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Management of Software Projects with GAs

Lenguajes y Ciencias de la Computación

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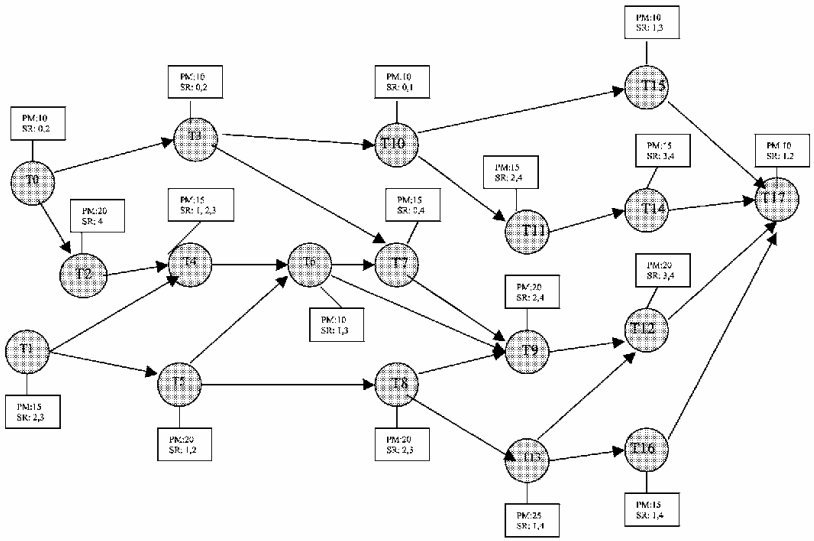
Introduction

- Modern software projects are very complex



- They could involve hundreds of people and resources
- There is a need to control people and processes efficiently
- An automatic tool could help the project manager

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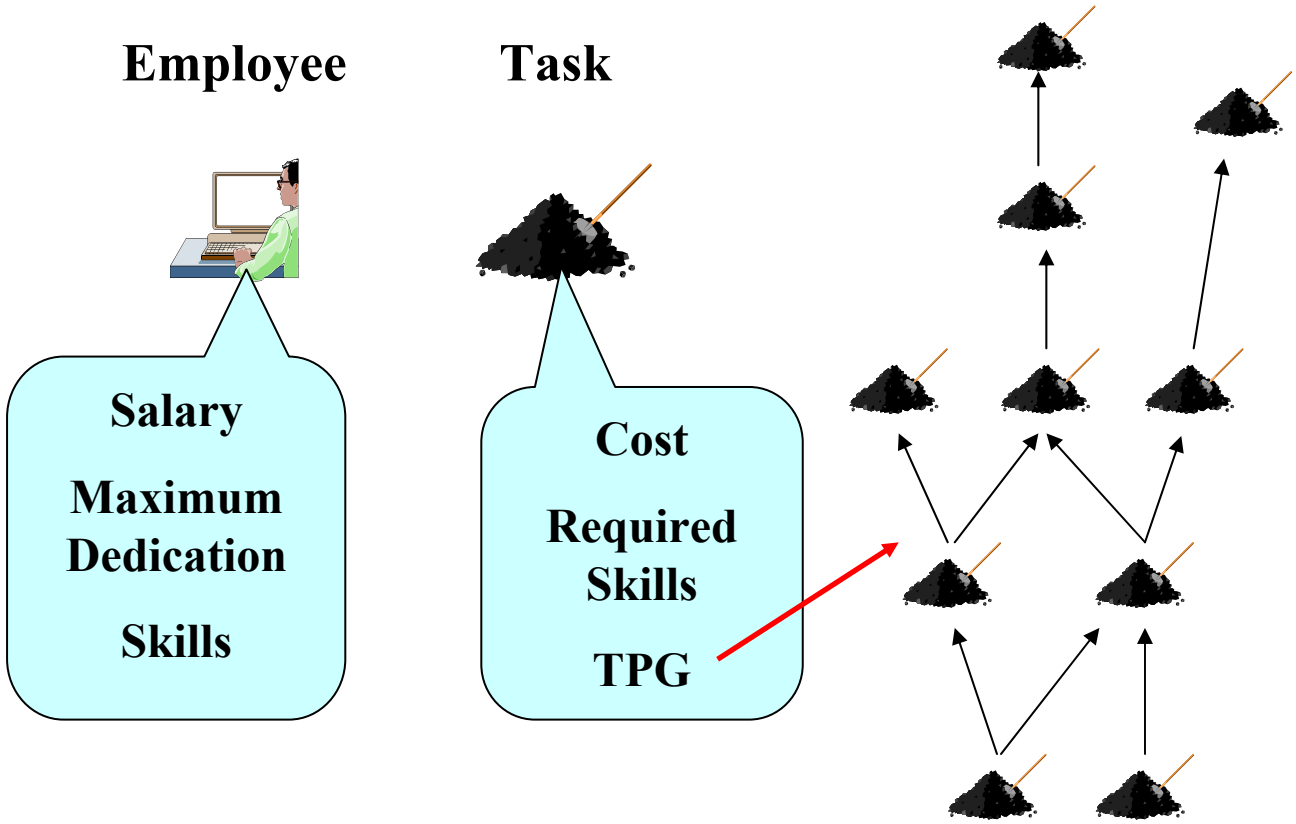
Project Scheduling Problem

