# The Future of ERP EP4: Quantum Computing

[00:00:00] **Laure:** I think the future ERP will use the best of breeds and combination of several disruptive technologies including quantum computing.

[00:00:08] **Richard:** Welcome to the future of ERP podcast from SAP. My name's Richard Howells and I'm the Vice President for Thought Leadership for SAP's ERP, Finance and Supply Chain Solutions. And I'm joined by my co-host ,Oyku.

[00:00:26] **Oyku:** Hello everyone. My name is Oyku Ilgar. I'm a blogger, marketer and podcaster in the area of ERP and supply chain at SAP. And today we're going to discuss quantum computing and its potential impact on business systems with our guest Laure Le Bars. Welcome Laure. Would you like to introduce yourself?

[00:00:41] **Laure:** Thank you Öykü. So I am a SAP, responsible of several European projects. And one example here, I'm the president of QuIC, the European Quantum Industry Consortium.

[00:00:52] **Richard:** Okay, so let's start by getting a common understanding of terms. My knowledge of quantum is the TV show Quantum Leap, [00:01:00] where a guy jumps from time period to time period. And I'm sure we're not gonna be talking about that. We're talking about quantum computing. So what exactly is quantum computing and why is it important for us to know about now?

[00:01:13] **Laure:** So quantum physics is the foundation of many modern technologies. This is not science fiction, those technologies are already widely used and part of everyone's daily life, like lasers, atomic clock, GPS, etc. And you may have heard of this second Quantum Revolution or quantum two zero. This is about the growing ability to manipulate quantum effects in these customized systems and materials. So this is a continuation of what existed before. And the community refers to or talk about four main domains, quantum sensors and methodology, which is more or less the most mature field quantum communication, quantum simulation and computing. So if I [00:02:00] look at quantum computing, we basically use two properties of this quantum mechanics, superposition and entanglement. So first the superposition means that, quantum objects, and when I say objects it's quantum particles. It could be a photon iron, electron, et cetera. So those quantum objects or particles can be in different states at the same time or in other wods quantum states can be piled up, added or superposed. So this is superposition. Entanglement is when those quantum particles are deeply connected without direct interaction. Say it another way, those quantum particles are correlated to each other, even if they're far apart, and we talk about hundred of kilometers eventually. So what happens is that any action that you do on one of this correlated [00:03:00] particle as imaged consequence on the other one, an immediate instantaneous, it's not speed of light or whatsoever. There is no exchange of signal. And by the way, this concept is the topic of the latest Nobel Prize in physics. Discerned to Anton Salinger and John Clause just last fall. So those two superposition and entanglement or counterintuitive, this is not the way the world behave. I mean, what we perceive, it's not easy to understand. And you have really have to be a specialist in quantum physics. But for quantum computing, we need to know those properties. We need to know that they exist, and we have to trust the quantum physicist who are mastering and using them. And from our side, having a mathematical representation of it. And then we can play with it.

[00:03:50] **Oyku:** You've just said this is another science fiction. I mean, we use quantum technologies in our daily lives widely, even though we are not realizing, and this is quite a new topic [00:04:00] for me, and maybe some of our listeners are feeling the same way. But we know a lot about cloud computing, for example. Maybe you can explain a little bit how quantum computing is different than today's computing technologies.

[00:04:14] **Laure:** That's a new approach. So it's combining those quantum physics and classical computer science. So let's see now how we can use those two principle I was mentioning in quantum computing. The community define quantum bits or qubit. This is a Quantum Information Unit, same way we have classical bit. The difference with qubit is that you can represent two states at the same time with certain probabilities for each state. So in classical bits, You have two states possible zero or one could not be both at the same time. It's either zero or one. Qubits can hold both possibilities, and will hold those probabilities and those level of possibilities until it is wed or measured, so [00:05:00] now that you have bits, you can do algorithms, you can process. So a classical algorithm is a sequence of states and transition between those states with different gates and or not, etc. So you have a state. You do an action on it, you go to an next set, etc. This is the touring machine. So quite similarly, a quantum algorithm will use those quantum bits and we'll have transitioned between different quantum states. So we will add in addition to the classical gates, we'll have new quantum gates. Using this superposition and entanglement, we can embed this in this quantum system. So as a matter for certain program classes, this technology allow an exponential number of operation to be executed in the single step. What I mean is that okay, if you have two qubits, you have two expert on two possibilities. This is really what I mean by exponential number of possibilities, which is much more powerful than the [00:06:00] classical bits where it's zero or one. If you have many bits you can have many option, but it's not so many as two exponents.

