Quantum leap

Advancing a strategy for quantum computing that will inspire, support and safeguard economic growth in the Middle East

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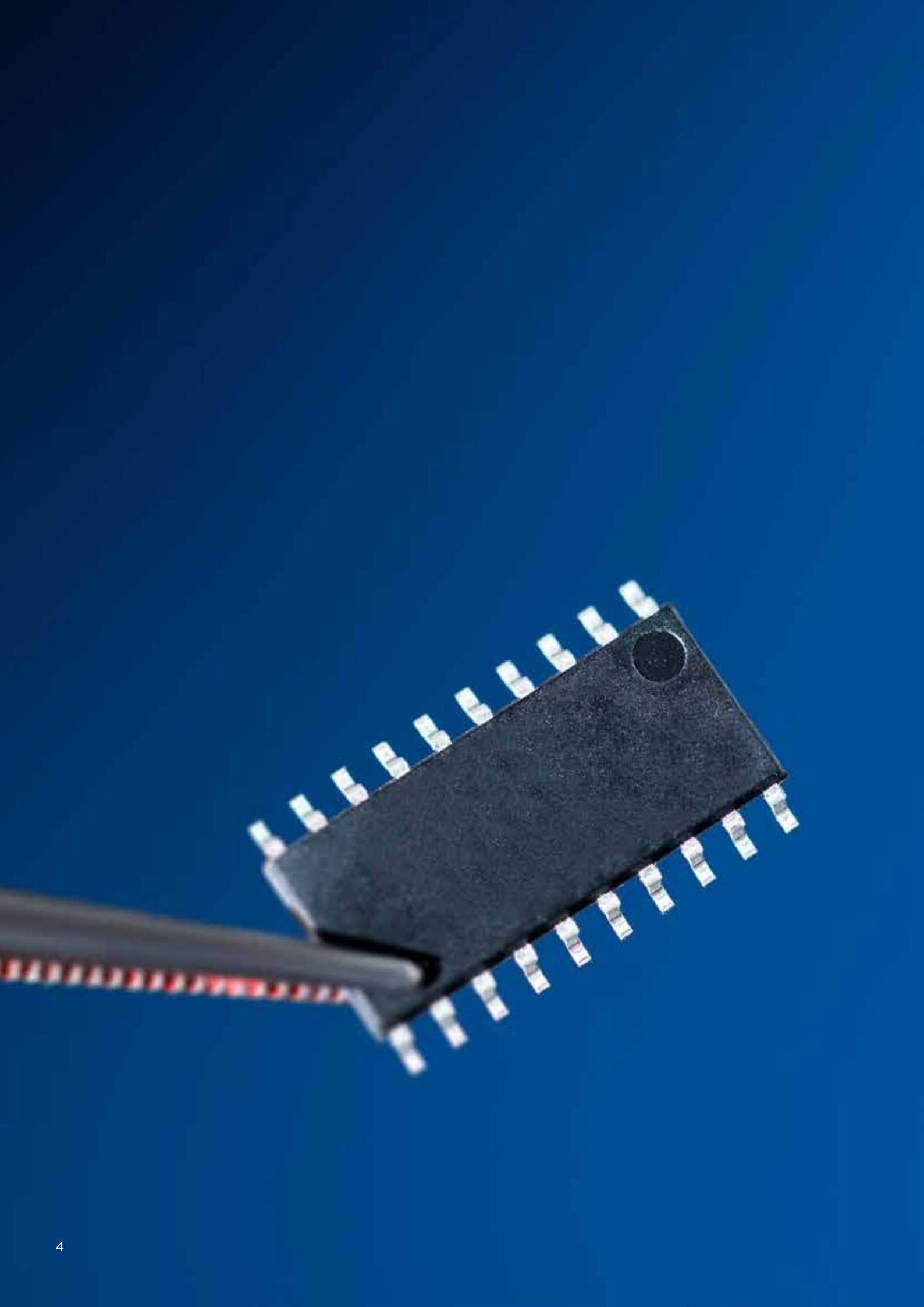

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Executive summary

Quantum computing is moving from the high-tech lab to mainstream commercial use over the next few years, representing the next major breakthrough in modern IT.

This dramatic shift will affect both how and how quickly computers are able to solve increasingly complex problems. Instead of performing calculations or testing infinite combinations of hypotheses sequentially, quantum computers can process almost infinite combinations of scenarios simultaneously – finding answers to questions that would otherwise be impossible to solve in a lifetime. The associated leap in data science will vastly accelerate medical and scientific advances and transform knowledge economies.

