

Identifying gaps in the AI hardware patent landscape to grow market share

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Contents

- 04** Executive summary
- 05** About AI hardware
- 06** AI hardware patent filings are growing rapidly
- 08** Types of AI hardware patents
- 09** Competing in a crowded landscape
- 12** Filing strategy by large and small companies
- 14** Advancing AI hardware into the future
- 15** Uncover answers with Clarivate

Executive summary

Inventive activity in artificial intelligence (AI) hardware is increasing at an extremely fast pace – almost 50% increase in patent filings is seen every year.

Organizations spend a lot of time, money, and resources developing new products in AI hardware. To be competitive, identify new opportunities, and avoid infringing on a competitor's intellectual property, these companies need a comprehensive view of the entire AI hardware landscape.

Like in any competitive innovation space, looking solely at the number of patents filed does not provide enough information for strategic decision making. Successfully securing a patent and launching a new product entails analyzing many factors across current offerings. The challenge is accessing this type of detailed data that shows current trends in AI hardware innovation along with the large, small, and emerging players, and considering the implications patent analysis can have on innovation strategy.

A critical component to patent research is finding the whitespace. In a world rapidly embracing and optimizing AI, more companies than ever are developing new technologies for AI-enabled hardware.

To be competitive in this space, both new and legacy competitors need to:

- Understand what is already available with existing hardware, including computing hardware for accelerating AI
- Determine how AI hardware is being applied in the marketplace
- Identify the top competitors
- Identify where the hardware is going in the future

We created this white paper to highlight the importance of having visibility into the patent landscape of AI hardware. For the information in this paper, we conducted a patent landscape analysis of the AI hardware space and are sharing our key insights. Such insights are one key element of the critical intelligence required to make informed intellectual property decisions specific to AI hardware and other innovation landscapes.

Gaining a Data-Driven Understanding of the AI Hardware Ecosystem

The analysis of the AI hardware ecosystem shared in this report focused on microprocessors and chips designed to enable machine learning, neural networks, or deep learning applications.

We identified 24,000 published invention families filed from 2010 to the present but did not include software. One subset focused on hardware with a configurable circuit, processor, chip, or similar concept, and the other subset captured hardware applications. All 24,000 patent families were mined in detail for distinct technical approaches.

24K

published invention families identified in the analysis

About AI hardware

Companies developing products or services for AI hardware want to know where there is “whitespace” in the market, how their inventions will fit into the current landscape, the novelty of their innovations compared to existing patents, and how they can capture new market share. Gaining the necessary insights at the detail needed for informed decision making to drive R&D budgets and direction requires companies to perform a detailed landscape analysis.

AI hardware is optimized in systems spanning a variety of uses, from embedded applications to large data centers.

Differentiators in AI hardware include various levels of power and performance, different application areas, and price tradeoffs.

The hardware plays an important role in supporting or accelerating many AI applications, including current business applications and those on the horizon that could be released in the coming months or years. The myriad players in the AI hardware space and the patents currently held by these companies can all influence an organization’s innovation strategy for developing new hardware.

What is AI hardware?

Artificial intelligence hardware is computing hardware that accelerates AI applications. It includes:

ASICs: Application-specific integrated circuits

CPUs: Microprocessors, microchips, and conventional hardware such as central processing units

GPUs: Graphics processing units

FPGAs: Field programmable gate arrays that enable AI applications in hardware.

The hardware provides differentiators for application development, machine learning, brain-inspired computing, and other use cases. Some applications, like spiking neural networks (SNNs), deep learning, deep neural networks (DNNs), and convolutional neural networks (CNNs), are computationally intensive and especially well-suited for hardware acceleration.

AI hardware patent filings are growing rapidly

AI hardware advancements are built on decades of computer architecture and system innovations by organizations around the globe. These include, for example, deep neural networks (DNNs) and convolutional neural networks (CNNs) in which computations are mostly dense matrix-matrix and matrix-vector multipliers, and they exploit data reuse, locality, and data density. Well-known computer technologies and architecture improvements now exploit these characteristics.

