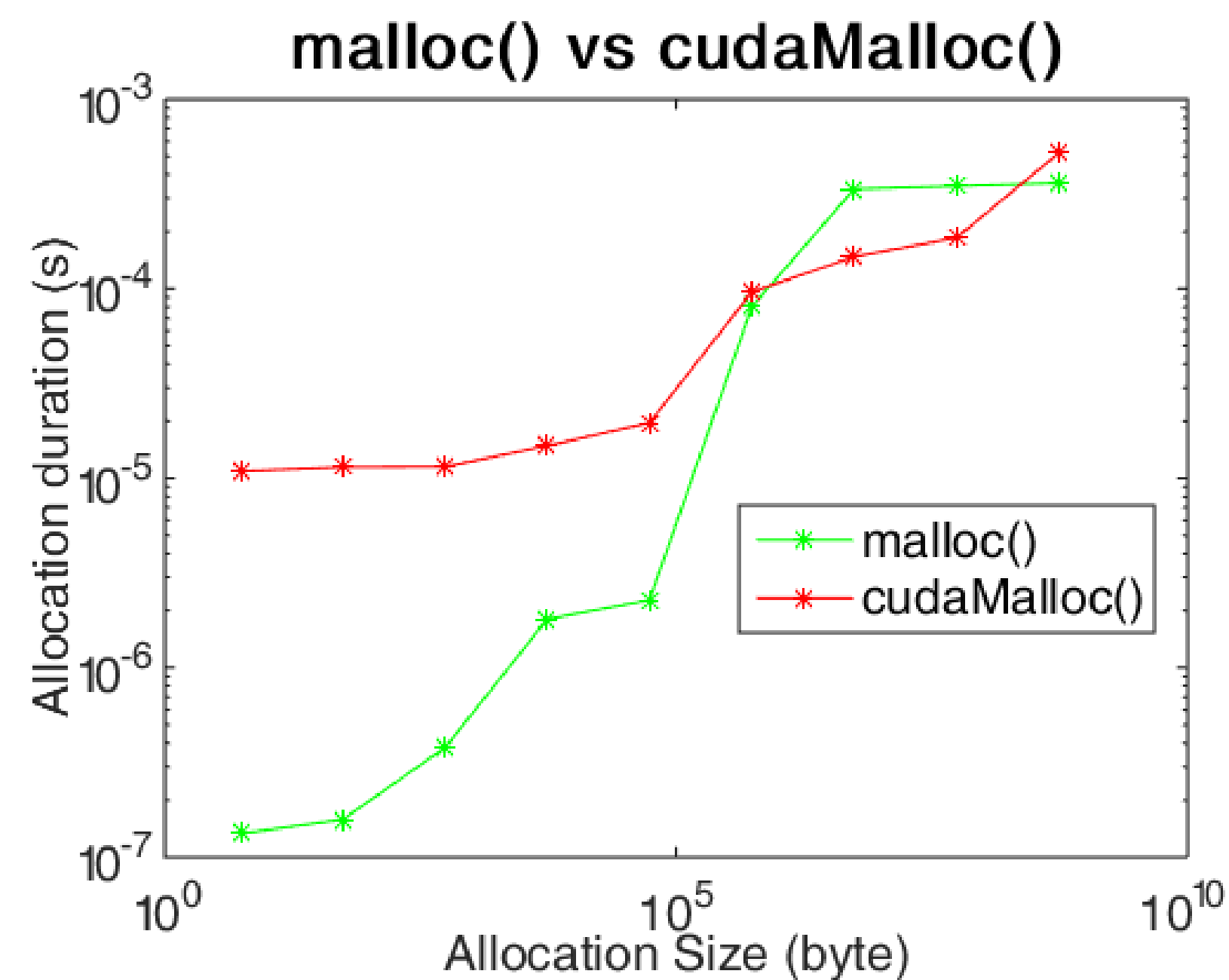


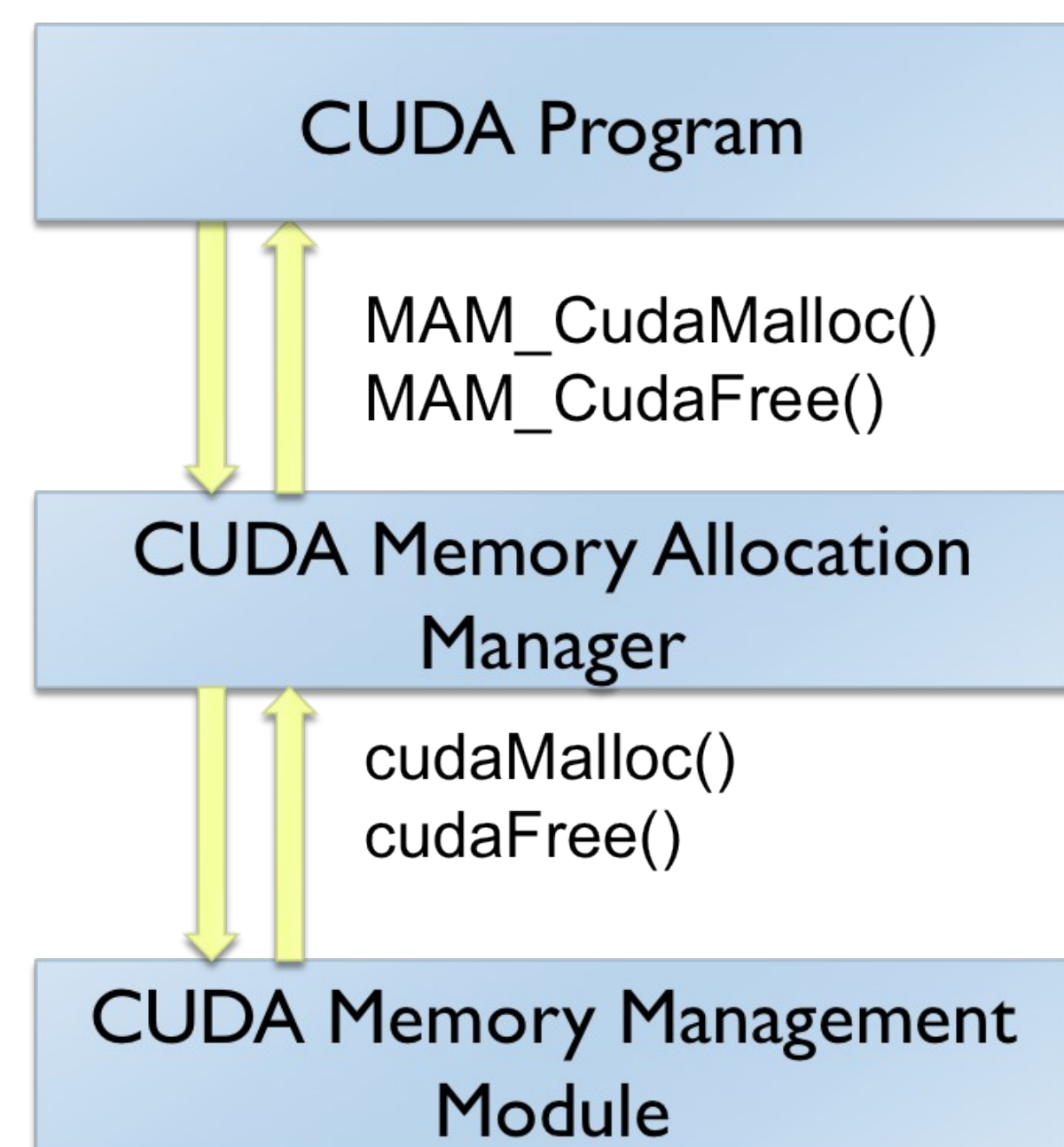
# MAM: A Memory Allocation Manager for GPUs

## Motivation



cudaMalloc() is slow especially when allocation size is 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 ?

