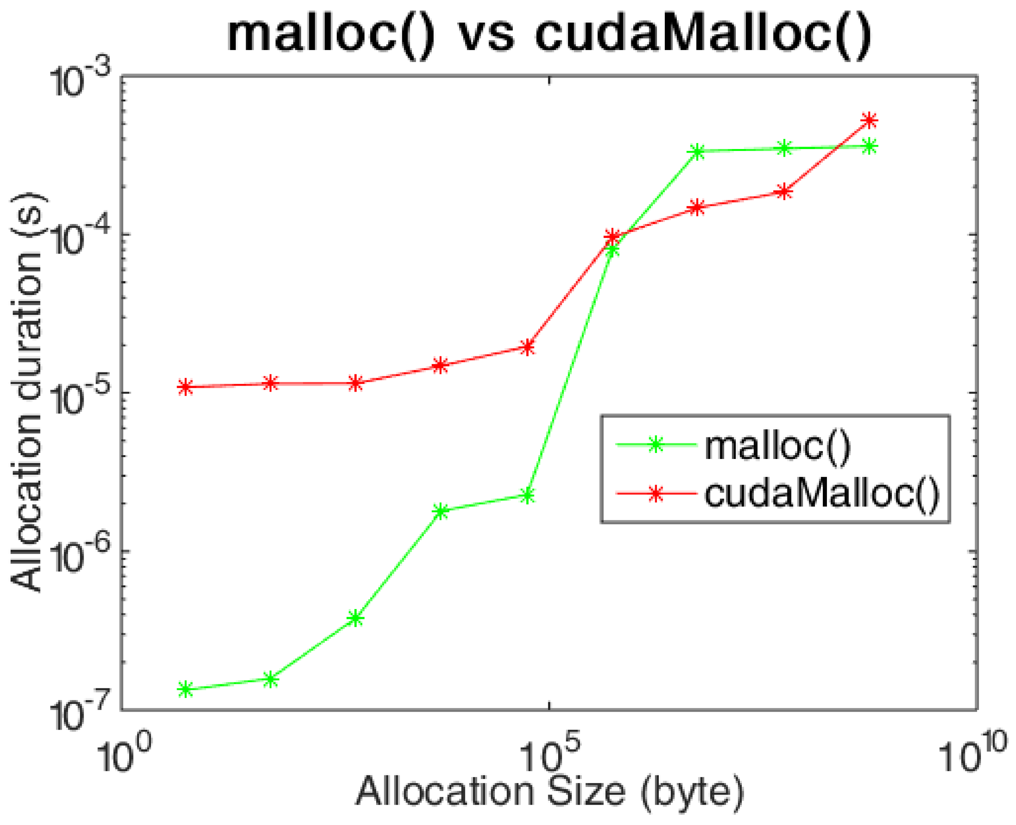
KOÇ UNIVERSITY
Computer Science and Engineering

MAM: A Memory Allocation Manager for GPUs

Can Aknesil
Computer Science and Engineering
Koç University
Istanbul, Turkey
caknesil13@ku.edu.tr

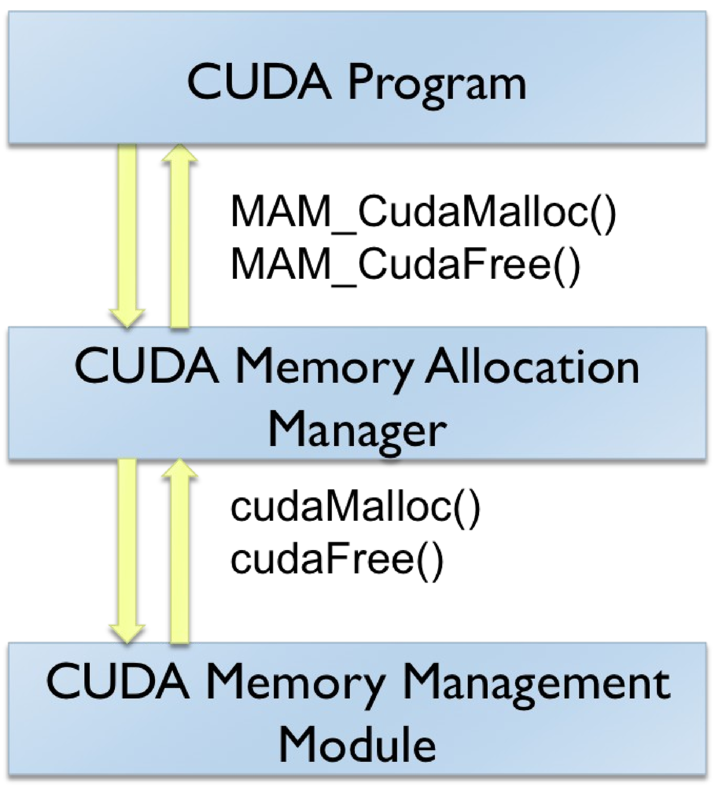
Didem Unat
Computer Science and Engineering
Koç University
Istanbul, Turkey
dunat@ku.edu.tr

Motivation



- *cudaMalloc()* is slow especially when allocation size if large.
- Applications requiring repetitive allocations may reduce the performance.
- We develop a memory management library primarily for GPUs.

