



Throwing Tools at Ranges

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Outline

- Setup
- Code example
- Google Benchmark
- Cachegrind
- Visual Studio Profiler
- Optimizing
- Conclusion



Setup

Setup

Laptop

Processor	12th Gen Intel(R) Core(TM) i7-12650H 2.3GHz
Cores	10
Logical Processors	16
L1-Cache	864 KB
L2-Cache	9,5 MB
L3-Cache	24 MB
RAM	16 GB
OS	Windows 11

PC

Processor	13th Gen Intel Core i7-13700KF @ 3.4GHz
Cores	16
Logical Processors	24
L1-Cache	1,4 MB
L2-Cache	24 MB
L3-Cache	30 MB
RAM	64 GB
OS	Windows 11



Code



A vertical strip showing a close-up of a wooden-handled tool, possibly a chisel or gouge, secured with a metal band and rivets to a wooden surface. The handle is made of light-colored wood and has a rounded, bulbous shape. The tool head is dark and pointed. The wooden surface it is attached to has several circular holes and is secured with metal bands and rivets.

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A vertical strip showing a close-up of a wooden-handled tool, possibly a chisel or gouge, secured with a metal band and rivets to a wooden surface. The handle is made of light-colored wood and has a rounded, bulbous shape. The tool's head is dark and pointed. The wooden surface it is attached to has several circular holes and is secured with metal bands and rivets.

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Function 1, C – style C++

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A vertical strip of a leather tool roll, showing various tools secured with brass straps. A large wooden-handled tool, possibly a gouge or chisel, is prominent in the center. Other tools, including a metal fork-like tool and a smaller wooden-handled tool, are visible on either side. The leather is brown and worn, with brass straps and rivets.

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A vertical strip showing a close-up of a leatherworking tool, likely a punch or awl, with a wooden handle and a metal head, resting on a perforated metal surface.

[illegible]

Function 2, C – style C++

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Function 3, C++23

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sắđ sắắắắ êđ tữ,
sắđ sắắắắ cắắắắ tữ,
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A vertical strip of a leather tool roll, showing a large wooden-handled tool (possibly a gouge or chisel) and a smaller metal tool (possibly a punch or awl) secured with brass straps.

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A vertical strip showing a close-up of a leatherworking tool, likely a punch or awl, with a wooden handle and a metal head, resting on a perforated metal surface.

Function 3, C – style C++

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Function 4, C++23

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A vertical strip showing a close-up of a leatherworking tool, likely a punch or awl, with a wooden handle and a metal tip, resting on a perforated metal surface.

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A vertical strip showing a close-up of a wooden-handled tool, possibly a chisel or gouge, secured with a metal band and rivets to a wooden surface. The handle is made of light-colored wood and has a rounded, bulbous shape. The tool head is dark and pointed. The wooden surface it is attached to has several circular holes and is secured with metal bands and rivets.

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Google Benchmark

Google Benchmark

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Google Benchmark

Run on (24 X 3450.41 MHz CPU s)

CPU Caches:

L1 Data 48 KiB (x12)

L1 Instruction 32 KiB (x12)

L2 Unified 2048 KiB (x12)

L3 Unified 30720 KiB (x1)

Benchmark	Time	CPU	Iterations
c_style_benchmark	23.0 ms	16.5 ms	56
cpp_17_benchmark	33.5 ms	21.5 ms	40
cpp_23_benchmark	321.0 ms	271.0 ms	3



Cachegrind



Cachegrind

```
[computer_name]:[path_to_program]$ valgrind --tool=cachegrind  
--branch-sim=yes  
--cache-sim=yes  
./program_to_execute
```

Cachegrind, C – style C++

```
I    refs:          91,939,877
I1  misses:         1,963
LLi misses:         1,926
I1  miss rate:      0.00%
LLi miss rate:      0.00%
```

