AUTONOMOUS NETWORKS POWER INDUSTRY 4.0

SUMMARY

Companies in most industries have been on a digital transformation path for several years, seeking to optimize their operations, reduce cost, improve customers' satisfaction, and grow revenue. This trend has accelerated over the past few months as companies realized the shortcomings of their existing operational frameworks in dealing with the sudden and pervasive market disruptions, as new business models start to emerge in many industries that are rooted in their reliance on digital enablement, and as the enabling technologies start to mature and be market tested.

Although each industry vertical has its own ecosystem, KPIs, operational metrics and requirements, and other parameters, underlying capabilities across most verticals include full automation; data gathering; storage and analytics; low-latency, real-time processing; and a nimble, adaptable communication infrastructure. One major fundamental infrastructure enabling these capabilities is a network that is fully automated, exceptionally reliable, and extremely fast. Such an infrastructure is the Autonomous Network (AN), as defined in the TM Forum recent paper.

Network automation is not new, but the level of automation (full automation) is now possible in the telecom infrastructure and is a major enabler of Industry 4.0. As industries in many verticals transform, they rely on technologies such as artificial intelligence, augmented reality, virtual reality, robotics Internet of Things, distributed cloud computing, and others. These technologies require zero touch, zero trouble and a zero-wait network, which TM Forum defines as the AN[1].

This paper highlights Healthcare 4.0 and Manufacturing 4.0 and explains how the enabling technologies supporting the evolution of these industries can be powered by the AN.

[1] https://inform.tmforum.org/research-reports/autonomous-networks-empowering-digital-transformation-for-smart-societies-and-industries/

Table of Contents

THE DIGITIZATION TREND

Digital transformation has been a major trend across most industries over the past few years. Companies and organizations of all sizes and across many industries have initiated major moves toward automation, the adoption of data as driver for processes and business models, the use of distributed computing, IoT and other technologies. At the same time, they have started rethinking their organizations to align them around a digitally enabled infrastructure. Examples include smart cities, where IoT technologies are used in applications such as lighting, sanitation, road repair, and others. Manufacturing and logistics have also made broad strides in adopting technologies such as IoT and augmented reality. What has held this effort somewhat back is the lack of advanced technology to enable automation and fast data processing and the challenges associated with organization redesign to better align with the needs of the digital enterprise. Today, the enabling technology is available and already has been deployed, but recent events have caused enterprises to speed up their organization redesigns to take advantage of the new technologies.

THE RECENT ACCELERATION OF DIGITIZATION

The pandemic is causing worldwide disruption on a massive and unprecedented scale and scope:

- Supply chains have been severely disrupted as consumption patterns are changing (for example, businesses are closing, and consumption is moving to homes) and factories are shutting down, which is driving the need to change procurement sources.
- The shortage of personal protective equipment (PPE) and the need to procure such scarce items across the globe were often not met, resulting in increased exposure to the virus
- Healthcare is changing drastically; people cannot seek treatment in their doctors' office and must use telehealth. Patients have stopped receiving regular treatments.
- The medical workload associated with COVID-19 has exploded with hospitals and other medical providers reallocating resources quickly and dealing with the massive onslaught of sick patients.
- Broadband consumption in the business market has declined precipitously as businesses shut down or adopt work from home arrangements.
- Broadband consumption in the residential market has increased substantially as people work, study, and engage in other online activities in their homes.

In the face of these challenges, telecom operators and businesses have pivoted as fast as they could:

- Operators have added network capacity to meet the growing demand for broadband.
- Businesses have been redesigning their supply chains.
- Hospitals have developed new triage procedures to cope with the onslaught of sick patients.

Despite their best efforts, the response has been uneven and for the most part suboptimal, because the tools that these businesses have are inadequate. For example, operators have increased capacity in the

last mile by sending technicians to add physical network components and often had to supplement these systems with additional hardware racks in their central operating locations. Although this met the short-term need, it is expensive and totally nonelastic. If utilization decreases in the future, the added capacity will be underused, resulting in stranded capital.

The pandemic has ushered an urgency to transform and demonstrates the importance of digital enablement as a major enabler of this transformation. It is true some form of digital enablement initially happened at the start of the pandemic, but it was reactive and scattershot at best. For example, telehealth emerged as the prevalent modality for delivering healthcare; online learning became the substitute for in-person education. Although these approaches are essential and play a role in providing continuity of care and education, they are far from being adequate and sufficient over the long term. Companies in all industries need much better digitally enabled business models and are now rushing to define and implement those business models at an astonishing rate. A recent survey by the World Economic Forum found that 80% of companies intend to digitize their processes; a study by the *Economist* highlights the type of technologies firms will be implementing.

