



# THE EDGE OF TODAY

ASSESSING THE ARTIFICIAL INTELLIGENCE OF THINGS (AIOT) MARKET, ITS OPPORTUNITIES, GROWTH, BARRIERS AND SOLUTIONS, ACCORDING TO ELECTRONICS ENGINEERS AROUND THE WORLD

MAY 2021

**XMOS**  
Bringing technology to life

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# ON THE CUSP OF TOMORROW'S TECHNOLOGY, TODAY

Last year, just before the pandemic, we published our in-depth research into the artificial intelligence of things (AIoT) market in “The Edge of Tomorrow”. At the time, the AIoT remained in its nascent stages — but, according to Gartner, the market for it had huge potential, promising to be worth \$3 trillion by 2025.

We explored the opportunities, examined potential applications, discussed the market and technical barriers, and introduced technical solutions that could be used to realise the vision of the AIoT.

A lot can change in a year. Since our report, the Covid-19 pandemic has wreaked havoc. Money is tight for businesses and consumers alike, and the technology world has scrambled to support our new ways of living.

So what impact has the last year had on the AIoT market, which Gartner claimed was so promising? Have the attitudes of electronics engineers changed?

To find out, we surveyed more than 100 electronics engineers, asking the same questions we did last year.

The headline finding? The demand for the AIoT has increased, and its opportunities have become much clearer in the last 12 months. This report, now appropriately entitled “The Edge of Today”, goes on to assess how attitudes have changed and explore how recent technological breakthroughs will help turn the vision of the AIoT into a reality once and for all.

XMOS carried out research with over 100 electronics engineers to ask them for their views regarding the technology building blocks of the AIoT, the barriers holding the market back, and their own design and commercial priorities for the future. This report captures those perspectives and offers unique insights into the way forward for the AIoT — with a clear technical roadmap for hardware manufacturers.

#### PRODUCTS THEY DESIGN

Battery-powered:	34%
Handheld:	15%
Low-power:	36%
Rugged:	15%
Consumer:	45%
Industrial:	46%
Other:	10%

#### INDUSTRIES THEY'RE IN

Consumer tech:	36%
Automotive:	6%
Manufacturing:	14%
Smart cities:	9%
Smart home:	11%
Healthcare:	4%
Telcoms:	2%
Other:	24%



# HOW THE AIOT WILL CHANGE EVERYTHING

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Before we assess the barriers to the AIoT and the potential solutions, we must first recap how we define the AIoT and explore how it will change the face of technology as we know it.

The artificial intelligence of things is the convergence of two major technology trends — artificial intelligence and the internet of things. Artificial intelligence is all about giving technology a level of “human” intelligence, while the internet of things creates a network of smart devices ‘at the edge’. The AIoT is the term we give to devices that are capable of making intelligent decisions on device — capable of sensing, extracting and interpreting information, and making decisions and/or taking actions without the need for cloud intelligence — a gamechanger for technology.

The AIoT has far-reaching implications for electronics in every industry, including the smart home, automotive, manufacturing, healthcare and smart cities.

## WHAT ALL THIS MEANS FOR THE ELECTRONICS INDUSTRY

Each of these sectors are already looking to improve technology with AI — and our research shows that over the past year, these desires have only intensified - 90% of electronics engineers say that incorporating artificial intelligence would increase their competitive advantage (up from 82% last year) — with 56% saying it would increase their competitive advantage significantly (up from 42% last year).

However, there is one industry that is set to benefit the most from the AIoT — the smart home. When asked where the biggest opportunity is for the AIoT, 40% of electronics engineers said the smart home, more than any other sector. That’s perhaps unsurprising in a pandemic-driven world where people are spending more time at home than ever before.

## AUTOMOTIVE

FROM AUTONOMOUS DRIVING AND DRIVER ATTENTION MONITORING TO THE CONVENIENCE OF VOICE-BASED CONTROL - OUR DRIVING EXPERIENCE WILL BE COMPLETELY TRANSFORMED IN THE NEXT DECADE.

## INDUSTRY 4.0

SOPHISTICATED INTELLIGENT SENSING CAN DELIVER HANDS-FREE PRECISION WITH MACHINERY OPERATION, IMPROVING SAFETY, SECURITY AND OPERABILITY, WHILE AT THE SAME TIME BRINGING REAL-TIME DATA AND INFERENCING FOR DEFECT DETECTION AND MAINTENANCE.

