

X-Mem

1.2.02

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Chapter 1

README

X-Mem: Extensible Memory Benchmarking Tool v1.2.02

The flexible open-source research tool for characterizing memory hierarchy throughput, latency, and power.

Originally authored by Mark Gottscho (Email: mgottscho@ucla.edu) as a Summer 2014 intern at Microsoft Research, Redmond, WA.

This project is under active development. Stay tuned for more updates.

PROJECT REVISION DATE: January 27, 2015.

LICENSE

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FEATURES

This tool is provided as open source with the hope of being useful to the broader research and development community. Here are some of X-Mem's features.

Flexibility: Easy reconfiguration for different combinations of tests

- Working sets in increments of 4KB, allowing cache through main memory-level benchmarking
- NUMA support
- Multi-threading for bandwidth saturation
- Regular access patterns: forward & reverse sequential as well as strides of 2, 4, 8, and 16 words

- Random access patterns
- Read and write
- 32, 64, 128, 256-bit width memory instructions

Extensibility: C++ object-oriented principles

- Supports rapid addition of new benchmark kernel routines by others
- Example: stream triad algorithm, impact of false sharing, etc. are possible with minor additions

Cross-platform: Currently implemented for Windows and GNU/Linux on x86-64 CPUs

- Designed to allow straightforward porting to other operating systems and ISAs

Memory throughput:

- Accurate measurement of sustained memory throughput to all levels of cache
- Burst mode benchmark kernels possible (extensible!)

Memory latency:

- Accurate measurement of round-trip unloaded memory latency to all levels of cache
- Loaded latency measurements planned

Memory power:

- Currently collecting DRAM power via custom driver exposed in Windows performance counter API
- Supports custom power instrumentation without much modification
- Thorough Documentation: extensive Doxygen source comments, HTML, PDF docs

For feature requests, please refer to the contact information at the end of this README.

RUNTIME PREREQUISITES

There are a few runtime prerequisites in order for the software to run correctly.

HARDWARE:

- Intel x86-64 CPU. RECOMMENDED: Recent CPU with SSE2 and AVX extended instruction sets for improved throughput benchmarking capabilities.

WINDOWS:

- Microsoft Windows 64-bit, 8.0 or later, Server 2012 or later.
- Microsoft Visual C++ 2013 Redistributables (64-bit)

GNU/LINUX:

- GNU utilities with support for C++11. Tested with gcc 4.8.2 on Ubuntu 14.04 LTS.
- (SUPPORT IS CURRENTLY SUSPENDED) If the binary is built with the option `USE_LARGE_PAGES`, you will need `libhugetlbfs`. You can obtain it at <http://libhugetlbfs.sourceforge.net>. On Ubuntu systems, you can install using `sudo apt-get install libhugetlbfs0`. Note that you may need to manually ensure that large pages are available from the OS. This can be done by running `hugeadm --pool-list`. It is recommended to set minimum pool to 1GB (in order to measure DRAM effectively). If needed, this can be done by running `hugeadm --pool-pages-min 2MB:512`.

INSTALLATION

The only file that is needed to run on Windows is xmem-win.exe, and xmem-linux on GNU/Linux. It has no other dependencies aside from the system prerequisites listed above.

USAGE

NOTE: On Windows, make sure you run X-Mem with Administrator privileges. This is needed in order to:

- Allocate "large pages" for improved performance as well as query if USE_LARGE_PAGES compile-time option is set
- Read performance counter data from the OS for reporting power (when applicable)
- Elevate thread priority and pin threads to CPUs for improved performance and benchmarking consistency

xmem [options]

Options:

| | |
|------------------------|---|
| -h, --help | Print usage and exit. |
| -l, --latency | Measure memory latency |
| -t, --throughput | Measure memory throughput |
| -w, --working_set_size | Working set size in KB. This must be a multiple of 4KB. |
| -n, --iterations | Iterations per benchmark test |
| -i, --base_test_index | Numerical index of the first benchmark, for tracking unique test IDs. |
| -f, --output_file | Output filename to use. If not specified, no output file generated. |

Examples:

```
xmem --help
xmem -h
xmem -t
xmem -t --latency -n10 -w524288 -f results.csv -i 101
```

BUILDING FROM SOURCE

Before building the source, enable and disable the relevant compile-time options in [src/include/common.h](#), under the section "User-configurable compilation configuration". Please read the comments by each #define statement to understand the context of each option.

After you have set the desired compile-time options, build the source. On Windows, running build-win.bat should suffice. On GNU/Linux, run build-linux.sh.

If you customize your build, make sure you use the "Release" mode for your OS. Do not include debug capabilities as it can dramatically affect performance of the benchmarks, leading to pessimistic results.

BUILD PREREQUISITES

There are a few software build prerequisites, depending on your platform.

WINDOWS:

- Any version of Visual Studio 2013 64-bit (also known as version 12.0).
- Python 2.7. You can obtain it at <http://www.python.org>.
- SCons build system. You can obtain it at <http://www.scons.org>. Build tested with SCons 2.3.4.

GNU/LINUX:

- gcc with support for the C++11 standard. Tested with gcc version 4.8.2 on Ubuntu 14.04 LTS for x86-64.
- Python 2.7. You can obtain it at <http://www.python.org>. On Ubuntu systems, you can install using "sudo apt-get install python2.7". You may need some other Python 2.7 packages as well.
- SCons build system. You can obtain it at <http://www.scons.org>. On Ubuntu systems, you can install using "sudo apt-get install scons". Build tested with SCons 2.3.4.
- (SUPPORT IS CURRENTLY SUSPENDED) If you want large page (huge page) support on GNU/Linux, you need kernel support. This can be verified on your installation by running "grep hugetlbfs /proc/filesystems". If you do not have huge page support in your kernel, you can build a kernel with the appropriate options switched on: "CONFIG_HUGETLB_PAGE" and "CONFIG_HUGETLBFS".
- (SUPPORT IS CURRENTLY SUSPENDED) libhugetlbfs. This is used for allocating "huge pages". You can obtain it at <http://libhugetlbfs.sourceforge.net>. On Ubuntu systems, you can install using "sudo apt-get install libhugetlbfs-dev".

DOCUMENTATION BUILD PREREQUISITES

The following tools are only needed for automatically regenerating source code documentation with HTML and PDF.

WINDOWS:

- doxygen tool. You can obtain it at <http://www.stack.nl/~dimitri/doxygen>.
- LaTeX distribution. You can get a Windows distribution at <http://www.miktex.org>.
- make for Windows. You can obtain it at <http://gnuwin32.sourceforge.net/packages/make.-htm>. You will have to manually add it to your Windows path.

GNU/LINUX:

- doxygen tool. You can obtain it at <http://www.stack.nl/~dimitri/doxygen>. On Ubuntu systems, you can install with "sudo apt-get install doxygen".
- LaTeX distribution. On Ubuntu systems, LaTeX distributed with doxygen should actually be sufficient. You can install with "sudo apt-get install doxygen-latex".
- make. This should be included on any GNU/Linux system.

SOURCE CODE DOCUMENTATION

The tool comes with built-in Doxygen comments in the source code, which can be used to generate both HTML and LaTeX -> PDF documentation. Documentation is maintained under the doc/ subdirectory. To build documentation after modifying the source, run build-docs-win.bat on Windows, or build-docs-linux.sh on GNU/Linux systems. Note that Doxygen and a LaTeX distribution must be installed on the system.

VERSION CONTROL

This project is under version control using git. Its master repository is hosted at <https://github.com/Microsoft/X-Mem.git>. There is also another fork at <https://github.com/nanocad-lab/X-Mem.git>, which generally mirrors Microsoft's repository.

CONTACT, FEEDBACK, AND BUG REPORTS

For questions, comments, criticism, bug reports, and other feedback for this software, please contact Mark Gottscho via email at mgottscho@ucla.edu or via web at <http://www.seas.ucla.edu/~gottscho>.

For inquiries about this work while conducted at Microsoft, please contact Dr. Mohammed Shoaib at mohammed.-shoaib@microsoft.com or Dr. Sriram Govindan at sgovin@microsoft.com.

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Chapter 2

Hierarchical Index

2.1 Class Hierarchy

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| xmem::config::third_party::Arg | 14 |
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| xmem::benchmark::LatencyBenchmark | 30 |
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| xmem::benchmark::BenchmarkManager | 23 |
| xmem::config::Configurator | 24 |
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| xmem::config::third_party::PrintUsagelImplementation::FunctionWriter< Function > | 30 |
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| xmem::config::third_party::PrintUsagelImplementation | 49 |
| xmem::thread::Runnable | 50 |
| xmem::benchmark::ThroughputBenchmarkWorker | 61 |
| xmem::power::PowerReader | 45 |
| xmem::config::third_party::Stats | 51 |
| xmem::thread::Thread | 56 |
| xmem::timers::Timer | 64 |

Chapter 3

Class Index

3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

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| xmem::config::third_party::Arg | |
| Functions for checking the validity of option arguments | 14 |
| xmem::benchmark::Benchmark | |
| Flexible abstract class for any memory benchmark | 15 |
| xmem::benchmark::BenchmarkManager | |
| Manages running all benchmarks at a high level | 23 |
| xmem::config::Configurator | |
| Handles all user input interpretation and generates the necessary flags for running benchmarks | 24 |
| xmem::config::third_party::Stats::CountOptionsAction | 26 |
| xmem::config::third_party::Descriptor | |
| Describes an option, its help text (usage) and how it should be parsed | 27 |
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| xmem::config::third_party::PrintUsagelImplementation::IStringWriter | 30 |
| xmem::benchmark::LatencyBenchmark | |
| A type of benchmark that measures memory latency via random pointer chasing. TODO: loaded latency tests | 30 |
| xmem::config::third_party::PrintUsagelImplementation::LinePartlterator | 32 |
| xmem::config::third_party::PrintUsagelImplementation::LineWrapper | 33 |
| xmem::config::third_party::MyArg | 34 |
| xmem::config::third_party::Option | |
| A parsed option from the command line together with its argument if it has one | 34 |
| xmem::config::third_party::PrintUsagelImplementation::OStreamWriter< OStream > | 40 |
| xmem::config::third_party::Parser | |
| Checks argument vectors for validity and parses them into data structures that are easier to work with | 40 |
| xmem::power::PowerReader | |
| An abstract base class for measuring power from an arbitrary source. This class is runnable using a worker thread | 45 |
| xmem::config::third_party::PrintUsagelImplementation | 49 |
| xmem::thread::Runnable | |
| A base class for any object that implements a thread-safe run() function for use by Thread objects | 50 |
| xmem::config::third_party::Stats | |
| Determines the minimum lengths of the buffer and options arrays used for Parser | 51 |
| xmem::config::third_party::Parser::StoreOptionAction | 53 |
| xmem::config::third_party::PrintUsagelImplementation::StreamWriter< Function, Stream > | 54 |
| xmem::config::third_party::PrintUsagelImplementation::SyscallWriter< Syscall > | 55 |

| | |
|--|----|
| xmem::config::third_party::PrintUsagImplementation::TemporaryWriter< Temporary > | 55 |
| xmem::thread::Thread | |
| Nice wrapped thread interface independent of particular OS API | 56 |
| xmem::benchmark::ThroughputBenchmark | |
| A type of benchmark that measures memory throughput either via sequential, strided sequential, or random access patterns | 58 |
| xmem::benchmark::ThroughputBenchmarkWorker | |
| Helper multithreading-friendly class to do the core throughput benchmark | 61 |
| xmem::timers::Timer | |
| This class abstracts a simple high resolution stopwatch timer. WARNING: these objects are NOT thread safe | 64 |

Chapter 4

File Index

4.1 File List

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| src/ benchmark_kernels.cpp | Implementation file for benchmark kernel functions for doing the actual work we care about. :) . | 67 |
| src/ BenchmarkManager.cpp | Implementation file for the BenchmarkManager class | 68 |
| src/ common.cpp | Implementation file for common preprocessor definitions, macros, functions, and global constants | 68 |
| src/ Configurator.cpp | Implementation file for the Configurator class and some helper data structures | 68 |
| src/ LatencyBenchmark.cpp | Implementation file for the LatencyBenchmark class | 92 |
| src/ main.cpp | Main entry point to the tool | 93 |
| src/ PowerReader.cpp | Implementation file for the PowerReader class | 93 |
| src/ Runnable.cpp | Implementation file for the Runnable class | 94 |
| src/ Thread.cpp | Implementation file for the Thread class | 94 |
| src/ ThroughputBenchmark.cpp | Implementation file for the ThroughputBenchmark class | 94 |
| src/ ThroughputBenchmarkWorker.cpp | Implementation file for the ThroughputBenchmarkWorker class | 95 |
| src/ Timer.cpp | Implementation file for the Timer class | 95 |
| src/include/ Benchmark.h | Header file for the Benchmark class | 69 |
| src/include/ benchmark_kernels.h | Header file for benchmark kernel functions for doing the actual work we care about. :) | 69 |
| src/include/ BenchmarkManager.h | Header file for the BenchmarkManager class | 78 |
| src/include/ common.h | Header file for common preprocessor definitions, macros, functions, and global constants | 78 |
| src/include/ Configurator.h | Header file for the Configurator class and some helper data structures | 84 |

| | |
|---|----|
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| Slightly-modified third-party code related to OptionParser | 85 |
| src/include/ LatencyBenchmark.h | |
| Header file for the LatencyBenchmark class | 85 |
| src/include/ MyArg.h | |
| Extensions to third-party optionparser-related code | 85 |
| src/include/ optionparser.h | |
| This is the only file required to use The Lean Mean C++ Option Parser. Just #include it and you're set | 86 |
| src/include/ PowerReader.h | |
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| src/include/x86_64/ TSCTimer.h | |
| Header file for the TSCTimer class as well as some C-style functions for working with the TSC timer hardware directly | 92 |
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| Header file for the QPCTimer class | 95 |
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Chapter 5

Class Documentation

5.1 xmem::config::third_party::Parser::Action Struct Reference

Inheritance diagram for xmem::config::third_party::Parser::Action:



Public Member Functions

- virtual bool [perform](#) ([Option](#) &)
Called by `Parser::workhorse()` for each [Option](#) that has been successfully parsed (including unknown options if they have a [Descriptor](#) whose [Descriptor::check_arg](#) does not return `ARG_ILLEGAL`).
- virtual bool [finished](#) (int numargs, const char **args)
Called by `Parser::workhorse()` after finishing the parse.

5.1.1 Member Function Documentation

5.1.1.1 virtual bool xmem::config::third_party::Parser::Action::finished (int numargs, const char ** args) [inline], [virtual]

Called by `Parser::workhorse()` after finishing the parse.

Parameters

| | |
|----------------|--|
| <i>numargs</i> | the number of non-option arguments remaining |
| <i>args</i> | pointer to the first remaining non-option argument (if numargs > 0). |

Returns

`false` iff a fatal error has occurred.

Reimplemented in [xmem::config::third_party::Parser::StoreOptionAction](#).

5.1.1.2 virtual bool xmem::config::third_party::Parser::Action::perform ([Option](#) &) [inline], [virtual]

Called by `Parser::workhorse()` for each [Option](#) that has been successfully parsed (including unknown options if they have a [Descriptor](#) whose [Descriptor::check_arg](#) does not return `ARG_ILLEGAL`).

Returns `false` iff a fatal error has occurred and the parse should be aborted.

Reimplemented in [xmem::config::third_party::Parser::StoreOptionAction](#), and [xmem::config::third_party::Stats::CountOptionsAction](#).

The documentation for this struct was generated from the following file:

- [src/include/optionparser.h](#)

5.2 xmem::config::third_party::Arg Struct Reference

Functions for checking the validity of option arguments.

```
#include <optionparser.h>
```

Inheritance diagram for `xmem::config::third_party::Arg`:



Static Public Member Functions

- static ArgStatus `None` (const [Option](#) &, bool)
For options that don't take an argument: Returns `ARG_NONE`.
- static ArgStatus `Optional` (const [Option](#) &option, bool)
Returns `ARG_OK` if the argument is attached and `ARG_IGNORE` otherwise.

5.2.1 Detailed Description

Functions for checking the validity of option arguments.

The following example code can serve as starting place for writing your own more complex `CheckArg` functions:

```

struct Arg: public option::Arg
{
    static void printError(const char* msg1, const option::Option& opt, const char* msg2)
    {
        fprintf(stderr, "ERROR: %s", msg1);
        fwrite(opt.name, opt.namelen, 1, stderr);
        fprintf(stderr, "%s", msg2);
    }

    static option::ArgStatus Unknown(const option::Option& option, bool msg)
    {
        if (msg) printError("Unknown option '", option, "'\n");
        return option::ARG_ILLEGAL;
    }

    static option::ArgStatus Required(const option::Option& option, bool msg)
    {
        if (option.arg != 0)
            return option::ARG_OK;

        if (msg) printError("Option '", option, "' requires an argument\n");
        return option::ARG_ILLEGAL;
    }

    static option::ArgStatus NonEmpty(const option::Option& option, bool msg)
    {

```

```

    if (option.arg != 0 && option.arg[0] != 0)
        return option::ARG_OK;

    if (msg) printError("Option '", option, "' requires a non-empty argument\n");
    return option::ARG_ILLEGAL;
}

static option::ArgStatus Numeric(const option::Option& option, bool msg)
{
    char* endptr = 0;
    if (option.arg != 0 && strtol(option.arg, &endptr, 10){});
    if (endptr != option.arg && *endptr == 0)
        return option::ARG_OK;

    if (msg) printError("Option '", option, "' requires a numeric argument\n");
    return option::ARG_ILLEGAL;
}
};

```

The documentation for this struct was generated from the following file:

- [src/include/optionparser.h](#)

5.3 xmem::benchmark::Benchmark Class Reference

Flexible abstract class for any memory benchmark.

```
#include <Benchmark.h>
```

Inheritance diagram for xmem::benchmark::Benchmark:



Public Member Functions

- **Benchmark** (void *mem_array, size_t len, uint32_t iterations, xmem::common::chunk_size_t chunk_size, uint32_t cpu_node, uint32_t mem_node, uint32_t num_worker_threads, std::string name, [xmem::timers::Timer](#) *timer, std::vector< [xmem::power::PowerReader](#) * > dram_power_readers)
Constructor.
- virtual **~Benchmark** ()
Destructor.
- virtual bool **run** ()=0
Runs the benchmark.
- virtual void **report_benchmark_info** ()=0
Reports benchmark configuration details to the console.
- virtual void **report_results** ()=0
Reports results to the console.
- void **report_power_results** ()
Reports power measurement results to the console.
- bool **isValid** ()
Checks to see that the object is in a valid state.
- bool **hasRun** ()
Checks to see if the benchmark has run.
- double **getMetricOnIter** (uint32_t iter)
Extracts the metric of interest for a given iteration. Units are interpreted by the inheriting class.

- double [getAverageMetric](#) ()
Gets the average benchmark metric across all iterations.
- double [getAverageDRAMPower](#) (uint32_t socket_id)
Gets the average DRAM power over the benchmark.
- double [getPeakDRAMPower](#) (uint32_t socket_id)
Gets the peak DRAM power over the benchmark.
- size_t [getLen](#) ()
Gets the length of the memory region in bytes. This is not necessarily the "working set size" depending on multi-threading configuration.
- uint32_t [getIterations](#) ()
Gets the number of iterations for this benchmark.
- xmem::common::chunk_size_t [getChunkSize](#) ()
Gets the width of memory access used in this benchmark.
- uint32_t [getCPUNode](#) ()
Gets the CPU NUMA node used in this benchmark.
- uint32_t [getMemNode](#) ()
Gets the memory NUMA node used in this benchmark.
- uint32_t [getNumThreads](#) ()
Gets the number of worker threads used in this benchmark.
- std::string [getName](#) ()
Gets the human-friendly name of this benchmark.

