

**VERTEILTE SYSTEME**

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# DGPF

<http://dgpf.sourceforge.net/>

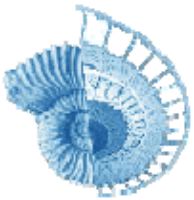
**An Adaptable Framework for Distributed Multi-Objective Search Algorithms Applied to the Genetic Programming of Sensor Networks**

BIOMA 2006

The 2nd International Conference on Bioinspired Optimization Methods and their Applications

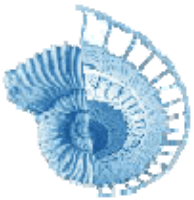
Tuesday, 2006-10-10, Session E, 15:20

Jožef Stefan International Postgraduate School, Jamova 39, 1000 Ljubljana, Slovenia



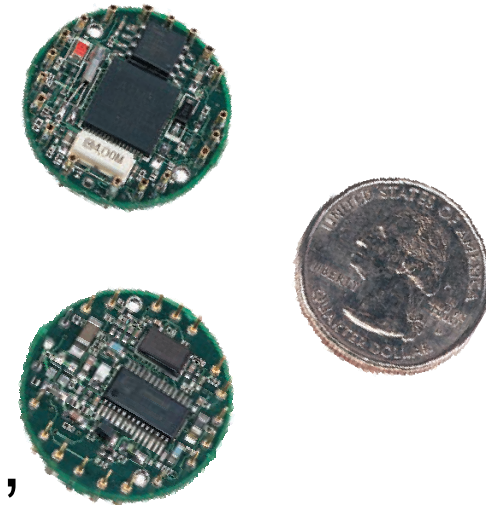
# Contents

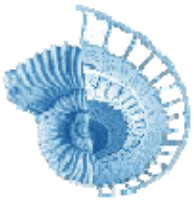
- Sensor Networks
- Representation for Algorithms
- Problems
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- Summary, Future Work, References



# Sensor Networks

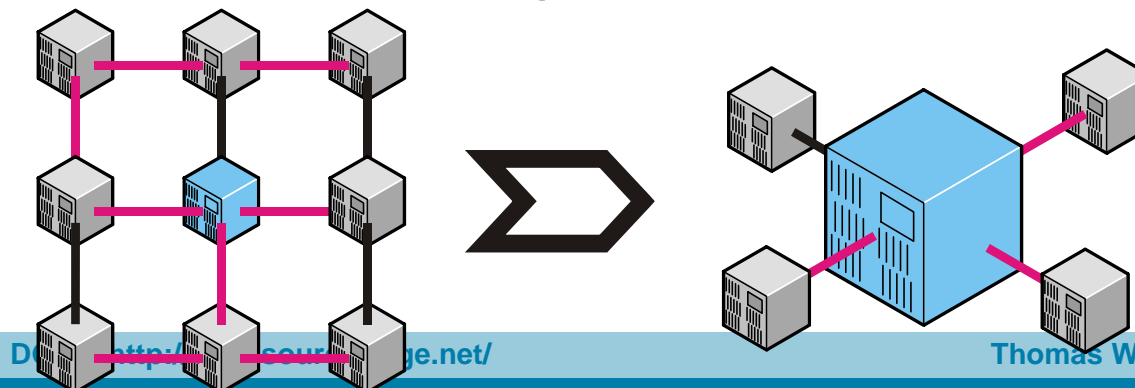
- Sensor nodes are small devices equipped with sensors and short range radio.
- Restricted in memory size, processing speed, and, most important, battery power
- Usually forming large scale distributed systems.
- Typical Applications:
  - Ecology (pollution, seismic activity, ethology)
  - Disaster Prevention (detection of forest fires, prediction of earthquakes, surveillance of contaminated areas)
  - Health Care, Military

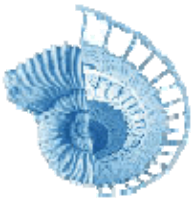




# Sensor Networks – Software Development

- Manual development: cumbersome, many things need to be regarded (routing, energy, ...)
- Using MDA: Model the application and let the MDA-system create the code.
  - Abstract model is simpler to understand
  - MDA tool generates code for modeled algorithm
- Extend this approach with GP: model the results wanted, instead of the algorithms





