

# Memory Analysis Intel® VTune™ Profiler

Heinrich Bockhorst

Durham, April 11<sup>th</sup> 2024



# Optimize Memory Access

## Memory Access Analysis - Intel® VTune™ Profiler

### Tune data structures for performance

- Attribute cache misses to data structures (not just the code causing the miss)
- Support for custom memory allocators

### Optimize NUMA latency & scalability

- True & false sharing optimization
- Auto detect max system bandwidth
- Easier tuning of inter-socket bandwidth

### Easier install, Latest processors

- No special drivers required on Linux\*

### Top Memory Objects by Latency

This section lists memory objects that introduced the highest latency to the overall application execution.

Memory Object	Total Latency	Loads	Stores	LLC Miss Count <sup>②</sup>
<a href="#">alloc_test.cpp:157 ( 30 MB )</a>	65.6%	4,239,327,176	4,475,334,256	0
<a href="#">alloc_test.cpp:135 ( 305 MB )</a>	6.8%	411,212,336	441,613,248	0
<a href="#">alloc_test.cpp:109 ( 305 MB )</a>	6.3%	439,213,176	449,613,488	0
<a href="#">alloc_test!l_data_init.436.0.6 ( 576 B )</a>	5.2%	742,422,272	676,820,304	0
<a href="#">[vmlinux]</a>	4.6%	173,605,208	116,003,480	0
[Others]	11.5%	1,533,646,008	1,674,450,232	0

\*N/A is applied to non-summable metrics.

Grouping: <span>Function / Memory Object / Allocation Stack</span>			
Function / Memory Object / Allocation Stack	Stores	LLC Miss Count ▼	
		Local DRAM Access Count	Remote DRAM Access Count
▼ <a href="#">doTriad\$omp\$parallel_for@2</a>	40,307,609,1...	2,439,273,176	2,430,472,912
▶ <a href="#">triad!c ( 152 MB )</a>	19,200,576	1,821,654,648	1,864,855,944
▶ <a href="#">triad!b ( 152 MB )</a>	10,400,312	615,218,456	560,816,824
▶ <a href="#">[Unknown]</a>	7,200,216	2,400,072	3,200,096
▶ <a href="#">triad!doTriad ( 2 MB )</a>	15,200,456	0	0
▶ <a href="#">[Stack]</a>	2,120,063,600	0	1,600,048
▶ <a href="#">triad!a ( 152 MB )</a>	38,135,544,0...	0	0
▶ <a href="#">update_blocked_averages</a>	6,400,192	2,400,072	0

# Memory Access Analysis

Intel® VTune™ Profiler

## Tune data structures for better performance

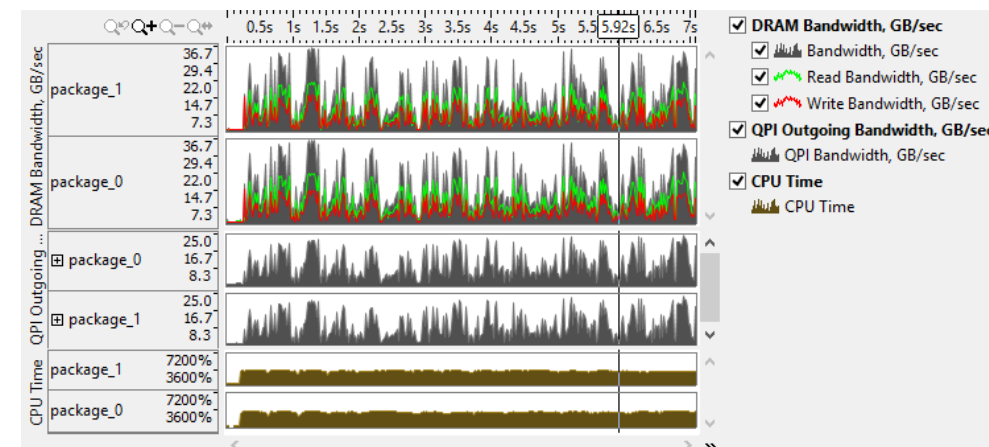
- Attribute cache misses to data structures

## Better Bandwidth Analysis for Non-Uniform Memory

- See Read & Write contributions to Total Bandwidth
- Easier tuning of multi-socket bandwidth