Protected Member Functions

- bool [_start_power_threads](#) ()
Starts the DRAM power measurement threads.
- bool [_stop_power_threads](#) ()
Stops the DRAM power measurement threads. This is a blocking call.

Protected Attributes

- void * [_mem_array](#)
- size_t [_len](#)
- uint32_t [_iterations](#)
- xmem::common::chunk_size_t [_chunk_size](#)
- size_t * [_indices](#)
- uint32_t [_cpu_node](#)
- uint32_t [_mem_node](#)
- uint32_t [_num_worker_threads](#)
- xmem::timers::Timer * [_timer](#)
- std::vector
 < xmem::power::PowerReader * > [_dram_power_readers](#)
- std::vector
 < xmem::thread::Thread * > [_dram_power_threads](#)
- std::vector< double > [_average_dram_power_socket](#)
- std::vector< double > [_peak_dram_power_socket](#)
- bool [_hasRun](#)
- std::vector< double > [_metricOnIter](#)
- double [_averageMetric](#)
- std::string [_name](#)
- bool [_obj_valid](#)
- bool [_warning](#)

5.3.1 Detailed Description

Flexible abstract class for any memory benchmark.

This class provides a generic interface for interacting with a benchmark. All benchmarks should be derived from this class.

5.3.2 Constructor & Destructor Documentation

5.3.2.1 `Benchmark (void * mem_array, size_t len, uint32_t iterations, xmem::common::chunk_size_t chunk_size, uint32_t cpu_node, uint32_t mem_node, uint32_t num_worker_threads, std::string name, xmem::timers::Timer * timer, std::vector< xmem::power::PowerReader * > dram_power_readers)`

Constructor.

Parameters

| | |
|-----------------------------|---|
| <i>mem_array</i> | a pointer to a contiguous chunk of memory that has been allocated for benchmarking among the worker threads. This should be aligned to a 256-bit boundary and should be the working set size times number of threads large. |
| <i>len</i> | Length of the raw <i>mem_array</i> in bytes. This should be a multiple of 4 KB pages. |
| <i>iterations</i> | Number of iterations to do of the complete benchmark, to average out results. |
| <i>passes_per_iteration</i> | Number of passes to do in each iteration, to ensure timed section of code is "long enough". |
| <i>chunk_size</i> | encoded size of an individual memory access. |
| <i>cpu_node</i> | the logical CPU NUMA node to use for the benchmark |
| <i>mem_node</i> | the logical memory NUMA node used in the benchmark |
| <i>num_worker_threads</i> | number of worker threads to use in the benchmark |
| <i>name</i> | name of the benchmark to use when reporting |
| <i>timer</i> | pointer to an existing Timer |
| <i>dram_power_readers</i> | vector of pointers to PowerReader objects for measuring DRAM power |

5.3.3 Member Function Documentation

5.3.3.1 `bool Benchmark::_start_power_threads () [protected]`

Starts the DRAM power measurement threads.

Returns

true on success

5.3.3.2 `bool Benchmark::_stop_power_threads () [protected]`

Stops the DRAM power measurement threads. This is a blocking call.

Returns

true on success

5.3.3.3 `double Benchmark::getAverageDRAMPower (uint32_t socket_id)`

Gets the average DRAM power over the benchmark.

Returns

The average DRAM power for a given socket in watts, or 0 if the data does not exist (power was unable to be collected or the benchmark has not run).

5.3.3.4 double Benchmark::getAverageMetric ()

Gets the average benchmark metric across all iterations.

Returns

The average metric.

5.3.3.5 xmem::common::chunk_size_t Benchmark::getChunkSize ()

Gets the width of memory access used in this benchmark.

Returns

The chunk size for this benchmark.

5.3.3.6 uint32_t Benchmark::getCPUNode ()

Gets the CPU NUMA node used in this benchmark.

Returns

The NUMA CPU node used in this benchmark.

5.3.3.7 uint32_t Benchmark::getIterations ()

Gets the number of iterations for this benchmark.

Returns

The number of iterations for this benchmark.

5.3.3.8 size_t Benchmark::getLen ()

Gets the length of the memory region in bytes. This is not necessarily the "working set size" depending on multi-threading configuration.

Returns

Length of the memory region in bytes.

5.3.3.9 uint32_t Benchmark::getMemNode ()

Gets the memory NUMA node used in this benchmark.

Returns

The NUMA memory node used in this benchmark.

5.3.3.10 double Benchmark::getMetricOnIter (uint32_t *iter*)

Extracts the metric of interest for a given iteration. Units are interpreted by the inheriting class.

Parameters

| | |
|-------------|-----------------------|
| <i>iter</i> | Iteration to extract. |
|-------------|-----------------------|

Returns

The metric on the iteration specified by the input.

5.3.3.11 `std::string Benchmark::getName ()`

Gets the human-friendly name of this benchmark.

Returns

The benchmark test name.

5.3.3.12 `uint32_t Benchmark::getNumThreads ()`

Gets the number of worker threads used in this benchmark.

Returns

The number of worker threads used in this benchmark.

5.3.3.13 `double Benchmark::getPeakDRAMPower (uint32_t socket_id)`

Gets the peak DRAM power over the benchmark.

Returns

The peak DRAM power for a given socket in watts, or 0 if the data does not exist (power was unable to be collected or the benchmark has not run).

5.3.3.14 `bool Benchmark::hasRun ()`

Checks to see if the benchmark has run.

Returns

True if [run\(\)](#) has already completed successfully.

5.3.3.15 `bool Benchmark::isValid ()`

Checks to see that the object is in a valid state.

Returns

True if the object was constructed correctly and can be used.

5.3.3.16 `virtual bool xmem::benchmark::Benchmark::run()` [pure virtual]

Runs the benchmark.

Returns

true on benchmark success

Implemented in [xmem::benchmark::ThroughputBenchmark](#), and [xmem::benchmark::LatencyBenchmark](#).

5.3.4 Member Data Documentation

5.3.4.1 `std::vector<double> xmem::benchmark::Benchmark::_average_dram_power_socket` [protected]

The average DRAM power in this benchmark, per socket.

5.3.4.2 `double xmem::benchmark::Benchmark::_averageMetric` [protected]

Average metric over all iterations. Unit-less because any benchmark can set this metric as needed. It is up to the descendant class to interpret units.

5.3.4.3 `xmem::common::chunk_size_t xmem::benchmark::Benchmark::_chunk_size` [protected]

Chunk size of memory accesses in this benchmark. TODO: Move this to [ThroughputBenchmark.h](#), as it does not apply in all situations, e.g. in [LatencyBenchmark](#).

5.3.4.4 `uint32_t xmem::benchmark::Benchmark::_cpu_node` [protected]

The CPU NUMA node used in this benchmark.

5.3.4.5 `std::vector<xmem::power::PowerReader*> xmem::benchmark::Benchmark::_dram_power_readers` [protected]

The power reading objects for measuring DRAM power on a per-socket basis during the benchmark.

5.3.4.6 `std::vector<xmem::thread::Thread*> xmem::benchmark::Benchmark::_dram_power_threads` [protected]

The power reading threads for measuring DRAM power on a per-socket basis during the benchmark. These work with the DRAM power readers. Although they are worker threads, they are not counted as the "official" benchmarking worker threads.

5.3.4.7 `bool xmem::benchmark::Benchmark::_hasRun` [protected]

Indicates whether the benchmark has run.

5.3.4.8 `size_t* xmem::benchmark::Benchmark::_indices` [protected]

Pointer to a list of indices. This is for indirect memory addressing. Currently unused. TODO: Remove this entirely?

5.3.4.9 `uint32_t xmem::benchmark::Benchmark::_iterations` [protected]

Number of iterations used in this benchmark.

5.3.4.10 `size_t xmem::benchmark::Benchmark::_len` [protected]

Length of the memory region in bytes. This is not the working set size per thread!

5.3.4.11 `void* xmem::benchmark::Benchmark::_mem_array` [protected]

Pointer to the memory region to use in this benchmark.

5.3.4.12 `uint32_t xmem::benchmark::Benchmark::_mem_node` [protected]

The memory NUMA node used in this benchmark.

5.3.4.13 `std::vector<double> xmem::benchmark::Benchmark::_metricOnIter` [protected]

Metrics for each iteration of the benchmark. Unit-less because any benchmark can set this metric as needed. It is up to the descendant class to interpret units.

5.3.4.14 `std::string xmem::benchmark::Benchmark::_name` [protected]

Name of this benchmark.

5.3.4.15 `uint32_t xmem::benchmark::Benchmark::_num_worker_threads` [protected]

The number of worker threads used in this benchmark.

5.3.4.16 `bool xmem::benchmark::Benchmark::_obj_valid` [protected]

Indicates whether this benchmark object is valid.

5.3.4.17 `std::vector<double> xmem::benchmark::Benchmark::_peak_dram_power_socket` [protected]

The peak DRAM power in this benchmark, per socket.

5.3.4.18 `xmem::timers::Timer* xmem::benchmark::Benchmark::_timer` [protected]

The reference timer for this benchmark. TODO: Remove this. It isn't thread safe anyway, so workers don't use it.

5.3.4.19 `bool xmem::benchmark::Benchmark::_warning` [protected]

Indicates whether the benchmarks results might be clearly questionable/inaccurate/incorrect due to a variety of factors.

The documentation for this class was generated from the following files:

- [src/include/Benchmark.h](#)
- [src/Benchmark.cpp](#)

5.4 xmem::benchmark::BenchmarkManager Class Reference

Manages running all benchmarks at a high level.

```
#include <BenchmarkManager.h>
```

Public Member Functions

- [BenchmarkManager](#) (size_t working_set_size, uint32_t iterations_per_benchmark, bool output_to_file, std::string results_filename)
Constructor.
- [~BenchmarkManager](#) ()
Destructor.
- bool [runAll](#) ()
Runs all possible benchmark configurations.
- bool [runThroughputBenchmarks](#) ()
Runs the throughput benchmarks.
- bool [runLatencyBenchmarks](#) ()
Runs the latency benchmark.

5.4.1 Detailed Description

Manages running all benchmarks at a high level.

5.4.2 Constructor & Destructor Documentation

5.4.2.1 [BenchmarkManager::BenchmarkManager](#) (size_t *working_set_size*, uint32_t *iterations_per_benchmark*, bool *output_to_file*, std::string *results_filename*)

Constructor.

Parameters

| | |
|---------------------------------|--|
| <i>working_set_size</i> | Total memory to test in bytes on each NUMA node. The BenchmarkManager will try to allocate them by itself. |
| <i>iterations_per_benchmark</i> | Number of passes to run for each individual benchmark. |
| <i>output_to_file</i> | If true, write to file specified by results_filename. |
| <i>results_filename</i> | Filename to write results to if output_to_file is true. |

5.4.3 Member Function Documentation

5.4.3.1 bool [BenchmarkManager::runAll](#) ()

Runs all possible benchmark configurations.

Returns

True on success.

5.4.3.2 `bool BenchmarkManager::runLatencyBenchmarks ()`

Runs the latency benchmark.

Returns

True on benchmarking success.

5.4.3.3 `bool BenchmarkManager::runThroughputBenchmarks ()`

Runs the throughput benchmarks.

Returns

True on benchmarking success.

The documentation for this class was generated from the following files:

- `src/include/BenchmarkManager.h`
- `src/BenchmarkManager.cpp`

5.5 `xmem::config::Configurator` Class Reference

Handles all user input interpretation and generates the necessary flags for running benchmarks.

```
#include <Configurator.h>
```

Public Member Functions

- `Configurator ()`
Default constructor. A default configuration is set. You will want to run `configureFromInput()` most likely.
- `Configurator (bool runLatency, bool runThroughput, size_t working_set_size, uint32_t iterations_per_test, std::string filename, bool use_output_file)`
Specialized constructor for when you don't want to get config from input, and you want to pass it in directly.
- `int configureFromInput (int argc, char *argv[])`
Configures the tool based on user's command-line inputs.
- `bool latencyTestSelected ()`
Indicates if the latency test has been selected.
- `bool throughputTestSelected ()`
Indicates if the throughput test has been selected.
- `size_t getWorkingSetSize ()`
Gets the working set size in bytes for each worker thread, if applicable.
- `uint32_t getIterationsPerTest ()`
Gets the number of iterations that should be run of each benchmark.
- `std::string getOutputFilename ()`
Gets the output filename to use, if applicable.
- `bool useOutputFile ()`
Determines whether to generate an output CSV file.

5.5.1 Detailed Description

Handles all user input interpretation and generates the necessary flags for running benchmarks.

5.5.2 Constructor & Destructor Documentation

5.5.2.1 `Configurator::Configurator (bool runLatency, bool runThroughput, size_t working_set_size, uint32_t iterations_per_test, std::string filename, bool use_output_file)`

Specialized constructor for when you don't want to get config from input, and you want to pass it in directly.

Parameters

| | |
|----------------------------|---|
| <i>runLatency</i> | Indicates latency benchmarks should be run. |
| <i>runThroughput</i> | Indicates throughput benchmarks should be run. |
| <i>working_set_size</i> | The total size of memory to test in all benchmarks, in bytes. This MUST be a multiple of 4KB pages. |
| <i>iterations_per_test</i> | For each unique benchmark test, this is the number of times to repeat it. |
| <i>filename</i> | Output filename to use. |
| <i>use_output_file</i> | If true, use the provided output filename. |

5.5.3 Member Function Documentation

5.5.3.1 `int Configurator::configureFromInput (int argc, char * argv[])`

Configures the tool based on user's command-line inputs.

Parameters

| | |
|-------------|--|
| <i>argc</i> | The argc from main() . |
| <i>argv</i> | The argv from main() . |

Returns

0 on success.

5.5.3.2 `uint32_t xmem::config::Configurator::getIterationsPerTest () [inline]`

Gets the number of iterations that should be run of each benchmark.

Returns

The iterations for each test.

5.5.3.3 `std::string xmem::config::Configurator::getOutputFilename () [inline]`

Gets the output filename to use, if applicable.

Returns

The output filename to use if [useOutputFile\(\)](#) returns true. Otherwise return value is "".

5.5.3.4 `size_t xmem::config::Configurator::getWorkingSetSize () [inline]`

Gets the working set size in bytes for each worker thread, if applicable.

Returns

The working set size in bytes.

5.5.3.5 `bool xmem::config::Configurator::latencyTestSelected () [inline]`

Indicates if the latency test has been selected.

Returns

True if the latency test has been selected to run.

5.5.3.6 `bool xmem::config::Configurator::throughputTestSelected () [inline]`

Indicates if the throughput test has been selected.

Returns

True if the throughput test has been selected to run.

5.5.3.7 `bool xmem::config::Configurator::useOutputFile () [inline]`

Determines whether to generate an output CSV file.

Returns

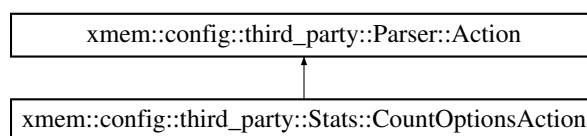
True if an output file should be used.

The documentation for this class was generated from the following files:

- [src/include/Configurator.h](#)
- [src/Configurator.cpp](#)

5.6 `xmem::config::third_party::Stats::CountOptionsAction` Class Reference

Inheritance diagram for `xmem::config::third_party::Stats::CountOptionsAction`:



Public Member Functions

- [CountOptionsAction](#) (unsigned *buffer_max_)
- bool [perform](#) ([Option](#) &)

Called by `Parser::workhorse()` for each [Option](#) that has been successfully parsed (including unknown options if they have a [Descriptor](#) whose [Descriptor::check_arg](#) does not return `ARG_ILLEGAL`).

5.6.1 Constructor & Destructor Documentation

5.6.1.1 `xmem::config::third_party::Stats::CountOptionsAction::CountOptionsAction (unsigned * buffer_max_) [inline]`

Creates a new [CountOptionsAction](#) that will increase *buffer_max_ for each parsed [Option](#).

5.6.2 Member Function Documentation

5.6.2.1 bool xmem::config::third_party::Stats::CountOptionsAction::perform (Option &) [inline],[virtual]

Called by Parser::workhorse() for each [Option](#) that has been successfully parsed (including unknown options if they have a [Descriptor](#) whose [Descriptor::check_arg](#) does not return ARG_ILLEGAL.

Returns `false` iff a fatal error has occurred and the parse should be aborted.

Reimplemented from [xmem::config::third_party::Parser::Action](#).

The documentation for this class was generated from the following file:

- [src/include/optionparser.h](#)

5.7 xmem::config::third_party::Descriptor Struct Reference

Describes an option, its help text (usage) and how it should be parsed.

```
#include <optionparser.h>
```

Public Attributes

- const unsigned [index](#)
Index of this option's linked list in the array filled in by the parser.
- const int [type](#)
Used to distinguish between options with the same [index](#). See [index](#) for details.
- const char *const [shortopt](#)
Each char in this string will be accepted as a short option character.
- const char *const [longopt](#)
The long option name (without the leading -).
- const CheckArg [check_arg](#)
For each option that matches [shortopt](#) or [longopt](#) this function will be called to check a potential argument to the option.
- const char * [help](#)
The usage text associated with the options in this [Descriptor](#).

5.7.1 Detailed Description

Describes an option, its help text (usage) and how it should be parsed.

The main input when constructing an [option::Parser](#) is an array of [Descriptors](#).

Example:

```
enum OptionIndex {CREATE, ...};
enum OptionType {DISABLE, ENABLE, OTHER};

const option::Descriptor usage[] = {
    { CREATE,                                // index
      OTHER,                                // type
      "c",                                  // shortopt
      "create",                              // longopt
      Arg::None,                             // check_arg
      "--create Tells the program to create something." // help
    }, ...
};
```

5.7.2 Member Data Documentation

5.7.2.1 `const CheckArg xmem::config::third_party::Descriptor::check_arg`

For each option that matches [shorpt](#) or [longopt](#) this function will be called to check a potential argument to the option.

This function will be called even if there is no potential argument. In that case it will be passed `NULL` as `arg` parameter. Do not confuse this with the empty string.

See `CheckArg` for more information.

5.7.2.2 `const char* xmem::config::third_party::Descriptor::help`

The usage text associated with the options in this [Descriptor](#).

You can use `option::printUsage()` to format your usage message based on the `help` texts. You can use dummy Descriptors where [shorpt](#) and [longopt](#) are both the empty string to add text to the usage that is not related to a specific option.

See `option::printUsage()` for special formatting characters you can use in `help` to get a column layout.

Attention

Must be UTF-8-encoded. If your compiler supports C++11 you can use the `"u8"` prefix to make sure string literals are properly encoded.

5.7.2.3 `const unsigned xmem::config::third_party::Descriptor::index`

Index of this option's linked list in the array filled in by the parser.

Command line options whose Descriptors have the same index will end up in the same linked list in the order in which they appear on the command line. If you have multiple long option aliases that refer to the same option, give their descriptors the same `index`.

If you have options that mean exactly opposite things (e.g. `-enable-foo` and `-disable-foo`), you should also give them the same `index`, but distinguish them through different values for `type`. That way they end up in the same list and you can just take the last element of the list and use its type. This way you get the usual behaviour where switches later on the command line override earlier ones without having to code it manually.