Cachegrind, C – style C++

```
I  refs:      91,939,877
I1 misses:    1,963
LLi misses:   1,926
I1 miss rate: 0.00%
LLi miss rate: 0.00%
```

```
D  refs:      26,669,524 (16,500,458 rd + 10,169,066 wr)
D1 misses:    4,514,544 ( 2,512,235 rd +  2,002,309 wr)
LLd misses:    4,509,449 ( 2,507,862 rd +  2,001,587 wr)
D1 miss rate: 16.9% (      15.2% +      19.7% )
LLd miss rate: 16.9% (      15.2% +      19.7% )
```


Cachegrind, C – style C++

I refs: 91,939,877
I1 misses: 1,963
LLi misses: 1,926
I1 miss rate: 0.00%
LLi miss rate: 0.00%

D refs: 26,669,524 (16,500,458 rd + 10,169,066 wr)
D1 misses: 4,514,544 (2,512,235 rd + 2,002,309 wr)
LLd misses: 4,509,449 (2,507,862 rd + 2,001,587 wr)
D1 miss rate: 16.9% (15.2% + 19.7%)
LLd miss rate: 16.9% (15.2% + 19.7%)

LL refs: 4,516,507 (2,514,198 rd + 2,002,309 wr)
LL misses: 4,511,375 (2,509,788 rd + 2,001,587 wr)
LL miss rate: 3.8% (2.3% + 19.7%)

Cachegrind, C – style C++

I refs: 91,939,877
I1 misses: 1,963
LLi misses: 1,926
I1 miss rate: 0.00%
LLi miss rate: 0.00%

D refs: 26,669,524 (16,500,458 rd + 10,169,066 wr)
D1 misses: 4,514,544 (2,512,235 rd + 2,002,309 wr)
LLd misses: 4,509,449 (2,507,862 rd + 2,001,587 wr)
D1 miss rate: 16.9% (15.2% + 19.7%)
LLd miss rate: 16.9% (15.2% + 19.7%)

LL refs: 4,516,507 (2,514,198 rd + 2,002,309 wr)
LL misses: 4,511,375 (2,509,788 rd + 2,001,587 wr)
LL miss rate: 3.8% (2.3% + 19.7%)

Branches: 11,304,682 (11,299,499 cond + 5,183 ind)
Mispredicts: 19,316 (18,183 cond + 1,133 ind)
Mispred rate: 0.2% (0.2% + 21.9%)

Cachegrind, C++17

I refs: 251,958,356
I1 misses: 1,990
LLi misses: 1,951
I1 miss rate: 0.00%
LLi miss rate: 0.00%

D refs: 156,720,645 (42,537,557 rd + 114,183,088 wr)
D1 misses: 6,014,632 (2,512,304 rd + 3,502,328 wr)
LLd misses: 5,979,274 (2,507,969 rd + 3,471,305 wr)
D1 miss rate: 3.8% (5.9% + 3.1%)
LLd miss rate: 3.8% (5.9% + 3.0%)

LL refs: 6,016,622 (2,514,294 rd + 3,502,328 wr)
LL misses: 5,981,225 (2,509,920 rd + 3,471,305 wr)
LL miss rate: 1.5% (0.9% + 3.0%)

Branches: 115,303,749 (115,298,564 cond + 5,185 ind)
Mispredicts: 19,336 (18,200 cond + 1,136 ind)
Mispred rate: 0.0% (0.0% + 21.9%)

Cachegrind, C++23

I refs: 397,921,904
I1 misses: 1,962
LLi misses: 1,892
I1 miss rate: 0.00%
LLi miss rate: 0.00%

D refs: 216,694,459 (92,525,700 rd + 124,168,759 wr)
D1 misses: 14,293 (12,033 rd + 2,260 wr)
LLd misses: 9,045 (7,516 rd + 1,529 wr)
D1 miss rate: 0.0% (0.0% + 0.0%)
LLd miss rate: 0.0% (0.0% + 0.0%)

LL refs: 16,255 (13,995 rd + 2,260 wr)
LL misses: 10,937 (9,408 rd + 1,529 wr)
LL miss rate: 0.0% (0.0% + 0.0%)