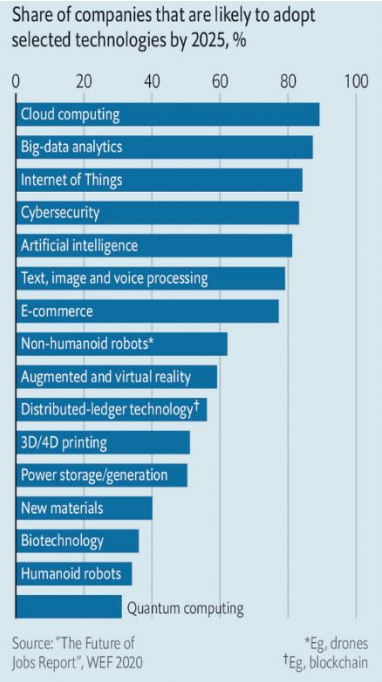

Figure 1. Adoption of Digital Technologies[2]

The rate of transformation is unprecedented, for example, a recent study by McKinsey showed that "increasing the use of advanced technologies in business decision making" takes 25.4 days, compared to the 635 days it takes in normal times[3].

[2] https://www.economist.com/finance-and-economics/2020/12/08/the-pandemic-could-give-way-to-an-era-of-rapid-productivity-growth?utm_campaign=the-economist-today&utm_medium=newsletter&utm_source=salesforce-marketing-cloud&utm_term=2020-12-08&utm_content=article-link-1&etear=nl_today_1.

How CSPs enable massive digitization

CSPs have been delivering the technologies and associated services to enable the transformation to digitization[3]:

- Scalable cloud infrastructures
- Edge compute resources
- IoT
- Blockchain
- Automated networks
- Real-time visibility

However, to realize the full promise of Industry 4.0, a communication infrastructure must provide the underlying framework for these technologies; this framework is Autonomous Networks.

Enabling accelerated digitization with autonomous networks

As they accelerate their digital transformation, companies in all industries will demand new services and capabilities from their suppliers and vendors. At the forefront are the service providers that deliver the underlying connectivity, hosting, and compute infrastructures that will provide the underlying infrastructure inherent to the digital firm. Cloud and edge computing, the secure and fast transport and processing of big data, IoT enablement, the delivery of Virtual Reality and Augmented Reality capabilities, cybersecurity, blockchain and others are some of the capabilities the service providers need to deliver at scale, with high reliability, velocity, elasticity, and flexibility in the future.

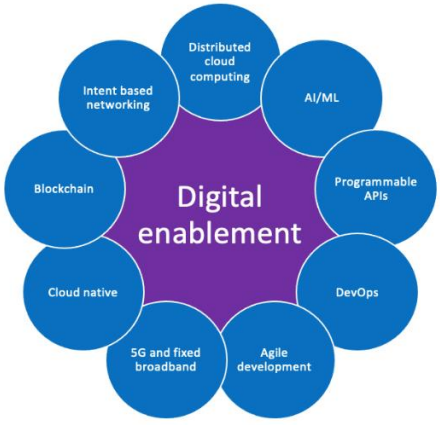

Figure 2. CSP Digital Enablement

Delivering these capabilities and others will not be possible with manual, siloed infrastructure. Although it is true that CSPs have started implementing software-based infrastructures, and many have introduced

[3] https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever?cid=other-eml-alt-mip-mck&hdpid=4df91e7b-7ea3-4351-963a-a82869d35704&hctky=1427362&hlkid=66ff0987ef3f4e78a280856cfb298ccb

automation capabilities across their networks and operating environments, the scale and complexity of what Industry 4.0 will require far exceeds the capabilities of most, if not all, CSPs today. A new framework is required: this framework relies on pervasive intelligence and automation; it demands a communication and an operating infrastructure that is a fully automated network that is self-healing, self-managing, and fully reliable.

Network automation is not a new concept, and most operators have already implemented some level of automation in their networks and operating environments. However, the level of automation currently in place is inadequate for the requirements of the market going forward. It is increasingly obvious that the market needs a much more comprehensive and pervasive level of automation in network infrastructure powered by intelligence implementation. The new level of automation must handle closed-loops as well as the capability to support full-cycle automation, enabled by AI. This level is referred to as Autonomous Networks (AN).