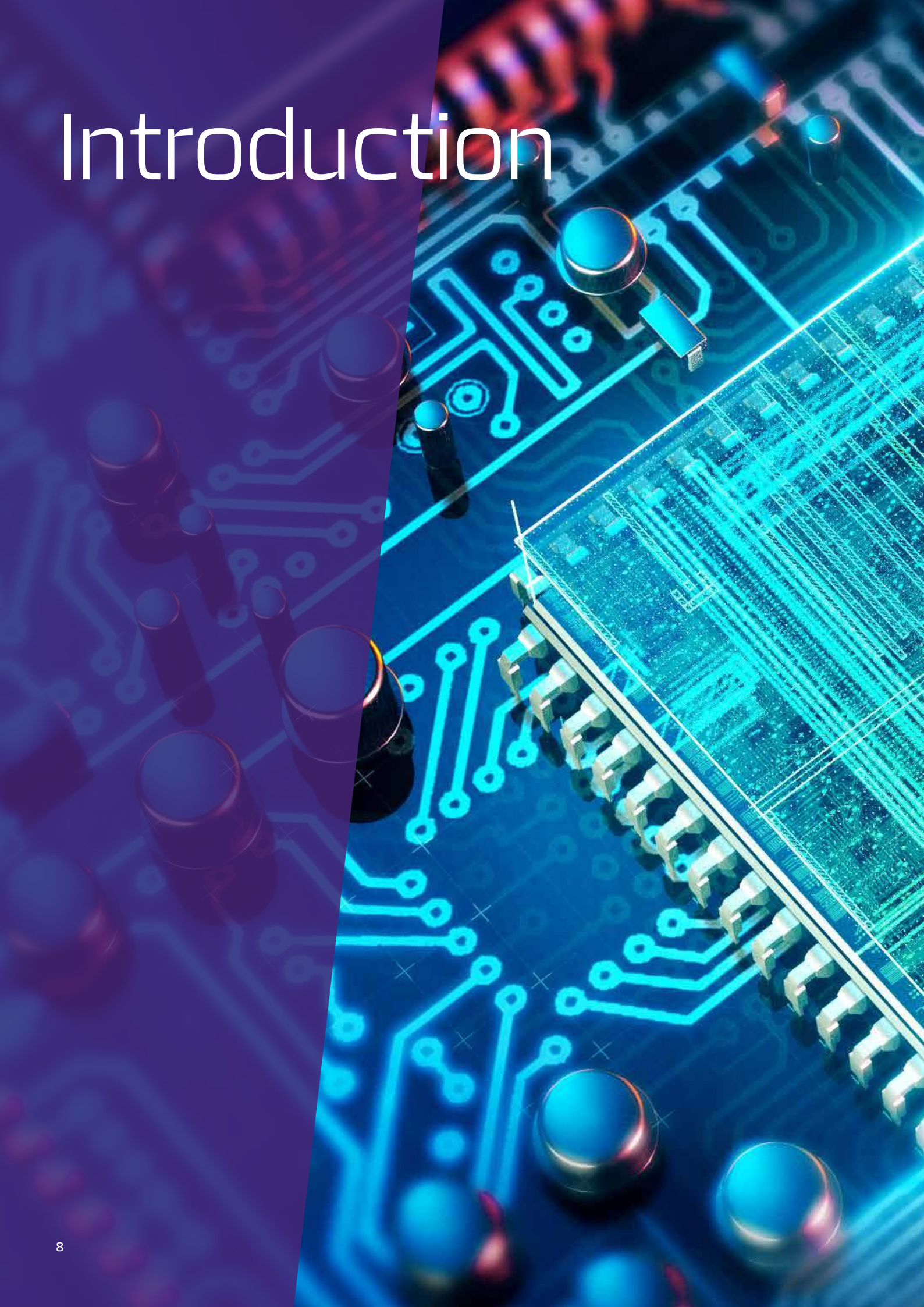
The technology also carries risks however. It may lead to a new wave of cybercrime, as quantum computers can crack even the most elaborate forms of encryption in use today. The implications are significant: sensitive national and commercial data – including anything shared over networks and in the cloud – will become highly vulnerable to cyber-theft or sabotage. Government intelligence, digital payments, blockchain transactions, people's health records, the electricity grid and other essential national infrastructure could all be at a significantly higher risk of a breach once quantum computing becomes widely accessible.

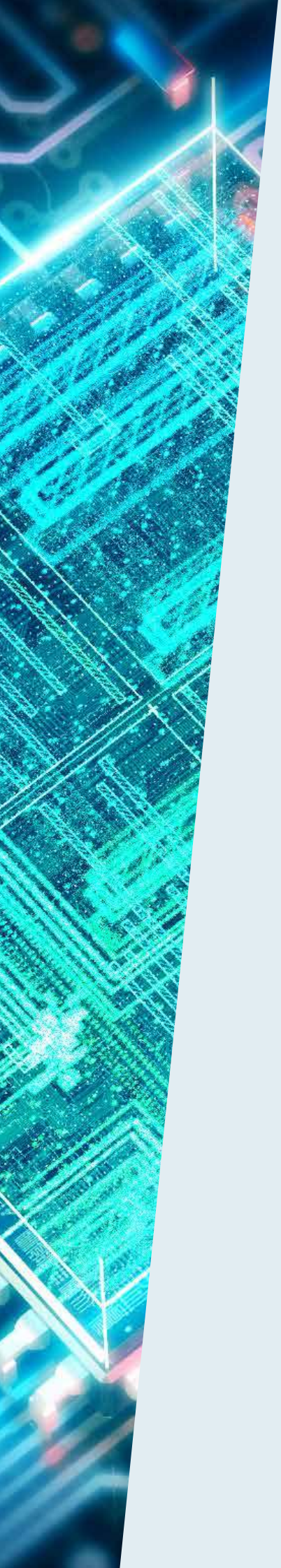
Other challenges relate to the relative speed with which respective governments and economies will be able to exploit quantum computing to support and protect new opportunities for economic growth. Many of the world's largest economies, including the US and China, are already investing heavily in quantum computing capabilities. Countries such as Russia and Australia have strategies in place to develop initiatives and nurture relevant talent. Others that do not keep pace might find that they are never able to catch up.

It will take time to grasp, shape and formulate strategies for the opportunities and challenges created by quantum computing, so planning must start now.

This paper assesses the potential impact of quantum computing, detailing expected opportunities and specific risks. It then drills down into the technology's specific relevance to economic and national security priorities in the Middle East. The paper concludes by describing the practical measures that Gulf nations will need to take to capitalise on quantum computing in their own economies – while simultaneously protecting their interests against the potentially significant security risks that are likely to emerge.

Introduction





Quantum computing represents a sweeping technological breakthrough that is set to change in the next few years so much of the way we work and interact. Its disruptive potential exceeds that of the internet, smartphones and cloud computing combined, and the way governments and economies operate will be radically and fundamentally altered.

It is computing itself that is the subject of this transformation. Quantum computers are able to perform complex calculations at 100 million times the speed of current computers.

When combined with other advanced technologies – Big Data analytics, artificial intelligence/machine learning, the Internet of Things (IoT) and cloud computing – the potential to accelerate discovery and innovation in almost any field of knowledge is beyond anything conceivable today.

The ramifications of all this are both exciting and frightening. The technology has the potential to bring major breakthroughs in medicine, energy exploration, space engineering and in many more areas. But it will also render existing forms of national security, including cyber-security, obsolete as the scale, speed and sophistication of malicious code-cracking outpaces current approaches to network and data protection.

These considerations should be creating a growing sense of urgency as quantum computing is approaching its breakout from the lab into the outside world. In May 2018, Forrester Research[1] predicted that the technology would 'take off' within the next two years, and governments in major world economies are now actively planning for it[2].