Tip:

Use an enum rather than plain ints for better readability, as shown in the example at [Descriptor](#).

5.7.2.4 `const char* const xmem::config::third_party::Descriptor::longopt`

The long option name (without the leading `-`).

If this [Descriptor](#) should not have a long option name, use the empty string `""`. `NULL` is not permitted here!

While [shorpt](#) allows multiple short option characters, each [Descriptor](#) can have only a single long option name. If you have multiple long option names referring to the same option use separate Descriptors that have the same `index` and `type`. You may repeat short option characters in such an alias [Descriptor](#) but there's no need to.

Dummy Descriptors:

You can use dummy Descriptors with an empty string for both [shorpt](#) and [longopt](#) to add text to the usage that is not related to a specific option. See [help](#). The first dummy [Descriptor](#) will be used for unknown options (see below).

Unknown Option Descriptor:

The first dummy [Descriptor](#) in the list of Descriptors, whose [shortopt](#) and [longopt](#) are both the empty string, will be used as the [Descriptor](#) for unknown options. An unknown option is a string in the argument vector that is not a lone minus ' - ' but starts with a minus character and does not match any [Descriptor](#)'s [shortopt](#) or [longopt](#). Note that the dummy descriptor's [check_arg](#) function *will* be called and its return value will be evaluated as usual. I.e. if it returns ARG_ILLEGAL the parsing will be aborted with `Parser::error()==true`. if [check_arg](#) does not return ARG_ILLEGAL the descriptor's [index](#) *will* be used to pick the linked list into which to put the unknown option.

If there is no dummy descriptor, unknown options will be dropped silently.

5.7.2.5 const char* const xmem::config::third_party::Descriptor::shortopt

Each char in this string will be accepted as a short option character.

The string must not include the minus character ' - ' or you'll get undefined behaviour.

If this [Descriptor](#) should not have short option characters, use the empty string "". NULL is not permitted here!

See [longopt](#) for more information.

5.7.2.6 const int xmem::config::third_party::Descriptor::type

Used to distinguish between options with the same [index](#). See [index](#) for details.

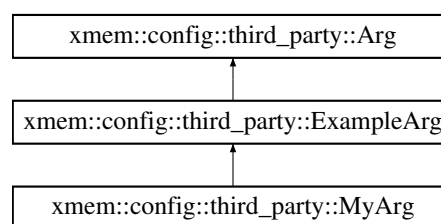
It is recommended that you use an enum rather than a plain int to make your code more readable.

The documentation for this struct was generated from the following file:

- [src/include/optionparser.h](#)

5.8 xmem::config::third_party::ExampleArg Class Reference

Inheritance diagram for xmem::config::third_party::ExampleArg:

**Static Public Member Functions**

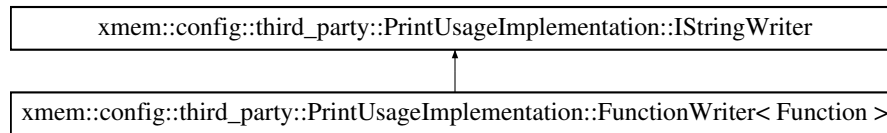
- static void **printError** (const char *msg1, const [Option](#) &opt, const char *msg2)
- static ArgStatus **Unknown** (const [Option](#) &option, bool msg)
- static ArgStatus **Required** (const [Option](#) &option, bool msg)
- static ArgStatus **NonEmpty** (const [Option](#) &option, bool msg)

The documentation for this class was generated from the following file:

- [src/include/ExampleArg.h](#)

5.9 xmem::config::third_party::PrintUsageImplementation::FunctionWriter< Function > Struct Template Reference

Inheritance diagram for xmem::config::third_party::PrintUsageImplementation::FunctionWriter< Function >:



Public Member Functions

- virtual void [operator\(\)](#) (const char *str, int size)
Writes the given number of chars beginning at the given pointer somewhere.
- **FunctionWriter** (Function *w)

Public Attributes

- Function * **write**

The documentation for this struct was generated from the following file:

- [src/include/optionparser.h](#)

5.10 xmem::config::third_party::PrintUsageImplementation::IStringWriter Struct Reference

Inheritance diagram for xmem::config::third_party::PrintUsageImplementation::IStringWriter:



Public Member Functions

- virtual void [operator\(\)](#) (const char *, int)
Writes the given number of chars beginning at the given pointer somewhere.

The documentation for this struct was generated from the following file:

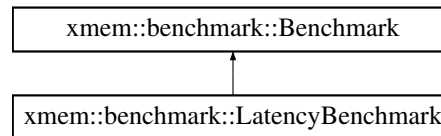
- [src/include/optionparser.h](#)

5.11 xmem::benchmark::LatencyBenchmark Class Reference

A type of benchmark that measures memory latency via random pointer chasing. TODO: loaded latency tests.

```
#include <LatencyBenchmark.h>
```

Inheritance diagram for xmem::benchmark::LatencyBenchmark:



Public Types

- typedef int32_t(* **LatencyBenchFunction**)(uintptr_t *, uintptr_t **, size_t)

Public Member Functions

- [LatencyBenchmark](#) (void *mem_array, size_t len, uint32_t iterations, uint32_t cpu_node, uint32_t mem_node, uint32_t num_worker_threads, std::string name, [xmem::timers::Timer](#) *timer, std::vector< [xmem::power::PowerReader](#) * > dram_power_readers)
- virtual [~LatencyBenchmark](#) ()
Destructor.
- virtual bool [run](#) ()
Runs the benchmark.
- virtual void [report_benchmark_info](#) ()
Outputs the benchmark configuration to the console.
- virtual void [report_results](#) ()
Outputs a report of the benchmark results to the console if [run\(\)](#) returned true.

Additional Inherited Members

5.11.1 Detailed Description

A type of benchmark that measures memory latency via random pointer chasing. TODO: loaded latency tests.

5.11.2 Constructor & Destructor Documentation

- 5.11.2.1 [LatencyBenchmark::LatencyBenchmark](#) (void * mem_array, size_t len, uint32_t iterations, uint32_t cpu_node, uint32_t mem_node, uint32_t num_worker_threads, std::string name, [xmem::timers::Timer](#) * timer, std::vector< [xmem::power::PowerReader](#) * > dram_power_readers)

Constructor.

Parameters

| | |
|---------------------------|---|
| <i>mem_array</i> | a pointer to a contiguous chunk of memory that has been allocated for benchmarking among the worker threads. This should be aligned to a 256-bit boundary and should be the working set size times number of threads large. |
| <i>len</i> | Length of the raw_mem_array in bytes. This should be a multiple of 4 KB pages. |
| <i>iterations</i> | Number of iterations (passes) to do of the complete benchmark. |
| <i>cpu_node</i> | the logical CPU NUMA node to use in the benchmark |
| <i>mem_node</i> | the logical memory NUMA node used in the benchmark |
| <i>num_worker_threads</i> | number of worker threads to use in the benchmark |

| | |
|---------------------------|--|
| <i>name</i> | name of the benchmark to use when reporting |
| <i>timer</i> | pointer to an existing Timer object |
| <i>dram_power_readers</i> | vector of pointers to PowerReader objects for measuring DRAM power |

5.11.3 Member Function Documentation

5.11.3.1 `bool LatencyBenchmark::run () [virtual]`

Runs the benchmark.

Returns

True on success.

Implements [xmem::benchmark::Benchmark](#).

The documentation for this class was generated from the following files:

- [src/include/LatencyBenchmark.h](#)
- [src/LatencyBenchmark.cpp](#)

5.12 `xmem::config::third_party::PrintUsageImplementation::LinePartIterator` Class Reference

Public Member Functions

- [LinePartIterator](#) (const [Descriptor](#) usage[])
Creates an iterator for usage.
- `bool nextTable ()`
Moves iteration to the next table (if any). Has to be called once on a new [LinePartIterator](#) to move to the 1st table.
- `void restartTable ()`
Reset iteration to the beginning of the current table.
- `bool nextRow ()`
Moves iteration to the next row (if any). Has to be called once after each call to [nextTable\(\)](#) to move to the 1st row of the table.
- `void restartRow ()`
Reset iteration to the beginning of the current row.
- `bool next ()`
Moves iteration to the next part (if any). Has to be called once after each call to [nextRow\(\)](#) to move to the 1st part of the row.
- `int column ()`
Returns the index (counting from 0) of the column in which the part pointed to by [data\(\)](#) is located.
- `int line ()`
Returns the index (counting from 0) of the line within the current column this part belongs to.
- `int length ()`
Returns the length of the part pointed to by [data\(\)](#) in raw chars (not UTF-8 characters).
- `int screenLength ()`
Returns the width in screen columns of the part pointed to by [data\(\)](#). Takes multi-byte UTF-8 sequences and wide characters into account.
- `const char * data ()`
Returns the current part of the iteration.

5.12.1 Member Function Documentation

5.12.1.1 bool xmem::config::third_party::PrintUsagelImplementation::LinePartIterator::next () [inline]

Moves iteration to the next part (if any). Has to be called once after each call to [nextRow\(\)](#) to move to the 1st part of the row.

Return values

| | |
|--------------|---|
| <i>false</i> | if moving to next part failed because no further part exists. |
|--------------|---|

See [LinePartIterator](#) for details about the iteration.

5.12.1.2 bool xmem::config::third_party::PrintUsagelImplementation::LinePartIterator::nextRow () [inline]

Moves iteration to the next row (if any). Has to be called once after each call to [nextTable\(\)](#) to move to the 1st row of the table.

Return values

| | |
|--------------|---|
| <i>false</i> | if moving to next row failed because no further row exists. |
|--------------|---|

5.12.1.3 bool xmem::config::third_party::PrintUsagelImplementation::LinePartIterator::nextTable () [inline]

Moves iteration to the next table (if any). Has to be called once on a new [LinePartIterator](#) to move to the 1st table.

Return values

| | |
|--------------|---|
| <i>false</i> | if moving to next table failed because no further table exists. |
|--------------|---|

The documentation for this class was generated from the following file:

- [src/include/optionparser.h](#)

5.13 xmem::config::third_party::PrintUsagelImplementation::LineWrapper Class Reference

Public Member Functions

- void [flush](#) (IStringWriter &write)
Writes out all remaining data from the [LineWrapper](#) using `write`. Unlike [process\(\)](#) this method indents all lines including the first and will output a `\n` at the end (but only if something has been written).
- void [process](#) (IStringWriter &write, const char *data, int len)
Process, wrap and output the next piece of data.
- [LineWrapper](#) (int x1, int x2)
Constructs a [LineWrapper](#) that wraps its output to fit into screen columns `x1` (incl.) to `x2` (excl.).

5.13.1 Constructor & Destructor Documentation

5.13.1.1 xmem::config::third_party::PrintUsagelImplementation::LineWrapper::LineWrapper (int x1, int x2) [inline]

Constructs a [LineWrapper](#) that wraps its output to fit into screen columns `x1` (incl.) to `x2` (excl.).

`x1` gives the indentation [LineWrapper](#) uses if it needs to indent.

5.13.2 Member Function Documentation

5.13.2.1 `void xmem::config::third_party::PrintUsagelImplementation::LineWrapper::process (IStringWriter & write, const char * data, int len) [inline]`

Process, wrap and output the next piece of data.

`process()` will output at least one line of output. This is not necessarily the `data` passed in. It may be data queued from a prior call to `process()`. If the internal buffer is full, more than 1 line will be output.

`process()` assumes that the a proper amount of indentation has already been output. It won't write any further indentation before the 1st line. If more than 1 line is written due to buffer constraints, the lines following the first will be indented by this method, though.

No `\n` is written by this method after the last line that is written.

Parameters

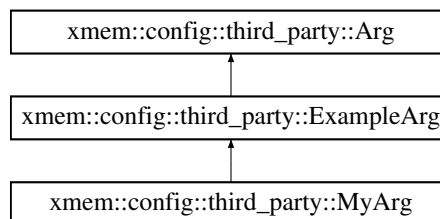
| | |
|--------------|---|
| <i>write</i> | where to write the data. |
| <i>data</i> | the new chunk of data to write. |
| <i>len</i> | the length of the chunk of data to write. |

The documentation for this class was generated from the following file:

- `src/include/optionparser.h`

5.14 xmem::config::third_party::MyArg Class Reference

Inheritance diagram for `xmem::config::third_party::MyArg`:



Static Public Member Functions

- static ArgStatus `Integer` (const `Option` &option, bool msg)
Checks an option that it is an integer.
- static ArgStatus `NonnegativeInteger` (const `Option` &option, bool msg)
Checks an option that it is a nonnegative integer.
- static ArgStatus `PositiveInteger` (const `Option` &option, bool msg)
Checks an option that it is a positive integer.

The documentation for this class was generated from the following file:

- `src/include/MyArg.h`

5.15 xmem::config::third_party::Option Class Reference

A parsed option from the command line together with its argument if it has one.

```
#include <optionparser.h>
```

Public Member Functions

- `int type () const`
Returns `Descriptor::type` of this `Option`'s `Descriptor`, or 0 if this `Option` is invalid (unused).
- `int index () const`
Returns `Descriptor::index` of this `Option`'s `Descriptor`, or -1 if this `Option` is invalid (unused).
- `int count ()`
Returns the number of times this `Option` (or others with the same `Descriptor::index`) occurs in the argument vector.
- `bool isFirst () const`
Returns true iff this is the first element of the linked list.
- `bool isLast () const`
Returns true iff this is the last element of the linked list.
- `Option * first ()`
Returns a pointer to the first element of the linked list.
- `Option * last ()`
Returns a pointer to the last element of the linked list.
- `Option * prev ()`
Returns a pointer to the previous element of the linked list or NULL if called on `first()`.
- `Option * prevwrap ()`
Returns a pointer to the previous element of the linked list with wrap-around from `first()` to `last()`.
- `Option * next ()`
Returns a pointer to the next element of the linked list or NULL if called on `last()`.
- `Option * nextwrap ()`
Returns a pointer to the next element of the linked list with wrap-around from `last()` to `first()`.
- `void append (Option *new_last)`
Makes `new_last` the new `last()` by chaining it into the list after `last()`.
- `operator const Option * () const`
Casts from `Option` to `const Option*` but only if this `Option` is valid.
- `operator Option * ()`
Casts from `Option` to `Option*` but only if this `Option` is valid.
- `Option ()`
Creates a new `Option` that is a one-element linked list and has NULL `desc`, `name`, `arg` and `namelen`.
- `Option (const Descriptor *desc_, const char *name_, const char *arg_)`
Creates a new `Option` that is a one-element linked list and has the given values for `desc`, `name` and `arg`.
- `void operator= (const Option &orig)`
Makes `*this` a copy of `orig` except for the linked list pointers.
- `Option (const Option &orig)`
Makes `*this` a copy of `orig` except for the linked list pointers.

Public Attributes

- `const Descriptor * desc`
Pointer to this `Option`'s `Descriptor`.
- `const char * name`
The name of the option as used on the command line.
- `const char * arg`
Pointer to this `Option`'s argument (if any).
- `int namelen`
The length of the option `name`.

5.15.1 Detailed Description

A parsed option from the command line together with its argument if it has one.

The [Parser](#) chains all parsed options with the same [Descriptor::index](#) together to form a linked list. This allows you to easily implement all of the common ways of handling repeated options and enable/disable pairs.

- Test for presence of a switch in the argument vector:

```
if ( options[QUIET] ) ...
```

- Evaluate `--enable-foo/--disable-foo` pair where the last one used wins:

```
if ( options[FOO].last()->type() == DISABLE ) ...
```

- Cumulative option (`-v` verbose, `-vv` more verbose, `-vvv` even more verbose):

```
int verbosity = options[VERBOSE].count();
```

- Iterate over all `--file=<fname>` arguments:

```
for (Option* opt = options[FILE]; opt; opt = opt->next())
    fname = opt->arg; ...
```

5.15.2 Constructor & Destructor Documentation

5.15.2.1 `xmem::config::third_party::Option::Option (const Descriptor * desc_, const char * name_, const char * arg_)`
[inline]

Creates a new [Option](#) that is a one-element linked list and has the given values for [desc](#), [name](#) and [arg](#).

If `name_` points at a character other than `'-'` it will be assumed to refer to a short option and [namelen](#) will be set to 1. Otherwise the length will extend to the first `'='` character or the string's 0-terminator.

5.15.2.2 `xmem::config::third_party::Option::Option (const Option & orig)` [inline]

Makes `*this` a copy of `orig` except for the linked list pointers.

After this operation `*this` will be a one-element linked list.

5.15.3 Member Function Documentation

5.15.3.1 `void xmem::config::third_party::Option::append (Option * new_last)` [inline]

Makes `new_last` the new [last\(\)](#) by chaining it into the list after [last\(\)](#).

It doesn't matter which element you call [append\(\)](#) on. The new element will always be appended to [last\(\)](#).

Attention

`new_last` must not yet be part of a list, or that list will become corrupted, because this method does not unchain `new_last` from an existing list.

5.15.3.2 `int xmem::config::third_party::Option::count ()` [inline]

Returns the number of times this [Option](#) (or others with the same [Descriptor::index](#)) occurs in the argument vector.

This corresponds to the number of elements in the linked list this [Option](#) is part of. It doesn't matter on which element you call [count\(\)](#). The return value is always the same.

Use this to implement cumulative options, such as `-v`, `-vv`, `-vvv` for different verbosity levels.

Returns 0 when called for an unused/invalid option.

5.15.3.3 `Option* xmem::config::third_party::Option::first () [inline]`

Returns a pointer to the first element of the linked list.

Use this when you want the first occurrence of an option on the command line to take precedence. Note that this is not the way most programs handle options. You should probably be using `last()` instead.

Note

This method may be called on an unused/invalid option and will return a pointer to the option itself.

5.15.3.4 `bool xmem::config::third_party::Option::isFirst () const [inline]`

Returns true iff this is the first element of the linked list.

The first element in the linked list is the first option on the command line that has the respective `Descriptor::index` value.

Returns true for an unused/invalid option.

5.15.3.5 `bool xmem::config::third_party::Option::isLast () const [inline]`

Returns true iff this is the last element of the linked list.

The last element in the linked list is the last option on the command line that has the respective `Descriptor::index` value.

Returns true for an unused/invalid option.

5.15.3.6 `Option* xmem::config::third_party::Option::last () [inline]`

Returns a pointer to the last element of the linked list.

Use this when you want the last occurrence of an option on the command line to take precedence. This is the most common way of handling conflicting options.

Note

This method may be called on an unused/invalid option and will return a pointer to the option itself.

Tip:

If you have options with opposite meanings (e.g. `-enable-foo` and `-disable-foo`), you can assign them the same `Descriptor::index` to get them into the same list. Distinguish them by `Descriptor::type` and all you have to do is check `last() -> type()` to get the state listed last on the command line.

5.15.3.7 `Option* xmem::config::third_party::Option::next () [inline]`

Returns a pointer to the next element of the linked list or NULL if called on `last()`.

If called on `last()` this method returns NULL. Otherwise it will return the option with the same `Descriptor::index` that follows this option on the command line.

5.15.3.8 `Option* xmem::config::third_party::Option::nextwrap () [inline]`

Returns a pointer to the next element of the linked list with wrap-around from `last()` to `first()`.

If called on `last()` this method returns `first()`. Otherwise it will return the option with the same `Descriptor::index` that follows this option on the command line.

5.15.3.9 `xmem::config::third_party::Option::operator const Option * () const` `[inline]`

Casts from [Option](#) to `const Option*` but only if this [Option](#) is valid.

