Cooperative Co-evolutionary Optimisation on Work Package Scheduling and Staff Assignments

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Motivations

Team Construction (TC)

How to assign staff into project teams?

Work Package Ordering (WPO)

How to put the WPs in a good order to execute?

Objective

To find earlier overall completion time of a project by optimising TC and WPO simultaneously

Outline

Solutions Representations: WPO and Staffing

Fitness Evaluation: Simulation of Execution

Cooperative Coevolution Process

Empirical Results

Solution Representation of TC

How to assign N staff into M teams?

	Staff 1	Staff 2	Staff 3	Staff 4	Staff 5	…	Staff 29	Staff 30
To Team	3	4	2	3	5	…	3	2

N staff

Species #1: assignment of staff to teams

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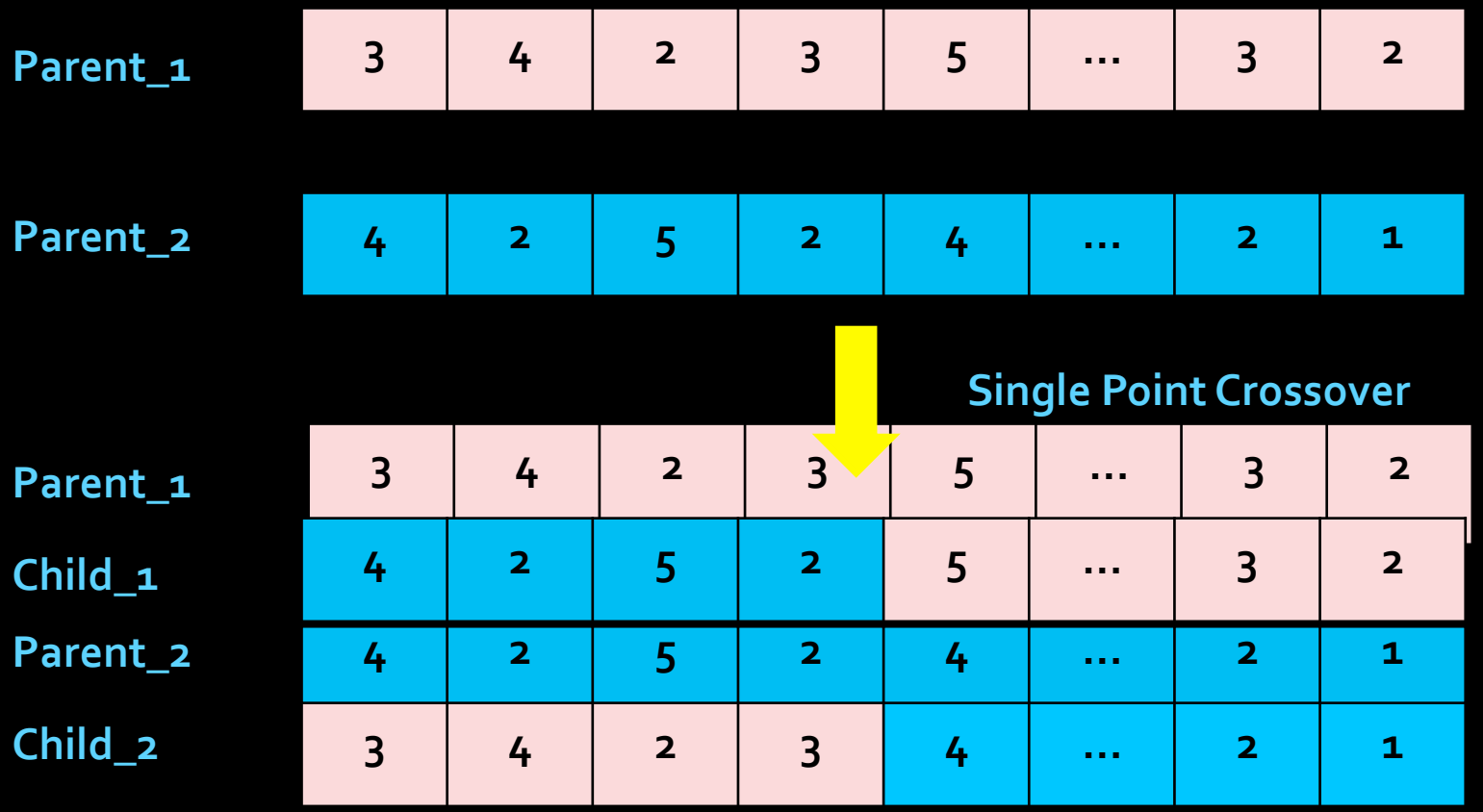
Genetic Operator on TC



Solution Representation of WPO

How to put the WPs in a perfect or near perfect order?

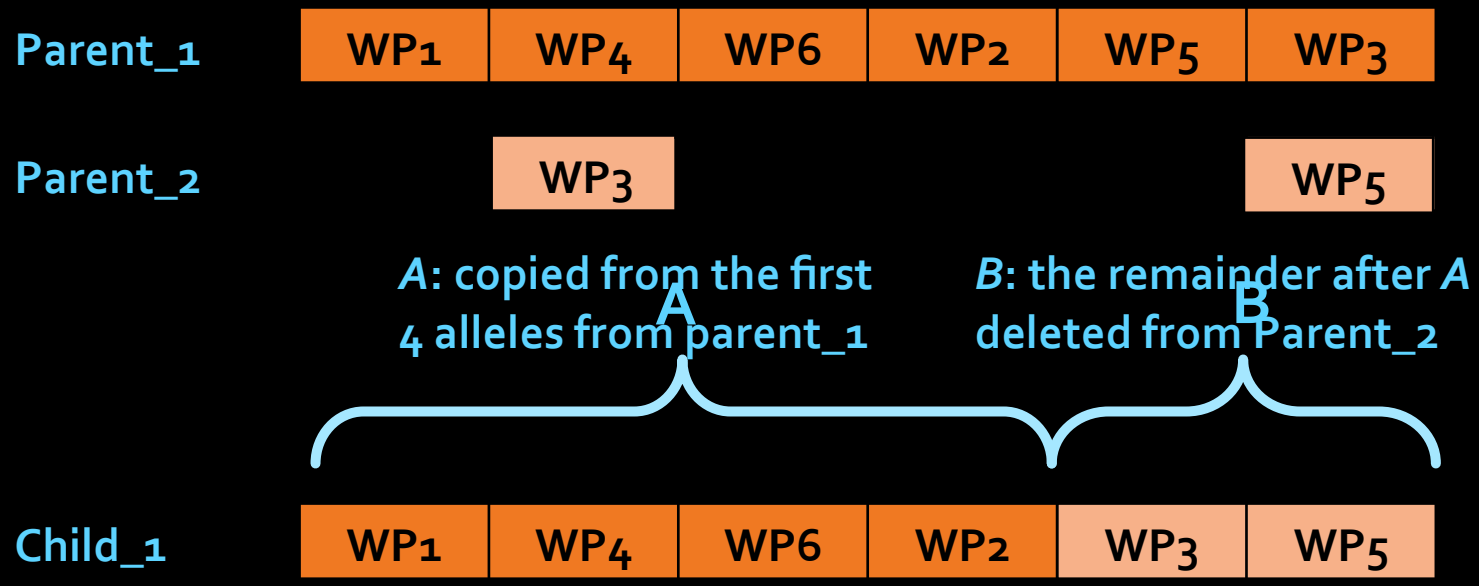
Perfect ordering = All teams are busy all the time and finish their last WP at the same time