The investment in quantum computing research should be a feature of all national strategic agendas and this is particularly the case in the Middle East, where research budgets are relatively modest yet the rewards of early investment could be considerable. The potential benefits fit with the region's long-term economic plans, and the necessity to stay ahead of new threats to national security.

Chapter 1

Quantum computing: opportunities, risks and reality

What is quantum computing and why is it important?

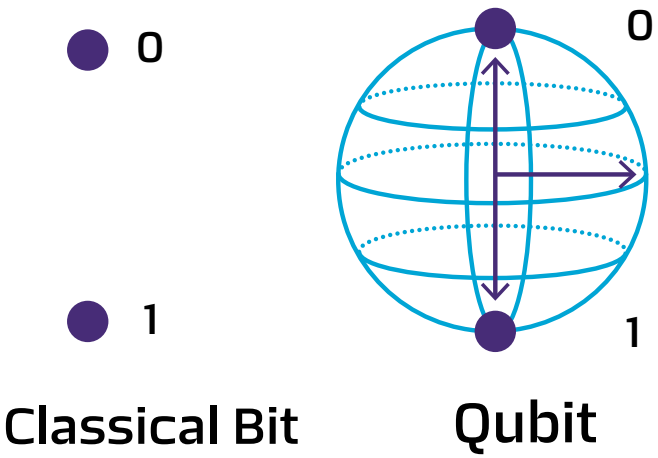
To non-mathematicians, quantum computing is best explained in relation to the traditional binary computing that is in use today.

Quantum computing's significance lies in its ability to comprehend and simultaneously consider an infinite range of scenarios[3]. This isn't possible in current computing, where at any given point a value can only be either 1 or 0, black or white, true or false.

Quantum computers, by contrast, can cope with values that are 1, 0, both, or somewhere in between: a grey scale[4]. (See Figure 1 for a visual representation of a quantum computing bit, or qubit, contrasted with a classical binary bit.) This makes it possible to perform infinite combinations of calculations and consider all options at the same time; that is, to crack codes and distil complex insights in minutes rather than months or years. As a result, its powers of problem-solving and prediction will exceed anything seen so far[5].

Figure 1

A quantum computing bit is not restricted to the values/possibilities it can hold



The global quantum-computing market will be worth $1.9bn in 2023, increasing to $8bn by 2027[6], in spending on associated software and services.

– Communications Industry Researches (CIR)

Expectations for the technology are unsurprisingly high. Communications Industry Researchers (CIR) estimates that the global quantum-computing market will be worth $1.9bn in 2023, increasing to $8bn by 2027[6], in spending on associated software and services. Other estimates are in the same ballpark for the next decade[7] but it will take time to develop software that is optimised to exploit quantum computing's power.

Right now, the first quantum computers are being tested and tech giants including IBM, Microsoft and Alibaba are working on how to blend the technology with cloud services in order to open up commercial access to the technology. Meanwhile, Google is looking at how to make it easier for developers to create software. Its Cirq open-source toolkit will allow algorithms to be created without a background in quantum physics[8]. Start-ups are getting in on the action, too. Canadian company D-Wave Systems aims to get quantum computing up and running in the public cloud[9], while California's Rigetti Computing is combining quantum computers with classical ones in a new cloud service.

Broad implications

Both the opportunities and threats associated with the technology come from quantum computing's ability to perform infinite complex calculations or analyses simultaneously, slashing through the steps and time these take at present.

To detect fraud, decipher data encryption or sequence human genomes, even the most powerful supercomputers or cloud-based data-analytics services today have to perform series of calculations over a long time. Quantum computing holds the promise of quickly finding answers to some of our most pressing scientific challenges, such as modelling oceans or space, genome profiling and finding treatments for disease.

It carries the potential to achieve important scientific advances at a pace never experienced before.

If the power of quantum computing is combined with Big Data and AI-enabled analytics it becomes possible to see how computers might take over patient diagnosis – instantaneously able to compare a current patient's symptom profile with a global case archive going back decades. Passenger and commercial traffic might be modelled and optimised in real time across high-density cities and commuter belts. Supply and demand for energy generation might be better balanced, while costs are controlled and yields boosted.

But with these extraordinary opportunities comes new levels of risk. Up to now, it has been sufficient to generate new forms of encryption at regular intervals to stay one step ahead of professional hackers and cyber-terrorists. By the time criminals had cracked the old code, a fresh algorithm would be in place. But in the era of quantum computing, this strategy for fighting cybercrime will no longer hold; criminals could unravel even the most complex encryption as quickly as computers could generate it. Critical infrastructure, data, communications, transactions, cryptocurrency and blockchain[10] activity could all suddenly become vulnerable; and to counter these threats national governments must urgently engage in pre-emptive programmes of investment, collaboration, research, experimentation and skill-building.

Quantum computing: a timeline

Although analyst firms and technology visionaries have differing views on how soon quantum computing will be widely in use, the consensus is that this isn't far away. Forrester believes there will be significant activity within two years[11]; IBM says five[12].

Bringing commercial offerings to the cloud is more complicated for a variety of reasons, including quantum computing's implications for data-centre temperature control and the cost of providing the technology[13].

But governments and other organisations can't wait until quantum computing is already being commercially harnessed: it will be too late to develop a strategic position and investment plan.

The only sure way to keep pace with this rapidly evolving technology field is to start formulating plans and alliances now.

Global opportunities: likely applications and early test cases

Quantum computing will pave the way for numerous important breakthroughs across many industries (see Figure 2).

But it is only as exciting and disruptive as the applications it facilitates. This will include anything harnessing artificial intelligence, such as using machine learning[14] to turn vast amounts of otherwise impenetrable data into actionable insights. Huge strides are already being made on existing supercomputers but these advances could be accelerated and applied to more complex sources such as detailed images or video.