# Representation for Algorithms

- Algorithms must be simulated for fitness determination

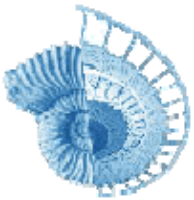
- Basic Instructions

- assembler-like
- Turing complete
- arithmetical operations
- conditional local jumps
- procedure calls
- interrupts for sensor/IO-data

## procedure\_0

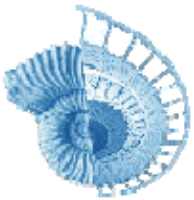
```
0: mem[1] = mem[1] % mem[0]
1: mem[0] = mem[0] % mem[1]
2: if zf then goto 6
3: if zf then call procedure_0
4: zf = (mem[1] >= mem[-1])
5: mem[0] = mem[1]
6: mem[-1] = mem[-1] + mem[1]
7: if zf then goto 3
8: mem[0] = mem[-1]
```

- Simulated on a virtual machine



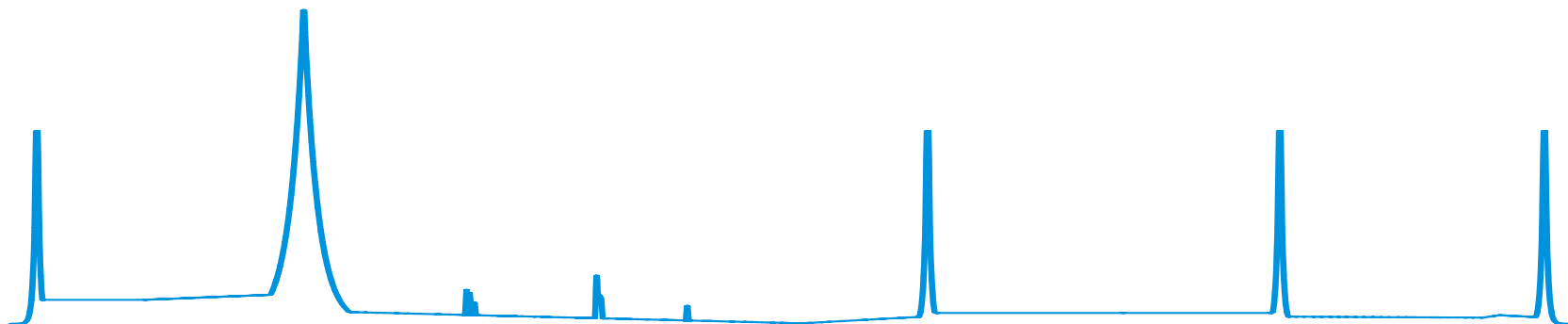
# Representation for Algorithms

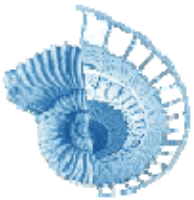
- Many virtual machines running asynchronously in a simulated network
  - messages are undirected radio broadcasts
  - will be received by any node in range
  - interrupt if message arrives
  - one node may only process one message at a time, other simultaneously arriving messages get lost
- Network extension to instruction set:
  - write to output buffer
  - send output buffer as a message



