

Digital Systems & Technology

## Five Converging Forces that Are Driving Technological Evolution

The digital era is catalyzing business, unleashing technological change that may appear chaotic on the surface but is resulting in massively powerful systems of intelligence that enable humans and machines to collaborate securely.

# Executive Summary

Today's digital age is delivering unparalleled technological innovations in which artificial intelligence (AI) and the Internet of Things (IoT) are combining to make devices and enterprises intelligent, responsive and ever more connected. This is paving the way for organizations to turn insights into foresights, and for senior leaders to make more informed and accurate decisions in real time.

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## Five converging forces that are driving technological evolution

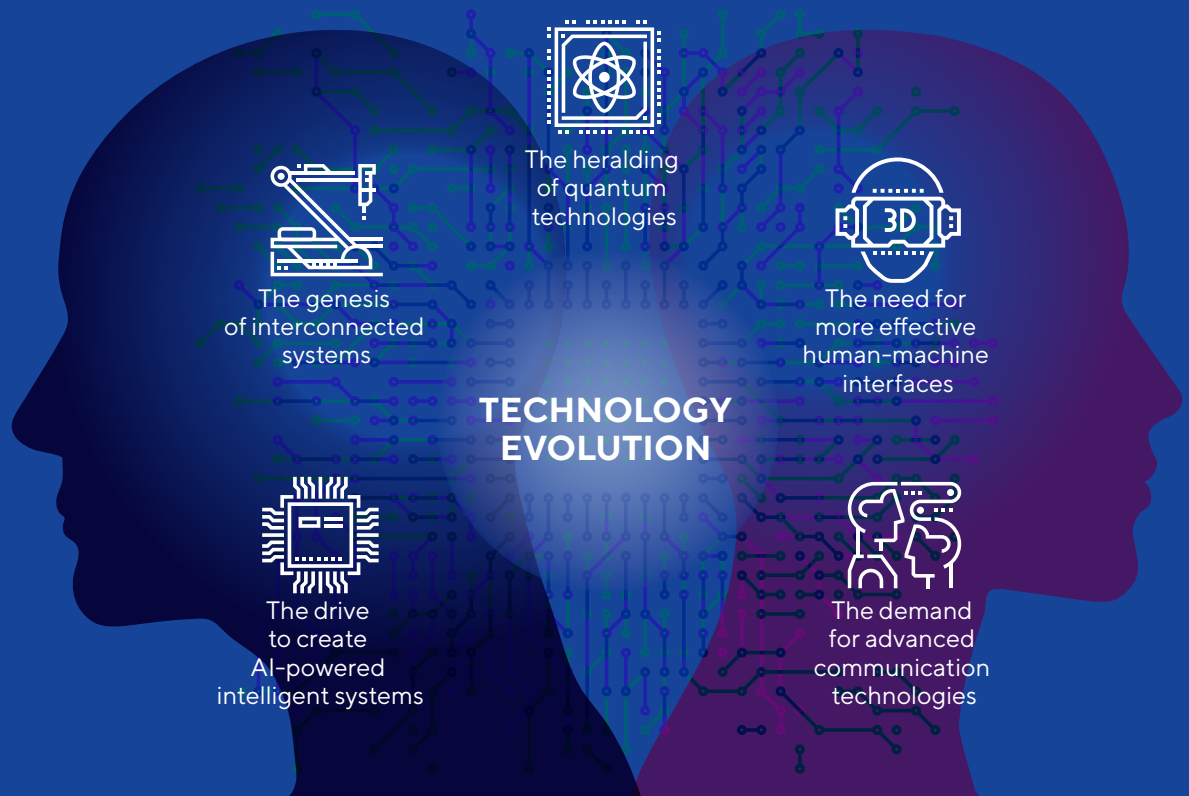


Figure 1

At the same time, new connected ecosystems are emerging that will change the way people, devices and organizations exist, work and interact. Transformative technologies such as 5G networks, interconnected IoT devices, ad hoc and decentralized networks, and collaborative autonomous systems are opening up newer means of communication with large data exchanges. In such scenarios, it is crucial for enterprises to make their systems more secure than ever – not only to guard against threats but also to be compliant with changing regulations that demand secure systems.

This white paper explores five converging forces that are driving the evolution and construction of a new technological future:

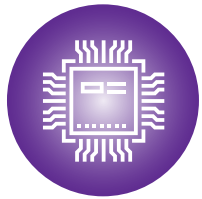
- **Force #1: The drive to create AI-powered intelligent systems pervading almost every existing technology is creating transformational impact.** From robotics to vehicles to application development, the world as we know it is becoming largely autonomous, which will enable enterprises to streamline business processes, transform customer experiences, reduce costs, and drive remarkable growth and profitability. AI will also augment humans, both in the workplace and for personal development. Collaborative robots (cobots) will supersede robots when it comes to human-AI collaboration.<sup>1</sup>
- **Force #2: The genesis of interconnected systems** with computing power located at the network's edge is increasing the power of systems of intelligence, as the data collected by sensors can be analyzed instantly for real-time insights, enabling people, devices and organizations to work smarter and respond faster. This is helping enterprise systems to become collaborative, cooperative and connected, leading to the evolution of swarm intelligence<sup>2</sup> and swarm robotics.<sup>3</sup> This is the next stage of the evolution of autonomous devices that will operate collaboratively, sharing workloads and handling complex computations.
- **Force #3: The need for more effective human-machine interfaces** that can deliver immersive AI-driven, hyper-personalized experiences for users will grow much stronger as such interfaces become key differentiators for companies and individuals alike. Rapid advances have already been made with augmented reality (AR), virtual reality (VR) and

mixed reality (MR), such as AR apps, VR headsets that provide immersive experiences, and Microsoft HoloLens-based applications that blend real and virtual worlds. These technologies are being applied to real-world use cases like product design, healthcare, learning and entertainment, enabling a high degree of immersion in human-machine interactions. This is also fueling a need for more effective human-machine interfaces, which will be taken to the next level as haptics and tactile internet<sup>4</sup> make it possible to extend touch-based interactions over the net.