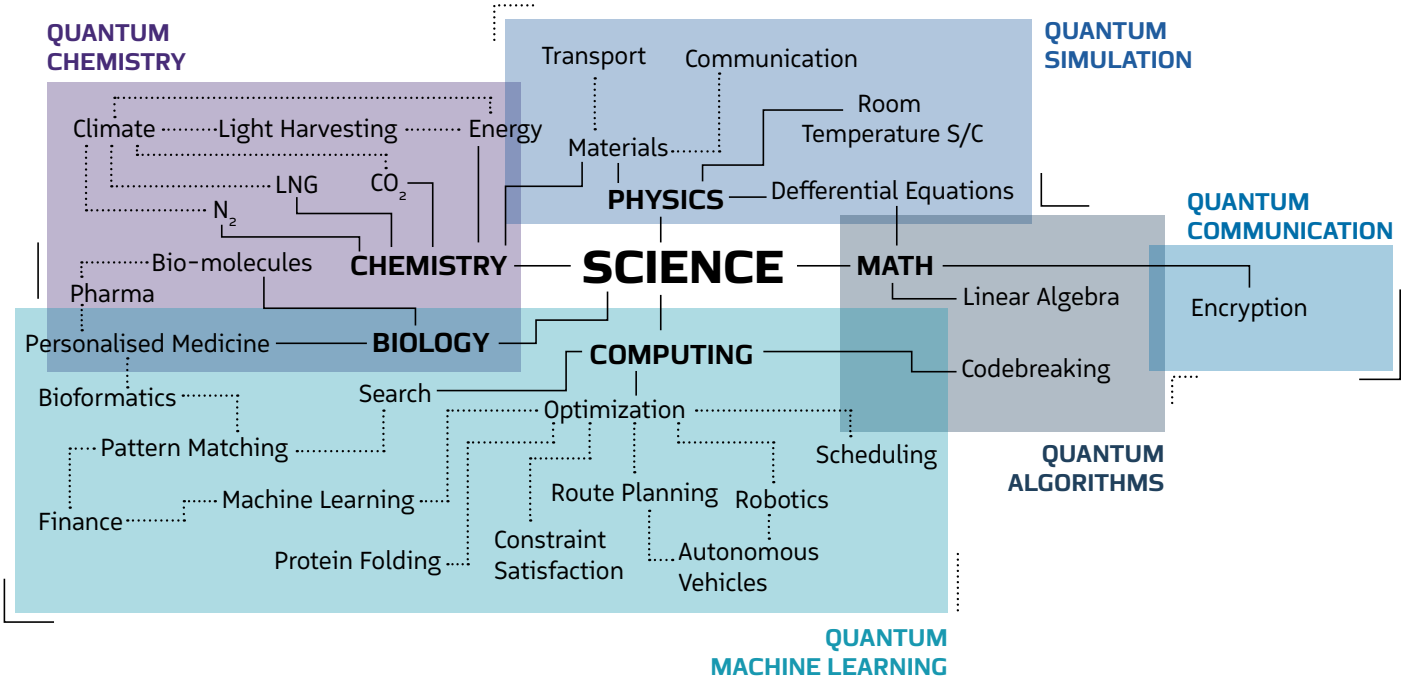


Figure 2

Potential applications for quantum computing (Source: Quantum Computing Market & Technologies – 2018-2024, Industry 4.0 Market Research,a division of HSRC, February 2018)

Scientific discovery

The most obvious applications for quantum computing, particularly in the short term, are scientific.

The ability to condense decades or even centuries of number-crunching into minutes is tantalisingly appealing to the scientific community, to governments and to the engineers who have brought quantum computing to its current point.

Tackling some of the biggest questions and challenges in the universe is also a powerful way to show what's possible with the technology.

In the field of medicine, Case Western Reserve University in Cleveland, Ohio in the US, has partnered with Microsoft to advance magnetic resonance fingerprinting[15] and to hone and accelerate the detection of tumours on MRI scans using quantum computing-inspired algorithms. Meanwhile the ability to model diseases such as dementia using historical and current data and/or by mapping the entirety of a patient's brain activity in real time[16], will also bring the chance of significant clinical breakthroughs closer.

The implications for drug research[17] are profound, specifically the opportunity to perform highly advanced data modelling, for example molecular comparisons, and hypothesis testing at record speeds.
The largest collection of quantum-computing algorithms to date is thought to comprise those that simulate complex chemistry and physics problems. Initial chemistry-oriented projects[18] are likely to involve simulation of small molecules and atoms, before tackling bigger feats such as modelling photosynthesis and improving catalysts for making renewable fuels.

In physics and engineering, quantum computing could help answer 'impossible' questions about the origins of the universe[19] and time, and accelerate rocket science and space analysis[20].

Similarly, quantum computing promises to help speed greater understanding of our oceans, climate and weather modelling[21], and bring more accurate and timely forecasting of natural events such as earthquakes and tsunamis.

Quantum computing has a lot more to offer financial services than a means of shoring up defences. Combined with AI, it also paves the way for faster and smarter optimisation of portfolios and investments.

Security

In the field of security, quantum computing's instantaneous analytics potential in highly complex scenarios offers a chance to identify and fend off new threats.

Provided that cyber-terrorism and cybercrime prevention teams have access to these capabilities ahead of those with malicious intent, the chances for combating next-generation cyber-warfare are strong.

Among the latest threats seen by governments and national organisations are instances of machines being hijacked for their computing power to mine cryptocurrencies[22]; election rigging[23]; and cyber-physical attacks (attacks on power grids[24], aircraft[25] and more) – on top of increasingly sophisticated and devastating ransomware attacks and breaches of sensitive data.

Quantum cryptography[26] is one area attracting early interest as organisations strive to stay ahead. By implementing 'quantum-safe' security solutions, quantum cryptographers will be able to encrypt their data to a new, hyper-resilient degree – far exceeding the level of protection offered by traditional cryptographic methods. As well as protecting data from real-time hacking, such approaches will also provide defences against a 'download now, decrypt later' approach – where criminals capture stolen encrypted information to decipher at a later point – for instance, when next-generation technology becomes available.

Financial services

As the financial services industry enters its next phase of transformation, prompted by developments including open banking and cryptocurrency, there is pressure both to innovate with new services and to intensify security measures. Braving uncharted territories, and with a more proactive approach towards fraud detection, there is demand for new capabilities. Quantum computing – once commercialised and made available via the cloud – will be an important resource for financial institutions and their ecosystem partners as they strive to maintain both control and service differentiation.

Market intelligence firm IDC highlights opportunities via quantum computing to provide new levels of protection to secure communications, as well as highly sophisticated random-number generation, supporting user authentication and the latest forms of online and mobile payments[27].