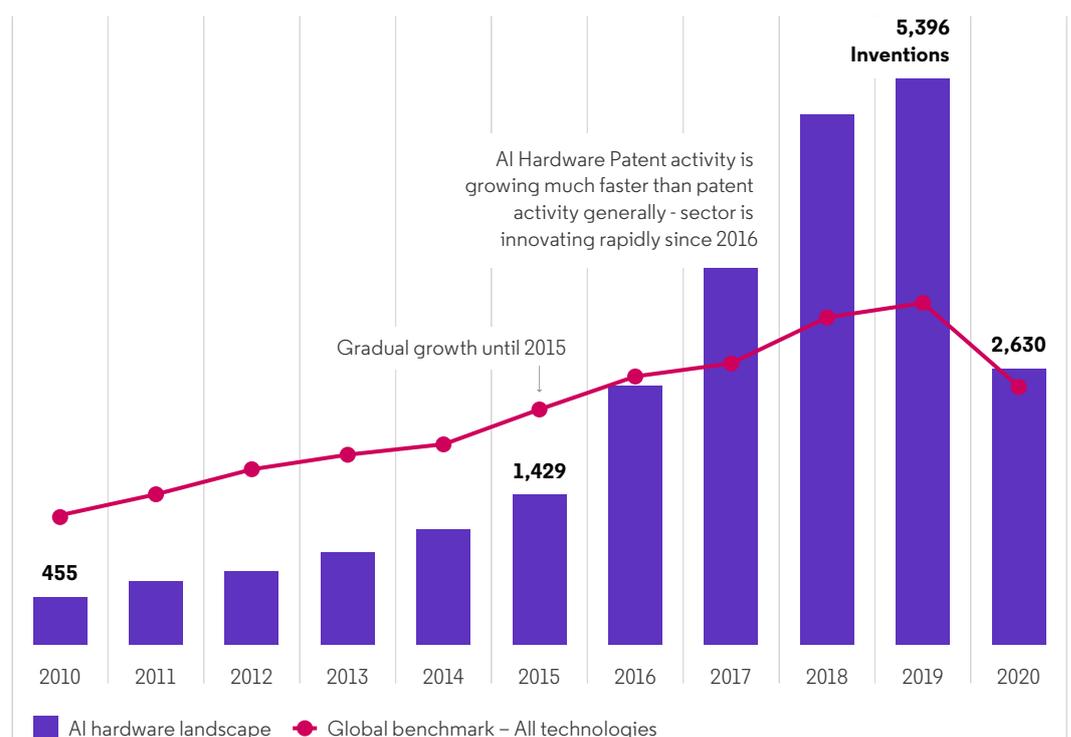
Today, a mix of large, small, startups, and emerging companies are all competing in the AI hardware space. Some are focused on developing computing hardware, while others are specializing in creating technologies that accelerate AI applications. Generally speaking, the hardware is also needed to efficiently support innovative software.

Rapid innovation has caused AI hardware patent filings to grow much faster than the global benchmark for all technologies since 2016 (Figure 1).

Patent activity kept pace with the global benchmark until 2015. A massive surge in filings surpassing the global benchmark is seen starting 2016.

Taking a closer look, academic and government entities are largely responsible for this massive surge in the recent years. The active and growing involvement from the academic and government sectors indicates ongoing fundamental research. These two sectors own 25% of the marketplace, which is more than two times higher than the global benchmark.

Figure 1: Growth of AI Hardware Patents



Innovation typically follows regional trends. Currently, innovation is primarily originating from Mainland China and the U.S., with Mainland China growing at a much faster rate in part because of the rise in patent filings from China-based academic and government entities. The field-programmable gate array (FPGA) category now represents the fastest-growing area of Chinese academic institutions.

To help inform filing strategies, we analyzed the success and grant rates at five major patent jurisdictions – the

