# Migration and Replacement Policies for Preserving Diversity in Dynamic Environments

David Millán-Ruiz and J. Ignacio Hidalgo (dmr@tid.es and hidalgo@dacya.ucm.es)

## Introduction

• It is not always straightforward to control the internal dynamics of a PGA based on the island model, especially whether we seek to ensure a *fair balance between exploration and exploitation* in the search process within a dynamic environment.

• The main **contribution** of this work lies in the determination of the *right setting-up* for a PGA when it is applied to *highly dynamic environments*.

• We also propose *new policies,* which are inspired in other domain's solutions, to preserve a fair balance between exploration and exploitation in the search process.

•Finally, we test out those policies in *three different topologies* in order to analyse their impact under *two different scenarios* which correspond to *real data* extracted from a multi-skill call centre.

## State of the art

• Pettey (1987) put forward a distributed model in which the best-fitted individuals of each node were migrated to each neighbour node in each generation, fully replacing the worst-fitted individuals

• Tanese (1987) proposed a parallel implementation where each population was broken into a small number of subpopulations.

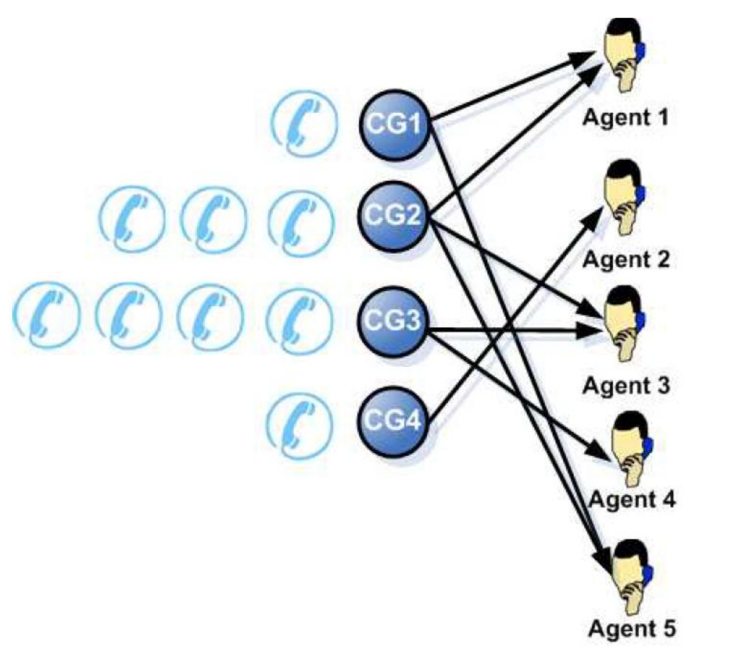
• Gordon (1992) and Adamidis (1994) reinforced the term of island model in their parallel proposals, while Collins (1992) launched a grid model where individuals were placed in a node and interacted with their neighbours.

• More recently, Lozano (2008) put forward an explicit measure of diversity which entailed the replacement of existing individuals with lower values for the features being measured.