If this [Option](#) is valid (i.e. `desc!=NULL`), returns this. Otherwise returns `NULL`. This allows testing an [Option](#) directly in an if-clause to see if it is used:

```
if (options[CREATE])
{
    ...
}
```

It also allows you to write loops like this:

```
for (Option* opt = options[FILE]; opt; opt = opt->next())
    fname = opt->arg; ...
```

5.15.3.10 `xmem::config::third_party::Option::operator Option * ()` `[inline]`

Casts from [Option](#) to `Option*` but only if this [Option](#) is valid.

If this [Option](#) is valid (i.e. `desc!=NULL`), returns this. Otherwise returns `NULL`. This allows testing an [Option](#) directly in an if-clause to see if it is used:

```
if (options[CREATE])
{
    ...
}
```

It also allows you to write loops like this:

```
for (Option* opt = options[FILE]; opt; opt = opt->next())
    fname = opt->arg; ...
```

5.15.3.11 `void xmem::config::third_party::Option::operator= (const Option & orig)` `[inline]`

Makes `*this` a copy of `orig` except for the linked list pointers.

After this operation `*this` will be a one-element linked list.

5.15.3.12 `Option* xmem::config::third_party::Option::prev ()` `[inline]`

Returns a pointer to the previous element of the linked list or `NULL` if called on [first\(\)](#).

If called on [first\(\)](#) this method returns `NULL`. Otherwise it will return the option with the same [Descriptor::index](#) that precedes this option on the command line.

5.15.3.13 `Option* xmem::config::third_party::Option::prevwrap ()` `[inline]`

Returns a pointer to the previous element of the linked list with wrap-around from [first\(\)](#) to [last\(\)](#).

If called on [first\(\)](#) this method returns [last\(\)](#). Otherwise it will return the option with the same [Descriptor::index](#) that precedes this option on the command line.

5.15.3.14 `int xmem::config::third_party::Option::type () const` `[inline]`

Returns [Descriptor::type](#) of this [Option](#)'s [Descriptor](#), or 0 if this [Option](#) is invalid (unused).

Because this method (and [last\(\)](#), too) can be used even on unused Options with `desc==0`, you can (provided you arrange your types properly) switch on [type\(\)](#) without testing validity first.

```
enum OptionType { UNUSED=0, DISABLED=0, ENABLED=1 };
enum OptionIndex { FOO };
const Descriptor usage[] = {
    { FOO, ENABLED, "", "enable-foo", Arg::None, 0 },
    { FOO, DISABLED, "", "disable-foo", Arg::None, 0 },
    { 0, 0, 0, 0, 0, 0 } };
...
switch(options[FOO].last()->type()) // no validity check required!
{
    case ENABLED: ...
    case DISABLED: ... // UNUSED==DISABLED !
}
```

5.15.4 Member Data Documentation

5.15.4.1 const char* xmem::config::third_party::Option::arg

Pointer to this [Option](#)'s argument (if any).

NULL if this option has no argument. Do not confuse this with the empty string which is a valid argument.

5.15.4.2 const Descriptor* xmem::config::third_party::Option::desc

Pointer to this [Option](#)'s [Descriptor](#).

Remember that the first dummy descriptor (see [Descriptor::longopt](#)) is used for unknown options.

Attention

`desc==NULL` signals that this [Option](#) is unused. This is the default state of elements in the result array. You don't need to test `desc` explicitly. You can simply write something like this:

```
if (options[CREATE])
{
    ...
}
```

This works because of operator `const Option*()` .

5.15.4.3 const char* xmem::config::third_party::Option::name

The name of the option as used on the command line.

The main purpose of this string is to be presented to the user in messages.

In the case of a long option, this is the actual `argv` pointer, i.e. the first character is a '-'. In the case of a short option this points to the option character within the `argv` string.

Note that in the case of a short option group or an attached option argument, this string will contain additional characters following the actual name. Use [namelen](#) to filter out the actual option name only.

5.15.4.4 int xmem::config::third_party::Option::namelen

The length of the option [name](#).

Because [name](#) points into the actual `argv` string, the option name may be followed by more characters (e.g. other short options in the same short option group). This value is the number of bytes (not characters!) that are part of the actual name.

For a short option, this length is always 1. For a long option this length is always at least 2 if single minus long options are permitted and at least 3 if they are disabled.

Note

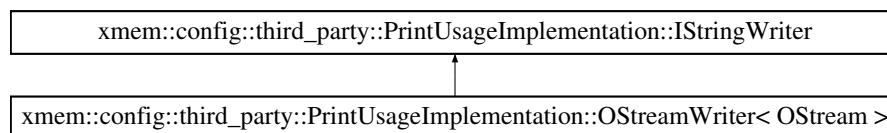
In the pathological case of a minus within a short option group (e.g. `-xf-z`), this length is incorrect, because this case will be misinterpreted as a long option and the name will therefore extend to the string's 0-terminator or a following '=' character if there is one. This is irrelevant for most uses of `name` and `namelen`. If you really need to distinguish the case of a long and a short option, compare `name` to the `argv` pointers. A long option's `name` is always identical to one of them, whereas a short option's is never.

The documentation for this class was generated from the following file:

- `src/include/optionparser.h`

5.16 `xmem::config::third_party::PrintUsageImplementation::OStreamWriter< OStream >` > Struct Template Reference

Inheritance diagram for `xmem::config::third_party::PrintUsageImplementation::OStreamWriter< OStream >`:

**Public Member Functions**

- virtual void `operator()` (const char *str, int size)
Writes the given number of chars beginning at the given pointer somewhere.
- **OStreamWriter** (OStream &o)

Public Attributes

- OStream & **ostream**

The documentation for this struct was generated from the following file:

- `src/include/optionparser.h`

5.17 `xmem::config::third_party::Parser` Class Reference

Checks argument vectors for validity and parses them into data structures that are easier to work with.

```
#include <optionparser.h>
```

Classes

- struct `Action`
- class `StoreOptionAction`

Public Member Functions

- [Parser](#) ()
Creates a new [Parser](#).
- [Parser](#) (bool gnu, const [Descriptor](#) usage[], int argc, const char **argv, [Option](#) options[], [Option](#) buffer[], int min_abbr_len=0, bool single_minus_longopt=false, int bufmax=-1)
Creates a new [Parser](#) and immediately parses the given argument vector.
- [Parser](#) (bool gnu, const [Descriptor](#) usage[], int argc, char **argv, [Option](#) options[], [Option](#) buffer[], int min_abbr_len=0, bool single_minus_longopt=false, int bufmax=-1)
[Parser](#)(...) with non-const argv.
- [Parser](#) (const [Descriptor](#) usage[], int argc, const char **argv, [Option](#) options[], [Option](#) buffer[], int min_abbr_len=0, bool single_minus_longopt=false, int bufmax=-1)
POSIX [Parser](#)(...) (gnu==false).
- [Parser](#) (const [Descriptor](#) usage[], int argc, char **argv, [Option](#) options[], [Option](#) buffer[], int min_abbr_len=0, bool single_minus_longopt=false, int bufmax=-1)
POSIX [Parser](#)(...) (gnu==false) with non-const argv.
- void [parse](#) (bool gnu, const [Descriptor](#) usage[], int argc, const char **argv, [Option](#) options[], [Option](#) buffer[], int min_abbr_len=0, bool single_minus_longopt=false, int bufmax=-1)
Parses the given argument vector.
- void [parse](#) (bool gnu, const [Descriptor](#) usage[], int argc, char **argv, [Option](#) options[], [Option](#) buffer[], int min_abbr_len=0, bool single_minus_longopt=false, int bufmax=-1)
[parse](#)() with non-const argv.
- void [parse](#) (const [Descriptor](#) usage[], int argc, const char **argv, [Option](#) options[], [Option](#) buffer[], int min_abbr_len=0, bool single_minus_longopt=false, int bufmax=-1)
POSIX [parse](#)() (gnu==false).
- void [parse](#) (const [Descriptor](#) usage[], int argc, char **argv, [Option](#) options[], [Option](#) buffer[], int min_abbr_len=0, bool single_minus_longopt=false, int bufmax=-1)
POSIX [parse](#)() (gnu==false) with non-const argv.
- int [optionsCount](#) ()
Returns the number of valid [Option](#) objects in `buffer[]`.
- int [nonOptionsCount](#) ()
Returns the number of non-option arguments that remained at the end of the most recent [parse](#)() that actually encountered non-option arguments.
- const char ** [nonOptions](#) ()
Returns a pointer to an array of non-option arguments (only valid if `nonOptionsCount()` > 0).
- const char * [nonOption](#) (int i)
Returns `nonOptions()` [i] (without checking if i is in range!).
- bool [error](#) ()
Returns `true` if an unrecoverable error occurred while parsing options.

Friends

- struct [Stats](#)

5.17.1 Detailed Description

Checks argument vectors for validity and parses them into data structures that are easier to work with.

Example:

```
int main(int argc, char* argv[])
{
    argc--=(argc>0); argv+=(argc>0); // skip program name argv[0] if present
    option::Stats stats(usage, argc, argv);
```

```

option::Option options[stats.options_max], buffer[stats.buffer_max];
option::Parser parse(usage, argc, argv, options, buffer);

if (parse.error())
    return 1;

if (options[HELP])
    ...

```

5.17.2 Constructor & Destructor Documentation

5.17.2.1 `xmem::config::third_party::Parser::Parser (bool gnu, const Descriptor usage[], int argc, const char ** argv, Option options[], Option buffer[], int min_abbr_len = 0, bool single_minus_longopt = false, int bufmax = -1) [inline]`

Creates a new [Parser](#) and immediately parses the given argument vector.

Parameters

| | |
|-----------------------------|---|
| <i>gnu</i> | if true, parse() will not stop at the first non-option argument. Instead it will reorder arguments so that all non-options are at the end. This is the default behaviour of GNU getopt() but is not conforming to POSIX. Note, that once the argument vector has been reordered, the <i>gnu</i> flag will have no further effect on this argument vector. So it is enough to pass <i>gnu==true</i> when creating Stats . |
| <i>usage</i> | Array of Descriptor objects that describe the options to support. The last entry of this array must have 0 in all fields. |
| <i>argc</i> | The number of elements from <i>argv</i> that are to be parsed. If you pass -1, the number will be determined automatically. In that case the <i>argv</i> list must end with a NULL pointer. |
| <i>argv</i> | The arguments to be parsed. If you pass -1 as <i>argc</i> the last pointer in the <i>argv</i> list must be NULL to mark the end. |
| <i>options</i> | Each entry is the first element of a linked list of Options. Each new option that is parsed will be appended to the list specified by that Option 's Descriptor::index . If an entry is not yet used (i.e. the Option is invalid), it will be replaced rather than appended to. The minimum length of this array is the greatest Descriptor::index value that occurs in <i>usage</i> PLUS ONE. |
| <i>buffer</i> | Each argument that is successfully parsed (including unknown arguments, if they have a Descriptor whose CheckArg does not return ARG_ILLEGAL) will be stored in this array. parse() scans the array for the first invalid entry and begins writing at that index. You can pass <i>bufmax</i> to limit the number of options stored. |
| <i>min_abbr_len</i> | Passing a value <i>min_abbr_len</i> > 0 enables abbreviated long options. The parser will match a prefix of a long option as if it was the full long option (e.g. -foob=10 will be interpreted as if it was -foobar=10), as long as the prefix has at least <i>min_abbr_len</i> characters (not counting the -) and is unambiguous. Be careful if combining <i>min_abbr_len</i> =1 with <i>single_minus_longopt</i> =true because the ambiguity check does not consider short options and abbreviated single minus long options will take precedence over short options. |
| <i>single_minus_longopt</i> | Passing true for this option allows long options to begin with a single minus. The double minus form will still be recognized. Note that single minus long options take precedence over short options and short option groups. E.g. -file would be interpreted as -file and not as -f -i -l -e (assuming a long option named "file" exists). |
| <i>bufmax</i> | The greatest index in the <i>buffer</i> [] array that parse() will write to is <i>bufmax</i> -1. If there are more options, they will be processed (in particular their CheckArg will be called) but not stored. If you used Stats::buffer_max to dimension this array, you can pass -1 (or not pass <i>bufmax</i> at all) which tells parse() that the buffer is "large enough". |

Attention

Remember that `options` and `buffer` store [Option objects](#), not pointers. Therefore it is not possible for the same object to be in both arrays. For those options that are found in both `buffer[]` and `options[]` the respective objects are independent copies. And only the objects in `options[]` are properly linked via [Option::next\(\)](#) and [Option::prev\(\)](#). You can iterate over `buffer[]` to process all options in the order they appear in the argument vector, but if you want access to the other Options with the same [Descriptor::index](#), then you *must* access the linked list via `options[]`. You can get the linked list in options from a buffer object via something like `options[buffer[i].index()]`.

5.17.3 Member Function Documentation**5.17.3.1 `bool xmem::config::third_party::Parser::error () [inline]`**

Returns `true` if an unrecoverable error occurred while parsing options.

An illegal argument to an option (i.e. `CheckArg` returns `ARG_ILLEGAL`) is an unrecoverable error that aborts the parse. Unknown options are only an error if their `CheckArg` function returns `ARG_ILLEGAL`. Otherwise they are collected. In that case if you want to exit the program if either an illegal argument or an unknown option has been passed, use code like this

```
if (parser.error() || options[UNKNOWN])
    exit(1);
```

5.17.3.2 `const char xmem::config::third_party::Parser::nonOptions () [inline]`**

Returns a pointer to an array of non-option arguments (only valid if [nonOptionsCount \(\)](#) > 0).

Note

- [parse\(\)](#) does not copy arguments, so this pointer points into the actual argument vector as passed to [parse\(\)](#).
- As explained at [nonOptionsCount\(\)](#) this pointer is only changed by [parse\(\)](#) calls that actually encounter non-option arguments. A [parse\(\)](#) call that encounters only options, will not change [nonOptions\(\)](#).

5.17.3.3 `int xmem::config::third_party::Parser::nonOptionsCount () [inline]`

Returns the number of non-option arguments that remained at the end of the most recent [parse\(\)](#) that actually encountered non-option arguments.

Note

A [parse\(\)](#) that does not encounter non-option arguments will leave this value as well as [nonOptions\(\)](#) undisturbed. This means you can feed the [Parser](#) a default argument vector that contains non-option arguments (e.g. a default filename). Then you feed it the actual arguments from the user. If the user has supplied at least one non-option argument, all of the non-option arguments from the default disappear and are replaced by the user's non-option arguments. However, if the user does not supply any non-option arguments the defaults will still be in effect.

5.17.3.4 `int xmem::config::third_party::Parser::optionsCount () [inline]`

Returns the number of valid [Option](#) objects in `buffer[]`.

Note

- The returned value always reflects the number of Options in the `buffer[]` array used for the most recent call to `parse()`.
- The count (and the `buffer[]`) includes unknown options if they are collected (see [Descriptor::longopt](#)).

5.17.3.5 `void xmem::config::third_party::Parser::parse (bool gnu, const Descriptor usage[], int argc, const char ** argv, Option options[], Option buffer[], int min_abbr_len = 0, bool single_minus_longopt = false, int bufmax = -1)`
`[inline]`

Parses the given argument vector.

Parameters

| | |
|-----------------------------|---|
| <i>gnu</i> | if true, parse() will not stop at the first non-option argument. Instead it will reorder arguments so that all non-options are at the end. This is the default behaviour of GNU <code>getopt()</code> but is not conforming to POSIX. Note, that once the argument vector has been reordered, the <code>gnu</code> flag will have no further effect on this argument vector. So it is enough to pass <code>gnu==true</code> when creating Stats . |
| <i>usage</i> | Array of Descriptor objects that describe the options to support. The last entry of this array must have 0 in all fields. |
| <i>argc</i> | The number of elements from <code>argv</code> that are to be parsed. If you pass -1, the number will be determined automatically. In that case the <code>argv</code> list must end with a NULL pointer. |
| <i>argv</i> | The arguments to be parsed. If you pass -1 as <code>argc</code> the last pointer in the <code>argv</code> list must be NULL to mark the end. |
| <i>options</i> | Each entry is the first element of a linked list of Options. Each new option that is parsed will be appended to the list specified by that Option's Descriptor::index . If an entry is not yet used (i.e. the Option is invalid), it will be replaced rather than appended to. The minimum length of this array is the greatest Descriptor::index value that occurs in <code>usage</code> PLUS ONE. |
| <i>buffer</i> | Each argument that is successfully parsed (including unknown arguments, if they have a Descriptor whose <code>CheckArg</code> does not return <code>ARG_ILLEGAL</code>) will be stored in this array. parse() scans the array for the first invalid entry and begins writing at that index. You can pass <code>bufmax</code> to limit the number of options stored. |
| <i>min_abbr_len</i> | Passing a value <code>min_abbr_len > 0</code> enables abbreviated long options. The parser will match a prefix of a long option as if it was the full long option (e.g. <code>-foob=10</code> will be interpreted as if it was <code>-foobar=10</code>), as long as the prefix has at least <code>min_abbr_len</code> characters (not counting the <code>-</code>) and is unambiguous. Be careful if combining <code>min_abbr_len=1</code> with <code>single_minus_longopt=true</code> because the ambiguity check does not consider short options and abbreviated single minus long options will take precedence over short options. |
| <i>single_minus_longopt</i> | Passing <code>true</code> for this option allows long options to begin with a single minus. The double minus form will still be recognized. Note that single minus long options take precedence over short options and short option groups. E.g. <code>-file</code> would be interpreted as <code>-file</code> and not as <code>-f -i -l -e</code> (assuming a long option named "file" exists). |
| <i>bufmax</i> | The greatest index in the <code>buffer[]</code> array that parse() will write to is <code>bufmax-1</code> . If there are more options, they will be processed (in particular their <code>CheckArg</code> will be called) but not stored. If you used Stats::buffer_max to dimension this array, you can pass -1 (or not pass <code>bufmax</code> at all) which tells parse() that the buffer is "large enough". |

Attention

Remember that `options` and `buffer` store [Option](#) objects, not pointers. Therefore it is not possible for the same object to be in both arrays. For those options that are found in both `buffer[]` and `options[]` the respective objects are independent copies. And only the objects in `options[]` are properly linked via [Option::next\(\)](#) and [Option::prev\(\)](#). You can iterate over `buffer[]` to process all options in the order they appear in the argument vector, but if you want access to the other Options with the same [Descriptor::index](#), then you *must*

access the linked list via `options[]`. You can get the linked list in options from a buffer object via something like `options[buffer[i].index()]`.

The documentation for this class was generated from the following file:

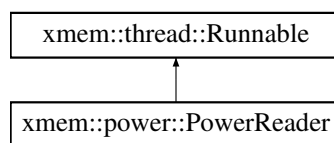
- [src/include/optionparser.h](#)

5.18 xmem::power::PowerReader Class Reference

An abstract base class for measuring power from an arbitrary source. This class is runnable using a worker thread.

```
#include <PowerReader.h>
```

Inheritance diagram for xmem::power::PowerReader:



Public Member Functions

- [PowerReader](#) (double sampling_period, double power_units, std::string name, int32_t cpu_affinity)
Constructor.
- [~PowerReader](#) ()
Destructor.
- virtual void [run](#) ()=0
Starts measuring power at the rate implied by the sampling_period passed in the constructor. Call [stop\(\)](#) to indicate to stop measuring.
- bool [stop](#) ()
Signals to stop measuring power. This is a non-blocking call and return does not indicate the measurement has actually stopped.
- bool [calculateMetrics](#) ()
Calculates the relevant metrics.
- bool [clear](#) ()
Clears the stored power data.
- bool [clear_and_reset](#) ()
Clears the stored power data and resets state so that a new thread can be used with this object.
- std::vector< double > [getPowerTrace](#) ()
Gets the power trace.
- double [getAveragePower](#) ()
Gets the average power.
- double [getPeakPower](#) ()
Gets the peak power.
- double [getLastSample](#) ()
Gets the last sample.
- double [getSamplingPeriod](#) ()
Gets the sampling period.
- double [getPowerUnits](#) ()
Gets the units of samples in watts.
- size_t [getNumSamples](#) ()

Gets the number of samples collected.