## THE SMART HOME

THE AIOT OPENS UP OPPORTUNITIES FOR GREATER SAFETY, PRIVACY AND CONVENIENCE, PROVIDING TOTAL CONTROL OF THE HOME ENVIRONMENT FOR INHABITANTS.

## CONNECTED HEALTHCARE

PRODUCT DEVELOPERS CAN EXTEND THE USE OF MONITORING CAPABILITIES (FOR EXAMPLE, BREATHING PATTERNS AND HEART RATE) AND ADD ADVANCED DIAGNOSTICS FOR EARLY MEDICAL ALERT CAPABILITIES - ENABLING HEALTH PROFESSIONALS TO MONITOR PATIENTS REMOTELY.

## SMART CITIES

WE'LL SEE IMPROVEMENTS IN SAFETY, SECURITY, CONVENIENCE AND EFFICIENCY. AI WILL OPTIMISE TRAFFIC FLOW, CITY PARKING, AND STREETLIGHT POWER, WHILE ALSO VOICE-ENABLING PUBLIC SERVICES TO REMOVE THE NEED TO TOUCH DIRTY OR POTENTIALLY CONTAMINATED SURFACES.

# HOW THE MARKET-LEVEL BARRIERS TO THE AIOT HAVE CHANGED

Last year's research highlighted three main market-level barriers to the growth of AI and the IoT — [security](#), [connectivity](#) and [scalability](#). These issues remain the biggest barriers, although our research this year shows that electronics engineers believe these issues are softening somewhat.

## SECURITY

Security is traditionally a big issue when it comes to artificial intelligence and the internet of things. AI requires data to work and as devices become smarter, the more (potentially sensitive) data they need. Moreover, as an increased number of devices become connected through the internet of things, they begin to share data with other devices potentially outside of the control of the original owner. The risk of data leaking increases dramatically — either through mismanagement or through the deliberate targeting of vulnerabilities within the networks.

However, despite the fact that these issues still exist, a considerably smaller proportion of engineers believe that data security and autonomy is a problem compared with last year. Now, just 31% say data security and autonomy is a barrier — down from 45% last year.

## CONNECTIVITY

Connectivity is also a significant barrier. Applications such as autonomous cars, where safety is paramount, simply cannot afford to be restricted by unreliable connectivity, high latency and low bandwidth when they need to make almost instantaneous decisions based on the changing environment around them. The same issue affects the safety of industrial machinery, where any latency risks jeopardising safety and security in hazardous environments.

However, like security, a smaller proportion of engineers are saying connectivity will be a problem compared with last year. Now, just 27% say that the potential of IoT will be restricted by network bandwidth limitations (down from 38% last year) and 26% say latency is a barrier (down from 32% last year).

## SCALABILITY

Scalability is the final issue. While the IoT relies on the cloud, the compute capabilities of the cloud will soon reach its limits, and therefore will not be able to scale sufficiently to allow the IoT to support the AIoT. The number of IoT devices is set to explode over the next few years, while at the same time the individual devices themselves are going to be sending more data — all of which is going to place unrealistic demands on the cloud.

25% of electronics engineers say scalability is a barrier, which is up slightly from 24% last year, while 18% say that cloud infrastructure limits the ability of the IoT to scale, down from 24% last year.

Clearly, these three issues of security, connectivity and scalability have not yet disappeared, but a year on from our last research, it appears that electronics engineers are feeling considerably more optimistic about being able to overcome these challenges. This change in attitude is testament to the chip industry, particularly those engineering breakthroughs in the past year that are starting to make the seemingly impossible task of embedding AI capabilities into end-point devices, commercially and technically viable.

# HOW THE DEVICE-LEVEL BARRIERS TO THE AIOT HAVE CHANGED

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While the market barriers to the AIoT are significant in their own right, engineers also highlighted last year that cost, power and design complexity are also issues for the AIoT at the individual device level. Research this year shows that, like the attitudes towards the market-level barriers, attitudes towards technical issues are also softening.

## THE COST, PROCESSING, POWER TRADE OFF

Cost remains the biggest barrier for electronics engineers. To reach the performance level needed to power the AIoT in devices, electronics engineers would traditionally have no choice but to use high-performance applications processors similar to those used in mobile phones. These are already expensive — and the need for even more power is only going to increase.

