FROM SCHOOLING TO SPACE:

Eight Predictions on How Technology Will Continue **to Change Our Lives in the Coming Year**

2021 is going to be a launchpad for change, and here's what's coming

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INTRODUCTION

2020 was a year **unlike any other**

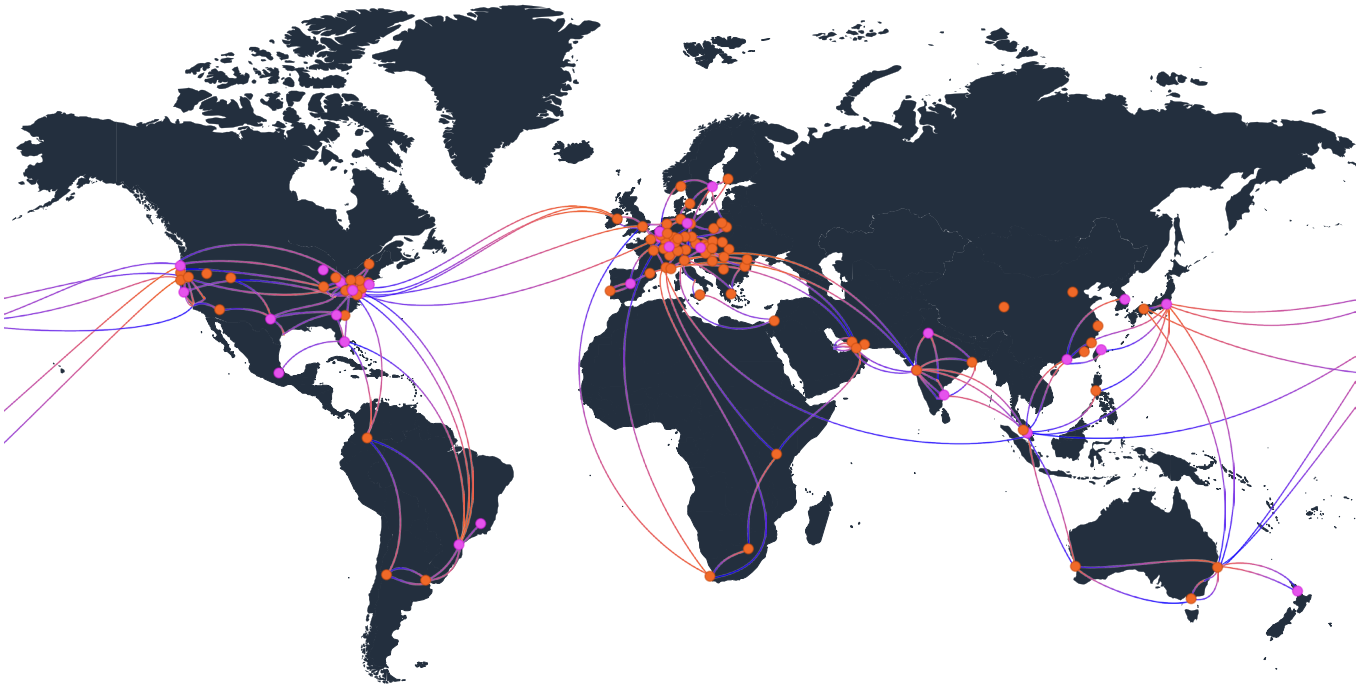
Businesses large and small, governments new and old all had to completely change what they do and how they operate. Helping us to manage this dramatic change was technology. Whether it was Blackboard continuing our children's education, Zoom becoming our business boardroom (and our pub), or Netflix being our night out at the movies, we relied on technology to help feed our families, teach our children, collaborate with co-workers, even entertain ourselves after yet another day in the house. Rather than slow us down, 2020 accelerated our shift to a digital world and I anticipate we won't go back any time soon. Thanks to this acceleration, from my vantage point, 2021 is going to be a launchpad for all kinds of change, and here are some of the areas that will be driving it.

PREDICTION ONE

Cloud will **be everywhere**

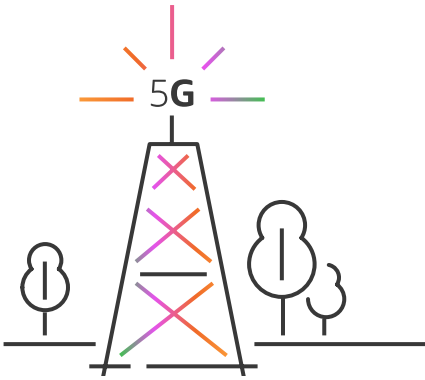
The days of all cloud capabilities being centralized in data centers are beginning to disappear. You can find cloud-based applications helping to boost the performance of ships out at sea, aircraft traversing the sky, and in our cars and homes. Access to the compute and storage of the cloud is spreading out of dense data centers and reaching into rural communities, remote wilderness, and even near-earth orbit. Practically speaking, the cloud is going everywhere.

