Intellectual Property at the Science And Technology Frontier:
AI, Biotechnology, and Quantum Computing

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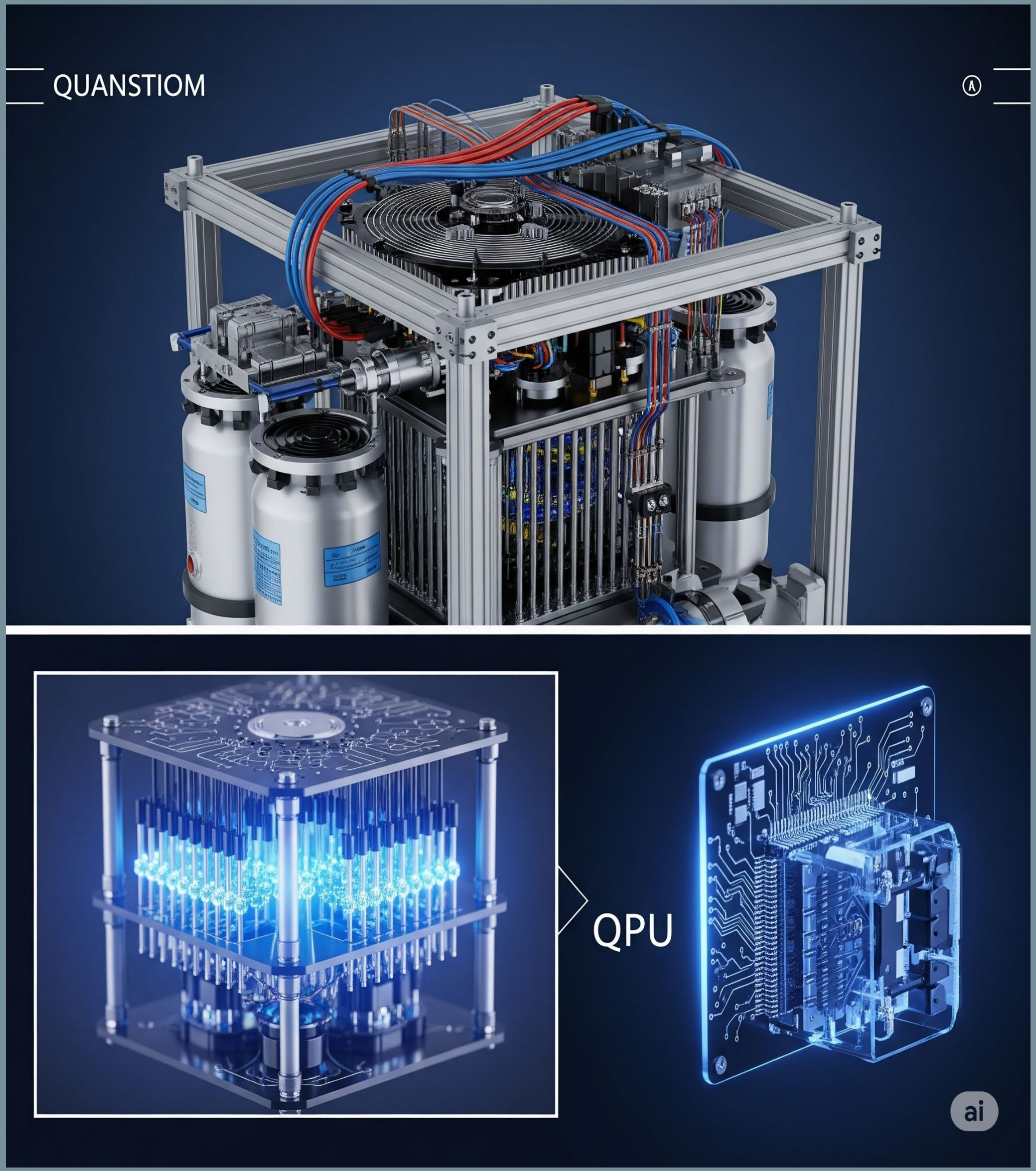
Quantum Computing and IP