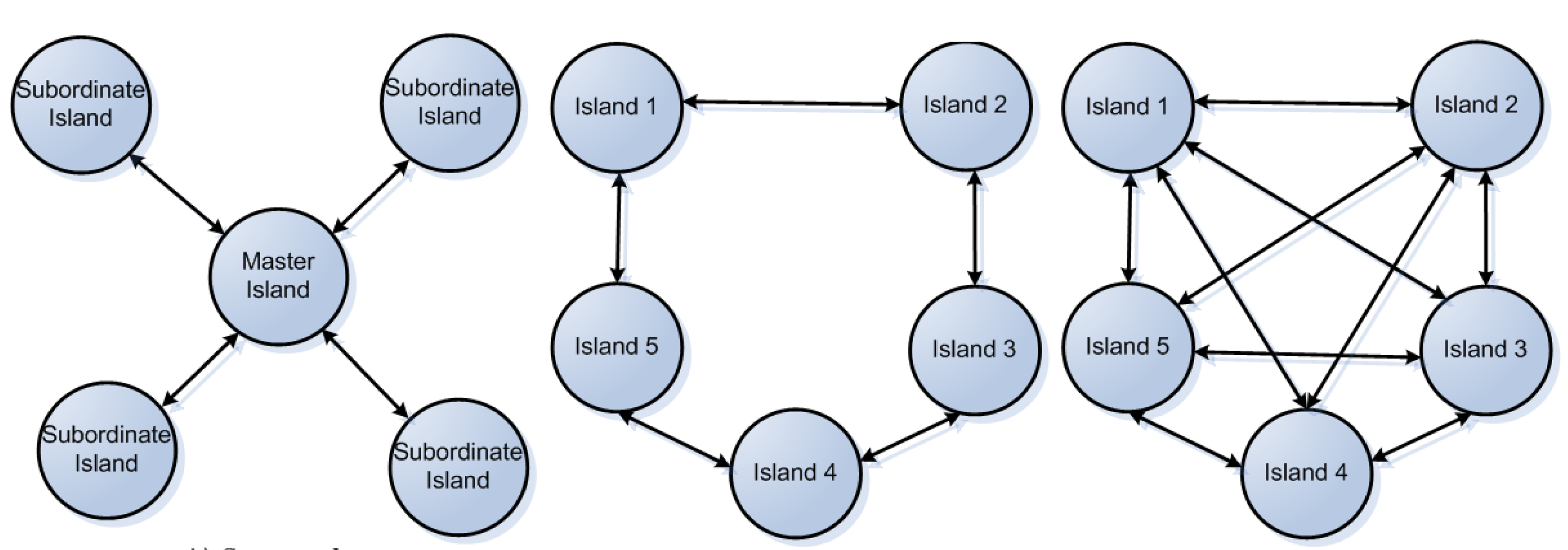
• Rucinski (2010) examined the impact of the migration topology on the island model.

• Araujo (2011) investigated, on a real parallel setup, a new strategy to enhance diversity in the island model.

## Setting-up of the PGA




• **Methodology**: Some PGA parameters have been fixed (migration frequency, amount of migrants, synchronism type, number of processing nodes, same configuration in the isolated islands, and stopping condition) while others have been varied (topology and migration and replacement policies) in order to understand what policies perform best in dynamic environments.




A) Star topology B) Ring topology C) All-to-all topology

| *Migration and replacement policies* | |
|---|---|
| BFI-WFI | Best-fitted individuals by worst-fitted individuals |
| BFI-RI | Best-fitted individuals by random individuals. |
| BFI-BFI | Best-fitted individuals by best-fitted individuals |
| BFI-MDI | Best-fitted individuals by most different individuals |
| **BFIA-WFI** | **Best-fitted individual + "Annealing" by worst-fitted individuals** |

## Configuration

| Parameter | Configuration |
|---|---|
| Encoding | Solution as an array of integers whose indexes represent the available agents at a given instant and the array contents refer to the profile assigned to each agent |
| Population size | 30 individuals |
| Initialization | Randomly generated |
| Selection | Binary tournament selection |
| Crossover | The offspring inherits the common points in their parents and randomly receives the rest of genes from them |
| Mutation | Probability of 0.03 |
| GA | Elitism steady-state scheme |
| Fitness function | We measure the service level resulting from the configuration of agents and incoming call |
| Number of islands | 5 populations |
| Topologies | Star, Bidirectional ring, All-to-All |
| Migration frequency | 60 seconds |
| Amount of migrants | 10% of population |

