# Hardware Garbage Collection

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CSEE 4840: Embedded System Design

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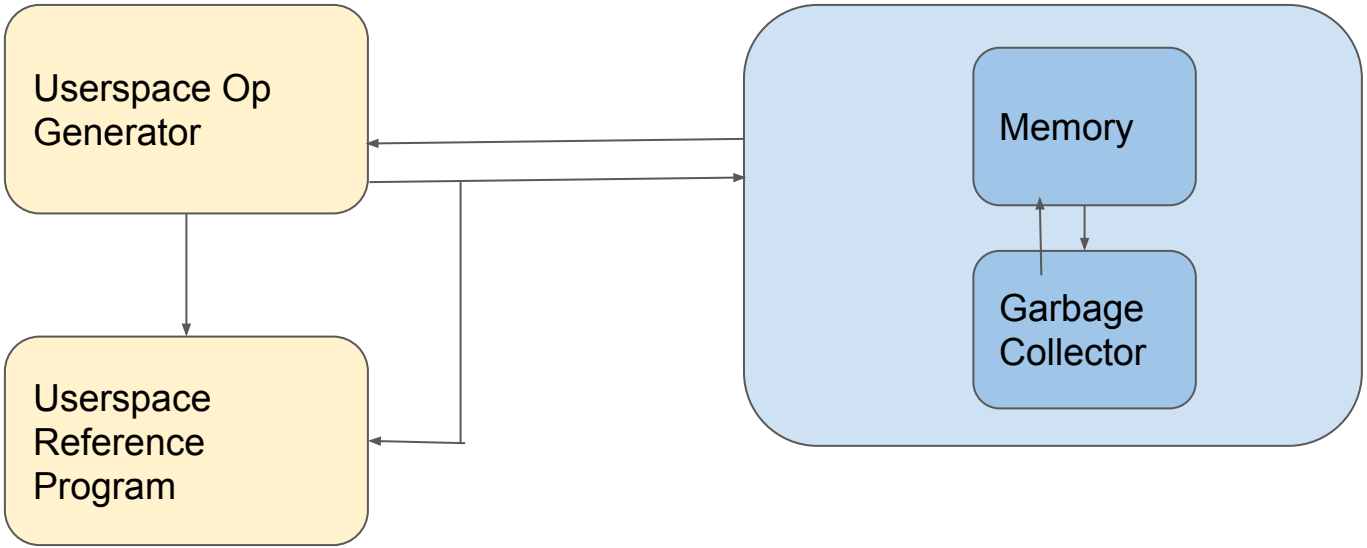
# Architecture



