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15 = 3×5 primary school for scientists or a near-term technological disruption?

by Dr. Ulrich Wurstbauer

Does this calculation ring a bell with you? Then there's a good chance you either have children in elementary school or you're aware of an important milestone toward quantum computing. It was the first experimental prime number factorization based on Shor's algorithm, which was done using qubits less than 2 decades ago[1].

Consider also that it's very common for new technologies to need to grow significantly in order to really leave academic research and enter business related fields. Obviously the same applies to quantum computation, but when is a good time to start looking at this emerging technology from business perspectives?

Strong evidence that the technological maturity level within quantum computers has changed can be deduced from the fact that companies building quantum computers publish — and stick — to the announced quantum computing hardware roadmap[2]. It is truly impressive that hardware companies manage to deliver certain milestones on this hardware roadmap and are entering the 100s to 1000s qubits in the next 1-3 years[3]. Also, very recent reports show that hardware architectures like the ones for IBM's Osprey and Condor quantum systems, enable scaling of the semiconductor production processes — a key ingredient of solving more and more complex tasks as we know from all our classical computing and programming knowledge.

Over the course of decades, hardware roadmaps have always been a major driver of the software landscape as seen in **Exhibit 1:** Classic hardware-software interaction influenced and driven from hardware development evolution.

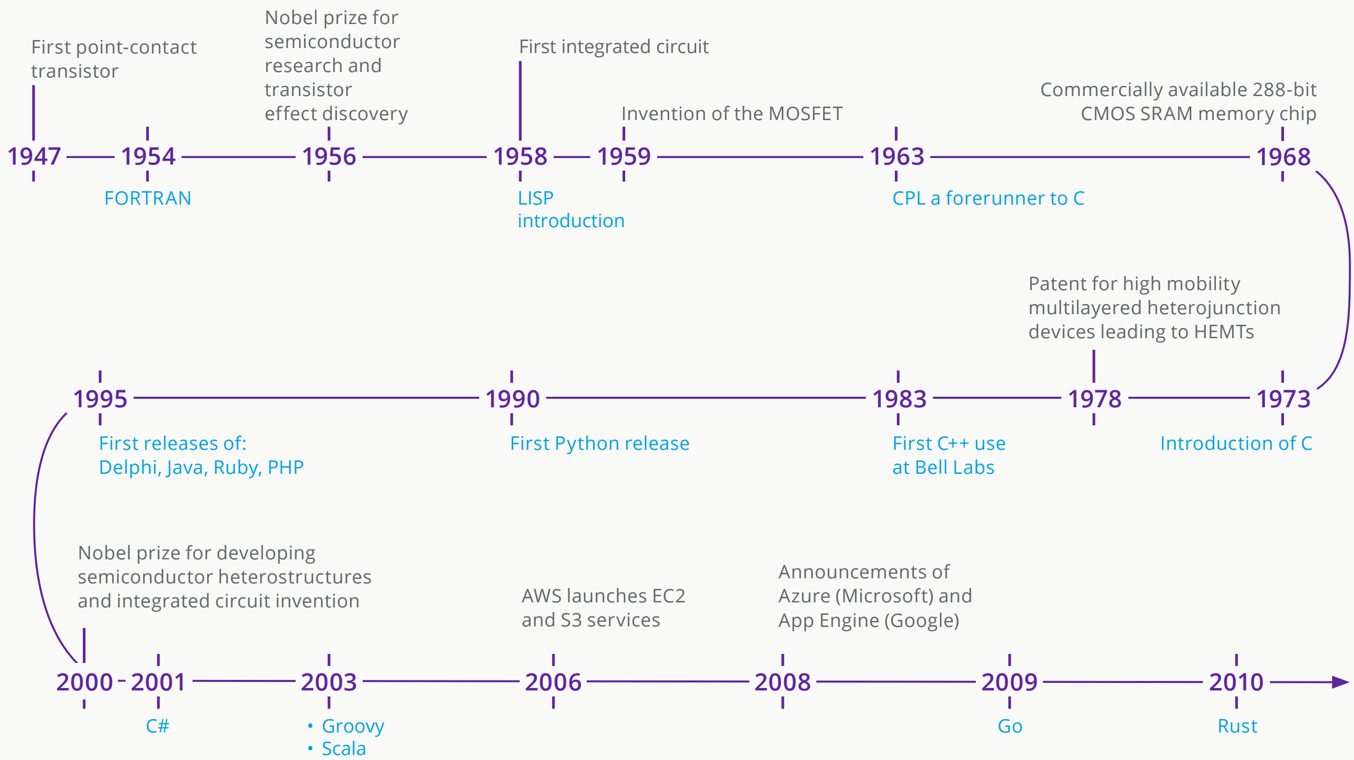


Exhibit 1: Classic hardware-software interaction influenced and driven from hardware development evolution.

1. Vandersypen, L., et al. Nature 414, 883–887 (2001). **https://doi.org/10.1038/414883a**

2. **https://research.ibm.com/blog/ibm-quantum-roadmap-2025**, **https://ionq.com/posts/december-09-2020-scaling-quantum-computer-roadmap**

3. Annealing quantum compute platforms are already well above the 1000 qubits

So, can quantum computing be considered as if it's in an early stage, comparable to the first microchips? From formal perspectives you can think of it in such a way, but like everything else within quantum computing, the pure number of qubit counting view is not that easy. Why?

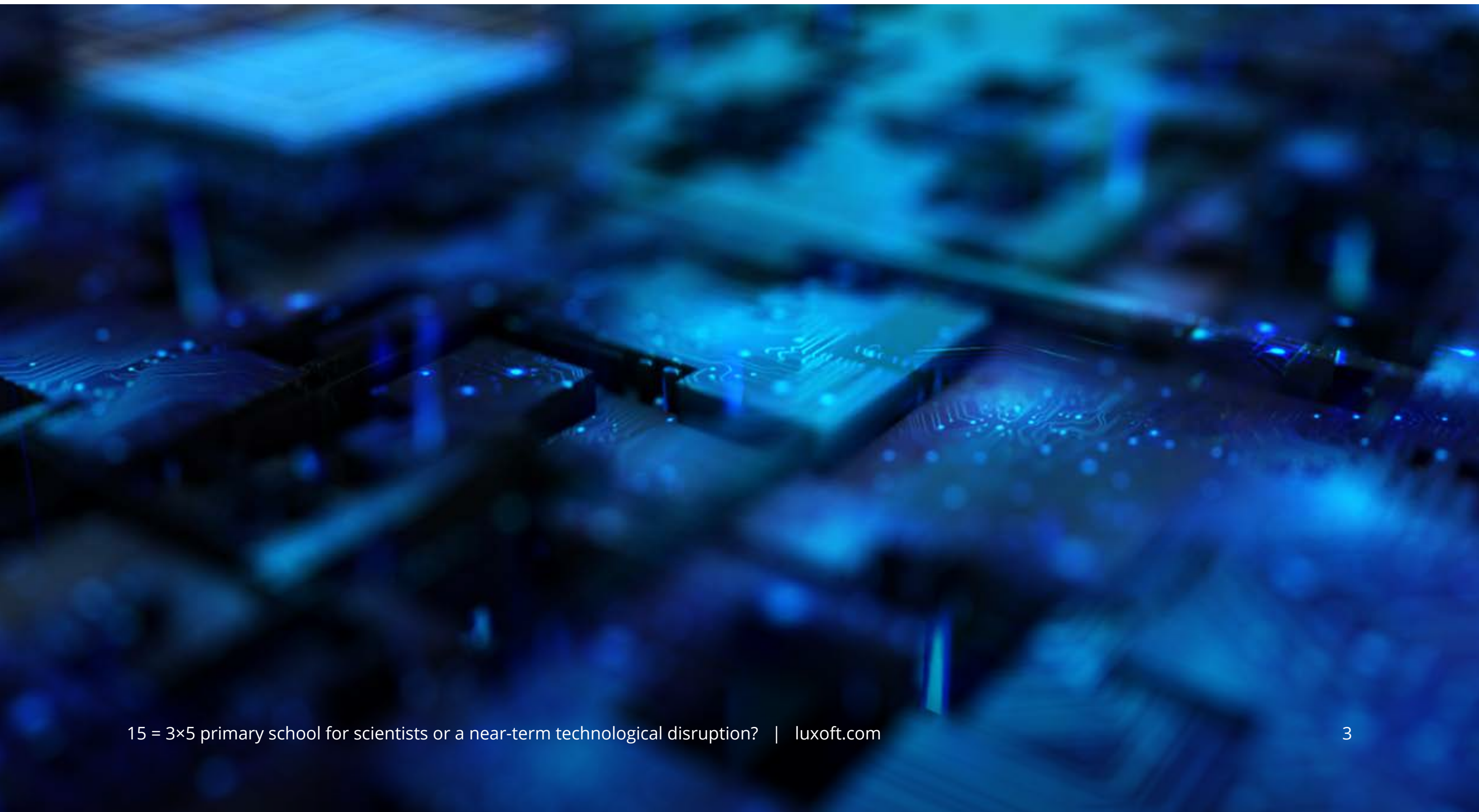
First of all, there are — and will be — various technical realizations of qubits. Each approach has its pluses and minuses when it comes to decoherence time, robustness of the states influencing error rates and their correction, and scalability, to name a few.