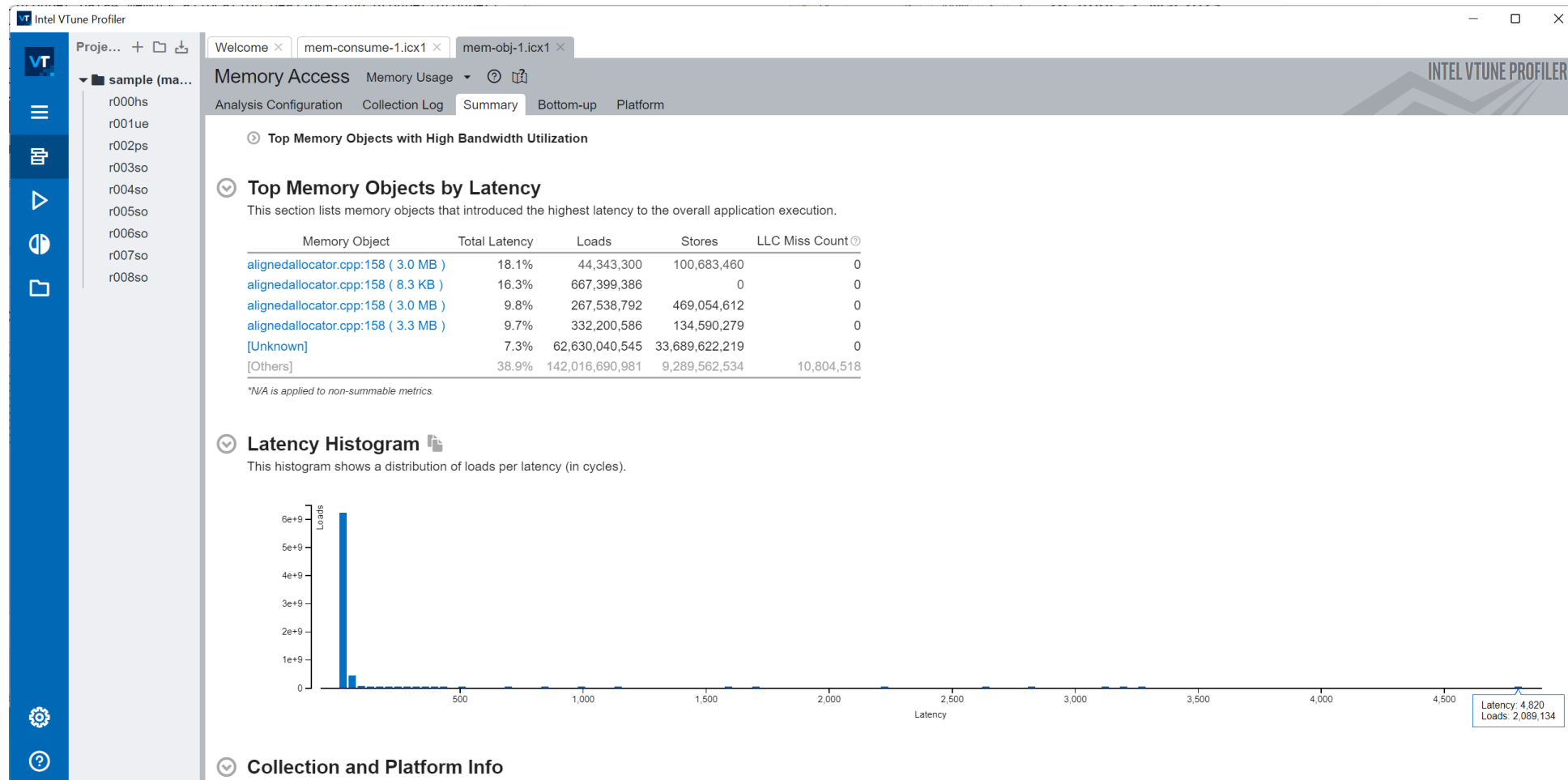
Grouping: Bandwidth Domain / Bandwidth Utilization Type / Memory Object / Allocation Stack