# Communication

Read/Write interface over Avalon bus

Hardware unit is slave device

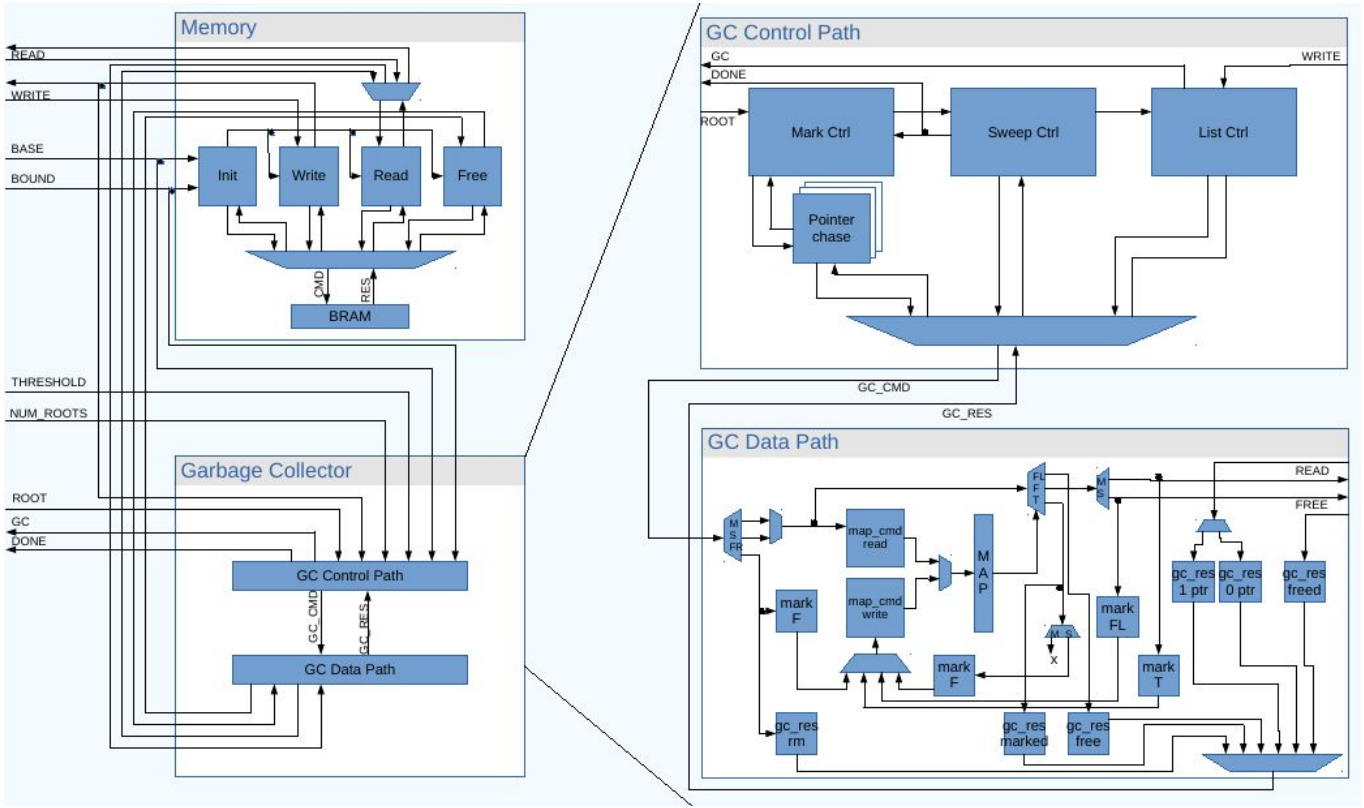
32 bit data

4 bit address

8 Addresses:

1. Status
2. Num Roots
3. Base
4. Bound
5. GC Threshold
6. Read Op/Res
7. Write Op/REs
8. BRAM

# Hardware

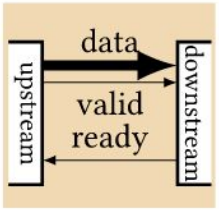

Memory
READ
WRITE
BASE
BOUND
Init
Write
Read
Free
CMD
RES
BRAM
THRESHOLD
NUM_ROOTS
ROOT
GC
DONE
Garbage Collector
GC Control Path
GC_CMD
GC_RES
GC Data Path
GC Control Path
GC
DONE
ROOT
WRITE
Mark Ctrl
Sweep Ctrl
List Ctrl
Pointer chase
GC_CMD
GC_RES
GC Data Path
READ
FREE
map_cmd read
map_cmd write
MAP
mark F
mark FL
mark F
mark T
gc_res 1 ptr
gc_res 0 ptr
gc_res freed
gc_res rm
gc_res marked
gc_res free

# Status Register

Bitmap:

- 0: Ready for read op
- 1: ready for write op
- 2: read response valid
- 3: write response valid
- 4: need gc
- 5: gc complete
- 6: ready for root input

# Handshake Protocol




| valid | ready | Meaning |
|---|---|---|
| 1 | 0 | Token valid; not consumed |
| 1 | 1 | Token transferred |
| 0 | – | No token to transfer |

Hardware expects handshake protocol

Ready signal won’t assert high for inputs until there is valid data at its input

Status register shows ready for input whenever input is consumed then holds valid input until hardware accepts token

# Software

User defined parameters:

- Memory base
- Memory bound
- GC threshold
- Num Roots
- Num Ops
- Op distribution (read/write)

Main.c

Operational loop

Polls hardware for status

Writes input ops and reads output results to hardware and reference implementation

Compares outputs and BRAM contents

# Software

Reference.c

Keeps a reference struct containing BRAM and list of roots

Write to the reference and read from the reference exactly as hardware should

Do garbage collection on reference

Roots in list have a “lifetime” that can be decremented

Hardware.c

Helper methods to access the module driver

- Initialize memory
- Poll status
- read/write ops
- read/write results
- Root ops

# Validation

Main software loop checks all read and write results read from hardware against reference implementation

Program prints error and exits if hardware does not match reference

Read out BRAM and compare to reference before and after garbage collection

Program prints error if hardware BRAM does not match reference

# Limitations

Need to reboot hardware after every run

To reset I would need to clear every token from the hardware system

- Significant changes to generated code