- **Force #4: The demand for advanced communication technologies** to be the foundation of critical infrastructure needed for a digital smart future is driving the growth of technologies such as 5G and light fidelity (Li-Fi).<sup>5</sup> The new technologies can transfer vast volumes of data at extremely high speeds, revolutionizing the future of intelligent, interconnected systems. Soon IoT-enabled devices will touch every aspect of our physical lives, calling for the transfer of huge amounts of data at very high speeds to build truly connected ecosystems. Although Wi-Fi makes up for 60% of today's global data transfer, it must overcome the lack of persistency among network connections and various security shortcomings.
- **Force #5: The compulsion to go beyond current technical limitations will push quantum technologies to the foreground.** In the fields of computing, sensing, imaging and metrology, quantum technologies are helping us transcend conventional bounds by ushering in new and novel technological possibilities across industries. Quantum's impact on communication security is already visible. Emerging technologies such as quantum key distribution and post-quantum cryptography<sup>6</sup> are set to revolutionize the IT security landscape, forcing business and technology leaders to evolve and reimagine their security strategies. Quantum sensing and imaging technologies are helping us visualize and measure physical dimensions with unprecedented granularity, promising to revolutionize industries like oil and gas, astronomy, optics and others.

Beneath these five forces of change, technologies are accelerating and aligning to make the digital future a near-term reality.

## Force #1: The drive for intelligent systems



The drive to create intelligent systems is not a new one, but it has been vitalized by automation's projected ROI and the advancements in analytics and AI such as machine learning (ML), cognitive computing, smart virtual agents, natural language processing, etc.<sup>7</sup> These advancements have been catalyzed further by companies' aggressive efforts to modernize IT systems, applications and processes, and make them scalable and nimble. This is premised on two key technology trends.

### Advances in automation will push analytics & AI to new heights

The emergence of AI and its varied applications is transforming customer experience in almost every field. Some newer advancements include generative adversarial networks (GANs)<sup>8</sup> which help in simulating visually perceived information; deep reinforcement learning<sup>9</sup> which enables AI to be goal-oriented; and explainable AI<sup>10</sup> which engenders trust and transparency in how AI is applied. All these and others will push boundaries further and create more effective AI solutions to real-world challenges.

## Creating AI-powered intelligent systems

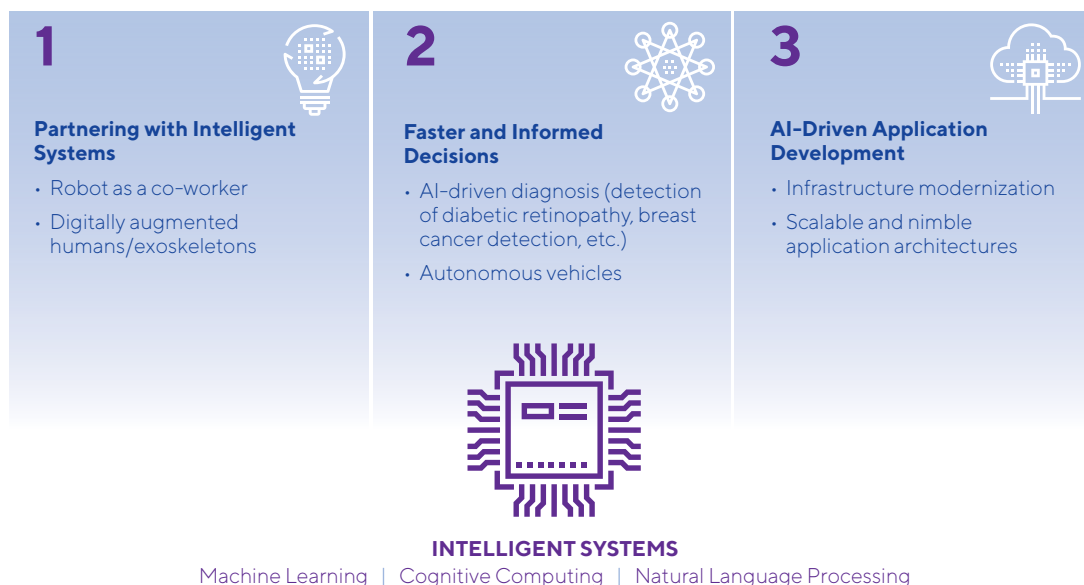


Figure 2



This will help increase quality of life such as in the healthcare field where there have been advances in the detection of diabetic retinopathy<sup>11</sup> and breast cancer.<sup>12</sup>

With analytics and AI redefining human possibilities, human-robot collaboration is set to transform the workforce. Sensors and wearables will make way for exoskeletons,<sup>13</sup> and these will all have a transformative impact on personal growth and quality of life.

The domino effect will accelerate the scale and speed of automation. Industry processes will become more efficient and effective — be it streamlined insurance<sup>14</sup> processes or enhanced regulatory compliance with automated screening of case safety reports.<sup>15</sup>

### **AI-driven application development & infrastructure modernization will increase IT scalability & nimbleness**

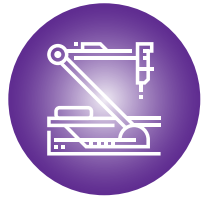
AI will also upend the software development lifecycle. Application development will become increasingly autonomous, leading to the inclusion of non-developers armed with tools and models to rapidly create and deploy new applications, even without knowing how to code. With ML algorithms, application testing will continue to become autonomous and zero touch.<sup>16</sup>

Microservices architectures<sup>17</sup> and containers<sup>18</sup> are being adopted to create and sustain cloud-native applications<sup>19</sup> that will accelerate digital innovation and create more scalable<sup>20</sup> and nimble application architectures. This will empower organizations to shift further to digital, and it will generate business agility and digitization of processes, real-time intelligence harnessing and more efficient IT operations.