- Consists in deciding "who does what" in a Software Project
- Main components:



- Skills: Java knowledge, database knowledge, leadership capacity, …

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Project Scheduling Problem

- Solution: a matrix with the dedication of the employees to each task

	T1	T2	T3	T4	T5	T6
E1	0.3	0.2	0.5	0.7	1.0	0.0
E2	0.0	0.0	0.2	0.1	0.5	0.8
E3	0.2	0.0	0.0	0.6	1.0	1.0
E4	0.4	0.6	0.0	0.0	0.0	1.0

- Objectives:
  - Minimize the project duration
  - Minimize the project cost
- Constraints:
  - All tasks must be performed by some employee
  - The union of the employees skills must include the required skills of the task they perform
  - No employee exceeds his/her maximum dedication

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Project Scheduling Problem

- Computation of the task and project duration

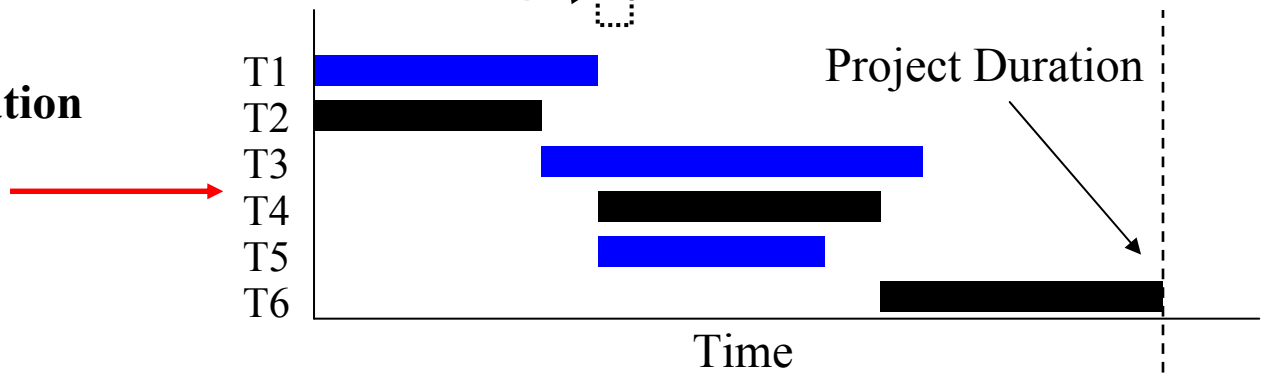
	T1	T2	T3	T4	T5	T6
E1	0.3	0.2	0.5	0.7	1.0	0.0
E2	0.0	0.0	0.2	0.1	0.5	0.8
E3	0.2	0.0	0.0	0.6	1.0	1.0
E4	0.4	0.6	0.0	0.0	0.0	1.0
∑		0.8				

$$\frac{\text{T2 cost}}{\square} = \text{T2 duration}$$

Tasks duration

\+

TPG



Project Scheduling Problem

- Computation of the project cost

	T1	T2	T3	T4	T5	T6
E1	0.3	0.2	0.5	0.7	1.0	0.0
$\sum$	× T1 dur	× T2 dur	× T3 dur	× T4 dur	× T5 dur	× T6 dur

