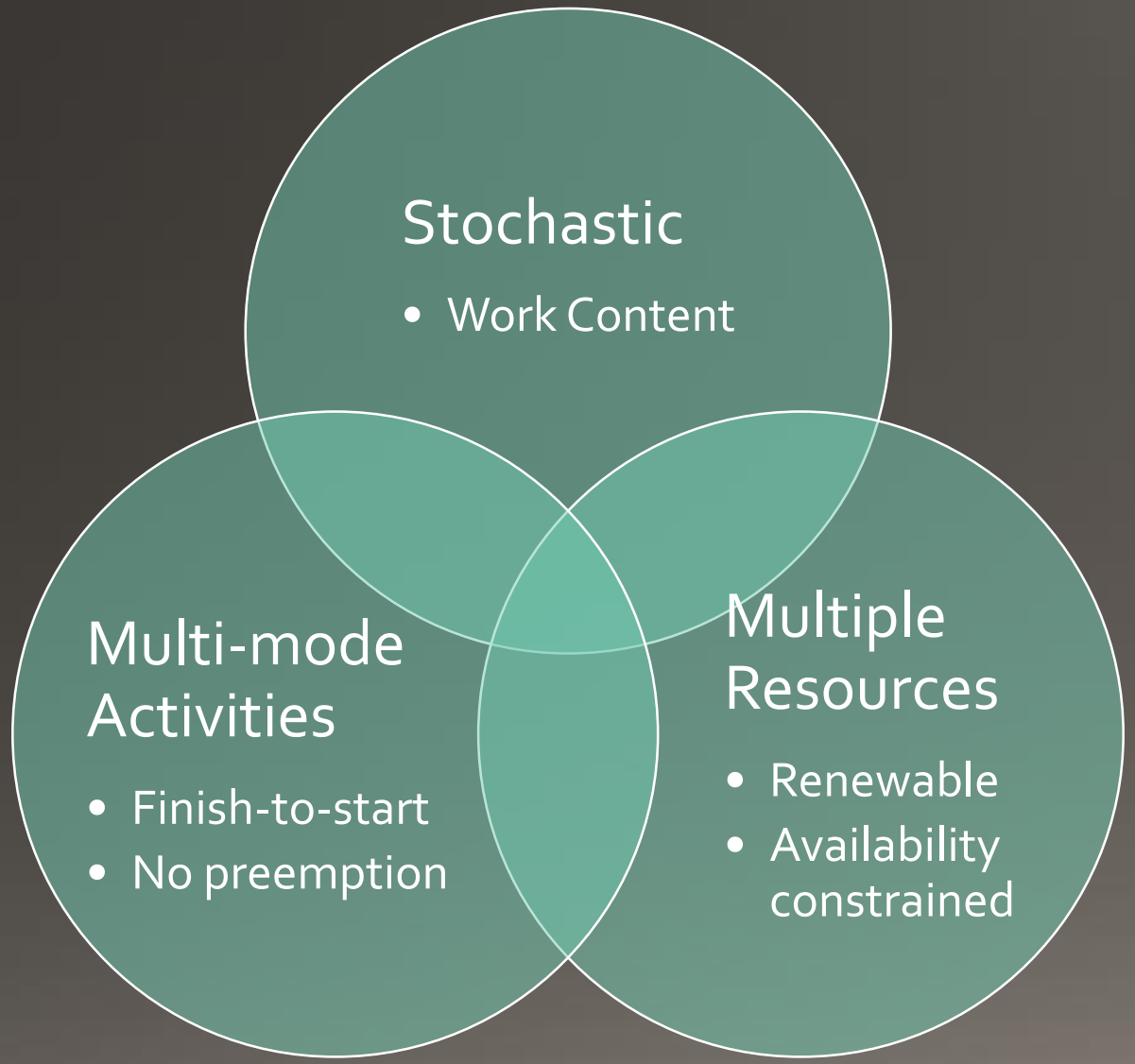
ProjMAN 2014

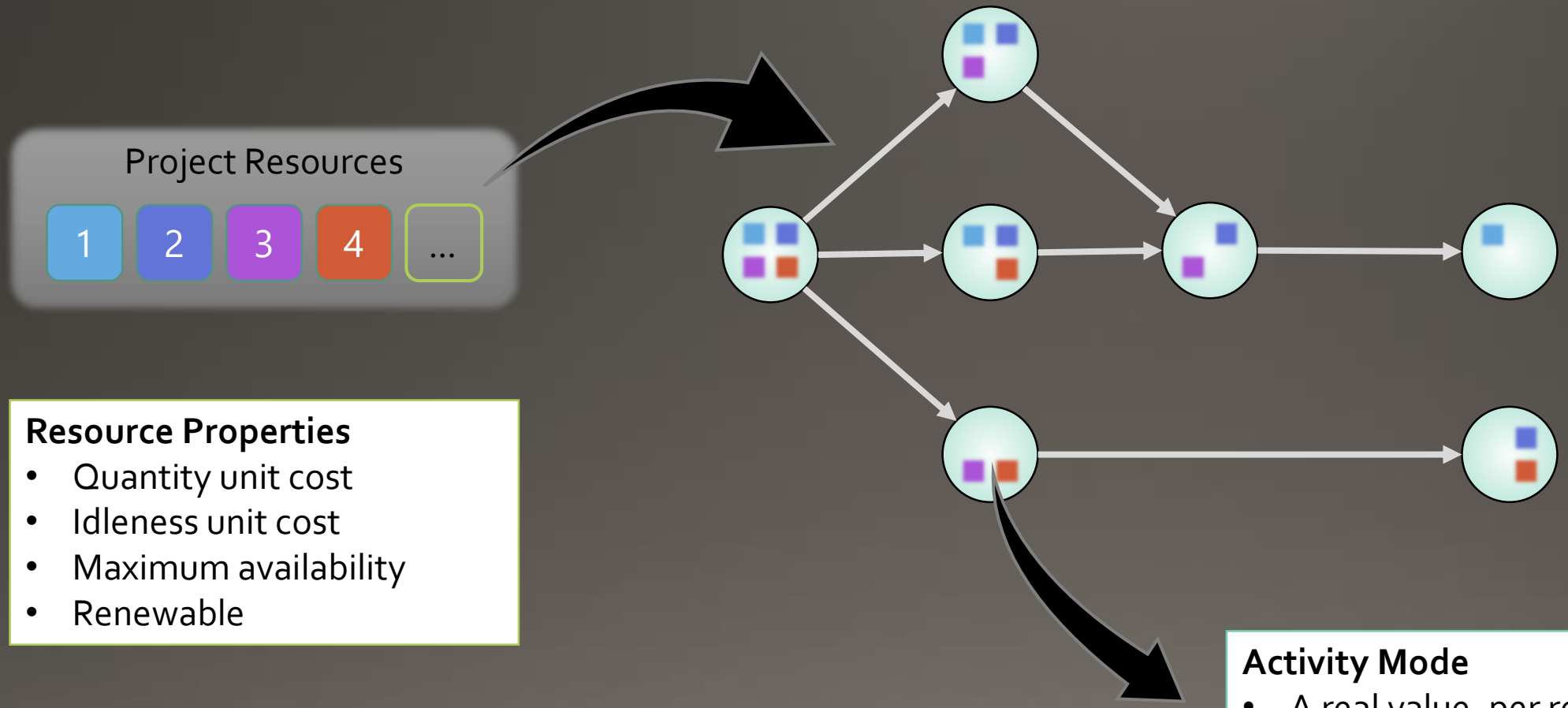
Scheduling of Multimodal Activities with Multiple Renewable and Availability Constrained Resources under Stochastic Conditions

