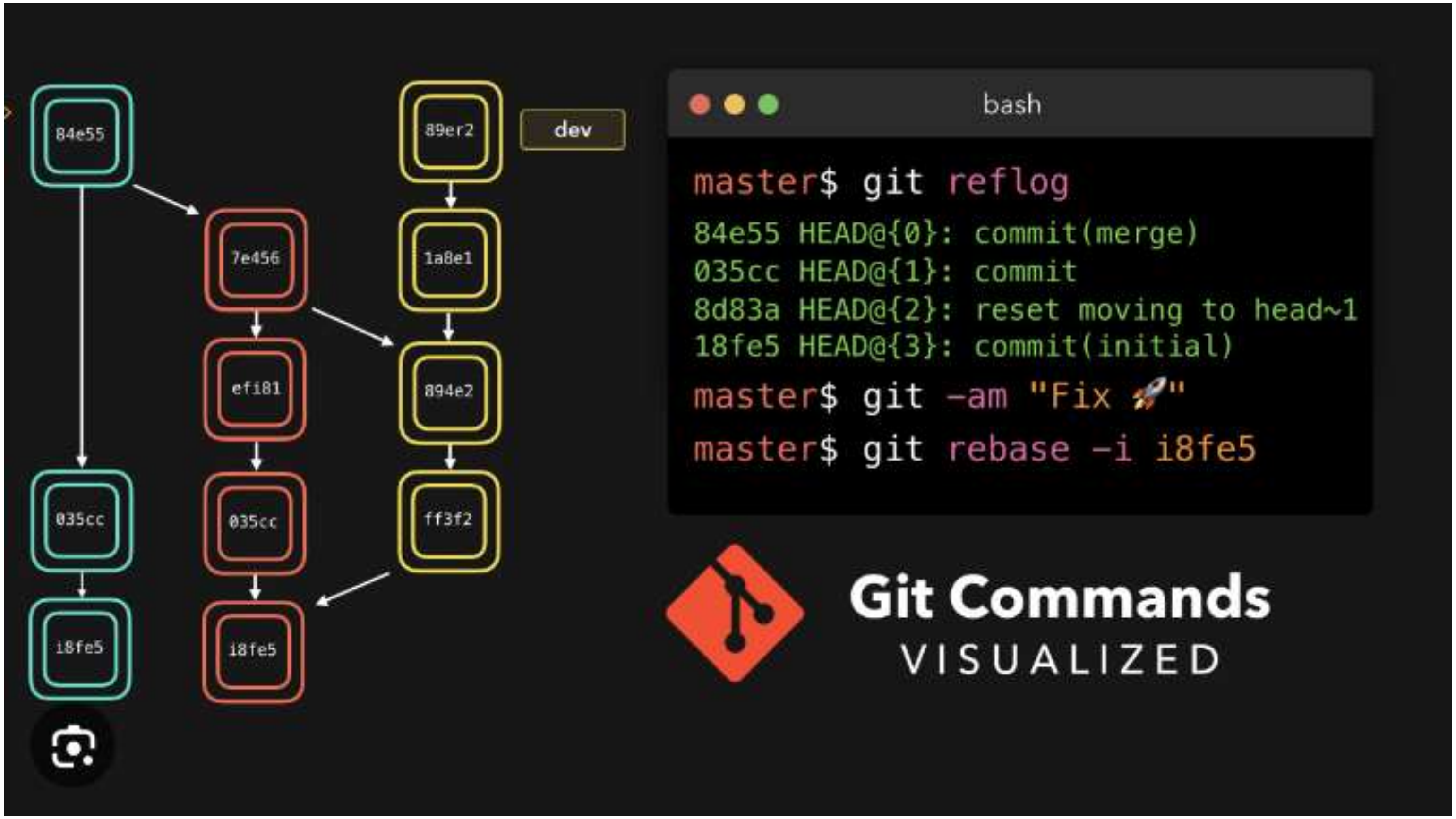


Time Complete Job:	[8, 10, 11, 15, 16, 16, 16, 15]
Workloads per Machine:	[12, 16, 10, 12, 8, 9, 6, 10]
Makespan-Cmax:	16
Total Workloads-Wmax:	83