Time dedicated to Task 3

Time dedicated to the project

× → **Employee E1 fee**

Salary

$\sum$ Employee fees = **Project Cost**

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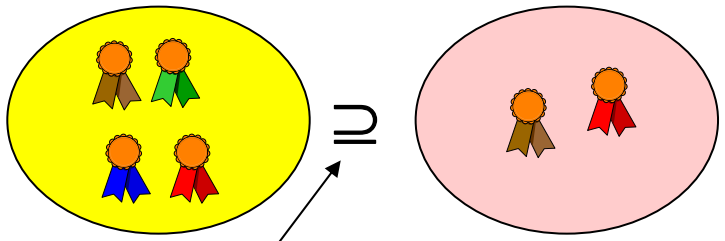
Project Scheduling Problem

- Constraints

	T1	T2	T3	T4	T5	T6
E1	0.3	0.2	0.5	0.7	1.0	0.0
E2	0.0	0.0	0.2	0.1	0.5	0.8
E3	0.2	0.0	0.0	0.6	1.0	1.0
E4	0.4	0.6	0.0	0.0	0.0	1.0
$\sum$	0.9 > 0					

1. All tasks must be performed by somebody



2. The union of the employees skills must include the required skills of the task they perform

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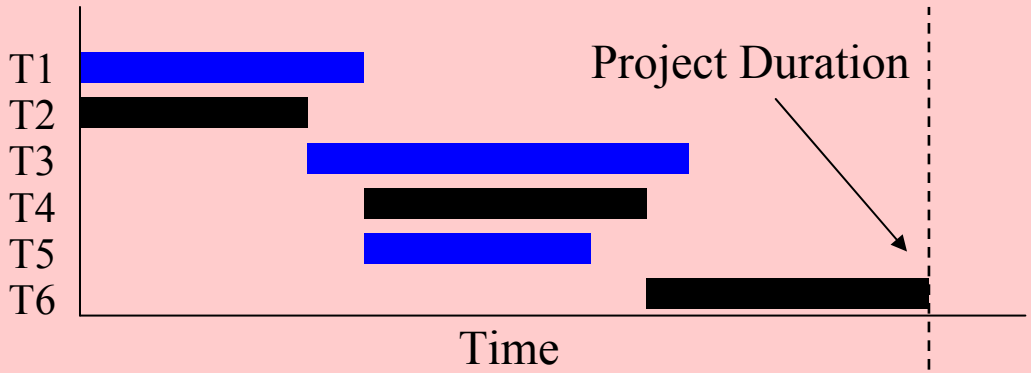
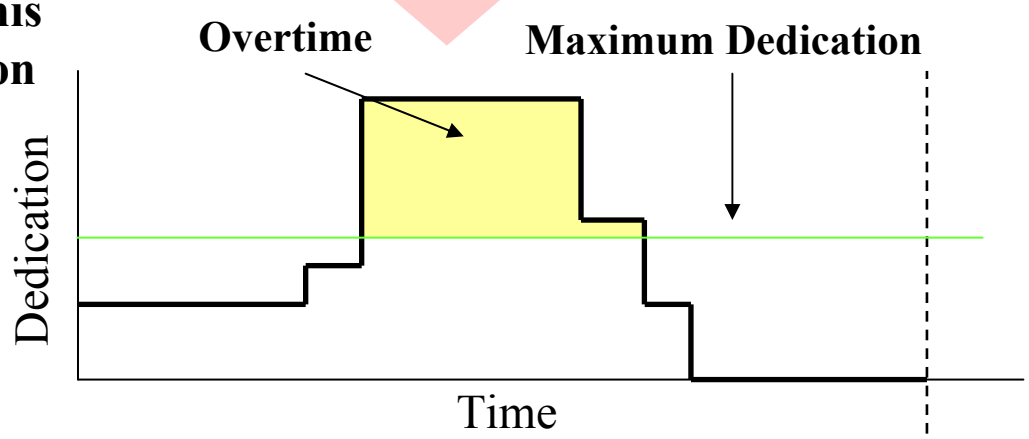
Project Scheduling Problem