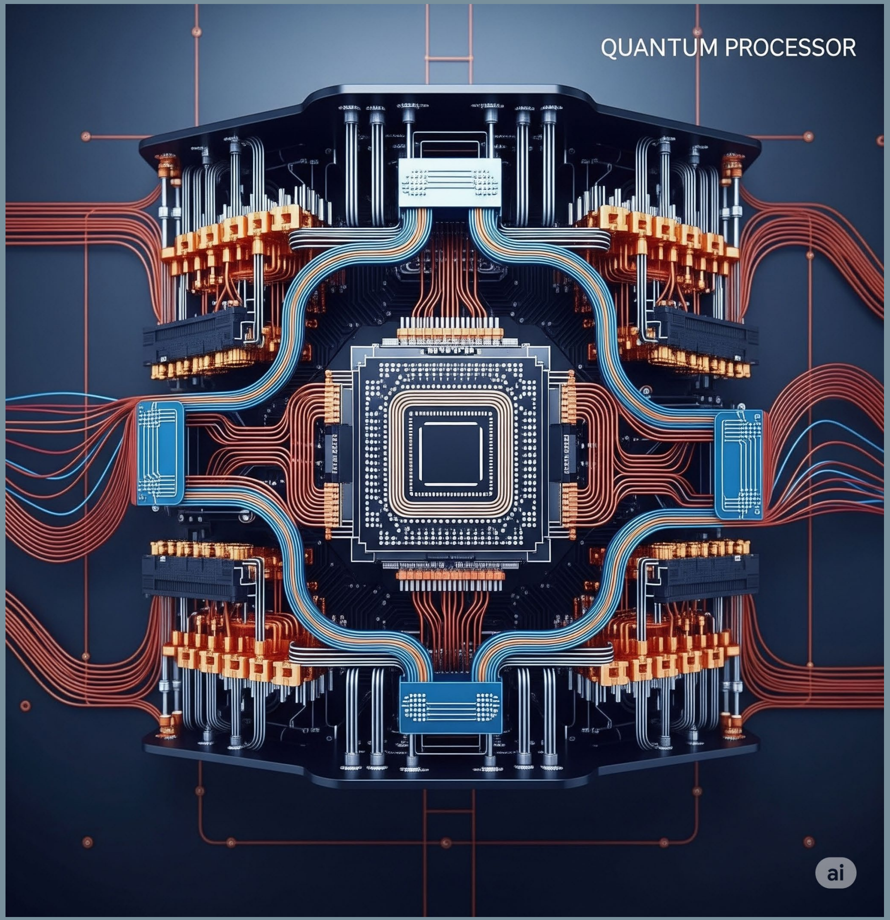
- Quantum computing takes advantage of the “entangled” nature of elementary particles and the capability of these particles to simultaneously be in different states, or “superposition”.

- These characteristics apparently permit a type of computer gate (or qubit) that in the past could be either in an on or off (1 or 0) position to be in an intermediate position, creating a vastly larger range of computational functions. A computer processor gate or bit that instead of answering a question “yes” or “no” (repeated billions of times a second), could instead answer “yes, yes+, yes++, yes +++,” to an effectively infinite degree, making computation almost infinitely faster. This computational power raises challenges including a potential threat to existing encryption standards which are effective because they require a vast amount of computation to “break”, which is unrealistic with existing computers, but which will not be unrealistic with quantum computers.



Quantum Computing

- Computers built to perform quantum mechanical calculations require extremely low temperatures and appear to be very sensitive to environmental conditions. At the moment, the construction of such machines is very costly. In addition, there are existing issues concerning the tendency of qubits to yield erroneous results, and improving "error correction" is one of the main objectives of current efforts in this field.
- The resources needed to engage in quantum computer research are very large, and the field is dominated by large corporate and government actors, albeit relying on more foundational fundamental science research.



Quantum Challenges

- Much of the advance in quantum computing is directed toward computing machines. These machines should not generally suffer from the problem of non-patentable subject matter. Quantum computers presumably confront the same types of challenges as classical computers in the sense that technology is constantly upgraded. Patents need to take into account flexibility for development within the specification of the patent application. The patent drafter must “thread a needle” between providing sufficient specificity to enable, while maintaining enough generality to cover a range of incremental development.
- Challenges facing patenting in the field of quantum computing are similar to those involving artificial intelligence. Quantum computing relies on mathematical formulas or algorithms, and those algorithms are subject to limitations on patenting based on their abstract characteristics.