Rui Moutinho – Student of Master in Informatics – UM (rumout@gmail.com)
Anabela Tereso – Department of Production and Systems – UM (anabelat@dps.uminho.pt)

The Model – Overview



The Model – Multiple Resources



Resource Properties

- Quantity unit cost
- Idleness unit cost
- Maximum availability
- Renewable

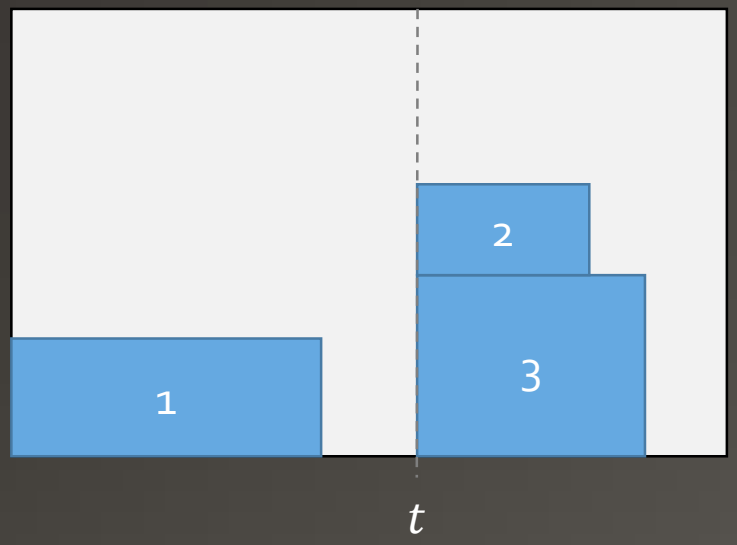
Activity Mode

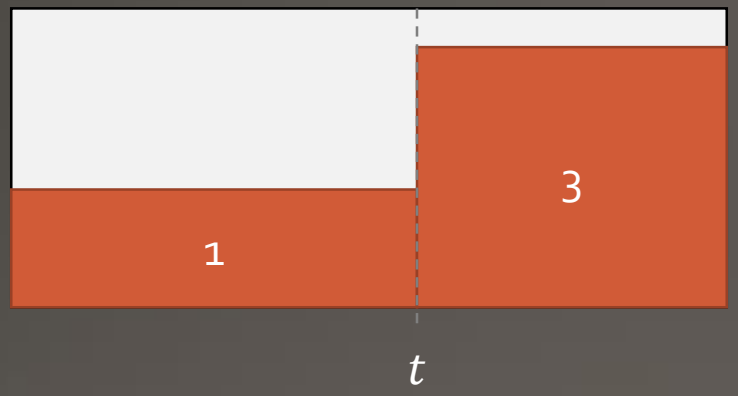
- A real value, per resource
- In a feasible interval

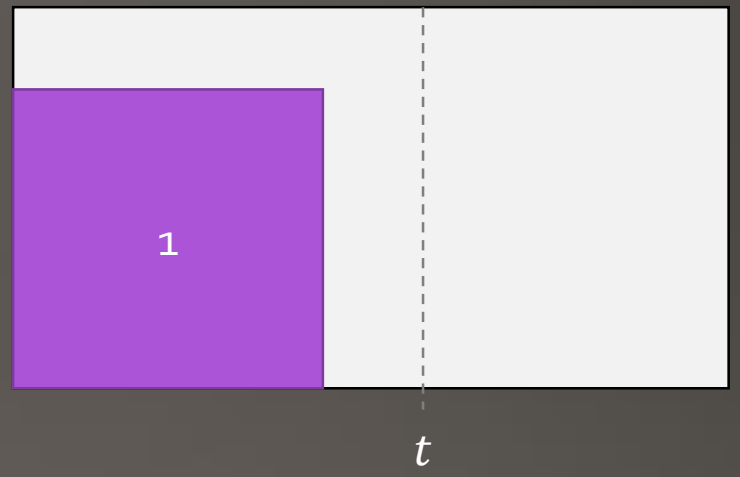
The Model – Schedule

$N = 3$ Precedence: (1,2)

$1 \rightarrow \{\blacksquare, \blacksquare, \blacksquare\}$ $2 \rightarrow \{\blacksquare\}$ $3 \rightarrow \{\blacksquare, \blacksquare\}$







Delay due to Precedence

- Activity 2 postponed to t (after activity 1)

