



# Genetic Programming in automated test code generation for a multi-threaded microprocessor.

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MSc. Machine Learning and Data Mining.

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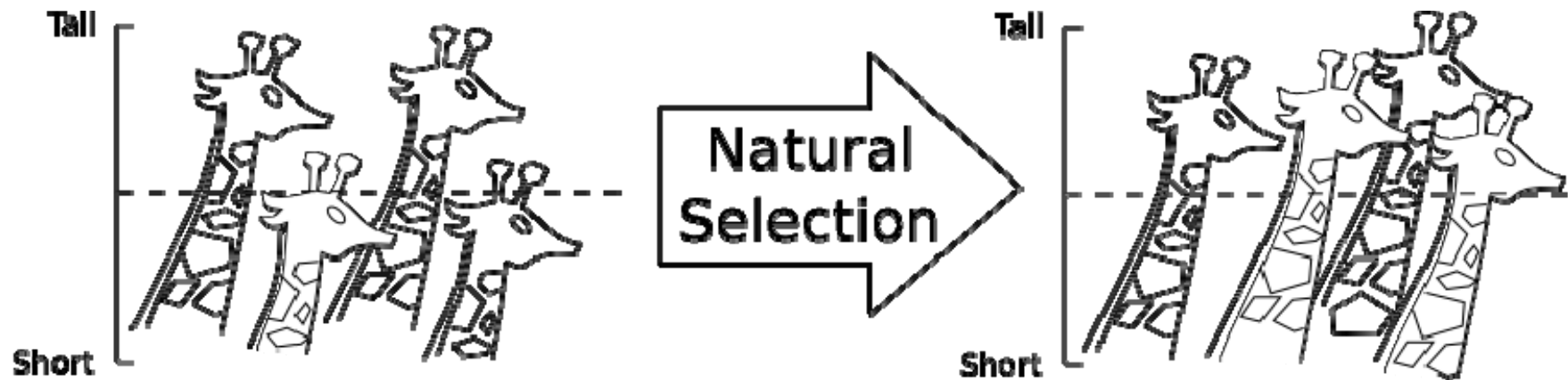
# Introduction

- The complexity of modern microprocessors makes verification difficult.
- Recent research on Coverage-Directed test Generation (CDG) uses machine learning approaches.
- Genetic Programming (GP) is one of the machine learning methods used in CDG.
- Initial experiments with GP in multi-threaded microprocessor verification show potential.
- Presentation starts with introduction to GP and a case study with the XMOS multi-threaded microprocessor.



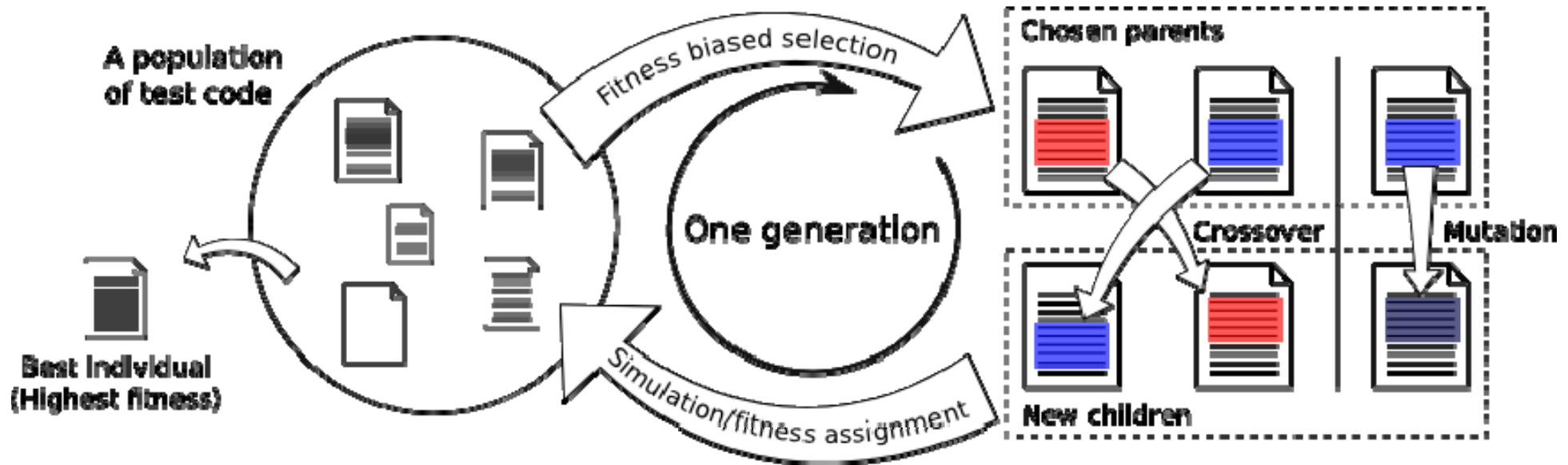
# 🌿 Fundamentals of Genetic Programming (GP)