# Problems

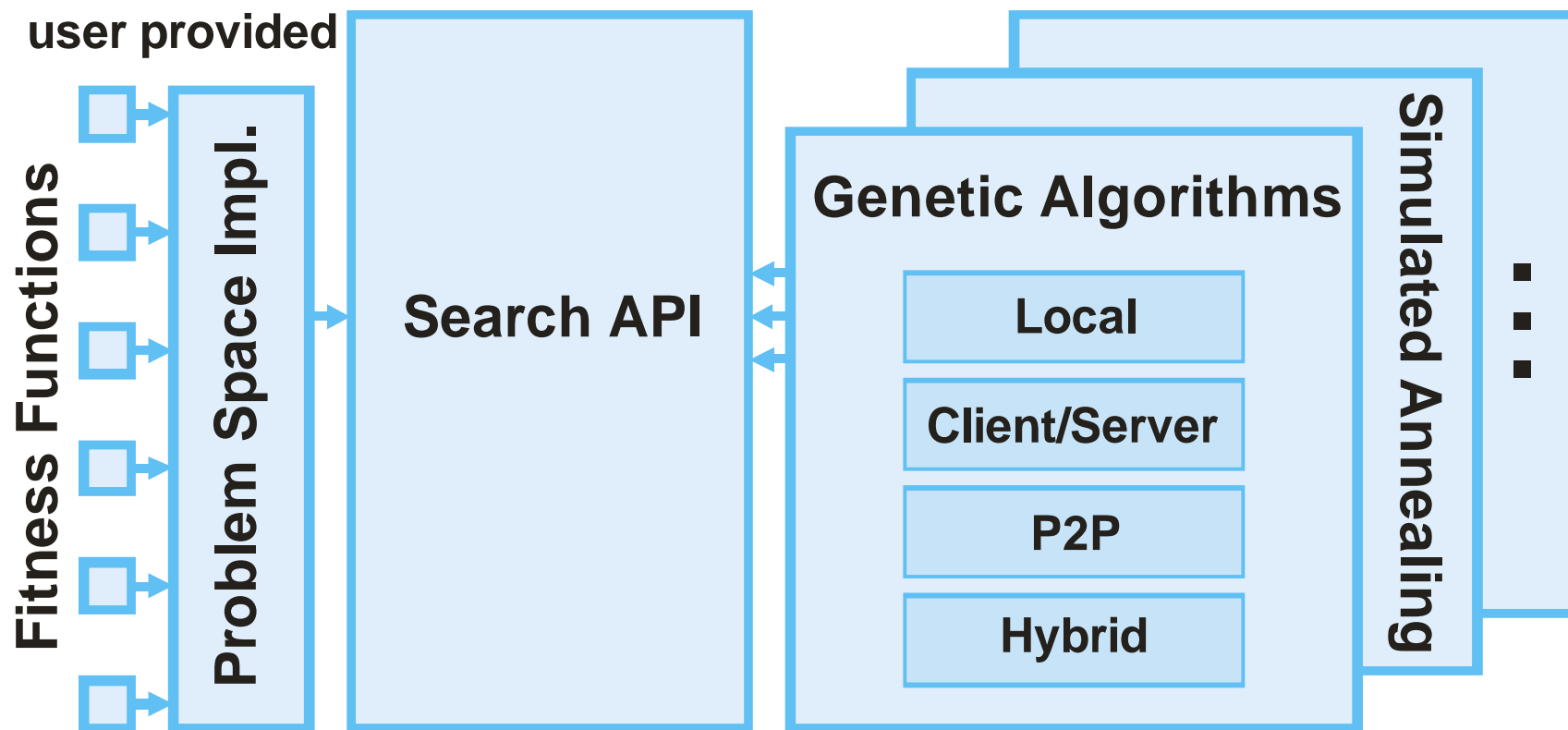
- Fitness landscapes of algorithms are rugged
- Check an algorithm's convergence speed – Fitness Functions need hooks "into the simulation"
- Need for multi-objective optimization:  
    functionality, code size, transmission count...
- Pareto-Optimal Set contains many useless programs  
(again producing useless offspring)