But quantum computing has a lot more to offer financial services than a means of shoring up defences. Combined with AI, it also paves the way for faster and smarter optimisation of portfolios and investments – and this potential has already drawn the interest of Barclays and JPMorgan Chase[28]. This in turn could force existing institutions to create new ways of differentiating their services. It could also be used to drive higher quality customer service while simultaneously reducing banks' risk. Example use cases include smarter trading[29] and streamlining of the lending process.

Infrastructure/utilities planning and optimisation

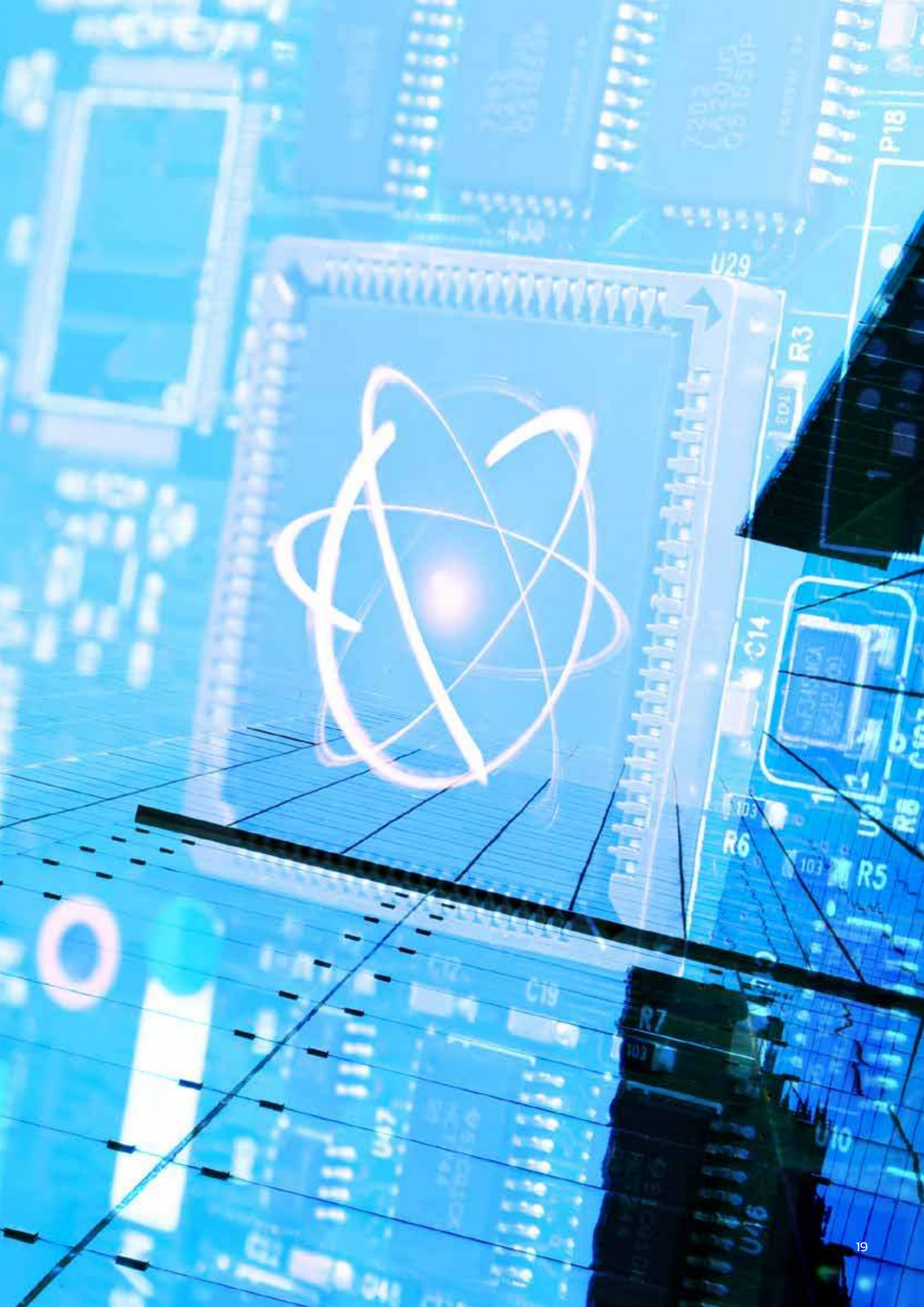
Economic constraints and growing populations continue to place pressure on national infrastructure, from utilities and communications to highways and transport systems.

Quantum computing offers governments and national service providers opportunities to plan and optimise facilities, resources and capacity, and manage demand in increasingly smarter ways

For instance using live data feeds from cameras and IoT sensors. It is no coincidence that Alibaba is making parallel investments in quantum computing and AI chip technology for IoT applications[30].

In the US, Cheniere Energy is working towards predictive maintenance, and optimising maintenance and repair work to prolong the life of assets, avoid unexpected downtime and reduce costs[31]. The company, which processes liquefied natural gas, uses IoT sensors to monitor its physical pipeline assets in real time.

Smart planning is also seen as the key to meeting targets on clean energy and optimising utilities to improve the efficiency of urban systems and the environment[32]. Quantum computing could accelerate advances by enabling authorities to manage resources and capacity more intelligently. In live situations, meanwhile, quantum computing could enable new ways to manage crowd control and traffic flow, especially in a future of autonomous vehicles, to keep people moving safely at peak times.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Any government strategy for quantum computing must be as comprehensive in its risk-prevention measures as in its fostering of national capability advancement and economic development.

The darker side of quantum computing: risks and challenges

While quantum computing has immense potential as a force for good, it also poses a considerable risk in the wrong hands. As successfully as subject experts and innovators might progress world knowledge and prevent future disasters, criminals and cyber-terrorists with access to equivalent facilities and skills could use the technology to instigate security crises, generate fear and frustrate positive progress.

Given that quantum computing's big selling point is its ability to cut through complexity and crack impossible problems instantly, the risk for security teams is that even the most seemingly impenetrable encryption measures could be deciphered immediately, rendering most if not all current approaches to cyber-security worthless.