[00:06:06] **Richard:** So we've talked a little bit about the theory of quantum computing but what does this mean to the people listening to this podcast? What does it mean to businesses and business systems? So are there some examples of potential use cases that you've been looking at?

[00:06:22] **Laure:** Yeah, and this is true, this is still theory. I mean, this quantum algorithms, people are working for two or three decades on it. We need the computers now. But what we know already is that on this theory, we prove that those quantum algorithms, once we have the machine to run on it, but those algorithms could solve problem more efficiently. So if I explain this, so on a classical computer, when the size of a problem increase the time goes exponentially. With a quantum algorithm, it will go much slower. It still takes time, but it's not going exponentially. We can say the other way around they may be exponentially quicker than [00:07:00] classical computers. So examples optimization problem like hood planning. This traditional travel salesperson, supplier management, energy distribution, or all kind of distribution you can think of, or any problem where you have to, many criteria with several and many data. So as soon as it increases, that becomes more and more complex. Financial portfolio management is also example. So the ability of a quantum algorithm to find the optimal solution, or at least one of the most optimal solution by analyzing this huge amount of data, more or less at the same time, as I mentioned parallels will help here where the classical computers will be overwhelmed by this exponential calculation when it comes to this enormous amount of data. So it's not magical. It's not one shot. It's just that it's a different approach, a different way of calculating. So it will be good for such problem like this. It may not good for [00:08:00] our other stuff. So, neural network, artificial intelligence, machine learning algorithms are also perfect candidates for such content processing. So, of course as we mentioned earlier, this is all on paper now. First those perfect qubits don't exist yet. There are some, but there is really experimental, it's still research mode, but we can already prepare on it. We can already think of what are the use cases, this and work on the aggregate itself to be waiting when those computers are ready.

[00:08:28] **Oyku:** Laura, you mentioned classical computers might get overwhelmed by exponential calculations and trying to process this enormous amount of data, but quantum computing is using different approach. So my question is, would do you think that the quantum computing supersede cloud computing?

[00:08:48] **Laure:** Not really. And this is not about having more power. It's not faster unless this is not intellectually challenging. it's really a different way of programming. So using those proposition and entanglement [00:09:00] properties so it could be good for certain tasks and problems, and the need to start to look at those possibility. So I think what we will see in the future is a combination of both approach especially in the type of software that we have at SAP. Let me take one example: invoice processing. So by essence, this pretty sequential process for the majority of cases, but then you have some cases where the invoice doesn't match exactly the payment or vice versa. So here we need AI processes to find the match. We do this already. But this typical case could be more efficient to have a quantum processing for such matching. Let's imagine we have this combination of classical and quantum computer. This is what I call a hybrid architecture. So the idea is to take the best of both words and to adapt to advantage of each, we process classically, sequentially the majority of invoices. Then at some point we call a content routine when necessary, and when we need to find a match or when we know that, okay, [00:10:00] here we are to a case where we'll go exponentially. So let's look to another way. My guess is that there will be those first quantum computers. They may be big for all kind of reasons, or they may be located in superior computing centers next to high performance computing exact scales of Penta scale whatsoever. So those quantum computers will be part of this cloud services as well. So will not replace it. Even long term, my dream is not only myself, by the way, it's to, you will have the CPU, the GPU next to it. You will have a QPU, so a quantum processing unit transparent for the user, but for the developers, it's like, okay, he knows when to call the CPU or the QPU and do this mix to be most efficient as possible. To summarize, those quantum computers will not replace classical computer. I mean, not from my personal point of view. This will be really a compliment obviously disruptive computing.

