CZECH TECHNICAL UNIVERSITY IN PRAGUE

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Parallel Genetic Algorithms

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- Which of the above can be parallelized easilly???

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But first:

- The difference between parallel model and parallel implementation.

Parallel Implementation vs. Parallel Model

Sequential implementation:

- The algorithm is able to run on a single machine in a single process, often in a single thread only.

Parallel implementation:

- The algorithm is able to take advantage of multiple CPU cores or multiple machines.

The effect of parallelization:

- Reduction in the solution time by *adding a computational power*.
- The speed-up should be proportional to the number of parallel machines.

Global model:

- The population is not divided in any way, the selection operator can consider all individuals.

Parallel model:

- The population is somehow divided into subpopulations, which limits mainly the selection operator.

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Possible combinations:

- Sequential implementation of the global model (usual case, simple GA)
- Parallel implementation of the global model (master-slave, brute-force speed-up)
- Sequential implementation of a parallel model (modified behavior)
- Parallel implementation of a parallel model (modified behavior, brute-force speed-up)

Parallelization of the Global Model

Master-slave model

Master

- runs the evolutionary algorithm, and
- controls the slaves, distributes the work.

Slaves

- take batches of individuals from the master,
- evaluate them, and
- send their fitness back to master.

Other possibilities:

- Sometimes we can parallelize also initialization, mutation, and (with a bit of care) crossover.
- The hardest parts to parallelize are selection and replacement.
- When does the parallelization actually pay off???

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Master-slave implementation does not change the behavior of the global model.

- Hints on implementation (locking, synchronizing) can be found in [Luk09, chap. 5].

[Luk09] Sean Luke. *Essentials of Metaheuristics*. 2009. available at http://cs.gmu.edu/∼sean/book/metaheuristics/.

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DEMO: Island model of PGA applied on TSP

`http://labe.felk.cvut.cz/~posik/pga`

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Migration topology: Where should we take the migrants from and where should we put them?

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  - topologies with the same DOC exhibit similar behavior
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  - diversity $\rightarrow$ convergence; population convergence vs. convergence in time

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Migration type: Can the migration events occur individually or in batches?

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- term *epoch* in the context of PGAs describes the part of evolution betweem 2 migration events

Other Parallel Models

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Also called *fine-grained PGA*:

- Population has a structure (1D grid, 2D toroidal grid, 3D cube, etc.)
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- Easy parallelization via multithreading.
- Very efficient model for *vector processors*, often found on GPUs:
  - many identical operations can be performed in parallel at one time

Model Combinations

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  - Can each deme use a *different fitness function*???

Injection Model

Heterogenous island model where

- each deme uses a different fitness function!!!
- Usable when many quality criteria must be assessed; each deme
  - concetrates on one criterion and
  - submits partial solutions to other demes to be reworked using another criterion.
- Each deme preserves solutions of high quality when only its particular criterion is applied.

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- Parallel models change the behavior of the EA:
  - they can reduce the danger of premature convergence and speed-up the algorithm in the same time.
- There are many possibilities on parallelization:
  - the optimal decision depends on the (parallel) computer architecture and on the task being solved
  - all possibilities introduce their own set of tunable parameters :-(