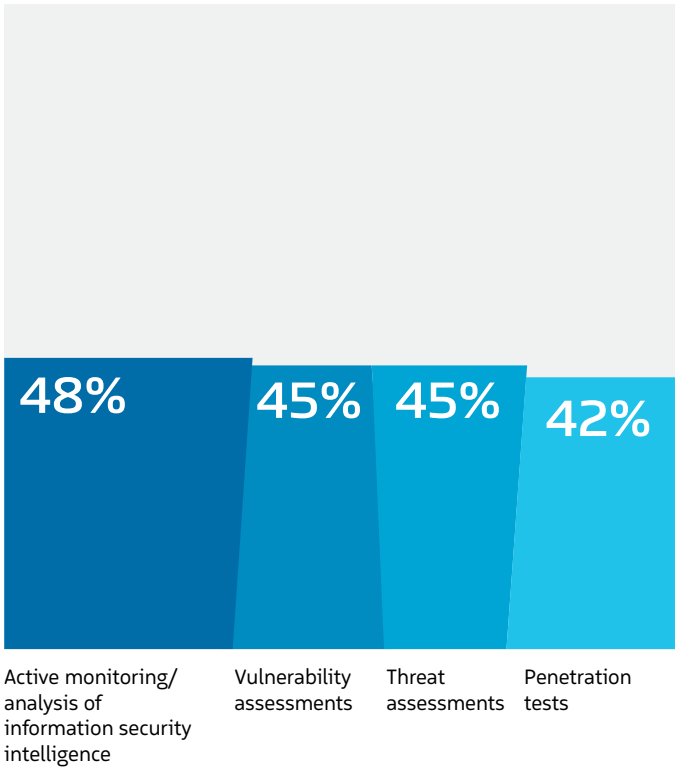
As transactions increasingly move through digital channels, and as cryptocurrencies rise in popularity, the sense of financial risk becomes even more acute[33].

For this reason, any government strategy for quantum computing must be as comprehensive in its risk-prevention measures as in its fostering of national capability advancement and economic development.

In a public forum discussion about the implications of quantum computing for business in May 2018[34], Arvind Krishna, IBM's director of research, claimed that quantum computers will be able instantly to break the encryption of sensitive data protected by today's strongest security. He said this could be a reality within five years because the technology is progressing so quickly. He advised that anyone wishing to keep data protected for longer than 10 years should lose no time in adopting alternative forms of encryption. Research by PwC confirms a general lack of preparedness for new forms of threat[35] (see Figure 3).

Figure 3

Less than half of survey respondents have adopted many of the key processes for uncovering cyber risk. (PwC Global State of Information Security® Survey 2018 – based on interviews with 9,500 executives across 122 countries.)



Although this may sound alarming, technology leaders are already ahead of the game, with priority projects dedicated to developing 'post QC' security alternatives. Microsoft, for instance, is involved with the US National Institute of Standards and Technology (NIST) Post-Quantum Project and has a team working with academia and industry on four candidates for cryptography systems that can withstand quantum-computer capabilities[36]. Post-quantum cyber-security is the subject of detailed research by universities around the world, too[37].

Chapter 2

Quantum computing in the Middle East: assessing emerging opportunities and challenges

The global response

Globally, activity and commentary around quantum computing has gained momentum in recent years as the tech giants vie for early dominance and national governments begin to appreciate the growing urgency and start to build serious strategies.

From Russia to China, Australia and the US, major economies are taking high-profile steps.

The Russian Quantum Centre (RQC), a non-governmental research organisation, currently has 12 active laboratories equipped to the tune of $9m, according to a May 2018 review of the facility[38]. It has been proactive in commercialisation of its innovations, having launched six hi-tech start-ups to date. In association with PwC, the Centre is working towards commercialising quantum information-security systems that will ensure the maximum protection from cyber-attacks[39]. Meanwhile specific developments are underway to establish a quantum network to transfer interbank data. The three-year project, announced in 2017, involves quantum key-distribution technology[40] and will enable communication through secure channels between organisations[41]. Quantum key distribution enables two parties to produce a shared random secret key – known only to them – which can then be used to encrypt and decrypt messages.

Meanwhile, China is building the world's largest quantum research facility on a 37-hectare site in Hefei, Anhui province[42]. In Australia, the government pledged AU$26m three years ago for the development of quantum-computing technology as part of the National Innovation and Science Agenda (NISA)[43]. And the US is investing heavily not only in underlying technology and experimentation, but also in strategic business relationships[44] and skills development[45] to secure and maintain a lead in Silicon Valley and beyond.

Elsewhere, the UK government has recently confirmed £20m funding for businesses and researchers to pioneer the use of quantum technologies[46]. And Europe as a whole has launched a billion-euro, 10-year Quantum Technologies Flagship project to progress and exploit advances in sensors, communications and computing[47].

The Gulf nations have been slow starters

Up to now, the Middle East – without the population and national research budgets of the global superpowers – has only partially addressed the potential for innovation in this field.

In the early stages, this position was prudent but as chips advance and the computers of the future take shape, governments in the region must formulate strategies and align themselves with the right partners. If they do not, they risk missing out on the many advantages that will be on offer across every sector, and they will face an increasing threat if they fail to plan for the next generation of cyber-security.

Among the many considerations for the Gulf nations will be the availability of relevant skills. Quantum computing is so complex, and under-represented in academia, that recruiting experts in the technology and its application poses a challenge.

Building up knowledge and specific skills in the field, along with preparing defensive post-quantum-computing cyber-strategies, can be considered urgent priorities.

Specific opportunities in the region

Above all, there is an urgency because quantum computing has so much to offer the region.

Opportunities range from improved optimisation of oil supplies and honed national intelligence to future-proofed national security and diversification into new industries.

Energy exploration and production efficiencies

Oil and petrochemical industries have long been a mainstay of Middle East economies and quantum computing, with its support for advanced, high-speed analytics at mass scale, presents opportunities for nations to hone oil exploration, optimise supply and demand, drive down costs in the production/supply chain and increase margins. BP has suggested there may be a surge in spending on oil and gas analytics to almost $20bn by 2019, from $4.3bn in 2014, as companies strive to be more efficient in their production activities, enabled by technology[48].