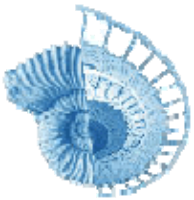




# Search API

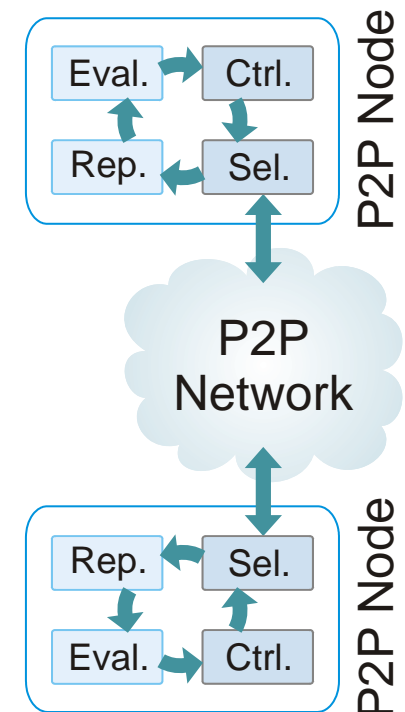
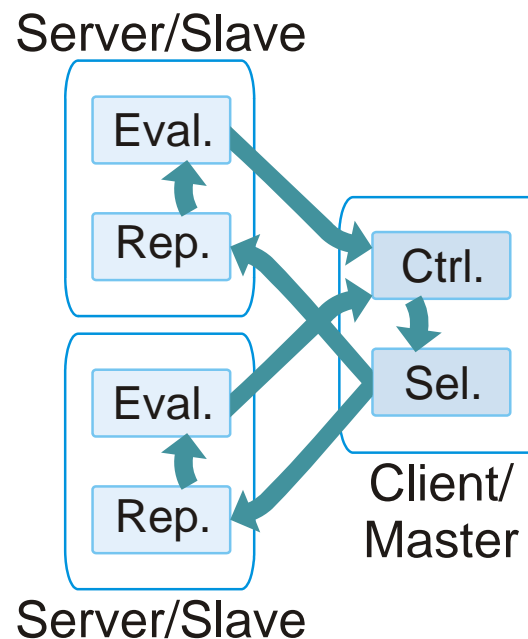
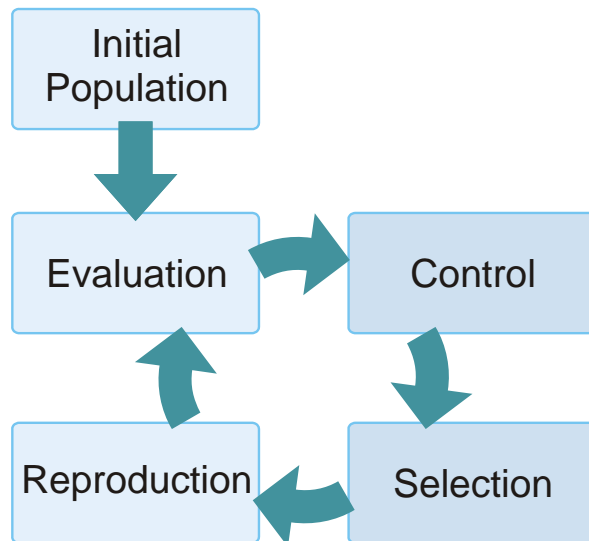
- Versatile search API with building blocks for search- and optimization algorithms

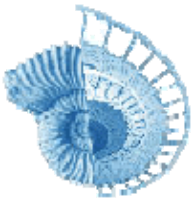




# Search API

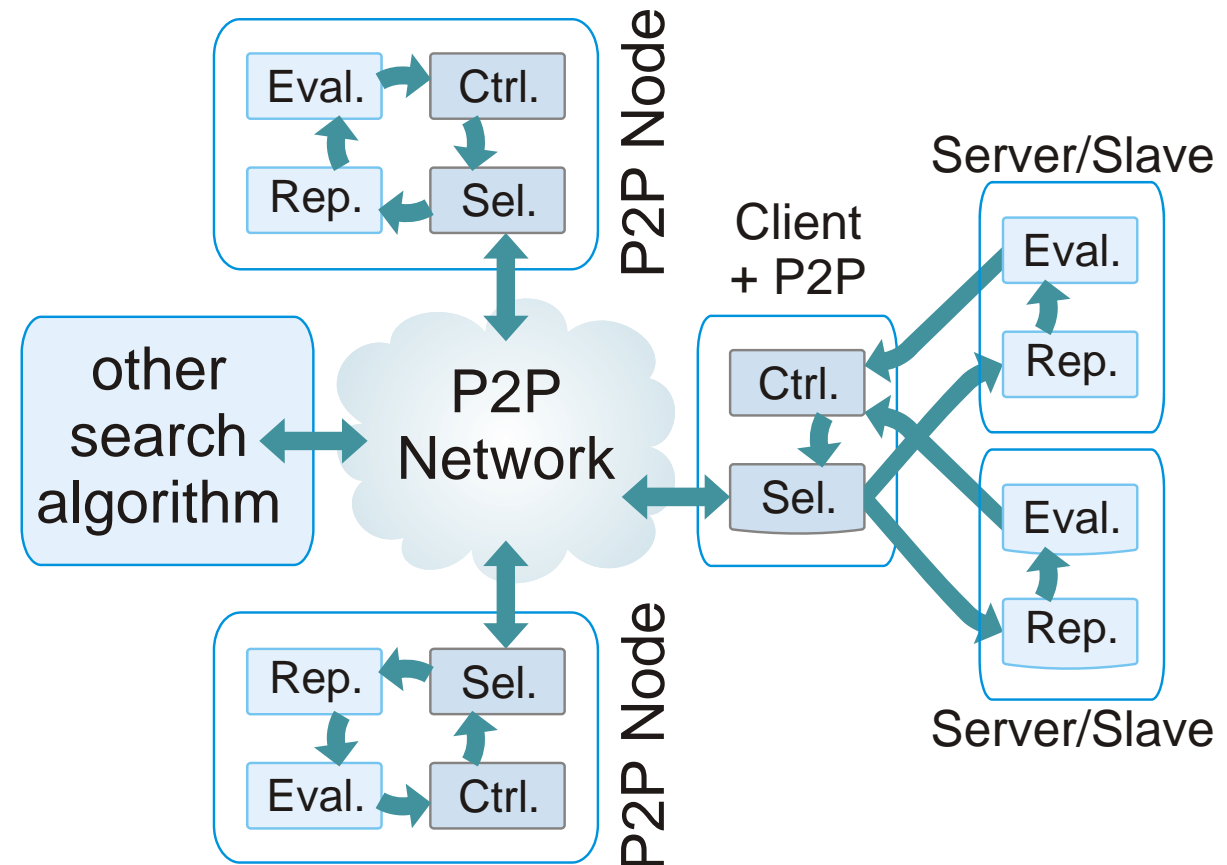
- Semantic mutation and crossover
- Prevalence: comparison of Individuals no longer based on strict domination but is user-defined
- Distribution utilities: C/S, P2P, C/S-P2P

