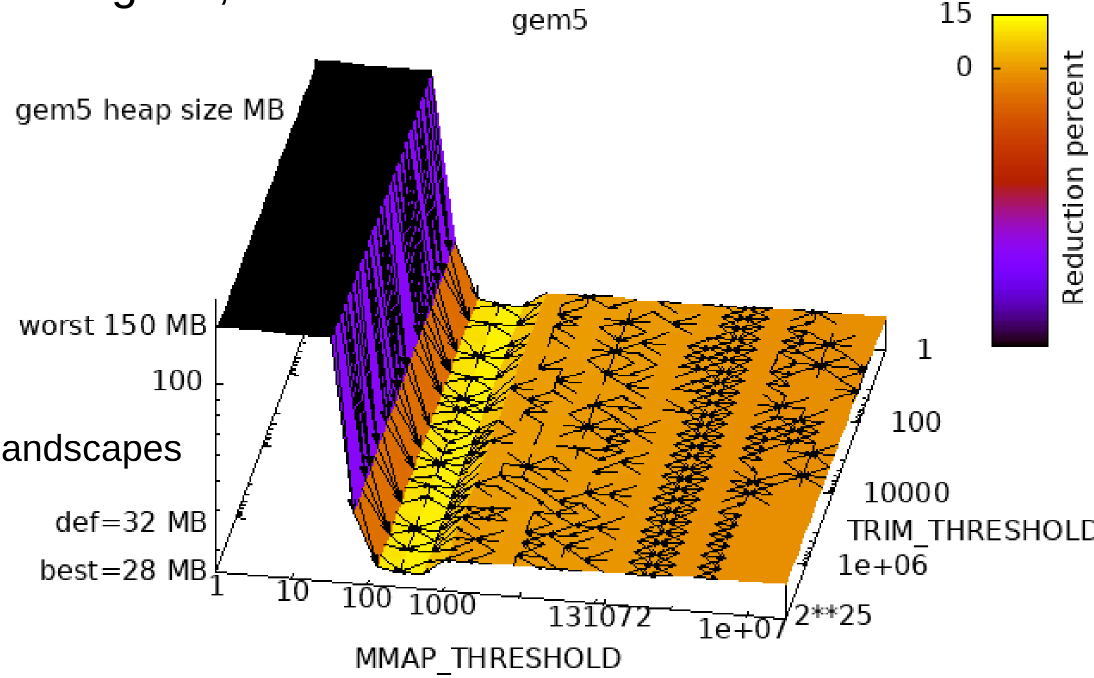
A Genetic Improvement Parameter Benchmark rand_malloc.c

24th UK Workshop on Computational Intelligence (UKCI 2025)

Can sometimes tune C++ dynamic memory.
Heap memory landscapes are smooth.

W. B. Langdon, UCL



The gem5 C++ glibc Heap Fitness Landscape,
GI @ ICSE 2025, Ottawa
W.B. Langdon and B.R. Bruce.

gem5/Z3/gcc/Clang/Redis glibc Heap Fitness Landscapes
Evo* 2025 Late-Breaking Abstracts.
W.B. Langdon, J.Petke, D. Clark

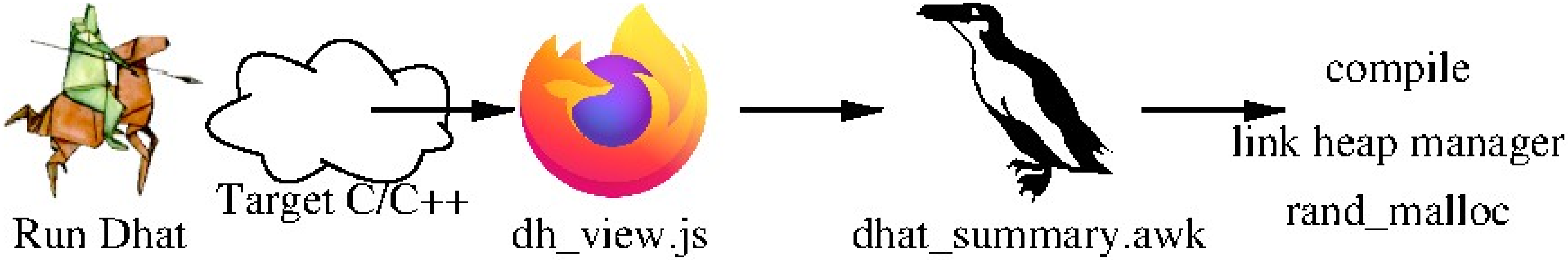
rand_malloc

- To stress test or tune your heap manager
- Real C/C++ heap sizes and durations
- Whole or subset
- Tune two versions of glibc parameters with Magpie or CMA-ES