Branches: 16,306,169 (16,301,012 cond + 5,157 ind)
Mispredicts: 19,213 (18,085 cond + 1,128 ind)
Mispred rate: 0.1% (0.1% + 21.9%)

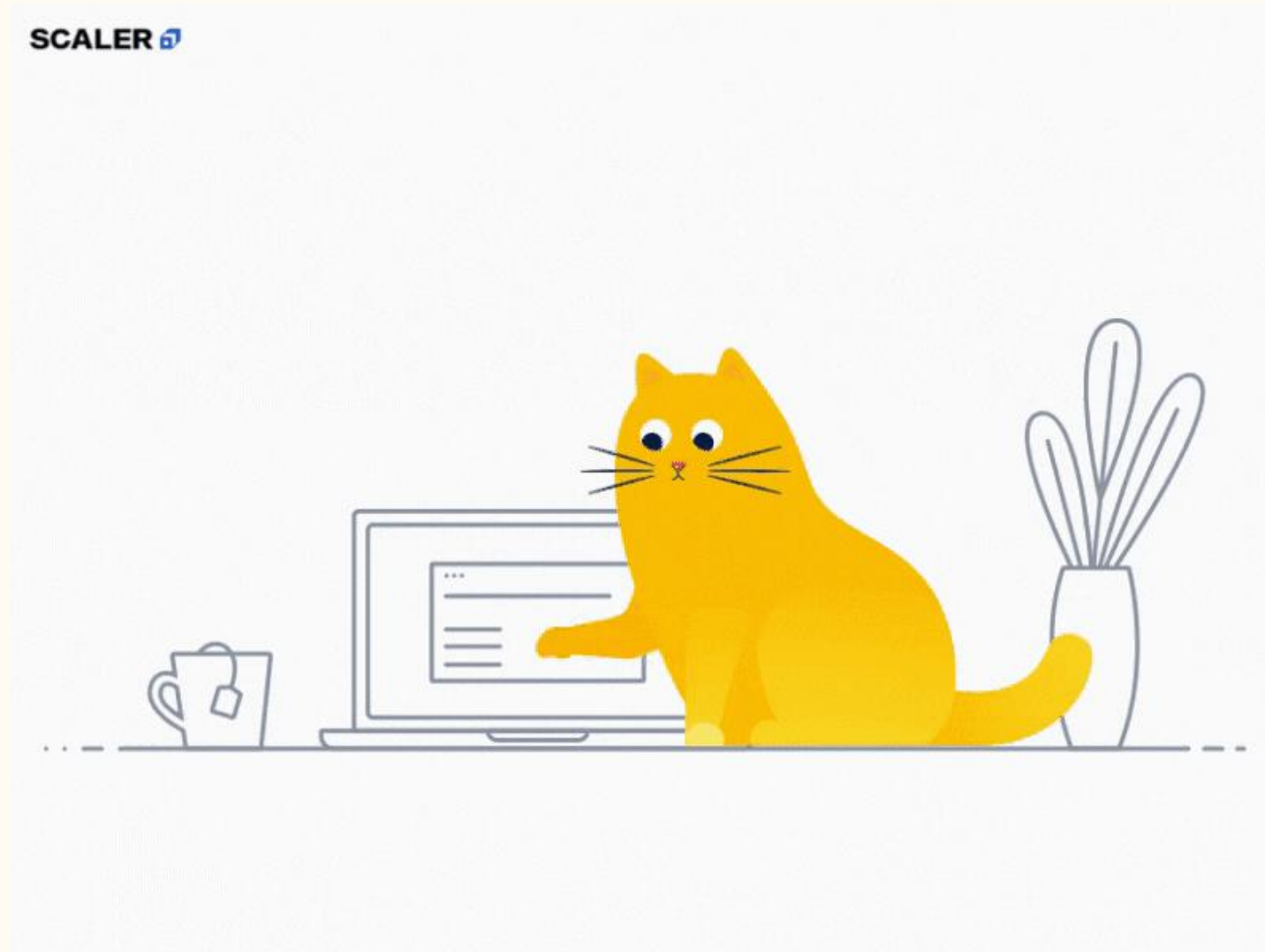
Cachegrind compare

	C-Style	C++17	C++23
I refs:	91,939,877	251,958,356	397,921,904
I1 misses:	1,963	1,990	1,962
LLi misses:	1,926	1,951	1,892
I1 miss rate:	0.00%	0.00%	0.00%
LLi miss rate:	0.00%	0.00%	0.00%
D refs:	26,669,524	156,720,645	216,694,459
D1 misses:	4,514,544	6,014,632	14,293
LLd misses:	4,509,449	5,979,274	9,045
D1 miss rate:	16.9%	3.8%	0.0%
LLd miss rate:	16.9%	3.8%	0.0%
LL refs:	4,516,507	6,016,622	16,255
LL misses:	4,511,375	5,981,225	10,937
LL miss rate:	3.8%	1.5%	0.0%
Branches:	11,304,682	115,303,749	16,306,169
Mispredicts:	19,316	19,336	19,213
Mispred rate:	0.2%	0.0%	0.1%



Profiling and Optimizing

Visual Studio Profiler



Function 3, C – style C++

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Optimizing, C – style C++

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A vertical strip showing a close-up of a leather tool, possibly a punch or awl, with a wooden handle and a metal tip, secured by a metal band.

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Optimizing, C – style C++

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sặặặặ sặặ

A vertical strip showing a close-up of a leatherworking tool, likely a punch or awl, with a wooden handle and a metal tip, resting on a perforated metal surface.

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gôx i_ht_h i ɲ i
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Optimizing, C – style C++

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A vertical strip of a leather tool roll, showing various tools secured with brass straps. A large wooden-handled tool, possibly a gouge or chisel, is prominent in the center. Other tools, including a metal fork-like tool and a smaller wooden-handled tool, are visible on either side. The leather is brown and worn, with brass straps and rivets.

