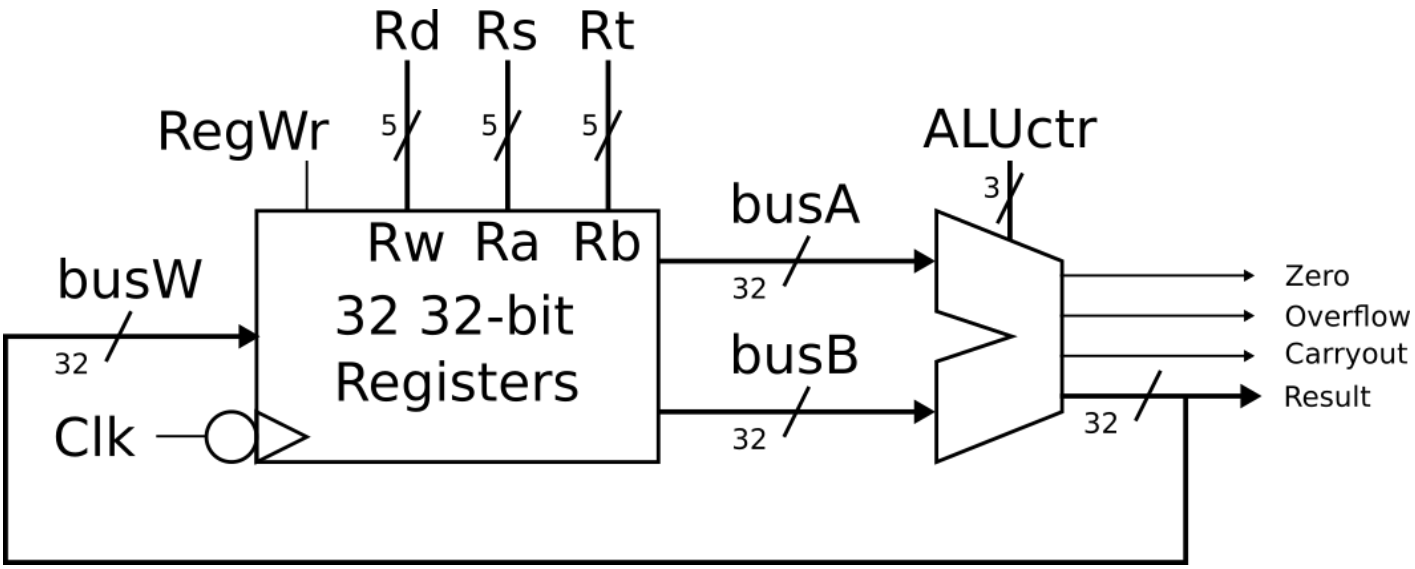
For full and partial credits, you must show your work and explain all steps.

Description

For this lab, you are required to design a 32-bit arithmetic logic unit (ALU) using the Very High Speed Integrated Circuit Hardware Description Language (VHDL). Your ALU needs to support, at a minimum, the following instructions:

- Addition
- Subtraction
- Bitwise AND
- Bitwise OR
- Logical left shift
- Logical right shift
- Arithmetic left shift
- Arithmetic right shift

In addition to the instruction output, the ALU must output a zero bit, overflow bit, and carryout bit. You must construct your ALU using a modular design that incorporates VHDL component instantiation. The 32-bit adder for your ALU must be constructed from cascaded single-bit adders. Finally, the input for your ALU must come from a 32-bit register file, which you must also create. The schematic for the register file and ALU is shown below. You are restricted to using `AND`, `OR`, `NOT`, and similar operations in your design; in other words, you are not permitted to use addition, subtraction, multiplication or similar operations. The only exception to this restriction is for mux components. You are permitted to use `case` statements within mux components only.



Note: By default, each lab is to be done individually, unless I explicitly mention this is a team assignment. However, you can discuss quietly with your fellow classmates in the lab session. Nevertheless, you need to develop your program by yourself Do not copy code from others.

Bonus
Additional points will be given if you also implement the design for a multiplier. The implementation must use the optimized design shown in class. Additionally, the design needs to include a testbench and simulation waveform verifying that it functions correctly.

Testing
You must construct a VHDL testbench for each component you create. Each testbench must also be accompanied with a simulation waveform to verify that it functions correctly.

Lab Report
The lab report generally should include the source code of your assembly programs, a brief description of how the programs work, and printouts of their correct execution.

Lab Report Template
A good lab report usually contains the following sections:

- Title, date, your name (or names of group members for the team project).
- Sign your name with the pledge, "On my honor, I have neither given nor received unauthorized aid on this assignment."
- Introduction. Briefly summarize the main content and goal of your lab. Highlight the main points only.
- Lab content. Describe the lab content in detail. What is the objective? What is the design approach? What components need to be implemented? How do you test your design and implementation?
- Problems solved and unsolved. We are interested in finding out the common pitfalls you have encountered, the root cause of them and how you solve them.
- Conclusion and references. Summarize your work and add references if needed.

Check-off Requirement
For check-off on this lab, show the source code to the teaching assistant (TA), and demonstrate for your TA that your programs execute correctly by the testing inputs and other inputs.

Submission Requirement
You need to submit your report and code to the assignment listed on Blackboard. You **must** structure your submission as follows:

- One PDF file for your report (your code must also be included in the body of the report)
- One ZIP file containing your code

Include each file in your submission. Blackboard allows you to include multiple files in your submission.