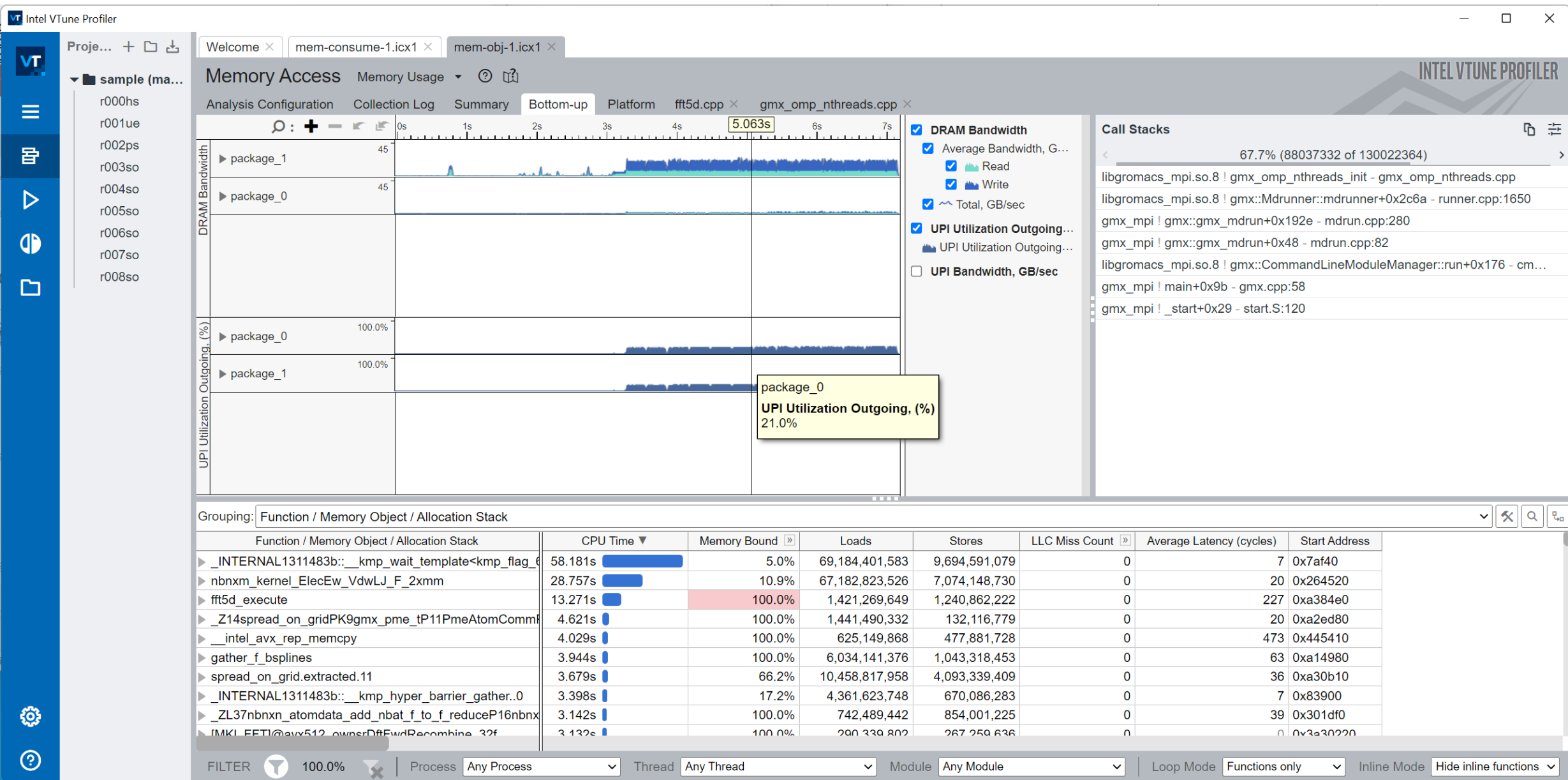
Bandwidth Domain / Bandwidth Utilization Type / Memory Object / Allocation Stack	Memory Bound	Loads	Stores	LLC Miss Count	Average Latency (cycles)
DRAM, GB/sec	0.657	125,874,377,622	16,061,040 ...	130,507,830	40
High	0.750	28,236,084,708	5,014,875, ...	75,304,518	91
+ stream.c:180 (76 MB )		900,002,700	654,009,810	18,301,098	495
+ stream.c:179 (76 MB )		1,050,003,150	667,210,008	33,301,998	487
+ stream.c:181 (76 MB )		1,434,004,302	907,213,608	20,101,206	412
Selected 1 row(s):	1.000	126,000,378	21,600,324	300,018	61



Seeing total bandwidth can suggest data blocking opportunities to change a bandwidth bound app into a compute bound app.