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## Force #2: The genesis of interconnected systems



The rapid progression of the IoT along with the need to collaborate and build complex systems of intelligence have been instrumental in the genesis of interconnected systems. The IoT, edge computing and digital twins are driving the initial momentum toward the creation and deployment of cyber-physical systems (CPS; see page 8 for more) with swarm intelligence that operate with a high degree of autonomy. This convergence of IoT, edge AI and digital twins will lead to interlinked ecosystems built on insights.

The IoT is driving massive business change across industries.<sup>21</sup> Countless sensors are being deployed every day and are generating huge volumes of data to be harnessed for gaining actionable insights that will help organizations make better decisions. Some examples include better predictive maintenance, supply chain optimization, hazard detection, fraud detection, remote monitoring of insured properties, remote patient monitoring and driverless cars, among many others.

### Interconnected systems

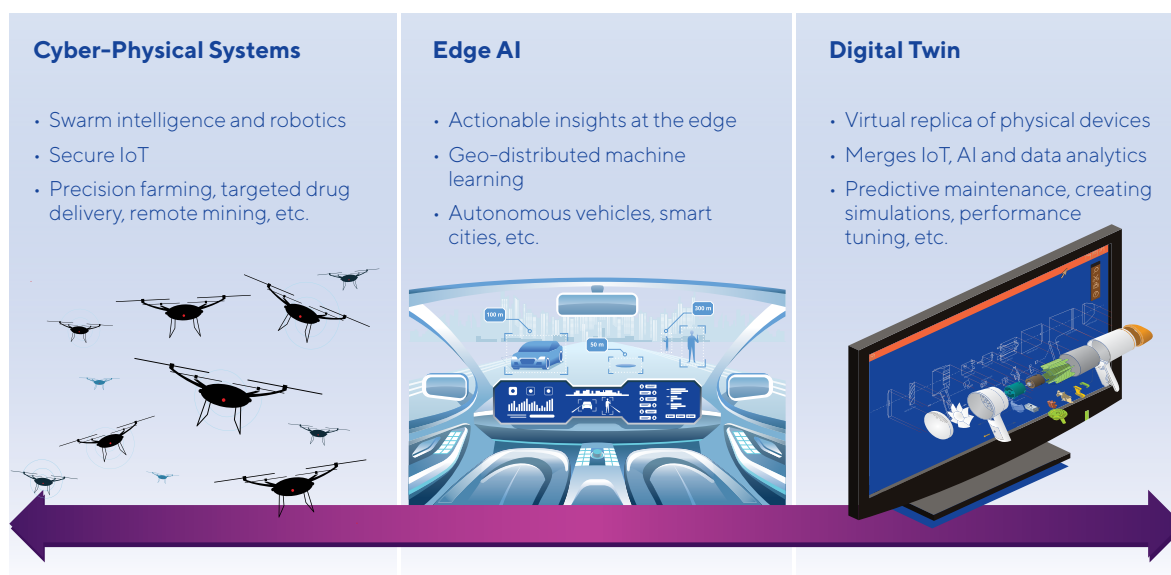


Figure 3

Edge analytics is helping overcome infrastructure limitations and making it possible to equip enterprises with actionable insights right at the bleeding edge,<sup>22</sup> in real time, where data is generated. Geo-distributed machine learning (GDML), or AI on the edge, will help systems tackle the challenges posed by data produced in a geographically dispersed manner. This helps applications to cope with expensive bandwidth requirements between data centers and enables compliance with geographically specific regulations and data sovereignty.

Digital twins are helping<sup>23</sup> organizations compete in a data-driven world where the virtual and physical seamlessly fuse. IoT ecosystems with real-time data and intelligence will help digital twins become more robust and enable enterprises to simulate multiple possibilities and make accurate and timely decisions based on these insights.

### **Cyber-physical systems will emerge as the new systems of intelligence of the future**

New and emerging systems of intelligence that are engineered to seamlessly integrate computational (cyber) and physical components are known as cyber-physical systems (CPS). By functioning autonomously and making decisions based on the insights gathered from their interactions with the physical environment as well as with each other, these systems will deliver enormous change in the quality of our lives and form the basis of new and emerging smart infrastructure, products and services. Multiple CPS are already making an impact, such as smart appliances that help in optimizing energy consumption and enhance home safety by receiving information and generating triggers, smart and connected vehicles that improve road safety by communicating with other vehicles and with their surroundings, and smart robots that help humans perform skilled tasks better such as assisting doctors in surgeries, helping factory workers on the shop floor, enabling logistics personnel handle inventory<sup>24</sup> more efficiently, etc.


Swarm intelligence and robotics is the next frontier for CPS, whereby the power of many combined cyber minds makes the overall system smarter, faster, more insightful and more creative. The key characteristics of a swarm system include autonomy, flexibility, cooperation, scalability and decentralized control. In other words, autonomous robots work toward one goal, and each of the robots is independent but works for all.

For example, swarm robots can enhance robotic endoscopy, by releasing a collection of micro-bots into the bloodstream to detect anomalies, at which point they can be reprogrammed for treatments like sewing tissues, targeted drug delivery, etc.



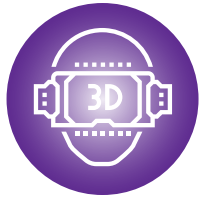
These characteristics are transforming the field of robotics, where physical devices will be used to achieve a desired collective behavior based on inter-robot interactions as well as their interactions with the environment. These swarms are also pitched to achieve tasks that are deemed technologically impossible now (due to the extensive amount of resources required). For example, a swarm of bots in the form of unmanned aerial vehicles can be sent to areas that are rendered inaccessible to humans for locating hazard sources like toxic gas dispersion, pipe leaks and radioactivity. Similar swarms can also be used for surveillance and intelligence-gathering for defense purposes. In the field of agriculture, a swarm of aerial drones can cover large expanses of farmlands to gather information about soil quality and plant health for targeted delivery of resources like fertilizers and pesticides.