sêṭṭuṣṇ ṣṭjḍ īṇṇês ṛsôḍuṭṭ ṭṇṛ, čêġîṇ , ṭṇṛ, êṇḍ ṭṇṛ, čêġîṇ , . .

A vertical strip showing a close-up of a wooden-handled tool, possibly a chisel or gouge, secured with a metal band and rivets to a wooden surface. The handle is made of light-colored wood and has a rounded, bulbous shape. The tool head is dark and pointed. The wooden surface it is attached to has several circular holes.

A vertical strip showing various tools, including a large wooden-handled tool with a metal head, a smaller tool with a wooden handle, and a tool with a metal head and a wooden handle, all secured with metal bands.

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A vertical strip showing a close-up of a leather tool, possibly a punch or awl, with a wooden handle and a metal tip, secured by a metal band.

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Google Benchmark

Optimized Benchmarks

Run on (24 X 3450.41 MHz CPU s)

CPU Caches:

L1 Data 48 KiB (x12)

L1 Instruction 32 KiB (x12)

L2 Unified 2048 KiB (x12)

L3 Unified 30720 KiB (x1)

Benchmark	Time	CPU	Iterations
c_style_benchmark	23.0 ms	16.5 ms	56
cpp_17_benchmark	33.5 ms	21.5 ms	40
cpp_23_benchmark	321 ms	271 ms	3
c_style_benchmark_optimized	12.3 ms	10.3 ms	56
cpp_17_benchmark_optimized	17.5 ms	15.3 ms	56
cpp_23_benchmark_optimized	11.5 ms	10.2 ms	75



Cachegrind

Cachegrind, optimized C – style C++

I refs: 75,939,042
I1 misses: 1,962
LLi misses: 1,925
I1 miss rate: 0.00%
LLi miss rate: 0.00%

D refs: 16,669,232 (12,500,264 rd + 4,168,968 wr)
D1 misses: 2,514,487 (1,512,192 rd + 1,002,295 wr)
LLd misses: 2,509,394 (1,507,821 rd + 1,001,573 wr)
D1 miss rate: 15.1% (12.1% + 24.0%)
LLd miss rate: 15.1% (12.1% + 24.0%)