Solution:

Species #2: orderings of the WPs

Genetic Operator on WPO

Genetic Operator on WPO



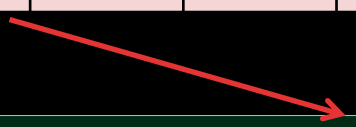
Fitness Evaluation

Objective

Earlier Overall Completion Time = Higher Fitness

	Staff 1	Staff 2	Staff 3	…	Staff n-1	Staff n
To Team	3	4	2	…	3	2

	WP1	WP4	..	WP60
Efforts	8	4		12



Processing Simulator

The `Best` available team picks the next WP before other available teams.

First Come First Served:

One WP blocks the queue of waiting WPs until its predecessors are all finished.

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Fitness Evaluation

Objective

Earlier Overall Completion Time = Higher Fitness

Processing Simulator

	T1	T2	…	T5
Capacity	6 staff	8 staff	…	7 staff
Date (it becomes available)	0	0	…	0

	WP1	WP4	..	WP60
Efforts	8	4		12
Start Time				
Finish Time				
To Team				

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Fitness Evaluation

Objective

Earlier Overall Completion Time = Higher Fitness

Processing Simulator

	T1	T2	...	T5
Capacity	6 staff	8 staff	...	7 staff
Date (it becomes available)	0	1st Day	...	0

	WP1	WP4	..	WP60
Efforts	8	4		12
Start Time	0th Day			
Finish Time	1st Day			
To Team	T2			

Fitness Evaluation

Objective

Earlier Overall Completion Time = Higher Fitness

Processing Simulator

	T1	T2	…	T5
Capacity	6 staff	8 staff	…	7 staff
Date (it becomes available)	22nd Day	21st Day	…	21st Day

	WP1	WP4	..	WP60
Efforts	8	4		12
Start Time	0th Day	0th Day		20th Day
Finish Time	1st Day	0.5th Day		22nd Day
To Team	T2	T3		T1

The latest finishing time is the overall completion time of a simulation.

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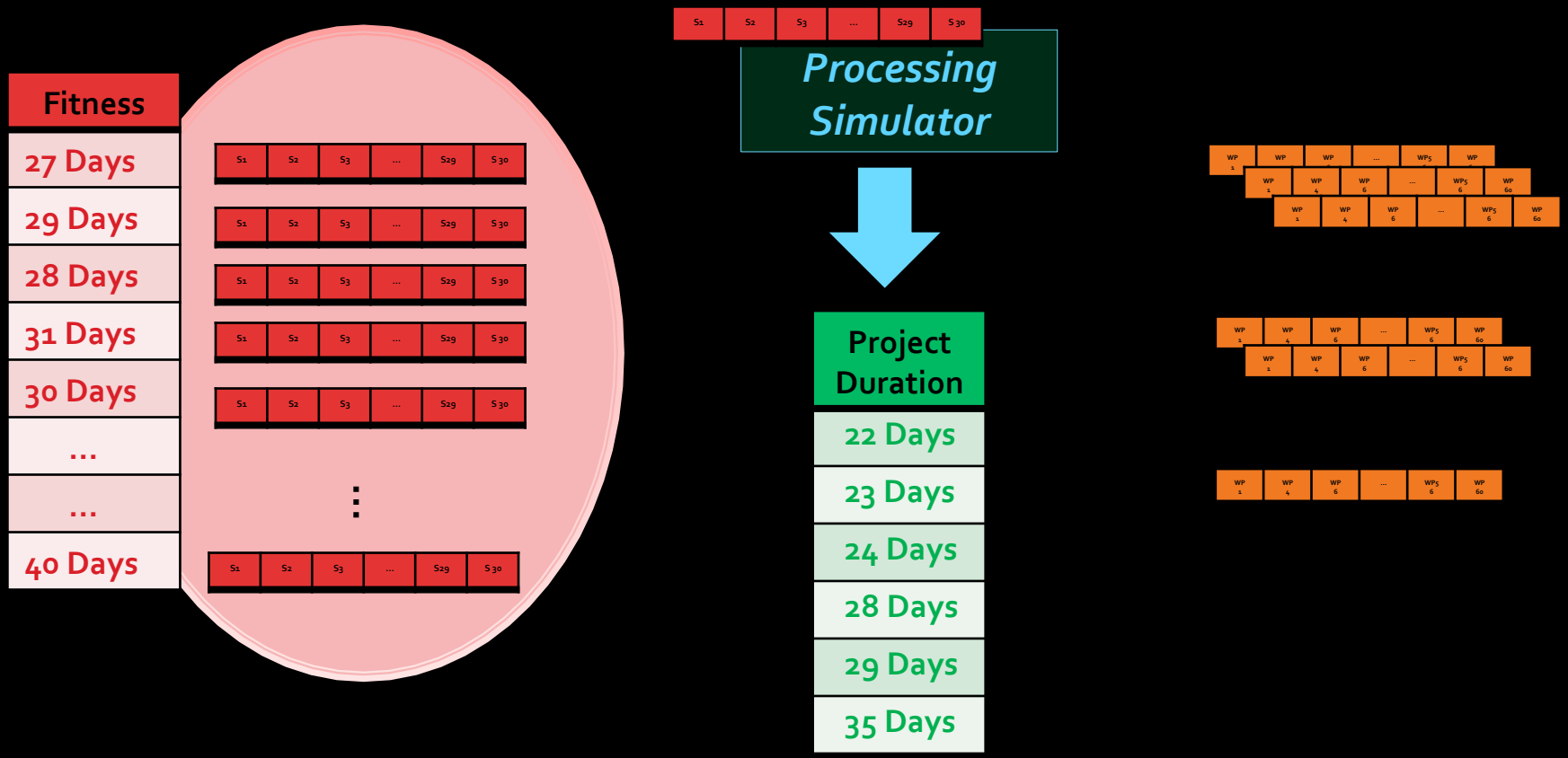
Cooperative Co-Evolutionary Process