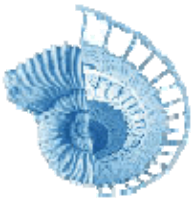




# Heterogeneous Search

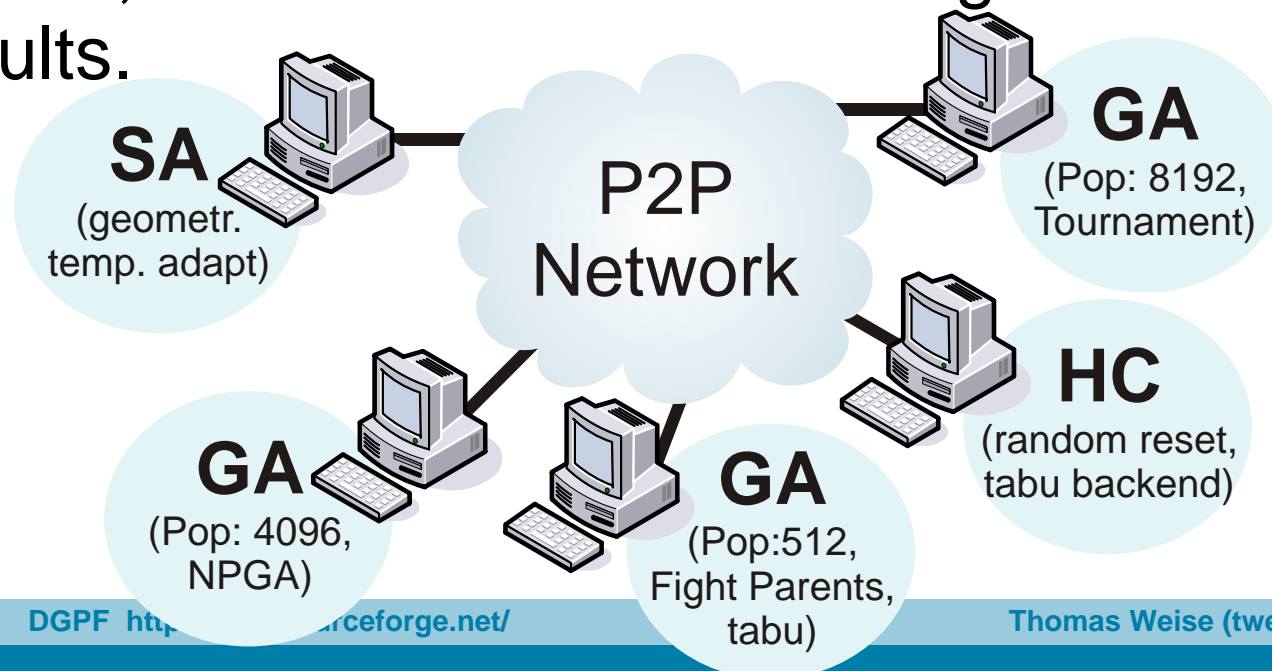
- P2P-Component: used for Island-Hopping in GA but can connect arbitrary search/optimization algorithms
- Genetic Algorithms, Simulated Annealing, and Stochastic Hill Climbing
- Algorithms are auto-adaptive and come with a implicit Tabu-Search backend