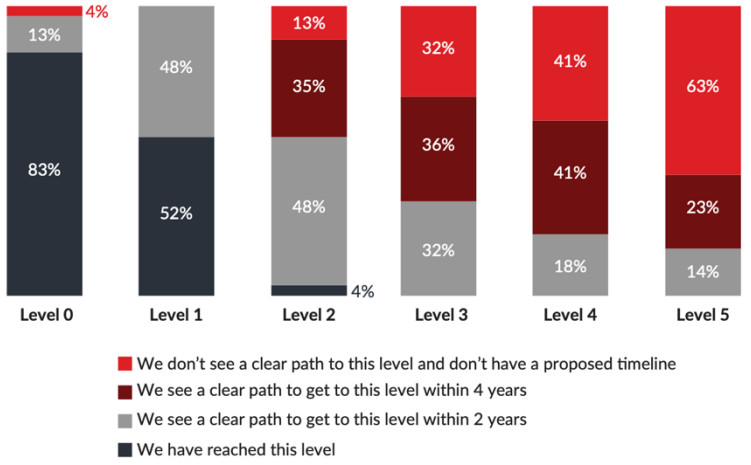

Figure 3. CSPs' Progress on Automation (Source: TM Forum 2020)

ANs are becoming an essential goal for every CSP and will be table stakes for success in a fast-transforming market as they become the bedrock of digital industries. Today, operators are in a better position to move toward AN:

- Market forces are making AN essential, and the pace of change is creating business opportunities for CSPs to grow revenue by offering end-to-end services across verticals.
- Many of the impediments to achieve AN are being mitigated by advances in technology[4].

DIGITAL ENABLEMENT IN INDUSTRY 4.0

Automation and data transformed into actionable information are the major enablers of Industry 4.0. These capabilities are considered essential for the transformation of the manufacturing, industrials, and

[4] https://acgcc.com/media/reports/files/ACG-Autonomous_Networks_Now_is_the_Time_Article_Dec2020_1.pdf

healthcare sectors, the two verticals on which we focus, because they are already experiencing significant change, driven in part by the current pandemic.

Although each vertical has its own ecosystems, operating goals and KPIs, applications, and customer needs, an underpinning requirement is the gathering and storage of data, the reliable movement of that data, high speeds over a versatile communication infrastructure, and the ability to dynamically adapt to changes in the business environment.

Digital enablement in healthcare

Healthcare has been transformed significantly over the past few months, as telehealth has become an accepted modality for delivering care in many countries. However, telehealth is just the beginning, the industry views virtual care as an essential component in care delivery in the future. The future of healthcare is connected.

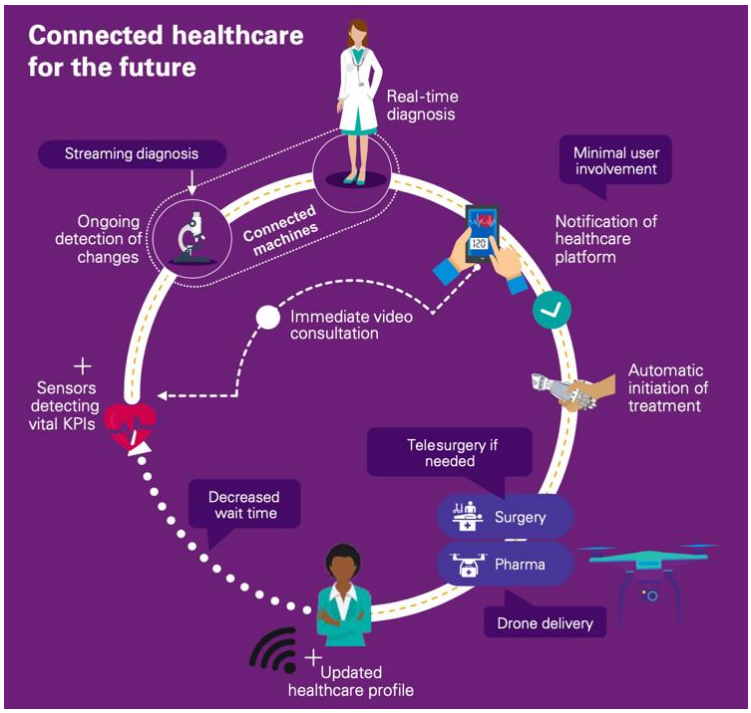

Figure 4. Connected Healthcare (Source: KPMG)

Historically, healthcare has largely operated in silos:

- Patients records are kept by various providers or health records repositories that are not integrated.
- Care is largely focused on condition treatment rather than preventive care.
- Limited patient monitoring relies on disparate devices often connected with unreliable technologies such as Bluetooth
- Triage and other processes in hospitals rely on ad-hoc, largely manual approaches.
- Clinical trials are conducted with limited technology without the ability to constantly monitor the trial participant to ensure adherence and to continuously collect valuable trial data.