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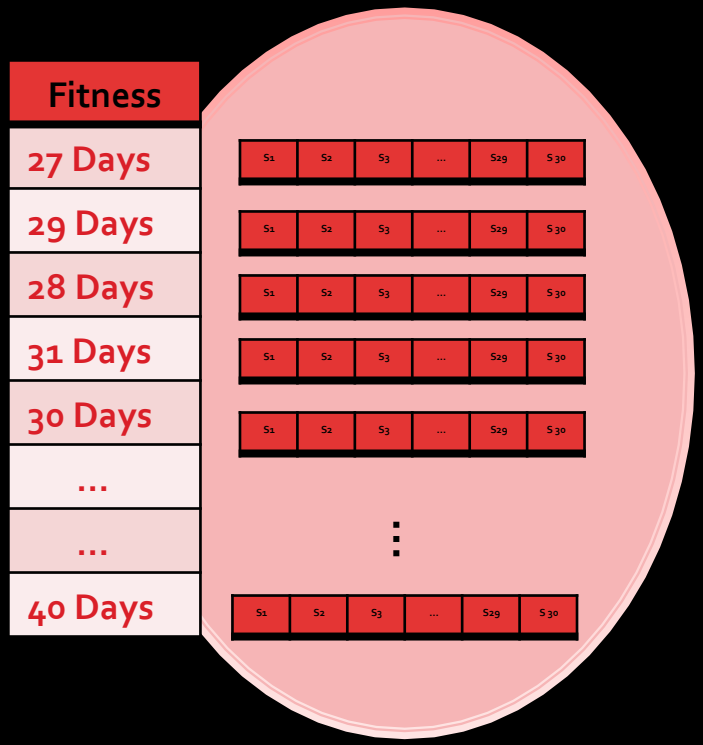
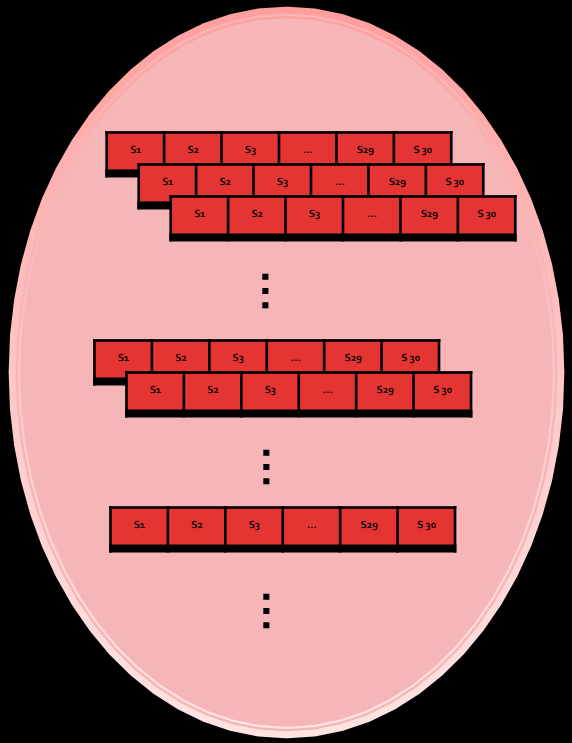


The next generation will be formed according to the fitness values.

Cooperative Co-Evolutionary Process



New generation formed, individuals are the sorted. It is ready to either reproduce or help the other specie to evolve.

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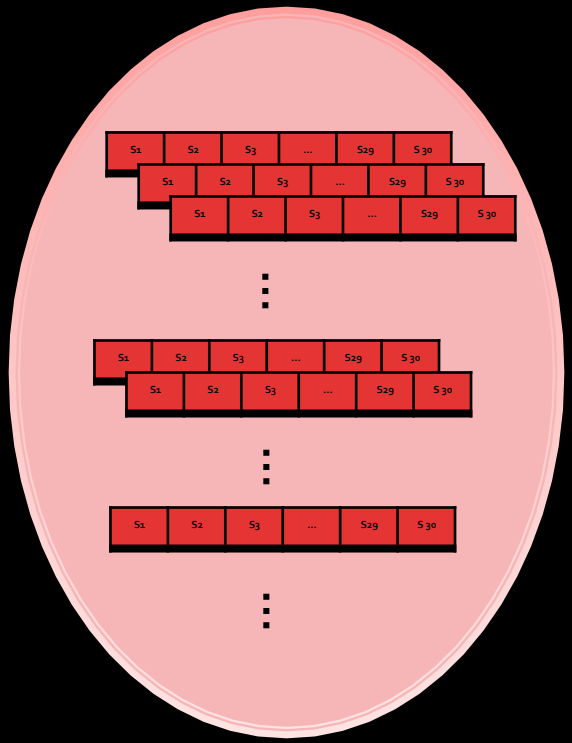
Cooperative Co-Evolutionary Process



if chose to reproduce

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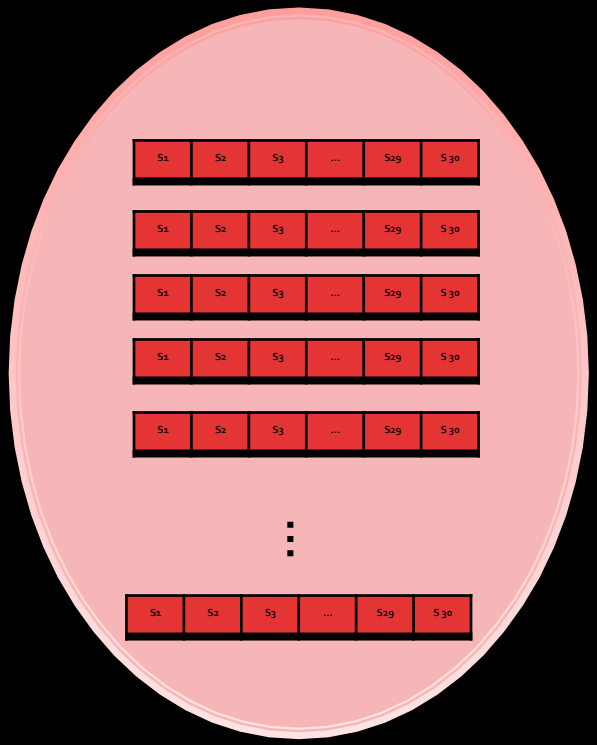
Cooperative Co-Evolutionary Process