4. GIT

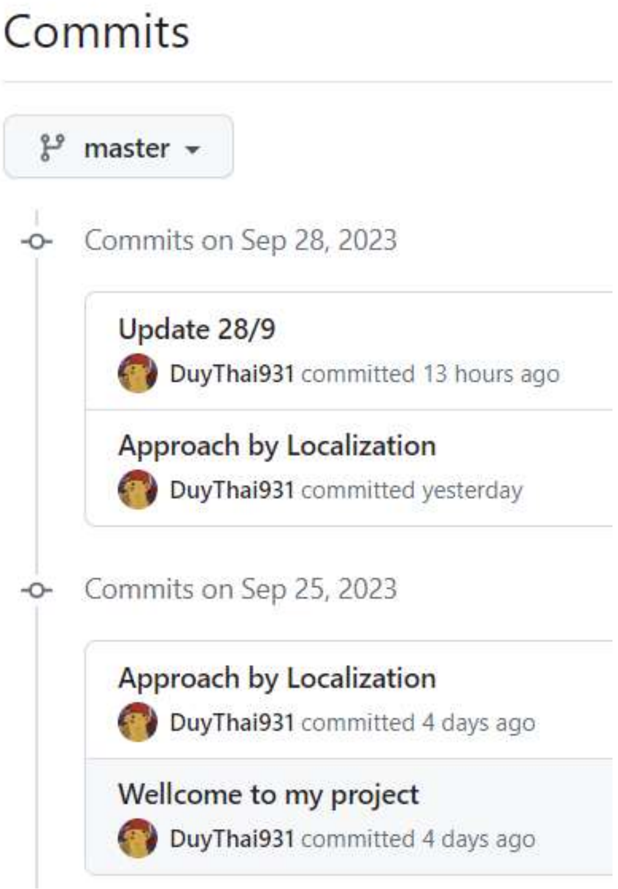
Git là hệ thống **kiểm soát phiên bản phân tán mà nguồn mở** (Open Source Distributed Version Control System). Các dự án thực tế thường có nhiều nhà phát triển làm việc song song. Vì vậy, một hệ thống kiểm soát phiên bản như **Git** là cần thiết để đảm bảo **không có xung đột mã giữa các nhà phát triển**. Ngoài ra, các yêu cầu trong dự án thay đổi thường xuyên. Vì vậy, cần một hệ thống **cho phép nhà phát triển quay lại phiên bản cũ hơn của mã**.