These are but a few of the impediments to improving health outcomes and to reducing the significant and constantly growing healthcare costs.

Healthcare is at an inflection point because of the pandemic, which has created an impetus for change. Remote treatment is driving technology adoption at an unprecedented rate, while at the same time regulation is being modified to remove pre-existing impediments to receiving virtual care (for example, extending reimbursement levels to telehealth and the relaxation of HIPAA rules in the US).

The digitization of healthcare is only starting; the industry will undergo a major digital transformation in the immediate future. Enabling healthcare digitization is the ability to connect data from disparate sources, analyze it in real time, and develop actionable insight, for example, for clinicians to monitor patients remotely and continuously, improve the accuracy of surgeries, and optimize resource utilization in hospitals. These advances will require zero fault continuous connectivity, distributed computing, pervasive AI, the ability to adapt to sudden change, high data throughput with low latency and ultimate reliability.

Some of the technologies that are essential for healthcare digitalization:

Data and AI: A major future requirement in healthcare is the availability of the right information at the point of care in real time, enabling the clinician to make intelligent, split-second, data-driven decisions. This should lead to better health outcomes and lower costs. Enabling these capabilities are health digital platforms that can securely connect and integrate data from varied sources and interoperability standards[5]. That data must be transformed into smart data that provides clinical insights, leveraging the capabilities of AI-powered analytics. AI federation is becoming an important effort; this is when data is federated from multiple sources to train AI algorithms. An example is Massachusetts General Hospital's work with MediBloc, a South Korean startup, to leverage blockchain networks for developing a safe mechanism for storing and sharing patient data that complement its existing electronic health records.
With AN, computations will be done in the cloud where the resources are and in the optimal place where the need is (for example, proximity to the source of data). The bandwidth carrying the data is dynamic and is integrated with computing and storage.

Virtual Reality: Another intriguing technology enabling the future of healthcare is virtual reality for surgery, pain management, and mental health. A real-life use case is virtual surgical rehearsal by Surgical Theater; another is pain management. At Cedars-Sinai, a study is focused on using VR for a non-drug approach to treating lower back pain[6]. With AN, the low latency needed for virtual reality is instantly ordered and implemented where it is needed, when it is needed, and the bandwidth is dynamically made available where needed and as needed.

[5] https://www.healthcareitnews.com/news/platform-digital-transformation

[6] https://www.cedars-sinai.org/blog/virtual-reality-future-healthcare.html

Augmented Reality: Blends real-world elements with virtual ones. Examples are 3D representations that enable surgeons to see patients' anatomy through skin and tissue or other types of organ visualization and presurgical patient information. Many companies are already offering such capabilities.

IoMT (Internet of Medical Things): Connected infrastructure of devices, software, hardware, and services for collecting, processing, and analyzing data for use by healthcare providers to use in delivering care. With AN, CSPs can dynamically provide the IoT communications and platform to deliver services such as remote patient monitoring or to monitor location and temperature of vaccines throughout the entire supply chain.

Robotics: This technology is playing an increasingly important role in multiple aspects of medicine, such as surgery, nursing, and others. Numerous hospitals have been using robotics for minimally invasive surgeries such as cardiothoracic, colorectal, throat and others. Recently, NYU Langone orthopedic surgeons have used robotics in computer-assisted hip and knee replacement. With AN, service providers can deliver the real-time, low-latency communication with on-demand data processing.

Remote patient monitoring: A major use case in digital healthcare

Remote Patient Monitoring (RPM) uses sensors and other digital technologies to collect medical and other health data from a patient and transmits that data securely to healthcare providers for clinical analysis. This area is experiencing significant growth and development, and in some cases, data collection is happening every few seconds or continuously. At the same time, sophisticated algorithms are analyzing that data in real time and sending alerts and notifications to clinicians. RPM requires exceptionally reliable network connectivity and the ability to transmit potentially large amounts of data in real time or close with no human involvement except for the clinical assessment and the delivery of care. RPM is the future of healthcare, as it contributes to lowering the cost of care delivery, and to improving health outcomes.