rand_malloc

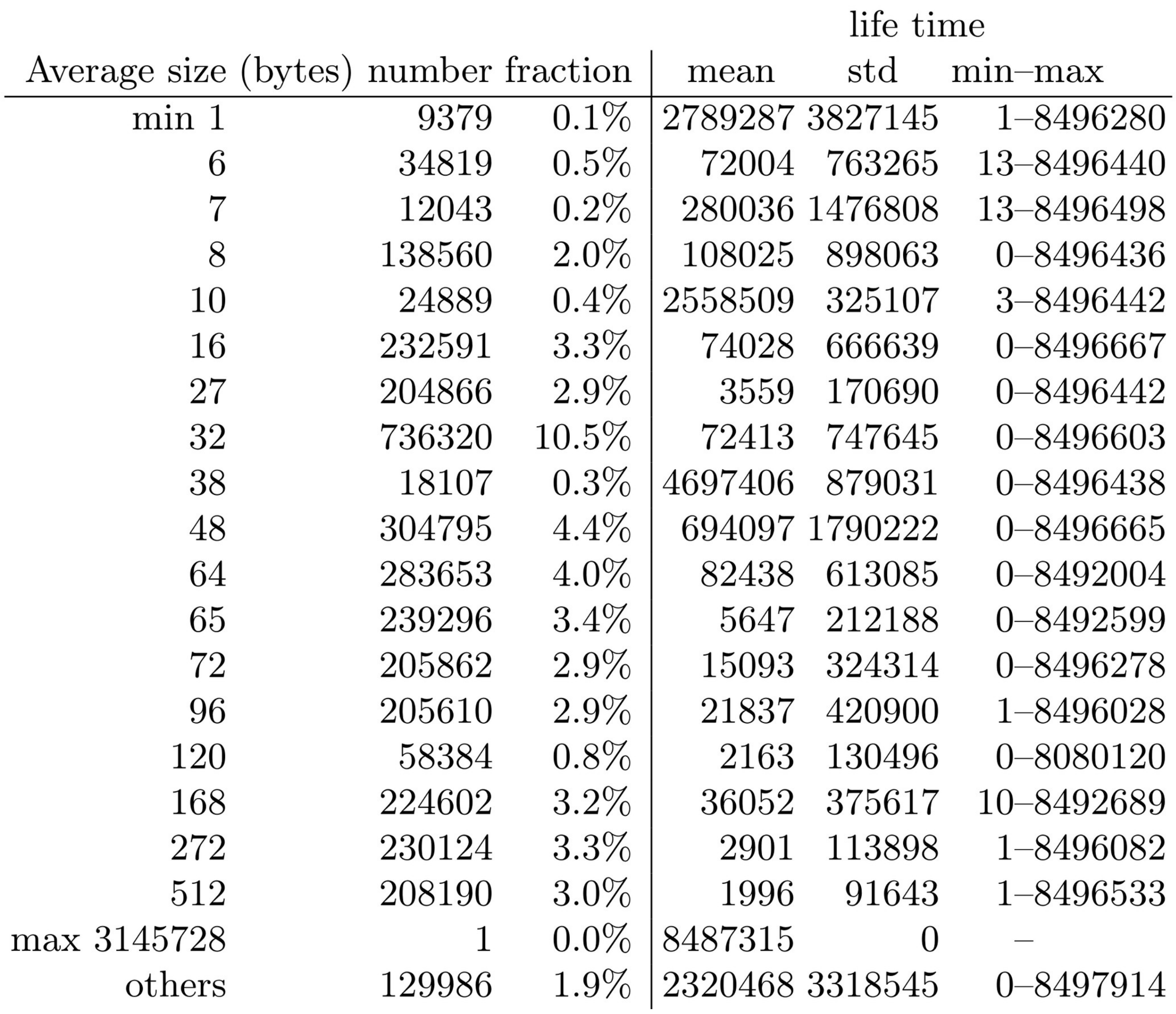
- Collect heap usage by million lines C++
- Convert valgrind dhat data to C code, compile + link with your heap manager
- Stress test or tune using real data
- Tuned glibc parameters with Magpie or CMA-ES