## Experimental Results & Conclusions

| Policy | Topology | Min | Max | Mean | SD | Rank |
|---|---|---|---|---|---|---|
| *BFI-WFI* | Star | 0.846698 | 0.847310 | 0.847092 | 0.0003 | 9 |
| *BFI-RI* | Star | 0.846744 | 0.847361 | 0.847102 | 0.0003 | 8 |
| *BFI-BFI* | Star | 0.846195 | 0.847068 | 0.846511 | 0.0004 | 12 |
| *BFI-MDI* | Star | 0.847119 | 0.847742 | 0.847471 | 0.0003 | 5 |
| *BFIA-WFI* | Star | 0.847119 | 0.847742 | 0.847489 | 0.0003 | 4 |
| *BFI-WFI* | Ring | 0.847141 | 0.848006 | 0.847535 | 0.0004 | 3 |
| *BFI-RI* | Ring | 0.846933 | 0.847908 | 0.847290 | 0.0004 | 7 |
| *BFI-BFI* | Ring | 0.847119 | 0.847742 | 0.847364 | 0.0003 | 6 |
| *BFI-MDI* | Ring | 0.853954 | 0.860611 | 0.858281 | 0.0031 | 2 |
| ***BFIA-WFI*** | **Ring** | **0.857322** | **0.861109** | **0.859702** | **0.0017** | **1** |
| *BFI-WFI* | Hub | 0.846149 | 0.847488 | 0.846856 | 0.0005 | 10 |
| *BFI-RI* | Hub | 0.846654 | 0.847201 | 0.846848 | 0.0002 | 11 |
| *BFI-BFI* | Hub | 0.834190 | 0.835465 | 0.834838 | 0.0005 | 14 |
| *BFI-MDI* | Hub | 0.831358 | 0.831984 | 0.831603 | 0.0003 | 15 |
| *BFIA-WFI* | Hub | 0.845520 | 0.846874 | 0.846378 | 0.0006 | 13 |

**MEDIUM-DIFFICULTY PROBLEM INSTANCE**

| Policy | Topology | Min | Max | Mean | SD | Rank |
|---|---|---|---|---|---|---|
| *BFI-WFI* | Star | 0.793660 | 0.793941 | 0.793796 | 0.0001 | 8 |
| *BFI-RI* | Star | 0.794102 | 0.794197 | 0.793561 | 0.0008 | 9 |
| *BFI-BFI* | Star | 0.791377 | 0.792888 | 0.792280 | 0.0007 | 12 |
| *BFI-MDI* | Star | 0.794265 | 0.794932 | 0.794693 | 0.0003 | 5 |
| *BFIA-WFI* | Star | 0.794288 | 0.795012 | 0.794688 | 0.0003 | 6 |
| *BFI-WFI* | Ring | 0.794610 | 0.795595 | 0.795223 | 0.0004 | 3 |
| *BFI-RI* | Ring | 0.794677 | 0.795216 | 0.794978 | 0.0002 | 4 |
| *BFI-BFI* | Ring | 0.794313 | 0.795221 | 0.794654 | 0.0004 | 7 |
| *BFI-MDI* | Ring | 0.792158 | 0.798497 | 0.796137 | 0.0028 | 2 |
| ***BFIA-WFI*** | **Ring** | **0.795679** | **0.798864** | **0.797696** | **0.0014** | **1** |
| *BFI-WFI* | Hub | 0.792373 | 0.792873 | 0.792669 | 0.0002 | 11 |
| *BFI-RI* | Hub | 0.791816 | 0.793589 | 0.792864 | 0.0008 | 10 |
| *BFI-BFI* | Hub | 0.790809 | 0.791874 | 0.791324 | 0.0004 | 14 |
| *BFI-MDI* | Hub | 0.790148 | 0.791492 | 0.790646 | 0.0006 | 15 |
| *BFIA-WFI* | Hub | 0.791097 | 0.791840 | 0.791566 | 0.0003 | 13 |

**HIGHLY-DIFFICULTY PROBLEM INSTANCE**

- Every configuration was run 30 times over two problem instance *of* real data taken from our call centre during two different days at the same hour: a one-day campaign and a normal day.
- Bidirectional ring seems to be the most appropriate topology for dynamic environments, most likely because this topology allows for opportune convergence while preserving the required diversity.
- Star topology also entails high-quality outcomes but quickly gets stagnated. The reason is that the master island receives many migrants from the subordinate islands after some migrations, implying that populations eventually become very similar. This intuitively involves a lack of diversity so that the gain of fitness gets fatally damaged. This phenomenon affects much more strongly to the hub topology.
- Replacing the worst-fitted individuals in the receiving population by the best-fitted individuals of the source population does not always behave better than taking the most different individuals. It implies that the PGA can run fewer generations but entails better fitness values in the end.
- Fitness-based comparisons can occasionally be deceptive.
- Replacing the best-fitted individuals by the best-fitted ones implies a slower convergence.

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