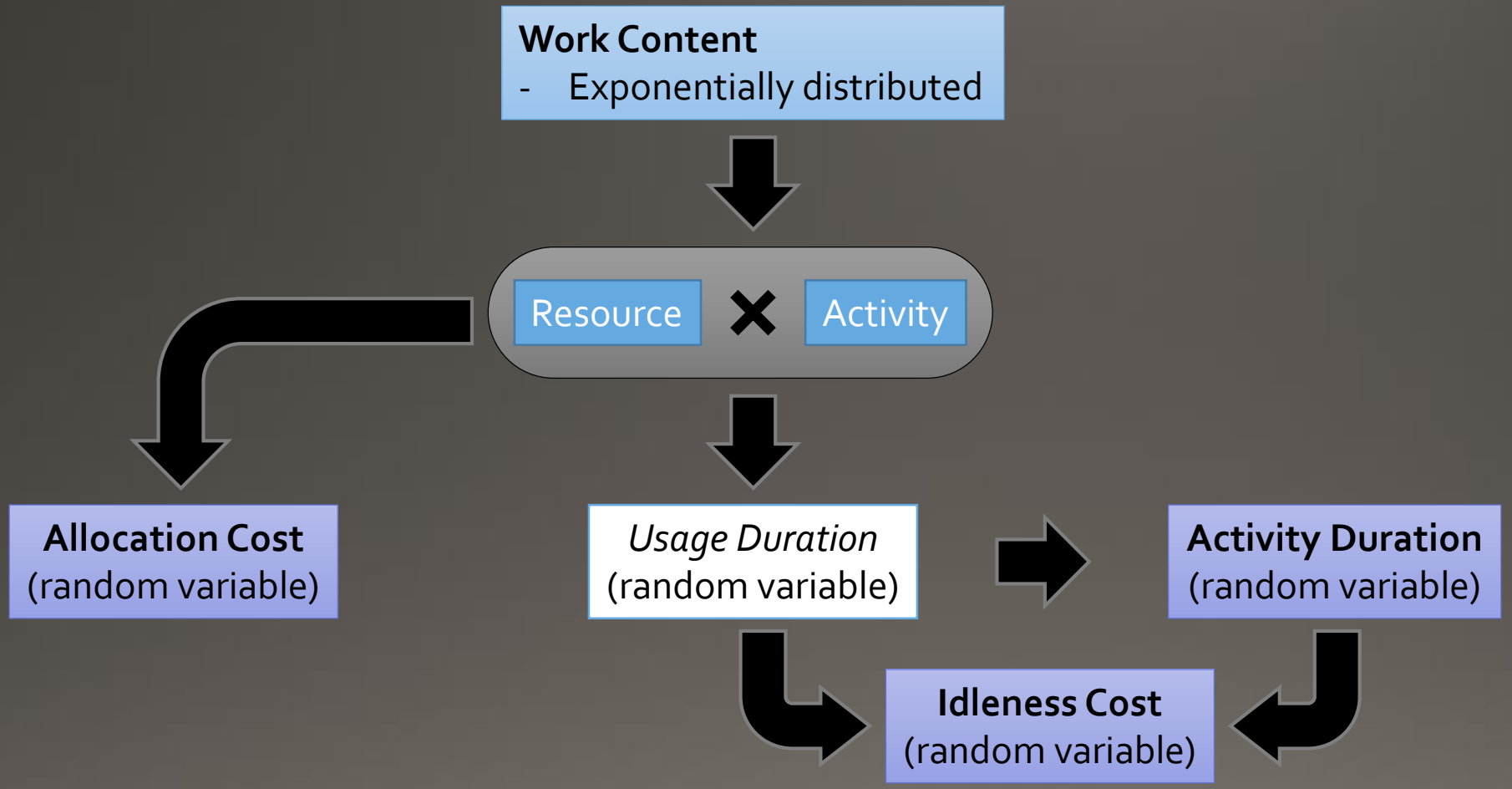
Delay due to Resource Capacity

- Activity 3 "forced" to start only at t because 1 claimed too much orange resource