- `std::string name ()`

Gets the name of this object.

Protected Attributes

- `bool _stop_signal`
- `double _power_units`
- `std::string _name`
- `int32_t _cpu_affinity`
- `std::vector< double > _power_trace`
- `double _average_power`
- `double _peak_power`
- `size_t _num_samples`
- `double _sampling_period`

Additional Inherited Members

5.18.1 Detailed Description

An abstract base class for measuring power from an arbitrary source. This class is runnable using a worker thread.

5.18.2 Constructor & Destructor Documentation

5.18.2.1 `PowerReader::PowerReader (double sampling_period, double power_units, std::string name, int32_t cpu_affinity)`

Constructor.

Parameters

| | |
|------------------------|---|
| <i>sampling_period</i> | The time between power samples in seconds. |
| <i>power_units</i> | The power units for each sample in watts. |
| <i>name</i> | The human-friendly name of this object. |
| <i>cpu_affinity</i> | The logical CPU to be used by the thread calling this object's <code>run()</code> method. If negative, any CPU is OK (no affinity). |

5.18.3 Member Function Documentation

5.18.3.1 `bool PowerReader::calculateMetrics ()`

Calculates the relevant metrics.

Returns

True on success.

5.18.3.2 `bool PowerReader::clear ()`

Clears the stored power data.

Returns

True on success.

5.18.3.3 bool PowerReader::clear_and_reset ()

Clears the stored power data and resets state so that a new thread can be used with this object.

Returns

True on success.

5.18.3.4 double PowerReader::getAveragePower ()

Gets the average power.

Returns

The average power from the measurements. If no data was collected, returns 0.

5.18.3.5 double PowerReader::getLastSample ()

Gets the last sample.

Returns

The last power sample measured.

5.18.3.6 size_t PowerReader::getNumSamples ()

Gets the number of samples collected.

Returns

Number of samples collected.

5.18.3.7 double PowerReader::getPeakPower ()

Gets the peak power.

Returns

The peak power sample from the measurements. If no data was collected, returns 0.

5.18.3.8 std::vector< double > PowerReader::getPowerTrace ()

Gets the power trace.

Returns

The measured power trace in a vector. If no data was collected, the vector will be empty.

5.18.3.9 double PowerReader::getPowerUnits ()

Gets the units of samples in watts.

Returns

The power units for each measurement sample in watts. For example, if each measurement is in milliwatts, then this returns 1e-3.

5.18.3.10 `double PowerReader::getSamplingPeriod ()`

Gets the sampling period.

Returns

The sampling period of the measurements in seconds.

5.18.3.11 `std::string PowerReader::name ()`

Gets the name of this object.

Returns

The human-friendly name of this [PowerReader](#).

5.18.3.12 `bool PowerReader::stop ()`

Signals to stop measuring power. This is a non-blocking call and return does not indicate the measurement has actually stopped.

Returns

True if it successfully signaled a stop.

5.18.4 Member Data Documentation

5.18.4.1 `double xmem::power::PowerReader::_average_power` `[protected]`

The average power.

5.18.4.2 `int32_t xmem::power::PowerReader::_cpu_affinity` `[protected]`

CPU affinity for any thread using this object's [run\(\)](#) method. If negative, no affinity preference.

5.18.4.3 `std::string xmem::power::PowerReader::_name` `[protected]`

Name of this object.

5.18.4.4 `size_t xmem::power::PowerReader::_num_samples` `[protected]`

The number of samples collected.

5.18.4.5 `double xmem::power::PowerReader::_peak_power` `[protected]`

The peak power observed.

5.18.4.6 `std::vector<double> xmem::power::PowerReader::_power_trace` `[protected]`

The time-ordered list of power samples. The first index is the oldest measurement.

5.18.4.7 `double xmem::power::PowerReader::_power_units` `[protected]`

Power units in watts.

5.18.4.8 `double xmem::power::PowerReader::_sampling_period` `[protected]`

Power sampling period in seconds.

5.18.4.9 `bool xmem::power::PowerReader::_stop_signal` `[protected]`

When true, the `run()` function should finish after the current sample iteration it is working on.

The documentation for this class was generated from the following files:

- `src/include/PowerReader.h`
- `src/PowerReader.cpp`

5.19 xmem::config::third_party::PrintUsagelImplementation Struct Reference

Classes

- struct `FunctionWriter`
- struct `IStringWriter`
- class `LinePartlterator`
- class `LineWrapper`
- struct `OStreamWriter`
- struct `StreamWriter`
- struct `SyscallWriter`
- struct `TemporaryWriter`

Static Public Member Functions

- static void `upmax` (int &i1, int i2)
- static void `indent` (`IStringWriter` &write, int &x, int want_x)
- static bool `isWideChar` (unsigned ch)
Returns true if ch is the unicode code point of a wide character.
- static void `printUsage` (`IStringWriter` &write, const `Descriptor` usage[], int width=80, int last_column_min_percent=50, int last_column_own_line_max_percent=75)

5.19.1 Member Function Documentation

5.19.1.1 `static bool xmem::config::third_party::PrintUsagelImplementation::isWideChar (unsigned ch)` `[inline]`,
`[static]`

Returns true if ch is the unicode code point of a wide character.

Note

The following character ranges are treated as wide

```
1100..115F
2329..232A (just 2 characters!)
2E80..A4C6 except for 303F
A960..A97C
AC00..D7FB
F900..FAFF
FE10..FE6B
FF01..FF60
FFE0..FFE6
1B000.....
```

The documentation for this struct was generated from the following file:

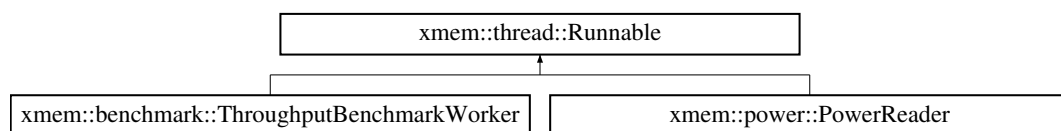
- `src/include/optionparser.h`

5.20 xmem::thread::Runnable Class Reference

A base class for any object that implements a thread-safe `run()` function for use by `Thread` objects.

```
#include <Runnable.h>
```

Inheritance diagram for `xmem::thread::Runnable`:



Public Member Functions

- `Runnable()`
Constructor.
- `~Runnable()`
Destructor.
- `virtual void run()=0`
Does some "work". Pure virtual method that any derived class must implement in a thread-safe manner.

Protected Member Functions

- `bool _acquireLock(int32_t timeout)`
Acquires the object lock to access all object state in thread-safe manner.
- `bool _releaseLock()`
Releases the object lock to access all object state in thread-safe manner.

5.20.1 Detailed Description

A base class for any object that implements a thread-safe `run()` function for use by `Thread` objects.

5.20.2 Member Function Documentation

5.20.2.1 `bool Runnable::_acquireLock(int32_t timeout)` [protected]

Acquires the object lock to access all object state in thread-safe manner.

Parameters

| | |
|----------------|---|
| <i>timeout</i> | timeout in milliseconds to acquire the lock. If 0, does not wait at all. If negative, waits indefinitely. |
|----------------|---|

Returns

true on success. If not successful, the lock was not acquired, possibly due to a timeout, or the lock might already be held.

5.20.2.2 bool Runnable::_releaseLock() [protected]

Releases the object lock to access all object state in thread-safe manner.

Returns

true on success. If not successful, the lock is either still held or the call was illegal (e.g., releasing a lock that was never acquired).

The documentation for this class was generated from the following files:

- src/include/Runnable.h
- src/Runnable.cpp

5.21 xmem::config::third_party::Stats Struct Reference

Determines the minimum lengths of the buffer and options arrays used for [Parser](#).

```
#include <optionparser.h>
```

Classes

- class [CountOptionsAction](#)

Public Member Functions

- [Stats](#) ()
Creates a [Stats](#) object with counts set to 1 (for the sentinel element).
- [Stats](#) (bool gnu, const [Descriptor](#) usage[], int argc, const char **argv, int min_abbr_len=0, bool single_minus_longopt=false)
*Creates a new [Stats](#) object and immediately updates it for the given *usage* and argument vector. You may pass 0 for *argc* and/or *argv*, if you just want to update [options_max](#).*
- [Stats](#) (bool gnu, const [Descriptor](#) usage[], int argc, char **argv, int min_abbr_len=0, bool single_minus_longopt=false)
[Stats](#)(...) with non-const argv.
- [Stats](#) (const [Descriptor](#) usage[], int argc, const char **argv, int min_abbr_len=0, bool single_minus_longopt=false)
POSIX [Stats](#)(...) (gnu==false).
- [Stats](#) (const [Descriptor](#) usage[], int argc, char **argv, int min_abbr_len=0, bool single_minus_longopt=false)
POSIX [Stats](#)(...) (gnu==false) with non-const argv.
- void [add](#) (bool gnu, const [Descriptor](#) usage[], int argc, const char **argv, int min_abbr_len=0, bool single_minus_longopt=false)

Updates this [Stats](#) object for the given `usage` and argument vector. You may pass 0 for `argc` and/or `argv`, if you just want to update `options_max`.

- void [add](#) (bool `gnu`, const [Descriptor](#) `usage`[], int `argc`, char **`argv`, int `min_abbr_len`=0, bool `single_minus_`-`longopt`=false)

[add\(\)](#) with non-const `argv`.

- void [add](#) (const [Descriptor](#) `usage`[], int `argc`, const char **`argv`, int `min_abbr_len`=0, bool `single_minus_`-`longopt`=false)

POSIX [add\(\)](#) (`gnu`==false).

- void [add](#) (const [Descriptor](#) `usage`[], int `argc`, char **`argv`, int `min_abbr_len`=0, bool `single_minus_`-`longopt`=false)

POSIX [add\(\)](#) (`gnu`==false) with non-const `argv`.

Public Attributes

- unsigned [buffer_max](#)

Number of elements needed for a `buffer`[] array to be used for [parsing](#) the same argument vectors that were fed into this [Stats](#) object.

- unsigned [options_max](#)

Number of elements needed for an `options`[] array to be used for [parsing](#) the same argument vectors that were fed into this [Stats](#) object.

5.21.1 Detailed Description

Determines the minimum lengths of the buffer and options arrays used for [Parser](#).

Because [Parser](#) doesn't use dynamic memory its output arrays have to be pre-allocated. If you don't want to use fixed size arrays (which may turn out too small, causing command line arguments to be dropped), you can use [Stats](#) to determine the correct sizes. [Stats](#) work cumulative. You can first pass in your default options and then the real options and afterwards the counts will reflect the union.

5.21.2 Constructor & Destructor Documentation

- 5.21.2.1 `xmem::config::third_party::Stats::Stats (bool gnu, const Descriptor usage[], int argc, const char ** argv, int min_abbr_len = 0, bool single_minus_longopt = false)` [[inline](#)]

Creates a new [Stats](#) object and immediately updates it for the given `usage` and argument vector. You may pass 0 for `argc` and/or `argv`, if you just want to update `options_max`.

Note

The calls to [Stats](#) methods must match the later calls to [Parser](#) methods. See [Parser::parse\(\)](#) for the meaning of the arguments.

5.21.3 Member Function Documentation

- 5.21.3.1 `void xmem::config::third_party::Stats::add (bool gnu, const Descriptor usage[], int argc, const char ** argv, int min_abbr_len = 0, bool single_minus_longopt = false)` [[inline](#)]

Updates this [Stats](#) object for the given `usage` and argument vector. You may pass 0 for `argc` and/or `argv`, if you just want to update `options_max`.

Note

The calls to [Stats](#) methods must match the later calls to [Parser](#) methods. See [Parser::parse\(\)](#) for the meaning of the arguments.

5.21.4 Member Data Documentation

5.21.4.1 unsigned xmem::config::third_party::Stats::buffer_max

Number of elements needed for a `buffer[]` array to be used for [parsing](#) the same argument vectors that were fed into this [Stats](#) object.

Note

This number is always 1 greater than the actual number needed, to give you a sentinel element.

5.21.4.2 unsigned xmem::config::third_party::Stats::options_max

Number of elements needed for an `options[]` array to be used for [parsing](#) the same argument vectors that were fed into this [Stats](#) object.

Note

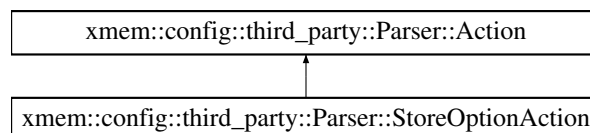
- This number is always 1 greater than the actual number needed, to give you a sentinel element.
- This number depends only on the `usage`, not the argument vectors, because the `options` array needs exactly one slot for each possible [Descriptor::index](#).

The documentation for this struct was generated from the following file:

- `src/include/optionparser.h`

5.22 xmem::config::third_party::Parser::StoreOptionAction Class Reference

Inheritance diagram for `xmem::config::third_party::Parser::StoreOptionAction`:



Public Member Functions

- [StoreOptionAction](#) ([Parser](#) &parser_, [Option](#) options[], [Option](#) buffer[], int bufmax_)
Number of slots in `buffer`. -1 means "large enough".
- bool [perform](#) ([Option](#) &option)
Called by `Parser::workhorse()` for each [Option](#) that has been successfully parsed (including unknown options if they have a [Descriptor](#) whose [Descriptor::check_arg](#) does not return `ARG_ILLEGAL`).
- bool [finished](#) (int numargs, const char **args)
Called by `Parser::workhorse()` after finishing the parse.

5.22.1 Constructor & Destructor Documentation

5.22.1.1 xmem::config::third_party::Parser::StoreOptionAction::StoreOptionAction ([Parser](#) &parser_, [Option](#) options[], [Option](#) buffer[], int bufmax_) [\[inline\]](#)

Number of slots in `buffer`. -1 means "large enough".

Creates a new `StoreOption` action.

Parameters

| | |
|-----------------|---|
| <i>parser_</i> | the parser whose op_count should be updated. |
| <i>options_</i> | each Option o is chained into the linked list <code>options_[o.desc->index]</code> |
| <i>buffer_</i> | each Option is appended to this array as long as there's a free slot. |
| <i>bufmax_</i> | number of slots in <code>buffer_</code> . -1 means "large enough". |

5.22.2 Member Function Documentation

5.22.2.1 `bool xmem::config::third_party::Parser::StoreOptionAction::finished (int numargs, const char ** args)`
`[inline],[virtual]`

Called by `Parser::workhorse()` after finishing the parse.

Parameters

| | |
|----------------|---|
| <i>numargs</i> | the number of non-option arguments remaining |
| <i>args</i> | pointer to the first remaining non-option argument (if <code>numargs > 0</code>). |

Returns

`false` iff a fatal error has occurred.

Reimplemented from [xmem::config::third_party::Parser::Action](#).

5.22.2.2 `bool xmem::config::third_party::Parser::StoreOptionAction::perform (Option &)` `[inline],[virtual]`

Called by `Parser::workhorse()` for each [Option](#) that has been successfully parsed (including unknown options if they have a [Descriptor](#) whose `Descriptor::check_arg` does not return `ARG_ILLEGAL`).

Returns `false` iff a fatal error has occurred and the parse should be aborted.

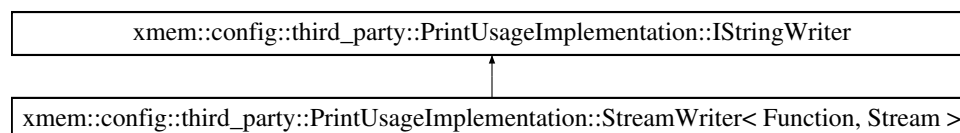
Reimplemented from [xmem::config::third_party::Parser::Action](#).

The documentation for this class was generated from the following file:

- [src/include/optionparser.h](#)

5.23 xmem::config::third_party::PrintUsageImplementation::StreamWriter< Function, Stream > Struct Template Reference

Inheritance diagram for `xmem::config::third_party::PrintUsageImplementation::StreamWriter< Function, Stream >`:



Public Member Functions

- virtual void [operator\(\)](#) (const char *str, int size)
Writes the given number of chars beginning at the given pointer somewhere.
- **StreamWriter** (Function *w, Stream *s)

Public Attributes

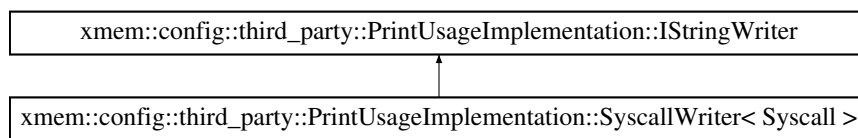
- Function * **fwrite**
- Stream * **stream**

The documentation for this struct was generated from the following file:

- [src/include/optionparser.h](#)

5.24 xmem::config::third_party::PrintUsageImplementation::SyscallWriter< Syscall > Struct Template Reference

Inheritance diagram for xmem::config::third_party::PrintUsageImplementation::SyscallWriter< Syscall >:



Public Member Functions

- virtual void [operator\(\)](#) (const char *str, int size)
Writes the given number of chars beginning at the given pointer somewhere.
- **SyscallWriter** (Syscall *w, int f)

Public Attributes

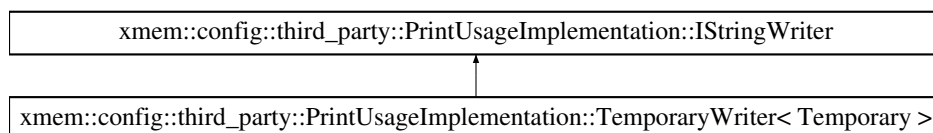
- Syscall * **write**
- int **fd**

The documentation for this struct was generated from the following file:

- [src/include/optionparser.h](#)

5.25 xmem::config::third_party::PrintUsageImplementation::TemporaryWriter< Temporary > Struct Template Reference

Inheritance diagram for xmem::config::third_party::PrintUsageImplementation::TemporaryWriter< Temporary >:



Public Member Functions

- virtual void [operator\(\)](#) (const char *str, int size)
Writes the given number of chars beginning at the given pointer somewhere.
- **TemporaryWriter** (const Temporary &u)

Public Attributes

- const Temporary & **userstream**

The documentation for this struct was generated from the following file:

- [src/include/optionparser.h](#)

5.26 xmem::thread::Thread Class Reference

a nice wrapped thread interface independent of particular OS API

```
#include <Thread.h>
```

Public Member Functions

- [Thread](#) ([Runnable](#) *target)
- [~Thread](#) ()
- bool [create_and_start](#) ()
- bool [join](#) ()
- bool [cancel](#) ()
- [int32_t](#) [getExitCode](#) ()
- bool [started](#) ()
- bool [completed](#) ()
- bool [validTarget](#) ()
- bool [created](#) ()
- bool [isThreadSuspended](#) ()
- bool [isThreadRunning](#) ()
- [Runnable](#) * [getTarget](#) ()

5.26.1 Detailed Description

a nice wrapped thread interface independent of particular OS API

5.26.2 Constructor & Destructor Documentation

5.26.2.1 Thread::Thread ([Runnable](#) * target)

Constructor. Does not actually create the real thread or run it.