# Latency Histogram shows distribution





# What's Using All The Memory?

## Memory Consumption Analysis

### See What Is Allocating Memory

- Lists top memory consuming functions and objects
- View source to understand cause
- Filter by time using the memory consumption timeline

### Standard & Custom Allocators

- Recognizes libc malloc/free, memkind and jemalloc libraries
- Use custom allocators after markup with ITT Notify API

### Languages

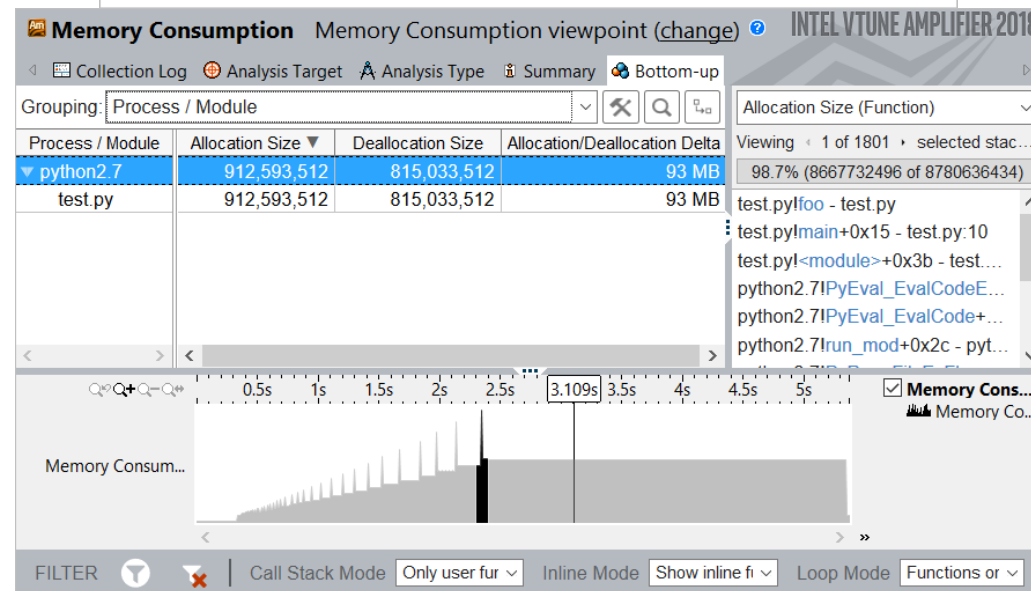
- Python\*
- Linux\*: Native C, C++, Fortran