- **Constraints**

	T1	T2	T3	T4	T5	T6
E1	0.3	0.2	0.5	0.7	1.0	0.0



3. Nobody exceeds his maximum dedication



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Project Scheduling Problem

- Project Scheduling Problem and Resource Constrained Project Scheduling are different Problems

RCPS		PSP
Fixed duration of activities	⟷	Fixed cost of tasks
Project duration	⟷	Project cost and duration
Several kinds of resources	⟷	One resource: employee

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Fitness Function

- We use a standard Genetic Algorithm with binary representation
- Fitness Function

$$f(\vec{x}) = \begin{cases} 1/q & \text{if the solution is feasible} \\ 1/(q+p) & \text{otherwise} \end{cases}$$

Quality term

Penalty term

Project duration

$$q = w_{co} \cdot p_{co} + w_{du} \cdot p_{du}$$

Project cost

Total project overtime

$$p = w_p + w_{nt} \cdot nt + w_{rs} \cdot rs + w_{ov} \cdot p_{ov}$$

Not performed tasks

Required skills

Weight	w_{co}	w_{du}	w_p	w_{nt}	w_{rs}	w_{ov}
Value	10^{-6}	0.1	100	10	10	0.1

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Representation

- Maximum dedication set to 1.0 for all the employees → $x_{ij} \in [0,1]$
- The matrix elements are discretized: eight possible values (3 bits)

	T1	T2	T3	T4	T5	T6
E1	0.3	0.2	0.5	0.7	1.0	0.0
E2	0.0	0.0	0.2	0.1	0.5	0.8
E3	0.2	0.0	0.0	0.6	1.0	1.0
E4	0.4	0.6	0.0	0.0	0.0	1.0

	T1	T2	T3	T4	T5	T6
E1	010	001	100	101	110	000
E2	000	000	001	001	100	110
E3	001	000	000	100	111	111
E4	010	100	000	000	000	111

Chromosome

010001100101110000000000…

Row major order

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Experiments

- We tackle 36 instances randomly created with an instance generator
- Two benchmark: 18 instances each one
- First benchmark: knowledge specialization fixed
  - Number of different skills: 10
  - Skills per employee: 4-5, 6-7
- Second benchmark: employee knowledge fixed
  - Number of different skills: 5 and 10
  - Skills per employee: 2-3
- Both benchmarks: influence of tasks and employees
  - Tasks: 10, 20, and 30
  - Employees: 5, 10, and 15
  - Skills per task: 2-3

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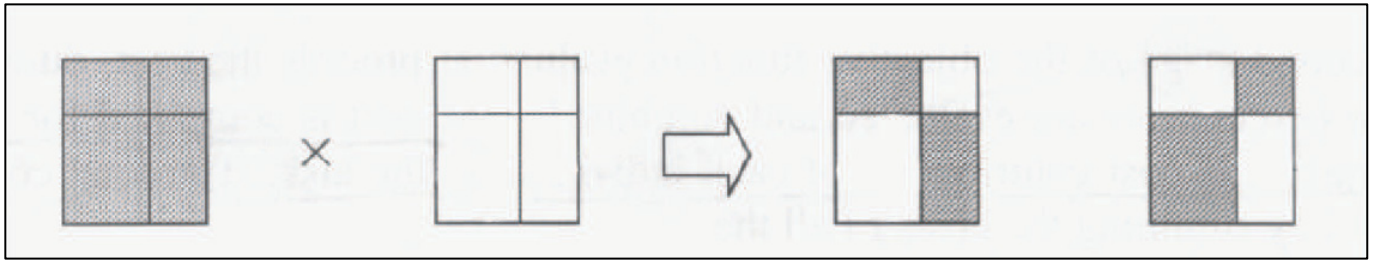
Experiments: GA Parameters

