Quantum Computing

Quantum computing is on a path of accelerating public interest due to the hope that new principles in quantum information will impact society as much as the information revolution and Moore's law. While there is reasonable basis for quantum computing being important, current public expectations have moved far beyond reality.

- The foundation of quantum computing is a unit called the qubit, the basic unit of information in a quantum computer. Making qubits and getting them talk to each o ther is a hard task, because they are touchy and easily give up their quantum-ness when in contact with the outside world. Connecting them and making them work together is a harder task. Vijayaraghavan, a professor at the Tata Institute of Fundamental Rese arch (TIFR) in Mumbai, has made a three qubit processor where each qubit is connected to each of the other two qubits.

- In terms of the number of qubits, it is trivial. Early this year, Google announced that it had a quantum processor with 72 qubits, and IBM had demonstrated a 50-qubit processor last year. But their processor architectures are different from that of the TIFR device. In the IBM-Google approach, a qubit is connected only to the neighbouring qubits. In the TIFR device, every qubit will be conn ected to every other qubit. If Vijayaraghavan manages to scale his processor to more qubits, he may have a processor that is very efficient in translating algorithms.
- Quantum computers are entirely different from the so called classical machines, as they a re capable of solving problems that are impossible for today's computers. In this sense, they are not super versions of today's computers. A supercomputer, no matter how fast, cannot break security codes used in military and business communications. A quantum computer can break them in minutes. If, for example, someone in the world develops a quantum computer, all of today's security codes become worthless. We would then need to design new ones using quantum computers.

- n the global race to build quantum computers, India has so far been present only in theory compared to US, China and the handful of other European countries that were spending large amounts of money. India had no national programme. It had a number of theorists, but only a few had been trying to build a quantum computing device.

- A few experimental research groups started emerging about five years ago, and some of them have made progress. Now the Department of Science and Technology (DST) wants to give them more money, as it realised that qu antum computers are essential to tackle problems that will develop in the future.

- Better solutions to current problems What problems w quantum computers solve better than classical comput and how much will it matter to society? There is a w studied algorithm for factoring numbers that implications to encryption and there are quantum compu algorithms for optimization that could find solutions clo to the global optimum than any algorithm on a class computer. Articles can address the degree to which soc may be changed by the relative improvement offered shifting from a classical to quantum computer For examp could a stockbroker using a quantum computer become m successful than one just using a classical one by pri stocks more accurately?
- New applications Quantum computers are believed capa of solving some problems that are intractable for tod computers. Some such problems are not curre considered important, thus it seems obvious that there be no big profitable companies selling solutions to problem. However, if a quantum computer can solve a kno but previously intractable problem, could companies em that sell new, useful products and then grow to be big profitable?
- Manufacturing Quantum computers have b demonstrated to the level of 50-2,000 qubits, creatin tantalizing parallel with early electronic computers 50–2,000 relays or vacuum tubes. In this parallel, Moo law and other effects boosted the number of ac components by a billion-fold in less than a century. Howev there is only one example of such a large improvem factor, and the improvement didn't come for "free" the was heavy investment in the development of curi semiconductors. Assuming quantum computer physic sound, what would be required to move resea demonstrations to commercial products?
- Quantum computer software engineering Early languag for both classical and quantum computers merely pro bookkeeping assistance for controlling the underl hardware, such as assembly language for class computers and gate sequences for quantum compute Programming languages for classical computers evolve embrace higher programmer productivity through, example, object orientation, domain specificity, and gr programming methods. To achieve quantum speedup, quan algorithms must invoke one of several uniquely quan features, such as qubit phase, interference, entanglem and so forth. How will quantum computer software imi toolchains that improve programmer productivity for uniquely quantum features neededto achieve quant speedup?
- Quantum machine learning and artificial intelligence The is both a theoretical basis and experimental evidence quantum computers can learn training sets more efficie

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