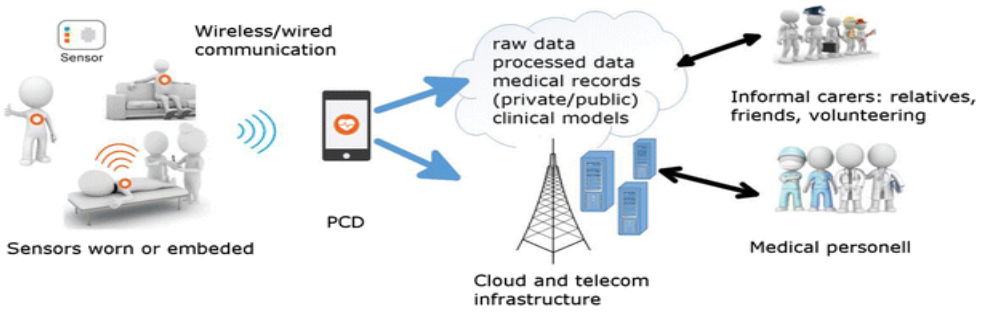

Figure 5. Remote Patient Monitoring[7]

At the heart of RPM is a high throughput, reliable telecommunication infrastructure and compute at the edge or in the cloud for data processing and advanced analytics to drive relevant clinical insights. A subset of RPM is the enablement of aging in place, where the homebound can stay in their homes while being monitored remotely. CSPs can deliver the IoT based solutions with home networking, connectivity to the

[7] https://link.springer.com/article/10.1007/s11517-018-1798-z/figures/4

monitoring entity, and data transport and processing. Telus of Canada has been offering such services for several years. Its Home Health Monitoring service enables patients with severe chronic conditions to monitor their health parameters from their homes and share the information with health professionals; this enables regular tracking for adjusting treatment and has led to reduced stress on the healthcare system, lower cost, and better health outcomes.

Digital enablement in manufacturing

Technology is becoming an essential enabler in the evolution of manufacturing, and manufacturers are shifting toward digitization as they embrace smart manufacturing, which encompasses the convergence of physical and digital systems and is referred to as Manufacturing 4.0. For manufacturing to digitize, information barriers that today exist across the ecosystem need to come down, processes need to be redesigned on the fly because of supply chain issues or to the need for modification to improve safety or adapt to unforeseen manufacturing issues. Data needs to be collected and analyzed in real time to inform on-going processes and adapt in real time while providing maximum visibility to enable preventive remediation, process improvement, and training.

Major automotive manufacturers such as GM, Toyota and Tesla have been automating their assembly plants and operations using robots and have been introducing data analytics into their supply chains, resulting in innovations such as just in time production. These advances have led to more flexibility and agility in adapting to demand shifts while reducing waste. Tesla has also introduced the concept of super automated factories[8]. BMW is another major auto manufacturer that relies on smart data analytics, smart logistics, automation, and connected distribution in its digital factories.
The major technologies enabling Manufacturing 4.0[9]:

Augmented reality: Example use cases include training, visualizing a finished product, and identifying unsafe work conditions. Text, stats, and images can be overlayed to augment the current work environment, providing invaluable real-time information to the workers and improving decision making, processes, and safety.

Virtual Reality: Enables real-life simulations of production environments, processes, and configurations, identifying potentially dangerous situations. It allows employees full immersion in a real-life environment for training or for task design or modification.

Robotics: Robotic automation is playing a large part in manufacturing, performing tasks such as welding, assembly, shipping, and handling raw material. Robots are working side by side with humans, leading to cost reductions, quality improvements, and improved productivity, particularly in mitigating the limitations imposed by the recent COVID-19 pandemic.

[8] https://roboticsandautomationnews.com/2020/04/06/how-automation-is-disrupting-all-kinds-of-manufacturing-in-2020/31499/

[9] https://www.bcg.com/en-us/capabilities/operations/embracing-industry-4.0-rediscovering-growth

Machine Learning and Artificial Intelligence: Allows for the collection of data from multiple sources and analyzing it in real-time with far-reaching improvements in manufacturing: predictive fault remediation, preventive maintenance, improved forecasting, optimizing robotics, and real-time monitoring.