Swarm robotics remain in the realm of applied research, but interesting use cases<sup>25</sup> (beyond those mentioned above) are under exploration by academia-industry partnerships.<sup>26</sup>

A futuristic factory floor with numerous robotic arms working on car chassis. The scene is illuminated with blue and green light, creating a high-tech atmosphere. The robotic arms are arranged in a grid pattern, and the car chassis are positioned on a conveyor belt system. The overall image conveys a sense of advanced automation and industrial efficiency.

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## Force #3: The need for more effective human-machine interfaces



In any scenario where the digital meets the physical world, human-machine interaction is critical. More immersive experiences will ensure better acceptance of products, services and interactions with smart machines that will lead to more innovative ways of applying technology. Enhanced human-machine interfacing is being driven by two important technology trends.

### Immersive experiences will be driven by AR/VR/holograms that deliver new virtual and mixed-reality worlds

AR and VR are already transforming the way enterprises and consumers communicate with each other, with branding and marketing being redefined as enterprises deliver highly personalized experiences<sup>27</sup> devoid of spatial limitations. Virtual showrooms can be created with the help of VR headsets, which will give customers a lifelike tour of products ranging from cars to home interiors. Training and learning will also be

### Immersive experiences

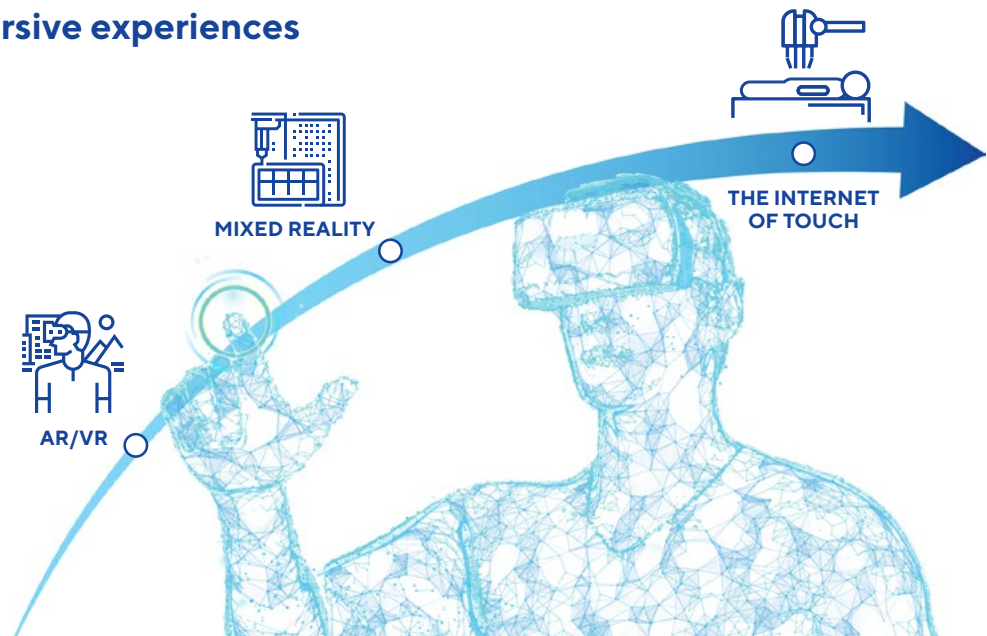


Figure 4

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transformed, given the ability of AR and VR to deliver more immersive visualizations. And entertainment will have a whole new dimension of immersion by allowing individuals to be participants in movies or games rather than just experiencing them on screens.

Intelligent holograms<sup>28</sup> will empower employees to collaborate across geographies and work in a smart shared environment. The increasing portability of holographic technology and the inculcation of AI into the creation, transmission and reception of holograms are enabling industries to make use of stagecraft blended with enhanced usability. This will have an impact on multiple industries.

In the medical industry, holography can help doctors prepare for surgical operations better by recreating human anatomy in 3-D. It will facilitate product design and development with experts across geographies collaborating on holographic models that realistically render product visualizations. A 3-D model can be hosted on the cloud and worked on simultaneously by designers at remote locations. Creating 3-D holographic displays of products in the retail space can help propel the sales process in real time. Holograms enable highly immersive interactions for businesspeople attending meetings or engagements with large consumer crowds. Some examples include Ralph Lauren's holographic fashion show,<sup>29</sup> the virtual performance by K-Pop,<sup>30</sup> musical holographic performances at the Billboard Music Awards,<sup>31</sup> etc.

The key in making these immersive experiences impactful is the application of AI and ML. A critical hurdle is to ensure that the rendering of full-field simulated environments and the realism of the AI/ML-augmented experiences can compensate for errors and incomplete data streams that often occur in real-world situations.

## The internet of touch is poised to recalibrate interactions

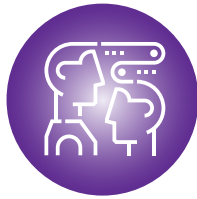
The so-called tactile internet will allow enterprises to innovate by extending human touch-based online interactions,<sup>32</sup> thereby opening up an endless range of possibilities across healthcare, manufacturing, education and other industries.

Haptics is widely used in tele-robotics, making it possible to provide remote consultation, treatment and even surgical operations.<sup>33</sup> It will have a transformational impact in training by enabling medical students to hone delicate computer-enabled surgical operations with the touch and feel of a human being. Although this development comes with complex hardware and software requirements,<sup>34</sup> it has the potential to reinvent how we live, work and play.

When fully realized, the tactile internet will forever change how we interact, communicate and reach out. Healthcare would no longer be location-dependent, remote mining and operations would be possible in high-risk areas, and hands-on learning and training would acquire a whole new meaning as the learner and the trainer can interact (through haptic sensors and actuators) as if they were co-located.

However, technological developments at both the network and application levels will be required to turn lofty concepts into tangible reality. This includes the emergence of 5G for efficient data transfer along with other technologies such as robotics, AR and VR — as well as automation and AI deployed at the application level.