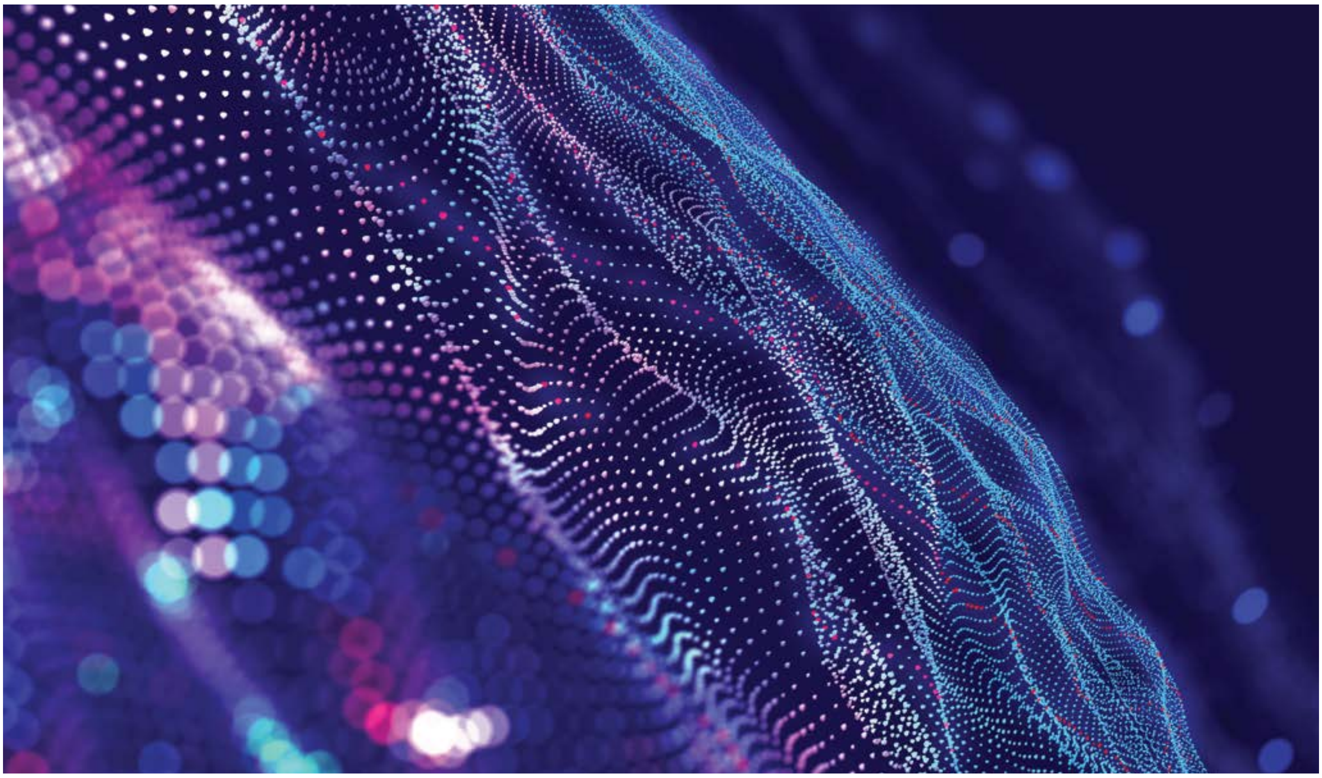
Second, there are many different companies; from big tech down to startups, looking to improve the current electrical engineering approaches, but also exploring new artificial material classes with enormous potential for new computing options.