No Resource Balance

- The complete availability usage is not enforced

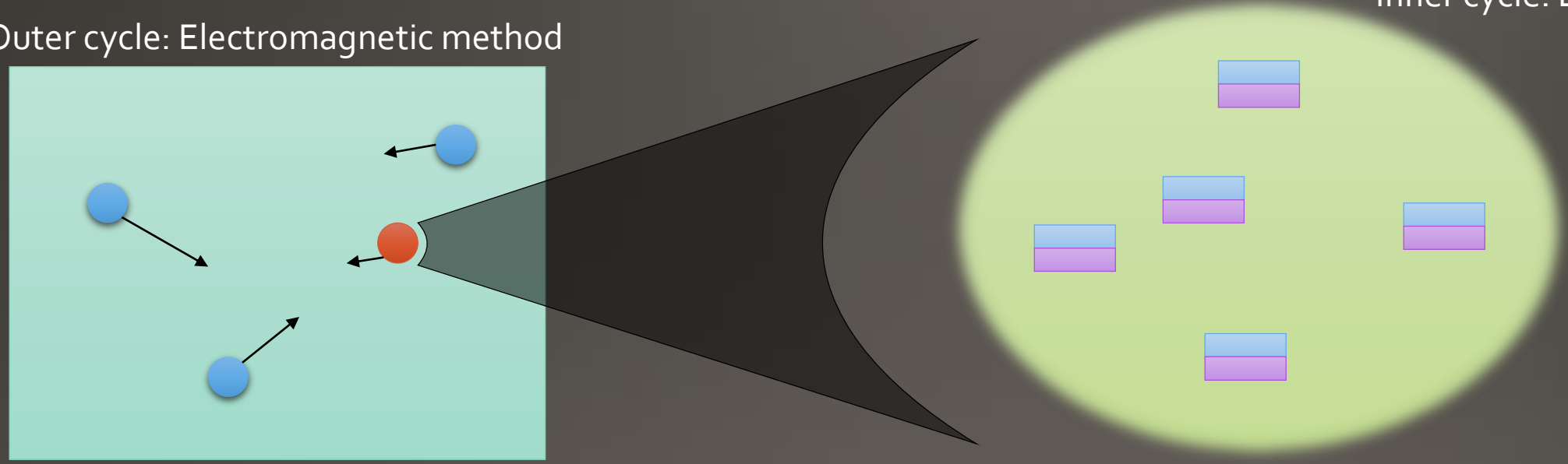
The Model – Stochastic Nature



Implementation – Overview

Outer cycle: Electromagnetic method

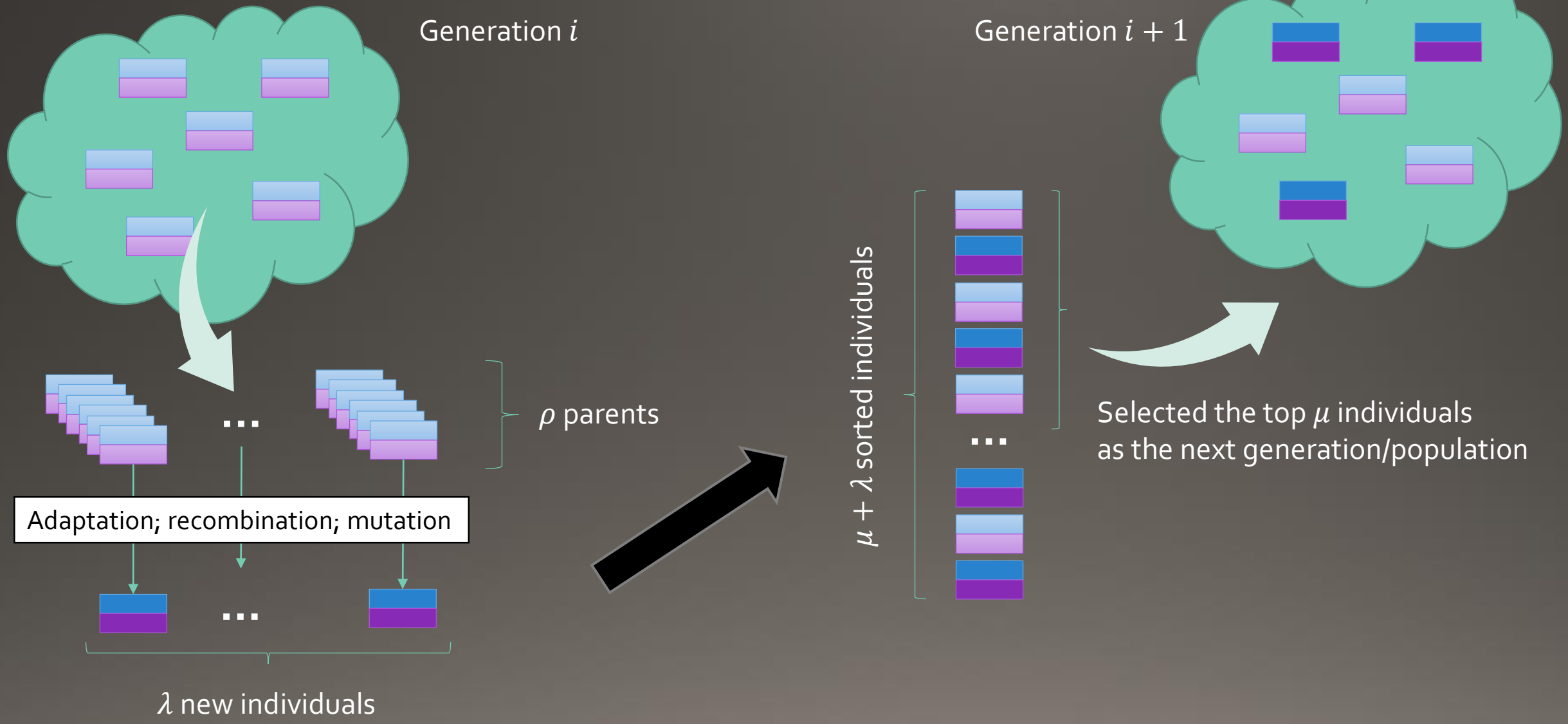
Inner cycle: ES $(\mu/\rho + \lambda)$



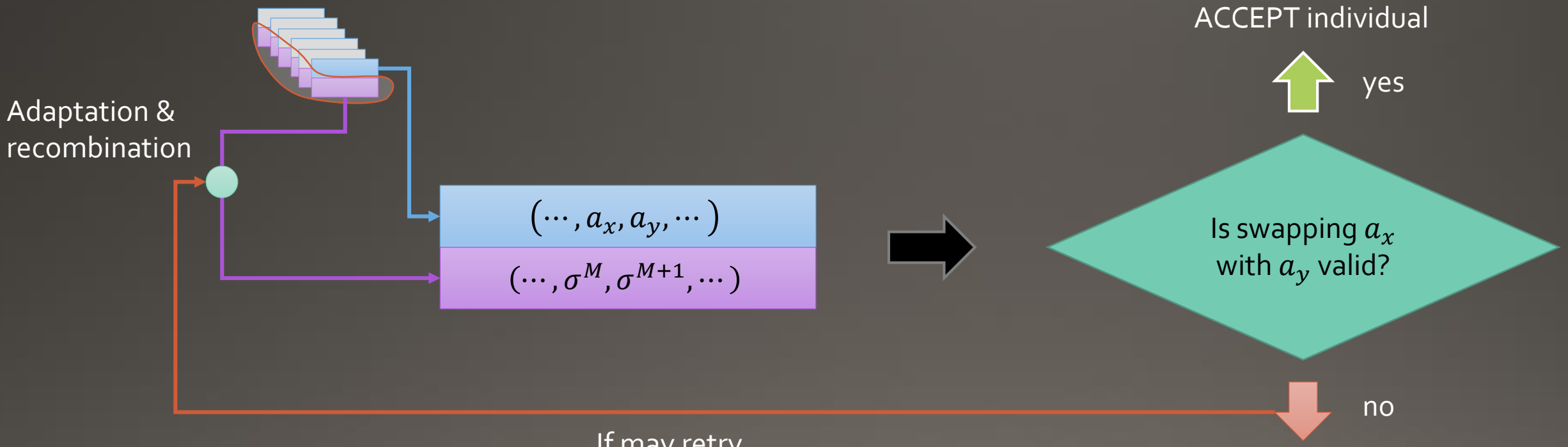
Particles moving (candidate solution)
Coordinates → allocation table
Greater attraction → better cost

Population changing between generations
Coordinates (data ■) → activity ordering
Coordinates (sd ■) → stepping control
Better schedule → best fit (in population)