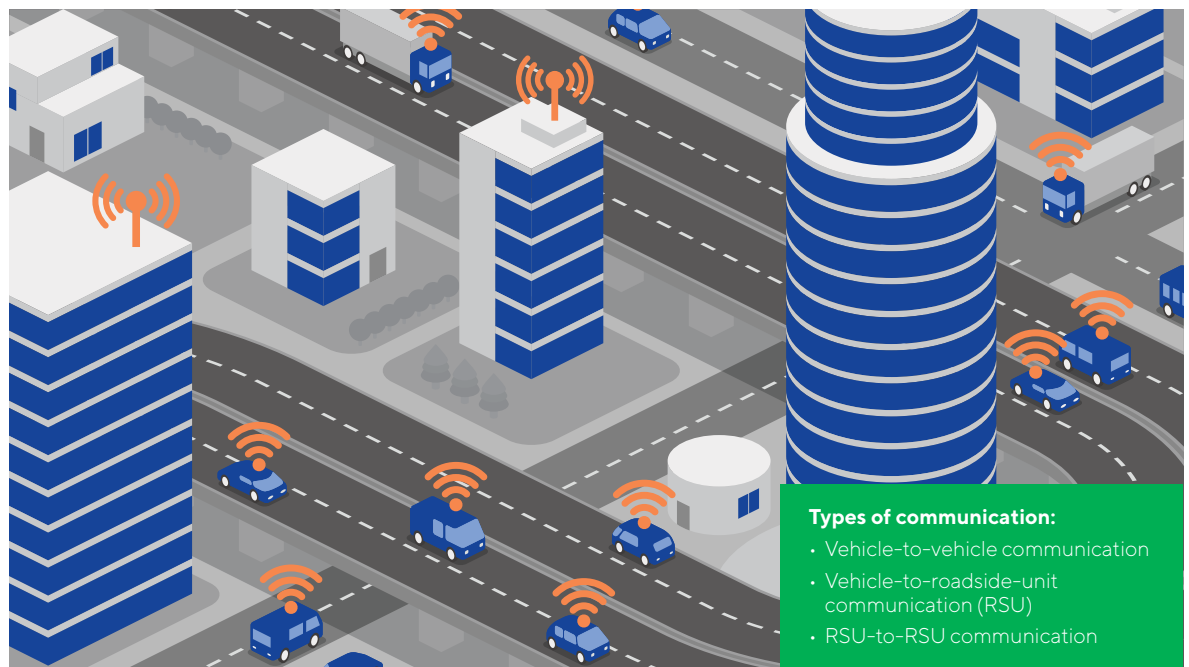
## Force #4: The demand for advanced communication technologies



The aforementioned forces require advanced communication technologies. Given the large amounts of data that will need to be rapidly transferred across numerous data-generating and data-consuming systems, the future will require a vast increase in the effectiveness of communication technologies.

New communication technologies such as 5G, wireless ad-hoc networks,<sup>35</sup> VANET,<sup>36</sup> etc. are emerging to improve the network infrastructure and advance communications. It is only after these become a reality that a more intelligent, interconnected world will be achievable. Two key developments will make this possible.

### Vehicular ad hoc network (VANET)



**Types of communication:**

- Vehicle-to-vehicle communication
- Vehicle-to-roadside-unit communication (RSU)
- RSU-to-RSU communication

Figure 5





5G will be a game changer for broadband experience by adding huge amounts of bandwidth beyond existing LTE networks. It will reduce latency and improve connection density by almost 10 times.

### **5G, ad hoc networks and VANET will power distributed data sharing and communication across connected systems**

The emergence of intelligent interconnected systems calls for seamless and swift data-sharing. 5G, which has been in development for nearly a decade, is set to make its debut very soon. 5G brings to the table low network latency, extreme flexibility and cost efficiency, and it promises to change the way we interact with information and entertainment services via a panoply of devices.

5G will be a game changer for broadband experience by adding huge amounts of bandwidth beyond existing LTE networks. It will reduce latency and improve connection density by almost 10 times.<sup>37</sup> 5G will play a significant role for autonomous vehicles, IoT devices and remote operation of machines, ranging from remote surgical operations to controlling heavy machinery in high-risk hazardous environments.

Given the huge surge in portable devices, wireless ad-hoc networks are emerging as a transformative field of communication. Mobile ad-hoc networks (MANETs) enable movable devices such as smartphones, sensors and laptops to communicate and collaborate with each other and offer network capabilities. Vehicular ad-hoc networks (VANETs) are expected to be the next frontier for the automotive industry and to be the key in the evolution of next-generation intelligent transportation systems (ITS) aimed at improved safety, traffic efficiency and driver experience.

In communication systems, the privacy and authenticity of information is of utmost importance, and should not be overlooked. We have engaged in a collaborative research with CSIR-CEERI Pilani<sup>38</sup> on VANET security. Conducting such research agendas is critical for industries to address key security standards.

### **Light fidelity will inch closer to meaningfully bring data wherever there is light**

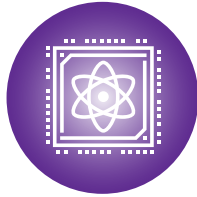
With growing concerns around wireless data transfer, the emergence of Li-Fi,<sup>39</sup> which uses light to transfer data, could unlock new communications modalities. Li-Fi can transfer 200-plus GB of data per second, making it 100 times faster than traditional Wi-Fis. Since Li-Fi signals cannot pass through walls, data transfer becomes more secure and contained within walls.

Li-Fi transmits data over visible light, ultraviolet and infrared spectrums, as compared to Wi-Fi which uses radio frequencies for data transmission. In sensitive areas such as operating theaters, aircrafts and power plants, where Wi-Fi is not best suited due to radiation concerns, Li-Fi can be an alternative means of connectivity.

While the benefits of Li-Fi in the era of IoT and big data are well recognized,<sup>40</sup> new research should yield commercially viable solutions<sup>41</sup> that can be test-driven in real-life situations such as providing connectivity underwater where radio waves cannot penetrate far, at explosion hazard environments, and on smart vehicles where LED versions of headlights and taillights can enable data transfer and anti-collision capabilities. This can lead to new market growth in Li-Fi technologies.<sup>42</sup>



## Force #5: The quantum paradigm and its security implications



Quantum technologies not only will find utility in real-world situations but will also create security challenges, challenges potentially more worrisome than anything we have seen in the modern digital era. Quantum will not only impact the way computers can be deployed but will also change the way we think about securing communications, applications and interactions.