then reproduce

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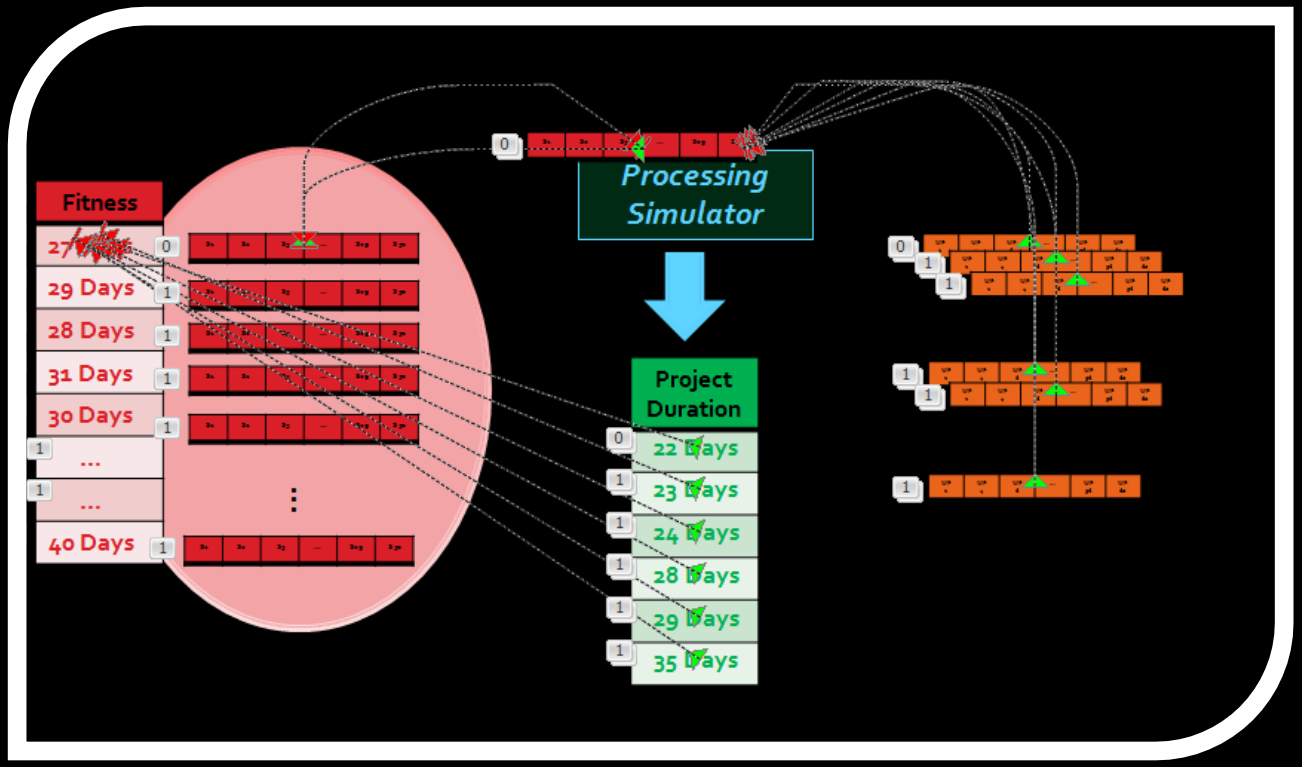
Cooperative Co-Evolutionary Process

and evaluate and select the best to form the next generation



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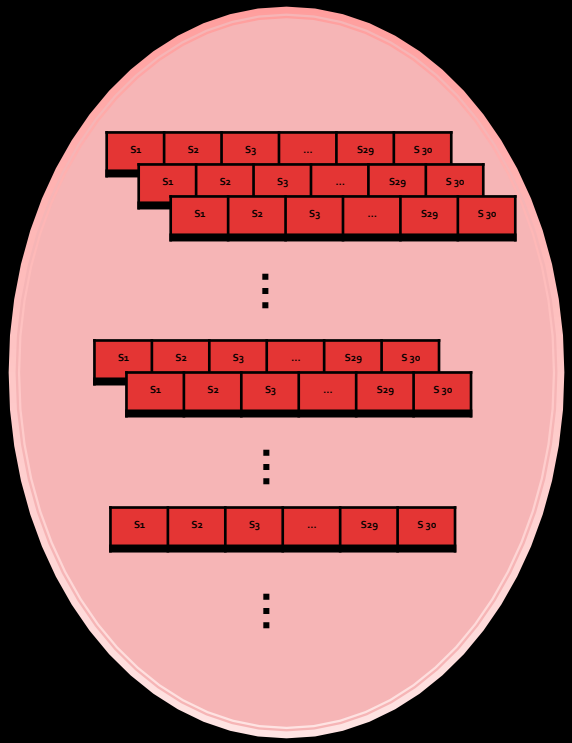

if chose to help the other population to evolve

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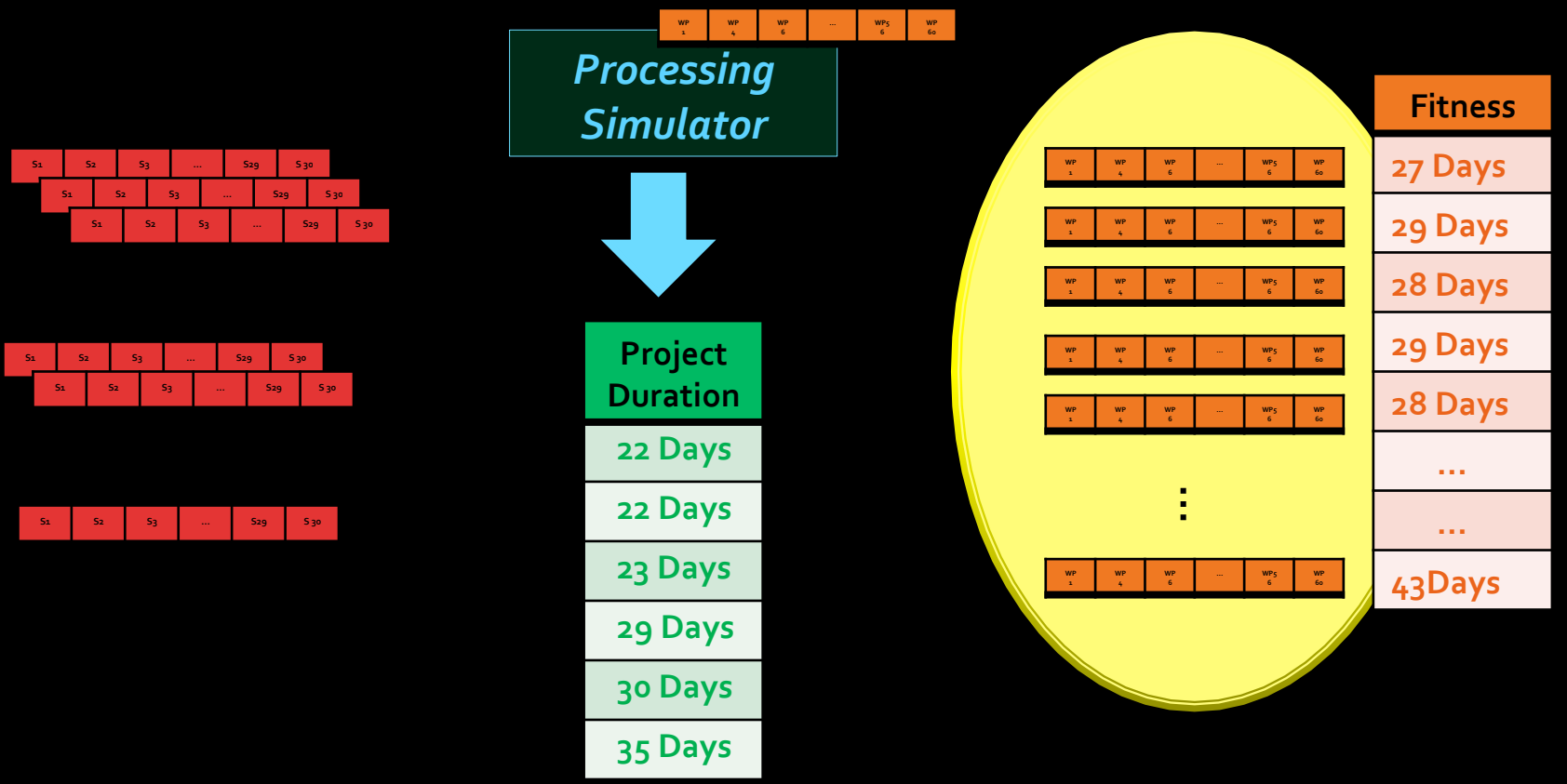
Cooperative Co-Evolutionary Process