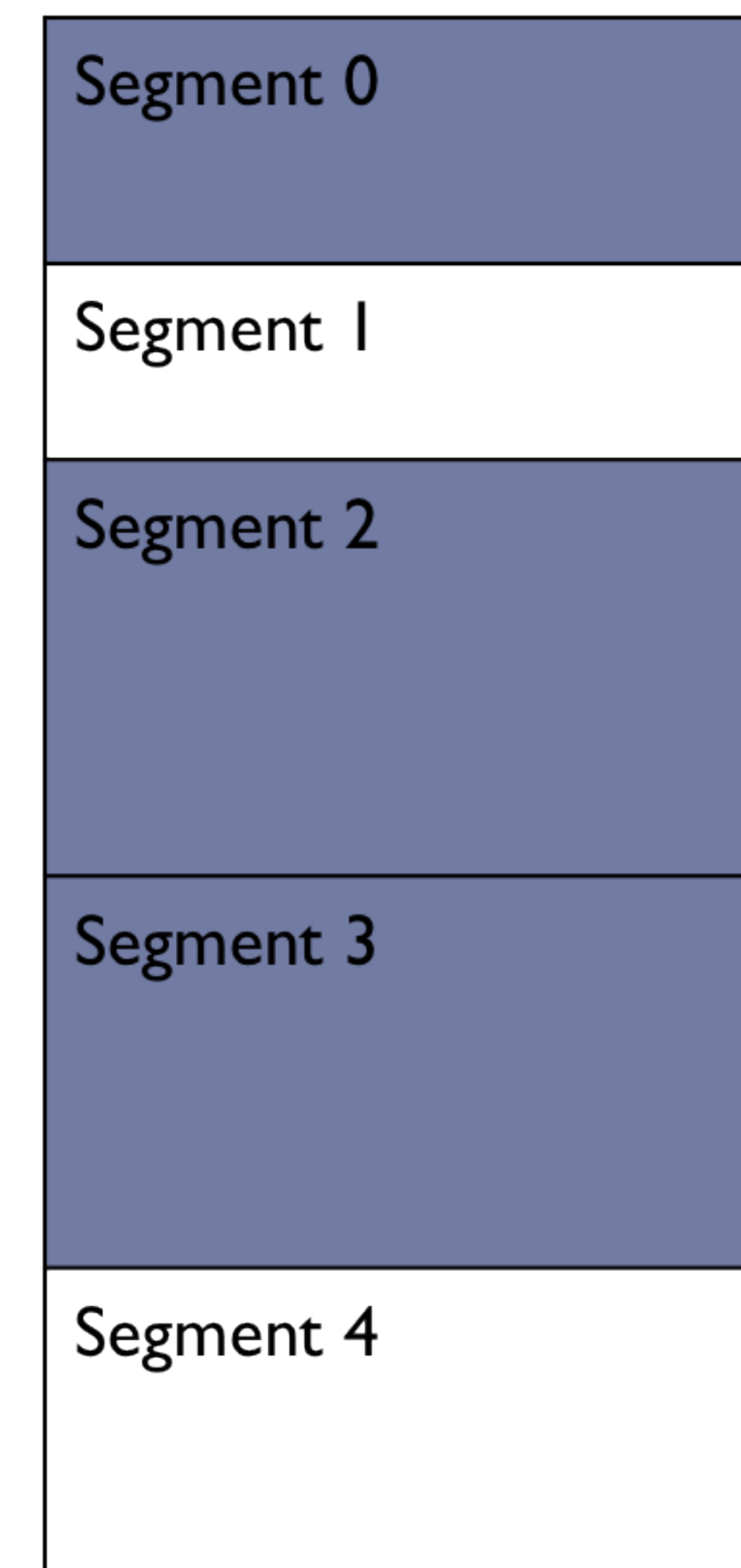
### WITHOUT MAM

```
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 */
};
```