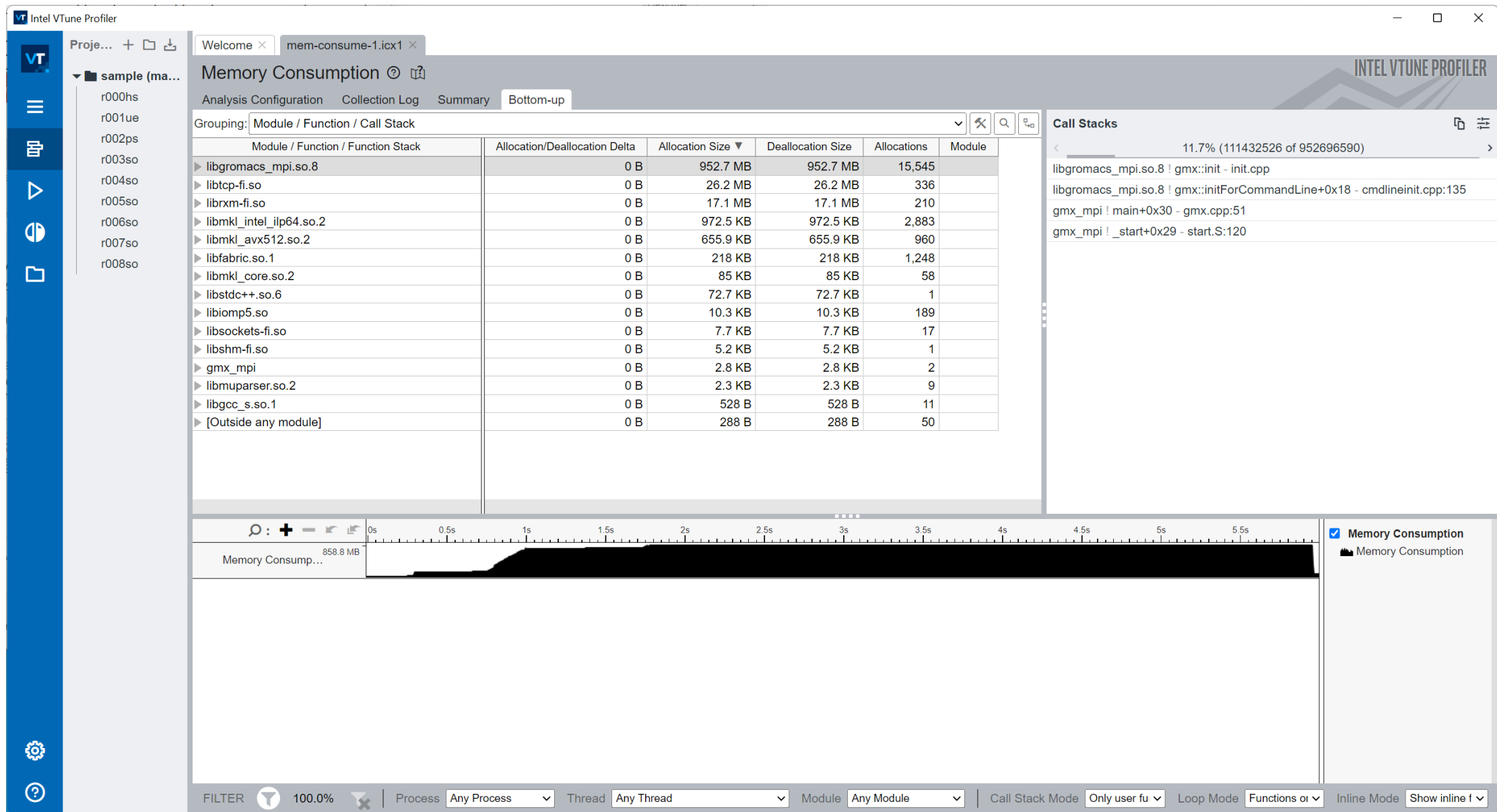
Native language support is not currently available for Windows\*

#### Top Memory-Consuming Objects

This section lists the most memory-consuming objects in your application. Optimizing these objects results in improving an overall application memory consumption.

Memory Object	Memory Consumption
dictobject.c:632 (768 B )	768 B
filedoalloc.c:120 (4 KB )	4 KB
iofopen.c:76 (568 B )	568 B
msort.c:224 (1 KB )	1 KB
dictobject.c:632 (3 KB )	3 KB
[Others]	217 TB





# Notices & Disclaimers

Intel technologies may require enabled hardware, software or service activation. Learn more at [intel.com](https://www.intel.com) or from the OEM or retailer.

Your costs and results may vary.

Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

**Optimization Notice:** Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice. Notice Revision #20110804. <https://software.intel.com/en-us/articles/optimization-notice>

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors.

Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. See backup for configuration details. For more complete information about performance and benchmark results, visit [www.intel.com/benchmarks](https://www.intel.com/benchmarks).

Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. See configuration disclosure for details. No product or component can be absolutely secure.

No license (express or implied, by estoppel or otherwise) to any intellectual property rights is granted by this document.

Intel disclaims all express and implied warranties, including without limitation, the implied warranties of merchantability, fitness for a particular purpose, and non-infringement, as well as any warranty arising from course of performance, course of dealing, or usage in trade.

© Intel Corporation. Intel, the Intel logo, and other Intel marks are trademarks of Intel Corporation or its subsidiaries. Other names and brands may be claimed as the property of others.