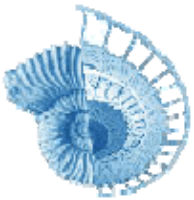




# Heterogeneous Search

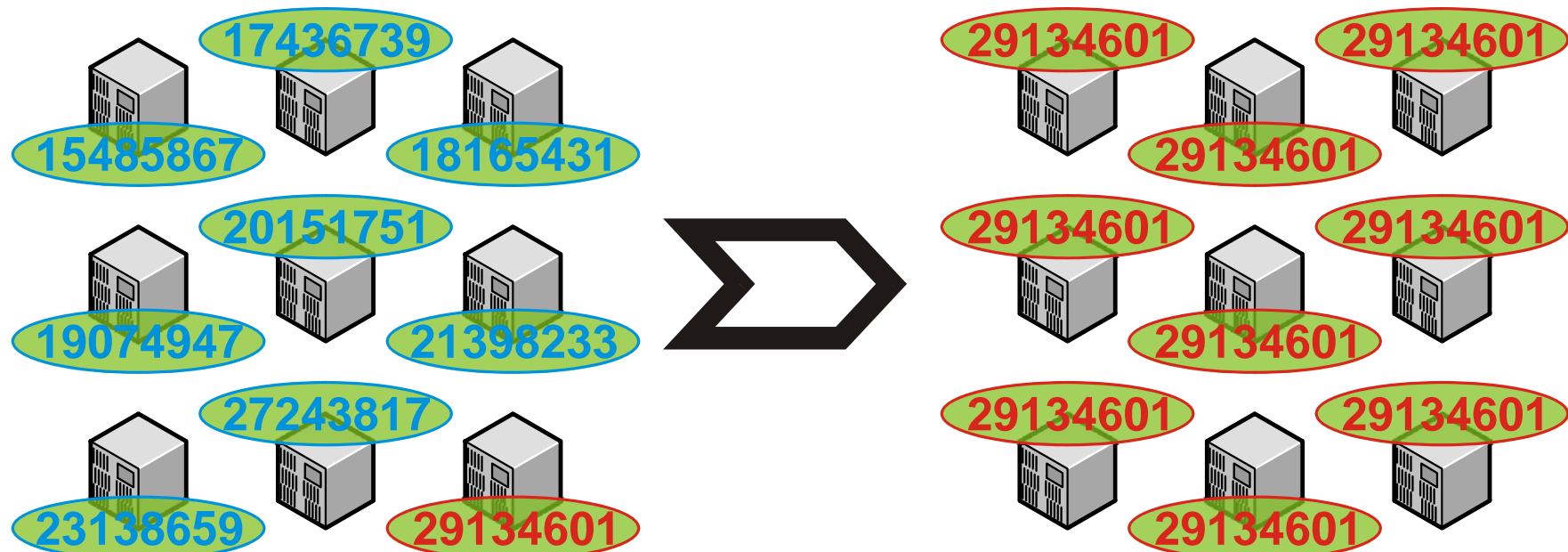
- It is not known beforehand which search/optimization algorithm may perform best for a problem.
- Algorithms may perform differently regarding the stage of the problem space exploration.
- In our case, a mixture of different algorithms yields the best results.