Parameters

| | |
|---------------|---|
| <i>target</i> | The target object to do some work with in a new thread. |
|---------------|---|

5.26.2.2 Thread::~~Thread ()

Destructor. Immediately cancels the thread if it exists. This can be unsafe!

5.26.3 Member Function Documentation

5.26.3.1 `bool Thread::cancel ()`

Cancels the worker thread immediately. This should only be done in emergencies, as it is effectively killed and undefined behavior might occur.

Returns

true if the worker thread was successfully killed.

5.26.3.2 `bool Thread::completed ()`

Returns

true if the thread completed, regardless of the manner in which it terminated. Returns false if it has not been started.

5.26.3.3 `bool Thread::create_and_start ()`

Creates and starts the thread immediately if the target [Runnable](#) is valid. This invokes the `run()` method in the [Runnable](#) target that was passed in the constructor.

Returns

true if the thread was successfully created and started.

5.26.3.4 `bool Thread::created ()`

Returns

true if the thread has been created successfully.

5.26.3.5 `int32_t Thread::getExitCode ()`

Returns

the exit code of the worker thread if it completed. If it did not complete or has not started, returns 0.

5.26.3.6 `Runnable * Thread::getTarget ()`

Returns

a pointer to the target [Runnable](#) object

5.26.3.7 `bool Thread::isThreadRunning ()`

Returns

true if the thread is running. Returns false if the thread has not been created.

5.26.3.8 bool Thread::isThreadSuspended ()

Returns

true if the thread is suspended. Returns false if the thread has not been created.

5.26.3.9 bool Thread::join ()

Blocks the calling thread until the worker thread managed by this object terminates. For simplicity, this does not support a timeout due to pthreads incompatibility with the Windows threading API. If the worker thread has already terminated, returns immediately. If the worker has not yet started, returns immediately.

Returns

true if the worker thread terminated successfully, false otherwise.

5.26.3.10 bool Thread::started ()

Returns

true if the thread has been started, regardless if has completed or not.

5.26.3.11 bool Thread::validTarget ()

Returns

true if the [Runnable](#) target is valid.

The documentation for this class was generated from the following files:

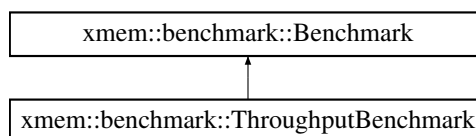
- [src/include/Thread.h](#)
- [src/Thread.cpp](#)

5.27 xmem::benchmark::ThroughputBenchmark Class Reference

A type of benchmark that measures memory throughput either via sequential, strided sequential, or random access patterns.

```
#include <ThroughputBenchmark.h>
```

Inheritance diagram for xmem::benchmark::ThroughputBenchmark:



Public Types

- typedef int32_t(* **ThroughputBenchFunction**)(void *, void *)

Public Member Functions

- [ThroughputBenchmark](#) (void *mem_array, size_t len, uint32_t iterations, xmem::common::chunk_size_t chunk_size, uint32_t cpu_node, uint32_t mem_node, uint32_t num_worker_threads, std::string name, [xmem::timers::Timer](#) *timer, std::vector< [xmem::power::PowerReader](#) * > dram_power_readers, int64_t stride_size, xmem::common::pattern_mode_t pattern_mode, xmem::common::rw_mode_t rw_mode)
Constructor.
- virtual [~ThroughputBenchmark](#) ()
Destructor.
- virtual bool [run](#) ()
Runs the benchmark.
- virtual void [report_benchmark_info](#) ()
Reports benchmark configuration details to the console.
- virtual void [report_results](#) ()
Reports results to the console.
- int64_t [getStrideSize](#) ()
Gets the stride size for this benchmark.
- xmem::common::pattern_mode_t [getPatternMode](#) ()
Gets the pattern mode for this benchmark.
- xmem::common::rw_mode_t [getRWMode](#) ()
Gets the read/write mode for this benchmark.

Additional Inherited Members

5.27.1 Detailed Description

A type of benchmark that measures memory throughput either via sequential, strided sequential, or random access patterns.

5.27.2 Constructor & Destructor Documentation

- 5.27.2.1 [ThroughputBenchmark::ThroughputBenchmark](#) (void * mem_array, size_t len, uint32_t iterations, xmem::common::chunk_size_t chunk_size, uint32_t cpu_node, uint32_t mem_node, uint32_t num_worker_threads, std::string name, xmem::timers::Timer * timer, std::vector< xmem::power::PowerReader * > dram_power_readers, int64_t stride_size, xmem::common::pattern_mode_t pattern_mode, xmem::common::rw_mode_t rw_mode)

Constructor.

Parameters

| | |
|-------------------|---|
| <i>mem_array</i> | a pointer to a contiguous chunk of memory that has been allocated for benchmarking among the worker threads. This should be aligned to a 256-bit boundary and should be the working set size times number of threads large. |
| <i>len</i> | Length of the raw_mem_array in bytes. This should be a multiple of 4 KB pages. |
| <i>iterations</i> | Number of iterations (passes) to do of the complete benchmark. |
| <i>chunk_size</i> | encoded size of an individual memory access. |
| <i>cpu_node</i> | the logical CPU NUMA node to use in the benchmark |
| <i>mem_node</i> | the logical memory NUMA node used in the benchmark |

| | |
|---------------------------|--|
| <i>num_worker_threads</i> | number of worker threads to use in the benchmark |
| <i>name</i> | name of the benchmark to use when reporting |
| <i>timer</i> | pointer to an existing Timer object |
| <i>dram_power_readers</i> | vector of pointers to PowerReader objects for measuring DRAM power |
| <i>stride_size</i> | For sequential access patterns, the stride counted in chunks. Negative values mean reverse access pattern. A stride of 1 is purely sequential. |
| <i>pattern_mode</i> | Indicates sequential or random access. |
| <i>rw_mode</i> | Indicates reads or writes. TODO: allow for a mixture |

5.27.3 Member Function Documentation

5.27.3.1 `pattern_mode_t` `ThroughputBenchmark::getPatternMode ()`

Gets the pattern mode for this benchmark.

Returns

The pattern mode enumerator.

5.27.3.2 `rw_mode_t` `ThroughputBenchmark::getRWMode ()`

Gets the read/write mode for this benchmark.

Returns

The read/write mix mode.

5.27.3.3 `int64_t` `ThroughputBenchmark::getStrideSize ()`

Gets the stride size for this benchmark.

Returns

The stride size in chunks.

5.27.3.4 `bool` `ThroughputBenchmark::run ()` `[virtual]`

Runs the benchmark.

Returns

true on success

Implements [xmem::benchmark::Benchmark](#).

The documentation for this class was generated from the following files:

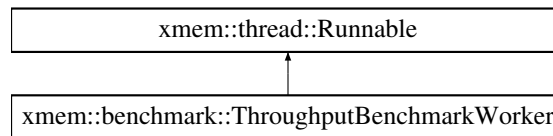
- [src/include/ThroughputBenchmark.h](#)
- [src/ThroughputBenchmark.cpp](#)

5.28 xmem::benchmark::ThroughputBenchmarkWorker Class Reference

Helper multithreading-friendly class to do the core throughput benchmark.

```
#include <ThroughputBenchmarkWorker.h>
```

Inheritance diagram for xmem::benchmark::ThroughputBenchmarkWorker:



Public Types

- typedef int32_t(* **BenchFunction**)(void *, void *)

Public Member Functions

- [ThroughputBenchmarkWorker](#) (void *mem_array, size_t len, BenchFunction bench_fptr, BenchFunction dummy_fptr, uint32_t cpu_affinity)

Constructor.

- virtual [~ThroughputBenchmarkWorker](#) ()

Destructor.

- virtual void [run](#) ()

Thread-safe worker method.

- size_t [getLen](#) ()

Gets the length of the memory region used by this worker.

- uint64_t [getBytesPerPass](#) ()

Gets the number of bytes used in each pass of the benchmark by this worker.

- uint64_t [getPasses](#) ()

Gets the number of passes for this worker.

- uint64_t [getElapsedTicks](#) ()

Gets the elapsed ticks for this worker on the core benchmark kernel.

- uint64_t [getElapsedDummyTicks](#) ()

Gets the elapsed ticks for this worker on the dummy version of the core benchmark kernel.

- uint64_t [getAdjustedTicks](#) ()

Gets the adjusted ticks for this worker. This is elapsed ticks minus elapsed dummy ticks.

- bool [hadWarning](#) ()

Indicates whether worker's results may be questionable/inaccurate/invalid.

Additional Inherited Members

5.28.1 Detailed Description

Helper multithreading-friendly class to do the core throughput benchmark.

5.28.2 Constructor & Destructor Documentation

5.28.2.1 `ThroughputBenchmarkWorker::ThroughputBenchmarkWorker (void * mem_array, size_t len, BenchFunction bench_fptr, BenchFunction dummy_fptr, uint32_t cpu_affinity)`

Constructor.

Parameters

| | |
|---------------------|---|
| <i>mem_array</i> | Pointer to the memory region to use by this worker. |
| <i>len</i> | Length of the memory region to use by this worker. |
| <i>bench_fptr</i> | Pointer to the core benchmark kernel to use. |
| <i>dummy_fptr</i> | Pointer to the dummy version of the core benchmark kernel to use. |
| <i>cpu_affinity</i> | Logical CPU identifier to lock this worker's thread to. |

5.28.3 Member Function Documentation

5.28.3.1 uint64_t ThroughputBenchmarkWorker::getAdjustedTicks ()

Gets the adjusted ticks for this worker. This is elapsed ticks minus elapsed dummy ticks.

Returns

The adjusted ticks for this worker.

5.28.3.2 uint64_t ThroughputBenchmarkWorker::getBytesPerPass ()

Gets the number of bytes used in each pass of the benchmark by this worker.

Returns

Number of bytes in each pass.

5.28.3.3 uint64_t ThroughputBenchmarkWorker::getElapsedDummyTicks ()

Gets the elapsed ticks for this worker on the dummy version of the core benchmark kernel.

Returns

The number of elapsed dummy ticks.

5.28.3.4 uint64_t ThroughputBenchmarkWorker::getElapsedTicks ()

Gets the elapsed ticks for this worker on the core benchmark kernel.

Returns

The number of elapsed ticks.

5.28.3.5 size_t ThroughputBenchmarkWorker::getLen ()

Gets the length of the memory region used by this worker.

Returns

Length of memory region in bytes.

5.28.3.6 `uint64_t ThroughputBenchmarkWorker::getPasses ()`

Gets the number of passes for this worker.

Returns

The number of passes.

5.28.3.7 `bool ThroughputBenchmarkWorker::hadWarning ()`

Indicates whether worker's results may be questionable/inaccurate/invalid.

Returns

True if the worker's results had a warning.

The documentation for this class was generated from the following files:

- [src/include/ThroughputBenchmarkWorker.h](#)
- [src/ThroughputBenchmarkWorker.cpp](#)

5.29 `xmem::timers::Timer` Class Reference

This class abstracts a simple high resolution stopwatch timer. WARNING: these objects are NOT thread safe.

```
#include <Timer.h>
```

Public Member Functions

- [Timer \(\)](#)
Constructor. This may take a noticeable amount of time.
- virtual void [start \(\)=0](#)
Starts the timer.
- virtual `uint64_t` [stop \(\)=0](#)
Stops the timer.
- double [stop_in_ns \(\)](#)
Stops the timer.
- `uint64_t` [get_ticks_per_sec \(\)](#)
Gets ticks per second for this timer.
- double [get_ns_per_tick \(\)](#)
Gets nanoseconds per tick for this timer.

Protected Attributes

- `uint64_t` [_ticks_per_sec](#)
- double [_ns_per_tick](#)

5.29.1 Detailed Description

This class abstracts a simple high resolution stopwatch timer. WARNING: these objects are NOT thread safe.

5.29.2 Member Function Documentation

5.29.2.1 `double Timer::get_ns_per_tick ()`

Gets nanoseconds per tick for this timer.

Returns

the number of nanoseconds per tick

5.29.2.2 `uint64_t Timer::get_ticks_per_sec ()`

Gets ticks per second for this timer.

Returns

The reported number of ticks per second.

5.29.2.3 `virtual uint64_t xmem::timers::Timer::stop ()` [pure virtual]

Stops the timer.

Returns

Elapsed time since last [start\(\)](#) call in ticks.

5.29.2.4 `double Timer::stop_in_ns ()`

Stops the timer.

Returns

Elapsed time since last [start\(\)](#) call in nanoseconds.

5.29.3 Member Data Documentation

5.29.3.1 `double xmem::timers::Timer::_ns_per_tick` [protected]

Nanoseconds per tick for this timer.

5.29.3.2 `uint64_t xmem::timers::Timer::_ticks_per_sec` [protected]

Ticks per second for this timer.

The documentation for this class was generated from the following files:

- [src/include/Timer.h](#)
- [src/Timer.cpp](#)

Chapter 6

File Documentation

6.1 src/Benchmark.cpp File Reference

Implementation file for the Benchmark class.

```
#include <Benchmark.h>
#include <common.h>
#include <PowerReader.h>
#include <cstdlib>
#include <iostream>
#include <vector>
```

6.1.1 Detailed Description

Implementation file for the Benchmark class.

6.2 src/benchmark_kernels.cpp File Reference

Implementation file for benchmark kernel functions for doing the actual work we care about. :)

```
#include <benchmark_kernels.h>
#include <common.h>
```

6.2.1 Detailed Description

Implementation file for benchmark kernel functions for doing the actual work we care about. :) Optimization tricks include:

- UNROLL macros to manual loop unrolling. This reduces the relative branch overhead of the loop. We don't want to benchmark loops, we want to benchmark memory! But unrolling too much can hurt code size and instruction locality, potentially decreasing I-cache utilization and causing extra overheads. This is why we allow multiple unroll lengths at compile-time.
- volatile keyword to prevent compiler from optimizing the code and removing instructions that we need. The compiler is too smart for its own good!

6.3 src/BenchmarkManager.cpp File Reference

Implementation file for the BenchmarkManager class.

```
#include <BenchmarkManager.h>
#include <common.h>
#include <stdint>
#include <stdlib.h>
#include <iostream>
#include <sstream>
#include <assert.h>
```

6.3.1 Detailed Description

Implementation file for the BenchmarkManager class.

6.4 src/common.cpp File Reference

Implementation file for common preprocessor definitions, macros, functions, and global constants.

```
#include <common.h>
#include <iostream>
```

Variables

- `size_t xmem::common::g_page_size`
- `size_t xmem::common::g_large_page_size`
- `uint32_t xmem::common::g_num_nodes`
- `uint32_t xmem::common::g_num_logical_cpus`
- `uint32_t xmem::common::g_num_physical_cpus`
- `uint32_t xmem::common::g_num_physical_packages`
- `uint32_t xmem::common::g_total_l1_caches`
- `uint32_t xmem::common::g_total_l2_caches`
- `uint32_t xmem::common::g_total_l3_caches`
- `uint32_t xmem::common::g_total_l4_caches`
- `uint32_t xmem::common::g_starting_test_index`
- `uint32_t xmem::common::g_test_index`

6.4.1 Detailed Description

Implementation file for common preprocessor definitions, macros, functions, and global constants.

6.5 src/Configurator.cpp File Reference

Implementation file for the Configurator class and some helper data structures.


```
#include <Configurator.h>
#include <common.h>
#include <optionparser.h>
#include <MyArg.h>
#include <cstdint>
#include <iostream>
#include <string>
```

6.5.1 Detailed Description

Implementation file for the Configurator class and some helper data structures.

6.6 src/include/Benchmark.h File Reference

Header file for the Benchmark class.

```
#include <common.h>
#include <Timer.h>
#include <PowerReader.h>
#include <Thread.h>
#include <Runnable.h>
#include <cstdint>
#include <string>
#include <vector>
```

Classes

- class [xmem::benchmark::Benchmark](#)
Flexible abstract class for any memory benchmark.

6.6.1 Detailed Description

Header file for the Benchmark class.

6.7 src/include/benchmark_kernels.h File Reference

Header file for benchmark kernel functions for doing the actual work we care about. :)

```
#include <cstdint>
#include <cstddef>
```

Functions

- `int32_t xmem::benchmark::benchmark_kernels::dummy_chasePointers (uintptr_t *, uintptr_t **, size_t len)`
Mimics the `__chasePointers()` method but doesn't do the memory accesses.
- `int32_t xmem::benchmark::benchmark_kernels::chasePointers (uintptr_t *first_address, uintptr_t **last_touched_address, size_t len)`
Walks over the allocated memory in random order by chasing pointers.

- `int32_t xmem::benchmark::benchmark_kernels::dummy_empty (void *, void *)`
Does nothing. Used for measuring the time it takes just to call a benchmark routine via function pointer.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwSequentialLoop_Word32 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in forward sequential Word 32 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwSequentialLoop_Word64 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in forward sequential Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwSequentialLoop_Word128 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in forward sequential Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwSequentialLoop_Word256 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in forward sequential Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revSequentialLoop_Word32 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in reverse sequential Word 32 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revSequentialLoop_Word64 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in reverse sequential Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revSequentialLoop_Word128 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in reverse sequential Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revSequentialLoop_Word256 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in reverse sequential Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride2Loop_Word32 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in forward 2-strided Word 32 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride2Loop_Word64 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in forward 2-strided Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride2Loop_Word128 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in forward 2-strided Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride2Loop_Word256 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in forward 2-strided Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride2Loop_Word32 (void *start_address, void *end_address)`
Used for measuring the time spent doing everything in reverse 2-strided Word 32 loops except for the memory access itself.

- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride2Loop_Word64` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 2-strided Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride2Loop_Word128` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 2-strided Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride2Loop_Word256` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 2-strided Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride4Loop_Word32` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 4-strided Word 32 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride4Loop_Word64` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 4-strided Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride4Loop_Word128` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 4-strided Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride4Loop_Word256` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 4-strided Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride4Loop_Word32` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 4-strided Word 32 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride4Loop_Word64` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 4-strided Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride4Loop_Word128` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 4-strided Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride4Loop_Word256` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 4-strided Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride8Loop_Word32` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 8-strided Word 32 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride8Loop_Word64` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 8-strided Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride8Loop_Word128` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 8-strided Word 128 loops except for the memory access itself.

- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride8Loop_Word256` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 8-strided Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride8Loop_Word32` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 8-strided Word 32 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride8Loop_Word64` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 8-strided Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride8Loop_Word128` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 8-strided Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride8Loop_Word256` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 8-strided Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride16Loop_Word32` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 16-strided Word 32 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride16Loop_Word64` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 16-strided Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride16Loop_Word128` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 16-strided Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_forwStride16Loop_Word256` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in forward 16-strided Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride16Loop_Word32` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 16-strided Word 32 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride16Loop_Word64` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 16-strided Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride16Loop_Word128` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 16-strided Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_revStride16Loop_Word256` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in reverse 16-strided Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_randomLoop_Word32` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in random Word 32 loops except for the memory access itself.