In one example, Petroleum Development Oman has installed sensors inside components across its 10,000 oil wells – alerting teams to the state of reservoirs, enabling timely, informed production decisions and boosting output. Quantum computing could make it possible to analyse this huge quantity of data at an unprecedented speed and provide new levels of insight in real time.
Quantum computing's scope for heightening security also offers a means to safeguard supply by proactively heading off any attempts at sabotage or system hacking.
An early indication of what's possible may come from the water industry. The Dubai Electricity and Water Authority (DEWA) has begun working with Microsoft to develop quantum-based solutions to address energy optimisation and other challenges[49]. It is the first organisation outside the US to participate in Microsoft's Quantum programme. As part of the arrangement, Microsoft will work closely with DEWA to identify the challenges where quantum computing will have the greatest impact.

Quantum computing could also help Gulf nations assess and maximise renewable energy potential as the region looks to play its part in tackling climate change. The International Renewable Energy Agency (IRENA) notes that in 2016, $11bn was invested in renewables across the Arab region – a nine-fold increase in just eight years – and that several countries in the region are now among the global frontrunners in renewable energy development, particularly solar power[50].

Knowledge industries

Quantum computing also holds promise for other economic priorities in the Middle East as countries seek to reduce their dependence on oil[51]. Dubai is setting out its stall as a technology hub for the region, fostering start-up activity to encourage local innovation. According to market intelligence firm CBInsights, start-up investment in the UAE exceeded $1bn in 2016, a year that also saw a 45 per cent increase in the number of privately owned start-ups that received equity funding in the country[52]. According to the UAE's Minister of State for Artificial Intelligence, science and technology will have the greatest impact on the region in the future[53].

If the region does succeed in taking a sizeable interest in quantum computing it could seize a share of a potentially huge future market while creating a talent pool that is currently lacking, both regionally and globally.

This would also put the Middle East in a strong position to capitalise on other emerging technologies that promise to transform economies, such as smart city developments. In 2018, Abu Dhabi was ranked top of a list of cities in the Middle East and Africa by the McKinsey Global Institute in its study Smart Cities: Digital Solutions for a More Liveable Future, which highlights urban ambitions in the region[54].

Meanwhile the UAE has said it wants 50 per cent of government transactions to use blockchain platforms over the next three years, with a view to generating savings of around $3bn. A large proportion of these savings are expected to come from transforming operational costs and increasing productivity in the federation's energy sector[55]. An investment in quantum computing would be important to keep ahead of any security issues related to blockchain, while the high-speed, vast-scale analytics enabled by quantum computing would help to hone efficiencies via optimisation of supply and demand.

Telecoms and digital media

Any ambitions for making more strategic use of technology place increasing importance on communications networks and bandwidth. Quantum computing's potential in the region will rely on network capacity, performance, reliability and security. Investment in these areas will also of course help to promote the rise of quantum computing through real-time resource and service monitoring and optimisation[56].

Financial services

The Middle East's fintech ambitions[57] will also be well served by an early plan for quantum computing. The UAE has been active in this area with its introduction of e-banking, e-dirhams, online platforms and other initiatives. An early position on quantum computing will assist plans to hone services and control risk using large-scale analytics at speed.

Region-specific risks and challenges

As noted in previous sections, the risks associated with quantum computing will be linked primarily to any failure to develop a capability, whether directly or via collaboration, in this fast-developing branch of technology. If other nations and/or rogue organisations have strong expertise and access to quantum-computing facilities and Gulf nations do not, the region will find itself at a disadvantage – security-wise and competitively – in its key vertical markets. And as it looks for new efficiencies, productivity, innovation and diversification, the Middle East may struggle to maintain or gain ground if it cannot match other parts of the world for analytics immediacy and precision.

Cyber-security attacks on key markets

Where there is success, there is risk – and the Middle East, in common with other international markets, has seen a rise in sophisticated cyber-attacks on its core assets, which potentially threaten economic performance if for example oil production is affected[58].

When PwC surveyed the region in 2016 for security exposure and protection, it found the Middle East to be at higher risk of attack than other international regions, while also being more vulnerable due to gaps in cyber-protection. Some 18 per cent of respondents from companies in the region reported that they had experienced in excess of 5,000 attacks over the period in question – higher than any other region and compared with a global average of only 9 per cent[59]. As an era of post-quantum computing draws closer, there is a growing sense of urgency for government organisations and businesses to adapt their security capabilities so they will be fit for purpose. If other economies are advanced in their efforts, the Middle East could stand out as a comparatively easy target. This could also drive up instances of economic crime[60].

Advanced preparations for quantum computing, however, could provide nations with advanced forensic capabilities so they can pinpoint and avert threats more readily.

Even just showing that countries and organisations in the region mean business and are vigilant about fraud and other economic crime can act as a deterrent.

Skills gaps

Maintaining, sourcing and developing relevant skills is a global issue (see Figure 4), but one that is especially acute in the Middle East. As the region strives for recognition in high-tech, finance and fintech, government agencies and businesses need to ensure they have access to a local talent pool.

As Gulf countries increase their efforts to attract technology talent from around the world[61], they must be able to demonstrate that local ambitions and projects will offer a challenging, motivating and competitive environment – focused on upcoming technologies and with a determination to lead in the field.