AWS Global | Infrastructure Map



24 Regions with 77 Availability Zones
Six announced Regions and 18 announced Availability Zones
More than 220 Edge Network Locations (8 new countries in 2020)
108 AWS Direct Connect locations

Five Local Zones
12 announced Local Zones
Eight Wavelength Zones



Today, AWS has regions and Points of Presence (PoPs) that enable cloud technologies to be closer than ever to customers across the world. Customers are deploying devices like AWS Snowball to gather petabytes of data from the slopes of volcanoes in Hawaii and research centers in Antarctica. AWS Outposts, which extend cloud infrastructure and tools into our customer's buildings, and AWS Local Zones, which put select infrastructure close to where customers need it, are helping those in urban areas to rapidly shrink their cumbersome datacenters. With AWS IoT Greengrass, edge devices can connect with each other, whether that is from inside someone's kitchen or from the handlebars of a cycle in the gym. As 5G networks expand, operators are deploying Wavelength Zones so application traffic from 5G devices can take full advantage of the low latency and high bandwidth. And when fast connections to the cloud are pushed to the farthest edges of the network, great things can happen.

By removing latency, and conducting more of the compute on the device at the edge of the network, we are beginning to overcome the one limitation that still faces all technology on earth, the speed of light. Those operations that require very low latency—from autonomous driving, to natural speech processing and translation, and the active management of vital infrastructure–no longer need to conduct round trips from remote corners of the earth to a central server. Tasks can now start to happen where the results are needed most. The outcome? Driverless cars become real. You can start to have more natural conversations with services like Alexa. Our factories, homes, and office spaces become increasingly efficient and resilient. And if gaming is your thing, not only will you no longer need to worry about lag hampering your experience, your skills will also be at full strength, wherever you are.

As the cloud extends out of centralized locations and into the environments that we live and work in every day, what we will increasingly see is the same software that runs in the cloud will run close to you, and that will lead to improvements in all aspects of our lives, from healthcare to transportation, entertainment, manufacturing, and more. In 2021, this push to the edge will accelerate.

PREDICTION TWO

The Internet of **machine learning**

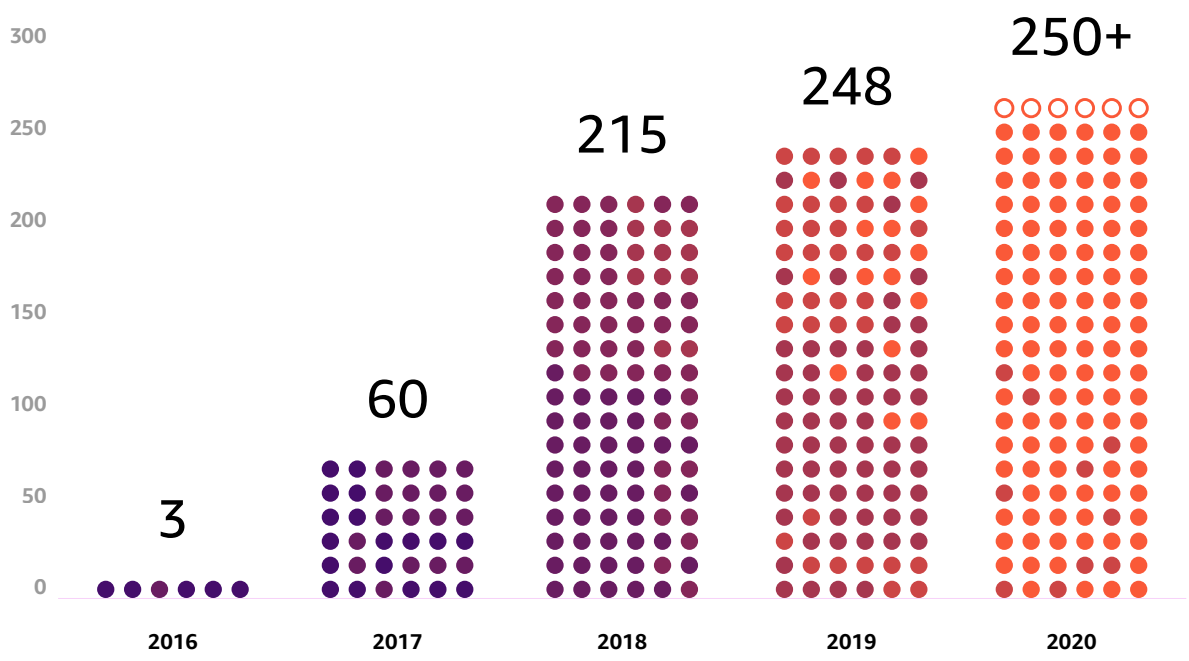
We are seeing a data explosion. To give this trend context, today we generate more data in one hour than was created during all of 2000 and more data will be created in the next three years than was created over the past 30.

In 2020, whether you were a data scientist or not, we all got a glimpse of this growing data curve as scientific researchers, pharmaceutical companies, governments, and healthcare institutes turned every resource toward developing vaccines, novel treatments, and other means to help the world stay healthy during the pandemic. All these efforts required generating and processing vast amounts of data. Whether in healthcare or other applications, the only realistic way to handle all the information we are seeing is to use ingestion and aggregation tools, married to Machine Learning (ML) models that can help make sense of it. It's no wonder then that this year ML went mainstream.

ML has historically been a computationally heavy workload that's incapable of running anywhere but on the most powerful hardware. However, with advancements in software and silicon, this will begin to change. Using a combination of AWS technologies, we'll see hardware and software working together at the edge to have a bigger impact than ever.