Digital Twin: This virtual representation of a real-life component or asset enables manufacturers to test multiple solutions before introducing the optimal one or to assess the impact of changing sourcing decisions on operations and costs. Boeing is a major user of this technology for aircraft design.

Industrial Internet of Things: IoT largely focuses on connecting thousands of machines and devices in an industrial setting. It enables companies to instrumentalize production lines, making them able to track and analyze processes and track assets at a very granular level, enabling better efficiencies, predictive maintenance, and cost savings.

Cloud and Edge Computing: Given the significant amount of data processing generated by IIoT and other technologies, companies will need compute capabilities in various locations based on the particular requirements of the tasks at hand.

Advanced Engineering: This uses 3D printing and other additive manufacturing techniques for rapid prototyping, speeding manufacturing, and reducing costs.
Complementing these technologies are agile development processes linking intelligent factory and product feedback into connected product engineering and development teams that are leveraging the digitized infrastructure in delivering their enhancements.

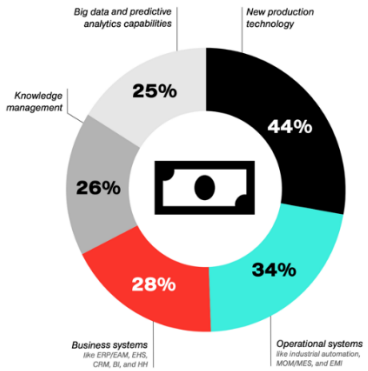

Figure 6. Areas of Investment in Technology for Manufacturing[10]

Data convergence, IIoT and analytics are the technologies driving major improvements and revenue growth in manufacturing as they connect systems and integrate data, move away from current silos, automate processes to reduce errors, improve quality, and provide better tracking and traceability. Enabling these capabilities are networks that need to be extremely reliable, responsive in real-time, fully, and automatically adaptable to changes in rather complex environments.

[10] https://img.en25.com/Web/PentoniNET/%7B586f9bbb-01c6-4145-be72-cba68ef62b5e%7D_A2020670-20430_Plex_State_of_Manufacturing_Technology_2020_FINAL.pdf

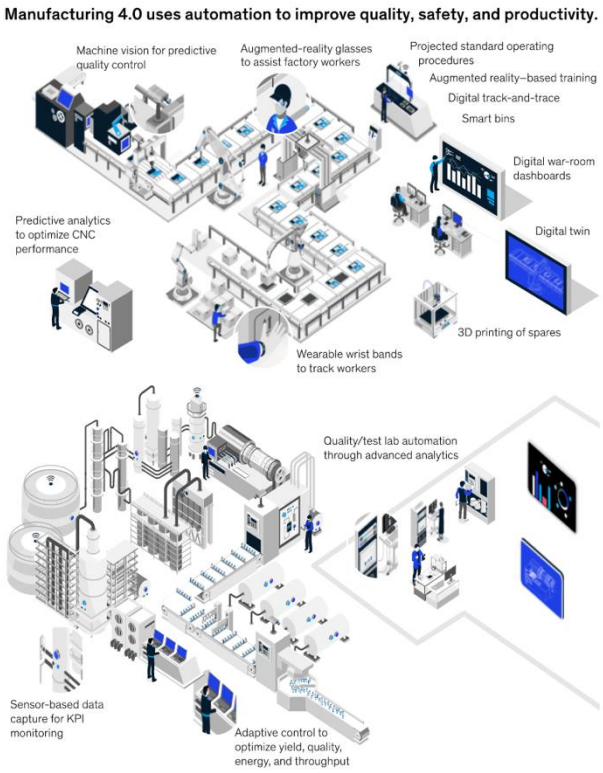

Figure 7. The Role of Automation in Manufacturing 4.0[11]

AUTONOMOUS NETWORKS POWER INDUSTRY 4.0

Achieving the promise of Industry 4.0 requires a complete transformation of the enterprise toward a digital operating model where employees design and oversee a software-automated, algorithm driven digital organization that delivers the goods[12]. At the heart of this enterprise is an AI factory that provides the underlying capability for data gathering, analytics, and decision making. This organization is modular or composable; it requires a new communication infrastructure that enables modularity, flexibility, scalability, and velocity. ACG Research has recently defined the concept of Intelligent Composable Fabric, which contains operations, information, and communications technology modules that flexibly compose the intelligent digital operations platform[13] of an enterprise. This fabric requires a communication infrastructure that is zero wait, zero touch, and zero trouble (Zero X). Such an infrastructure can only be delivered by autonomous networks.