- We perform 100 independent runs of the GA for each instance

Parameter	Value
Population size	64
Selection	2-tournament (2 inds.)
Recombination	2-D SPX
Mutation	Bit-Flip (1/length)
Replacement	Elitist
Stop criterion	5000 steps

Chromosome

	T1	T2	T3	T4	T5	T6
E1	010	001	100	101	110	000
E2	000	000	001	001	100	110
E3	001	000	000	100	111	111
E4	010	100	000	000	000	111



2-D Single Point Crossover

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Experiments: First Benchmark

- **Hit percentage** (number of runs finding a feasible solution)

	4-5 skills/emp			6-7 skills/emp		
	employees			employees		
tasks	5	10	15	5	10	15
10	94	97	97	84	100	97
20	0	6	43	0	76	0
30	0	0	0	0	0	0

Larger search space

- The search space increases with the number of tasks and employees
- With more employees it is easier to find a solution
- With more tasks it is more difficult to find a solution

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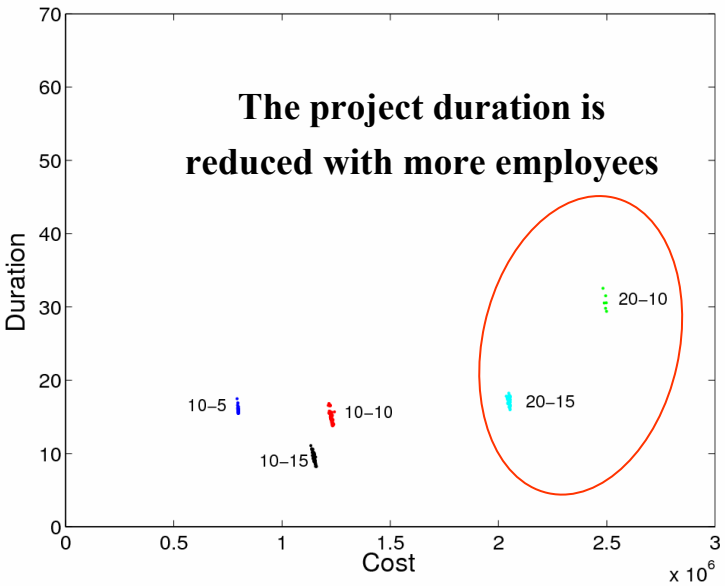
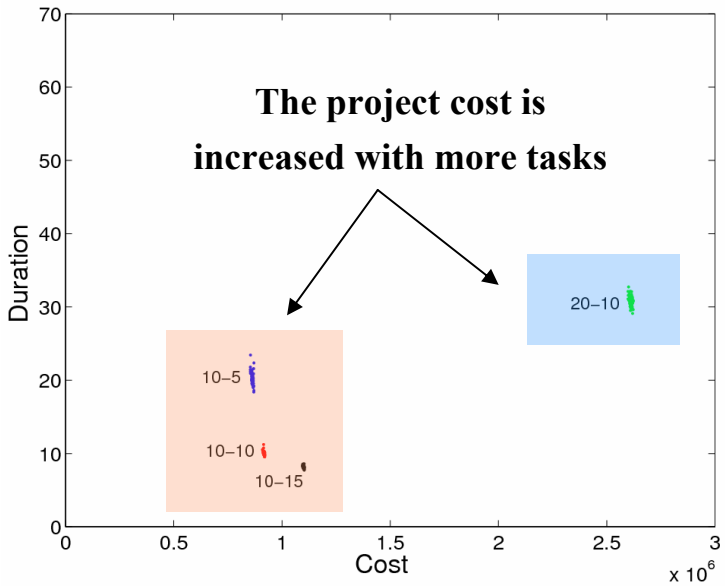
Experiments: First Benchmark