By moving towards the edge, what we will see in the coming year is an acceleration of the adoption of ML models across industries and government. In manufacturing, we will see ML embedded on production lines, able to spot production anomalies in real time. In agriculture, ML models will help farmers manage precious resources, such as soil and water, more intelligently.

Amazon SageMaker is among the fastest-growing services in AWS history, and the pace of innovation in ML is only increasing with **250+ new features launched this year**.



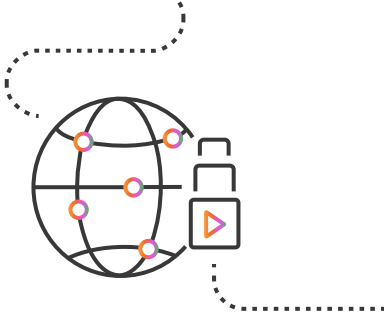
For the parts of the world where small-holder farmers are the majority, across Southeast Asia and Africa for example, pushing the use of ML models into new applications and the collection of data closer to the edge will be revolutionary in helping them increase the yield of their crops and find the best price for their effort.

One AWS customer in Southeast Asia I have spent time with is HARA. Based in Jakarta, Indonesia, HARA is a great example of this approach in action. HARA uses ML to analyze data from hundreds of thousands of small holder farmers across the region. The data collected in their fields by people and devices includes the seasonal growth cycles of their farms—what it took to grow their crop, and what they were able to earn from it. That analysis not only helps farmers get access to reasonable credit, but as the pandemic has continued, HARA is using its platform to identify the places and people who need food the most, match them with the farmers who have it, and figure out the logistics in between. Yes, this is a hard, human problem, but technology is ready to help solve it.

As ML continues to expand, we will also see an explosion in machine-to-machine (M2M) connections. In 2018, only 33% of connections on the internet were M2M according to Cisco's annual internet report. If you have an Echo, any smart home gadget, or are following how cars and trucks are quickly evolving, you can already see what's coming–a proliferation of sensors and devices connected to the cloud and each other. In 2021, I see M2M hitting 50% of all connections and ramping higher from there.

With this rise in M2M connections feeding data into more ML models, we are starting to see more custom silicon, tailored for ML. With AWS Inferentia, we are beginning to see how we can drive down the costs of ML in terms of power and compute. As those costs continue to decrease and performance increases, we'll see ML use-cases performing the computation and building new models at the edge. It's a game-changer for applications that require very low latency.

For a real-world example, take the wildfires that consumed the Australian bush and the West Coast of the United States in 2020. In the future, ML models running in devices at the edge can help us predict fire danger by modeling current second-by-second conditions against historic conflagrations—on the ground—rather than back in a central data center. This will result in data to help agencies prevent and fight fires, as well as a more accurate, and faster version of the "fire hazard risk today" signs we see around the world. As with developing safe, effective vaccines, getting food to people who need it most, or tackling the effects of climate change like wildfires, technology and technologists in partnership with policy makers and communities can have a positive impact on the world around us.



PREDICTION THREE

In 2021, pictures, video, and audio **will speak more than words**

A few years ago, in an article for *Wired*, I talked about the death of the keyboard due to the rapid rise of voice-activated computing, and the rise of user interfaces that allow humans to communicate with machines, and with each other, in a much more natural way. As we move into 2021 and beyond, I predict this phasing out of the keyboard will continue, but in an evolved way.

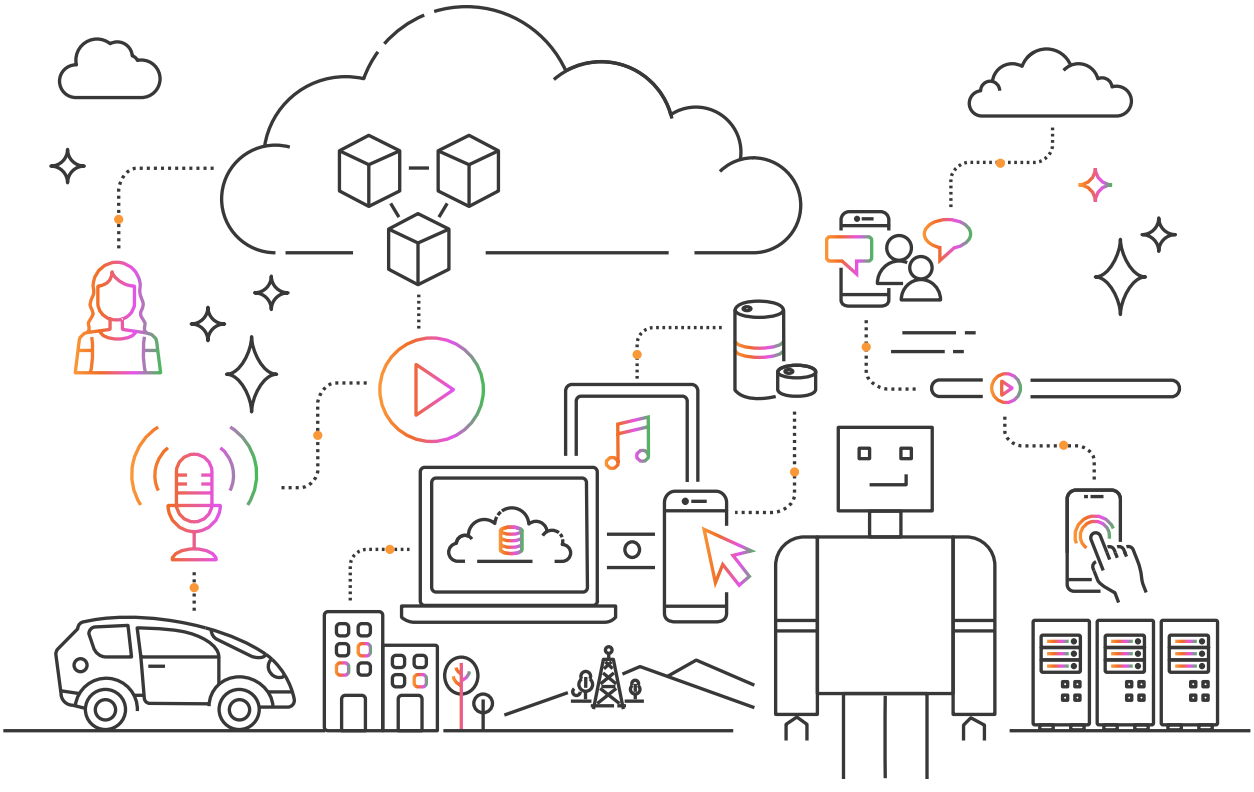
In the past year, and as we all entered into the depths of lockdown, we increasingly communicated via audio, video, and images. As a result, the amount of text we consume on our screens is being reduced as we make much more use of multimedia to communicate. On the average day on Twitter, 80% of messages contain some kind of image or video, or are just an image or video. Over the summer, Twitter began to roll out audio tweets for iOS users, further acknowledging the trend. Some of this has been enabled by the rapid reduction in the cost and ability to store data in the cloud.

