# Gem5 Parsec Simulation Analysis

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# Cache Associativity Testing on Parsec using Gem5

**Base Parameters**

- 2-core 3GHz Timing CPU
- 2-way associative L1
- 4-way associative L2 with 1 bank
- 3GB Dual channel DDR4-2400
- Sim datasize: simsmall

**Modified parameters**

- L1 Cache Associativity
  - 2, 4, 8
- L2 Cache Associativity
  - 4, 8, 16
- Cache type
  - Private L1, shared L2 (classic) (P-L1-S-L2)
  - MESI Two Level (Ruby) (M-2-L)

# Performance Analysis

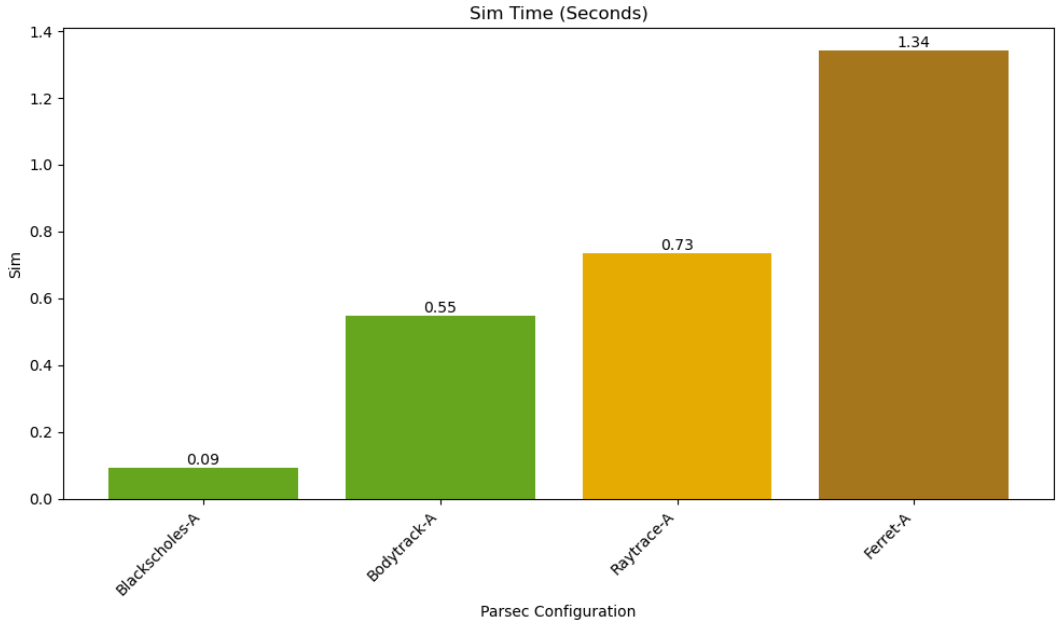
I have used the below parameter to analyze the timing-related performance of a simulation. The below parameters are used to understand how efficiently the simulation is running:

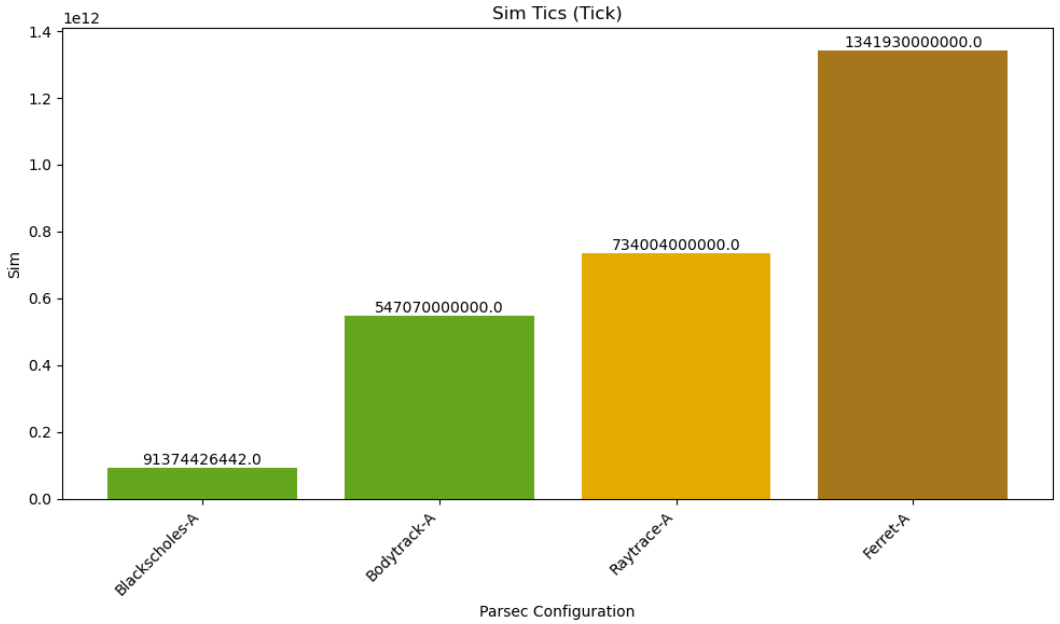
- **simSeconds (Simulation Seconds):** This indicates the total simulated time in seconds. It provides a better understanding of the overall duration of the simulation.
- **simTicks (Simulation Ticks):** This represents the total number of simulation ticks.
- **hostSeconds (Host Seconds):** This shows the real-time elapsed on the host machine. It is used for evaluating the efficiency of the simulation concerning real-world time.
- **Total Wallclock Time (min):** This represents the actual, real-world time your computer takes to run the simulation.
- **Note: Cache Associativity is defined in the table and graph as A, B, C where A= [2,4], B=[4,8], and C=[8,16] associativity.**

# Performance Analysis Using P-L1-S-L2 Cache A

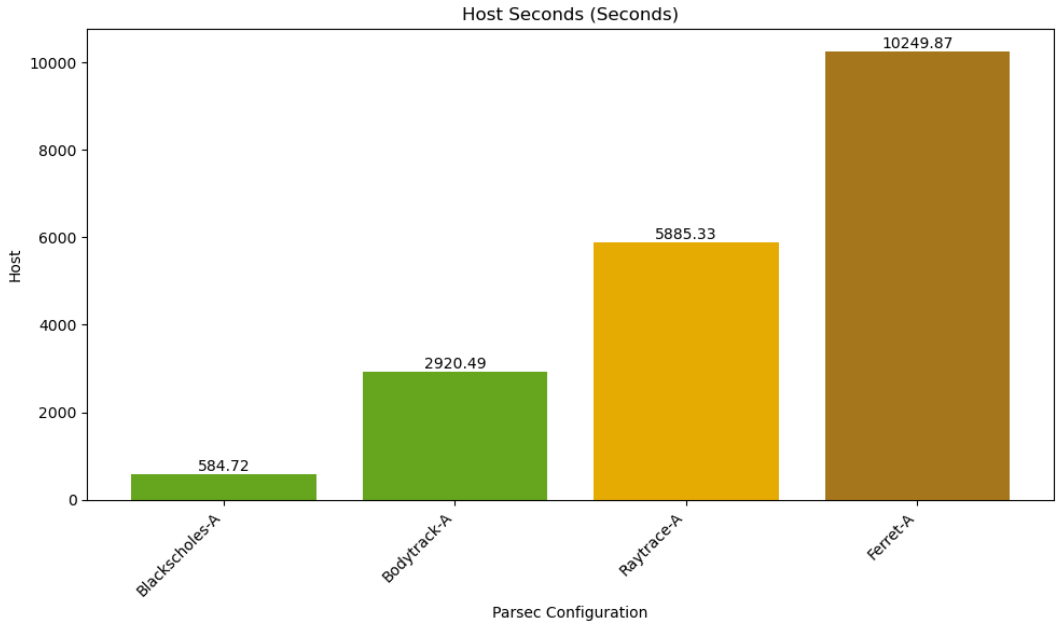
| Performance Analysis | Blackscholes-A-PRIVATE_L1_SHARED_L2 | Bodytrack-A-PRIVATE_L1_SHARED_L2 | Raytrace-A-PRIVATE_L1_SHARED_L2 | Ferret-A-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| **Sim Time (seconds)** | 0.091374 | 0.54707 | 0.734004 | 1.341934 |
| **Sim Tics (Tick)** | 91374426442 | 5.4707E+11 | 7.34004E+11 | 1.34193E+12 |
| **Host Seconds (seconds)** | 584.72 | 2920.49 | 5885.33 | 10249.87 |
| **Total Wallclock Time (minutes)** | 10.08 | 49.03 | 98.64 | 171.56 |

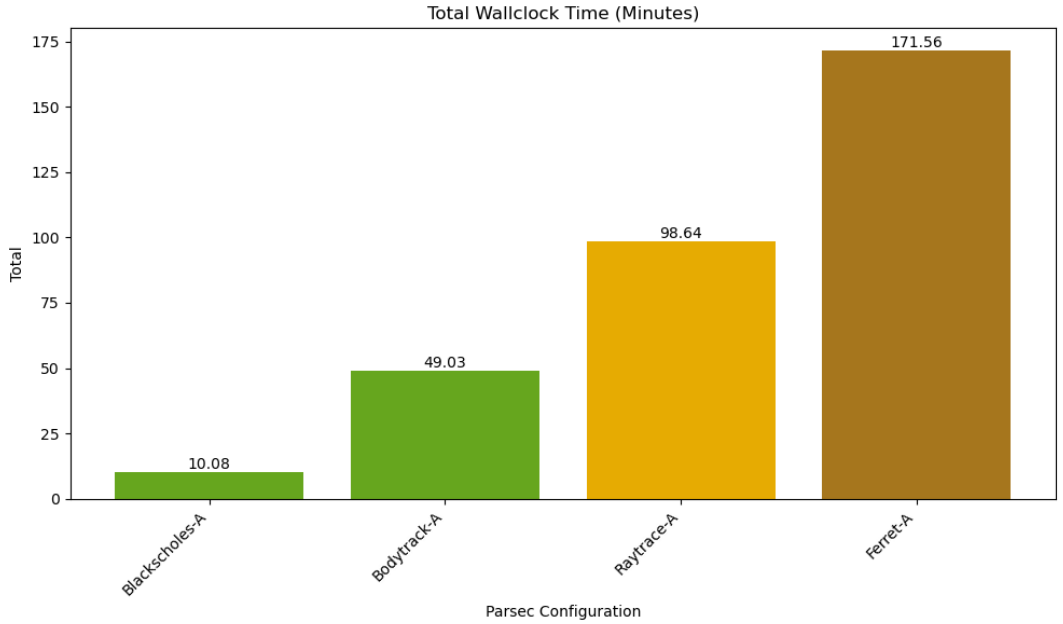
# Performance Analysis Using P-L1-S-L2 Cache A



# Performance Analysis Using P-L1-S-L2 Cache A

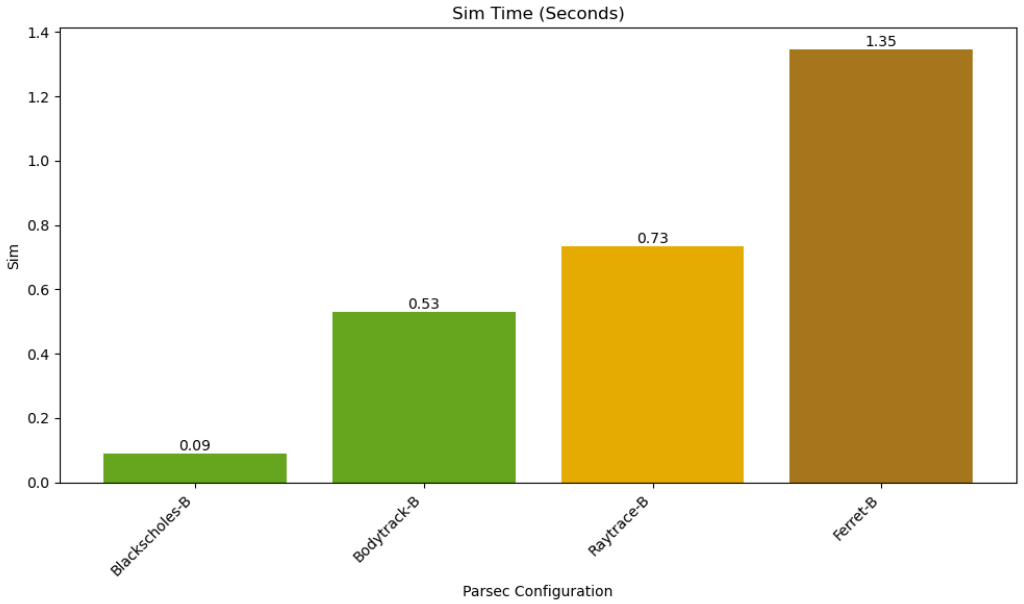


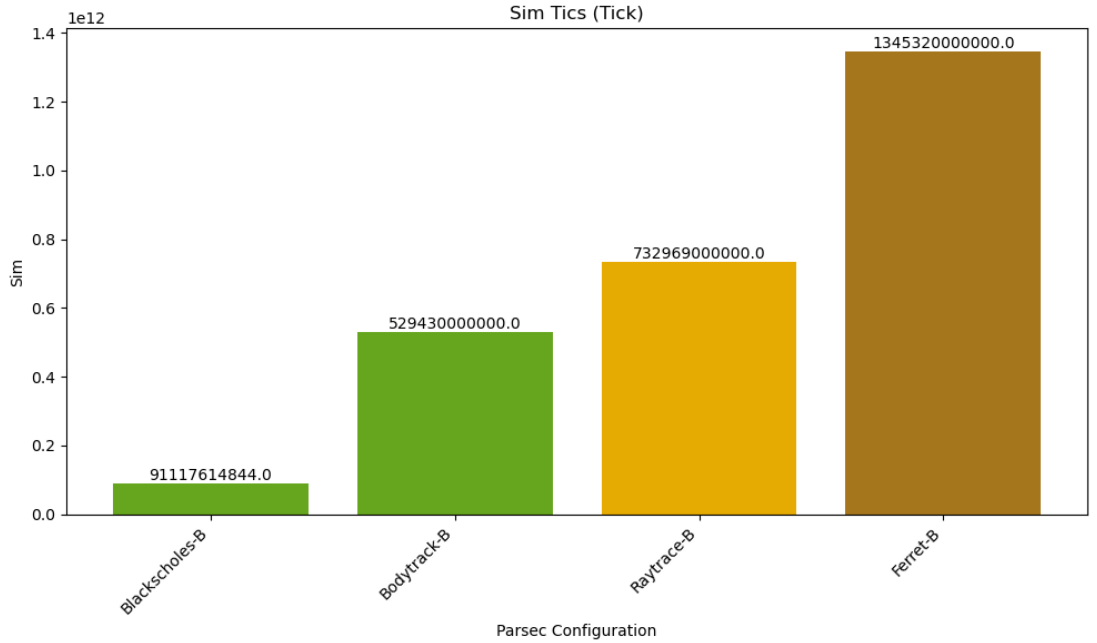



# Performance Analysis Using P-L1-S-L2 Cache B

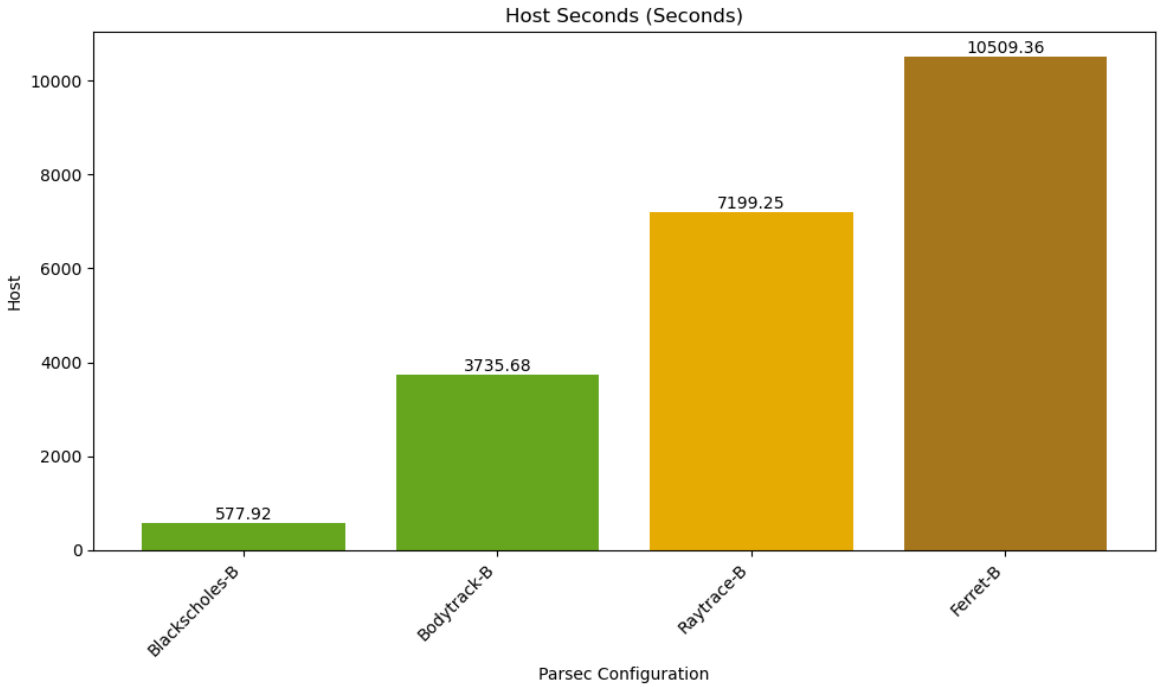
| Performance Analysis | Blackscholes-B-PRIVATE_L1_SHARED_L2 | Bodytrack-B-PRIVATE_L1_SHARED_L2 | Raytrace-B-PRIVATE_L1_SHARED_L2 | Ferret-B-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| **Sim Time (seconds)** | 0.091118 | 0.52943 | 0.732969 | 1.345323 |
| **Sim Tics (Tick)** | 91117614844 | 5.2943E+11 | 7.32969E+11 | 1.34532E+12 |
| **Host Seconds (seconds)** | 577.92 | 3735.68 | 7199.25 | 10509.36 |
| **Total Wallclock Time (minutes)** | 10.63 | 63.94 | 120.83 | 175.75 |

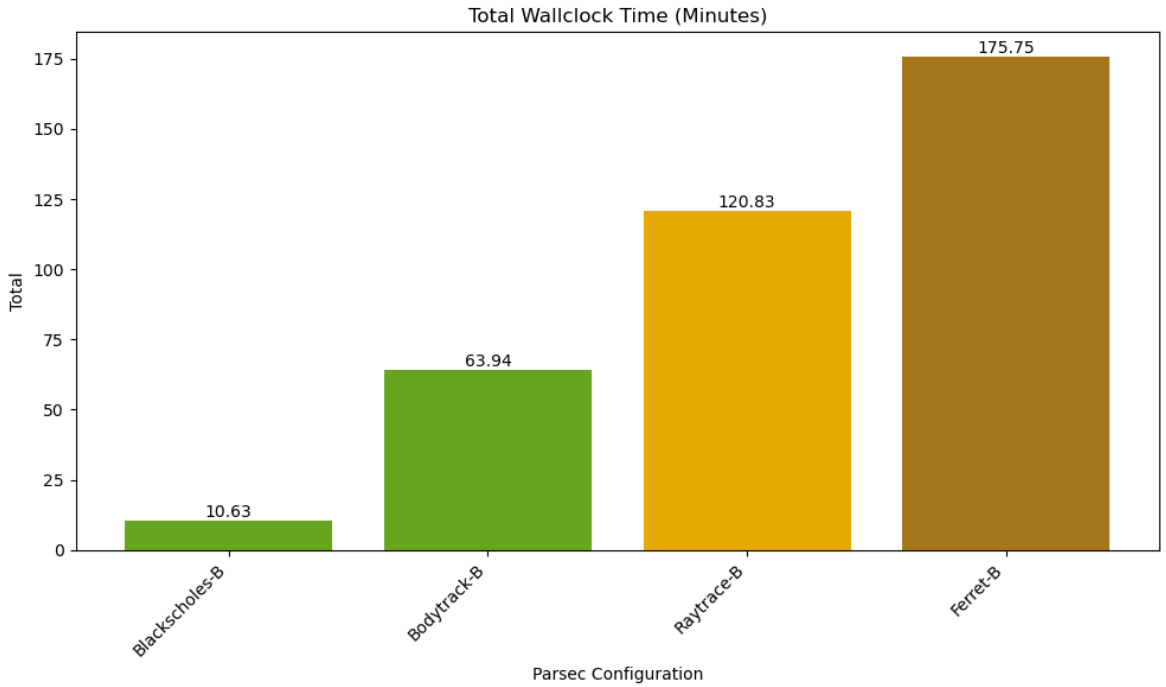
# Performance Analysis Using P-L1-S-L2 Cache B