[00:10:56] **Richard:** Well, we are talking about the future of ERP podcast [00:11:00] and we're certainly talking about a futuristic topic here. So who is leading the way at the moment when it comes to quantum computing?

[00:11:08] **Laure:** Difficult to say, and this potential to solve problems and to be disrupted is attracting many actors and in all quantum technologies, not computing by the way, but in quantum computing for sure. And there is a geopolitical waste just starting so and so int some are is also key in some aspects. So you find here big companies like traditional one like IBM but many startups as well. And on both side, on the hardware side as well, on the software side. And we know the potential. It could be more powerful, but those hardware are much more difficult to develop than classical hardware because you touch this quantum level, this is very unstable, not easy to master, etc. So whatever happens, there will be a lot of prototyping, benchmarking tests, et cetera. The development of those future quantum ships will be expensive, at least for at the beginning. And [00:12:00] we need to scale up number of quality speed of the cubic technologies and the more we grow, the more difficult it is, cuz those qubit could be pretty unstable and they interact with each other, not the way we want. So that's a major challenge for whoever is developing this hardware. And yeah, we will need to bring those quantum processes together. So the number of qubit is important, but not enough. We need gate fidelity cubit fidelity to start with gate fidelity. So efficiency is everywhere. It's not just because you have qubit that it solves everything. We need a web robust supply chain for all those components and that's one of the challenge in the future. So it's difficult to say, who leads now, we will lead in the future. There will probably plenty of actors emerge or disappear or bigger. So that's difficult to know. For us at SAP, it's even worse in the sense that we are more or less at the end of the chain because we cannot just have a quantum computer that solve, okay, we have one [00:13:00] problem and we solve it, and great, we have a solution. We need something that is universal, reprogrammable, reliable. We work on this application layer, so we have to be compatible with whatever come as hardware or different qubit technologies. I didn't mention it, but there is superconducting qubit, iron trap, photons, etc. Somehow we should not care as SAP. This is the hardware part. We need to look at this abstraction layer. So we have to partner with the different hardware provider. And ultimately we need this subsection level and we need to be agnostic, hardware, independent, and of course making sure that what the hardware providers are developing is also serving our needs. That's really interesting what will happen in future. It's difficult to know what will come first. It's not only private companies. We could see a lot of investment in form from different states, also worldwide, also European commission, [00:14:00] VCs, private fundings, etc.

[00:14:03] **Richard:** It's great to see SAP at the forefront of research of future technologies, but you mentioned the consortium called QuIC, a little earlier. Could you explain what it is and its role in this whole research?

[00:14:17] **Laure:** As mentioned earlier, I'm the president of QuIC. This is European Quantim Industry Consortium that's the official name. This is a non-for-profit association that we confounded in two years ago with several major actors so large enterprise, like SAP, Atos, Bosch, Airbus, Thales, etc. From startup up to middle enterprise investors as well. We have VCs or members, startups, I mentioned it. The main target is really to build a community, hacked as a collaborative hub throughout Europe. And to build this ecosystem we want european economy to flourish and those actors to becoming leaders. And by the way [00:15:00] association is industry led, but we also have important research and technology organization as members. This QuIC covers not only quantum computers, but all quantum technologies in all those four domains. And also transversal topic market trends, standardization, skills, IP. We don't define standardization, but we collectively sit together and express the needs and define what are the needs. And we dialogue with the standardization bodies and say, look, this is what, industry will need. Same for skills, IP, etc. So this is important that bring the actor together. It's not just about helping the startups. This is where bringing this community, helping each other. We may have competitors inside it. So that's important to still build up this community. Another example this, one output that we are particularly proud of is the strategic industry world map. So we are version two this year. weeks. So this [00:16:00] documents present really a collective use of creek members regarding the development of the quantum industry for the coming decade. And along those verticals, as I mentioned earlier, also all enabling technologies. It as part of it, it also expressed the needs of the industry. What are key elements? Is there any showstopper here? Is there specific critical component that are important to making sure we don't have any supply chain issue? So, hold this to achieve. So not just the development of the industry itself, but also making sure the environmental and social objectives could be achieved. So This is really by members, for members and this one map is also serves as a guide to inform policies to orient governance support in different state, also with the European Commission, for example, and extend the value chain to make sure we call, as I mentioned earlier, all these critical components. And by the way, [00:17:00] QuIC also collaborates with sister association we say, or counterparts in US. UEDC, Canada, Japan, QStar those four association recently established this International Council of Quantum Industry Association and we plan to grow. There will be other region, other countries. So the idea is also to strenght this ecosystem at the international level, and topics are more or less the same. It's also about standardization, IP critical components, et cetera.