### Quantum will eventually find utility in various real-world situations

Quantum technologies are emerging from the realm of research to drive viable industrial prototypes in a number of areas, such as secure communications and cryptography,<sup>43</sup> bio-medicine and genetics, and others. Organizations and governments worldwide are intensifying their efforts<sup>44</sup> to attain quantum supremacy.

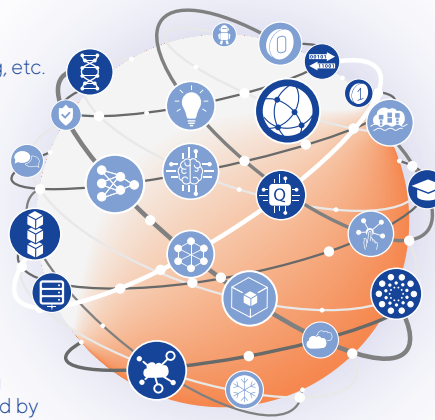
## Quantum technologies

### Quantum Imaging

- High performance single photon detectors (SPADS)
- Seeing through smoke, bacterial diagnostics, underwater imaging, etc.

### Quantum Computing

- Quantum advantage, for solving problems faster than classical computers
- Quantum supremacy, for solving problems which cannot be solved by classical computers



### Quantum Sensing

- Gravity sensors for measuring gravity gradients
- Atomic clocks
- Constructing 3-D maps of surroundings for gas exploration, volcanology, etc.

### Quantum Communication

- Secure communications
- Quantum key distribution
- Post-quantum cryptography

Figure 6


The application of quantum technologies is widespread. With the promise of moving beyond limitations of shot noise and Rayleigh diffraction limits, a new generation of optical instruments will issue that can help us visualize dimensions beyond the possibilities of current technologies. Through gravity and gravity gradient sensing, it has the potential to benefit applications that require inspection of the underground space for detection of hidden hazards, potentially allowing early detection of sinkholes and more accurate road maintenance. In healthcare and molecular biology, quantum sensing will detect biological agents in a fraction of the time required today.

Quantum computers are beginning to emerge, and can already run small-scale applications. In 2019, more powerful and flexible quantum<sup>45</sup> systems will come into being. In the coming five to 10 years,<sup>46</sup> commercially available quantum computers will drop in price and will open up transformative avenues for enterprises.

### **Cybersecurity priorities will lean toward post-quantum vulnerabilities & will be augmented by data protection laws & regulations**

Post-quantum cryptography will emerge as a core technology focus area to research and explore in the near future given the rise in quantum computing capabilities. Organizations, standards bodies and companies will work toward new encryption standards and algorithms.<sup>47</sup> This is especially pertinent for security in a post-quantum world since many of the existing cryptographic algorithms will largely be rendered worthless when it comes to securing information and/or assets in the post-quantum era.

New regulations, such as the General Data Protection Regulation (GDPR) and the subsequent data protection regulations enacted across countries, will force organizations to enact measures to proactively safeguard<sup>48</sup> against data breaches and vulnerabilities.



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## Now what? Recommendations for staying ahead

As new digital technologies rapidly progress, it is imperative for businesses to be aware of these advancements and remain in sync. Businesses have historically been built around three key goals: the drive to increase productivity and efficiency, the need to deliver better experiences to users (customers, partners and employees) and the need to remain relevant in the marketplace.

To ensure that these goals are met, business leaders need to understand when to evaluate and adopt emerging technologies so the required investments provide optimal returns and deliver competitive advantage – i.e., organizations must not deploy these technologies too early or too late to pay off in an appreciable way.

So how should decision-makers tackle these forces and trends? We recommend the following key guiding principles.