Implementation – ES $(\mu/\rho + \lambda)$



Implementation – Validation



Discussion – Test Cases

Test Case A

$N = 11 \quad T_D = 28$

$c_L = 8 \quad c_E = 0.8$

single resource	multiple resources
$R_1 = 1.5$	$R_1 = 3 \quad R_2 = 3 \quad R_3 = 3$
A-S	A-M

Test Case B

$N = 24 \quad T_D = 223$

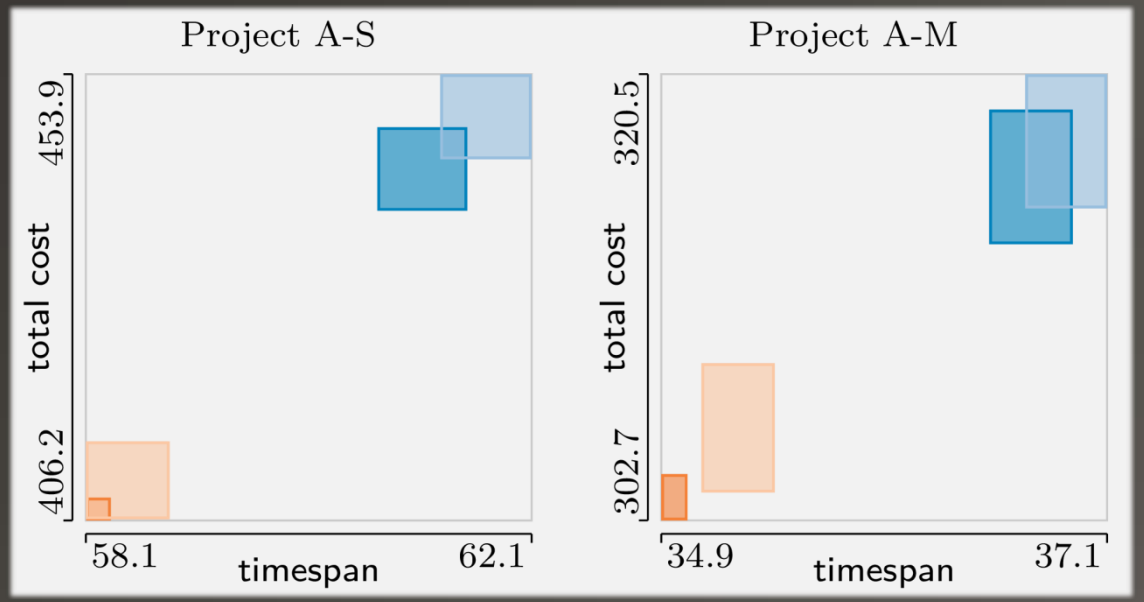
$c_L = 12 \quad c_E = 1.2$

single resource	multiple resources
$R_1 = 5$	$R_1 = 1.5 \quad R_2 = 3$
B-S	B-M

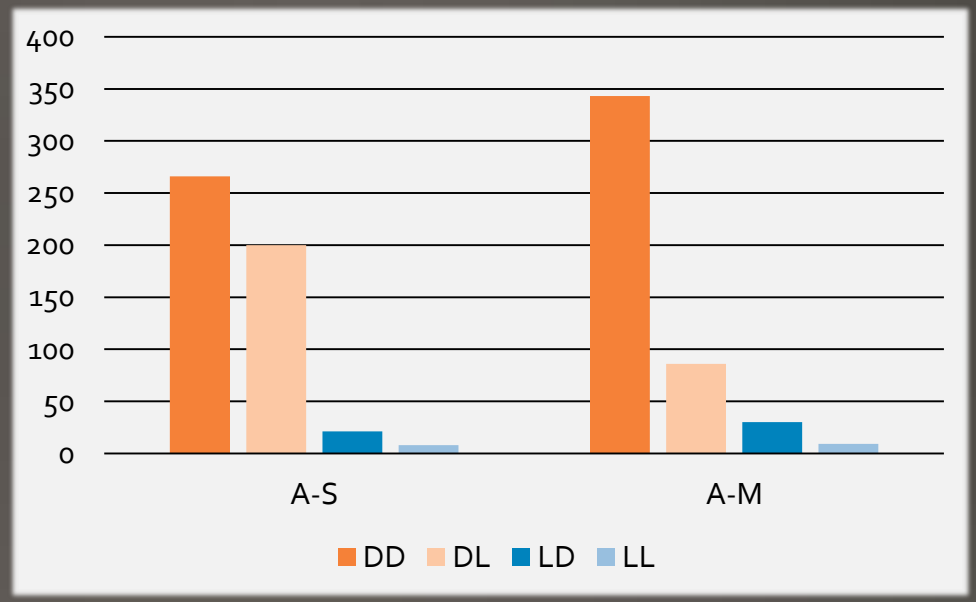
N: activity count T_D: due date c_L: unit tardiness cost c_E: unit bonus fee R_x: maximum availability of resource x

Discussion – Configurations (A)

Confidence Intervals for the Mean at 90%



Mean Execution Time per Simulation (ms)