Companies who want to stay relevant to their customers need to be keenly aware of these changing habits, rather than relying on keyboard, mouse, or other mechanical ways of asking customers to interact with their products and services. When it comes to building relationships and transacting with a brand, customers want to do what is natural, so companies should explore this move away from the keyboard and towards more natural user interfaces. Alexa already allows customers to conduct their Amazon shopping with their voice, and we are excited about the adoption we are seeing there.

This shift to more natural forms of communication will also enable greater equity when it comes to accessing services and information for all of us. For those that never learned to read or write, their voice might be their only mode to access information. In Ghana, for example, a company like Cow Tribe dispatches vaccines, feed, or a veterinarian to a cow herder in need, via simple voice commands. People with disabilities who can't navigate a touchpad or keyboard, can tell a screen to show them photos from last summer, order food from a nearby restaurant, or ask a smart speaker to call the kids.

And don't forget all that video, audio, and all those images—on Twitter and elsewhere—also becomes a source of data that will offer new insights and prompt new products and services. Think about music. As we made the transition to digital music, audio became a source of data for analysis to not just play your favorite song, but also offer new ways to follow trends, discover new artists, and draw on the entire history of music, genres, and artists to match the music to a mood, a few words, or a place.

In 2021 and beyond, the use of audio, video, and images will continue to replace written text in everything from social platforms to business operations, and cloud technologies will play a significant role in meeting that demand.

