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Reg#: Fa21-bcs-026

Subject: CC Lab Terminal

Question 3: Give example for optimization used in mini compiler?

Optimization in a mini compiler involves techniques to improve the performance and efficiency of the generated code. Here are examples of common optimizations used in a mini compiler:

**1. Constant Folding**

Constant folding evaluates constant expressions at compile time instead of runtime.

**Example:**

int x = 2 + 3;

**Optimized:**

int x = 5;

**2. Dead Code Elimination**

Removes code that will never execute or doesn't affect the program's outcome.

**Example:**

int x = 5;

x = 10; // The first assignment is unnecessary.

**Optimized:**

int x = 10;

**3. Common Subexpression Elimination (CSE)**

Eliminates redundant calculations of the same expression.

**Example:**

int a = b + c;

int d = b + c + e;

**Optimized:**

int temp = b + c;

int a = temp;

int d = temp + e;

**4. Loop-Invariant Code Motion**

Moves computations that don’t change within a loop outside the loop.

**Example:**

for (int i = 0; i < n; i++) {

int temp = x + y; // This doesn't change per iteration.

arr[i] = temp \* i;

}

**Optimized:**

int temp = x + y;

for (int i = 0; i < n; i++) {

arr[i] = temp \* i;

}

**5. Strength Reduction**

Replaces expensive operations with cheaper ones.

**Example:**

for (int i = 0; i < n; i++) {

int x = i \* 2;

}

**Optimized:**

for (int i = 0; i < n; i++) {

int x = i << 1; // Replace multiplication with a bit shift.

}

**6. Peephole Optimization**

Performs local optimizations in small instruction windows.

**Example (assembly):**

LOAD R1, #5

ADD R1, #0

**Optimized (assembly):**

LOAD R1, #5

**7. Inline Expansion**

Replaces a function call with the actual function body to eliminate the overhead of a call.

**Example:**

int square(int x) {

return x \* x;

}

int y = square(5);

**Optimized:**

int y = 5 \* 5;

**8. Register Allocation**

Assigns frequently used variables to CPU registers to avoid repeated memory accesses.

Example: Variables a, b, and c are accessed repeatedly, so they are assigned to registers instead of memory.

These techniques aim to reduce execution time, memory usage, or both, making the mini compiler's output more efficient.