- `int32_t xmem::benchmark::benchmark_kernels::dummy_randomLoop_Word64` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in random Word 64 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_randomLoop_Word128` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in random Word 128 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::dummy_randomLoop_Word256` (void *start_address, void *end_address)
Used for measuring the time spent doing everything in random Word 256 loops except for the memory access itself.
- `int32_t xmem::benchmark::benchmark_kernels::forwSequentialRead_Word32` (void *start_address, void *end_address)
Walks over the allocated memory forward sequentially, reading in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwSequentialRead_Word64` (void *start_address, void *end_address)
Walks over the allocated memory forward sequentially, reading in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwSequentialRead_Word128` (void *start_address, void *end_address)
Walks over the allocated memory forward sequentially, reading in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwSequentialRead_Word256` (void *start_address, void *end_address)
Walks over the allocated memory forward sequentially, reading in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revSequentialRead_Word32` (void *start_address, void *end_address)
Walks over the allocated memory reverse sequentially, reading in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revSequentialRead_Word64` (void *start_address, void *end_address)
Walks over the allocated memory reverse sequentially, reading in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revSequentialRead_Word128` (void *start_address, void *end_address)
Walks over the allocated memory reverse sequentially, reading in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revSequentialRead_Word256` (void *start_address, void *end_address)
Walks over the allocated memory reverse sequentially, reading in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwSequentialWrite_Word32` (void *start_address, void *end_address)
Walks over the allocated memory forward sequentially, writing in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwSequentialWrite_Word64` (void *start_address, void *end_address)
Walks over the allocated memory forward sequentially, writing in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwSequentialWrite_Word128` (void *start_address, void *end_address)
Walks over the allocated memory forward sequentially, writing in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwSequentialWrite_Word256` (void *start_address, void *end_address)
Walks over the allocated memory forward sequentially, writing in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revSequentialWrite_Word32` (void *start_address, void *end_address)
Walks over the allocated memory reverse sequentially, writing in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revSequentialWrite_Word64` (void *start_address, void *end_address)
Walks over the allocated memory reverse sequentially, writing in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revSequentialWrite_Word128` (void *start_address, void *end_address)

Walks over the allocated memory reverse sequentially, writing in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revSequentialWrite_Word256` (void *start_address, void *end_address)

Walks over the allocated memory reverse sequentially, writing in 256-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride2Read_Word32` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 2, reading in 32-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride2Read_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 2, reading in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride2Read_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 2, reading in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride2Read_Word256` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 2, reading in 256-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride2Read_Word32` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 2, reading in 32-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride2Read_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 2, reading in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride2Read_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 2, reading in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride2Read_Word256` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 2, reading in 256-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride2Write_Word32` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 2, writing in 32-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride2Write_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 2, writing in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride2Write_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 2, writing in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride2Write_Word256` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 2, writing in 256-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride2Write_Word32` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 2, writing in 32-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride2Write_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 2, writing in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride2Write_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 2, writing in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride2Write_Word256` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 2, writing in 256-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride4Read_Word32` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 4, reading in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride4Read_Word64` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 4, reading in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride4Read_Word128` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 4, reading in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride4Read_Word256` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 4, reading in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride4Read_Word32` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 4, reading in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride4Read_Word64` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 4, reading in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride4Read_Word128` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 4, reading in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride4Read_Word256` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 4, reading in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride4Write_Word32` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 4, writing in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride4Write_Word64` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 4, writing in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride4Write_Word128` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 4, writing in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride4Write_Word256` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 4, writing in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride4Write_Word32` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 4, writing in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride4Write_Word64` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 4, writing in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride4Write_Word128` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 4, writing in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride4Write_Word256` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 4, writing in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride8Read_Word32` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 8, reading in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride8Read_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 8, reading in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride8Read_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 8, reading in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride8Read_Word256` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 8, reading in 256-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride8Read_Word32` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 8, reading in 32-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride8Read_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 8, reading in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride8Read_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 8, reading in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride8Read_Word256` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 8, reading in 256-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride8Write_Word32` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 8, writing in 32-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride8Write_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 8, writing in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride8Write_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 8, writing in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride8Write_Word256` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 8, writing in 256-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride8Write_Word32` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 8, writing in 32-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride8Write_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 8, writing in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride8Write_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 8, writing in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::revStride8Write_Word256` (void *start_address, void *end_address)

Walks over the allocated memory in reverse strides of size 8, writing in 256-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride16Read_Word32` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 16, reading in 32-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride16Read_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 16, reading in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride16Read_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in forward strides of size 16, reading in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::forwStride16Read_Word256` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 16, reading in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride16Read_Word32` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 16, reading in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride16Read_Word64` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 16, reading in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride16Read_Word128` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 16, reading in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride16Read_Word256` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 16, reading in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride16Write_Word32` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 16, writing in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride16Write_Word64` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 16, writing in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride16Write_Word128` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 16, writing in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::forwStride16Write_Word256` (void *start_address, void *end_address)
Walks over the allocated memory in forward strides of size 16, writing in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride16Write_Word32` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 16, writing in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride16Write_Word64` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 16, writing in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride16Write_Word128` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 16, writing in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::revStride16Write_Word256` (void *start_address, void *end_address)
Walks over the allocated memory in reverse strides of size 16, writing in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::randomRead_Word32` (void *start_address, void *end_address)
Walks over the allocated memory in random order, reading in 32-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::randomRead_Word64` (void *start_address, void *end_address)
Walks over the allocated memory in random order, reading in 64-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::randomRead_Word128` (void *start_address, void *end_address)
Walks over the allocated memory in random order, reading in 128-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::randomRead_Word256` (void *start_address, void *end_address)
Walks over the allocated memory in random order, reading in 256-bit chunks.
- `int32_t xmem::benchmark::benchmark_kernels::randomWrite_Word32` (void *start_address, void *end_address)

Walks over the allocated memory in random order, writing in 32-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::randomWrite_Word64` (void *start_address, void *end_address)

Walks over the allocated memory in random order, writing in 64-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::randomWrite_Word128` (void *start_address, void *end_address)

Walks over the allocated memory in random order, writing in 128-bit chunks.

- `int32_t xmem::benchmark::benchmark_kernels::randomWrite_Word256` (void *start_address, void *end_address)

Walks over the allocated memory in random order, writing in 256-bit chunks.

6.7.1 Detailed Description

Header file for benchmark kernel functions for doing the actual work we care about. :)

6.8 src/include/BenchmarkManager.h File Reference

Header file for the BenchmarkManager class.

```
#include <common.h>
#include <Timer.h>
#include <PowerReader.h>
#include <Benchmark.h>
#include <ThroughputBenchmark.h>
#include <LatencyBenchmark.h>
#include <cstdint>
#include <vector>
#include <fstream>
```

Classes

- class `xmem::benchmark::BenchmarkManager`
Manages running all benchmarks at a high level.

6.8.1 Detailed Description

Header file for the BenchmarkManager class.

6.9 src/include/common.h File Reference

Header file for common preprocessor definitions, macros, functions, and global constants.

```
#include <cstdint>
#include <cstddef>
```

Macros

- `#define VERSION "1.2.02"`
- `#define KB 1024`

- `#define MB 1048576`
- `#define MB_4 4194304`
- `#define MB_16 16777216`
- `#define MB_64 67108864`
- `#define MB_256 268435456`
- `#define MB_512 536870912`
- `#define GB 1073741824`
- `#define GB_4 4294967296`
- `#define DEFAULT_PAGE_SIZE 4*KB`
- `#define DEFAULT_LARGE_PAGE_SIZE 2*MB`
- `#define DEFAULT_WORKING_SET_SIZE DEFAULT_PAGE_SIZE`
- `#define DEFAULT_NUM_NODES 0`
- `#define DEFAULT_NUM_PHYSICAL_PACKAGES 0`
- `#define DEFAULT_NUM_PHYSICAL_CPUS 0`
- `#define DEFAULT_NUM_LOGICAL_CPUS 0`
- `#define DEFAULT_NUM_L1_CACHES 0`
- `#define DEFAULT_NUM_L2_CACHES 0`
- `#define DEFAULT_NUM_L3_CACHES 0`
- `#define DEFAULT_NUM_L4_CACHES 0`
- `#define MIN_ELAPSED_TICKS 10000`
- `#define UNROLL2(x) x x`
- `#define UNROLL4(x) UNROLL2(x) UNROLL2(x)`
- `#define UNROLL8(x) UNROLL4(x) UNROLL4(x)`
- `#define UNROLL16(x) UNROLL8(x) UNROLL8(x)`
- `#define UNROLL32(x) UNROLL16(x) UNROLL16(x)`
- `#define UNROLL64(x) UNROLL32(x) UNROLL32(x)`
- `#define UNROLL128(x) UNROLL64(x) UNROLL64(x)`
- `#define UNROLL256(x) UNROLL128(x) UNROLL128(x)`
- `#define UNROLL512(x) UNROLL256(x) UNROLL256(x)`
- `#define UNROLL1024(x) UNROLL512(x) UNROLL512(x)`
- `#define UNROLL2048(x) UNROLL1024(x) UNROLL1024(x)`
- `#define UNROLL4096(x) UNROLL2048(x) UNROLL2048(x)`
- `#define UNROLL8192(x) UNROLL4096(x) UNROLL4096(x)`
- `#define UNROLL16384(x) UNROLL8192(x) UNROLL8192(x)`
- `#define UNROLL32768(x) UNROLL16384(x) UNROLL16384(x)`
- `#define UNROLL65536(x) UNROLL32768(x) UNROLL32768(x)`
- `#define LATENCY_BENCHMARK_UNROLL_LENGTH 512`
- `#define VERBOSE`
- `#define USE_ALL_NUMA_NODES`
- `#define MULTITHREADING_ENABLE`
- `#define USE_TSC_TIMER`
- `#define USE_TIME_BASED_BENCHMARKS`
- `#define BENCHMARK_DURATION_SEC 4`
- `#define THROUGHPUT_BENCHMARK_BYTES_PER_PASS 4096`
- `#define USE_CHUNK_32b`
- `#define USE_THROUGHPUT_SEQUENTIAL_PATTERN`
- `#define USE_THROUGHPUT_FORW_STRIDE_1`
- `#define USE_THROUGHPUT_FORW_STRIDE_2`
- `#define USE_THROUGHPUT_FORW_STRIDE_4`
- `#define USE_THROUGHPUT_FORW_STRIDE_8`
- `#define USE_THROUGHPUT_FORW_STRIDE_16`
- `#define USE_THROUGHPUT_REV_STRIDE_1`
- `#define USE_THROUGHPUT_REV_STRIDE_2`
- `#define USE_THROUGHPUT_REV_STRIDE_4`
- `#define USE_THROUGHPUT_REV_STRIDE_8`

- `#define USE_THROUGHPUT_REV_STRIDE_16`
- `#define USE_THROUGHPUT_READS`
- `#define USE_THROUGHPUT_WRITES`
- `#define USE_LATENCY_BENCHMARK_RANDOM_SHUFFLE_PATTERN`
- `#define POWER_SAMPLING_PERIOD_SEC 1`

Typedefs

- `typedef uint32_t xmem::common::Word32_t`

Enumerations

- `enum pattern_mode_t { SEQUENTIAL, NUM_PATTERN_MODES }`
Memory access patterns are broadly categorized by sequential or random-access.
- `enum rw_mode_t { READ, WRITE, NUM_RW_MODES }`
Memory access patterns are broadly categorized by reads and writes.
- `enum chunk_size_t { CHUNK_32b, NUM_CHUNK_SIZES }`
Legal memory read/write chunk sizes in bits.

Functions

- `void xmem::common::print_welcome_message ()`
Prints a basic welcome message to the console with useful information.
- `void xmem::common::print_types_report ()`
Prints the various C/C++ types to the console for this machine.
- `void xmem::common::print_compile_time_options ()`
Prints compile-time option information to the console.
- `void xmem::common::test_timers ()`
Tests any enabled timers and outputs results to the console for sanity checking.
- `void xmem::common::test_thread_affinities ()`
Checks to see if the calling thread can be locked to all logical CPUs in the system, and reports to the console the progress.
- `bool xmem::common::lock_thread_to_numa_node (uint32_t numa_node)`
Sets the affinity of the calling thread to the lowest numbered logical CPU in the given NUMA node. TODO: Improve this functionality, it is quite limiting.
- `bool xmem::common::unlock_thread_to_numa_node ()`
Clears the affinity of the calling thread to any given NUMA node.
- `bool xmem::common::lock_thread_to_cpu (uint32_t cpu_id)`
Sets the affinity of the calling thread to a given logical CPU.
- `bool xmem::common::unlock_thread_to_cpu ()`
Clears the affinity of the calling thread to any given logical CPU.
- `int32_t xmem::common::cpu_id_in_numa_node (uint32_t numa_node, uint32_t cpu_in_node)`
Gets the CPU ID for a logical CPU of interest in a particular NUMA node. For example, if numa_node is 1 and cpu_in_node is 2, and there are 4 logical CPUs per node, then this will give the answer 6 (6th CPU), assuming CPU IDs start at 0.
- `size_t xmem::common::compute_number_of_passes (size_t working_set_size_KB)`
Computes the number of passes to use for a given working set size in KB, when size-based benchmarking mode is enabled at compile-time. You may want to change this implementation to suit your needs. See the compile-time options in [common.h](#).
- `bool xmem::common::config_page_size ()`
Queries the page sizes from the system and sets relevant global variables.
- `int32_t xmem::common::query_sys_info ()`
Sets up global variables based on system information at runtime.

6.9.1 Detailed Description

Header file for common preprocessor definitions, macros, functions, and global constants.

6.9.2 Macro Definition Documentation

6.9.2.1 `#define BENCHMARK_DURATION_SEC 4`

RECOMMENDED VALUE: At least 2. Number of seconds to run in each benchmark.

6.9.2.2 `#define DEFAULT_LARGE_PAGE_SIZE 2*MB`

Default platform large page size in bytes. This generally should not be relied on, but is a failsafe.

6.9.2.3 `#define DEFAULT_NUM_L1_CACHES 0`

Default number of L1 caches.

6.9.2.4 `#define DEFAULT_NUM_L2_CACHES 0`

Default number of L2 caches.

6.9.2.5 `#define DEFAULT_NUM_L3_CACHES 0`

Default number of L3 caches.

6.9.2.6 `#define DEFAULT_NUM_L4_CACHES 0`

Default number of L4 caches.

6.9.2.7 `#define DEFAULT_NUM_LOGICAL_CPUS 0`

Default number of logical CPU cores.

6.9.2.8 `#define DEFAULT_NUM_NODES 0`

Default number of NUMA nodes.

6.9.2.9 `#define DEFAULT_NUM_PHYSICAL_CPUS 0`

Default number of physical CPU cores.

6.9.2.10 `#define DEFAULT_NUM_PHYSICAL_PACKAGES 0`

Default number of physical packages.

6.9.2.11 `#define DEFAULT_PAGE_SIZE 4*KB`

Default platform page size in bytes. This generally should not be relied on, but is a failsafe.

6.9.2.12 #define DEFAULT_WORKING_SET_SIZE DEFAULT_PAGE_SIZE

Default working set size in bytes.

6.9.2.13 #define LATENCY_BENCHMARK_UNROLL_LENGTH 512

Number of unrolls in the latency benchmark pointer chasing core function.

6.9.2.14 #define MIN_ELAPSED_TICKS 10000

If any routine measured fewer than this number of ticks its results should be viewed with suspicion. This is because the latency of the timer itself will matter.

6.9.2.15 #define MULTITHREADING_ENABLE

RECOMMENDED ENABLED. Use multiple threads for benchmarks wherever applicable. Note that power measurement is always done with multiple threads separate from the benchmarking threads, regardless if this option is set or not.

6.9.2.16 #define POWER_SAMPLING_PERIOD_SEC 1

RECOMMENDED VALUE: 1. Sampling period in seconds for all power measurement mechanisms.

6.9.2.17 #define THROUGHPUT_BENCHMARK_BYTES_PER_PASS 4096

RECOMMENDED VALUE: 4096. Number of bytes read or written per pass of any ThroughputBenchmark. This must be less than or equal to the minimum working set size, which is currently 4 KB.

6.9.2.18 #define USE_ALL_NUMA_NODES

RECOMMENDED ENABLED. Test all NUMA node combinations for CPU and memory. If disabled, only node 0 is used for both CPU and memory.

6.9.2.19 #define USE_CHUNK_32b

RECOMMENDED DISABLED. Use 32-bit chunks.

6.9.2.20 #define USE_LATENCY_BENCHMARK_RANDOM_SHUFFLE_PATTERN

RECOMMENDED ENABLED. In latency benchmarks, generate the pointer chasing pattern using a random shuffle, which has a chance of creating small cycles. Much faster to run but strictly less correct. $O(N)$

6.9.2.21 #define USE_THROUGHPUT_FORW_STRIDE_1

RECOMMENDED ENABLED. In throughput benchmarks with sequential pattern, do forward strides of 1 chunk (forward sequential).

6.9.2.22 #define USE_THROUGHPUT_FORW_STRIDE_16

RECOMMENDED DISABLED. In throughput benchmarks with sequential pattern, do forward strides of 16 chunks.

6.9.2.23 #define USE_THROUGHPUT_FORW_STRIDE_2

RECOMMENDED DISABLED. In throughput benchmarks with sequential pattern, do forward strides of 2 chunks.

6.9.2.24 #define USE_THROUGHPUT_FORW_STRIDE_4

RECOMMENDED DISABLED. In throughput benchmarks with sequential pattern, do forward strides of 4 chunks.

6.9.2.25 #define USE_THROUGHPUT_FORW_STRIDE_8

RECOMMENDED DISABLED. In throughput benchmarks with sequential pattern, do forward strides of 8 chunks.

6.9.2.26 #define USE_THROUGHPUT_READS

RECOMMENDED ENABLED. In throughput benchmarks, read from memory.

6.9.2.27 #define USE_THROUGHPUT_REV_STRIDE_1

RECOMMENDED ENABLED. In throughput benchmarks with sequential pattern, do reverse strides of 1 chunk (reverse sequential).

6.9.2.28 #define USE_THROUGHPUT_REV_STRIDE_16

RECOMMENDED DISABLED. In throughput benchmarks with sequential pattern, do reverse strides of 16 chunks.

6.9.2.29 #define USE_THROUGHPUT_REV_STRIDE_2

RECOMMENDED DISABLED. In throughput benchmarks with sequential pattern, do reverse strides of 2 chunks.

6.9.2.30 #define USE_THROUGHPUT_REV_STRIDE_4

RECOMMENDED DISABLED. In throughput benchmarks with sequential pattern, do reverse strides of 4 chunks.

6.9.2.31 #define USE_THROUGHPUT_REV_STRIDE_8

RECOMMENDED DISABLED. In throughput benchmarks with sequential pattern, do reverse strides of 8 chunks.

6.9.2.32 #define USE_THROUGHPUT_SEQUENTIAL_PATTERN

RECOMMENDED ENABLED. Run the sequential family pattern of ThroughputBenchmarks.

6.9.2.33 #define USE_THROUGHPUT_WRITES

RECOMMENDED ENABLED. In throughput benchmarks, write to memory.

6.9.2.34 `#define USE_TIME_BASED_BENCHMARKS`

RECOMMENDED ENABLED. All benchmarks run for an estimated amount of time, and the figures of merit are computed based on the amount of memory accesses completed in the time limit. This mode has more consistent runtime across different machines, memory performance, and working set sizes, but may have more conservative measurements for differing levels of cache hierarchy (overestimating latency and underestimating throughput).