73% of engineers say that their on-device processing requirements are already “high” or “very high” (up from 56% last year) and 51% want to add more on-device processing power (up from 40% last year). The good news though is that a smaller proportion of engineers are citing cost as a barrier to ramping up processing requirements. Just 48% of engineers say cost is a barrier now — down from 64% last year — suggesting that electronics engineers are beginning to see the benefit of breakthrough chip technology. Moreover, on the power side, just 53% say energy consumption is a challenge (down from 65% last year).

## DESIGN COMPLEXITY

Designing in the AIoT has the potential to be an extremely complex undertaking. AIoT systems require many different classes of compute — signal conditioning, inference and classification, communications, control and connectivity. These may be provided by discrete solutions with individual development environments, making system design complex and time consuming. However, much like the other challenges we’ve mentioned, electronics engineers are becoming more positive about overcoming these challenges. Today, just 38% say design complexity is a significant barrier, down from 49% last year.

# WHERE THE MARKET STANDS NOW



Clearly the AIoT has the potential to improve the competitive advantage of products and change the world as we know it. And since last year, the market and attitudes towards it have come on leaps and bounds. And while the hurdles in the way of the AIoT have not yet completely disappeared, the future of technology is already considerably clearer than it was a year ago.

So what needs to happen now for the AIoT industry to progress?

First, devices need to reduce their reliance on the cloud for intelligence. This is a huge shift from the operational model that has quickly established itself with the IoT. 77% of electronics engineers agree that more on-device/edge processing will be necessary to deal with the exponential growth of data from the IoT devices and to enable the transition to the AIoT (up from 70% last year).

But moving away from the cloud also tackles some of the other hurdles in the way of the AIoT. By moving key tasks to on-device processing, the security and latency concerns around the IoT reduce significantly. Moreover, on-device processing frees the AIoT from bandwidth and network connectivity limitations, which means the industry can scale freely.

But if we are to move to an on-device processing model, electronics engineers will need to massively increase the available on-device processing power. Indeed, 84% of electronics engineers expect device processing power requirements to increase for future products (up from 77% last year) — with 38% saying it'll increase significantly (up from 25% last year).

However, we need to deliver this extra computing power without adding to the BOM cost or the power budget of what are inherently low-cost, low-power devices. These might sound like paradoxical demands that might be impossible to resolve, but chip vendors are increasingly introducing technology solutions designed specifically for the AIoT.

# XSCORE.AI: SOLVING THE MARKET BARRIERS

One solution that came to market in the past year is xcore.ai — the world's lowest cost, most flexible AI processor. xcore.ai is enabling developers to embed intelligence at the edge and unlock the power of AIoT once and for all.

With uniquely programmable input/output ports, fast processing and neural network capabilities, xcore.ai locally processes data quickly, enabling devices to make intelligent decisions without needing the internet. This way of operating helps solve the main barriers to the AIoT cited by engineers.

## ENHANCED DATA SECURITY

xcore.ai has a suite of advanced security features including secure boot, one-time-programmable key storage, true random number generation and custom security instructions. These features provide a foundation for significantly improved safety for both data and decision making.

More importantly, by reducing the need to communicate with the cloud, xcore.ai automatically lowers the risk of data leaking. All necessary data and subsequent decisions can be made by the device itself, thereby protecting that data from attack — directly addressing the biggest concern by electronics engineers.

## ZERO CONNECTIVITY ISSUES

By reducing the need for the cloud to make on-device decisions, engineers can embed intelligence into devices that will work anywhere, perfect for applications that cannot rely on network connectivity or bandwidth limitations for safety and security reasons.

## SCALABILITY WITHOUT LIMITS

xcore.ai's architecture is inherently scalable, enabling device manufacturers to dramatically increase the volumes of artificial-intelligence capable devices. Moreover, by moving the processing to the edge, xcore.ai removes dependence upon the cloud, enabling the AIoT to finally scale without being held back by the cloud's scaling limitations when processing billions more devices and petabytes more data in years to come.

On the device itself however, xcore.ai offers the fastest reacting I/O on any processor. It's so fast that it's possible to re-create hardware protocols for system communications and control in software. This capability enables embedded system designers to create their own highly integrated application-specific chip and get to market with differentiated solutions at unprecedented speed.

# XCORE.AI: SOLVING THE DEVICE-LEVEL CHALLENGES



xcore.ai solves market-level barriers, it solves age-old technical barriers as well regarding [cost](#), [processing](#), [power](#) and [design complexity](#).