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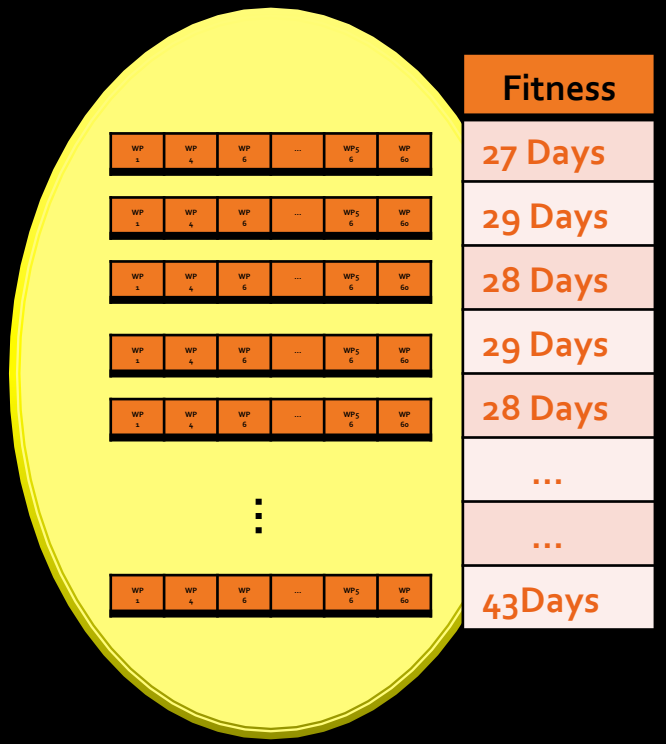

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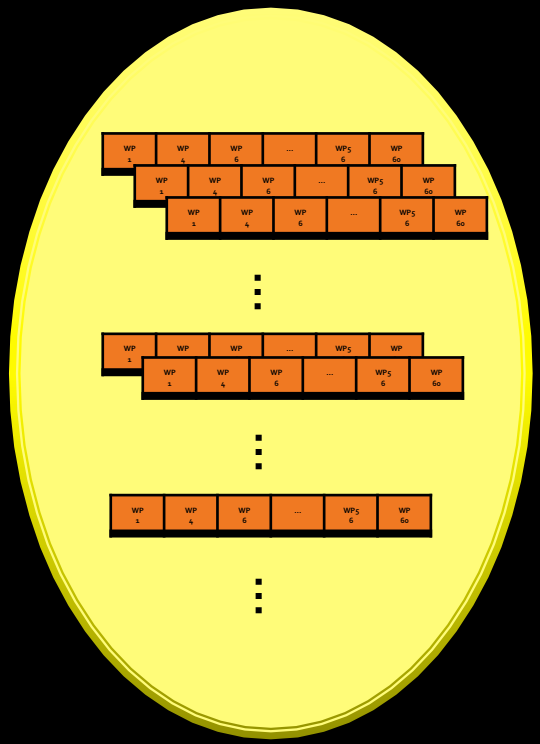
Cooperative Co-Evolutionary Process

New generation formed

To reproduce
Or to help the other specie to evolve



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Research Questions

RQ0: (Sanity Check)

Do CCEAs outperform random search?

RQ1: (Effectiveness)

How effective is the CCEA approach compared to the alternatives in terms of finding an earlier completion time?

RQ2: (Efficiency)

Given the same number of evaluations, which algorithm finds the best-so-far solution soonest?

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Experimental Setup

apply 3 sets of configurations

Configurations for CCEA	Internal Generation Num	External Generation Num
I	1	100
II	10	10
III Classic GA	100	1

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on 4 real-world projects

Projects	#WPs	#Dep.	Total Efforts (Person-Days)
A	84	0	536
B	120	102	594
C	253	226	833
D	60	57	68

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runs it 30 times for each combination above

Software Projects

Projects	#WPs	#Dep.	Total Efforts (Person-Days)
A	84	0	536
B	120	102	594
C	253	226	833
D	60	57	68

Project A

Massive, fixing Y2K problem, NO dependency

Project B

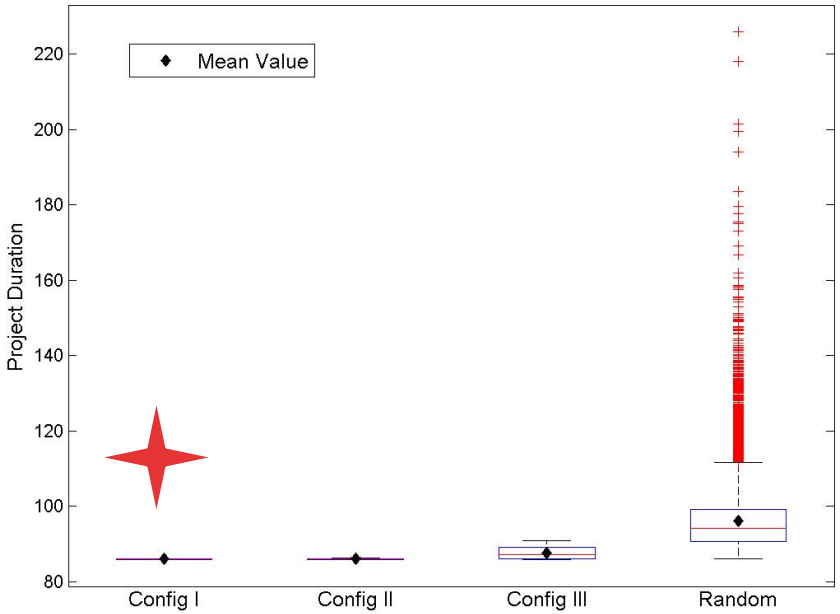
Large data-intensive, multi-platform software system