[00:17:32] **Oyku:** Laure, you were mentioning several major business actors, large enterprises like SAP, Atos, Bosh, Airbus. I believe there is a common topic that might be of interest to these companies, which is cyber security. So how can quantum computing help with cyber security?

[00:17:48] **Laure:** Two side of it. So first on one hand, when a quantum computer has the possibility to solve quickly this factorization problem, and considering that. The encryption [00:18:00] we use today, like RSA is mainly based on this factorization. Then we have a threat on the actual encryption on all the classical computing. So we have to develop new security processes different way, different protocol to protect the actual data against a potential future quantum computer destroy it or read it actually. All this ranch is what we call quantum safe or quantum resistant. You may even fight post quantum. And this can be done now. I mean, this is a mathematical problem. You don't need qubits here. You don't need to understand quantum physics. You just need to understand the way the quantum computer could break it. And by the way, SAP security research team or colleague from this already working on it, to look at how to protect, how to integrate those new security protocols in the product. So that's one part. The other side is that I mentioned earlier, one of this domain is quantum communication, and this is where, and this is more [00:19:00] constrictive here, there is those quantum technologies will bring a new range of possibilities. So let me explain here. By essence, quantum communication is protected against eavesdropping. So this will help us to do trusted communication. And I forgot maybe to mention one property, which is part of the quantum physics. When you measure, a quantum particle, so including a qubit, the quantum state disappear. So in other way, reading it measuring is destroying the quantum state. So that's one of the difficulty in the quantum computer, because you create your qubit, you make your operation, then you have to measure and you measure, you destroy. But that's okay, we just recreate it, et cetera. That could be an advantage in the case of the communication because it actually means that it's impossible to create an identical copy of qubit or quantum [00:20:00] state that you don't know before arbitrary one. This is more or less the no cloning principle of quantum physics. So it's based on the, in determinist you cannot define all the parameters of this quantum particular at the same time. So what looks like something that is challenging is actually protecting it. So it means that, if you send your cubits on the Y line and someone intercepted, so it means intercepted. They read it, they measure it right away. That's because it lost the quantum state. You know, right away that someone read it. So you can just start again, your protocol and send a new security key, et cetera. In the case of the classical communication, if someone intercept your message, you will never know until it's publicly leaked somewhere, and it could be leaked really later on. So now you know it right away. That's, one of the positive aspect. So this no cloning principle is still causing challenges as I mentioned on the [00:21:00] development the quantum internet, because You will have to do quantum repeaters at some point. How to do this? It's one of the challenge which I will not go into because I'm not the specialist, but we have plenty of researchers and industry. This will come before quantum computer. So the good news is, if we talk about this, quantum internet is if we use photon for qubits, we can use the optical fibers cause we use photons or the satellite. And we could use the same optic fiber or the same, satellite link to mix. Qubit communication and classical communication. So you don't have to build a brand new parallel network. I mean physical network in parallel. We can use the actual one. So this is another field which is developing quite quickly. And it's also of course everything related to security and cyber security is very important. So European Commission, for example, is investing in these innovations for both the terrestrial [00:22:00] and the special quantum commission communication infrastructures. It's called, Euro Qci. SAP by the way, is a partner since 2017 of a project called Quantum Internet Alliance. So again our colleagues for SAP security research. So the project aims to build a blueprint defined protocols for this European quantum internet. Here it's essentially terrestrial, so sending, qubits to a remote content processor and making sure this secure, communication and delegated. So this project, by the way, is part of this program called European Quantum Technology program. Just the beginning, but that's really the blueprint of the future.