rand_malloc



- Collect heap usage by target (gem5) using Valgrind’s dhat
- rand_malloc real alloc/free in random order
    - uses real alloc size and scaled duration (default 500x)
- Use a subset or every new/delete

gem5 heap size/simulation steps



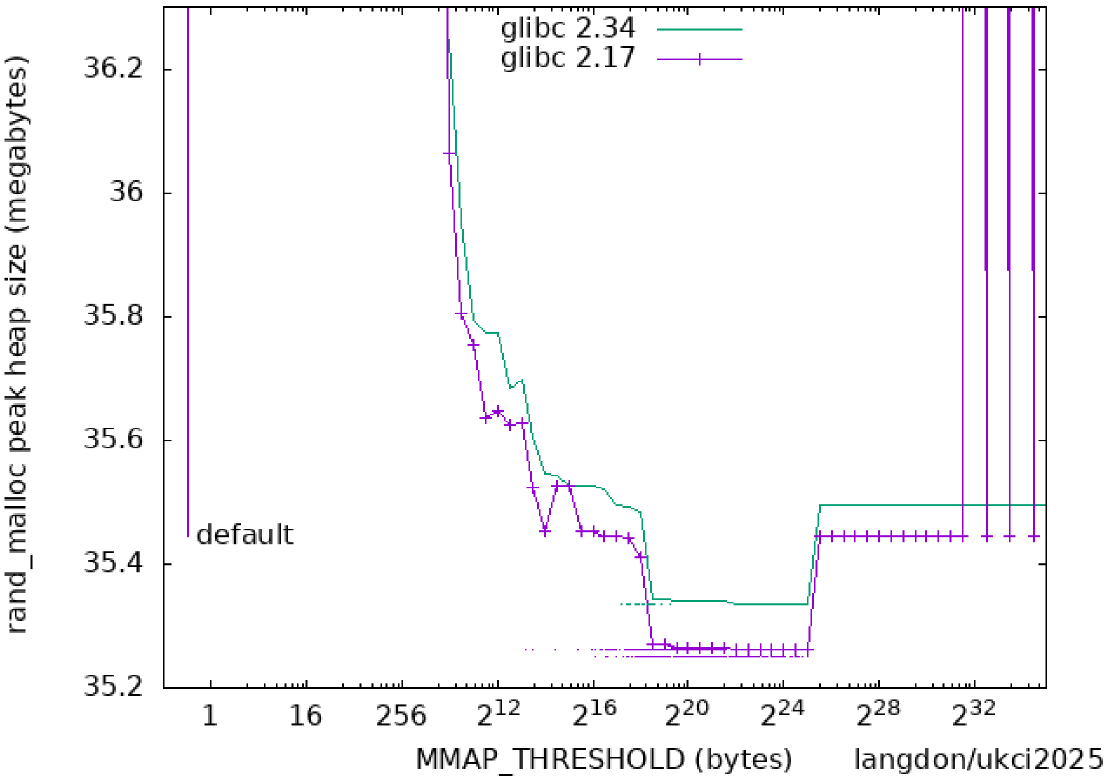
			life time		
Average size (bytes)	number	fraction	mean	std	min–max
min 1	9379	0.1%	2789287	3827145	1–8496280
6	34819	0.5%	72004	763265	13–8496440
7	12043	0.2%	280036	1476808	13–8496498
8	138560	2.0%	108025	898063	0–8496436
10	24889	0.4%	2558509	325107	3–8496442
16	232591	3.3%	74028	666639	0–8496667
27	204866	2.9%	3559	170690	0–8496442
32	736320	10.5%	72413	747645	0–8496603
38	18107	0.3%	4697406	879031	0–8496438
48	304795	4.4%	694097	1790222	0–8496665
64	283653	4.0%	82438	613085	0–8492004
65	239296	3.4%	5647	212188	0–8492599
72	205862	2.9%	15093	324314	0–8496278
96	205610	2.9%	21837	420900	1–8496028
120	58384	0.8%	2163	130496	0–8080120
168	224602	3.2%	36052	375617	10–8492689
272	230124	3.3%	2901	113898	1–8496082
512	208190	3.0%	1996	91643	1–8496533
max 3145728	1	0.0%	8487315	0	–
others	129986	1.9%	2320468	3318545	0–8497914

gem5 heap size/simulation steps

- Range of sizes 1 byte to 3MB
- Huge range of very variable durations
  - (55 instructions, modeled as zero) to
  - whole gem5 run duration 8.5 million simulation steps.
- gem5 continuously adds/removes (stresses heap memory manager) whereas:
  - GCC LLVM compilers, Z3, Redis free only at end