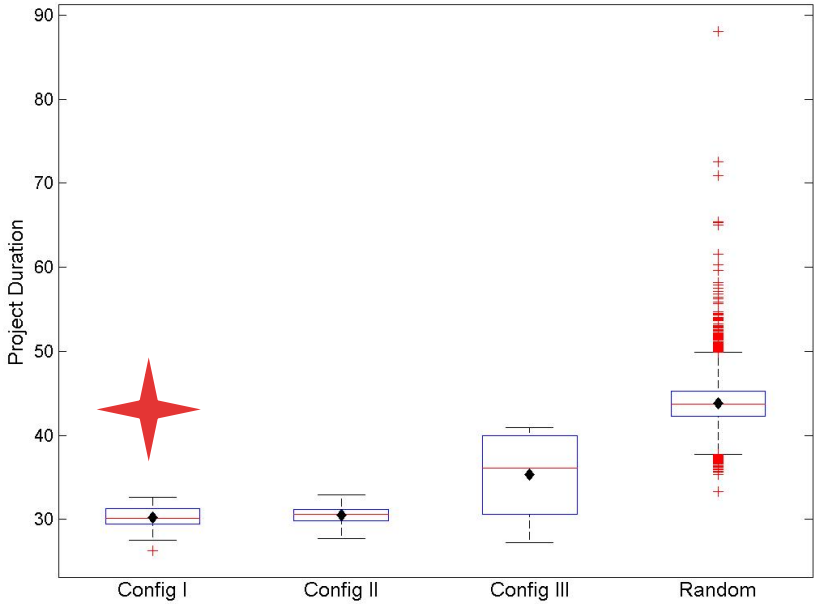
Project C (SoftChoice.com)

Online selling system, hard/software, solutions

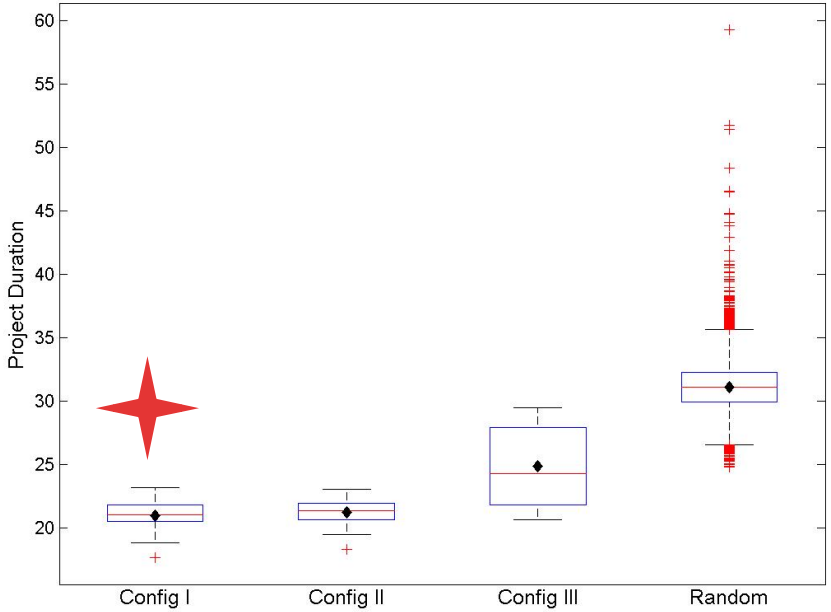
*Project D (*QuoteToOrder *)*

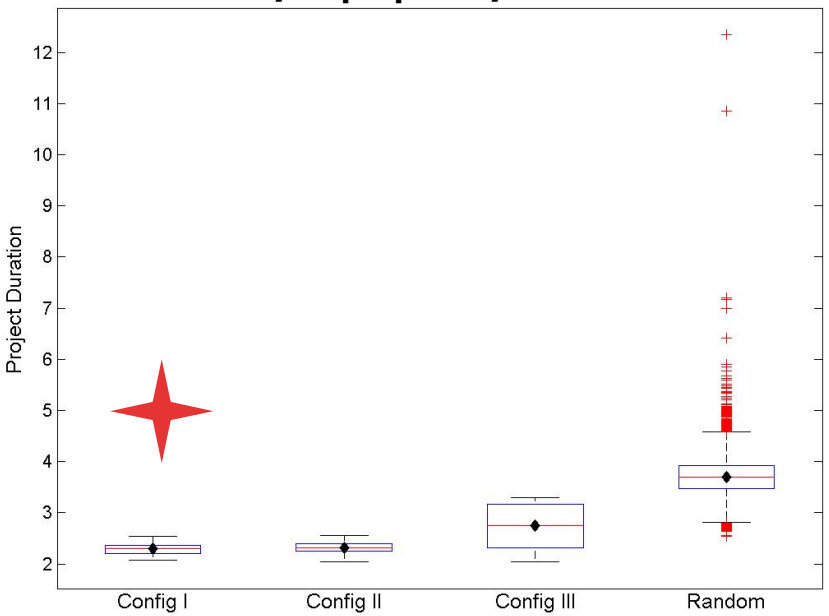
Medium sized project, change on a large sales company





Best solutions found in each of 30 runs on CCEAs, 1-pop GA, Random





Statistical Analysis (Wilcoxon Rank Sum Test)

p-values for WRST	Projects			
	A	B	C	D
Config. I vs II	0.7229	0.1885	0.4481	0.2449
Config. I vs III	5.04E-08	3.00E-11	2.78E-07	2.19E-07
Config. II vs III	1.47E-07	8.86E-10	2.08E-06	1.28E-06
Config. I vs Random	3.97E-40	3.82E-40	3.83E-40	3.83E-40
Config. II vs Random	3.97E-40	3.82E-40	3.83E-40	3.83E-40
Config. III vs Random	2.70E-30	6.04E-37	3.13E-36	3.66E-36

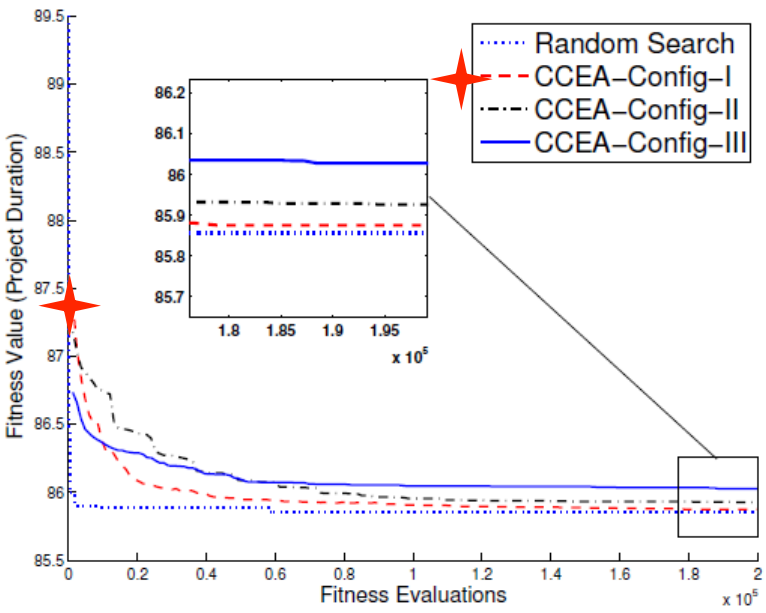
Row#1: No significant difference on two proper CCEAs