# Performance Analysis Using P-L1-S-L2 Cache B

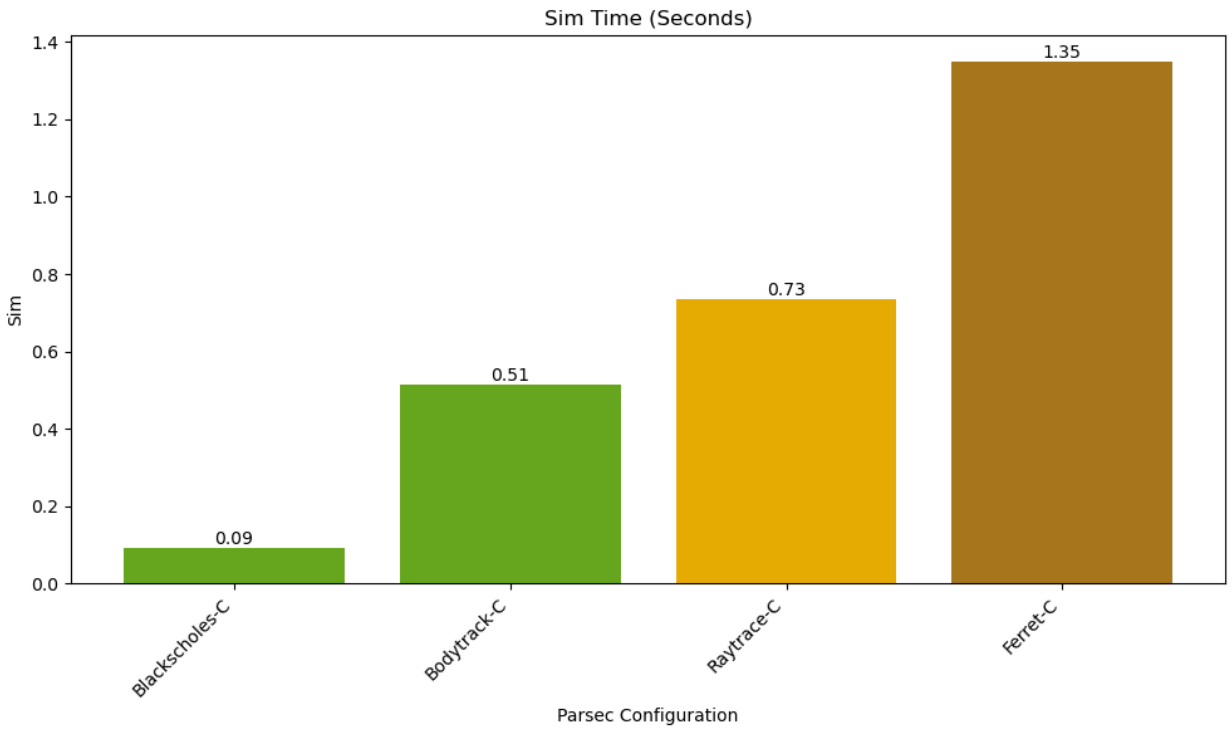


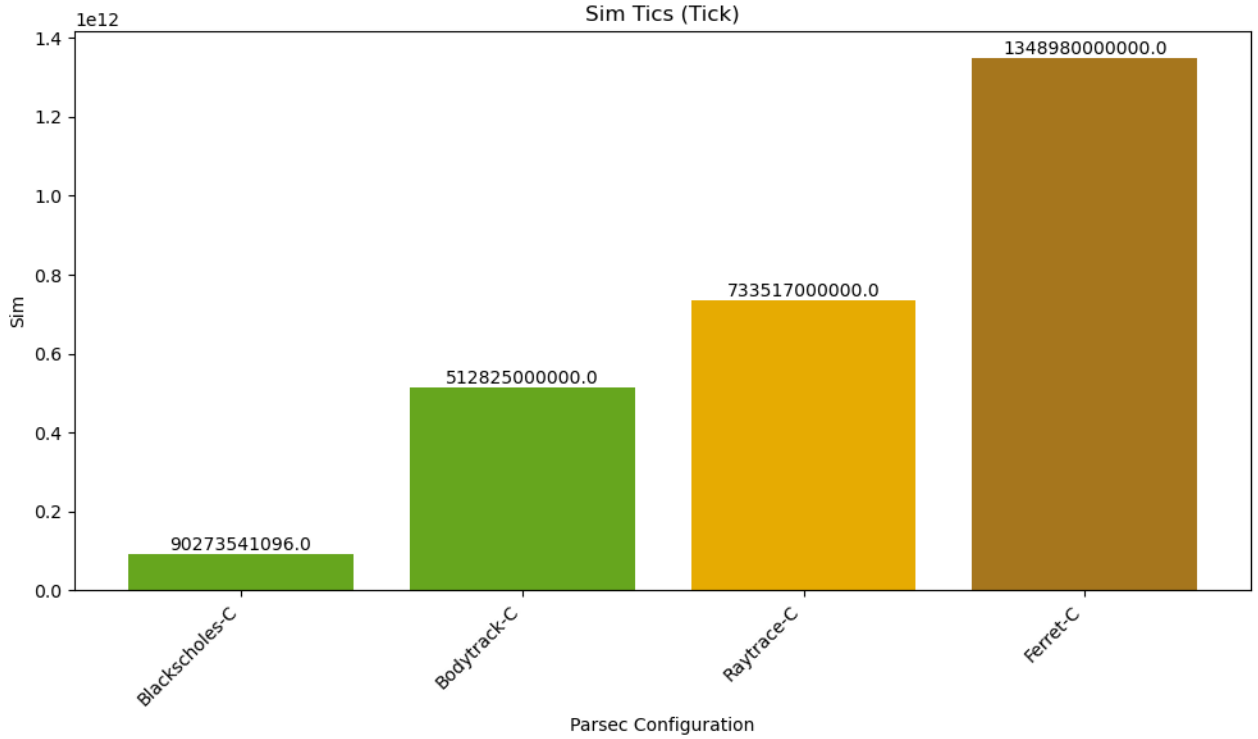



# Performance Analysis Using P-L1-S-L2 Cache C

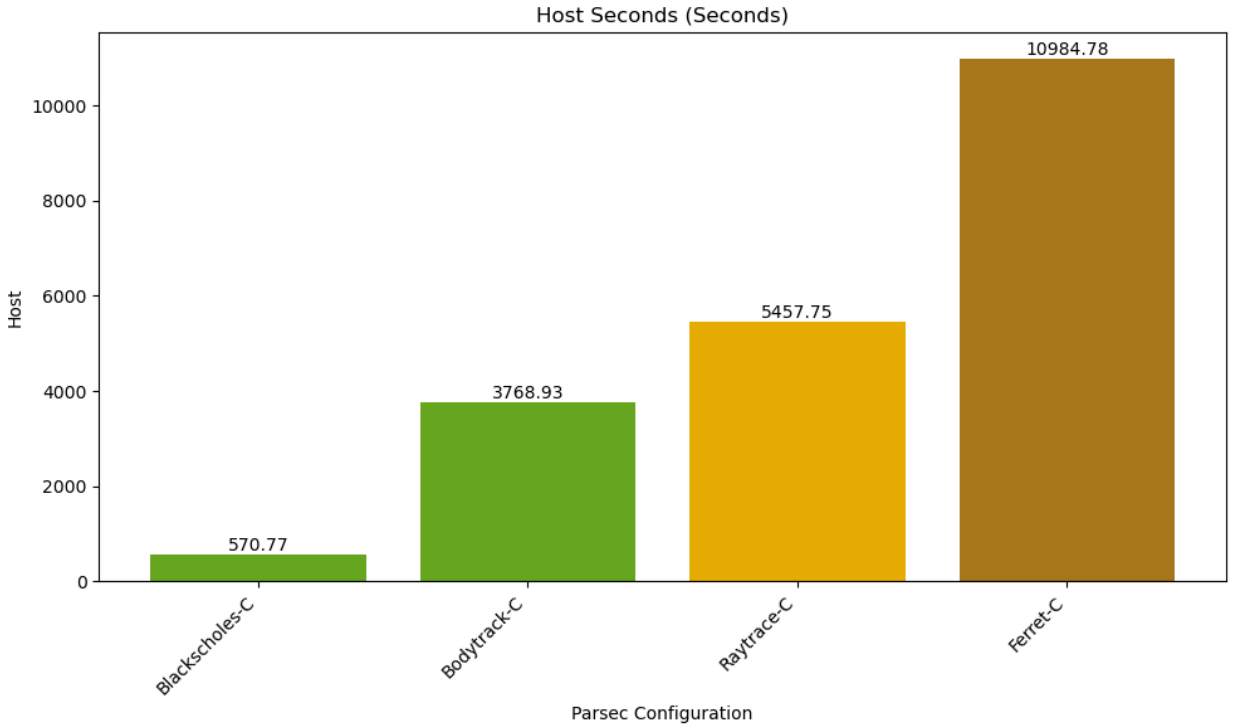
| Performance Analysis | Blackscholes-C-PRIVATE_L1_SHARED_L2 | Bodytrack-C-PRIVATE_L1_SHARED_L2 | Raytrace-C-PRIVATE_L1_SHARED_L2 | Ferret-C-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| **Sim Time (seconds)** | 0.090274 | 0.512825 | 0.733517 | 1.348978 |
| **Sim Tics (Tick)** | 90273541096 | 5.12825E+11 | 7.33517E+11 | 1.34898E+12 |
| **Host Seconds (seconds)** | 570.77 | 3768.93 | 5457.75 | 10984.78 |
| **Total Wallclock Time (minutes)** | 9.85 | 80.07 | 91.82 | 183.53 |

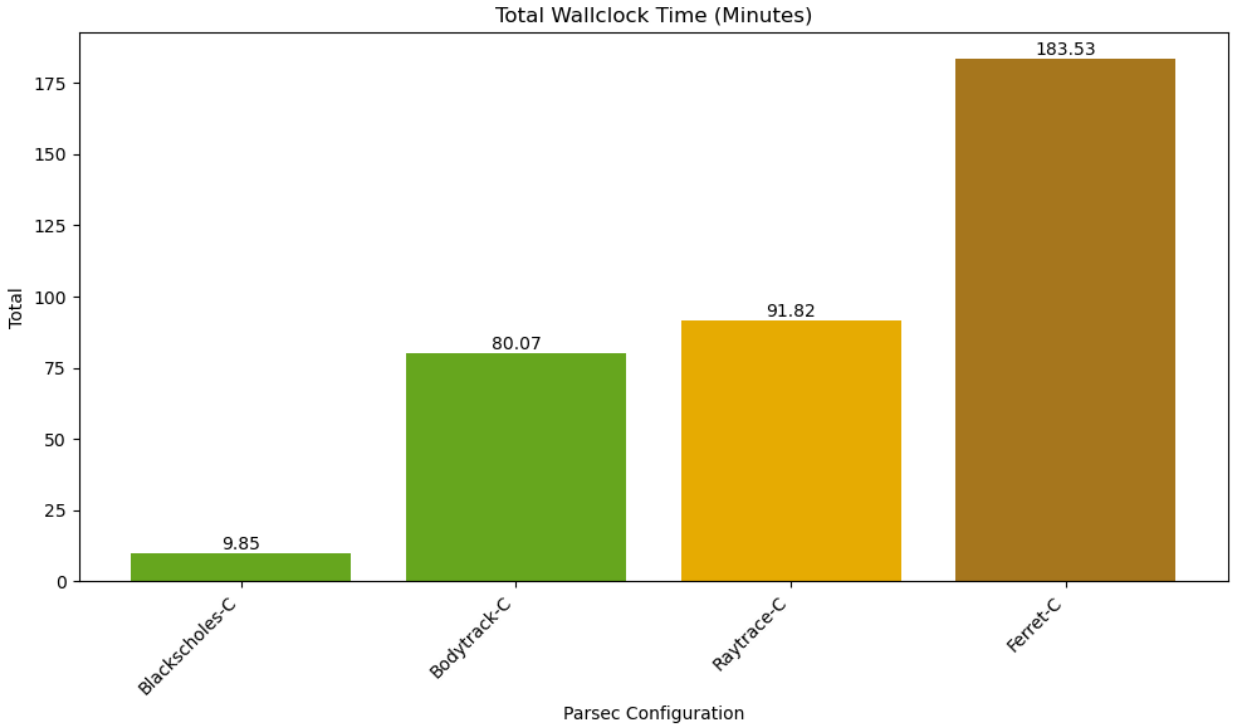
# Performance Analysis Using P-L1-S-L2 Cache C



# Performance Analysis Using P-L1-S-L2 Cache C

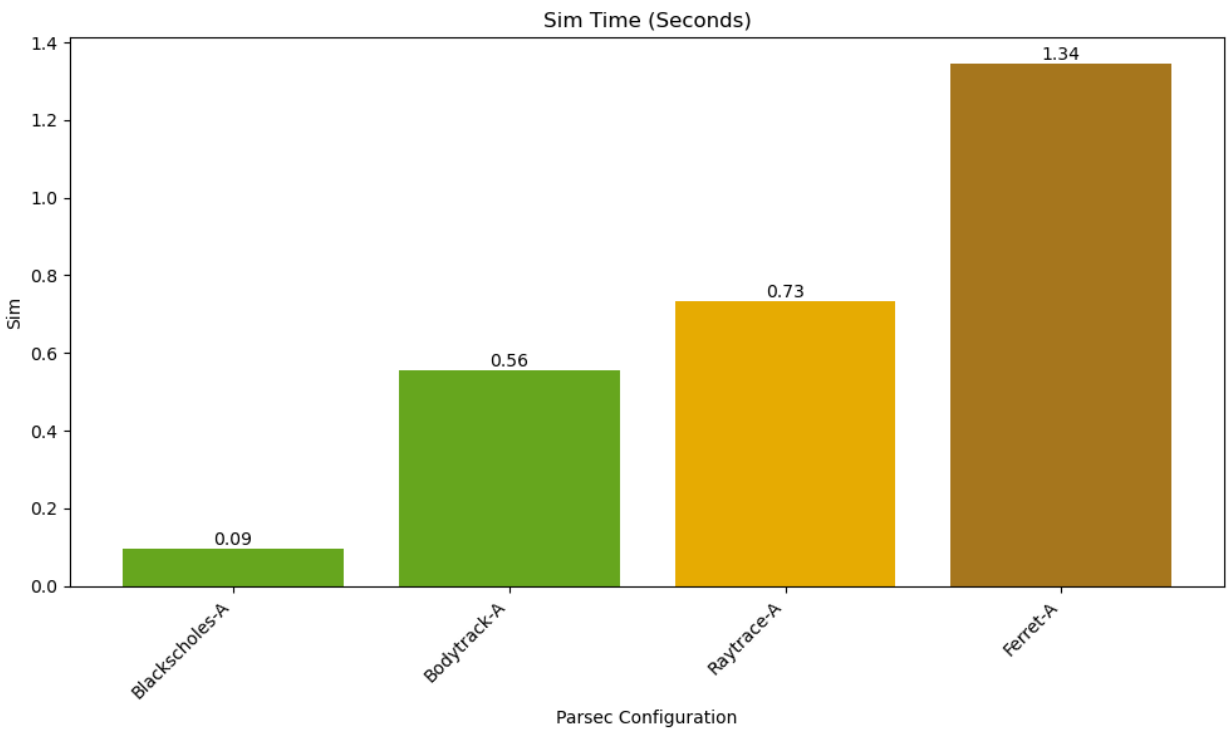


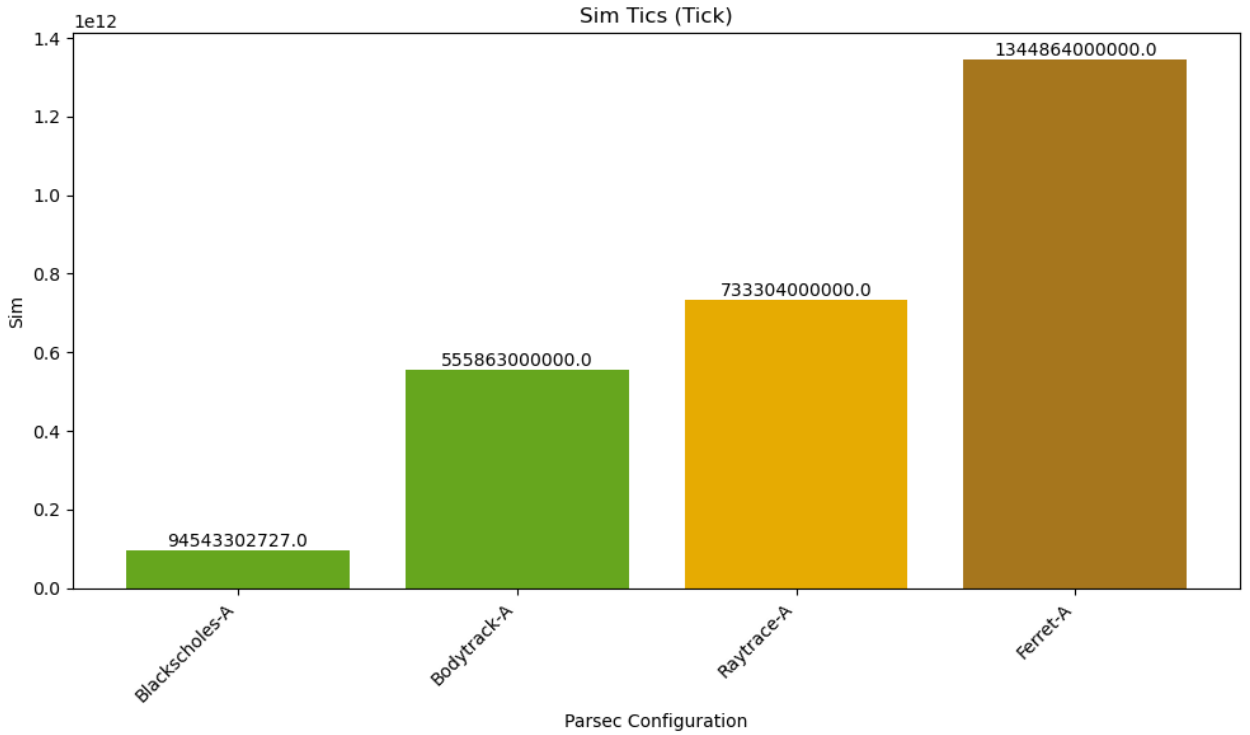



# Performance Analysis Using M-2-L Cache A

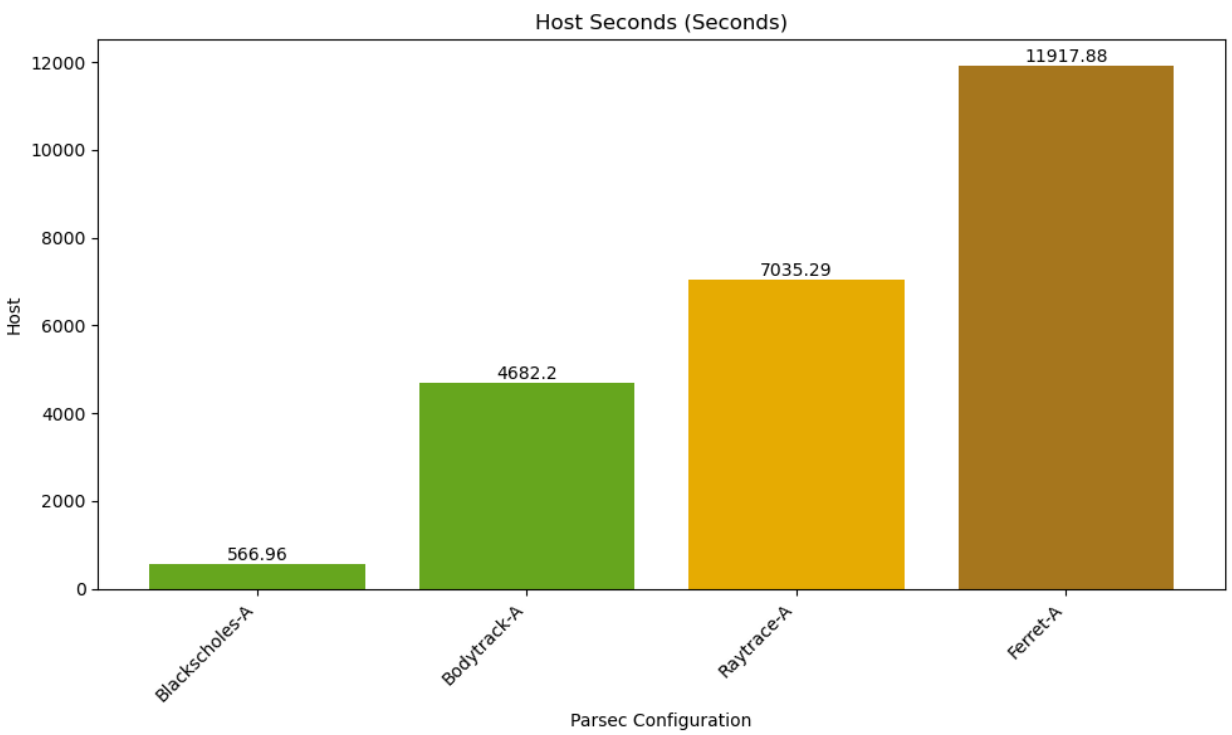
| Performance Analysis | Blackscholes-A-Mesi_Two_Level | Bodytrack-A-Mesi_Two_Level | Raytrace-A-Mesi_Two_Level | Ferret-A-Mesi_Two_Level |
|---|---|---|---|---|
| **Sim Time (seconds)** | 0.094543 | 0.555863 | 0.733304 | 1.344864 |
| **Sim Tics (Tick)** | 94543302727 | 5.55863E+11 | 7.33304E+11 | 1.34486E+12 |
| **Host Seconds (seconds)** | 566.96 | 4682.2 | 7035.29 | 11917.88 |
| **Total Wallclock Time (minutes)** | 9.81 | 79.38 | 121.6 | 199.37 |