Optimised glibc landscape

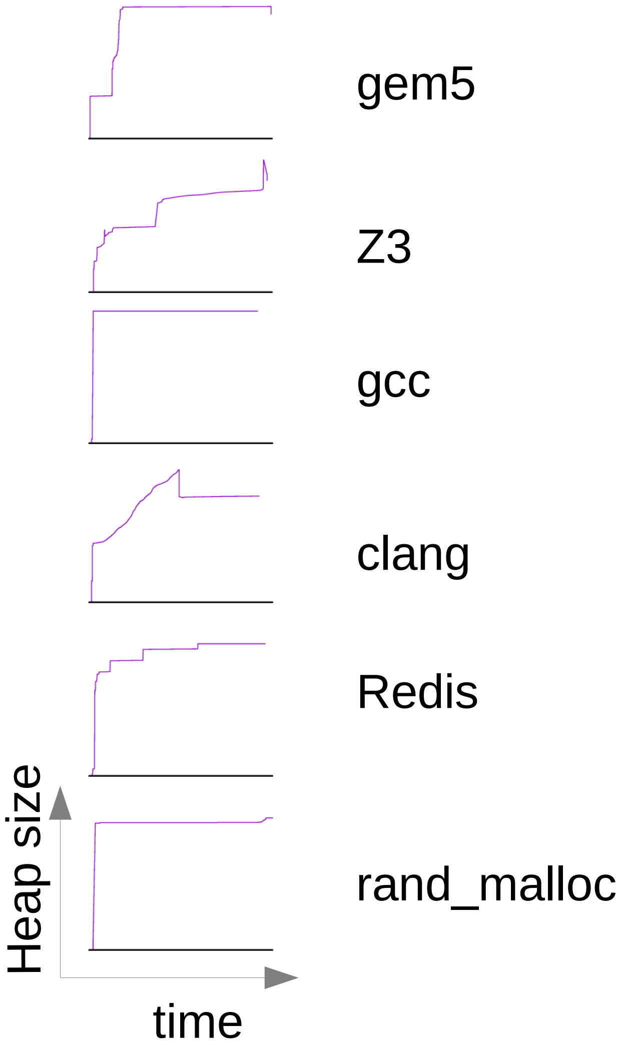
(1 dimensional slice of 3D space)



Glibc 2.17 saving up to 188KBytes

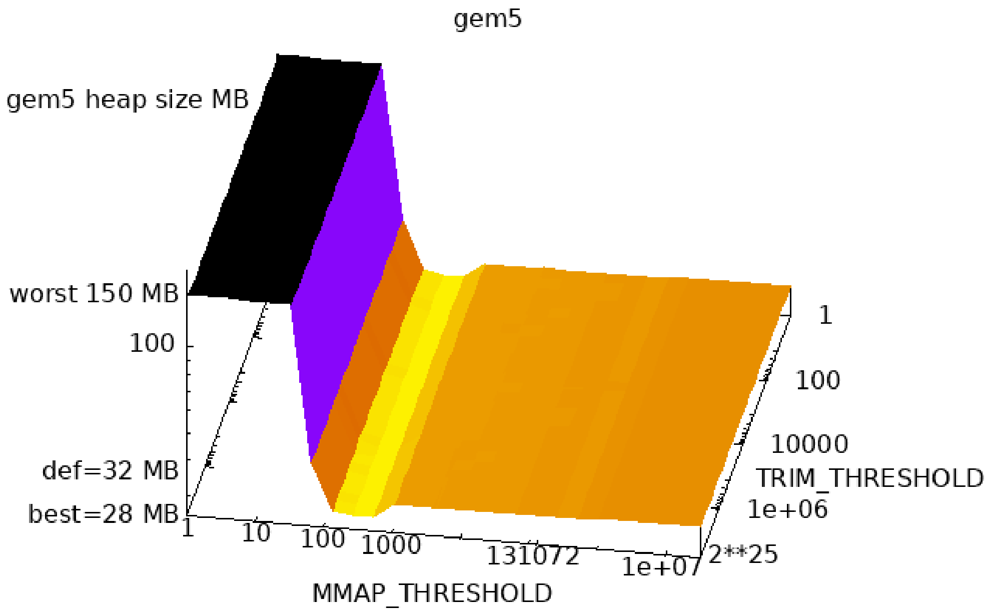
Heap benchmarks

Program	Lines of code
gem5 chip simulation	1,300,000
Z3 microsoft theorem prover	600,000
g++ compiler	15,000,000
LLVM clang compiler	2,900,000
Redis Ltd. data store	150,000
rand_malloc	256 (data 3,502,084)



