FreeRTOS Architecture Part 1

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Contents

Defensive Programmig

Defensive Programmig. Expect the unexpected

Defensive programming is a bit like always wearing a full suit of armor. It's about preparing for the worst while hoping for the best, much like someone living in a zombie apocalypse with a bunker full of canned goods. In this approach, every function call is a potential trick, every user input a Trojan horse, and paranoia isn't just recommended, it's required!

Defensive Programmig. Expect the unexpected

Good Practice

Defensive Programmig. Expect the unexpected

- Thats why is a good practice to use C++
- C++ has Zero Over Head Principle.
- Learn C++ and you can find a better job,and just add a plus to your resume.

Using const for Safety

- const keyword: ensures variables are not modified after initialization.
- Use const to protect function parameters, class members, and pointers.
- Example: void process(const Data& data); guarantees data remains unchanged.
- This is used for read only variables.

Using const in C++

```cpp
class Person {
  public:
      string name;
      int age;
      Person(string n, int a) : name(n), age(a) {}

      void print() const {
          cout << "Name: " << name << ", Age: " << age
               << endl;
      }
  };

  void displayPerson(const Person& p) {
      p.print();
  }
```

Memory Managment

Memory Hierarchy: A Light-Hearted Tour

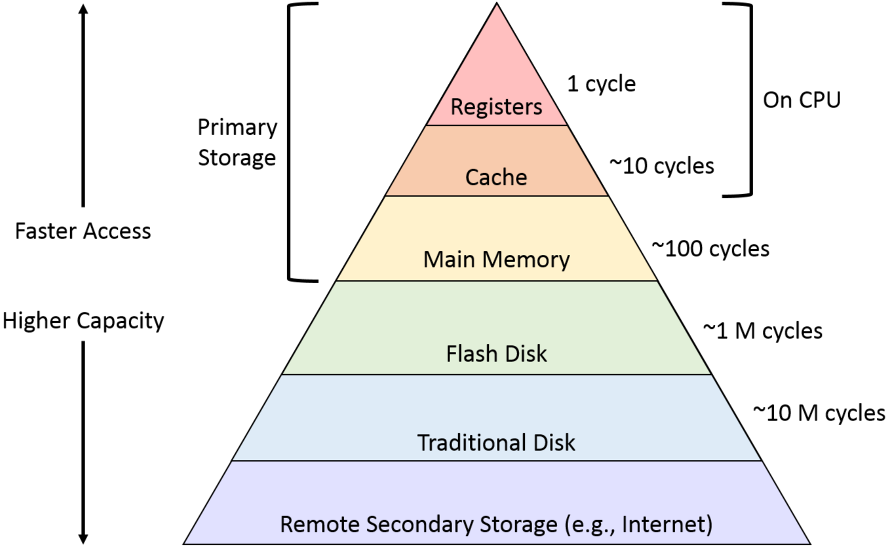
- **Registers:** The speed-demons of memory. Too fast to care, but you really should!
- **Cache:** The backseat driver of computing. It makes decisions you didn't ask for, often with surprising results.

Friendly Reminder

Regularly clearing your cache: not just good practice, it's like digital detox for your devices!

- **RAM (Random Access Memory):** The workaholic of memory. When it runs out, things go south quickly—plan wisely!
- **Storage:** The elephant's graveyard. Where all your code and files go to rest. Yes, your code lives somewhere physical!

Memory Hierarchy



The Memory Hierarchy

How does many values has singles variable?

- One?
- Two?

How does many values has singles variable?

- One?
- Two?

A variable has two values

- One : Its current value
- Two : Its current addres

Passing by Copy

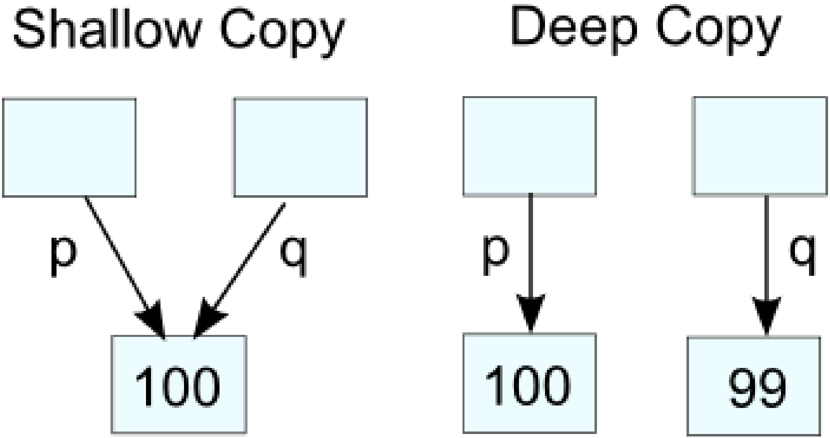
- When parameters are passed by copy, a new instance of the argument is created.
- Modifications within the function do not affect the original variable.
- Best used when you need to ensure the original data remains unchanged.

```
void incrementByCopy(int x) {
    x = x + 1;
    cout << "Inside function: " << x << endl;
}

int main() {
    int a = 5;
    incrementByCopy(a);
    cout << "Outside function: " << a << endl;
}
```