LL refs: 2,516,449 (1,514,154 rd + 1,002,295 wr)
LL misses: 2,511,319 (1,509,746 rd + 1,001,573 wr)
LL miss rate: 2.7% (1.7% + 24.0%)

Branches: 5,304,551 (5,299,380 cond + 5,171 ind)
Mispredicts: 19,298 (18,165 cond + 1,133 ind)
Mispred rate: 0.4% (0.3% + 21.9%)

Cachegrind, optimized C – style C++

I refs:	91,939,877	75,939,042
I1 misses:	1,963	1,962
LLi misses:	1,926	1,925
I1 miss rate:	0.00%	0.00%
LLi miss rate:	0.00%	0.00%
D refs:	26,669,524	16,669,232
D1 misses:	4,514,544	2,514,487
LLd misses:	4,509,449	2,509,394
D1 miss rate:	16.9%	15.1%
LLd miss rate:	16.9%	15.1%
LL refs:	4,516,507	2,516,449
LL misses:	4,511,375	2,511,319
LL miss rate:	3.8%	2.7%
Branches:	11,304,682	5,304,551
Mispredicts:	19,316	19,298
Mispred rate:	0.2%	0.4%

Cachegrind, optimized C++17

I refs: 167,963,436
I1 misses: 1,979
LLi misses: 1,936
I1 miss rate: 0.00%
LLi miss rate: 0.00%

D refs: 84,672,327 (14,503,351 rd + 70,168,976 wr)
D1 misses: 3,514,637 (1,512,340 rd + 2,002,297 wr)
LLd misses: 3,129,489 (1,507,995 rd + 1,621,494 wr)
D1 miss rate: 4.2% (10.4% + 2.9%)
LLd miss rate: 3.7% (10.4% + 2.3%)

LL refs: 3,516,616 (1,514,319 rd + 2,002,297 wr)
LL misses: 3,131,425 (1,509,931 rd + 1,621,494 wr)
LL miss rate: 1.2% (0.8% + 2.3%)

Branches: 72,315,609 (72,310,435 cond + 5,174 ind)
Mispredicts: 19,324 (18,188 cond + 1,136 ind)
Mispred rate: 0.0% (0.0% + 22.0%)

Cachegrind, optimized C++17

I	refs:	252,376,633	164,384,131
I1	misses:	2,044	2,033
LLi	misses:	1,976	1,965
I1	miss rate:	0.00%	0.00%
LLi	miss rate:	0.00%	0.00%
D	refs:	144,802,262	84,759,055
D1	misses:	6,015,098	3,515,169
LLd	misses:	5,979,557	3,131,856
D1	miss rate:	4.2%	4.1%
LLd	miss rate:	4.1%	3.7%
LL	refs:	6,017,142	3,517,202
LL	misses:	5,981,533	3,133,821
LL	miss rate:	1.5%	1.3%
Branches:	115,330,825	72,338,768	
Mispredicts:	18,725	18,732	
Mispred rate:	0.0%	0.0%	

Cachegrind, optimized C++23

I refs: 138,525,327
I1 misses: 2,026
LLi misses: 1,975
I1 miss rate: 0.00%
LLi miss rate: 0.00%

D refs: 48,780,211 (34,557,732 rd + 14,222,479 wr)
D1 misses: 2,064,246 (1,037,564 rd + 1,026,682 wr)
LLd misses: 1,368,086 (342,212 rd + 1,025,874 wr)
D1 miss rate: 4.2% (3.0% + 7.2%)
LLd miss rate: 2.8% (1.0% + 7.2%)

LL refs: 2,066,272 (1,039,590 rd + 1,026,682 wr)
LL misses: 1,370,061 (344,187 rd + 1,025,874 wr)
LL miss rate: 0.7% (0.2% + 7.2%)

Branches: 11,467,193 (11,461,893 cond + 5,300 ind)
Mispredicts: 23,556 (22,419 cond + 1,137 ind)
Mispred rate: 0.2% (0.2% + 21.5%)