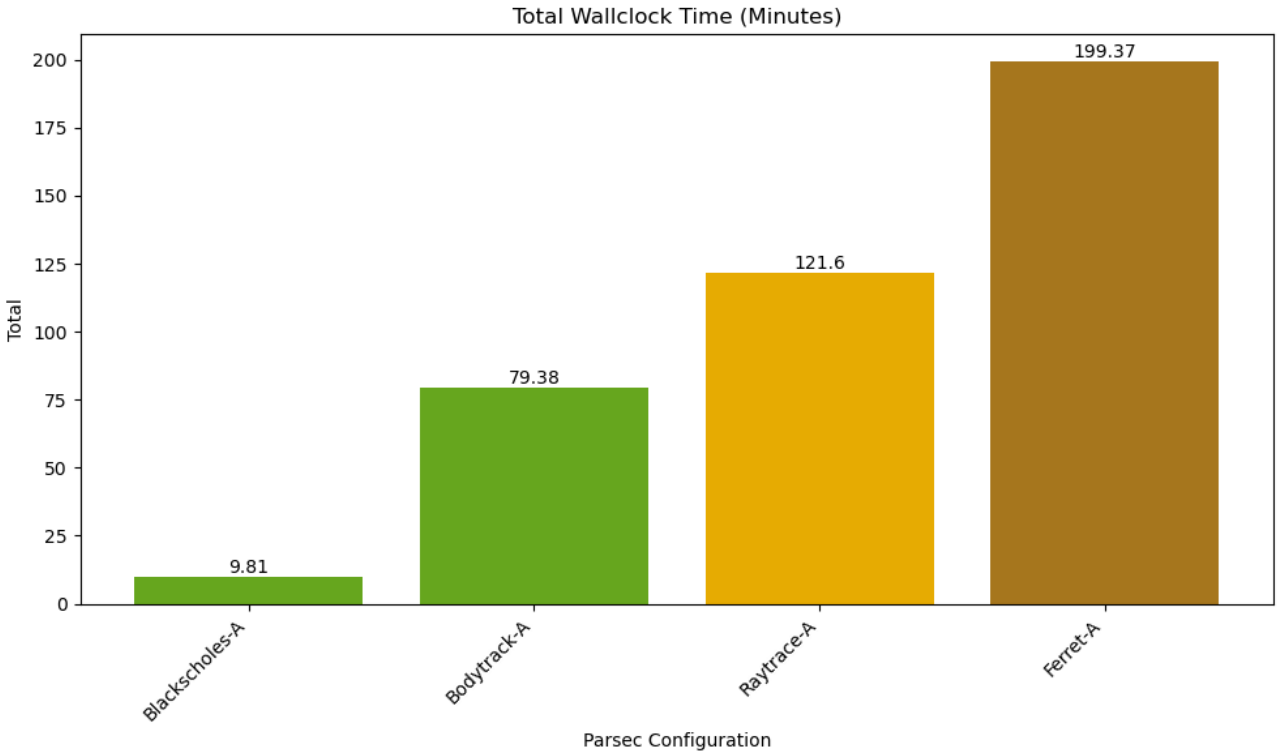
# Performance Analysis Using M-2-L Cache A



# Performance Analysis Using M-2-L Cache A

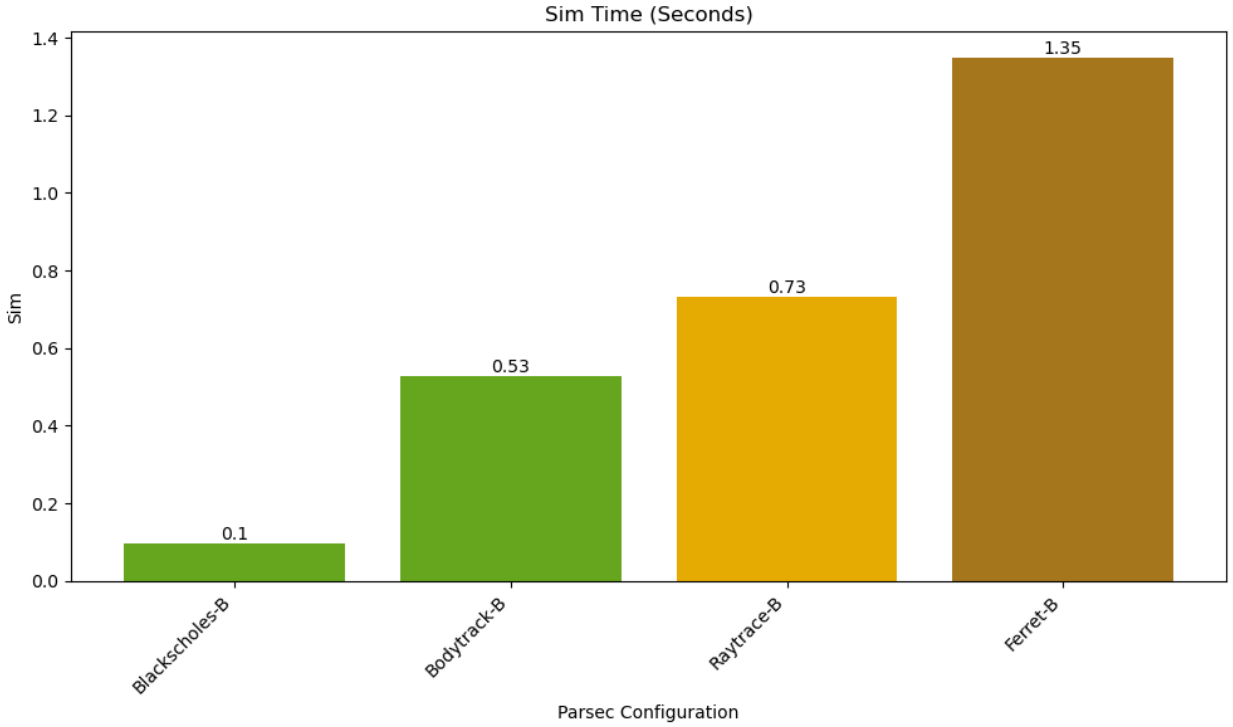


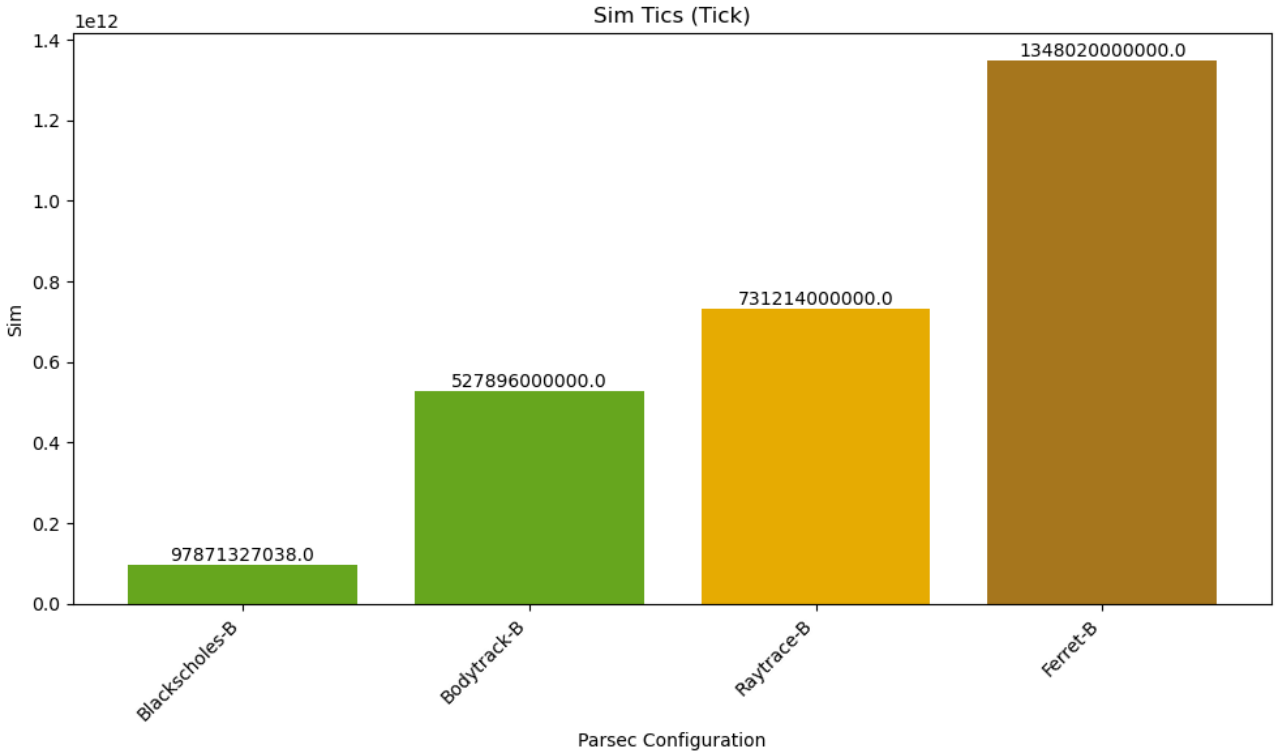



# Performance Analysis Using M-2-L Cache B

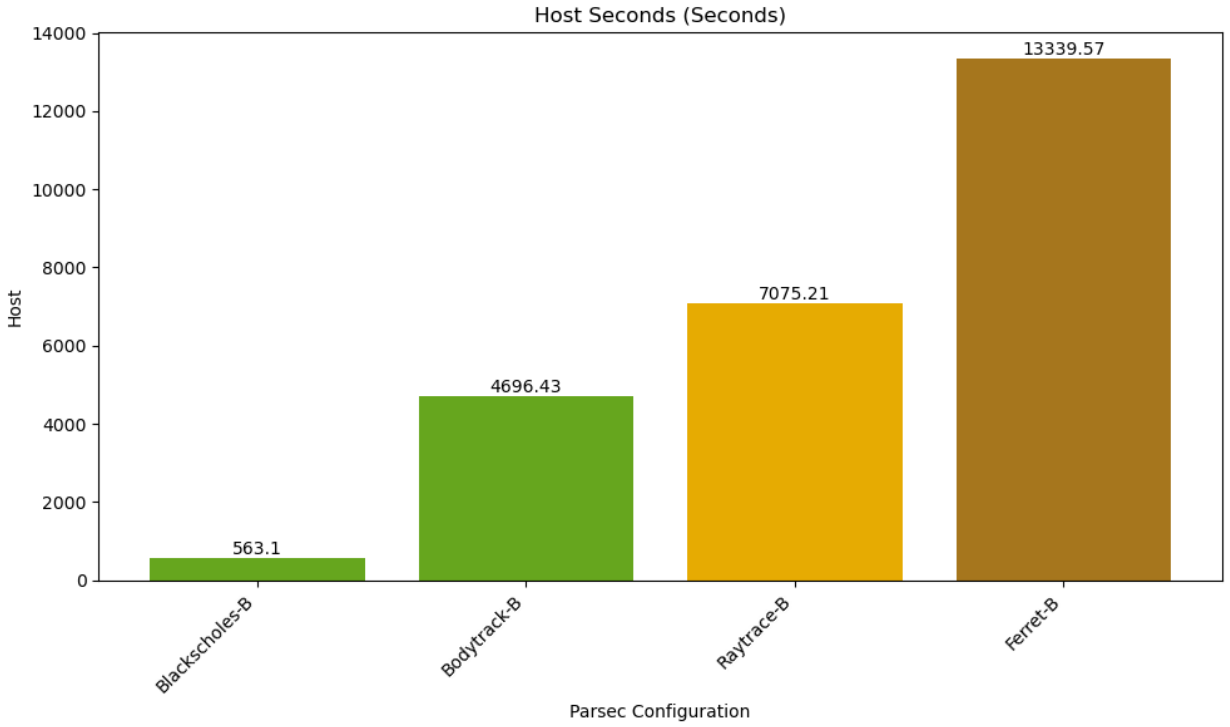
| Performance Analysis | Blackscholes-B-Mesi_Two_Level | Bodytrack-B-Mesi_Two_Level | Raytrace-B-Mesi_Two_Level | Ferret-B-Mesi_Two_Level |
|---|---|---|---|---|
| Sim Time (seconds) | 0.097871 | 0.527896 | 0.731214 | 1.348016 |
| Sim Tics (Tick) | 97871327038 | 5.27896E+11 | 7.31214E+11 | 1.34802E+12 |
| Host Seconds (seconds) | 563.1 | 4696.43 | 7075.21 | 13339.57 |
| Total Wallclock Time (minutes) | 9.74 | 78.88 | 118.6 | 223.47 |

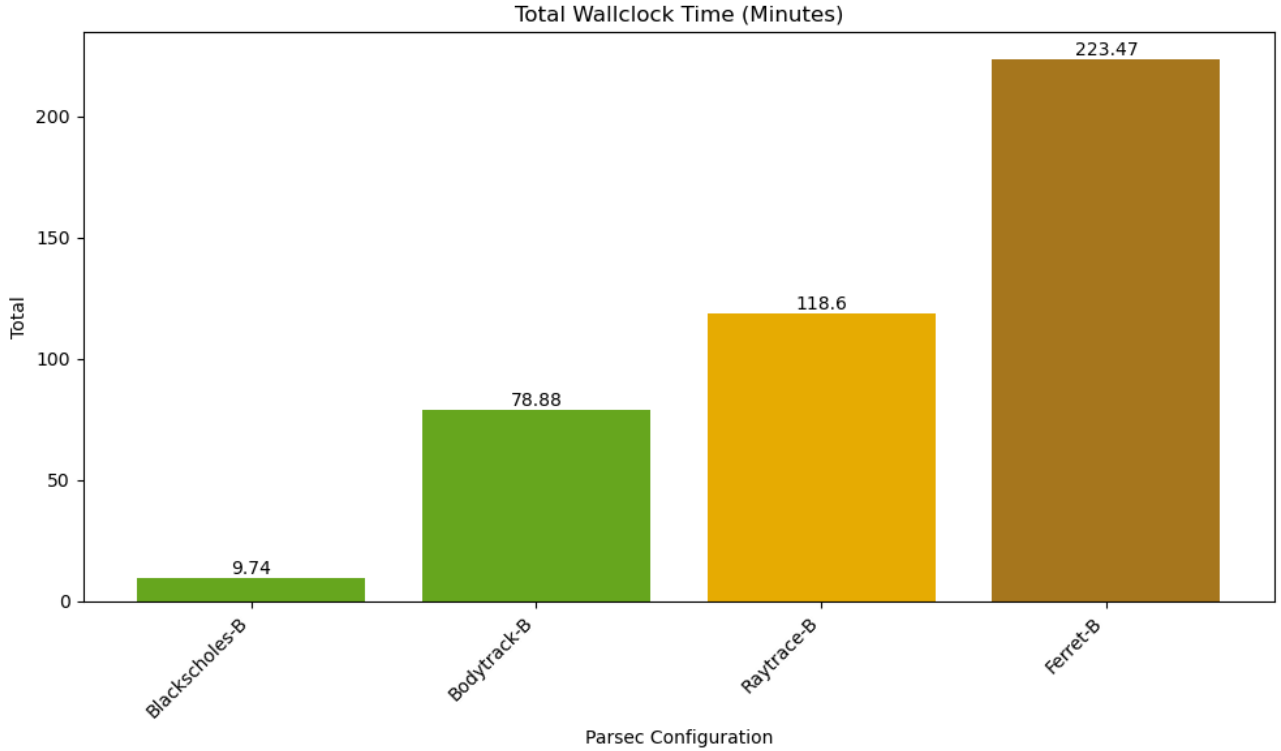
# Performance Analysis Using M-2-L Cache B