Passing by Reference

- Passing by reference sends a reference to the original variable.
- Any changes inside the function affect the original variable.
- More efficient for large data structures but must be used carefully.

```
void incrementByReference(int& x) {
    x = x + 1;
    cout << "Inside function: " << x << endl;
}

int main() {
    int a = 5;
    incrementByReference(a);
    cout << "Outside function: " << a << endl;
}
```


Shallow Copy
p
q
100
Deep Copy
p
q
100
99

Stack and Heap memory

Stack Memory

- **Definition:** Stack memory is a region of memory where data is added or removed in a last-in-first-out (LIFO) manner.
- **Usage:** Primarily used for static memory allocation, including function call stack (local variables, function parameters).
- **Characteristics:**
  - Fixed size, typically allocated at the start of the program.
  - Automatic management, with variables being pushed { onto the stack and popped off }when no longer needed.
  - Yes the { and } mean something in the code!!! `QuizzSwitchCase.cpp`
  - Fast access due to locality of reference and simplicity of allocation mechanism (moving the stack pointer).
- **Limitations:**
  - Limited space, which can lead to stack overflow if too many function calls or large arrays are declared.
  - No resizing, and not suitable for dynamically allocated data.

Heap Memory

- **Definition:** Heap memory is a region of memory used for dynamic memory allocation where blocks of memory are allocated and freed in an arbitrary order.
- **Usage:** Utilized for allocating memory at runtime when the amount of memory needed cannot be determined at compile time.
- **Characteristics:**
  - Dynamically grows and shrinks based on application needs.
  - Managed through library routines or operating system functions like malloc() and free() in C.
  - Flexible, but with higher overhead and slower access compared to stack memory.
- **Limitations:**
  - Can lead to memory fragmentation.
  - User error for bad manual handling. `BadLinkedList.cpp`

Function Pointers

- **What Are They?** Variables that store the address of a function.
- **Use Cases:**
  - Modular software design.
  - Passing functions as arguments.
- **Syntax Example:**
  - `void (*funPtr)(int) = &fun;`

Callbacks

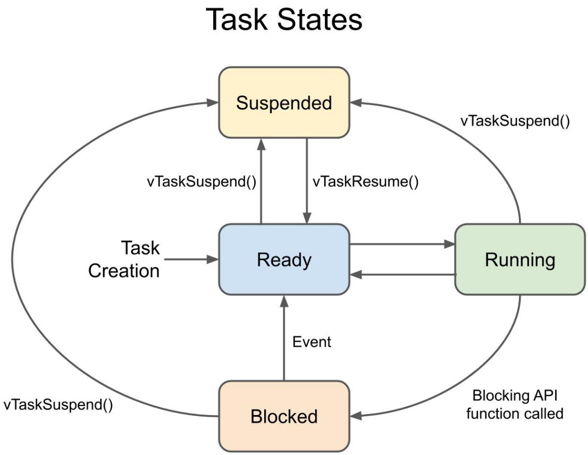
- **Definition:** Functions passed as arguments to other functions.
- **Purpose:**
  - Allow a lower-level software layer to call a function in a higher-level layer.
  - Used extensively for event-driven programming.
- **Example Use:**
  - Asynchronous data processing.
  - Reacting to user inputs or software events.

Task similar to Function Pointer

- **Task as Function Pointer:**
  - In FreeRTOS, tasks are defined by function pointers.
  - Function defines task behavior and is invoked when the task runs.
- **How It Works:**
  - `xTaskCreate(pvTaskCode, "TaskName", STACK_SIZE, NULL, Priority, NULL);`
- **Advantages:**
  - Flexibility in task management.
  - Easy integration of different functionalities.

Scheduler

Task States in FreeRTOS



Understanding Task States

- **Task Creation**: A new task starts in the *Ready* state, waiting to be scheduled to run.
- **Ready**: Tasks in this state are ready to run but are currently not being executed by the CPU.
- **Running**: The state of the currently executing task. Only one task can be in this state at a time on single-core systems.
- **Blocked**: A task enters this state if it cannot continue because it is waiting for an event or resource. It will remain blocked until the event occurs or the resource becomes available.
- **Suspended**: Tasks in this state are intentionally suspended by the application, possibly to conserve power or CPU time. They are not schedulable until they are explicitly resumed.
- **Transitions**:

Task States in FreeRTOS

- *vTaskSuspend()* moves a task to *Suspended*.
- *vTaskResume()* moves a task from *Suspended* back to *Ready*.
- An event or the availability of a resource moves a task from *Blocked* to *Ready*.
- Tasks switch from *Ready* to *Running* based on scheduler decisions and priority.

Note

Only the scheduler can move tasks into the *Running* state or handle transitions when a blocking API function is called.