Cachegrind, optimized C++23

I refs:	397,921,904	138,525,327
I1 misses:	1,962	2,026
LLi misses:	1,892	1,975
I1 miss rate:	0.00%	0.00%
LLi miss rate:	0.00%	0.00%
D refs:	216,694,459	48,780,211
D1 misses:	14,293	2,064,246
LLd misses:	9,045	1,368,086
D1 miss rate:	0.0%	4.2%
LLd miss rate:	0.0%	2.8%
LL refs:	16,255	2,066,272
LL misses:	10,937	1,370,061
LL miss rate:	0.0%	0.7%
Branches:	16,306,169	11,467,193
Mispredicts:	19,213	23,556
Mispred rate:	0.1%	0.2%

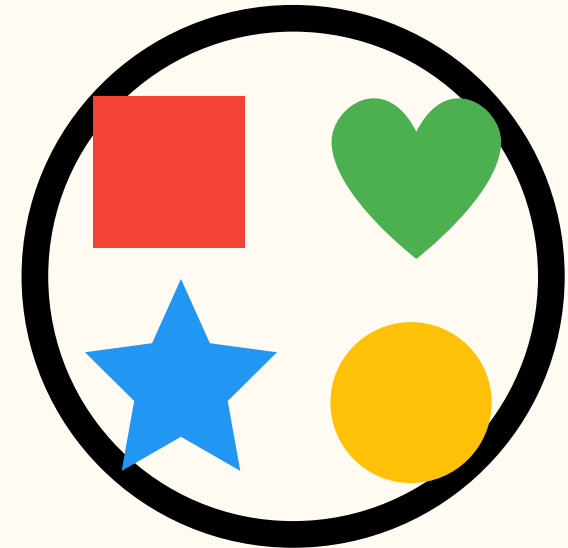
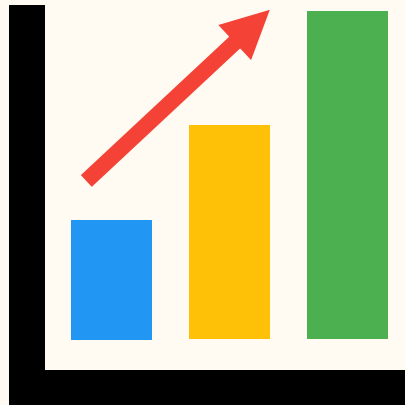
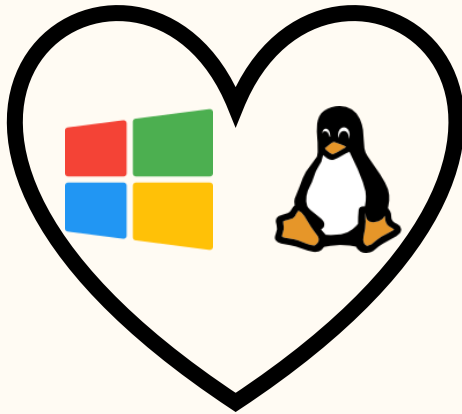
Cachegrind compare optimized

	C-Style	C++17	C++23
I refs:	75,939,042	167,963,436	138,525,327
I1 misses:	1,962	1,979	2,026
LLi misses:	1,925	1,936	1,975
I1 miss rate:	0.00%	0.00%	0.00%
LLi miss rate:	0.00%	0.00%	0.00%
D refs:	16,669,232	84,672,327	48,780,211
D1 misses:	2,514,487	3,514,637	2,064,246
LLd misses:	2,509,394	3,129,489	1,368,086
D1 miss rate:	15.1%	4.2%	4.2%
LLd miss rate:	15.1%	3.7%	2.8%
LL refs:	2,516,449	3,516,616	2,066,272
LL misses:	2,511,319	3,131,425	1,370,061
LL miss rate:	2.7%	1.2%	0.7%
Branches:	5,304,551	72,315,609	11,467,193
Mispredicts:	19,298	19,324	23,556
Mispred rate:	0.4%	0.0%	0.2%



Next?

Conclusion



Questions?

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#include <C++>

tinaul