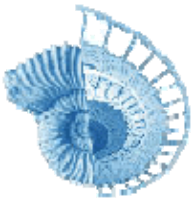




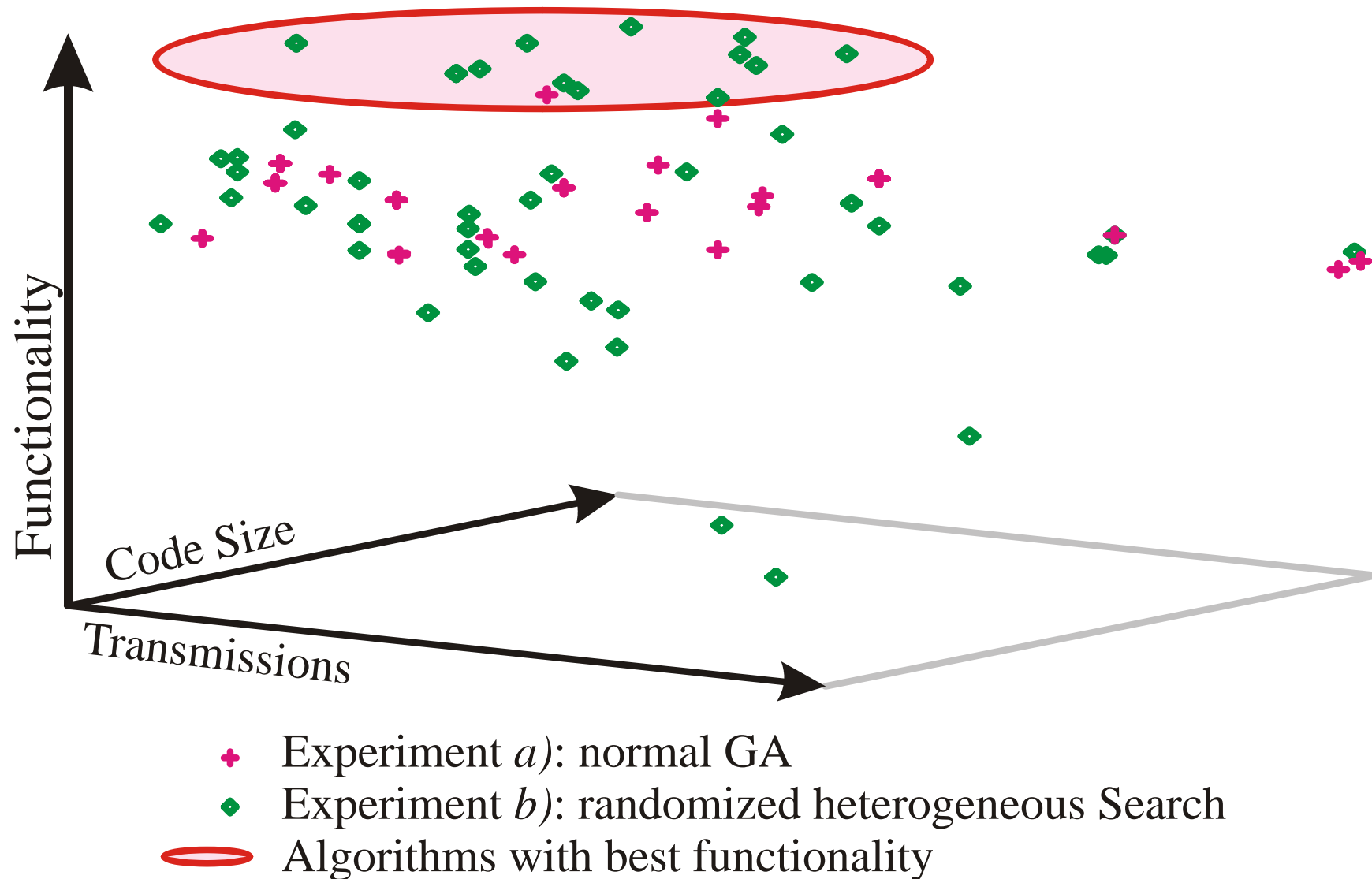
# Experiment

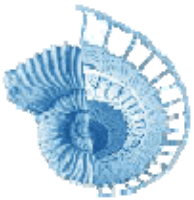
- Evolve an "Election Algorithm"
  - all nodes in the virtual network have an unique id
  - the node with the highest id wins
  - all nodes should receive knowledge of this id
  - multi-objective optimization





# Experiment





# Experiment

*called on startup*

*store 1st variable into  
output buffer*

*send output buffer  
go back to start*

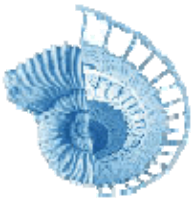
## procedure\_0

```
0: push mem[0]
1: some useless operations used
2: to stall and, as a consequence,
3: reduce transmissions in the
4: simulated/evaluated time span
5: send
6: goto 0
```

*called asynchronously when  
a message comes in  
compare the known and  
the received value  
if no improvement then exit  
exchange values*