- GP is based on the natural evolution process.
- Darwin Theorem: Natural selection promotes favourable heritable traits in successive generations.
- In GP, each individual in a population is given a quantitative measurement to reflect the quality of an individual relative to the environment.



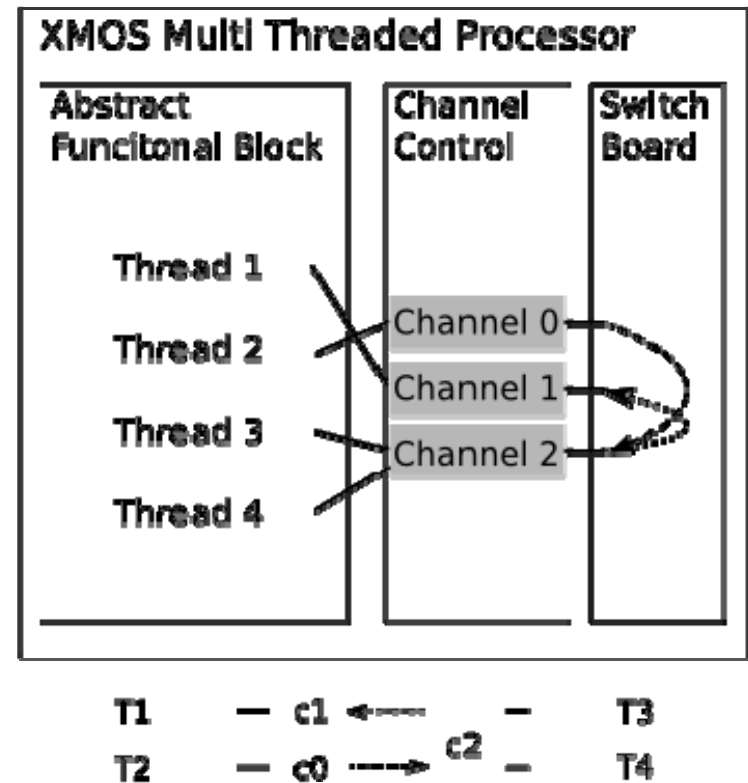
# 🔥 GP in test code generation

- Selection algorithm samples two individuals from the population based on their fitness values (e.g. Higher fitness value individuals get sampled more often).
- The parents are merged using genetic operators to produce new individuals.
- An external simulator is used to evaluate the fitness of the new individuals.
- GP implementation in Coverage-Directed test Generation requires less expert knowledge compared to other methods (e.g. Bayesian Network).