4. GIT

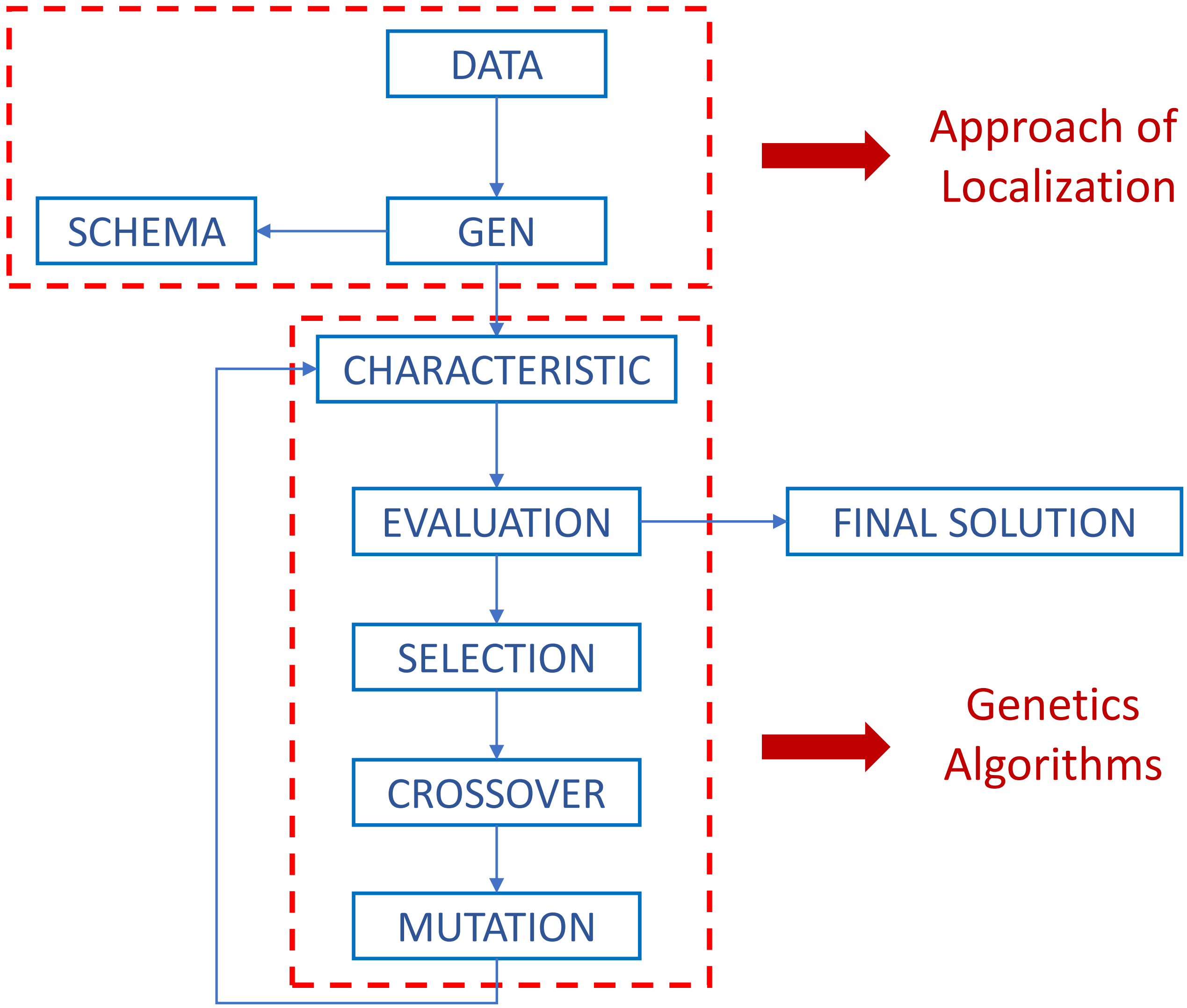


84e55
7e456
89er2
dev
1a8e1
ef181
894e2
035cc
035cc
ff3f2
i8fe5
i8fe5
bash
master$ git reflog
84e55 HEAD@{0}: commit(merge)
035cc HEAD@{1}: commit
8d83a HEAD@{2}: reset moving to head~1
18fe5 HEAD@{3}: commit(initial)
master$ git -am "Fix 🚀"
master$ git rebase -i i8fe5
Git Commands
VISUALIZED

4. GIT


Commits
master
Commits on Sep 28, 2023
Update 28/9
DuyThai931 committed 13 hours ago
Approach by Localization
DuyThai931 committed yesterday
Commits on Sep 25, 2023
Approach by Localization
DuyThai931 committed 4 days ago
Wellcome to my project
DuyThai931 committed 4 days ago

5. CGAs


DATA
SCHEMA
GEN
CHARACTERISTIC
EVALUATION
FINAL SOLUTION
SELECTION
CROSSOVER
MUTATION
Approach of Localization
Genetics Algorithms

Approach of Localization

Starting from a table D presenting the processing times possibilities on the various machines, create a new table D' whose size is the same one as the table D;
create a table S whose size is the same one as the table D (S is going to represent chosen assignments);
initialize all elements of S to 0 ($S_{i,j,k} = 0$);
recopy D in D';

```
FOR (j=1; j ≤ N )
    FOR(i=1; i ≤ nj)
•    Min= +∞ ;
•    Position=1 ;
•    FOR(k=1; k ≤ M)
            IF (d'i,j,k <Min) Then {Min= d'i,j,k; Position=k;}
            End IF
        End FOR
•    Si,j,Position =1 (assignment of O i,j to the machine MPosition);
        // updating of D':
•    FOR(i'=i+1; i' ≤ nj)
            d'i',j,Position = d'i',j,Position + di,j,Position;
        End FOR
•    FOR(j'=j+1; j' ≤ N)
                FOR(i'=1; i' ≤ nj')
                d'i',j',Position = d'i',j',Position + di,j,Position;
                End FOR
        End FOR
    End FOR
End FOR
```