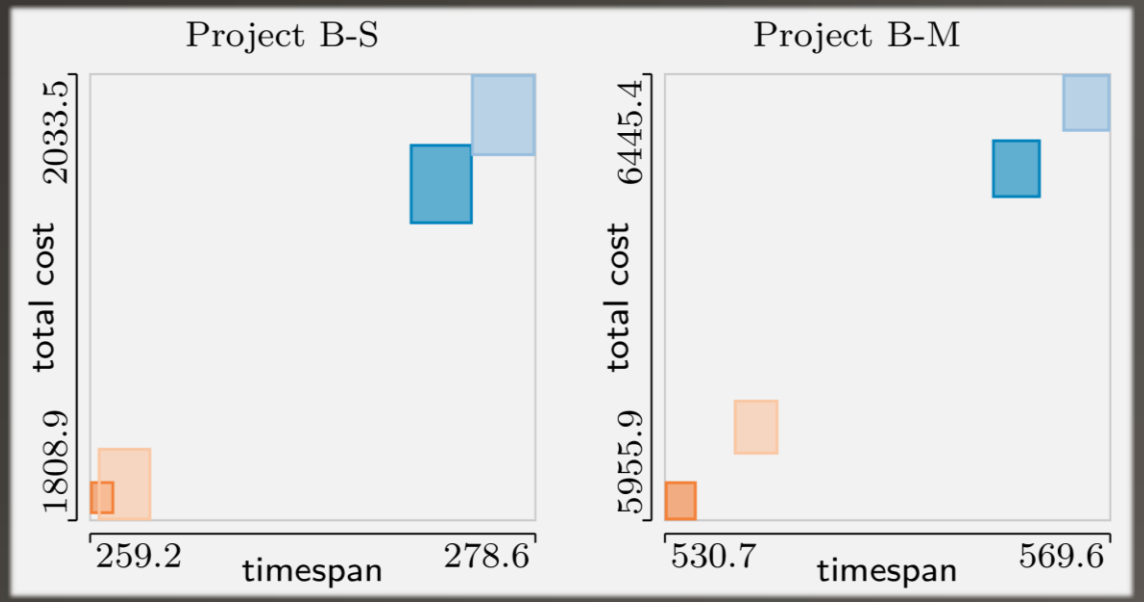
- DD & DL achieve both lesser cost and lesser timespan
- DD marginally better at timespan than DL, in A-M

- DD & DL take much longer than LD & LL

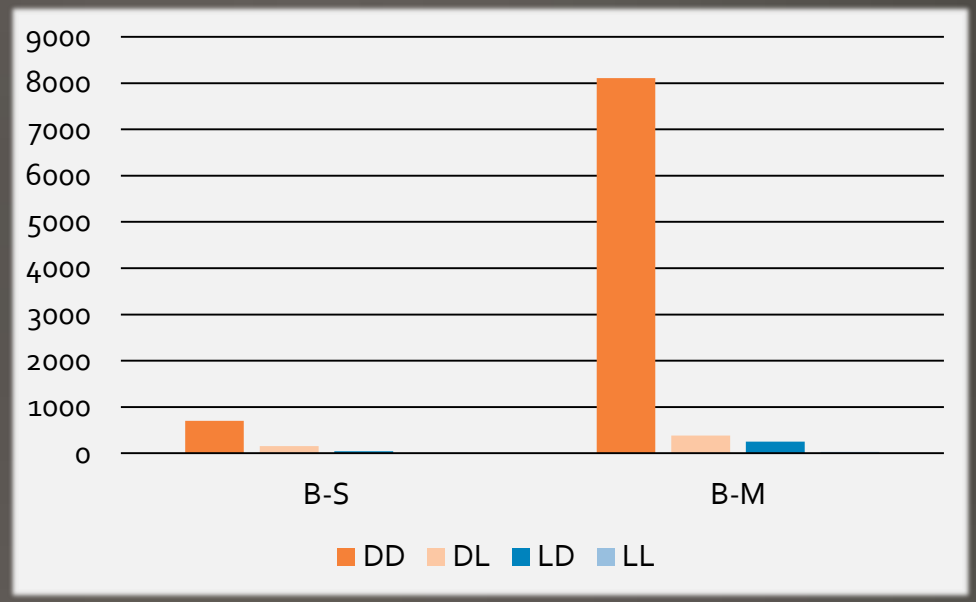
Configurations: <EM><ES> D: Default L: Light (less computationally cumbersome)

Discussion – Configurations (B)

Confidence Intervals for the Mean at 90%



Mean Execution Time per Simulation (ms)



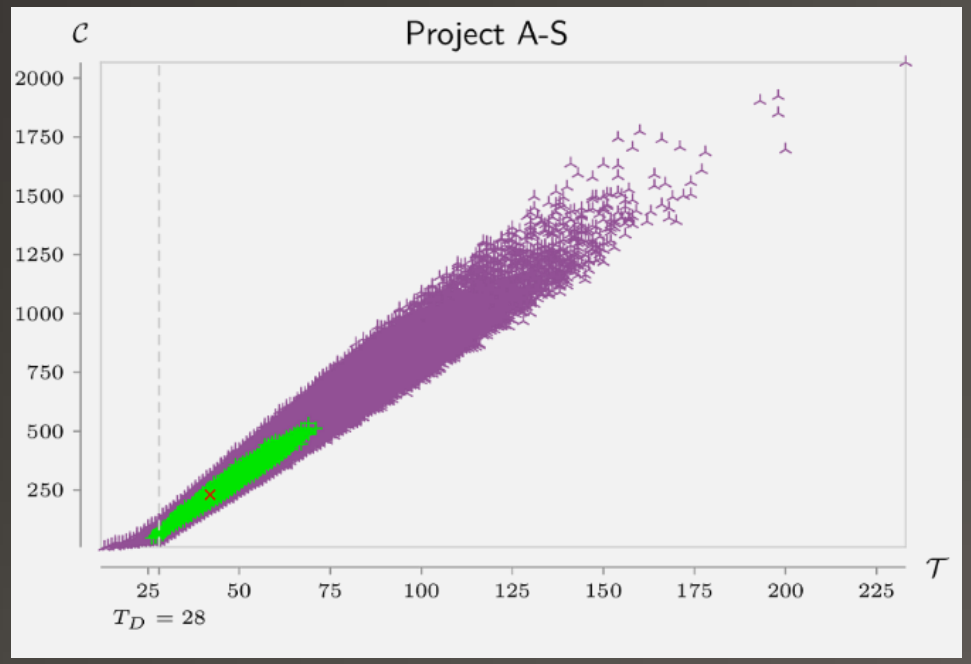
- DD & DL achieve both lesser cost and lesser timespan
- DD better at both cost and timespan than DL, in B-M