Row#2&3: Diff. between CCEAs and Classic GA are statistically significant

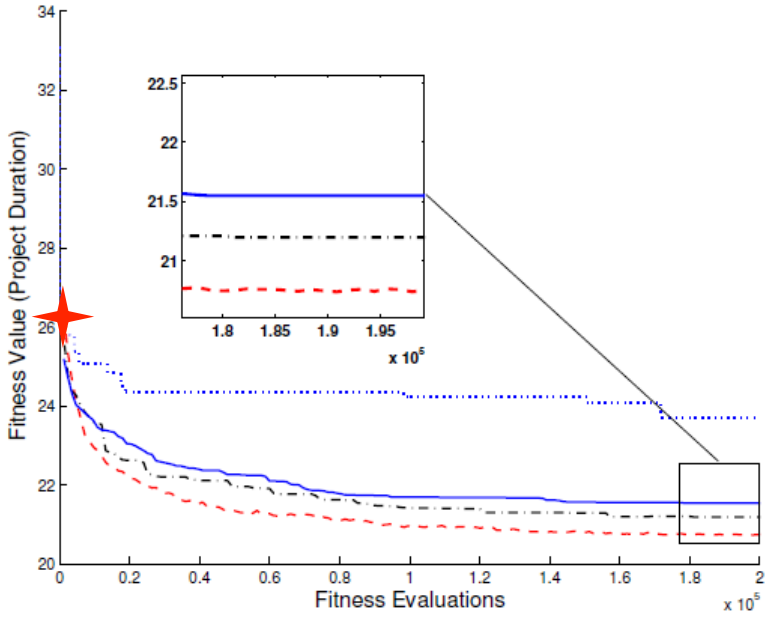
Row#4-6: GAs are all significantly better than Random