### Recommendations: three guiding principles

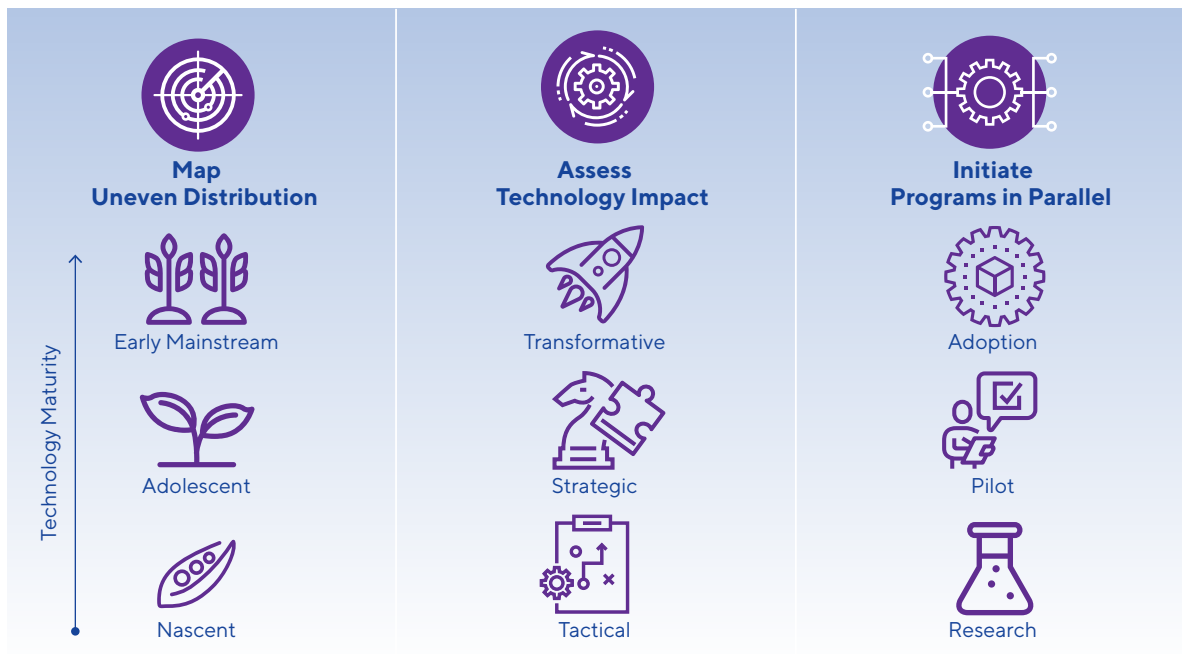


Figure 7



## Principle #1: Acknowledge and map uneven distribution


It is a given that all technologies do not mature at the same rate. For instance, while RFID may now be technologically mature, widespread adoption has lagged. In comparison, API usage in mobile applications matured rapidly, from both a technological and an adoption standpoint. Also, each business is different, as are their long-term strategies and roadmap; what is considered mature for one type of business may be still an evolving technology for another.

VR, for instance, is now a mainstream technology for entertainment and gaming concerns, but is still considered a fringe technology for banking institutions. Acknowledging and mapping out how unevenly the future of technology will be distributed is therefore paramount for companies that want to maintain strategic focus while not missing the forest for the trees.

A useful technique in such a scenario is the creation of “technology radar” that serves as a guide to technologies across two key maturity dimensions: maturity of the technology itself and maturity of its business applicability. Such radar can define three categorical levels, namely:

- I Nascent technologies:** Those that are still in their early phases, still needing to evolve, where the real impact is not very clear. Quantum technologies, for instance, fall under this category in the sense that while there is a lot of hope and buzz about them, it has yet to be seen if and when they will really mature.
- I Adolescent technologies:** Those that are reasonably mature, where there is enough evidence of real-world impact on businesses and applicability can be conceptualized and demonstrated via reality-based use cases that are being explored and developed.
- I Early mainstream technologies:** Those that have emerged into the mainstream where benefits are being realized or are visible in short order. These use cases should be well defined, pointing to projects that are on the cusp of being implemented, with a means for documenting how investments could yield returns.

This radar will help businesses obtain a clear and immediate view of emerging technologies. However, a team will need to continuously refresh this radar by examining and tracking the technologies’ development. As in any dynamic scenario, the technologies change; some will fall off the radar, while others will emerge. Having clear visibility on this distribution will help businesses prioritize their focus.



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## Principle #2: Assess impact of the technologies

Once the technologies are mapped, businesses should look at the impact that can be spawned in their own domains. For instance, automation and AI are changing the very fundamentals of how business models are evolving. Under this circumstance, it is key to evaluate and assess the following three impact parameters which will help businesses prioritize their adoption strategies:

- I Tactical technologies:** Some technologies will impact business operations tactically. They will yield incremental gains in productivity and process improvements that can deliver ROI quickly and provide short-term benefits. However, they are limited to acting as tools wielded by business operations rather than bringing about radical change. It is important to identify these technologies on the radar since they identify low-hanging fruit and highlight investment dollars for the other two categories.
- I Strategic technologies:** These technologies will help businesses formulate and execute their business strategy. They may not provide ROI quickly, but with a bit of vision and deft implementation, such technologies can illuminate possibilities for businesses to scale up and to increase their market share. This could mean providing the means to reach new markets, develop new products and offerings, or enhance customer experiences. These technologies can be immediately piloted to assess their impact in real-world situations, allowing companies to learn from early experiences and evolve accordingly.
- I Transformative technologies:** These technologies will fundamentally alter the DNA of an organization and its business model. It is most beneficial to identify them early on so organizations can become innovators and early adopters. However, bear in mind that technology maturity and transformative impact are not necessarily co-related. Still, it makes sense to avoid a late start rather than never getting in the game.

Mapping the technologies across these three impact categories will enable organizations to zoom in on key areas of focus and investment, and to take action to adopt the right technologies at the right time and place. It will also help them avoid seemingly exciting technologies that may have minimal impact, or to discover less-exciting technologies that can have transformative impact. At the end of the day, any technology that provides opportunities for immediate implementation and swift ROI should be considered. This then helps companies develop an executable action plan.

## Principle #3: Activate programs to explore and apply new technologies

While the first two principles help companies gain visibility on the technology landscape and identify priorities, this just lays the foundation and platform for taking action. When it comes to action itself, there are three key programs that businesses need to undertake:

- I Research programs:** These will be primarily in nascent technologies that have been identified as having transformative and/or strategic impact on the business. They will require long-term investments and working with partners such as academic and research institutions. This will help companies leverage intellectual capital outside the organization, develop intellectual property that has commercial potential



Companies can select the right investments, decide on the technologies to use, evaluate technology vendors and service providers, and create adoption programs that will help them implement technologies of relevance within their mainstream business processes.

and create new, disruptive innovations. Timeframes are typically longer here since research does not deliver immediate results; however, the potential of a successful program to benefit companies is immense.

- I Pilot programs:** A more mid-term approach, pilot programs are suited for technologies that are adolescent and early mainstream, regardless of their impact on business. Such programs entail establishing a dedicated team to take them up by providing the necessary executive vision and direction, identifying and defining relevant use cases, and proceeding with the implementation of pilots to learn and course correct. This will help companies view demonstrable benefits and embrace adoption whenever and wherever necessary.
- I Adoption programs:** This is where the rubber truly meets the road and decisions are made. Companies can select the right investments, decide on the technologies to use, evaluate technology vendors and service providers, and create adoption programs that will help them implement technologies of relevance within their mainstream business processes. These programs must go through proofs of concept and proofs of technologies, inculcate strong change management principles and be monitored closely for realization of benefits.

These three programs will typically run in parallel, and will be unevenly distributed in terms of both investments made and technologies selected. However, it is important for organizations to ensure there is momentum on all three fronts even though the proportion may vary based on immediate needs of business.