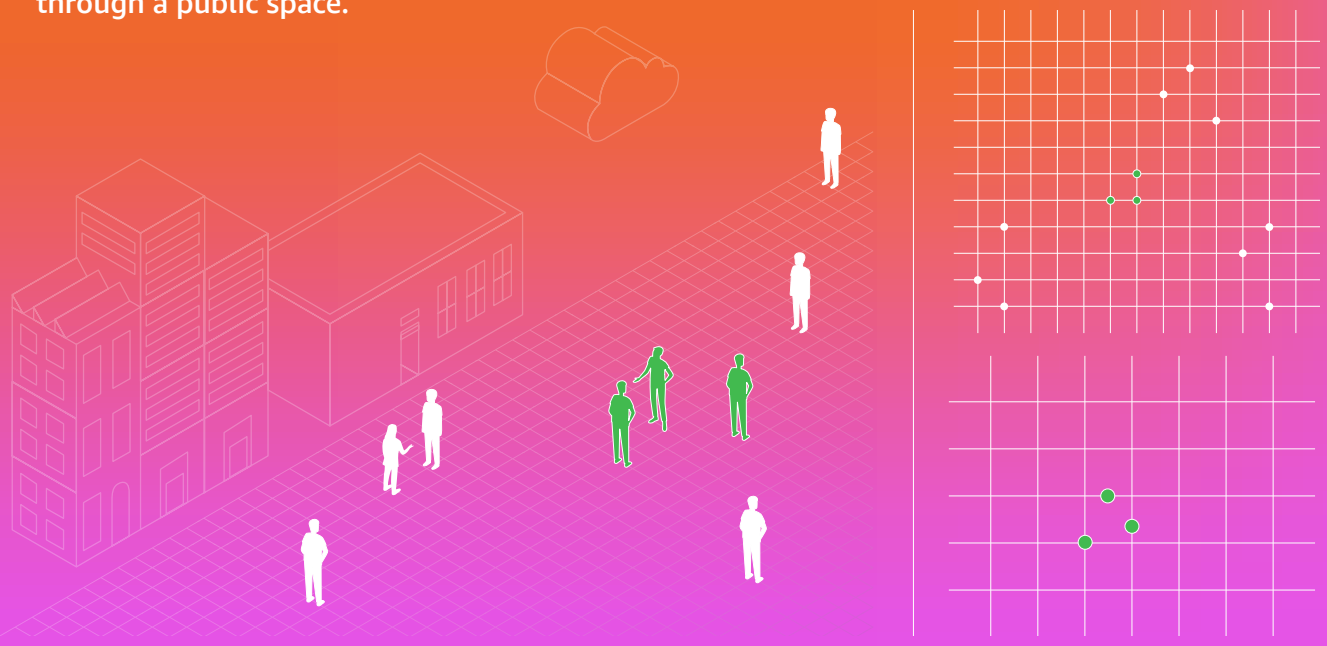


PREDICTION FOUR

Technology will transform our physical **worlds as much as our digital worlds**

In 2020 we were introduced to social distancing. As we spaced ourselves out, it gave us all the chance to take stock and rethink how our cities live, breathe, and flow. Many of the places we live and work have been built on decades-old assumptions (or centuries-old, depending on where you live) that don't hold up anymore—or at the very least, don't perform well in a pandemic.

Heat map of how people move through a public space.



With the help of advanced data analytics, 2021 is the year when we will start to figure out how to better design our cities to give us the advantages of social distancing, without feeling so distant. Our planning will consider things like how we make our communities healthier and safer, rather than simply denser and more efficient. It's the true convergence of the digital and the physical.

For example, using advanced data analytics technologies and ML, cities will be able to analyze foot traffic to understand how pedestrians move around, whether that is filing into a stadium, out of a grocery store, or onto a subway platform. Big-box stores have been using a version of this technology for many years to analyze the foot traffic at any given moment, and help move people in real-time past the best deals or advertising. But add ML models to the tool kit, with a desire to solve tougher real-world problems, and we can spot the bottlenecks and the danger spots before they occur.

We can start to predict hour-by-hour pedestrian traffic and offer suggestions for how to safely move through our cities and institutions during the height of summer's tourist season or in the middle of winter's flu season. Consider a museum. With the aid of these technologies we'll soon understand how best to place the artwork, or design the exits from a bathroom to prevent people from bumping into each other and maintain a safe social distance.

Another physical transformation we will see is less social and more financial—the rapidly vanishing need for cash in our pockets. One of the biggest changes from the pandemic has been the rise of cashless payments. In some bars and restaurants around the world, cash is forbidden. As a result, we have seen the dramatic rise in new online payment platforms whose businesses are built in the cloud, and whose underlying encryption and ledger systems—blockchain is one example—are cloud-based as well. Those options will only proliferate as the world increasingly accelerates to digital technologies that replace antiquated, centuries-old approaches.

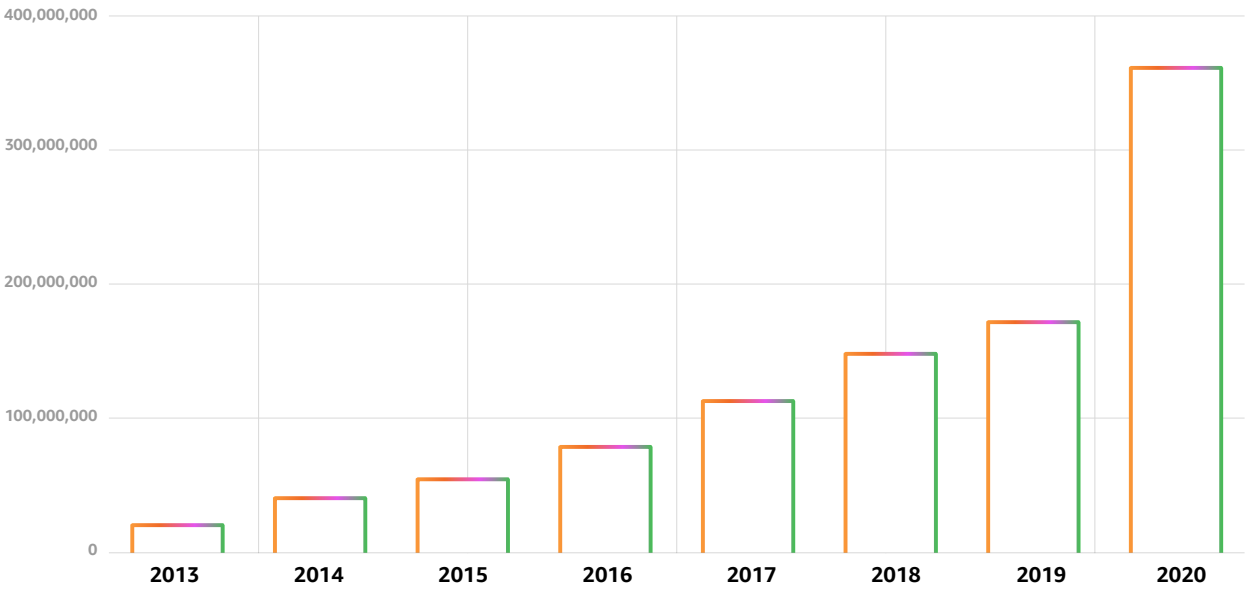
PREDICTION FIVE

Remote learning earns **its place in education**

Over the past few years we have seen radical change in almost every industry, with one glaring exception–education. Most educational institutes have operated in a similar way to when I was in school, many, many, many years ago. And while we've slowly started to see change here through online options such as Coursera, or services like Chegg, with COVID-19 education was forced to go through a rapid reinvention, almost more than any other industry. And it isn't going back.

