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BLM19302E - Computer Organization & Architecture
ARM Assembly Min-Heap Implementation
Assignment 1

Project Concept

The aim of this project is to implement a min-heap data structure in ARM Assembly language. I will provide an overview of the implementation details and functionalities of the three main procedures: build, find and sort. I will also provide details about the two subroutines used, heap_insert and extract_min.

Procedure Implementation

Build Procedure:

- The build procedure constructs a min-heap data structure from a given list of integers.
- It starts by loading the first integer from the list and initializes the heap size to 0.
- The procedure iterates through each integer in the list, inserting it into the heap using the heap_insert subroutine.
- The procedure keeps working until negative max int (NEGMAXINT) is reached.
- Then it returns the address of the constructed heap.

Find Procedure:

- The find procedure searches for a target value within the min-heap.
- It initializes the search result to 0 and starts from the root node.
- The procedure compares the value of each node with the target value until it finds a match or reaches the end of the heap.
- If a match is found, it sets the search result to 1; otherwise, it remains 0.
- If a match is found, the address of the found element is returned.

Sort Procedure:

- The sort procedure sorts the elements of the min-heap in ascending order.
- It repeatedly extracts the minimum element from the heap using the extract_min subroutine and stores it in a sorted list.
- The sorting process continues until the heap is empty.

Subroutines

Heap Insertion (heap_insert):

- Inserts a new value into the min-heap.
- It first checks if the heap is full by comparing the current heap size with the heap capacity.
- If the heap is not full, it increments the heap size and inserts the new element at the end of the heap.
- After insertion, it performs a **heapify-up** operation to maintain the min-heap property.

Extract Minimum (extract_min):

- Extracts the minimum element from the min-heap.
- It replaces the root element (minimum) with the last element of the heap and decrements the heap size.
- Then, it performs a **heapify-down** operation from the root to maintain the min-heap property.

Main Function

The main function tests the 3 procedures and manages their parameters.

Build Procedure Parameters:

The address of the unsorted list is loaded into register r0.
The address of the heap base is loaded into register r1.

The procedure returns the heap base into register r0.

Find Procedure Parameters:

The target value to be found is set and loaded into register r0.

The address of the heap base is loaded into register r1.

The procedure returns 0 if the target is not found and 1 if it is found into register r0.
If the target was found, its address is returned into register r1.

Sort Procedure Parameters:

The address of the heap base is loaded into register r1.
The heap size is loaded from memory to register r0.
The address of the empty sorted list is loaded into register r2.

The procedure returns the address of the first element of the sorted list into register r0.

Sources

- The laboratory code on LMS was used as reference.
- ChatGPT was used to ask about how assembly language works, how certain instructions function and how loops work.

Conclusion

I was successfully able to implement a min-heap data structure in assembly. This assignment has helped me better understand ARM Assembly, has helped me work on concepts that I had not fully understood before and has allowed me to make a great leap in my Assembly coding ability.