Project

A

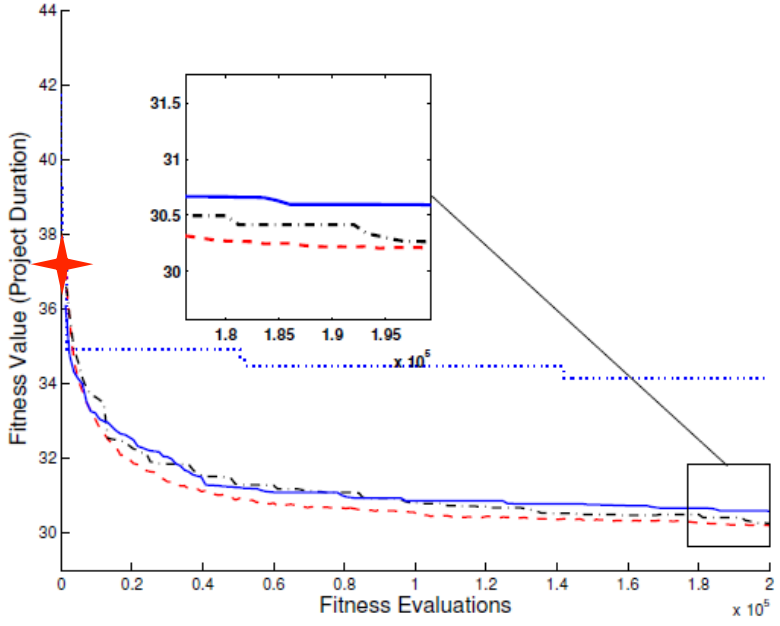


B

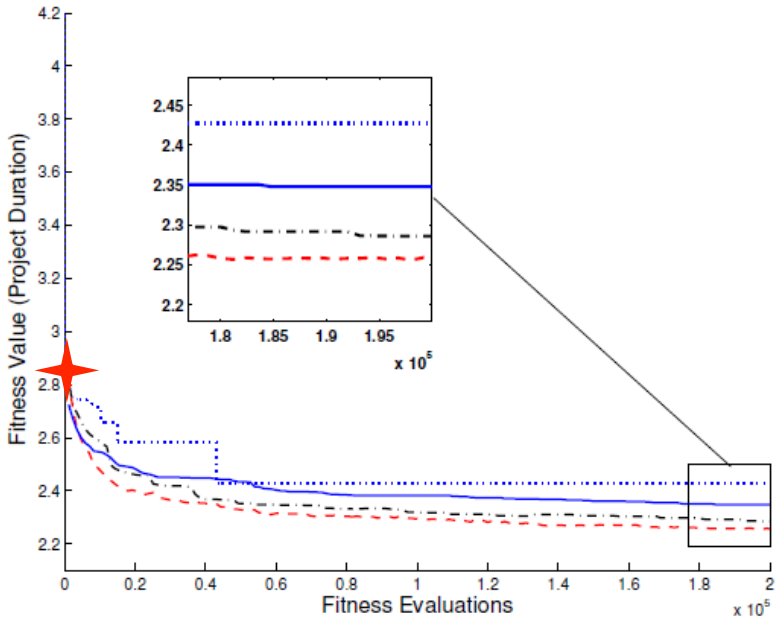


Best solutions found so far over time

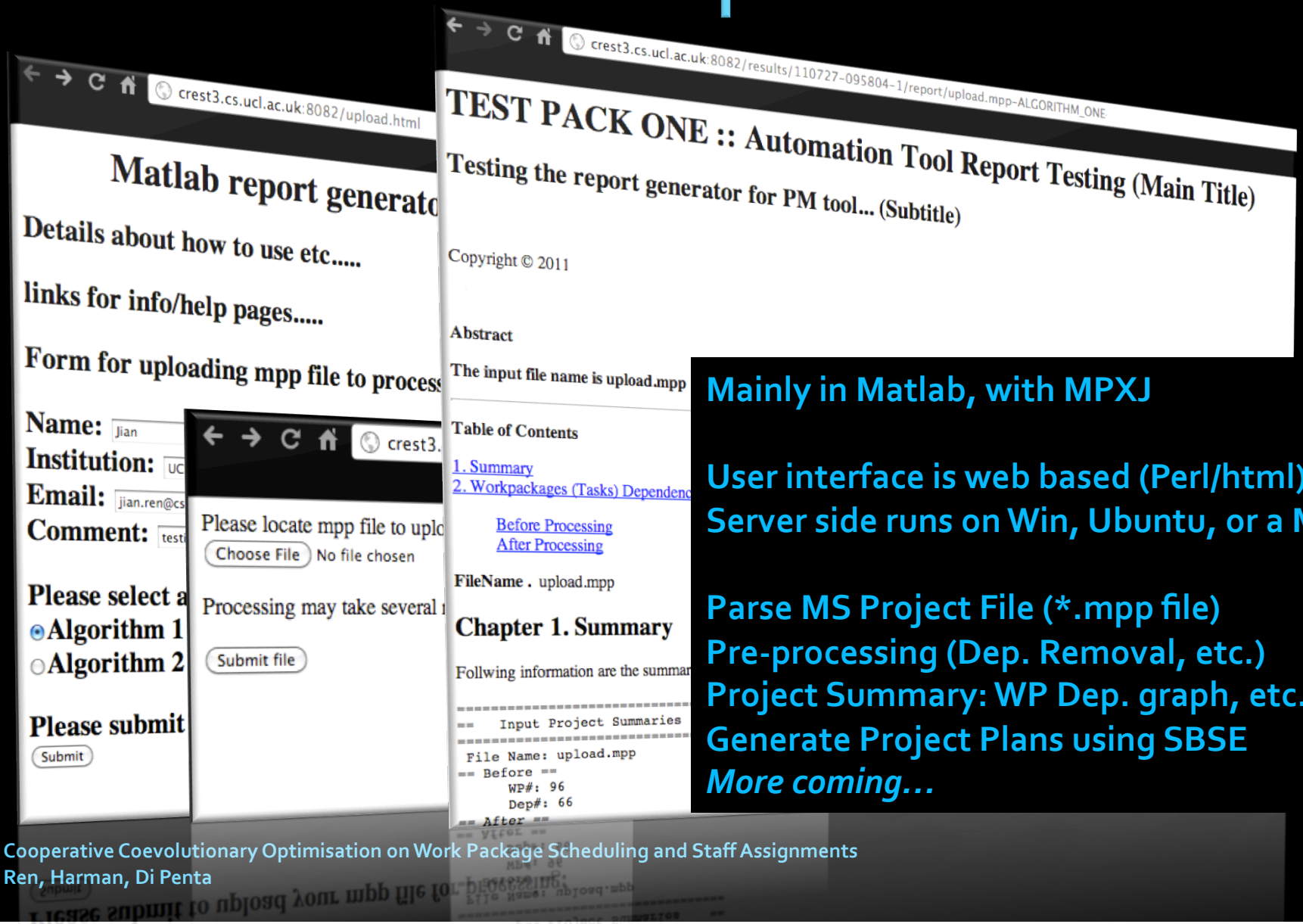
C



D



Automatic Plan Report Generator



Mainly in Matlab, with MPXJ

User interface is web based (Perl/html).
Server side runs on Win, Ubuntu, or a Mac.

Parse MS Project File (*.mpp file)
Pre-processing (Dep. Removal, etc.)
Project Summary: WP Dep. graph, etc.
Generate Project Plans using SBSE
More coming…

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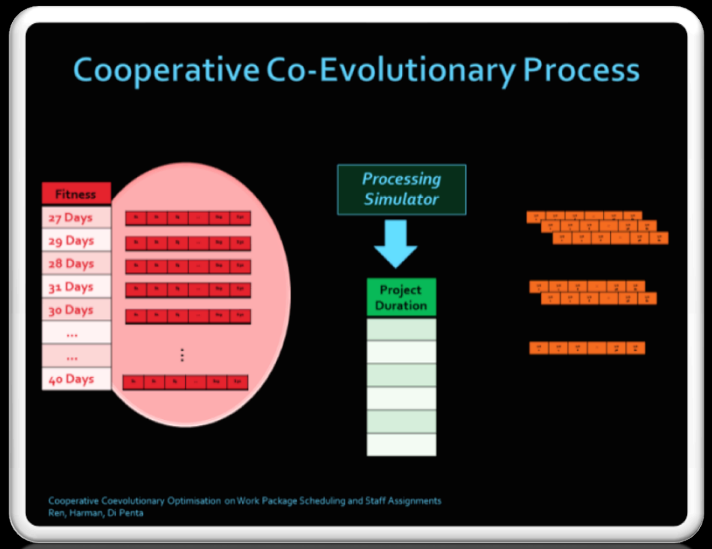
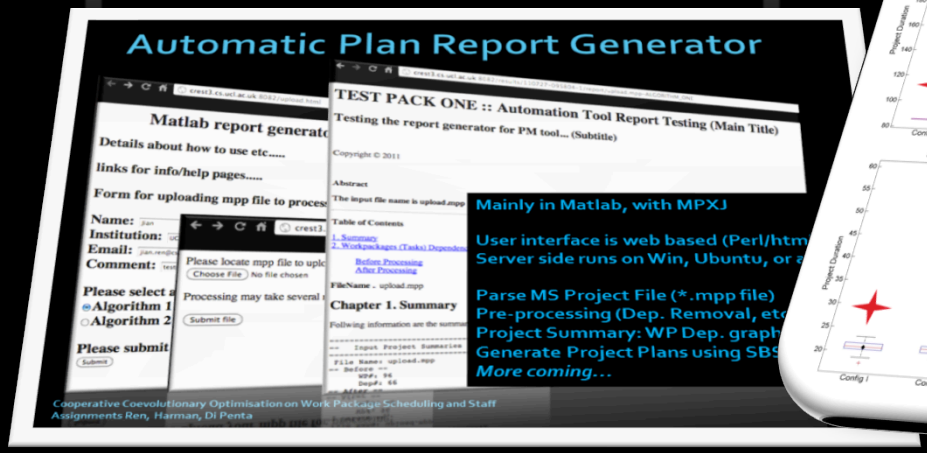
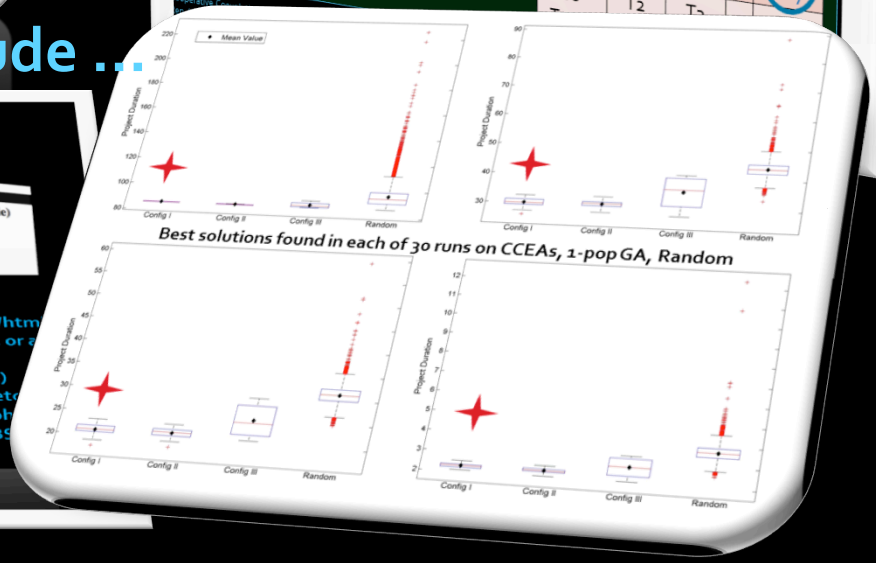


To conclude …





CCEA Optimisation also suitable for dividing a large software engineering problem into smaller solvable ones.

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