## Endnotes

- <sup>1</sup> [www.cognizant.com/whitepapers/the-robot-as-coworker-codex2666.pdf](http://www.cognizant.com/whitepapers/the-robot-as-coworker-codex2666.pdf).
- <sup>2</sup> [https://en.wikipedia.org/wiki/Swarm\\_intelligence](https://en.wikipedia.org/wiki/Swarm_intelligence).
- <sup>3</sup> [https://en.wikipedia.org/wiki/Swarm\\_robotics](https://en.wikipedia.org/wiki/Swarm_robotics).
- <sup>4</sup> [www.cognizant.com/whitepapers/21-more-jobs-of-the-future-a-guide-to-getting-and-staying-employed-through-2029-codex3928.pdf](http://www.cognizant.com/whitepapers/21-more-jobs-of-the-future-a-guide-to-getting-and-staying-employed-through-2029-codex3928.pdf).
- <sup>5</sup> <https://en.wikipedia.org/wiki/Li-Fi>.
- <sup>6</sup> <https://quantumxc.com/quantum-encryption-vs-post-quantum-cryptography-infographic/>.
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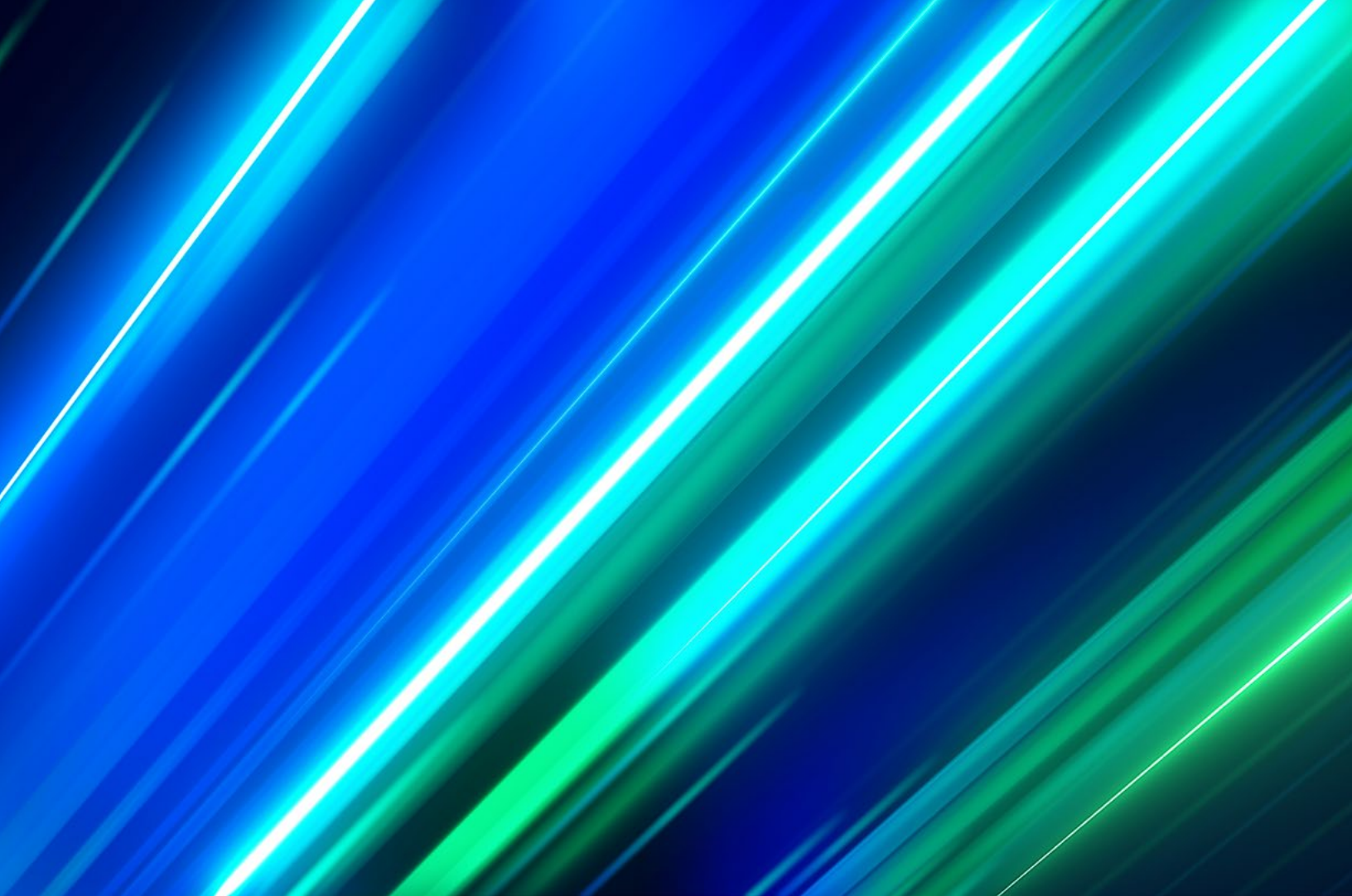


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Cognizant's Global Technology Office (GTO) is a research and development incubator that explores how emerging technologies can be applied to solve our clients' business challenges – today and tomorrow. We partner with leading academic and research institutions worldwide, as well as our business units and practices, to research and experiment with a cornucopia of technologies – from advanced forms of artificial intelligence and swarm robotics, through quantum technologies and mixed reality – via pilots and proofs of concept that determine their real-world application and potential business benefit. To learn more, contact us at [inquiry@cognizant.com](mailto:inquiry@cognizant.com).

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Cognizant (Nasdaq-100: CTSH) is one of the world's leading professional services companies, transforming clients' business, operating and technology models for the digital era. Our unique industry-based, consultative approach helps clients envision, build and run more innovative and efficient businesses. Headquartered in the U.S., Cognizant is ranked 195 on the Fortune 500 and is consistently listed among the most admired companies in the world. Learn how Cognizant helps clients lead with digital at [www.cognizant.com](http://www.cognizant.com) or follow us @Cognizant.



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