## 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
```

## 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.

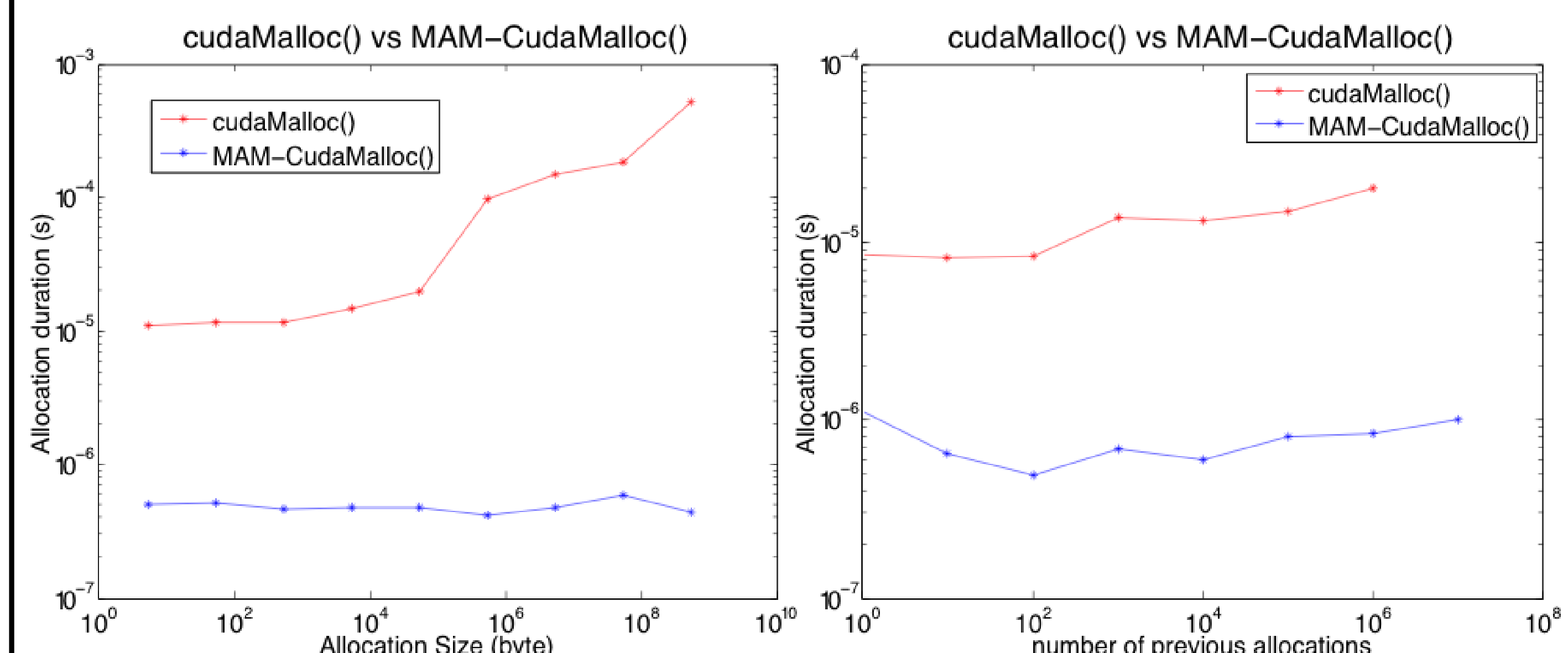
## Deallocation Algorithm

```
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



- MAM performs better in the measurement which is according to the allocation size. While the allocation duration of cudaMalloc() increases linearly, the duration of MAM\_CudaMalloc() stays constant.
- MAM performs better also in the measurement which is according to the number of previously allocated segments.