# Performance Analysis Using M-2-L Cache B

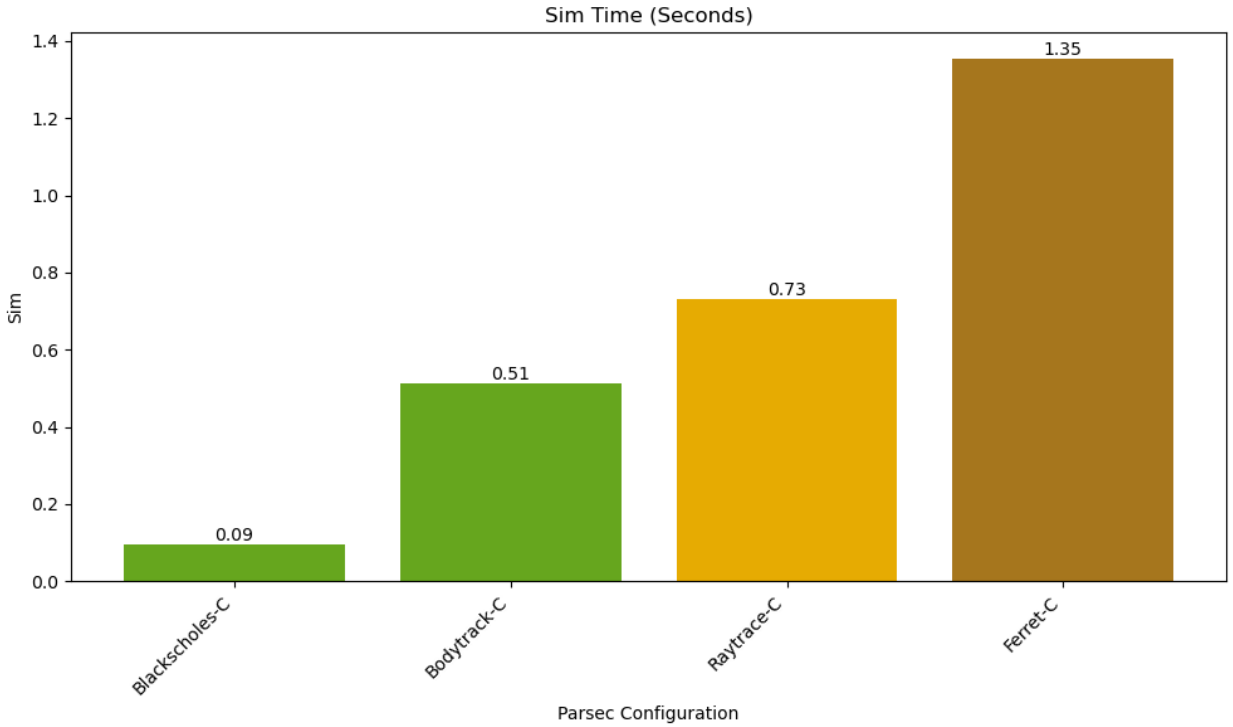


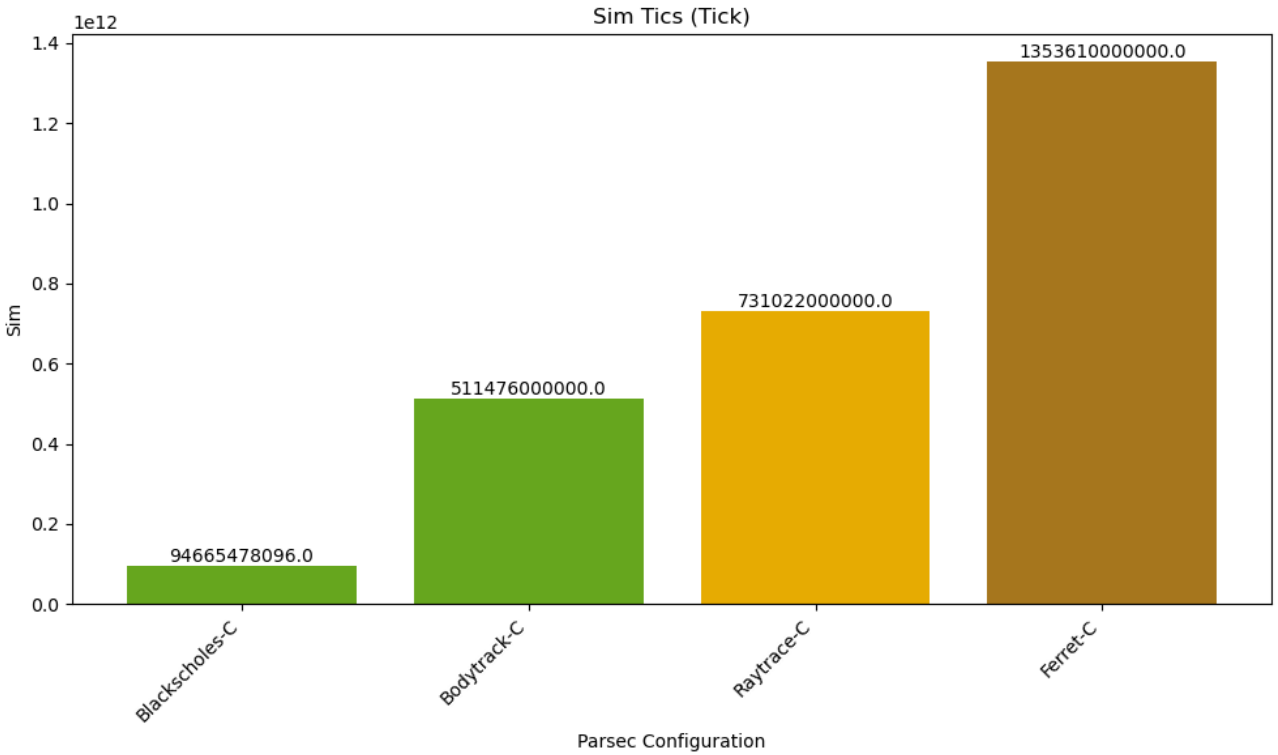



# Performance Analysis Using M-2-L Cache C

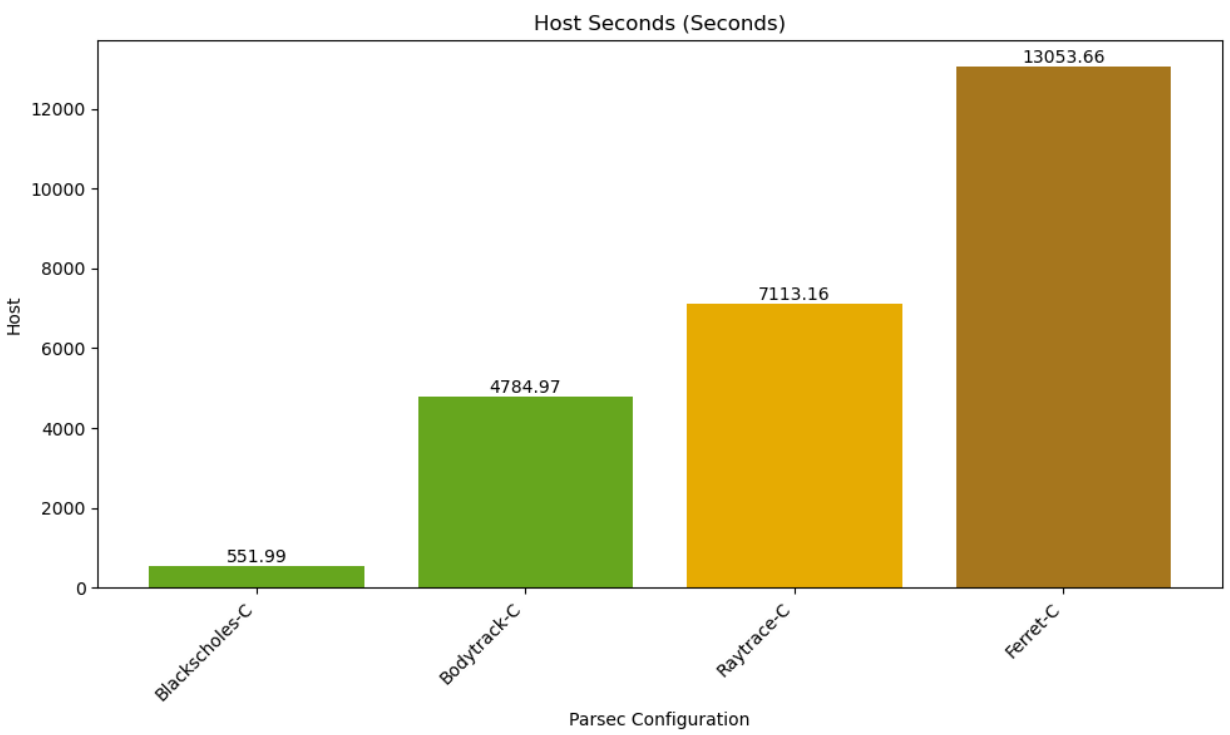
| Performance Analysis | Blackscholes-C-Mesi_Two_Level | Bodytrack-C-Mesi_Two_Level | Raytrace-C-Mesi_Two_Level | Ferret-C-Mesi_Two_Level |
|---|---|---|---|---|
| Sim Time (seconds) | 0.094665 | 0.511476 | 0.731022 | 1.353612 |
| Sim Tics (Tick) | 94665478096 | 5.11476E+11 | 7.31022E+11 | 1.35361E+12 |
| Host Seconds (seconds) | 551.99 | 4784.97 | 7113.16 | 13053.66 |
| Total Wallclock Time (minutes) | 9.53 | 81.62 | 119.29 | 218.56 |

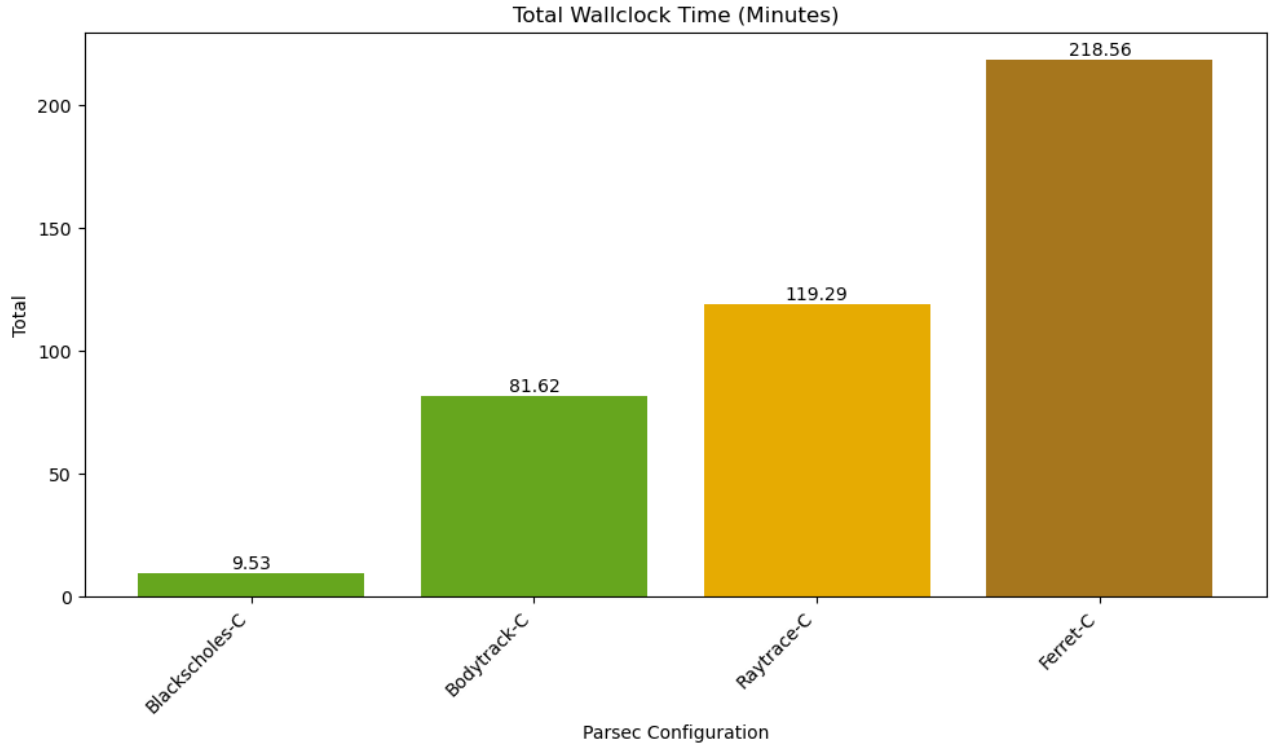
# Performance Analysis Using M-2-L Cache C



# Performance Analysis Using M-2-L Cache C



# Workload Analysis

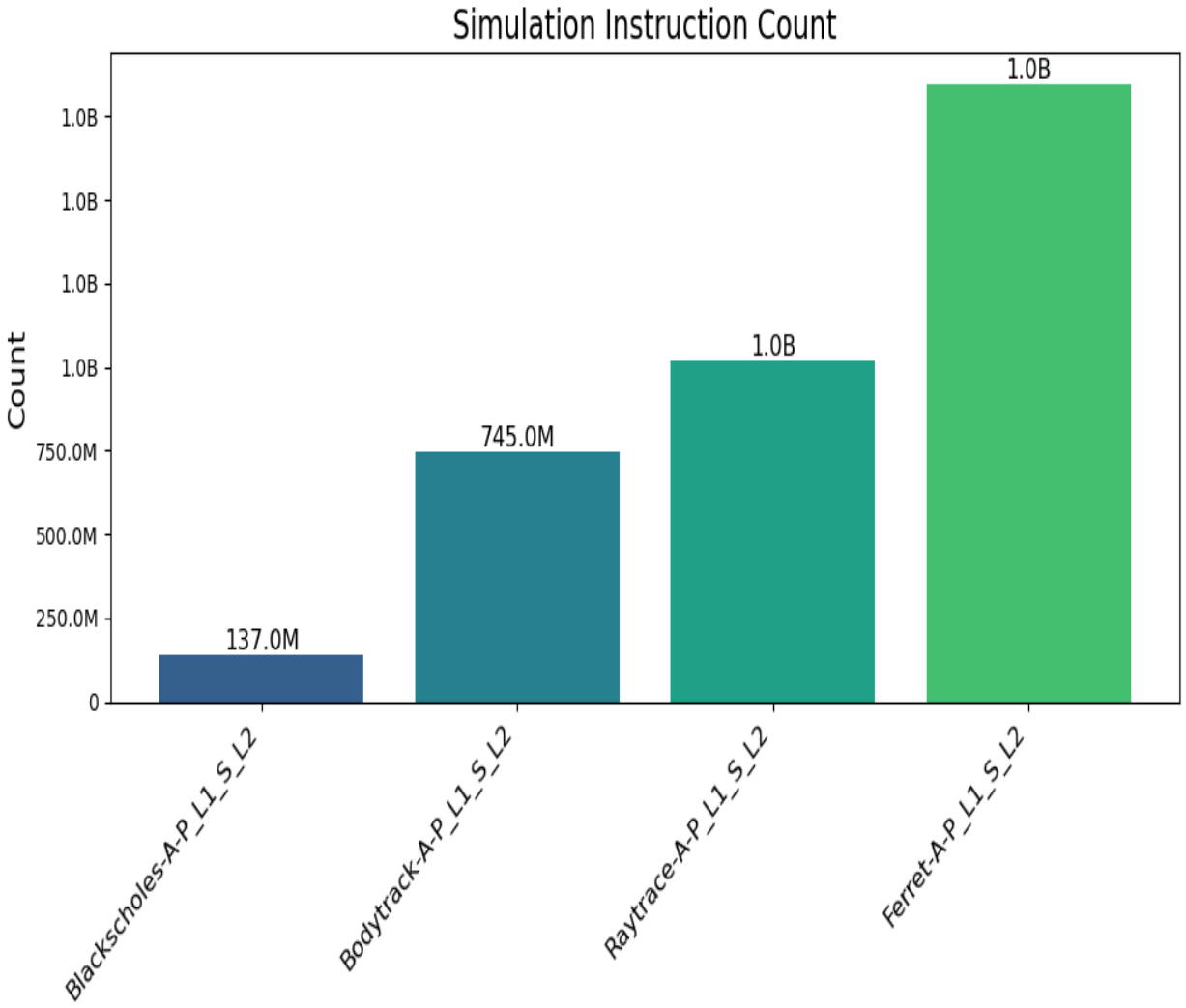
I have used the parameter below to analyze the computational intensity of a simulation. The below parameters are used to analyze the workload.

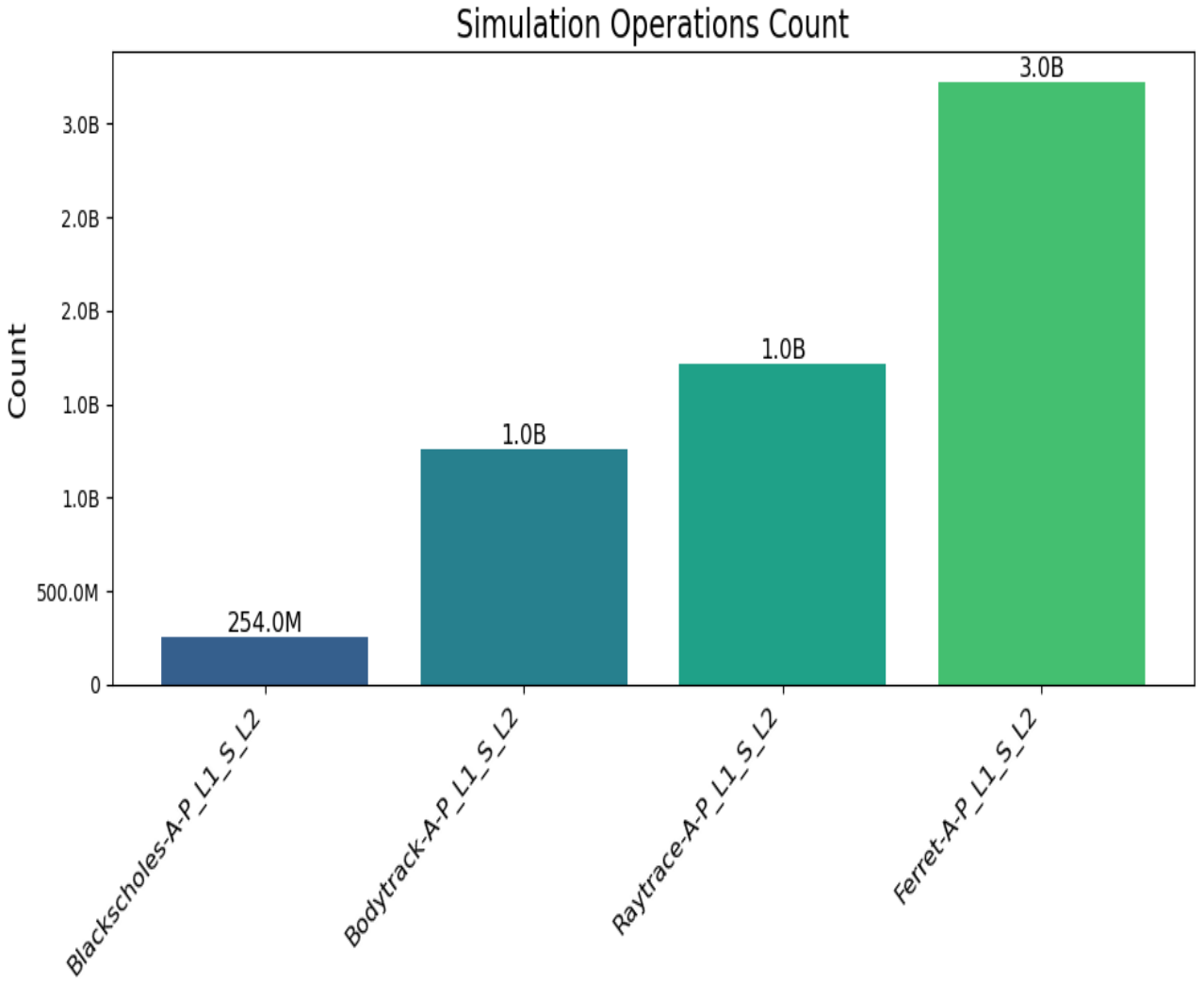
- **simInsts (Simulated Instructions)**: The total number of instructions simulated. This is crucial for understanding the computational workload of the simulation.
- **simOps (Simulated Operations)**: The number of operations, including micro-operations, gives insight into the complexity and intensity of the simulation workload.
- **hostInstRate**: The rate at which the simulator processes instructions per second of host time, indicating the efficiency of the simulation.
- **Note: Cache Associativity is defined in the table and graph as A, B, C where A= [2,4], B=[4,8], and C=[8,16] associativity.**