6.9.2.35 `#define USE_TSC_TIMER`

RECOMMENDED DISABLED. Use the Intel Time Stamp Counter native hardware timer. Only use this if you know what you are doing.

6.9.2.36 `#define VERBOSE`

Increases console output information detail by a lot.

6.10 `src/include/Configurator.h` File Reference

Header file for the Configurator class and some helper data structures.

```
#include <common.h>
#include <optionparser.h>
#include <MyArg.h>
#include <cstdint>
#include <string>
```

Classes

- class `xmem::config::Configurator`

Handles all user input interpretation and generates the necessary flags for running benchmarks.

Enumerations

- enum `optionIndex` {
UNKNOWN, HELP, MEAS_LATENCY, MEAS_THROUGHPUT,
WORKING_SET_SIZE, ITERATIONS, BASE_TEST_INDEX, OUTPUT_FILE }

Enumerates all possible types of command-line options.

Variables

- const third_party::Descriptor `xmem::config::usage` []

Command-line option descriptors as needed by stuff in `<config/third_party/optionparser.h>`. This is basically the help message content.

6.10.1 Detailed Description

Header file for the Configurator class and some helper data structures.

6.11 src/include/ExampleArg.h File Reference

Slightly-modified third-party code related to OptionParser.

```
#include <optionparser.h>
#include <cstdint>
#include <stdio.h>
```

Classes

- class [xmem::config::third_party::ExampleArg](#)

6.11.1 Detailed Description

Slightly-modified third-party code related to OptionParser.

6.12 src/include/LatencyBenchmark.h File Reference

Header file for the LatencyBenchmark class.

```
#include <Benchmark.h>
#include <common.h>
#include <cstdint>
#include <string>
```

Classes

- class [xmem::benchmark::LatencyBenchmark](#)

A type of benchmark that measures memory latency via random pointer chasing. TODO: loaded latency tests.

6.12.1 Detailed Description

Header file for the LatencyBenchmark class.

6.13 src/include/MyArg.h File Reference

Extensions to third-party optionparser-related code.

```
#include <ExampleArg.h>
#include <cstdint>
#include <stdio.h>
#include <stdlib.h>
```

Classes

- class [xmem::config::third_party::MyArg](#)

6.13.1 Detailed Description

Extensions to third-party optionparser-related code.

6.14 src/include/optionparser.h File Reference

This is the only file required to use The Lean Mean C++ Option Parser. Just #include it and you're set.

Classes

- struct [xmem::config::third_party::Descriptor](#)
Describes an option, its help text (usage) and how it should be parsed.
- class [xmem::config::third_party::Option](#)
A parsed option from the command line together with its argument if it has one.
- struct [xmem::config::third_party::Arg](#)
Functions for checking the validity of option arguments.
- struct [xmem::config::third_party::Stats](#)
Determines the minimum lengths of the buffer and options arrays used for [Parser](#).
- class [xmem::config::third_party::Parser](#)
Checks argument vectors for validity and parses them into data structures that are easier to work with.
- struct [xmem::config::third_party::Parser::Action](#)
- class [xmem::config::third_party::Stats::CountOptionsAction](#)
- class [xmem::config::third_party::Parser::StoreOptionAction](#)
- struct [xmem::config::third_party::PrintUsagelImplementation](#)
- struct [xmem::config::third_party::PrintUsagelImplementation::IStringWriter](#)
- struct [xmem::config::third_party::PrintUsagelImplementation::FunctionWriter< Function >](#)
- struct [xmem::config::third_party::PrintUsagelImplementation::OStreamWriter< OStream >](#)
- struct [xmem::config::third_party::PrintUsagelImplementation::TemporaryWriter< Temporary >](#)
- struct [xmem::config::third_party::PrintUsagelImplementation::SyscallWriter< Syscall >](#)
- struct [xmem::config::third_party::PrintUsagelImplementation::StreamWriter< Function, Stream >](#)
- class [xmem::config::third_party::PrintUsagelImplementation::LinePartIterator](#)
- class [xmem::config::third_party::PrintUsagelImplementation::LineWrapper](#)

Typedefs

- typedef ArgStatus(* [xmem::config::third_party::CheckArg](#))(const Option &option, bool msg)
Signature of functions that check if an argument is valid for a certain type of option.

Enumerations

- enum ArgStatus { [xmem::config::third_party::ARG_NONE](#), [xmem::config::third_party::ARG_OK](#), [xmem::config::third_party::ARG_IGNORE](#), [xmem::config::third_party::ARG_ILLEGAL](#) }
Possible results when checking if an argument is valid for a certain option.

Functions

- `template<typename OStream >`
`void xmem::config::third_party::printUsage (OStream &prn, const Descriptor usage[], int width=80, int last_column_min_percent=50, int last_column_own_line_max_percent=75)`
Outputs a nicely formatted usage string with support for multi-column formatting and line-wrapping.
- `template<typename Function >`
`void xmem::config::third_party::printUsage (Function *prn, const Descriptor usage[], int width=80, int last_column_min_percent=50, int last_column_own_line_max_percent=75)`
- `template<typename Temporary >`
`void xmem::config::third_party::printUsage (const Temporary &prn, const Descriptor usage[], int width=80, int last_column_min_percent=50, int last_column_own_line_max_percent=75)`
- `template<typename Syscall >`
`void xmem::config::third_party::printUsage (Syscall *prn, int fd, const Descriptor usage[], int width=80, int last_column_min_percent=50, int last_column_own_line_max_percent=75)`
- `template<typename Function, typename Stream >`
`void xmem::config::third_party::printUsage (Function *prn, Stream *stream, const Descriptor usage[], int width=80, int last_column_min_percent=50, int last_column_own_line_max_percent=75)`

6.14.1 Detailed Description

This is the only file required to use The Lean Mean C++ Option Parser. Just `#include` it and you're set. The Lean Mean C++ Option Parser handles the program's command line arguments (`argc`, `argv`). It supports the short and long option formats of `getopt()`, `getopt_long()` and `getopt_long_only()` but has a more convenient interface. The following features set it apart from other option parsers:

Highlights:

- It is a header-only library. Just `#include "optionparser.h"` and you're set.
- It is freestanding. There are no dependencies whatsoever, not even the C or C++ standard library.
- It has a usage message formatter that supports column alignment and line wrapping. This aids localization because it adapts to translated strings that are shorter or longer (even if they contain Asian wide characters).
- Unlike `getopt()` and derivatives it doesn't force you to loop through options sequentially. Instead you can access options directly like this:
 - Test for presence of a switch in the argument vector:


```
if ( options[QUIET] ) ...
```
 - Evaluate `--enable-foo/--disable-foo` pair where the last one used wins:


```
if ( options[FOO].last()->type() == DISABLE ) ...
```
 - Cumulative option (`-v verbose`, `-vv more verbose`, `-vvv even more verbose`):


```
int verbosity = options[VERBOSE].count();
```
 - Iterate over all `--file=<fname>` arguments:


```
for (Option* opt = options[FILE]; opt; opt = opt->next())
    fname = opt->arg; ...
```
 - If you really want to, you can still process all arguments in order:


```
for (int i = 0; i < p.optionsCount(); ++i) {
    Option& opt = buffer[i];
    switch (opt.index()) {
        case HELP: ...
        case VERBOSE: ...
        case FILE:   fname = opt.arg; ...
        case UNKNOWN: ...
    }
}
```

Despite these features the code size remains tiny. It is smaller than `uClibc`'s GNU `getopt()` and just a couple 100 bytes larger than `uClibc`'s SUSv3 `getopt()`.

(This does not include the usage formatter, of course. But you don't have to use that.)

Download:

Tarball with examples and test programs: [optionparser-1.3.tar.gz](#)
 Just the header (this is all you really need): [optionparser.h](#)

Changelog:

Version 1.3: Compatible with Microsoft Visual C++.

Version 1.2: Added `Option::namelen` and removed the extraction of short option characters into a special buffer.

Changed `Arg::Optional` to accept arguments if they are attached rather than separate. This is what GNU `getopt()` does and how POSIX recommends utilities should interpret their arguments.

Version 1.1: Optional mode with argument reordering as done by GNU `getopt()`, so that options and non-options can be mixed. See `Parser::parse()`.

Feedback:

Send questions, bug reports, feature requests etc. to: **`optionparser-feedback (a) lists.sourceforge.net`**

Example program:

(Note: `option::*` identifiers are links that take you to their documentation.)

```
#include <iostream>
#include "optionparser.h"

enum optionIndex { UNKNOWN, HELP, PLUS };
const option::Descriptor usage[] =
{
    {UNKNOWN, 0, "", "", option::Arg::None, "USAGE: example [options]\n\n"
    "Options:" },
    {HELP, 0, "", "help", option::Arg::None, " --help \tPrint usage and exit." },
    {PLUS, 0, "p", "plus", option::Arg::None, " --plus, -p \tIncrement count." },
    {UNKNOWN, 0, "", "", option::Arg::None, "\nExamples:\n"
    " example --unknown -- --this_is_no_option\n"
    " example -unk --plus -ppp file1 file2\n" },
    {0,0,0,0,0,0}
};

int main(int argc, char* argv[])
{
    argc-= (argc>0); argv+= (argc>0); // skip program name argv[0] if present
    option::Stats stats(usage, argc, argv);
    option::Option options[stats.options_max], buffer[stats.buffer_max];
    option::Parser parse(usage, argc, argv, options, buffer);

    if (parse.error())
        return 1;

    if (options[HELP] || argc == 0) {
        option::printUsage(std::cout, usage);
        return 0;
    }

    std::cout << "--plus count: " <<
        options[PLUS].count() << "\n";

    for (option::Option* opt = options[UNKNOWN]; opt; opt = opt->next())
        std::cout << "Unknown option: " << opt->name << "\n";

    for (int i = 0; i < parse.nonOptionsCount(); ++i)
        std::cout << "Non-option #" << i << ": " << parse.nonOption(i) << "\n";
}
```

Option syntax:

- The Lean Mean C++ Option Parser follows POSIX `getopt()` conventions and supports GNU-style `getopt_long()` long options as well as Perl-style single-minus long options (`getopt_long_only()`).
- short options have the format `-X` where `X` is any character that fits in a char.
- short options can be grouped, i.e. `-X -Y` is equivalent to `-XY`.
- a short option may take an argument either separate (`-X foo`) or attached (`-Xfoo`). You can make the parser accept the additional format `-X=foo` by registering `X` as a long option (in addition to being a short option) and enabling single-minus long options.
- an argument-taking short option may be grouped if it is the last in the group, e.g. `-ABCXfoo` or `-ABCX foo` (`foo` is the argument to the `-X` option).

- a lone minus character `'-'` is not treated as an option. It is customarily used where a file name is expected to refer to stdin or stdout.
 - long options have the format `-option-name`.
 - the option-name of a long option can be anything and include any characters. Even `=` characters will work, but don't do that.
 - [optional] long options may be abbreviated as long as the abbreviation is unambiguous. You can set a minimum length for abbreviations.
 - [optional] long options may begin with a single minus. The double minus form is always accepted, too.
 - a long option may take an argument either separate (`-option arg`) or attached (`-option=arg`). In the attached form the equals sign is mandatory.
 - an empty string can be passed as an attached long option argument: `-option-name=`. Note the distinction between an empty string as argument and no argument at all.
 - an empty string is permitted as separate argument to both long and short options.
 - Arguments to both short and long options may start with a `'-'` character. E.g. `-X-X`, `-X -X` or `-long-X=-X`. If `-X` and `-long-X` take an argument, that argument will be `"-X"` in all 3 cases.
 - If using the built-in `Arg::Optional`, optional arguments must be attached.
 - the special option `-` (i.e. without a name) terminates the list of options. Everything that follows is a non-option argument, even if it starts with a `'-'` character. The `-` itself will not appear in the parse results.
 - the first argument that doesn't start with `'-'` or `'-'` and does not belong to a preceding argument-taking option, will terminate the option list and is the first non-option argument. All following command line arguments are treated as non-option arguments, even if they start with `'-'`.
- NOTE: This behaviour is mandated by POSIX, but GNU `getopt()` only honours this if it is explicitly requested (e.g. by setting `POSIXLY_CORRECT`).
- You can enable the GNU behaviour by passing `true` as first argument to e.g. `Parser::parse()`.
- Arguments that look like options (i.e. `'-'` followed by at least 1 character) but aren't, are NOT treated as non-option arguments. They are treated as unknown options and are collected into a list of unknown options for error reporting.
- This means that in order to pass a first non-option argument beginning with the minus character it is required to use the `-` special option, e.g.

```
program -x -- --strange-filename
```

In this example, `--strange-filename` is a non-option argument. If the `-` were omitted, it would be treated as an unknown option.

See `option::Descriptor::longopt` for information on how to collect unknown options.

6.15 src/include/PowerReader.h File Reference

Header file for the PowerReader class.

```
#include <common.h>
#include <Runnable.h>
#include <cstdint>
#include <vector>
#include <string>
```

Classes

- class [xmempower::PowerReader](#)

An abstract base class for measuring power from an arbitrary source. This class is runnable using a worker thread.

6.15.1 Detailed Description

Header file for the PowerReader class.

6.16 src/include/Runnable.h File Reference

Header file for the Runnable class.

```
#include <cstdint>
```

Classes

- class [xmem::thread::Runnable](#)

A base class for any object that implements a thread-safe [run\(\)](#) function for use by [Thread](#) objects.

6.16.1 Detailed Description

Header file for the Runnable class.

6.17 src/include/Thread.h File Reference

Header file for the Thread class.

```
#include <Runnable.h>  
#include <cstdint>
```

Classes

- class [xmem::thread::Thread](#)

a nice wrapped thread interface independent of particular OS API

6.17.1 Detailed Description

Header file for the Thread class.

6.18 src/include/ThroughputBenchmark.h File Reference

Header file for the ThroughputBenchmark class.

```
#include <Benchmark.h>  
#include <common.h>  
#include <cstdint>  
#include <string>
```

Classes

- class [xmem::benchmark::ThroughputBenchmark](#)

A type of benchmark that measures memory throughput either via sequential, strided sequential, or random access patterns.

6.18.1 Detailed Description

Header file for the ThroughputBenchmark class.

6.19 src/include/ThroughputBenchmarkWorker.h File Reference

Header file for the ThroughputBenchmarkWorker class.

```
#include <Runnable.h>
#include <common.h>
#include <cstdint>
```

Classes

- class [xmem::benchmark::ThroughputBenchmarkWorker](#)

Helper multithreading-friendly class to do the core throughput benchmark.

6.19.1 Detailed Description

Header file for the ThroughputBenchmarkWorker class.

6.20 src/include/Timer.h File Reference

Header file for the Timer class.

```
#include <cstdint>
```

Classes

- class [xmem::timers::Timer](#)

This class abstracts a simple high resolution stopwatch timer. WARNING: these objects are NOT thread safe.

6.20.1 Detailed Description

Header file for the Timer class.

6.21 src/include/win/QPCTimer.h File Reference

Header file for the QPCTimer class.

6.21.1 Detailed Description

Header file for the QPCTimer class.

6.22 src/include/win/win_common_third_party.h File Reference

Header file for some third-party helper code for working with Windows APIs.

6.22.1 Detailed Description

Header file for some third-party helper code for working with Windows APIs.

6.23 src/include/win/win_CPdhQuery.h File Reference

Header and implementation file for some third-party code for measuring Windows OS-exposed performance counters.

6.23.1 Detailed Description

Header and implementation file for some third-party code for measuring Windows OS-exposed performance counters.

6.24 src/include/win/WindowsDRAMPowerReader.h File Reference

Header file for the WindowsDRAMPowerReader class.

6.24.1 Detailed Description

Header file for the WindowsDRAMPowerReader class.

6.25 src/include/x86_64/TSCTimer.h File Reference

Header file for the TSCTimer class as well as some C-style functions for working with the TSC timer hardware directly.

```
#include <common.h>
```

6.25.1 Detailed Description

Header file for the TSCTimer class as well as some C-style functions for working with the TSC timer hardware directly.

6.26 src/LatencyBenchmark.cpp File Reference

Implementation file for the LatencyBenchmark class.


```
#include <LatencyBenchmark.h>
#include <common.h>
#include <benchmark_kernels.h>
#include <iostream>
#include <algorithm>
#include <random>
#include <assert.h>
#include <time.h>
```

6.26.1 Detailed Description

Implementation file for the LatencyBenchmark class.

6.27 src/main.cpp File Reference

main entry point to the tool

```
#include <common.h>
#include <Configurator.h>
#include <BenchmarkManager.h>
#include <iostream>
```

Functions

- `int main (int argc, char *argv[])`

The main entry point to the program.

6.27.1 Detailed Description

main entry point to the tool This tool is designed to measure bandwidth and latency of the memory system using several access patterns, strides, and working set sizes. The primary goal is to measure DRAM performance, although it can also measure cache performance depending on the configuration.

6.28 src/PowerReader.cpp File Reference

Implementation file for the PowerReader class.

```
#include <PowerReader.h>
#include <common.h>
#include <stdint>
#include <vector>
#include <iostream>
```

6.28.1 Detailed Description

Implementation file for the PowerReader class.

6.29 src/Runnable.cpp File Reference

Implementation file for the Runnable class.

```
#include <Runnable.h>
#include <iostream>
```

Variables

- return **false**

6.29.1 Detailed Description

Implementation file for the Runnable class.

6.30 src/Thread.cpp File Reference

Implementation file for the Thread class.

```
#include <Thread.h>
#include <stdlib.h>
#include <iostream>
```

Variables

- return **false**
- return **true**

6.30.1 Detailed Description

Implementation file for the Thread class.

6.31 src/ThroughputBenchmark.cpp File Reference

Implementation file for the ThroughputBenchmark class.

```
#include <ThroughputBenchmark.h>
#include <common.h>
#include <ThroughputBenchmarkWorker.h>
#include <benchmark_kernels.h>
#include <Thread.h>
#include <Runnable.h>
#include <iostream>
#include <algorithm>
#include <assert.h>
#include <random>
#include <time.h>
```

6.31.1 Detailed Description

Implementation file for the ThroughputBenchmark class.

6.32 src/ThroughputBenchmarkWorker.cpp File Reference

Implementation file for the ThroughputBenchmarkWorker class.

```
#include <ThroughputBenchmarkWorker.h>
#include <benchmark_kernels.h>
#include <common.h>
#include <iostream>
```

6.32.1 Detailed Description

Implementation file for the ThroughputBenchmarkWorker class.

6.33 src/Timer.cpp File Reference

Implementation file for the Timer class.

```
#include <Timer.h>
```

6.33.1 Detailed Description

Implementation file for the Timer class.

6.34 src/win/QPCTimer.cpp File Reference

Header file for the QPCTimer class.

6.34.1 Detailed Description

Header file for the QPCTimer class.

6.35 src/win/win_common_third_party.cpp File Reference

Implementation file for some third-party helper code for working with Windows APIs.

6.35.1 Detailed Description

Implementation file for some third-party helper code for working with Windows APIs.

6.36 src/win/WindowsDRAMPowerReader.cpp File Reference

Implementation file for the WindowsDRAMPowerReader class.

6.36.1 Detailed Description

Implementation file for the WindowsDRAMPowerReader class.

6.37 src/x86_64/TSCTimer.cpp File Reference

Implementation file for the TSCTimer class as well as some C-style functions for working with the TSC timer hardware directly.

```
#include <x86_64/TSCTimer.h>
```

6.37.1 Detailed Description

Implementation file for the TSCTimer class as well as some C-style functions for working with the TSC timer hardware directly.

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