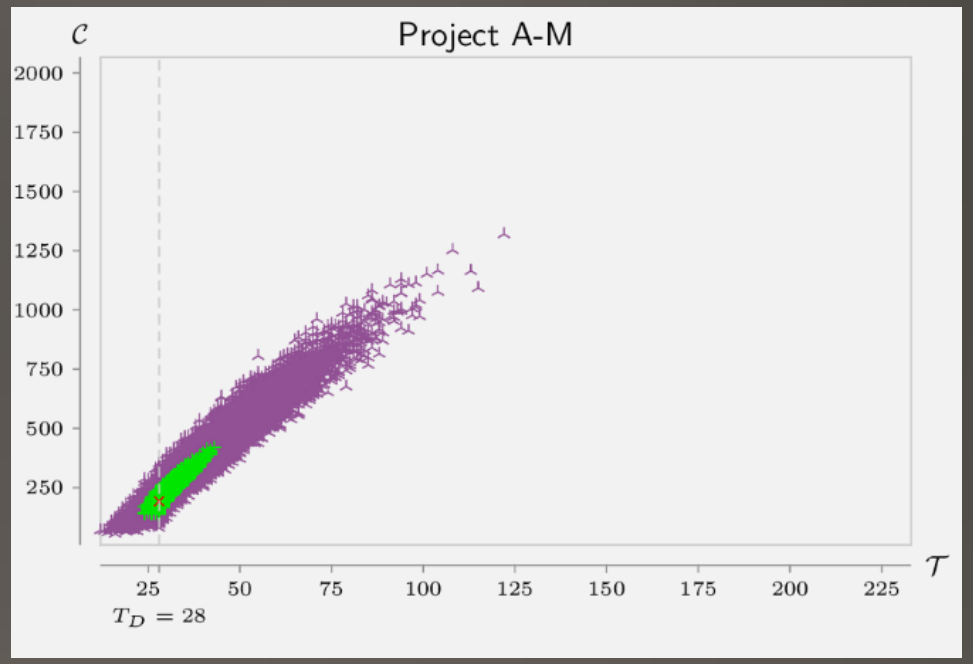
- DD & DL take much longer than LD & LL
- DD at B-M is abnormally greater

Configurations: <EM><ES> D: Default L: Light (less computationally cumbersome)

Discussion – Dispersion (A@DD)

Scatter Plots: Overall Distribution of the Obtained Results





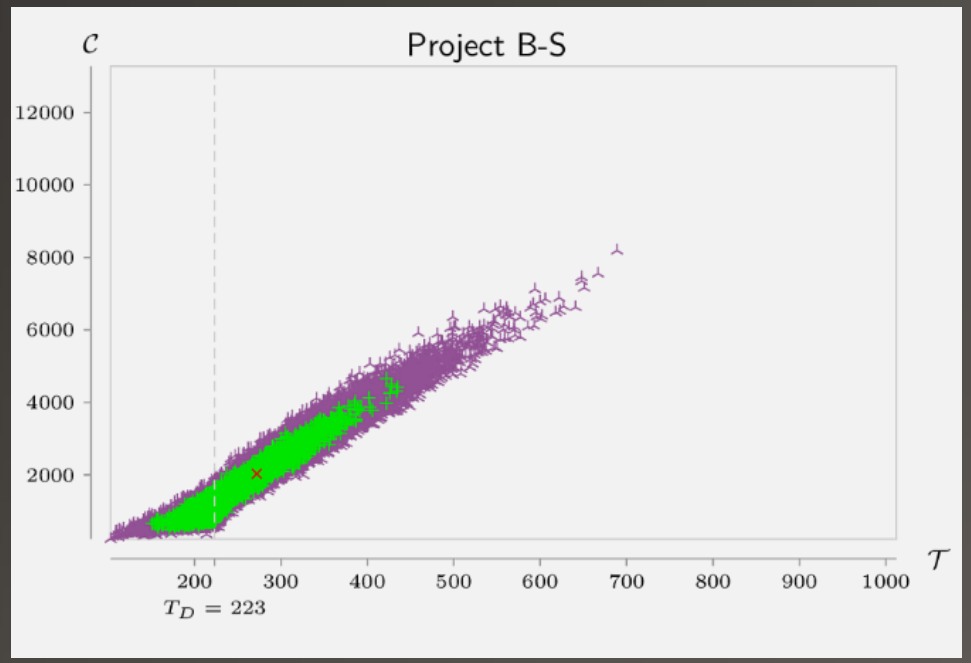
- Different behavior before and after T_D: bonus versus penalty
- More frequent results around T_D

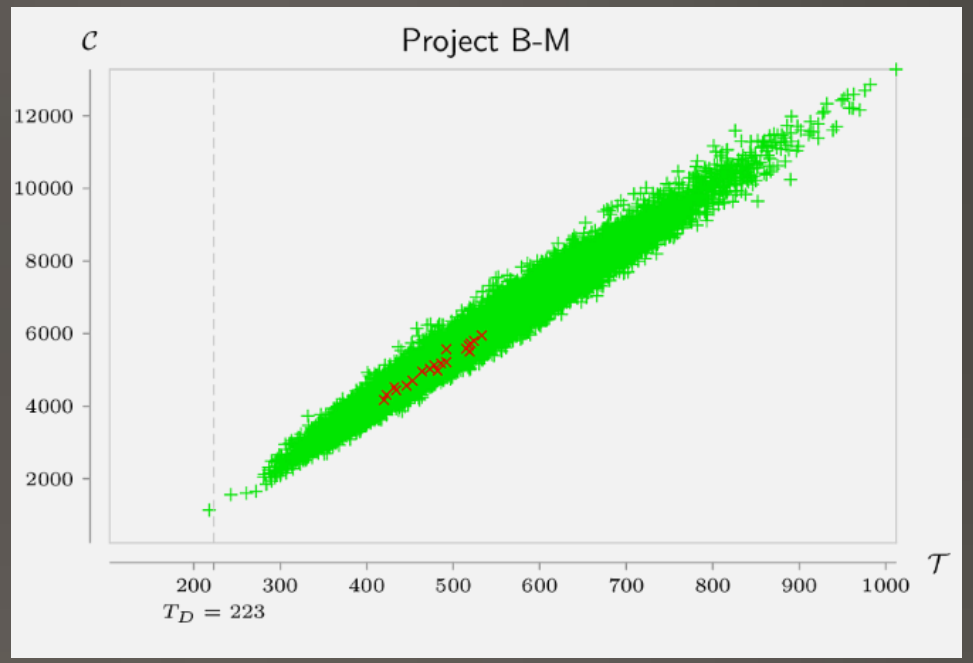
- A-M with lesser timespan and cost: maximum availability is more permissive
- The cost amplitude, per each timespan value, is greater for A-M