# Workload Analysis Using P-L1-S-L2 Cache A

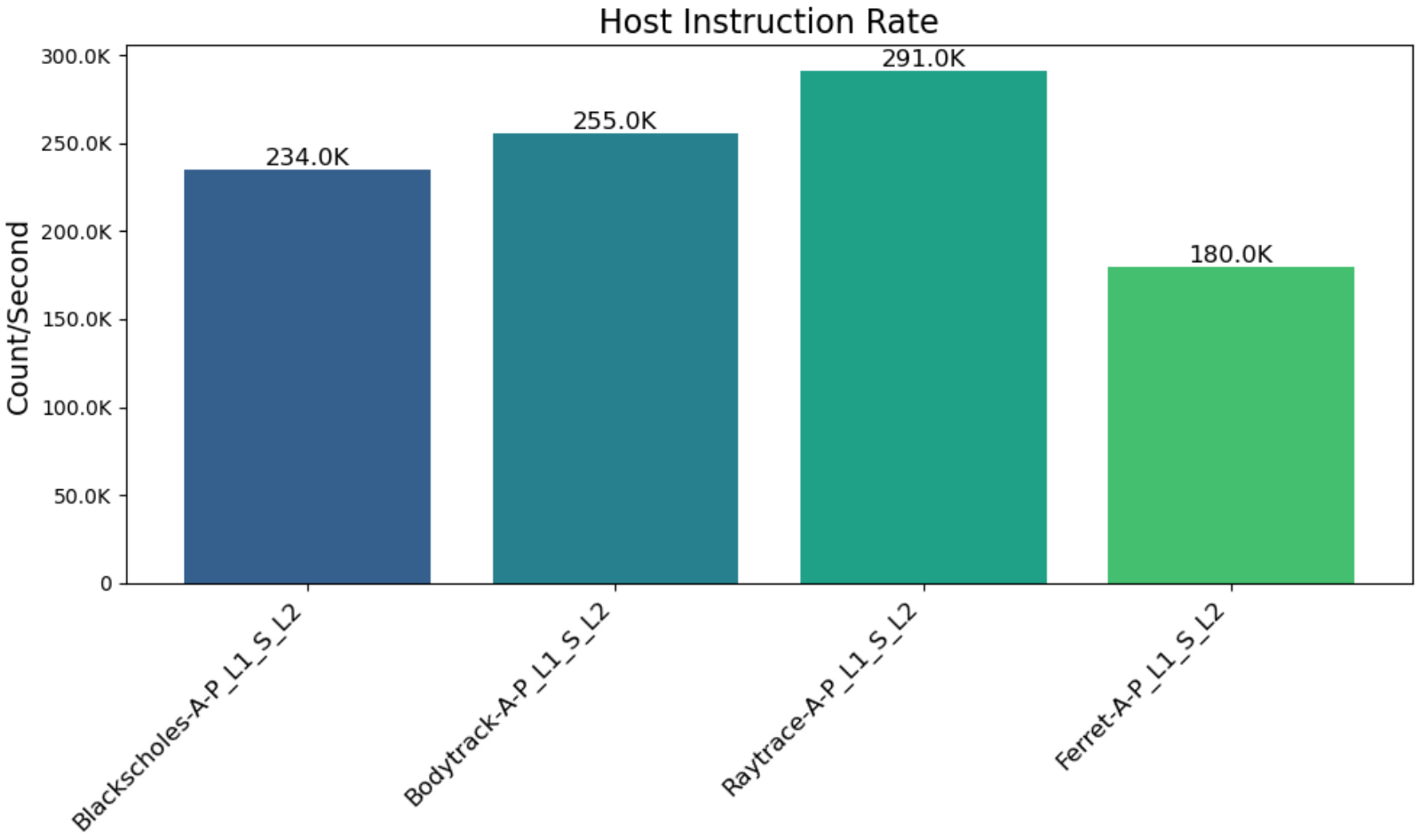
| Workload Charachterization | Blackscholes-A-PRIVATE_L1_SHARED_L2 | Bodytrack-A-PRIVATE_L1_SHARED_L2 | Raytrace-A-PRIVATE_L1_SHARED_L2 | Ferret-A-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| Sim Instruction (Count) | 137361628 | 745716965 | 1018866223 | 1845500428 |
| Sim Ops (Count) | 254010039 | 1262304430 | 1712951700 | 3222886689 |
| Host Instrsuction Rate (Count/Second) | 234919 | 255339 | 291054 | 180051 |

# Workload Analysis Using P-L1-S-L2 Cache A



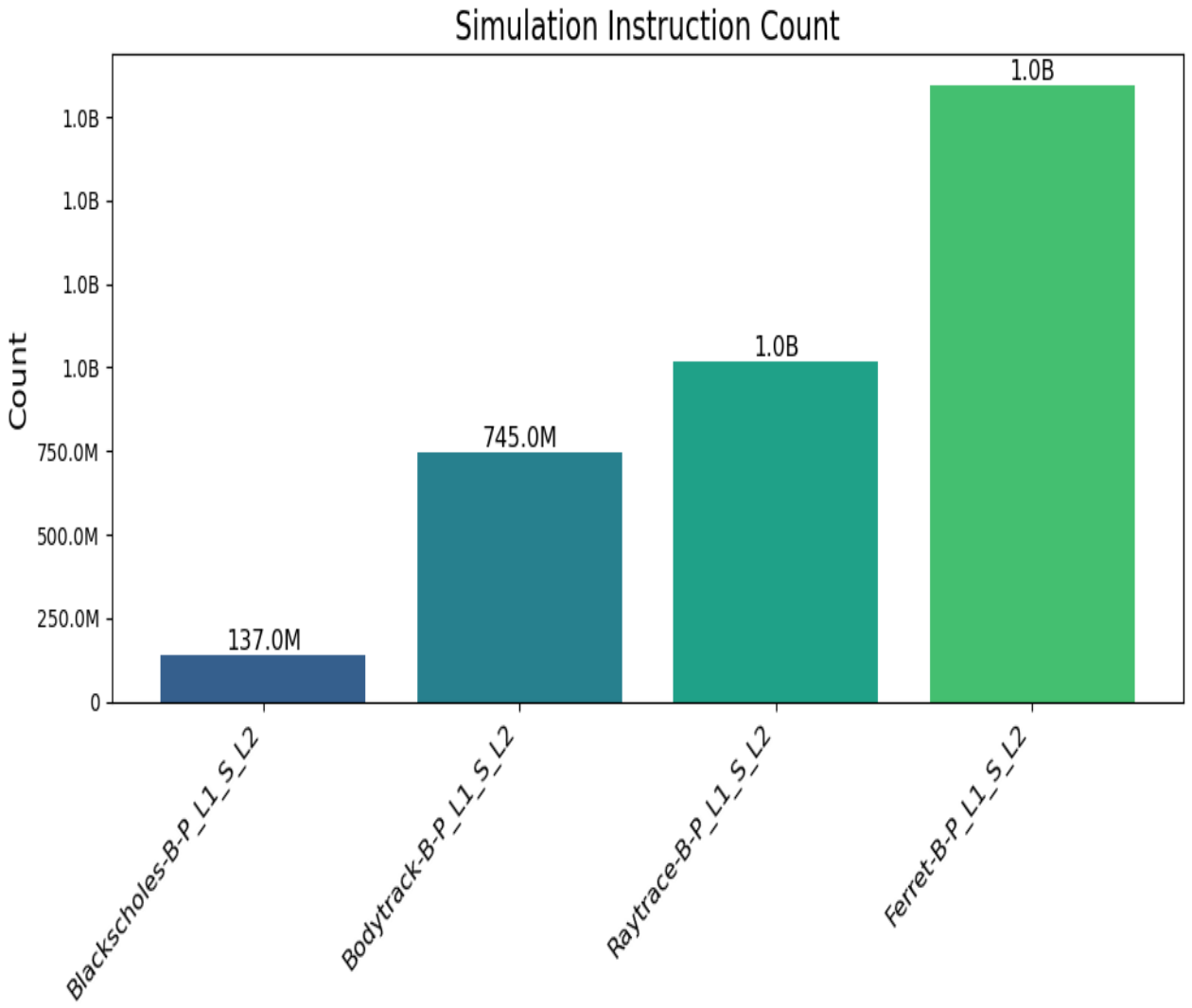
# Workload Analysis Using P-L1-S-L2 Cache A

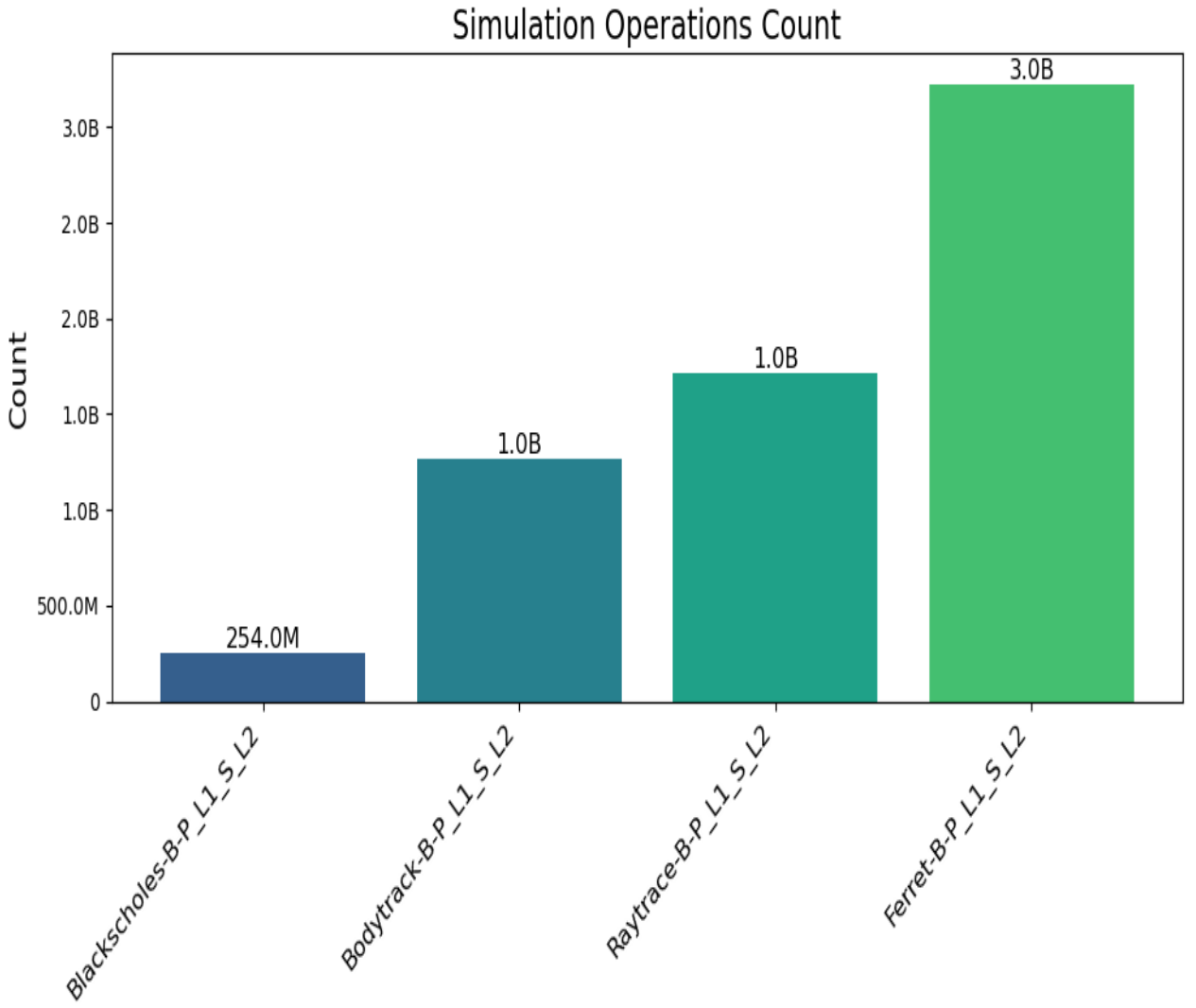


# Workload Analysis Using P-L1-S-L2 Cache B

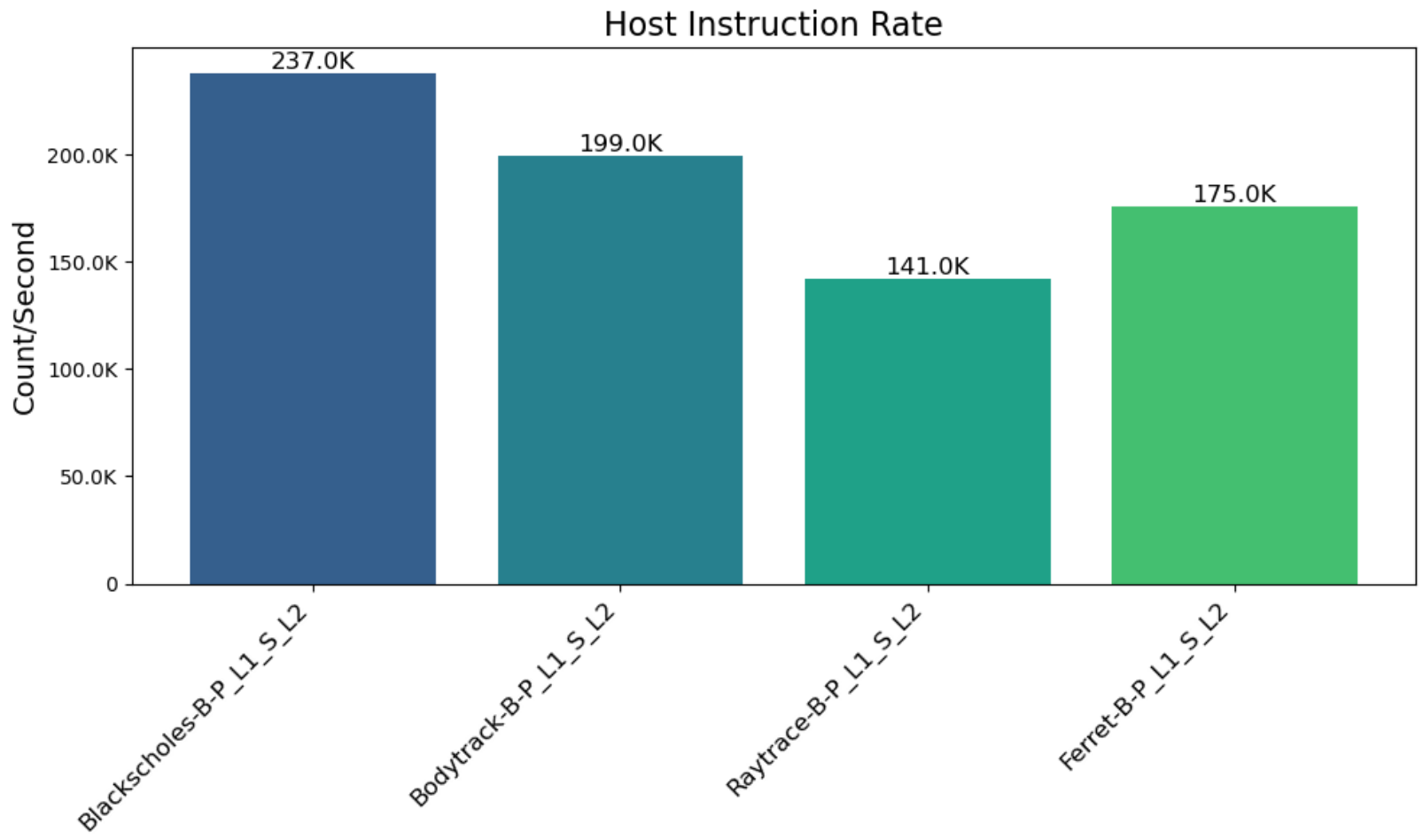
| Workload Charachterization | Blackscholes-B-PRIVATE_L1_SHARED_L2 | Bodytrack-B-PRIVATE_L1_SHARED_L2 | Raytrace-B-PRIVATE_L1_SHARED_L2 | Ferret-B-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| Sim Instruction (Count) | 137448613 | 745580154 | 1020283584 | 1845370554 |
| Sim Ops (Count) | 254154842 | 1261991252 | 1715777206 | 3222798984 |
| Host Instrsuction Rate (Count/Second) | 237835 | 199583 | 141721 | 175593 |

# Workload Analysis Using P-L1-S-L2 Cache B



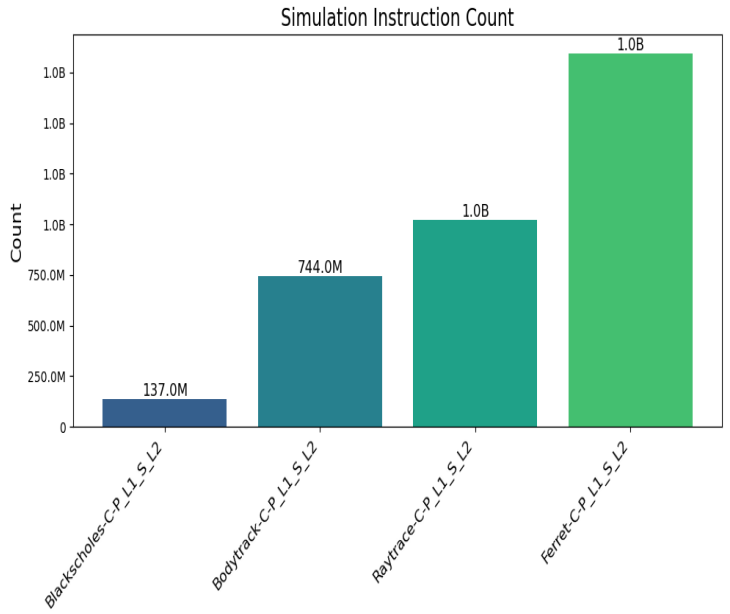
# Workload Analysis Using P-L1-S-L2 Cache B

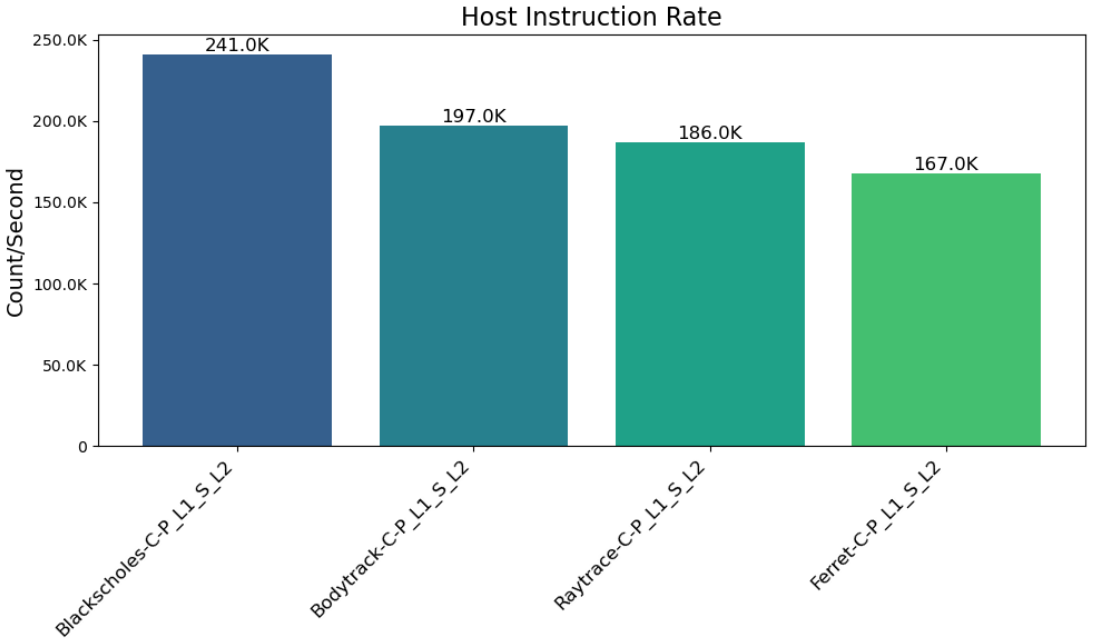


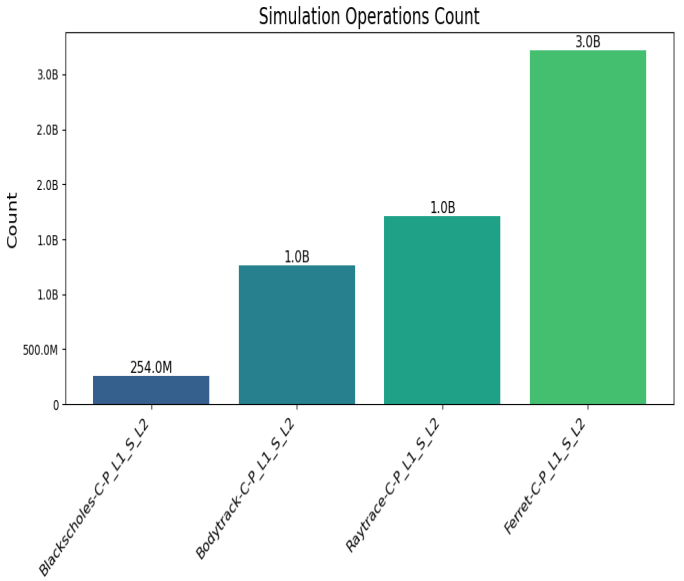
# Workload Analysis Using P-L1-S-L2 Cache C

| Workload Charachterization | Blackscholes-C-PRIVATE_L1_SHARED_L2 | Bodytrack-C-PRIVATE_L1_SHARED_L2 | Raytrace-C-PRIVATE_L1_SHARED_L2 | Ferret-C-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| Sim Instruction (Count) | 137613838 | 744436275 | 1018684400 | 1843556135 |
| Sim Ops (Count) | 254528120 | 1259434104 | 1712549853 | 3219848551 |
| Host Instrsuction Rate (Count/Second) | 241104 | 197519 | 186649 | 167828 |