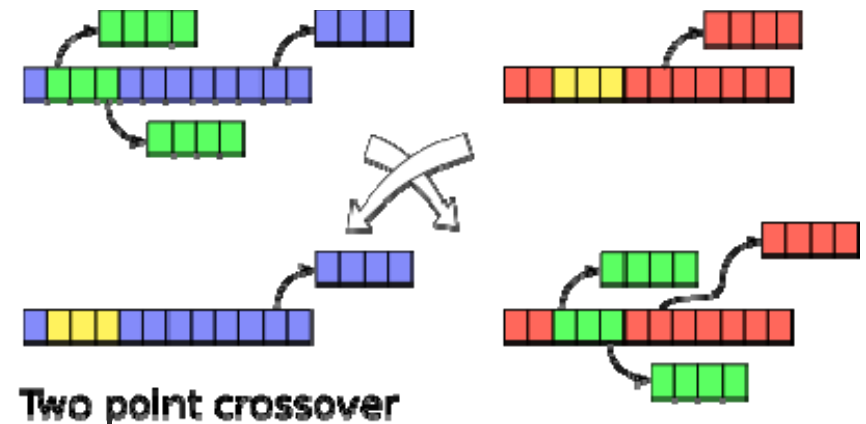
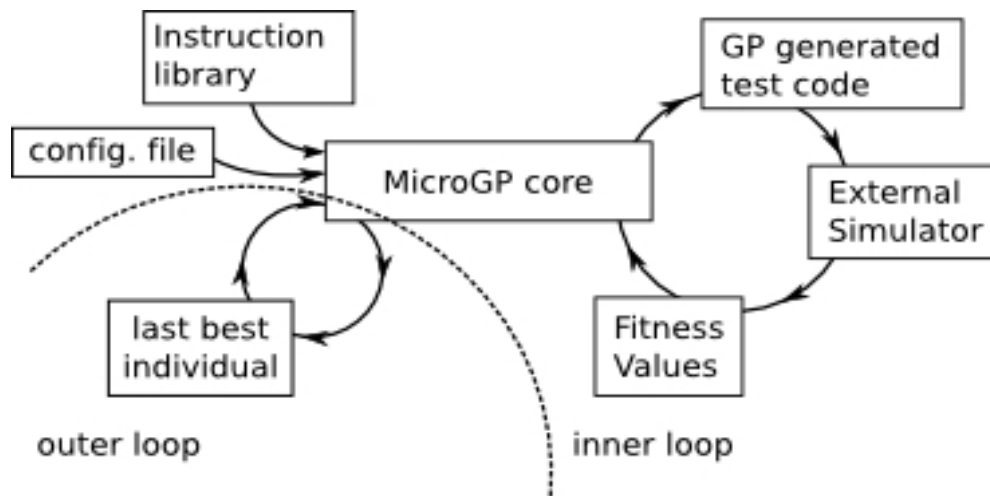
# Case study: XMOS multi-threaded microprocessor

- Software Defined Silicon (SDS).
- Up to 8 threads running simultaneously in one single core.
- Experiment focuses on channel communication.
- Channel communication design requires a number of threads to exercise the corner cases.
- However, the timing window to trigger corner cases, such as race conditions, is very narrow.