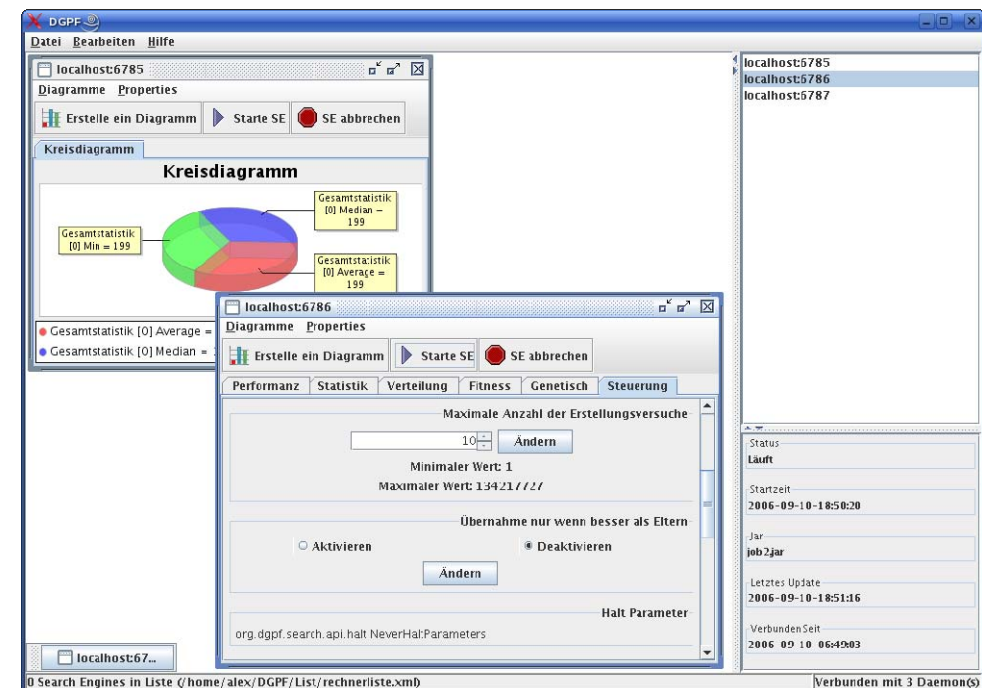
## procedure\_1

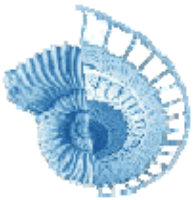
```
0: zf = (mem[-1] < mem[0])
1: if zf then goto 3 // =exit
2: xchg mem[-1], mem[0]
```



# Summary

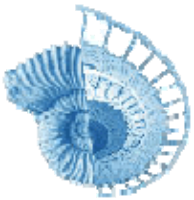
- Versatile distributed Framework for auto-adaptive, multi-objective search- and optimization algorithms
- Genetic Programming can help to find simple distributed algorithms applicable for sensor networks.
- Heterogeneous searches can provide better performance
- Cluster Management Tool for easy search deployment





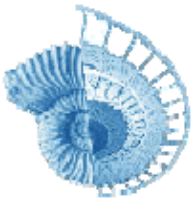
# Future Work

- **Tackle more complex distributed algorithms**
- Transform evolved algorithms into source code
- Extend search API
- Implement extended versions of algorithms like SPEA-II
- Test also PSO and deterministic algorithms like A\*
- Extend auto-adaptation capabilities
- Extend Cluster Management Tool



# References

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Thanks for your attention.

**Questions?**

Framework available as Open-Source at  
<http://dgpf.sourceforge.net/>  
[weise@vs.uni-kassel.de](mailto:weise@vs.uni-kassel.de)

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Contact Thomas Weise at tweise@gmx.de or http://www.it-weise.de/.},
copyright   = {unrestricted},
abstract    = {We present DGPF, a framework providing multi-objective, auto-adaptive search algorithms with a focus on Genetic Programming. We first introduce a Common Search API, suitable to explore arbitrary problem spaces with different search algorithms. Using our implementation of Genetic Algorithms as an example, we elaborate on the distribution utilities of the framework which enable local, Master/Slave, Peer-To-Peer, and P2P/MS hybrid distributed search execution. We also discuss how heterogeneous searches consisting of multiple, cooperative search algorithms can be constructed. Sensor networks are distributed systems of nodes with scarce resources. We demonstrate how Genetic Programming based on our framework can be applied to create algorithms for sensor nodes that use these resources very efficiently.},
keywords    = {Genetic Programming, Genetic Algorithms, DGPF, Sensor Network, Sensor Node},
language    = {en},
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