- Project Cost against duration of the solutions



4-5 skills per employee



6-7 skills per employee

- Inclination of the point swarms → cost-duration tradeoff

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Experiments: Second Benchmark

- **Hit percentage (number of runs finding a feasible solution)**

	5 skills			10 skills		
	employees			employees		
tasks	5	10	15	5	10	15
10	98	99	100	61	85	85
20	6	9	12	8	1	6
30	0	0	0	0	0	0

Larger search space

- **We have a similar behavior now with tasks and employees**
- **The problem becomes harder when a higher knowledge is required**

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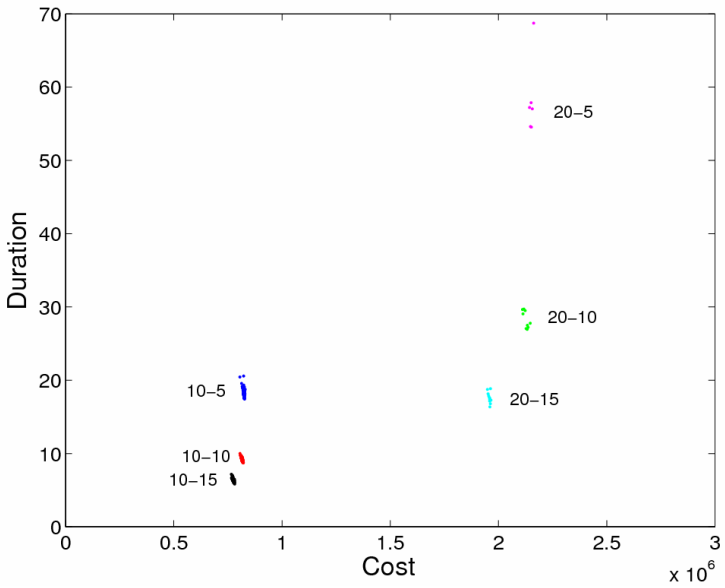
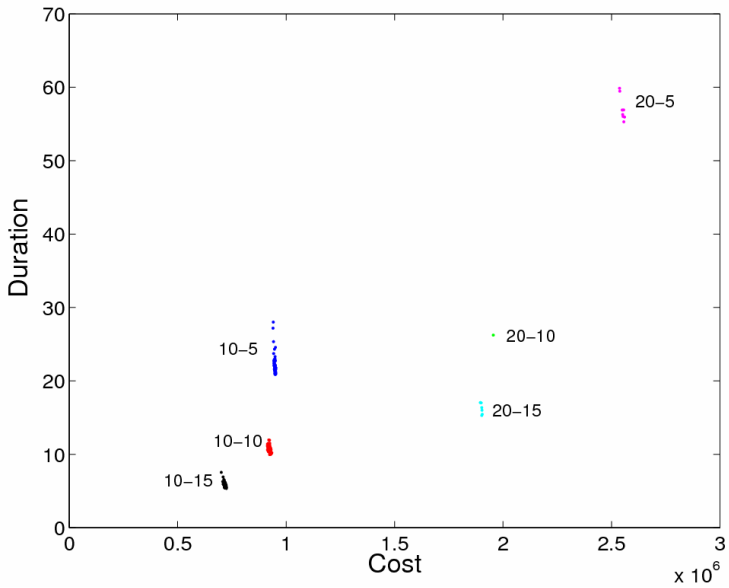
Experiments: Second Benchmark

- Project Cost against duration of the solutions



5 different skills in the project



10 different skills in the project

- The knowledge required does not affect the cost and duration

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Conclusions & Future Work

Conclusions

- The presented tool allows project managers to study different scenarios
- The difficulty of the problem is increased with the number of tasks and the number of required skills
- The project duration is reduced with the number of employees
- The project cost is increased with the number of tasks

Future Work

- Study new instances with other aspects
- Apply other algorithms
- Solve the problem in a multiobjective manner

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THE END

Thanks for your attention !!!