Colors: visual recognition of the Percentiles of Absolute Frequency Violet: $< 90\%$; Green: $\geq 90\%$ & $< 100\%$; Red: $= 100\%$

Discussion – Dispersion (B@DD)

Scatter Plots: Overall Distribution of the Obtained Results



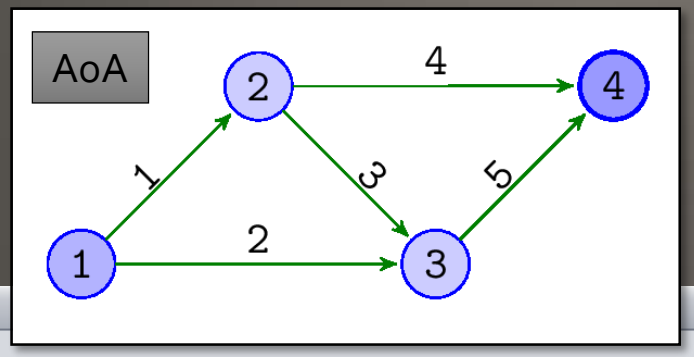


- B-S within A-S (and A-M) observations

- B-M results (almost) all above T_D.
- B-M not showing apparent convergence (multiple modal results)

Colors: visual recognition of the Percentiles of Absolute Frequency Violet: $< 90\%$; Green: $\geq 90\%$ & $< 100\%$; Red: $= 100\%$

Example



Result Data Inspector [D:\VirtualBox VMs\Shared RW\macra_db_2013 - Cópia.sqlite]

Project: MP_Net02_4_3155 (11)

Allocator Configuration: 10;250;0

Scheduler Configuration: 10;20;5;250;1

Confidence Interval: Percentage: 90,...

Graphic

Resource: r1

Resource: r2

Resource: r3

Resource: r4

Result 98 of 205::19002 $\bar{x}$=924.58±5.97 σ=500.65

Quantity Cost: 873.690 Idleness Cost: 69.200 Earliness Bonus: 18.400

Total Cost: 924.490 Makespan: 97

$$T_D = 120$$
$$R_1 = 3$$
$$R_2 = 1.5$$
$$R_3 = 5$$
$$R_4 = 5$$

Conclusions

Sensibility

- EM algorithm configuration
- Maximum resource availability

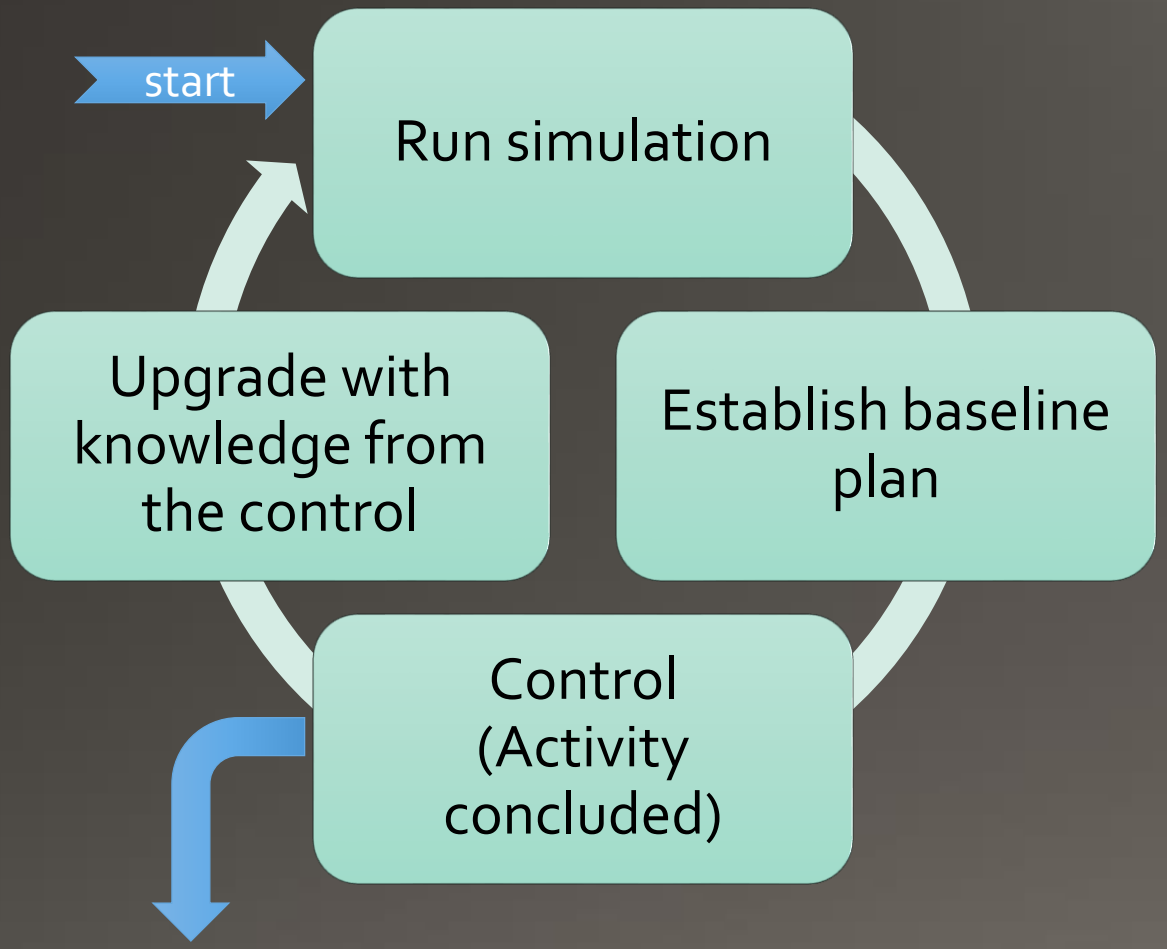
Multiple Resources

- Wider cost interval for each project duration (idleness cost)

Convergence

- Project duration tends towards due date
- Scarce results with both great cost and time
- Due date if overoptimistic may disrupt convergence

Future Research



Immediate caveats

- What to do if many activities finish at the same time (control)?
- The simulation rerunning must be kept swift

Your Questions!