Recently, I talked to some high school students in Warsaw, Poland who use the online learning service Brainly to keep up with their school work and help each other through classes. Tools like Brainly have exploded as desperate parents are making sure their kids are learning in this new, remote educational reality.

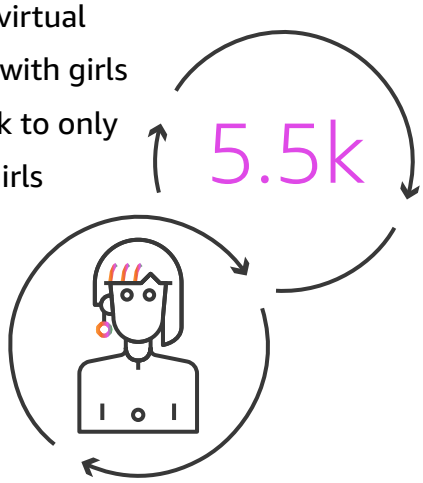
Brainly Users (Web+App)



Source: Brainly

Technology, and access to it, has played a huge role in children's education during this pandemic. This next year is when we're going to prove that remote learning can work and may be a better option for some, and that it can have a positive, and more persistent role in education.

Another good example is the work Kimberly Bryant, the founder of Black Girls CODE (BGC), is doing. Like all educators, Kimberly was forced to conduct her computer science curriculum for girls ages 7-17 online during the pandemic. In a typical year BGC might reach 5,500 students in its classrooms but in just one month of virtual sessions this spring, it reached almost half that annual number, with girls joining from all over the world. Kimberly says BGC won't go back to only in-person teaching, she has seen the scale she can hit, and the girls she can help—wherever they are.



The pandemic, as with many other changes we have witnessed this year, forced us to adapt. But we don't need a global health crisis for classes online to make sense. Having remote schooling (and working) options widely available at any time also means that kids can stay home when they are sick, but still get their education and not fall behind classmates. Or what if there is no school to go to at all? If there is an internet connection there is at least the possibility for some kind of education.

No question, I think we should send our kids back to classrooms, and to each other, but there will be other interruptions. Remote classes give school systems, and students, the flexibility to respond to unforeseen events, whether pandemics, natural disasters, or man-made calamities–to keep the learning going.

PREDICTION SIX

Small businesses will race to the cloud, and **Southeast Asia and sub-Saharan Africa will lead the way**

In 2021 and beyond, we're going to see a massive shift in small businesses beginning to make use of advanced cloud technology to reach their customers and we're going to see an explosion of higher-level technologies and service providers—that will cater to these small businesses. It will be helping small business to do everything from spinning up a chatbot to help with answering frequently asked questions, to getting a dead-simple CRM system in place and running within minutes. Small business get the benefits of sophisticated architectures and applications without having to invest in the time and expense of building it themselves.

The cloud everywhere trend described above is what is enabling this. What is driving it is the experience that most small businesses faced this past year where, in many cases, the difference between surviving and not was an ability to leverage technology. A little-known fact is that only 47 percent of small and medium businesses in the US have their own website. Expect this number to grow in 2021. Expanding this trend globally, we should look to nations in Southeast Asia including Indonesia, the Philippines, Thailand, and Vietnam and in Africa—Kenya, Nigeria, and South Africa to lead the way.

Before 2020, I used to spend a lot of my time in these parts of the world, talking with customers and listening to their stories of how they are using technology to overcome local challenges. In my time in these regions I have seen a great potential amongst their small, and medium sized businesses and have always been inspired by their stories. In sub-Saharan Africa, 90 percent of all companies are small businesses, which make up 40 percent of GDP, and account for $700 billion in the economy. In Southeast Asian countries, small and micro businesses account for 99 percent of businesses in several key sectors, most notably tourism and handicrafts. Online penetration in these countries is already among the highest in the world so going online allows small and micro businesses to reach beyond their communities and stay trading even when their worlds are shutting down around them.

SMEs are a vital component of economies, creating jobs and **enabling inclusive growth**

	Percent of Businesses	Share of the GDP	Women Owned
EU	99.8%	57%	27%
US	99.7%	44%	37%
SE Asia	99%	43%	23%
Africa	90%	40%	30%
LATAM	99.5%	25%	26%

Source: Eurostat, Individual SME Authorities, Association of SE Asian nations, Mastercard Index of Women Entrepreneurs 2020

A good example is Warung Pintar, in Indonesia, which combines both the technical services and the small business side with its cloud-connected food stands. Picture the roadside food and sundry stands that are ubiquitous in Indonesia, and across SE Asia and other parts of the world—in Latin America you might call them a tiendita. These very places are usually run by a solo-operator and you can get a cold drink, a snack, and top up your mobile. Warung Pintar's version offers all of that, but the stall and its operations are connected to the cloud. A Warung Pintar stall operator now gets inventory management and tracking, sales analytics, cashless payments, WIFI, and more, all in a bright yellow package. Operators of these stalls might have previously relied solely on passing foot traffic but can now start to know and nurture their customer base. Previously, the items they stocked and sold were sourced mostly on gut feel, but they can now analyze and understand what's making them money and what's just taking up scarce space.