# Workload Analysis Using P-L1-S-L2 Cache C



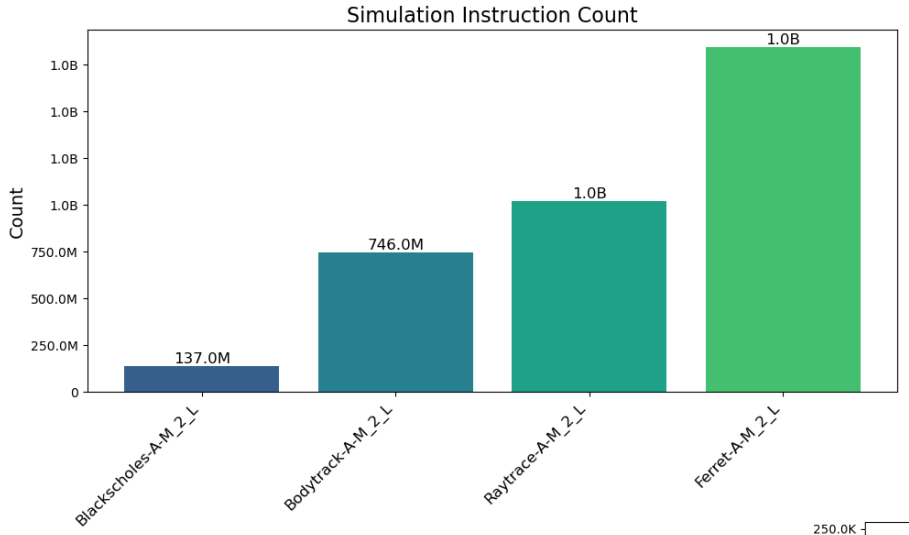



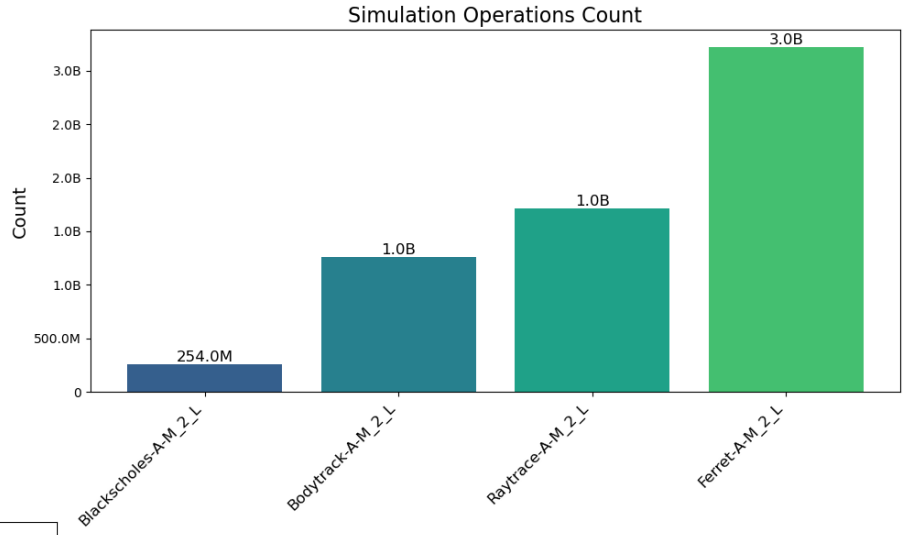



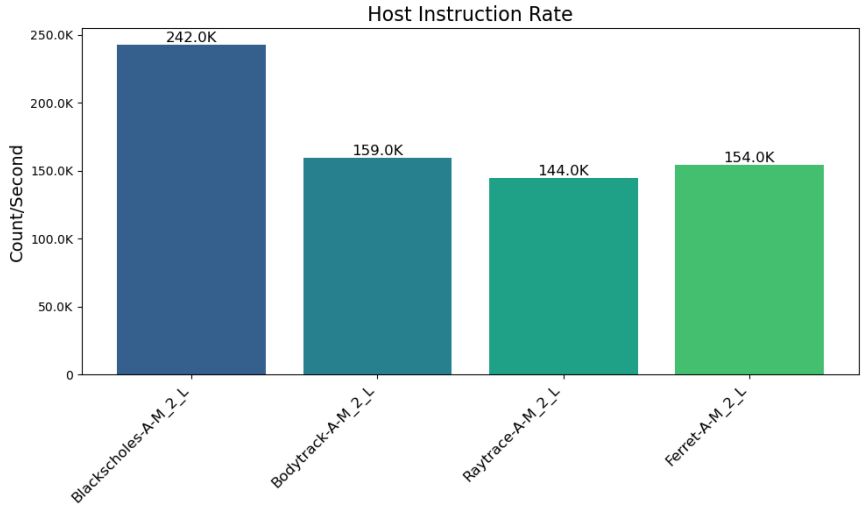
# Workload Analysis Using M-2-L Cache A

| Workload Characterization | Blackscholes-A-M-2-L | Bodytrack-A-M-2-L | Raytrace-A-M-2-L | Ferret-A-M-2-L |
|---|---|---|---|---|
| Sim Instruction (Count) | 137609035 | 746854929 | 1019148207 | 1843516103 |
| Sim Ops (Count) | 254523771 | 1264292337 | 1713617509 | 3219243548 |
| Host Instrsuction Rate (Count/Second) | 242714 | 159509 | 144862 | 154685 |

# Workload Analysis Using M-2-L Cache A



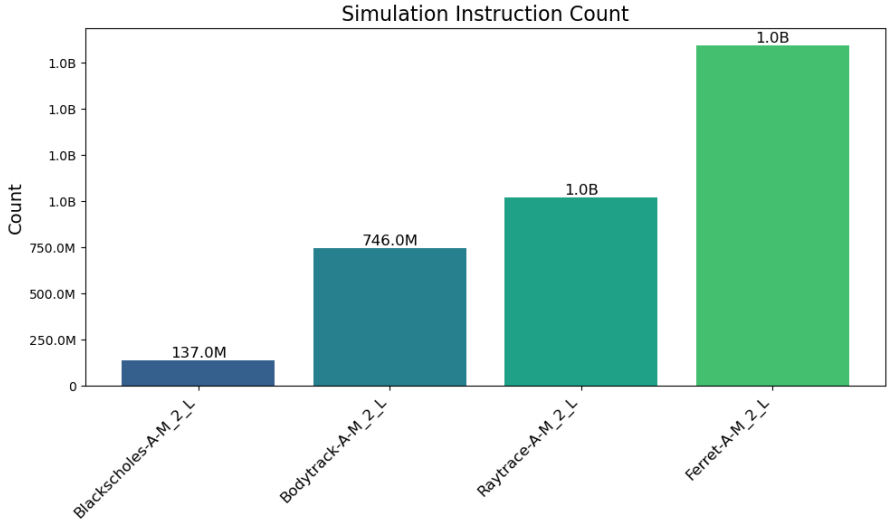



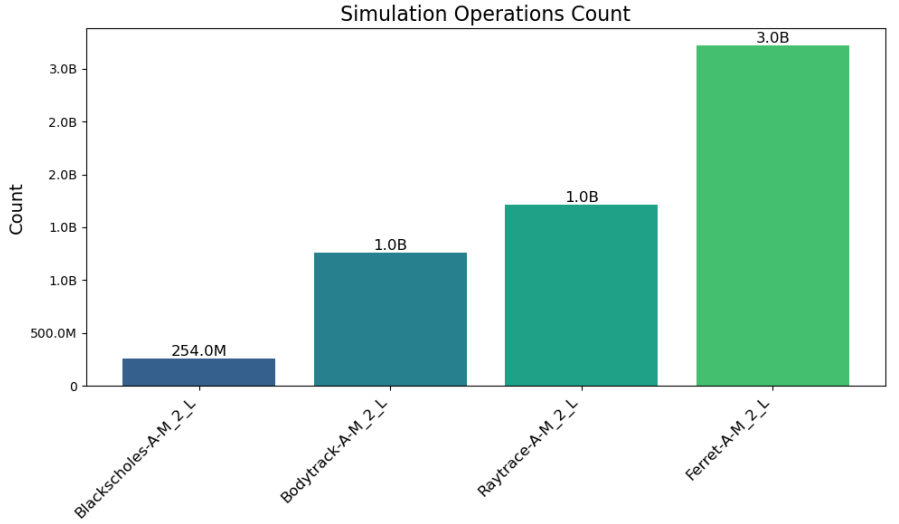



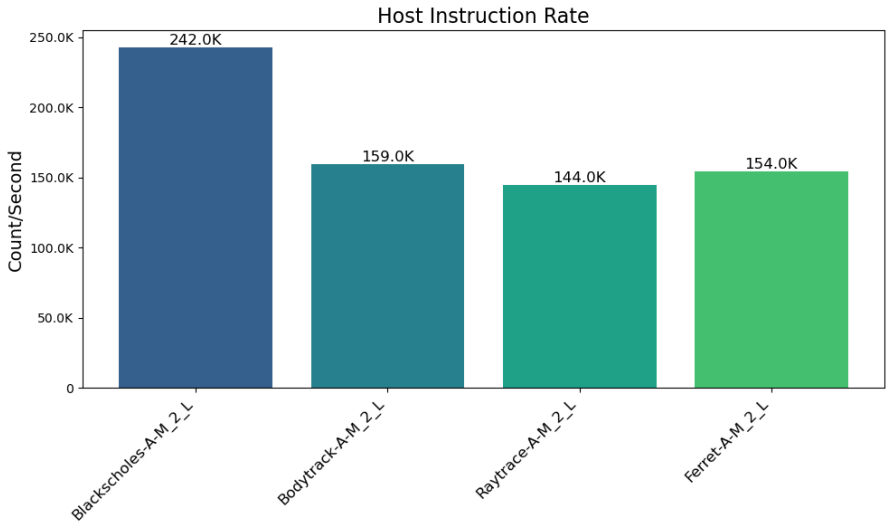
# Workload Analysis Using M-2-L Cache B

| Workload Charachterization | Blackscholes-B-M-2-L | Bodytrack-B-M-2-L | Raytrace-B-M-2-L | Ferret-B-M-2-L |
|---|---|---|---|---|
| Sim Instruction (Count) | 137332418 | 745131221 | 1018840471 | 1843642172 |
| Sim Ops (Count) | 253884917 | 1261031094 | 1712856055 | 3219458463 |
| Host Instrsuction Rate (Count/Second) | 243885 | 158659 | 144001 | 138209 |

# Workload Analysis Using M-2-L Cache B



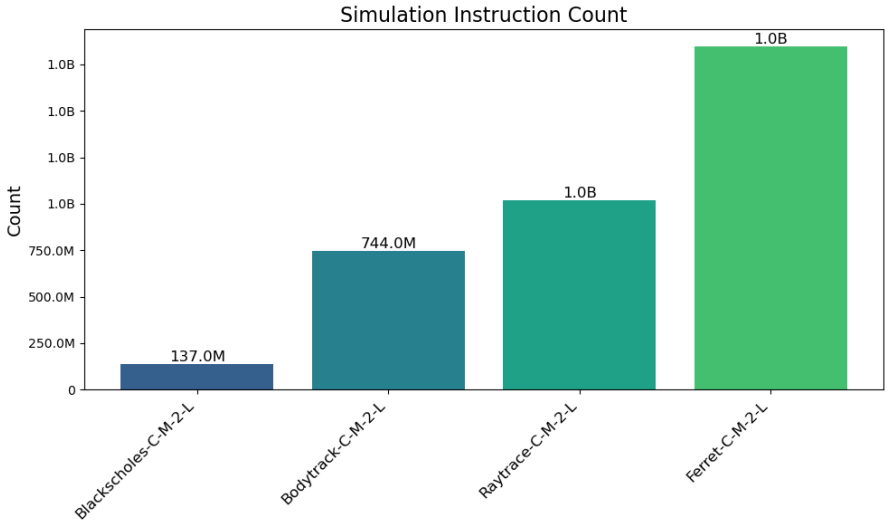



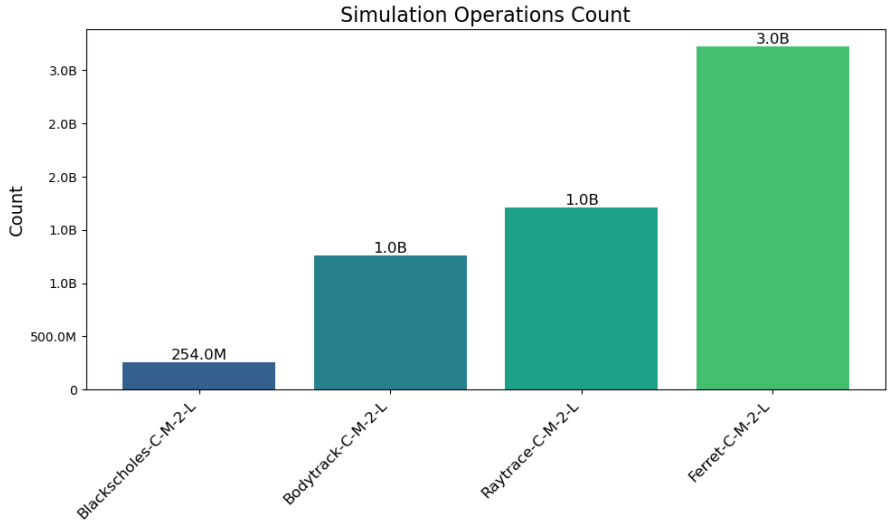



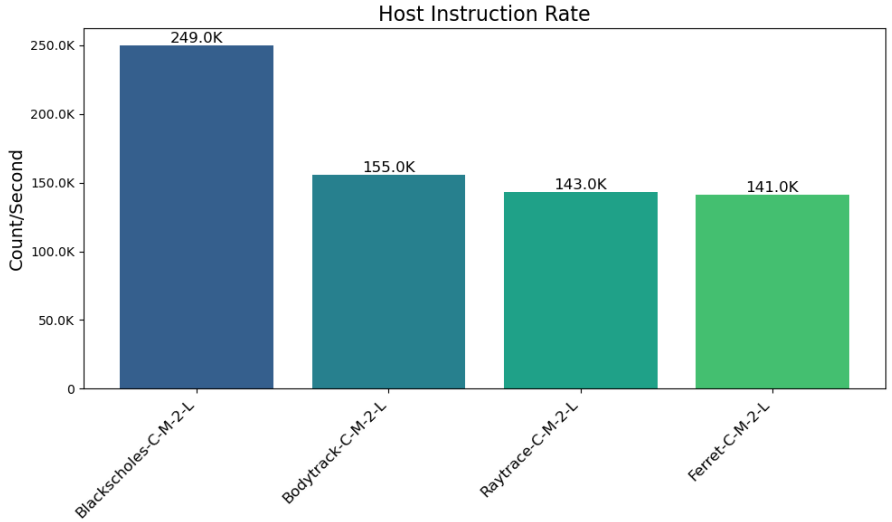
# Workload Analysis Using M-2-L Cache C

| Workload Charachterization | Blackscholes-B-M-2-L | Bodytrack-B-M-2-L | Raytrace-B-M-2-L | Ferret-B-M-2-L |
|---|---|---|---|---|
| Sim Instruction (Count) | 137332418 | 745131221 | 1018840471 | 1843642172 |
| Sim Ops (Count) | 253884917 | 1261031094 | 1712856055 | 3219458463 |
| Host Instrsuction Rate (Count/Second) | 243885 | 158659 | 144001 | 138209 |

# Workload Analysis Using M-2-L Cache C




# Cache Analysis

In order to evaluate the cache performance of the Parsec benchmark simulated by Gem5, I utilized statistics such as cache hits, misses, and accesses to determine the Hit Rate and Miss Rate. The following parameters were taken into consideration:

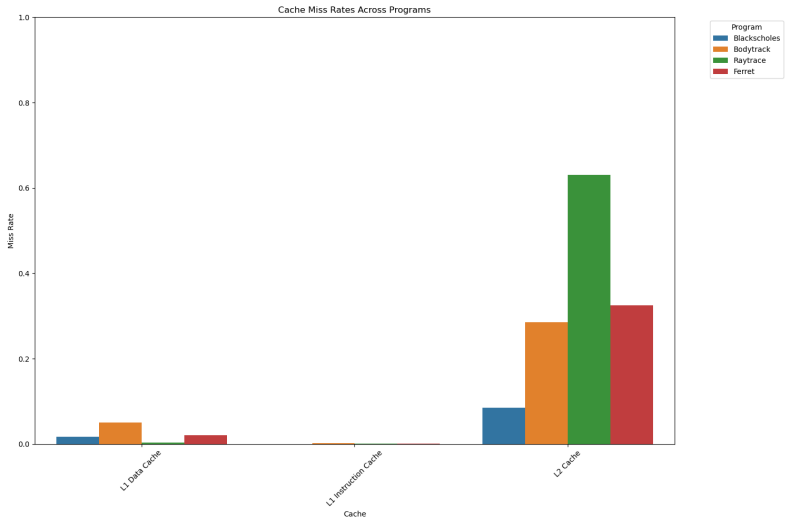
- **Hits ('m_demand_hits'):** A cache hit occurs when the requested data is found in the cache memory.
- **Misses ('m_demand_misses'):** A cache miss occurs when the requested data is not found in the cache.
- **Accesses ('m_demand_accesses'):** A cache access refers to the total number of attempts made by the CPU to retrieve data from the cache. This includes both hits and misses.
- **Hit Rate:** The hit rate is the ratio of hits to total accesses. It indicates how often the processor is able to find the requested data. A higher hit rate implies better cache performance.
- **Miss Rate:** The miss rate is the ratio of misses to total accesses. It indicates how often the processor is unable to find the requested data in the L1 data cache. A lower miss rate is better as it implies fewer instances where the processor needs to fetch data from slower memory hierarchies.

