BosonQ PSI Hackathon

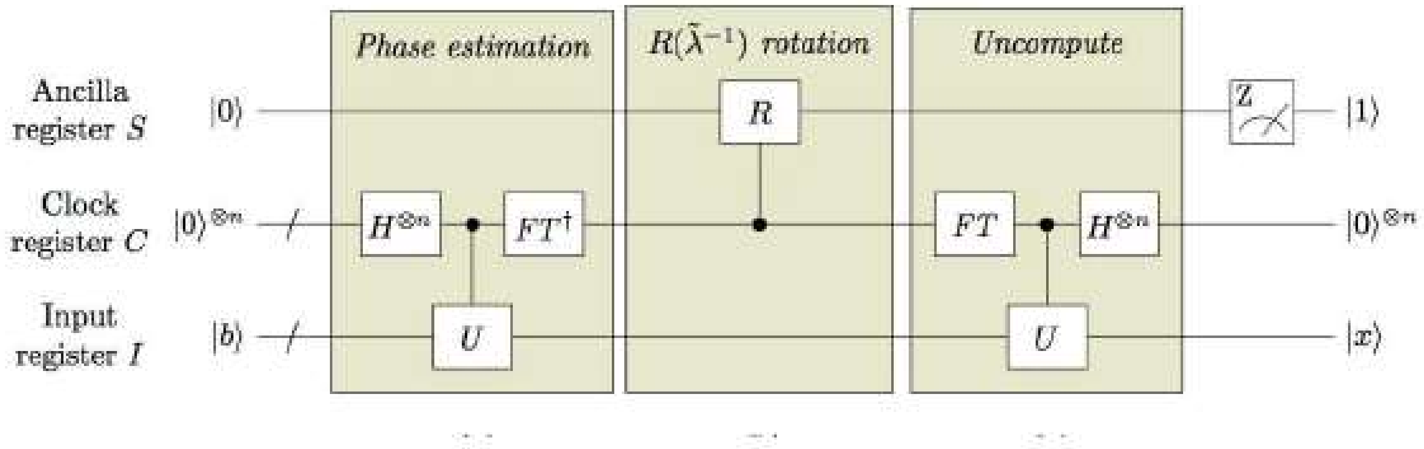
Quantum Computing Approach for 1 D wave FDM Problem

High Level Overall Approach

1. **Formulate Finite Difference Discretization of First Order Wave Equation by Implicit method, first order in time and second order in space.**
   $u_i^n + (C/2) * (u_{i-1}^{n+1} - u_{i+1}^{n+1}) = u_i^{n+1}$

   Let CFL number be 'C' = cΔt/Δx, rearranging known and unknown terms.

2. Using FDM represent overall scenario in set of linear equations.
3. Convert set of linear equations to symmetric Tridiagonal matrices (Ax =b), as an input to HHL algorithm.
4. As 41 (x) variables require values , defined 3 set of registers as an input,
   - Input register with 6 qubits
   - Clock Register with 6 qubits
   - Ancilla Register with 1 qubit
5. Select time interval (t) so that QPE will give a 6-bit binary approximation
6. Apply the HHL algorithm **(detailed version on next slide) ,** execute the quantum circuit on local simulator and visualize state vector for values.
7. Transpilation for Circuit Optimization (to improve qubit connectivity and reduce depth)
8. For optimizing algorithm & Error correction on real Quantum Computing device:
   - Perform a test run on real Quantum Device
   - Transpile Circuit using real device backend
   - Calibrate measurement errors using Qiskit Ignis
   - Create the Measurement Fitter Object in Ignis
   - Mitigate the measurement errors in our previous device run



HHL Algorithm

1.Load the data (Initialize the Input register and Clock register)
2.Apply Quantum Phase Estimation (QPE).
3.Add an ancilla qubit and apply a rotation conditioned.
4.Apply QPE††,ignoring possible errors from QPE.
5.Measure the ancilla qubit in the computational basis. If the outcome is 1, the register is in the post-measurement state
6.Apply an observable M to calculate F(x):=⟨x|M|x⟩F(x):=⟨x|M|x⟩.