## COST EFFECTIVENESS

xcore.ai delivers the world's most flexible and affordable high performance processing for the AIoT. xcore.ai offers unparalleled opportunities for integration, which keeps eBOM costs low, and design potential high.

## NEAR-INSTANT DECISION MAKING

xcore.ai is lightning fast and predictable, with execution determinism measured in single-digit nanoseconds, which enables products to think and make decisions at speed. With general purpose compute, AI acceleration, powerful DSP and instantaneous I/O control, xcore.ai enables devices to sense, infer, decide and react in real time.

## LOW POWER CONSUMPTION

xcore.ai works on an “always-ready” basis rather than an “always-on”, which keeps power consumption to a minimum. xcore.ai takes less than 10 milliseconds to boot from zero power and nanoseconds to transition from low power standby to full performance.

## DESIGN SIMPLICITY

The unique features and performance of xcore.ai are accessible quickly and easily through industry-standard tools and techniques. The flexible, unified programming model ensures that AI, DSP, control and communication capabilities can be developed simultaneously and coexist reliably — both at design time and in the field. This capability means designers can architect their own application-specific chip in software and get to market with differentiated solutions at unprecedented speed.

## XCORE.AI OFFERS

32 x IMPROVEMENT IN AI PERFORMANCE

16 x FASTER I/O PROCESSING

15 x DIGITAL SIGNAL PROCESSING PERFORMANCE

21 x 16-BIT MACs

## VS ARM CORTEX M7\*

\* NXP i.MX RT1060 processor selected as integrated solution appealing to similar markets.

# XCORE.AI: HOMING IN ON THE SMART HOME

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As we saw earlier in this report, electronics engineers believe that the biggest opportunity for the AIoT is the smart home. With people now spending more time at home than ever before, manufacturers of electronic devices for domestic use are keen to improve the experience of being at home.

But the smart home as we know it isn't perfect. There are still some significant issues hindering its growth, including data privacy, energy use and bandwidth limitations. xcore.ai enables manufacturers to engineer these challenges into irrelevance once and for all.

## THE NEXT GENERATION SMART HOME

xcore.ai goes further than simply solving today's issues. It can provide the foundation for the next generation of smart technology around the home. At the moment, most smart home technology revolves around voice interaction. While voice is an excellent start, it still only represents one of the five human senses.

xcore.ai's flexible compute and I/O capabilities enable application developers to specify multiple sensors of the same or different types to be interfaced and processed to build information about an environment that can be used to deliver greater insight and differentiation.

For example, with advanced imaging and radar technology, a smart home can recognise who enters the living room, and automatically set the lighting, heating, TV and music to that particular person's preference. Radar technology combined with sound detection can accurately determine whether an elderly relative has had a fall in their house, and alert nearby family members or the emergency services automatically.

xcore.ai is the perfect chip for each and every one of these use cases. With its design simplicity and flexibility, home tech manufacturers can easily embed intelligence within their products, and create an environment of connected devices around the home, operating in an entirely private manner, to take the smart home to the next level.

# XCORE.AI: THE KEY TO UNLOCKING THE AIOT MARKET



Attitudes towards the AIoT have changed dramatically in the last year. What was once perhaps a low priority for many engineers is now seen as a commercially viable key differentiator thanks to technological breakthroughs like xcore.ai. Over the coming years, we can therefore expect a huge rise in demand for flexible chip technology from electronics manufacturers across the board as they embed intelligence into their products.

The AIoT industry is now on track to achieving Gartner's market valuation prediction of \$3 trillion by 2025. Once it hits that mark, technology as we know it will never look the same.

To find out more about xcore.ai, visit its [product page](#) on the XMOS website or [get in touch](#).

## ABOUT XMOS

In 2005, a small team assembled to create a fast and flexible microcontroller that would enable designers to respond quickly to diversifying market demand. The first (XS1) and second (xcore-200) generation processors put unprecedented I/O capability (available through software for the first time) alongside significant DSP and control processing — establishing XMOS as a name in the audio sector.

The vision quickly shifted towards AI. Caught between two very different technical and commercial models, Graphcore was formed to focus on server-side AI, and XMOS continued the quest towards low-cost embedded intelligence (edge-AI). Most recently XMOS enabled voice to become mainstream, releasing the XVF3510 — a disruptive high-performance, low cost far-field 2-mic voice interface. This was followed up with xcore.ai — a new crossover processor for the AIoT that brings AI, DSP, control and I/O together in a single device.



XCORE.AI  
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DO MORE

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