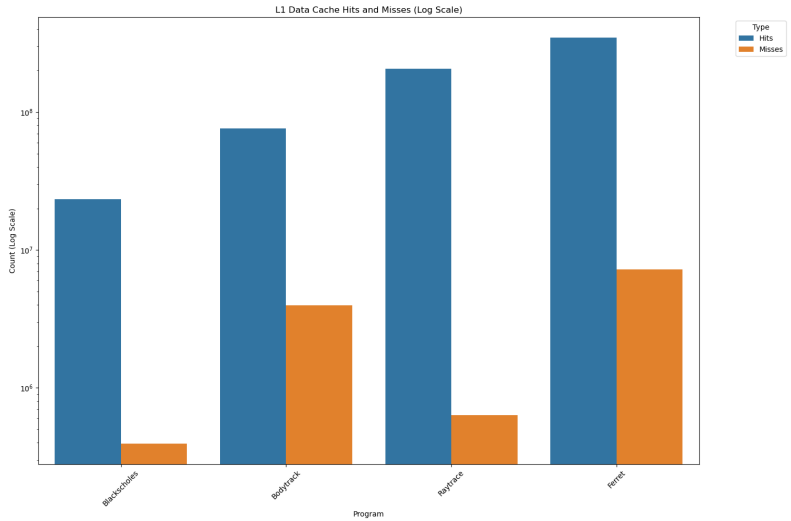
- **Note: Cache Associativity is defined in the table and graph as A, B, C where A= [2,4], B=[4,8], and C=[8,16] associativity.**

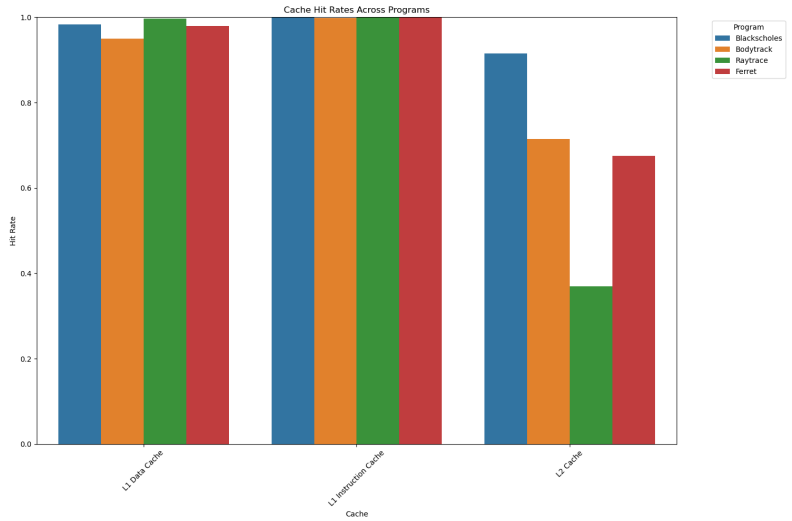
# Cache Analysis Using P-L1-S-L2 Cache A

| Cache Performance | Blackscholes-A-PRIVATE_L1_SHARED_L2 | Bodytrack-A-PRIVATE_L1_SHARED_L2 | Raytrace-A-PRIVATE_L1_SHARED_L2 | Ferret-A-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| **L1 Data Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 23328608 | 76054857 | 205869677 | 347467941 |
| Misses ('m_demand_misses') | 393333 | 3981567 | 633174 | 7254196 |
| Accesses ('m_demand_accesses') | 23721941 | 80036424 | 206502851 | 354722137 |
| Hit Rate (Hits/Accesses) | 0.983419021 | 0.950253062 | 0.996933824 | 0.979549638 |
| Miss Rate (Misses/Accesses) | 0.016580979 | 0.049746938 | 0.003066176 | 0.020450362 |
| **L1 Instruction Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 104301193 | 443919929 | 731265176 | 1417376028 |
| Misses ('m_demand_misses') | 13806 | 881483 | 187153 | 478823 |
| Accesses ('m_demand_accesses') | 104314999 | 444801412 | 731452329 | 1417854851 |
| Hit Rate (Hits/Accesses) | 0.999867651 | 0.998018255 | 0.999744135 | 0.999662291 |
| Miss Rate (Misses/Accesses) | 0.000132349 | 0.001981745 | 0.000255865 | 0.000337709 |
| **L2 Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 592448 | 7457387 | 616494 | 10130569 |
| Misses ('m_demand_misses') | 54946 | 2975733 | 1052479 | 4882118 |
| Accesses ('m_demand_accesses') | 647394 | 10433120 | 1668973 | 15012687 |
| Hit Rate (Hits/Accesses) | 0.915127419 | 0.714780142 | 0.369385245 | 0.67480052 |
| Miss Rate (Misses/Accesses) | 0.084872581 | 0.285219858 | 0.630614755 | 0.32519948 |

# Cache Analysis Using P-L1-S-L2 Cache A



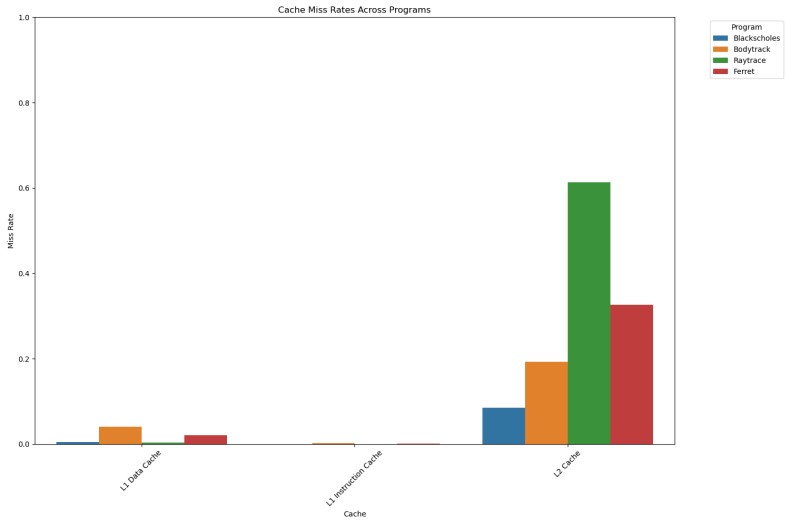



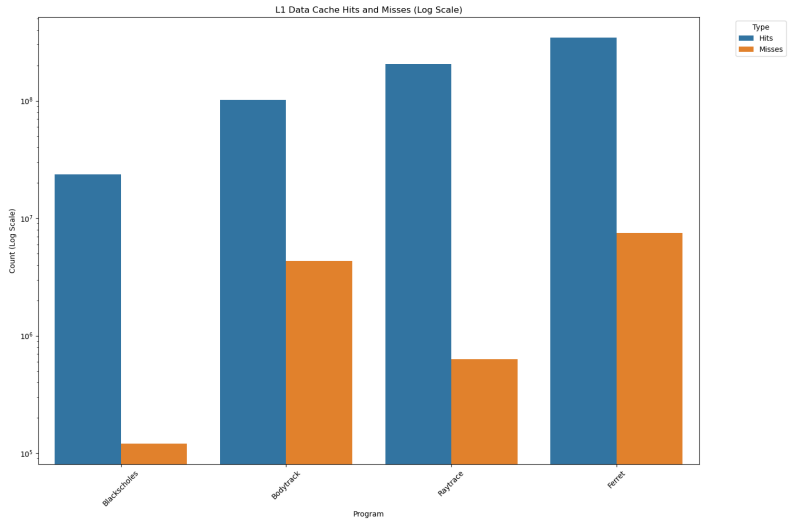



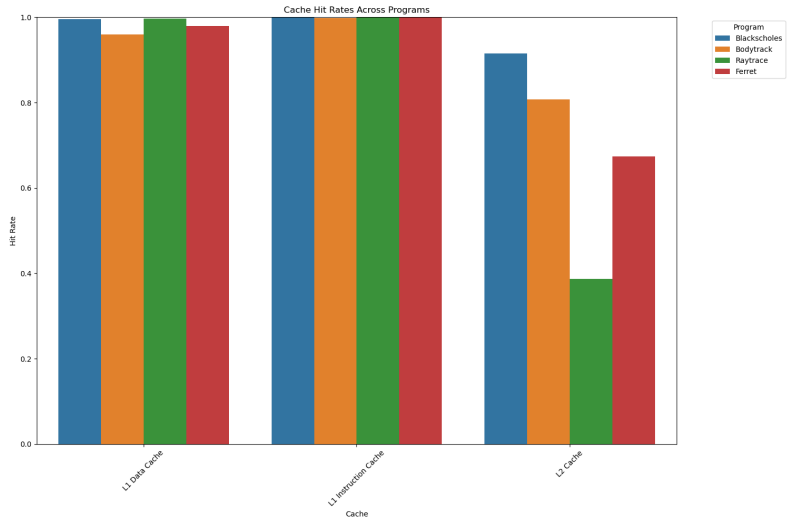
# Cache Analysis Using P-L1-S-L2 Cache B

| Cache Performance | Blackscholes-B-PRIVATE_L1_SHARED_L2 | Bodytrack-B-PRIVATE_L1_SHARED_L2 | Raytrace-B-PRIVATE_L1_SHARED_L2 | Ferret-B-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| **L1 Data Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 23619581 | 101626401 | 206150686 | 345413355 |
| Misses ('m_demand_misses') | 120565 | 4344974 | 630979 | 7471206 |
| Accesses ('m_demand_accesses') | 23740146 | 105971375 | 206781665 | 352884561 |
| Hit Rate (Hits/Accesses) | 0.994921472 | 0.958998607 | 0.996948574 | 0.978828187 |
| Miss Rate (Misses/Accesses) | 0.005078528 | 0.041001393 | 0.003051426 | 0.021171813 |
| **L1 Instruction Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 104400728 | 566534708 | 734515833 | 1398278583 |
| Misses ('m_demand_misses') | 8545 | 1069825 | 158547 | 481755 |
| Accesses ('m_demand_accesses') | 104409273 | 567604533 | 734674380 | 1398760338 |
| Hit Rate (Hits/Accesses) | 0.999918159 | 0.998115193 | 0.999784194 | 0.999655584 |
| Miss Rate (Misses/Accesses) | 8.18414E-05 | 0.001884807 | 0.000215806 | 0.000344416 |
| **L2 Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 228757 | 8228805 | 622715 | 9870900 |
| Misses ('m_demand_misses') | 21376 | 1958802 | 986326 | 4769344 |
| Accesses ('m_demand_accesses') | 250133 | 10187607 | 1609041 | 14640244 |
| Hit Rate (Hits/Accesses) | 0.914541464 | 0.807726977 | 0.387010026 | 0.674230566 |
| Miss Rate (Misses/Accesses) | 0.085458536 | 0.192273023 | 0.612989974 | 0.325769434 |

# Cache Analysis Using P-L1-S-L2 Cache B



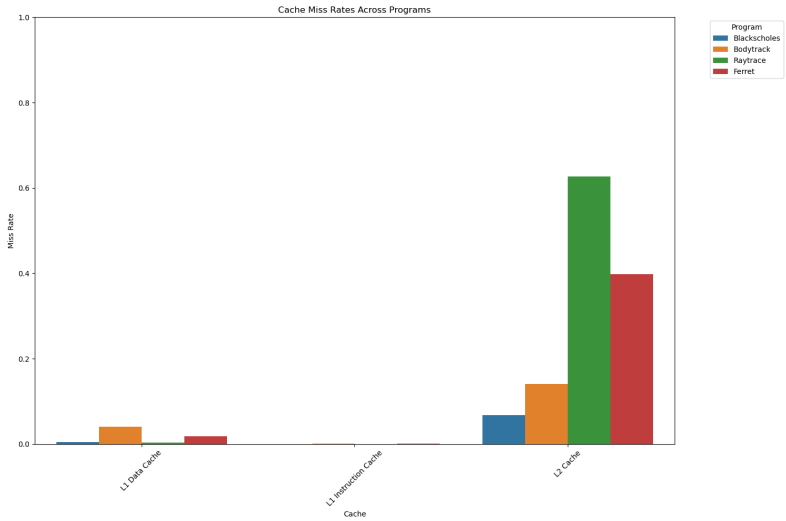



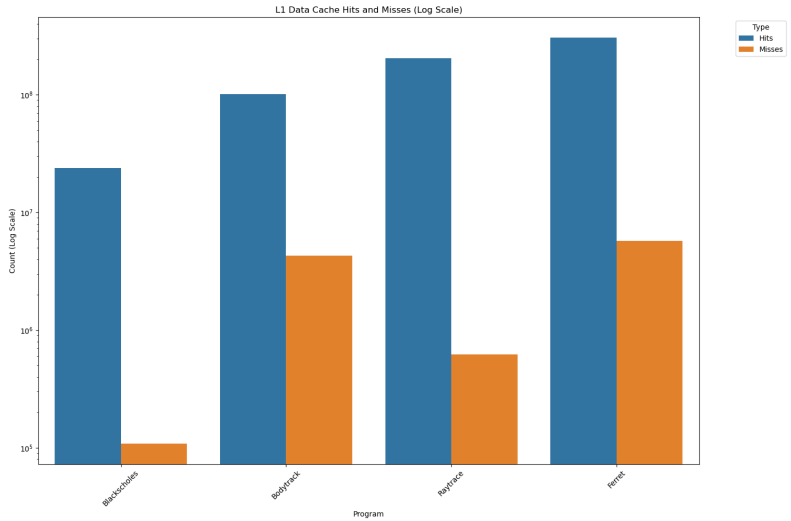



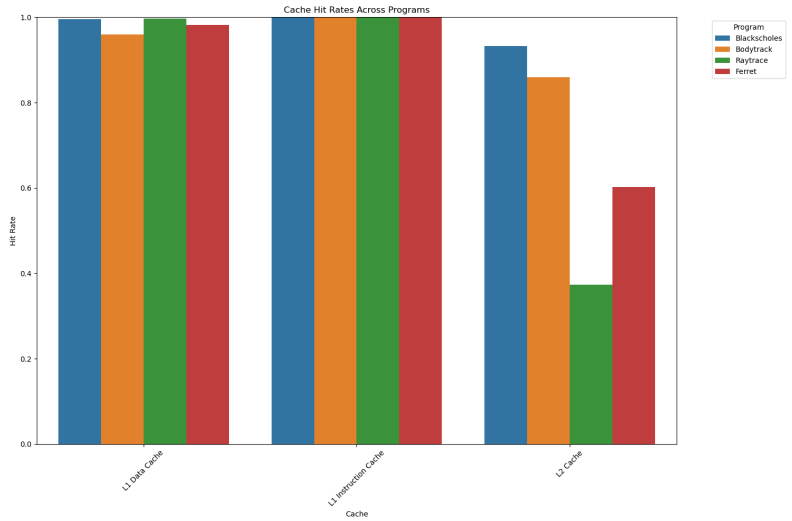
# Cache Analysis Using P-L1-S-L2 Cache C

| Cache Performance | Blackscholes-C-PRIVATE_L1_SHARED_L2 | Bodytrack-C-PRIVATE_L1_SHARED_L2 | Raytrace-C-PRIVATE_L1_SHARED_L2 | Ferret-C-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| **L1 Data Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 23787270 | 101541961 | 205057381 | 306620444 |
| Misses ('m_demand_misses') | 108244 | 4303508 | 619742 | 5723445 |
| Accesses ('m_demand_accesses') | 23895514 | 105845469 | 205677123 | 312343889 |
| Hit Rate (Hits/Accesses) | 0.995470112 | 0.959341594 | 0.996986821 | 0.981675822 |
| Miss Rate (Misses/Accesses) | 0.004529888 | 0.040658406 | 0.003013179 | 0.018324178 |
| **L1 Instruction Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 104913742 | 566673129 | 730456300 | 1232843962 |
| Misses ('m_demand_misses') | 9556 | 634541 | 148370 | 527378 |
| Accesses ('m_demand_accesses') | 104923298 | 567307670 | 730604670 | 1233371340 |
| Hit Rate (Hits/Accesses) | 0.999908924 | 0.998881487 | 0.999796922 | 0.999572409 |
| Miss Rate (Misses/Accesses) | 9.10761E-05 | 0.001118513 | 0.000203078 | 0.000427591 |
| **L2 Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 215993 | 7956230 | 580226 | 8138844 |
| Misses ('m_demand_misses') | 15578 | 1300362 | 973218 | 5367715 |
| Accesses ('m_demand_accesses') | 231571 | 9256592 | 1553444 | 13506559 |
| Hit Rate (Hits/Accesses) | 0.932729055 | 0.859520437 | 0.373509441 | 0.602584567 |
| Miss Rate (Misses/Accesses) | 0.067270945 | 0.140479563 | 0.626490559 | 0.397415433 |

# Cache Analysis Using P-L1-S-L2 Cache C



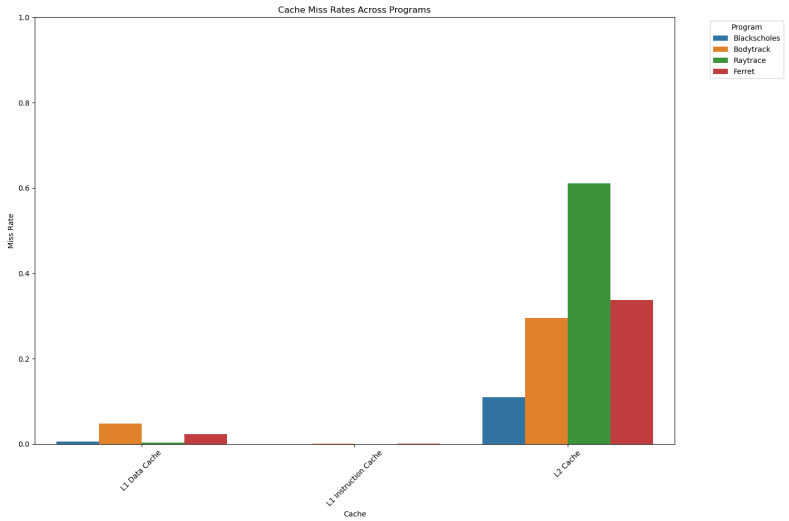



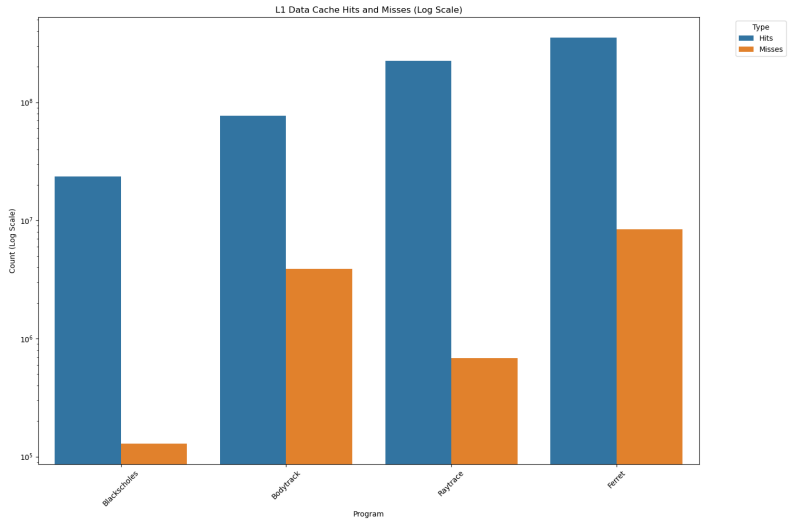



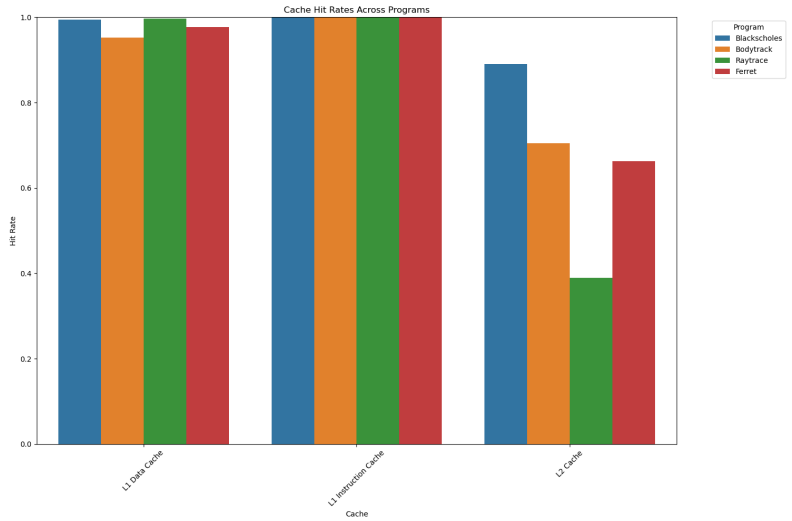
# Cache Analysis Using M-2-L Cache A

| Cache Performance | Blackscholes-A-Mesi_Two_Level | Bodytrack-A-Mesi_Two_Level | Raytrace-A-Mesi_Two_Level | Ferret-A-Mesi_Two_Level |
|---|---|---|---|---|
| **L1 Data Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 23600244 | 77060600 | 224259941 | 354042535 |
| Misses ('m_demand_misses') | 128565 | 3889043 | 685823 | 8394120 |
| Accesses ('m_demand_accesses') | 23728809 | 80949643 | 224945764 | 362436655 |
| Hit Rate (Hits/Accesses) | 0.994581903 | 0.951957256 | 0.996951163 | 0.97683976 |
| Miss Rate (Misses/Accesses) | 0.005418097 | 0.048042744 | 0.003048837 | 0.02316024 |
| **L1 Instruction Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 104356877 | 449087019 | 801118947 | 1386347161 |
| Misses ('m_demand_misses') | 13768 | 547683 | 173547 | 634712 |
| Accesses ('m_demand_accesses') | 104370645 | 449634702 | 801292494 | 1386981873 |
| Hit Rate (Hits/Accesses) | 0.999868086 | 0.998781938 | 0.999783416 | 0.999542379 |
| Miss Rate (Misses/Accesses) | 0.000131914 | 0.001218062 | 0.000216584 | 0.000457621 |
| **L2 Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 251420 | 6736909 | 686112 | 10440158 |
| Misses ('m_demand_misses') | 30896 | 2816863 | 1074928 | 5323457 |
| Accesses ('m_demand_accesses') | 282316 | 9553772 | 1761040 | 15763615 |
| Hit Rate (Hits/Accesses) | 0.890562349 | 0.705156979 | 0.389606142 | 0.662294658 |
| Miss Rate (Misses/Accesses) | 0.109437651 | 0.294843021 | 0.610393858 | 0.337705342 |