As these small businesses bring their unique perspectives and often craft goods to the world, expect them to begin to leapfrog a lot of the business practices we see in more established countries. These countries are not burdened with legacy technology or legacy thinking around what is possible for them, so the sky is the limit.

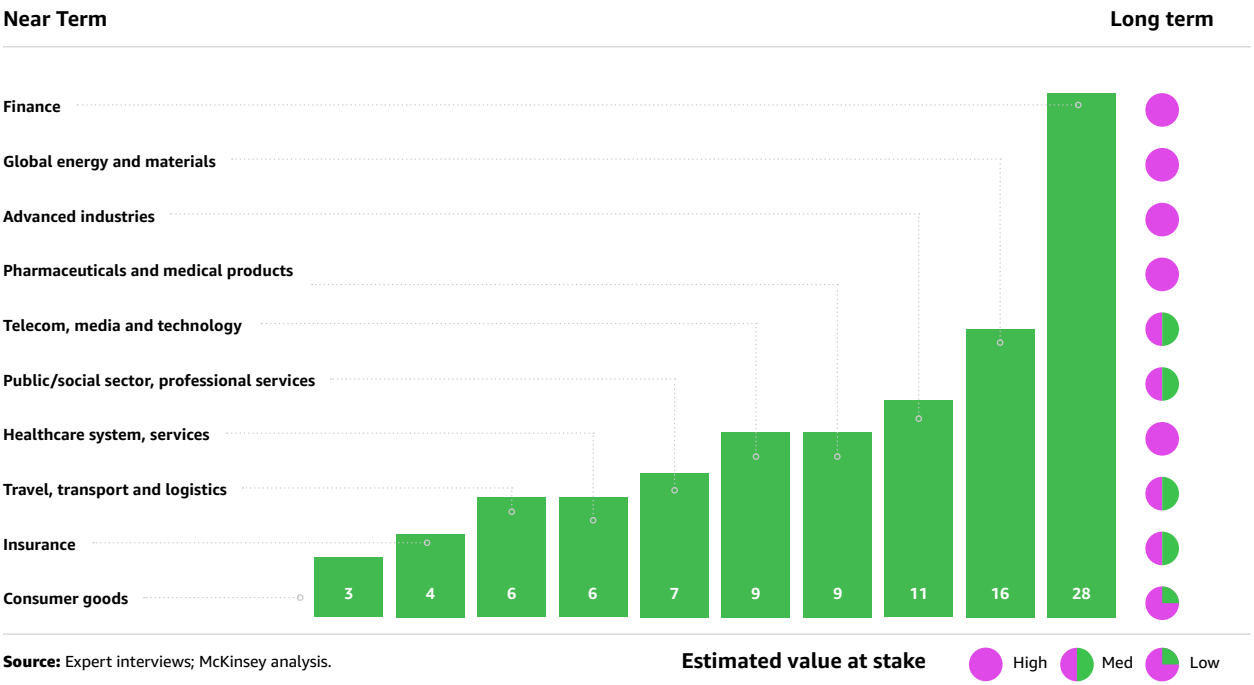
PREDICTION SEVEN

Quantum Computing **starts to bloom**

Something we have seen again and again in the past is if you can democratize the most advanced, most complex technology and make it affordable, available, and understandable to as many people as possible, great things happen.

At re:Invent 2019 we announced Amazon Braket, a fully managed quantum computing service that helps researchers and developers get started with the technology to accelerate research and discovery, and in 2020 we made it available to everyone. Before Amazon Braket, you needed to be one of the world's most advanced research institutes or one of the world's richest companies to have access to quantum computing hardware. With Amazon Braket, anyone can now use quantum machines for as little as $0.30.

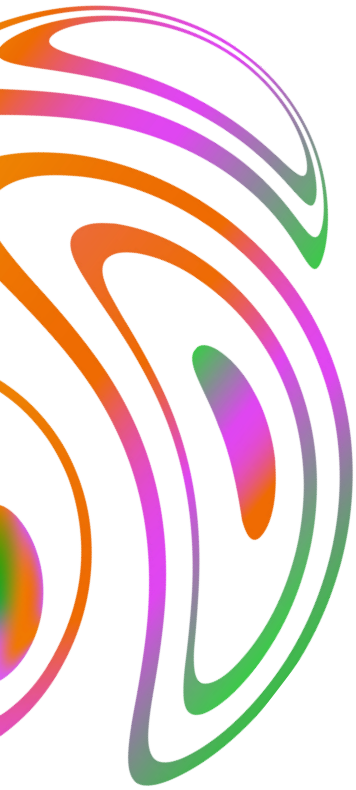
Distribution of quantum-computing use case, 2019, %