Conclusions

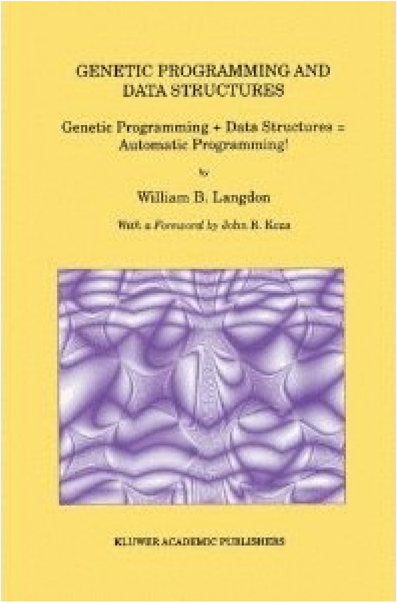
- Not all SBSE search problems are hard.
- Genetic Improvement can be applied to software parameters as well as code. Eg glibc 37 run time parameters. Use any optimiser
- gem5 is a million+ lines but C++ 7 dimensional new/delete landscape is smooth, collapses to essentially one dimension broad good fitness valley (4 10^{17} solutions) large basin of attraction. Gives 11% heap reduction without loss of speed
- Other non-trivial C++ programs have similar smooth landscapes but tuning GNU glibc malloc gives only marginal improvement
- Magpie can tune parameters as well as multi-language code



4e17 = 400 Quadrillion

Genetic Programming

W. B. Langdon



GENETIC PROGRAMMING AND DATA STRUCTURES

Genetic Programming + Data Structures = Automatic Programming!

by

William B. Langdon

With a Foreword by John R. Koza

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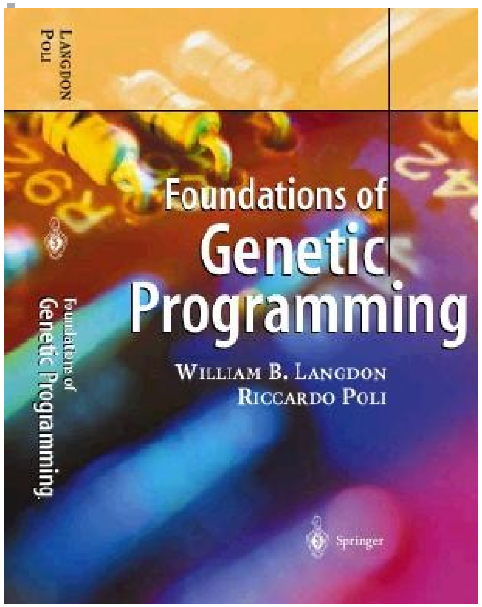

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Foundations of Genetic Programming

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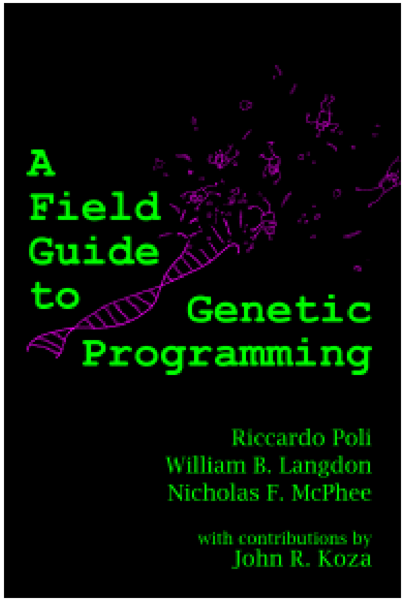

A Field Guide to Genetic Programming

Riccardo Poli
William B. Langdon
Nicholas F. McPhee

with contributions by
John R. Koza

The Genetic Programming Bibliography

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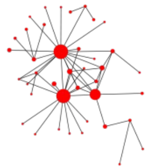

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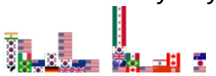

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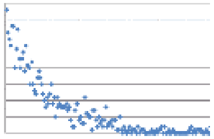

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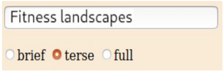

Fitness landscapes

○ brief ● terse ○ full

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