And third, we're currently transforming the biggest chunks of business computing needs to be run on cloud-based systems and that fraction is still growing. So combining specialized machines, such as a quantum computer, with the already existing infrastructure is obviously the path to follow — indeed, you can already spin up corresponding services on your cloud provider of choice.

But does this solve all problems? Of course not, it's quite the opposite. This journey is just getting started, but why? Because we need to build up the knowledge and experience of how to use this new computing hardware properly and learn the pros and cons when it comes to real application programming.

But hold on, what potential applications are feasible? One of the most prominent ones, if not the most prominent, is paving the way to quantum cryptography and security. It's based on the 15 = 3 x 5 calculation and deals with the prime factorization of large numbers. Those numbers are the fundamentals of our current encryption mechanisms. And yes, that has huge impact; think of financial and banking capital markets as well as your privacy related topics. It also has an impact on all of our mobility needs, since vehicle makers need to ensure that only approved and safe software gets deployed in their vehicles (which in the future will be connected, autonomous and software defined).





Quantum computers are already being used in R&D for new materials. This is especially the case in the e-mobility domain with all efforts spent on developing new, better and longer lasting batteries. As a side comment, such chemical targeting usage also holds true for drug and other material research.

Another typical problem within the automotive industry is route optimization at scale. All current productive approaches are only capable of solving the problem from an ego perspective, meaning excluding the interconnection of other traffic participants. With quantum computing, you can get a bird's eye perspective as you can optimize the traffic flow (meaning each individuals' navigation route) depending on everyone else's needs. Think about it in your next traffic jam — how beneficial would it be if we time optimized the use of all the existing road network options in your metropolitan area?

And then there's also the large area of data analytics and quantum machine learning. With respect to this, autonomous vehicle (AV) experts should at least start digging into quantum based high computing options, if not yet done so already. The AV development landscape is evolving very fast and potential use cases arise around scenario generation at scale, including the identification of corner case situations in simulations. This would enable later in-depth analysis with classical high compute needs. In addition, the field of quantum machine learning is also showing high potential to speed up learning processes[4] which allows faster understanding of large amounts of data — a very typical, if not the most, characteristic challenge for autonomous driving development. In this regard, **Luxoft** and **DXC** bring in depth technical expertise to enable our clients to perform end-to-end developments at scale.

So, building up the right expertise also on quantum computing is of high value to meet future development needs and will also require us to spend sufficient time on this new computing option which is already here. We just need to get started and used to the quaint behaviors of the quantum world.

4. Huang HY et al. Science. 2022 Jun 10;376(6598):1182-1186. doi: 10.1126/science.abn7293

About **the author**

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Dr. rer. nat. Ulrich Wurstbauer is chief technologist for autonomous driving at Luxoft. He's responsible for strategic developments in the field of autonomous driving, function development and virtual validation. Before starting his current in-depth work on automotive technologies with a strong focus on simulation and digital twin technologies, he received his PhD in the area of solid-state physics where he also did his post-doc. He worked on the newly developed 2D material graphene with its unique and very special quantum physics behavior. Ulrich has authored more than a dozen research papers in addition to filing four national and international patent applications.

If you'd like to find out more visit **luxoft.com** or consult our expert at **uwurstbauer@dxc.com**

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Luxoft is the design, data and development arm of DXC Technology, providing bespoke, end-to-end technology solutions for mission-critical systems, products and services. We help create data-fueled organizations, solving complex operational, technological and strategic challenges. Our passion is building resilient businesses, while generating new business channels and revenue streams, exceptional user experiences and modernized operations at scale.

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