Quantum Challenges

- There is a “prior art” issue with respect to quantum computing because foundational research has typically been published in open academic fora, making anticipation a problem. Further, the field is evolving very rapidly and quantum computer programs do not stay “static”, so they need to be described and claimed at some level. The patent drafter has to thread the needle between code and a too-high level abstraction.
- A large number of patents have been granted with respect to quantum computing to large private companies such as IBM and Google, as well as to various companies in China, such as Alibaba, Baidu and Huawei.
- **Focus of Patents:** Current patent filings span a wide range of quantum technologies, including qubit modalities, quantum gates and circuits, quantum processors, cryogenic and control systems, quantum sensors, quantum algorithms (for machine learning, optimization, cryptography), error correction methods, and quantum-classical hybrid algorithms.

Specific Patent Issues

- **Prior Art Complexity:** Quantum computing is a rapidly evolving field with deep roots in academic research. This results in a vast and quickly expanding body of non-patent literature (e.g., pre-print archives like arXiv) that complicates prior art searches and the assessment of novelty and non-obviousness. Identifying truly novel contributions in such a dynamic and interdisciplinary landscape is a significant challenge for both applicants and patent examiners.
- **Enablement and Written Description:** The complexity and often counter-intuitive nature of quantum mechanics can make it difficult to satisfy the patent disclosure requirements of enablement and written description. An applicant must describe the quantum invention in sufficient detail to allow a person skilled in the art to make and use it without undue experimentation. Given the probabilistic and sometimes unpredictable behavior of quantum systems, and the specialized knowledge required, meeting this standard can be demanding. Patent examiners may also lack the highly specialized expertise to fully grasp the nuances of quantum inventions, creating communication barriers.
- **Rapid Obsolescence:** The swift pace of advancement in quantum computing means that some patented technologies might become obsolete relatively quickly, potentially even before a patent is granted or shortly thereafter. However, foundational patents related to qubit fabrication, error correction architectures, or core quantum hardware components are likely to retain long-term value.

The Merger of Emerging Technologies

- A key point with respect to the emerging technologies discussed above is that developments are not taking place in isolation. In fact, the technologies are profoundly interrelated.
- At perhaps the deepest level, quantum computing that is based in principles of quantum mechanics is a highly arcane subject matter which is accessible to a very limited number of “human” scientists. It is counterintuitive, and difficult to explain. AI’s are not subject to the same biological and structural limitations as human scientists and are proving adept at addressing complex technical issues faced by quantum computer engineers. Without too much exaggeration, the time may be coming when quantum computers can only really be understood by AI’s and there will be a symbiotic relationship between the two. Though the stuff of science fiction, we may see the emergence of a new form of “computational entity”.
- This is not, however, the stuff of science fiction alone. In fact, a great deal of investment is being made into this “merger of fields” by the biggest players in the AI and quantum computer spaces, like Google, IBM, Microsoft and the various entities in China.

The Merger of Emerging Technologies and IP

- Likewise, it should be clear that pharmaceutical sciences are being profoundly affected by developments in AI through mechanisms such as AlphaFold, and it appears that analyzing and predicting molecular structures will be a particular strength of quantum computing. The three fields will combine to accelerate the process of innovation.
- In the context of these lectures, the question arises “what does this have to do with intellectual property?” At least in part the answer would be that it may make patenting and patents so complex that it will be extraordinarily difficult to assess the criteria of patentability. Once patents are granted a “patent thicket” may arise that will be extremely difficult for follow-on innovators to navigate.
- The natural tendency would be to create a high level of concentration at the level of the heavily funded actors who possess patent portfolios that others will need to access to pursue research. The question may also arise whether patents are really necessary in an environment that is evolving so rapidly. Will monetization depend on recognition of IP or will the level of resources needed to deploy AI and quantum computers be so large that IP will only be a subsidiary factor?