[11] https://www.mckinsey.com/business-functions/operations/our-insights/industry-40-reimagining-manufacturing-operations-after-covid-19.

[12] "Competing in the age of AI," Marco Iansiti, Karim R. Lakhani, Harvard Business Review Press.

[13] Paul Parker-Johnson, ACG Research private conversation, December 2020.

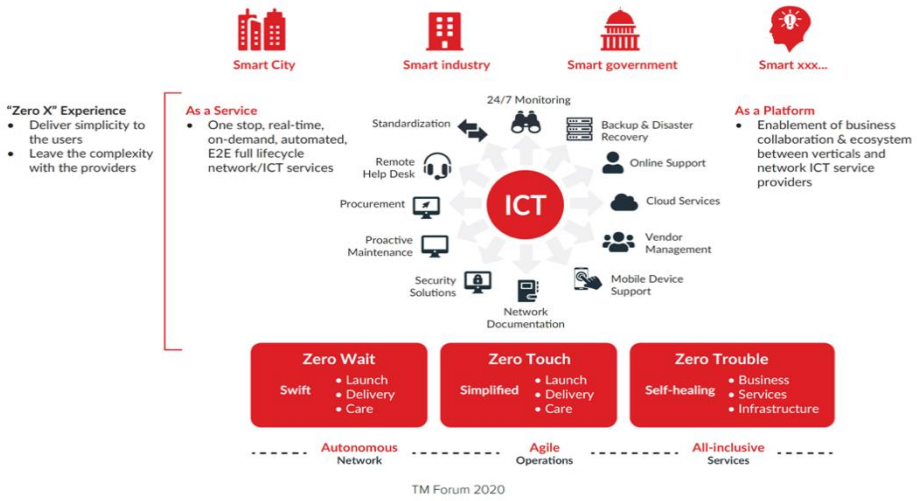

Figure 8. Vision of Autonomous Networks (Source: TM Forum, 2020)

Although there are multiple levels of automation, the truly digital enterprise is only realized at the maximum level of automation or full automation where the system possesses closed-loop automation capabilities across multiple services, multiple domains, and the entire life cycle. Only in this case can Zero X be realized.

At the heart of autonomous networks are autonomous domains that form the basis for closed-loop automation. They expose network capabilities that can be used by the enterprise without exposing the complexity, enabling the enterprise to define business rules and to use the capabilities as needed and when needed by the business on a modular level. These capabilities are self-assuring, providing maximum reliability to the business.

As AI becomes the runtime of the digital enterprise of the future, the firm will be rearchitected to leverage the power of data, networks, and AI. This is only possible when the underlying network infrastructure delivers the resiliency, scalability, and automation that is enabled by autonomous networks.

CONCLUSION

The pandemic has ushered a digital acceleration on an unprecedented scale and scope. Although some of the changes were short-term focused, meant to blunt the impact of the pandemic, the crisis has caused leaders in every industry to rethink their business models, with digital enablement front and center to their strategies. Healthcare is at the forefront of this transformation; patients are receiving virtual care in their homes, vaccines that normally take years to bring to market will be in the market within a few months. Digital enablement is the foundation of this transformation, and this foundation has to be powered by a network that is autonomous, ultra-fast, extremely reliable, flexible, and highly scalable. That autonomous network is the only route to achieve this transformation because enables the diversity, agility, dynamic scalability, and security requirements of Industry 4.0. Now is the time for the autonomous

network, which is not simply the next thing; it is essential to enabling the world to deal with shocks, to deliver the dynamism that will be needed in every industry going forward.

The business conditions are ripe, but the technology has also evolved to a point where this premise is now possible and indeed realizable. Innovative CSP vendors are already introducing AN solutions, and CSPs are beginning to draw plans with their vendors and partners to evolve their technology and business models to make autonomous networks a market reality.

Thank you to my ACG colleague Mark Mortensen for his significant contributions to this paper

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ACG Research provides in-depth research on ICT innovations and the transformations they create. The firm researches architecture and product developments in a range of ICT market segments. It highlights innovators, early adopters and their solutions in podcasts, webinars and a range of report and briefing formats. It does primary research on forces shaping the segments in which it is working and performs in-depth economic and business case analyses in the same. Its market forecast, outlook and market share reports are referenced widely by stakeholders in its target segments.