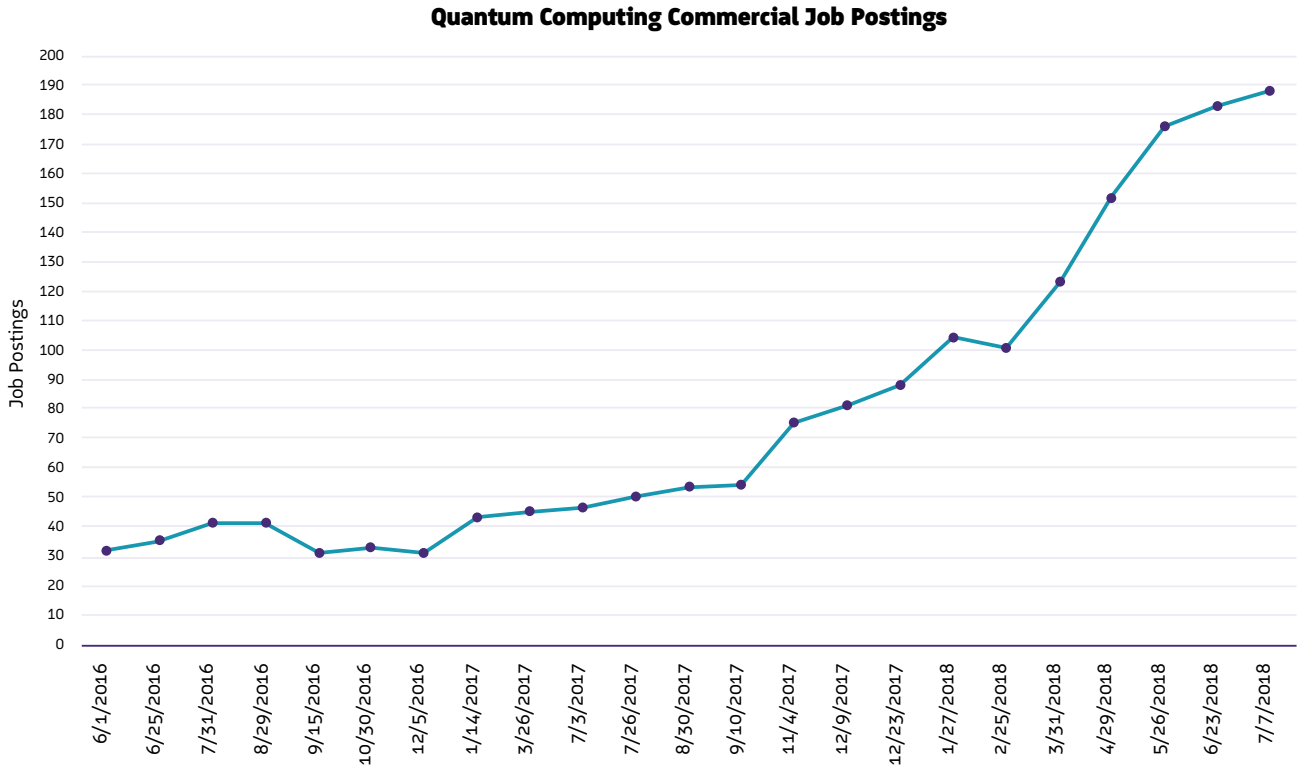


Figure 4

Global job postings indicate a six-fold growth in quantum-computing-related openings between 2016 and 2018 (source: Quantum Computing Report, 2018)

Matching digital advances with data safeguards

'Smart government' and other digital transformation initiatives across the Middle East mean that increasing volumes of sensitive data are being captured, shared and held electronically, rendering them potentially vulnerable to interception.

The UAE now ranks alongside Sweden, outpacing Spain, Canada, Germany, the Netherlands, Estonia, Portugal and Russia, in the smart electronic-services index, according to the UN Department of Economic and Social Affairs[63]. As more sensitive national or commercial information takes digital form, the more critical it is that cyber-defences are fit for purpose.

Peacekeeping

It is worth briefly noting that as long as all nations have equivalent code-breaking and advanced intelligence capabilities, the impact on peacekeeping in the region remains balanced. But as more powerful nations embrace quantum computing, the international landscape will become more complex – and potentially precarious.

Chapter 3

Developing a quantum-computing roadmap for Middle East nations

How then should the Middle East compete with the massive investment deployed in quantum computing by the world's largest economies? The answers are likely to be found in a combination of building awareness, strategic planning and tactical collaboration. Where the readiness gap is already too great or local resources are lacking, Gulf nation leaders will need to look to appropriate partners to help bolster their position.

Proactive networking, education, talent development and policymaking must all play their part.

Currently, the quantum-computing talent shortage is universal. The US's own visa barriers[64] are undermining its attempts to attract foreign experts to its national quantum-computing skills pool. The European Union is seeing a surge in backing for curbs against free movement of people, and that could make skills issues hard to resolve too. At this point, there may be an advantage to be gained if Middle East nations act quickly.

Demonstrating intent

The challenge demands clear leadership. Quantum computing is complex, seismic in its potential and technically and financially demanding. Determined coordination from the front is crucial as nations strive to make the best use of their time and budgets.

Announcements of large-scale funding in other regions have demonstrated commitment to attract talent, start-ups and technology test cases.

Internationally, state-championed competitions have become a popular vehicle for attracting innovation and ideas from across academia and entrepreneur communities.

Major economies such as the US see competitions as a means of accelerating solutions to next-generation cyber-security/post-quantum-computing cryptography[65].

Governments can obviously learn from other countries' initiatives, and combine this with harnessing the insights of independent external subject experts.

Networking and policymaking

Working with universities is an obvious strategy for building knowledge and capability, and for courting next-generation skills. Universities such as Oxford, Harvard and MIT feature among the top 10 leading organisations in quantum computing internationally.

It is also important to consider that, while major tech brands are making a lot of noise about the technology, the majority of active innovators today are SMEs and start-ups (40 per cent).[66]

This is a good indication of the relationships that governments should aim to cultivate.

In developing a plan, governments should seek to convene meetings with representatives from across major industries to establish where specific national priorities lie. Strategies and policies need then to be formulated and progressed – covering everything from potential points of vulnerability and exposure to existing national strengths that can be used as useful foundations. Setting this out up front will allow government bodies to focus initial investment, identify the types of collaboration that will be most beneficial, unlock or expand existing technology potential and ensure that all efforts deliver targeted returns.

Government policies will also have to be explicit about measures to prepare new cyber-security capabilities that stand up in the quantum-computing era and any additional measures that will give countries an edge in the global market.

An international list of government and non-profit agencies that perform research or provide funding for quantum computing, with possible partnership potential, can be found at https://quantumcomputingreport.com/players/governmentnon-profit/[67].

Conclusion: taking up position

Although quantum computing is set to emerge into the real world in a handful of years, it is still for now in its relatively early stages. One of the main opportunities in the short term for nations in the Middle East therefore will be to foster experimentation and encourage the development of potential use cases.

The best chance for local economies to invest wisely, attract the right skills and gain a competitive edge will be if they concentrate their efforts on practical uses for the new technology for the established local energy economy and the region's emerging financial services, high-tech and adjacent knowledge industries such as smart city development. Gulf nations taking action soon definitely have a good chance of exploiting quantum computing to their advantage, and in staying competitive with other regions that until now have taken the lead.

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