Measurement-Based Quantum Computing

Classical vs Quantum computing

classical computing transforms n-bit {0,1} strings to n-bit {0,1} strings.
Quantum computing bit strings: n-bits of tensor product of 2D complex inner product space (a single qubit lives on a Bloch sphere)

Superposition & Entanglement

"state" of system are basically properties of a system (e.g., position, momentum, charge, etc.)

classical state: all properties are known at all times.

quantum state: some properties can have different probabilities of being observed at the same time (this is referred to as the "superposition" of different properties)
(Square of the magnitude is the probability of observing a certain state.)

composite states (in quantum): tensor product of individual particle states.

Uncertainty principle: some quantities intrinsically can't be known at he same time.
"Observable" is something that you can measure.
Two operators commute = means that they can be observed at the same time.
Spin operators in different directions don't commute. (For example, you can't measure spin direction x and z at the same time. you can only measure one direction at a time. You still have full control over what direction you want to measure though.)

Entangled state: Composite state that **can't** be broken down to a tensor product of individual states
Entanglement represents correlated information between systems. (can persist even over large distances)

Measurements: collapses the superposition state into a definite vector.

What if I take entangled states and take measurements on one subsystem..?
(This collapses the state of something on the other system..? so you need to know which direction the first system was measured in…?)

Quantum teleportation:
Take two systems with entangled state far apart (phi and psi)
first person can do unitary operations on phi and their side of psi (this can transform the basis..?), and then makes measurement on phi and their side of psi in some basis.
Then the second person can do some pre-agreed instructions to measure their side of the system, in order to recover phi on their side (phi is recovered on an extra qubit on the 2nd person's side).
The whole purpose of this is to transmit phi from person1 to person2.

Any unitary operator in U(2^n) can be constructed from SU(2) operators and a single inter-qubit operator.

C-PHASE commutes with phase rotation and entangles qubits together.

Lines connecting two qubits in the circuit diagram refer to "inter-qubit operations".
But the circuit diagrams can be represented instead as graphs (abstracted out). Each node is like a snapshot in time (local operations, inter-qubit operations). From left to right is progression in time.

But take this graph-based representation, and instead of snapshots of operations in time, think of the nodes as qubits in space -- this is the idea of measurement-based quantum computing.

Basically **trading off time and space**. If your lab is good at creating qubits and putting them into entangled states, but they don't last too long, MBQC could be a good way to go.

Qubits connected by vertices (horizontally) can be thought of as a time evolution of the previous qubit. (Connected vertices are entangled.) Vertical connections are inter-qubit operation entanglements.
Use teleportation techniques to measure each qubit and move on.

Too much entanglement could be problematic for MBQC.