# 🌿 Implemented CDG loop

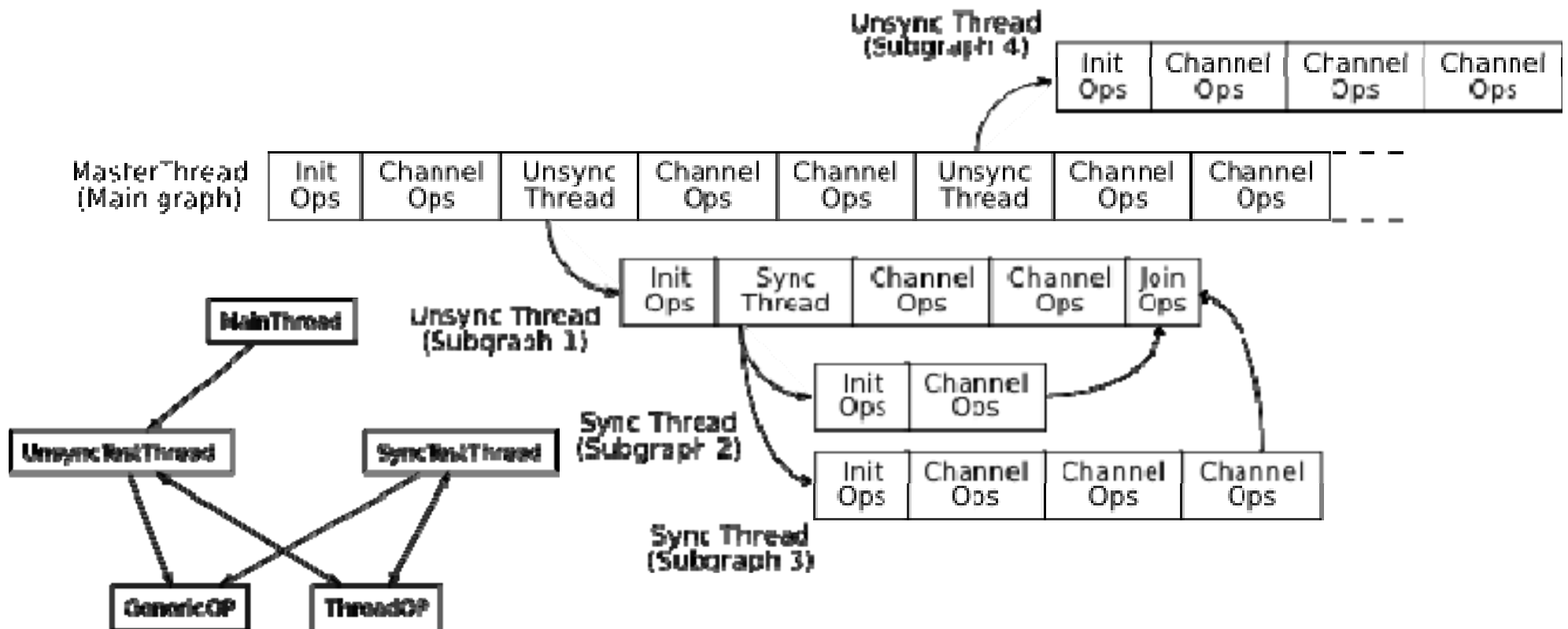
- The experiment extends the existing MicoGP\* program.
- Expert knowledge is encoded in an instruction library.
- An individual is a graph; the nodes in a graph are constructed from the basic building blocks in the library.
- The extended MicroGP includes 2 crossover and 5 mutation operators.
- A double looped system is used to enhance the performance of MicroGP.



\* MicroGP research group  
<http://www.cad.polito.it/research/microgp.html>

# 🌿 Encoding multi-threaded test code in GP

- A test program can be represented by a graph; a node in a graph maps to a channel operation and a branch represents the content of a new thread.