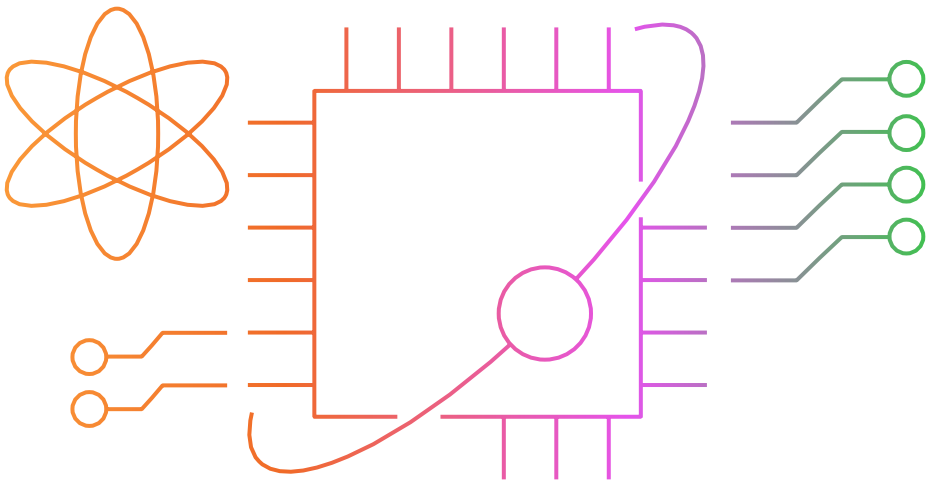


Source: Expert interviews; McKinsey analysis.

There is no question we are at the early stages of this mind-bending approach to computing, but that is the point of Braket. It's especially important in this exploratory time that we let as many people as possible get their hands dirty and their brains wrapped around quantum computing. As companies and institutions begin to experiment with quantum for the first time, and as that expertise starts to move beyond the academic world, we'll see business plans and the early seeds of products and services that center around a quantum future. That is where experimentation with Braket comes into play. As we have seen with ML, when the software ecosystem can truly leverage the hardware, we will see thousands of applications take shape.

In time, likely over the next decade or so, you will see quantum computing transform areas such as chemical engineering, material science, drug discovery, financial portfolio optimization, machine learning, and more. But it only does that if a growing diversity of people start to imagine a way forward. Based on our experience with making advanced cloud technologies affordable, available, and understandable to everyone, 2021 will be the year the quantum computer starts to bloom.





PREDICTION EIGHT

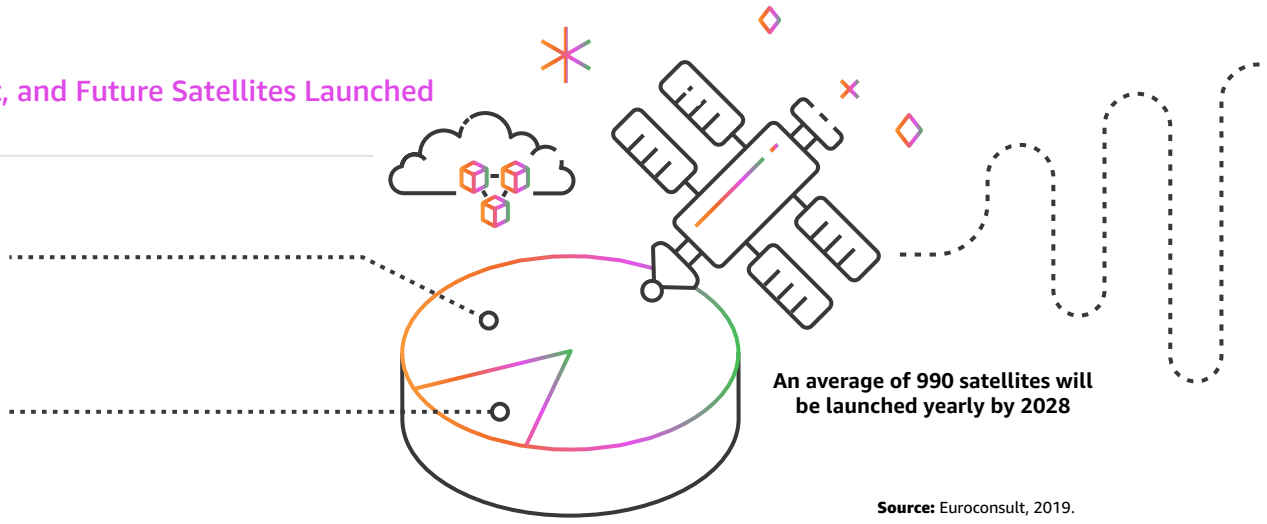
The final **frontier...**

For technology to fulfill its potential to help everyone around the world to live a better life, we shouldn't go out and around the world as much as we should go up and above it.

In 2019, we launched a service called AWS Ground Station that lets you control satellite communications, process data, and scale your operations without having to worry about building or managing your own ground station infrastructure. We have seen a fantastic uptake in this service, but we think it is only just the beginning. In 2021 and beyond, I predict space will be the area where we see some of the greatest advancements when it comes to cloud technologies.

We're already seeing that the ability to access and process satellite data is helping researchers to track glacial recession, maritime agencies protect vulnerable marine reserves, and agronomists better predict food supply. Startups are looking to make space the home for a new breed of fast, secure networks. By making access to space affordable and accessible to every developer, I'm looking forward to seeing the innovations that come back down to earth and can help us all to grow and prosper.

Past, Present, and Future Satellites Launched



Source: Euroconsult, 2019.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