What is MAM ?



- MAM is a C library that provides an abstraction layer between the programmer and the memory management module of CUDA environment.
- MAM removes the overhead of memory allocation and deallocation.

How to use MAM ?

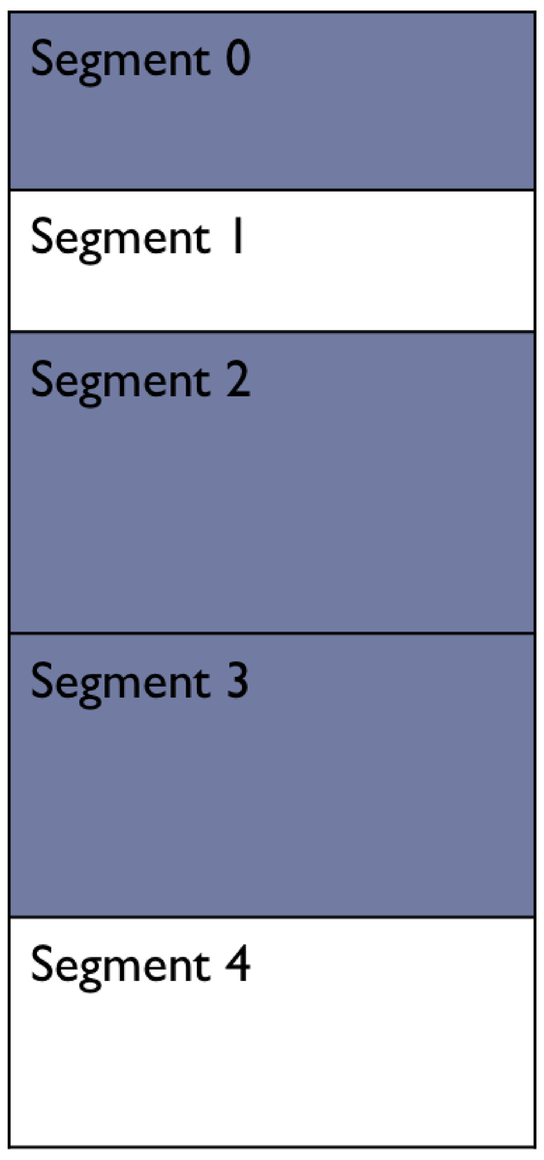
WITHOUT MAM

```
cudaMalloc(&ptr,
 size);
...
cudaFree(ptr);
```

WITH MAM

```
MAM_Create();
MAM_CudaMalloc(&ptr,
 size);
...
MAM_CudaFree(ptr);
MAM_Destroy();
```

How MAM Works ?



Blue: Segments being used
White: Empty segments

- When *MAM_Create()* is called, a large continuous **chunk** of memory is allocated on the device.
- The size of the chunk is expected to be greater than the total size of the memory that will be allocated by the CUDA program at a time instance.
- During allocation and deallocation, MAM manipulates ***segments*** of the chunk by creating and destroying them.
- Each *segment* is nothing but a small sized structure stored in the host memory.

```
struct segment {
  void *basePtr;
  size_t size;
  char isEmpty;
  /* data related to data
  structures */
};
```

Data Structures in MAM

The Pointer Tree

- Stores empty segments sorted according to their sizes.
- Red-Black Tree is used.

The Size Tree-Dictionary

- Stores empty segments sorted according to their sizes
- Red-Black Tree is used.

Allocation Algorithm

procedure ALLOCATE
  Find a best-fitting empty segment from the tree-dictionary *O(log n)*
  Mark the segment as filled *O(1)*
  if The segment perfectly fits *O(1)* **then**
    Remove segment from tree-dictionary *O(log n)*
  else
    Resize it *O(1)*
    Remove it from tree-dictionary *O(log n)*
    Create a new empty segment *O(1)*
    Insert it in pointer-tree & tree-dictionary *O(log n)*
  end if
  Return the base pointer of filled segment *O(1)*
end procedure

Deallocation Algorithm

procedure DEALLOCATE
  Find the segment in the pointer-tree *O(log n)*
  Mark the segment as empty *O(1)*
  Get previous and next segments *O(log n)*
  if the previous segment is empty *O(1)* **then**
    Remove the segment being newly emptied from pointer-tree and tree-dictionary *O(log n)*
    Destroy the segment being newly emptied *O(1)*
    Resize previous segment *O(1)*
    Replace it in tree-dictionary *O(log n)*
    Assign it to the variable stored the destroyed segment *O(log n)*
  end if
  // repeat the similar procedure for next segment.
end procedure

For both algorithms,
- Time complexity: O(log n)
- Space complexity: O(n)

where n = number of segments

Performance Results