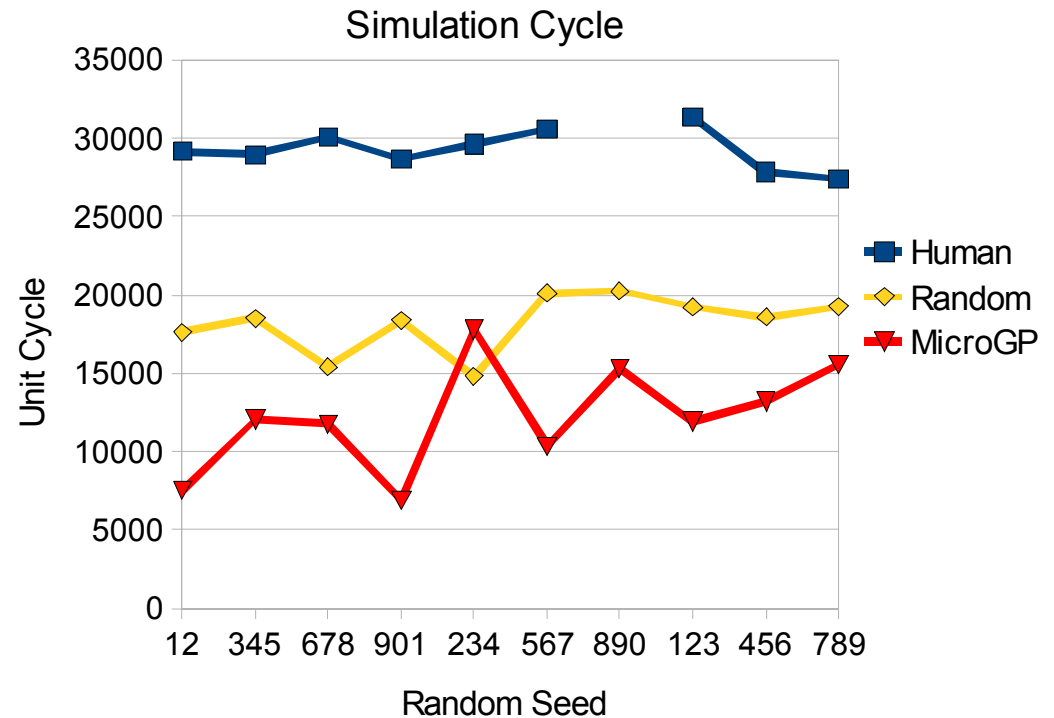
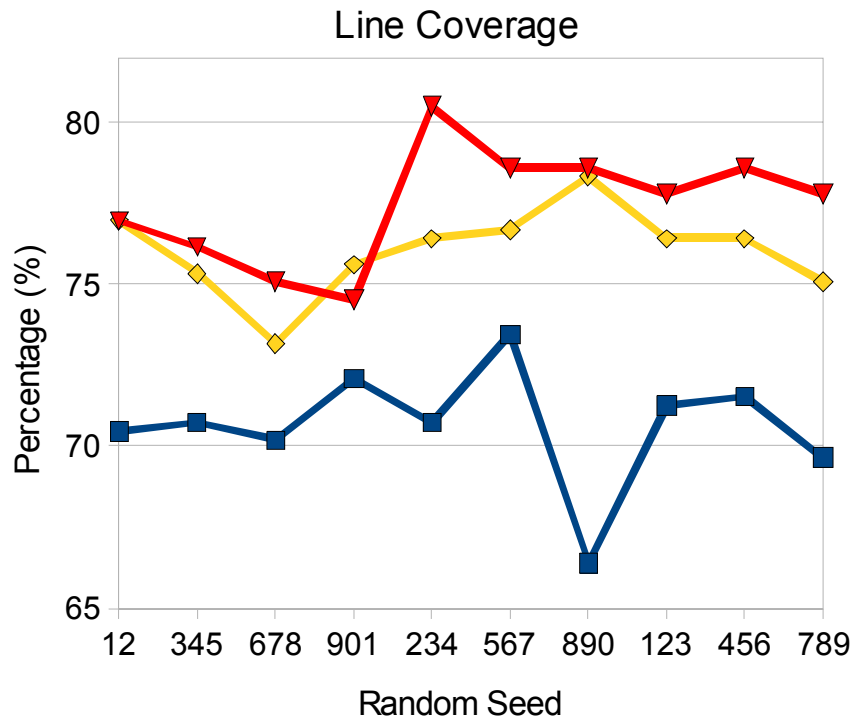


# Feedback measurements

- Improves basic coverage measurements such as line coverage and branch coverage.
- Minimises simulation cycles.
- Minimises the main graph to encourage more threads in test code.
- Balances the distribution of operations among the threads.
- Increases operation on channel IO.
- All feedback measurements are optimised together with different priority.



# Experiment Results



- Test code generated by MicroGP method is significantly better than human engineer and randomly generated sequences.
- Actual line coverage improved to 94% and up to 50% cycle reduction.

Thank you.  
Questions ?