# Cache Analysis Using M-2-L Cache A



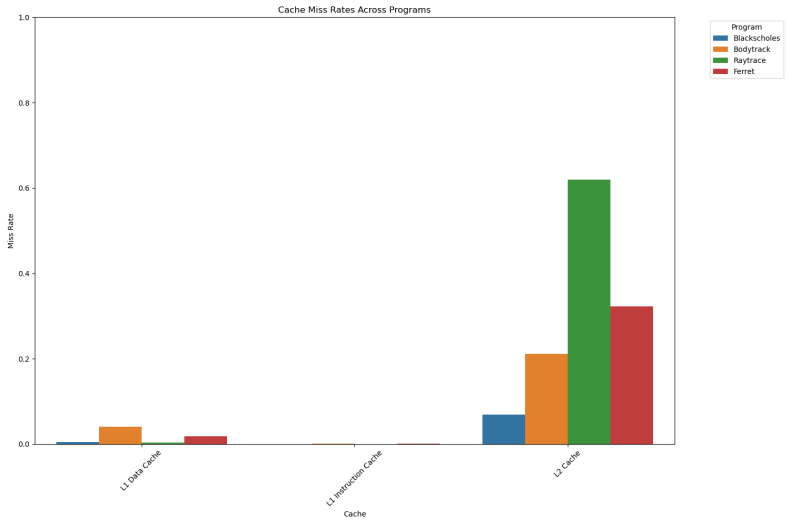



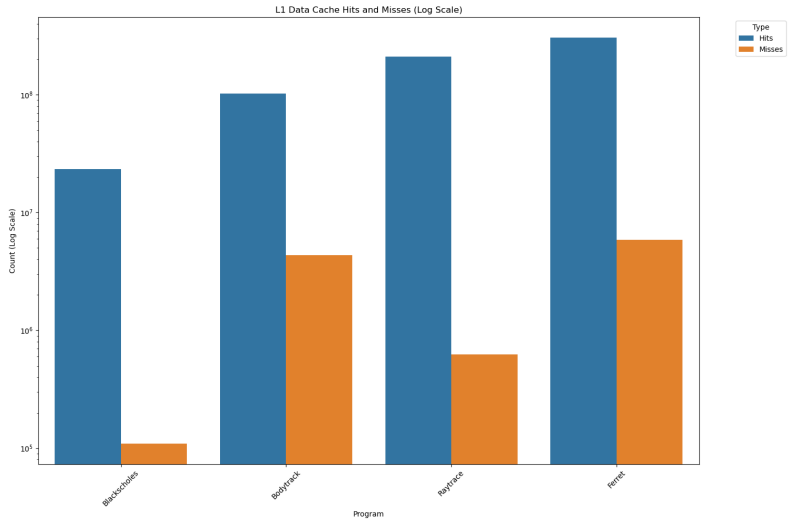



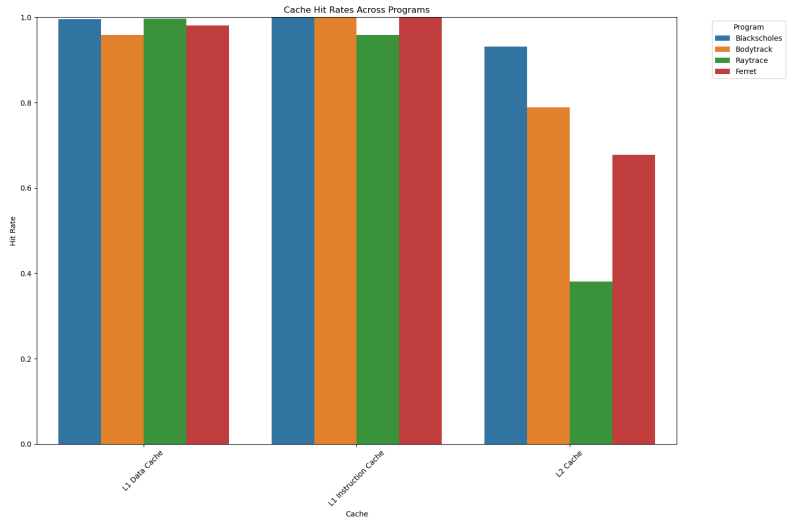
# Cache Analysis Using M-2-L Cache B

| Cache Performance | Blackscholes-B-Mesi_Two_Level | Bodytrack-B-Mesi_Two_Level | Raytrace-B-Mesi_Two_Level | Ferret-B-Mesi_Two_Level |
|---|---|---|---|---|
| **L1 Data Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 23384468 | 101799626 | 210956024 | 305587145 |
| Misses ('m_demand_misses') | 109207 | 4355995 | 623589 | 5844637 |
| Accesses ('m_demand_accesses') | 23493675 | 106155621 | 211579613 | 311431782 |
| Hit Rate (Hits/Accesses) | 0.995351643 | 0.958965951 | 0.997052698 | 0.98123301 |
| Miss Rate (Misses/Accesses) | 0.004648357 | 0.041034049 | 0.002947302 | 0.01876699 |
| **L1 Instruction Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 104542353 | 567835663 | 751176283 | 1225752191 |
| Misses ('m_demand_misses') | 9192 | 724940 | 161173 | 419513 |
| Accesses ('m_demand_accesses') | 104551545 | 568560603 | 783811352 | 1226171704 |
| Hit Rate (Hits/Accesses) | 0.999912082 | 0.998724956 | 0.958363618 | 0.999657868 |
| Miss Rate (Misses/Accesses) | 8.79184E-05 | 0.001275044 | 0.000205627 | 0.000342132 |
| **L2 Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 220796 | 7494428 | 593034 | 9424362 |
| Misses ('m_demand_misses') | 16271 | 2003955 | 965211 | 4475233 |
| Accesses ('m_demand_accesses') | 237067 | 9498383 | 1558245 | 13899595 |
| Hit Rate (Hits/Accesses) | 0.931365395 | 0.789021458 | 0.38057815 | 0.67803141 |
| Miss Rate (Misses/Accesses) | 0.068634605 | 0.210978542 | 0.61942185 | 0.32196859 |

# Cache Analysis Using M-2-L Cache B



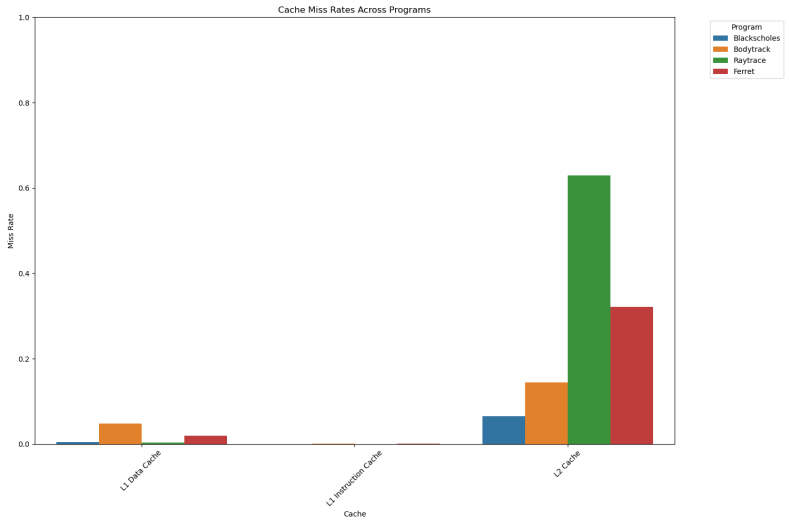



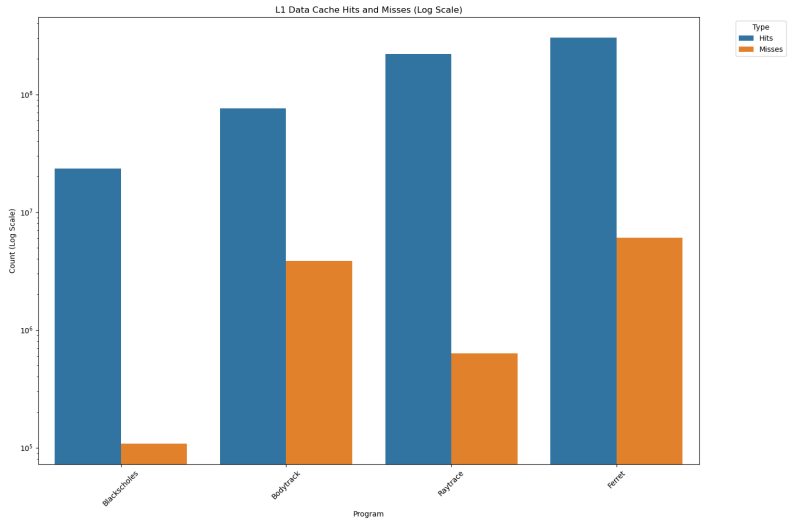



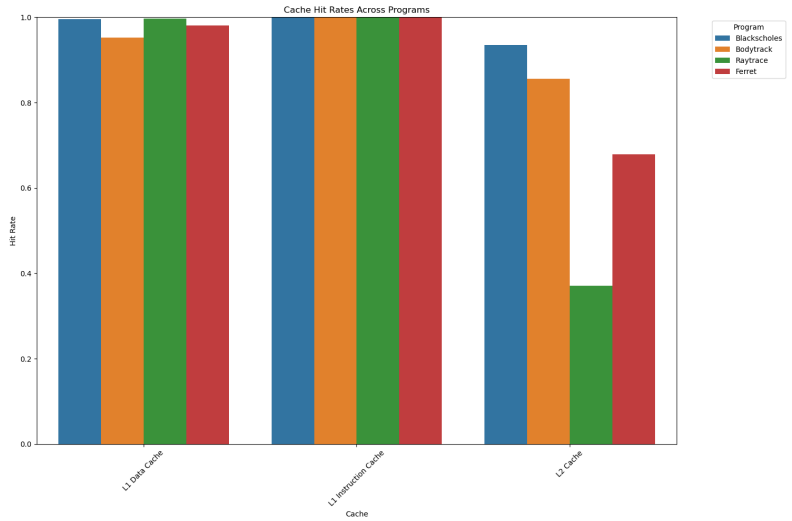
# Cache Analysis Using M-2-L Cache C

| Cache Performance | Blackscholes-C-Mesi_Two_Level | Bodytrack-C-Mesi_Two_Level | Raytrace-C-Mesi_Two_Level | Ferret-C-Mesi_Two_Level |
|---|---|---|---|---|
| **L1 Data Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 23540193 | 75793695 | 220114226 | 304016839 |
| Misses ('m_demand_misses') | 108065 | 3851346 | 631027 | 6039118 |
| Accesses ('m_demand_accesses') | 23648258 | 79645041 | 220745253 | 310055957 |
| Hit Rate (Hits/Accesses) | 0.995430319 | 0.951643618 | 0.997141379 | 0.98052249 |
| Miss Rate (Misses/Accesses) | 0.004569681 | 0.048356382 | 0.002858621 | 0.01947751 |
| **L1 Instruction Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 104202306 | 442837526 | 783800879 | 1190796805 |
| Misses ('m_demand_misses') | 10996 | 529330 | 125101 | 418540 |
| Accesses ('m_demand_accesses') | 104213302 | 443366856 | 783925980 | 1191215345 |
| Hit Rate (Hits/Accesses) | 0.999894486 | 0.998806113 | 0.999840417 | 0.999648645 |
| Miss Rate (Misses/Accesses) | 0.000105514 | 0.001193887 | 0.000159583 | 0.000351355 |
| **L2 Cache Analysis** | | | | |
| Hits ('m_demand_hits') | 219829 | 7958350 | 566627 | 9131299 |
| Misses ('m_demand_misses') | 15209 | 1342617 | 963054 | 4328065 |
| Accesses ('m_demand_accesses') | 235038 | 9300967 | 1529681 | 13459364 |
| Hit Rate (Hits/Accesses) | 0.935291315 | 0.85564759 | 0.370421676 | 0.678434657 |
| Miss Rate (Misses/Accesses) | 0.064708685 | 0.14435241 | 0.629578324 | 0.321565343 |

# Cache Analysis Using M-2-L Cache C



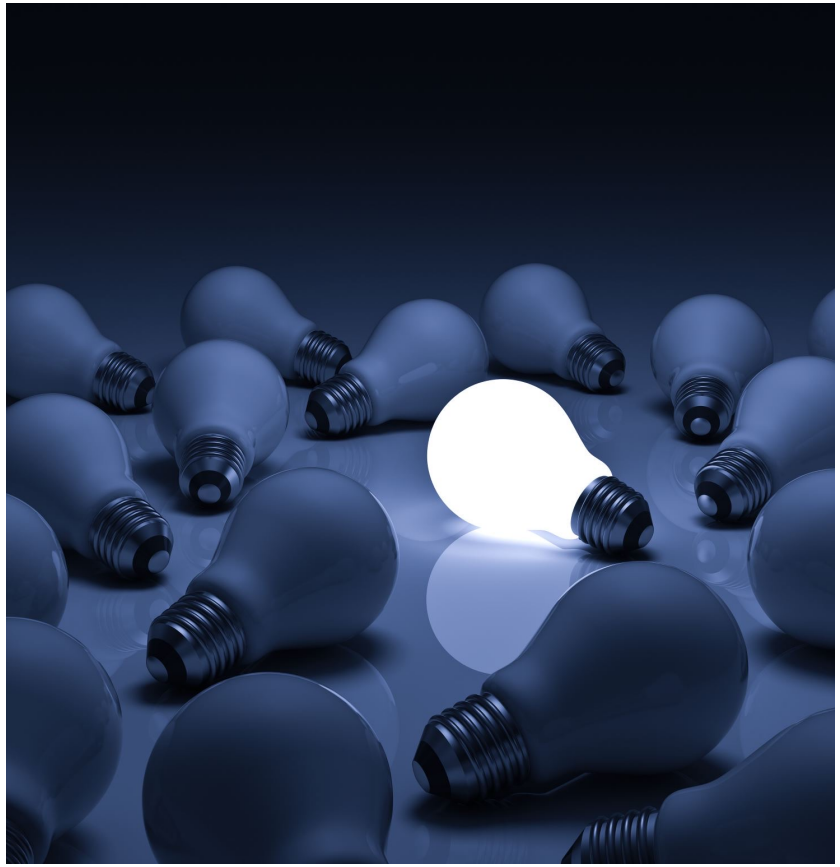



# Dram Power Draw Analysis

I utilized statistics such as average power to evaluate the Dram Power Draw of the Parsec benchmark simulated by Gem5. The following parameters were taken into consideration:

- **Average Power:** In gem5, this is defined as a core power per rank.
- **Note: Cache Associativity is defined in the table and graph as A, B, C where A= [2,4], B=[4,8], and C=[8,16] cache associativity.**



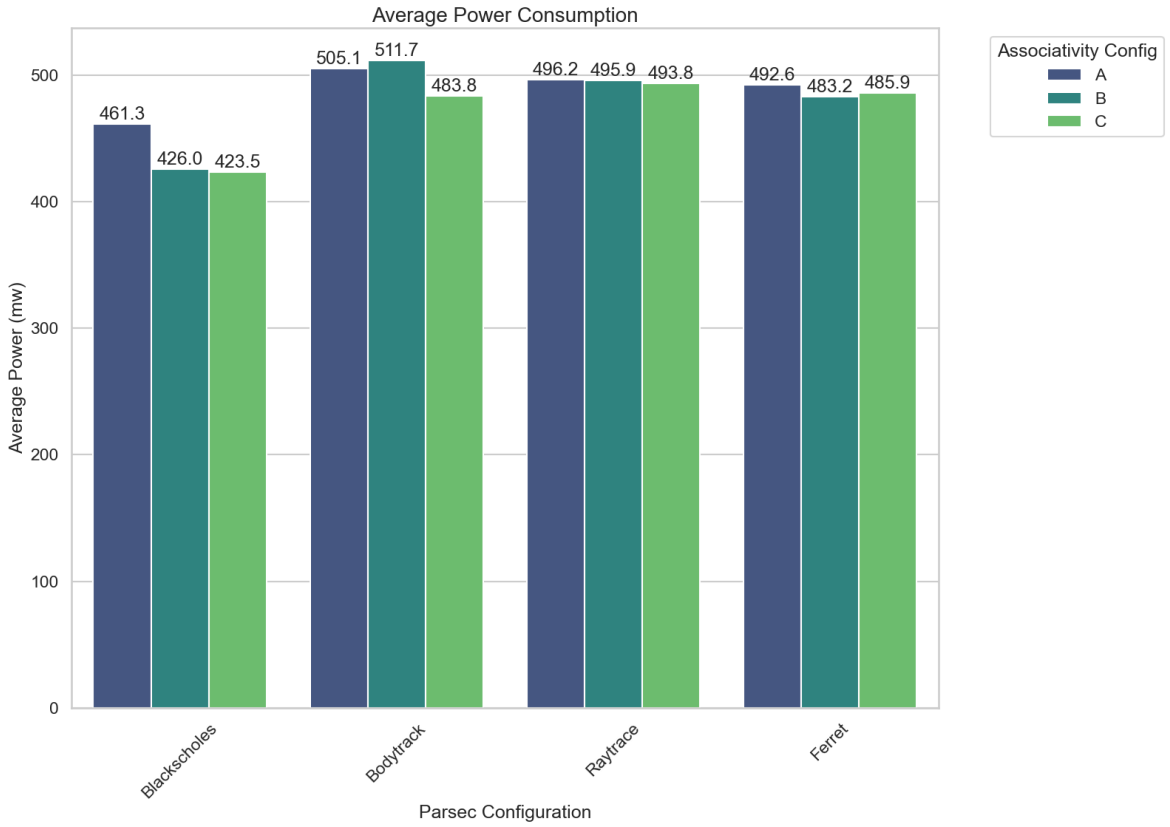
# Power Analysis Using P-L1-S-L2 Cache

| Power Analysis | Blackscholes-A-PRIVATE_L1_SHARED_L2 | Bodytrack-A-PRIVATE_L1_SHARED_L2 | Raytrace-A-PRIVATE_L1_SHARED_L2 | Ferret-A-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| Average Power (mw) | 461.329111 | 505.101617 | 496.227008 | 492.604799 |

| Power Analysis | Blackscholes-B-PRIVATE_L1_SHARED_L2 | Bodytrack-B-PRIVATE_L1_SHARED_L2 | Raytrace-B-PRIVATE_L1_SHARED_L2 | Ferret-B-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| Average Power (mw) | 426.021113 | 511.702805 | 495.917521 | 483.171388 |

| Power Analysis | Blackscholes-C-PRIVATE_L1_SHARED_L2 | Bodytrack-C-PRIVATE_L1_SHARED_L2 | Raytrace-C-PRIVATE_L1_SHARED_L2 | Ferret-C-PRIVATE_L1_SHARED_L2 |
|---|---|---|---|---|
| Average Power (mw) | 423.479573 | 483.815412 | 493.839784 | 485.875951 |

# Power Analysis Using P-L1-S-L2 Cache



# Power Analysis Using M-2-L Cache

| Power Analysis | Blackscholes-A-Mesi_Two_Level | Bodytrack-A-Mesi_Two_Level | Raytrace-A-Mesi_Two_Level | Ferret-A-Mesi_Two_Level |
|---|---|---|---|---|
| Average Power (mw) | 438.38001 | 518.737079 | 495.247416 | 497.575251 |

| Power Analysis | Blackscholes-B-Mesi_Two_Level | Bodytrack-B-Mesi_Two_Level | Raytrace-B-Mesi_Two_Level | Ferret-B-Mesi_Two_Level |
|---|---|---|---|---|
| Average Power (mw) | 420.618532 | 502.199569 | 493.614774 | 484.187783 |

| Power Analysis | Blackscholes-C-Mesi_Two_Level | Bodytrack-C-Mesi_Two_Level | Raytrace-C-Mesi_Two_Level | Ferret-C-Mesi_Two_Level |
|---|---|---|---|---|
| Average Power (mw) | 418.022906 | 492.11442 | 495.173898 | 477.473307 |

# Power Analysis Using P-L1-S-L2 Cache