[00:22:43] **Oyku:** Can we look at this topic from a little bit business perspective? Like what are some business benefits that you think companies can see from quantum computing?

[00:22:54] **Laure:** it's important all the security aspect. So that's, one aspect, and if I go back to this, [00:23:00] example that we gave those optimization problem that could benefit in different industry. And here it could be a pharmaceutical, telecommunication, agriculture, medicine, finance, energy, et cetera. You have everywhere optimization problem. If you look at pharmaceutical, you have in mind a new molecule, but before building it, you want to simulate, the behavior of this future molecule. So here, quantum computing could do that. There are plenty of cases where using it as a mix with the actual classical computer and tech, the best of breed, so all economic sectors basically could benefit from it. Maybe finance will be the first one. And pharmaceutical, I mentioned it's difficult to predict and maybe in parallel, but that will come. One aspect as well, it could be more sustainable in the sense that, okay, it's not using a huge computing power. It's used a different way, it could be a more sustainable way to do it. We still have to be careful [00:24:00] because the energy to run a quantum computer could destroy the benefit. So this is also future challenges that we have to take care of. We mentioned the industry, but there is also all the aspect of societal impact, improving healthcare, addressing poverty. Looking at the climate model simulation could benefit for, this is typical optimization problem here as well. So that's also areas. I don't think there is any domain that could not benefit of it. Then of course, it will take time and there will be a benchmark and test until we really reach a level that everyone could look at it.

[00:24:35] **Oyku:** Is there any question that we haven't asked or any important aspect that we haven't touched that you think we should? Would you like to add anything else?

[00:24:43] **Laure:** I'm not a specialist. I mean, I was interested by the topic and I try to, I think nobody should be afraid of it. It's not so complicated. It's a little more complicated than classical computing, but we should have the same approach. When we look at the software development as a software [00:25:00] application developer it's like, okay, there are quantum builds, there are superposition, there entanglement et cetera. But then there is a mathematical representation. Is it probabilities? Is it physical representation of it? So let's use this mathematical representation to build the algorithm and trust whoever is building quantum computers that they will do the quantum gates, et cetera. Same way we do in classical computers. We know it's all based on zero and one and transformation of state. You don't need to understand the physics of electricity to be a good programmer. You need to understand what is an algorithm of it. How to go from one set to the next. So I will use the same analogy and say, okay, don't be afraid of it. Don't listen to whoever is telling you this is very complicated. Nobody understand. It's okay, let's look at you specialty and how to integrate in the classical software computing and a software engineer [00:26:00] shouldadd to the actual knowledge, this additional knowledge. So we have to prepare the skills of the future and this is my view, that software developers who should learn quantum computing and quantum software development and not quantum physicists who should learn to program.

[00:26:16] **Richard:** Laure. We're coming to the end of the podcast and we ask all of our guests this final question. So if you could summarize in a few sentences, in your opinion, when we take into account quantum computing, what is the future of ERP?

[00:26:33] **Laure:** So I have this holistic view. I think the future ERP will use the best of breeds and combination of several disruptive technologies the edge, edge et cetera, including quantum computing.

[00:26:47] **Richard:** Thanks very much. Well, Laure, thanks so much for an intriguing conversation. I've certainly learned a lot today, and to be totally honest, I'm glad that there are teams of experts out there thinking about this [00:27:00] topic so that I don't have to, I'll leave it to the experts like you. So thanks for a great conversation.

[00:27:05] **Laure:** Thank you.

[00:27:06] **Richard:** And I'd like to thank all of you for listen. Please mark us as a favorite and you can get regular update and information about future episodes. But until next time, from Oyku and I thank you for discussing the future of ERP.