TABLE I
TABLE D

		M1	M2	M3	M4
J 1	O 1,1	1	3	4	1
	O 2,1	3	8	2	1
	O 3,1	3	5	4	7
J 2	O 1,2	4	1	1	4
	O 2,2	2	3	9	3
	O 3,2	9	1	2	2
J 3	O 1,3	8	6	3	5
	O 2,3	4	5	8	1

Approach of Localization

TABLE I
TABLE D

		M1	M2	M3	M4
J1	O1,1	1	3	4	1
	O2,1	3	8	2	1
	O3,1	3	5	4	7
J2	O1,2	4	1	1	4
	O2,2	2	3	9	3
	O3,2	9	1	2	2
J3	O1,3	8	6	3	5
	O2,3	4	5	8	1

+1

i = 1

TABLE II
TABLE D' FOR $j = 1$ AND $i = 1$

		M1	M2	M3	M4
J1	O1,1	1	3	4	1
	O2,1	4	8	2	1
	O3,1	4	5	4	7
J2	O1,2	5	1	1	4
	O2,2	3	3	9	3
	O3,2	10	1	2	2
J3	O1,3	9	6	3	5
	O2,3	5	5	8	1

TABLE IV
ASSIGNMENT S1

		M1	M2	M3	M4
J1	O1,1	1	0	0	0
	O2,1	0	0	0	1
	O3,1	1	0	0	0
J2	O1,2	0	1	0	0
	O2,2	0	1	0	0
	O3,2	0	0	1	0
J3	O1,3	0	0	1	0
	O2,3	0	0	0	1

+1

i = 2

TABLE III
TABLE D' FOR $j = 1$ AND $i = 2$

		M1	M2	M3	M4
J1	O1,1	1	3	4	1
	O2,1	4	8	2	1
	O3,1	4	5	4	8
J2	O1,2	5	1	1	5
	O2,2	3	3	9	4
	O3,2	10	1	2	3
J3	O1,3	9	6	3	6
	O2,3	5	5	8	2

Approach of Localization

TABLE IV
ASSIGNMENT S1

		M1	M2	M3	M4
J1	O1,1	1	0	0	0
	O2,1	0	0	0	1
	O3,1	1	0	0	0
J2	O1,2	0	1	0	0
	O2,2	0	1	0	0
	O3,2	0	0	1	0
J3	O1,3	0	0	1	0
	O2,3	0	0	0	1

TABLE XVII
A SCHEDULE GIVEN BY THE AL

	Ope 1	Ope 2	Ope 3
J1	4, 0, 1	4, 1, 2	1, 3, 6
J2	2, 0, 1	1, 1, 3	2, 3, 4
J3	3, 0, 3	4, 3, 4	******

Machines workloads (W_k): $\{W_1 = 5, W_2 = 2, W_3 = 3, W_4 = 3\}$.
The sum of workloads of machines $W = \sum W_k = 13$.
The workload of the most loaded machine $= \text{Max}(W_k) = 5$.
The makespan $= C_{\max} = 6$.

Beginning Scheduling Algorithm
initialize the vector of machines availabilities Dispo_Machine[k]=0 for each machine M_K ($k \leq M$);
initialize the vector of jobs availabilities Dispo_Job[j]=0 for each job j ($j \leq N$);
FOR ($i=1, i \leq \text{Max}_j(n_j)$)
- construct the set E_i of operations to schedule from S:
  $E_i = \{O_{i,j} / S_{i,j,k} = 1, 1 \leq j \leq N\}$;
- classify the operations of E_i according to the chosen priority rule;
- **FOR** ($j=1 ; 1 \leq j \leq N$)
  - calculate starting times by following the same order given by the classification of E_i according to the formula:
    $t_{i,j}$ = Max(Dispo_Machine[k], Dispo_Job[j]) such that $S_{i,j,k} = 1$;
  - updating of the vector of machine availabilities:
    Dispo_Machine[k]= $t_{i,j} + d_{i,j,k}$;
  - updating of the vector of job availabilities:
    Dispo_Job[j]= $t_{i,j} + d_{i,j,k}$;

  End FOR

End FOR
End Scheduling Algorithm

Approach of Localization

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THANK YOU !