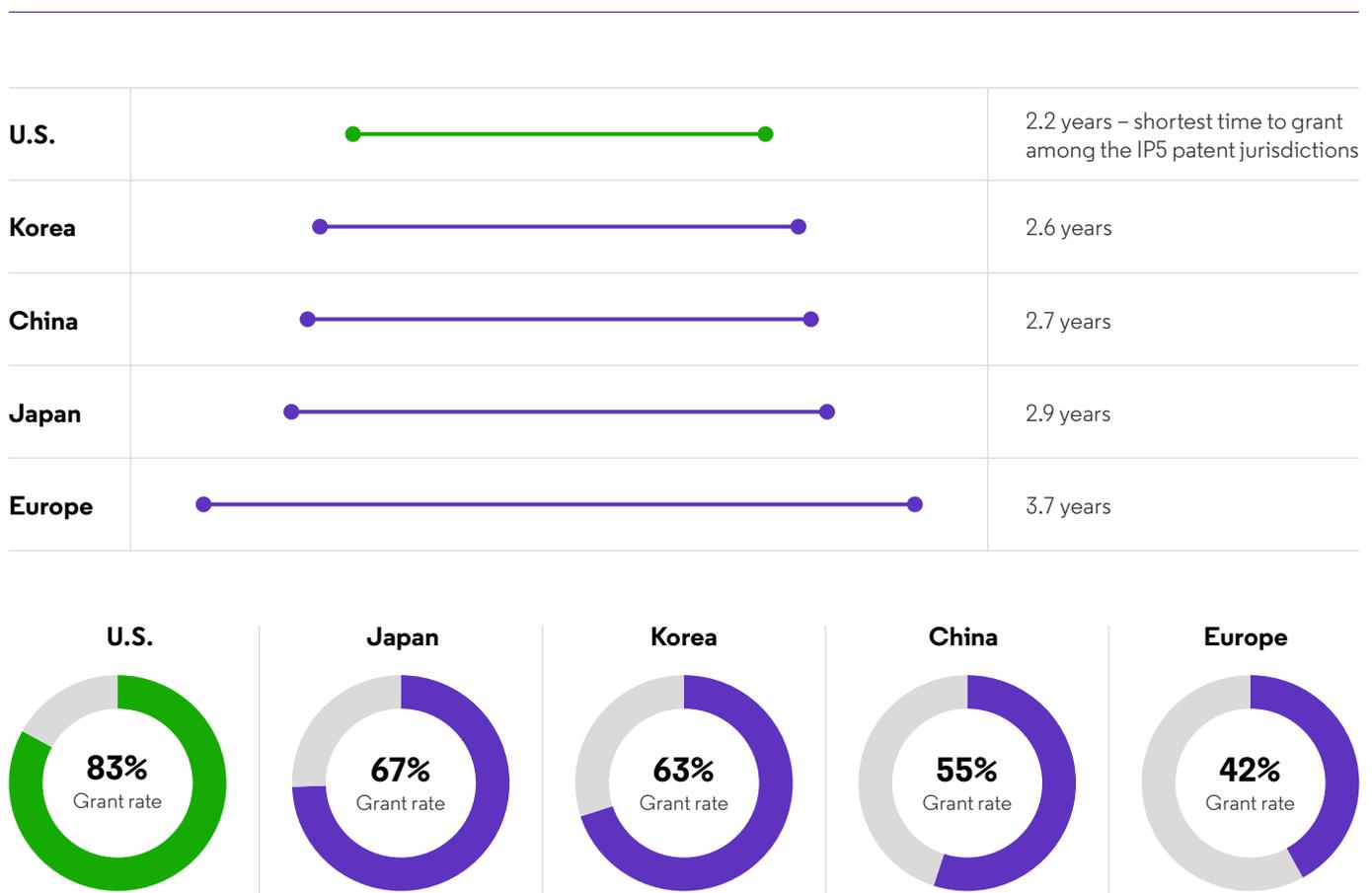
United States, Japan, South Korea, Mainland China, and Europe. To accurately calculate the grant rate, we first determined the length of time it takes for a filed patent to undergo an examination and be granted. During this pendency period, the patent exists only as a potential intellectual property right.

Based on grant rate calculation which factors pendency period as well, the United States offers the highest success rate for patent applicants with the shortest pendency period. The pendency period represents

the average number of months from the patent application filing date to the date the application reaches final disposition, meaning a patent is either issued or the application is withdrawn. The shorter the pendency period, the faster organizations receive the patent to protect their intellectual property.

Filing is always a strategic decision, and pendency periods factor into the decisions because some countries are more favorable to AI hardware patents than others. This can result in quicker approvals (Figure 2).

Figure 2: Success Rates and Pendency Periods for Patent Applicants



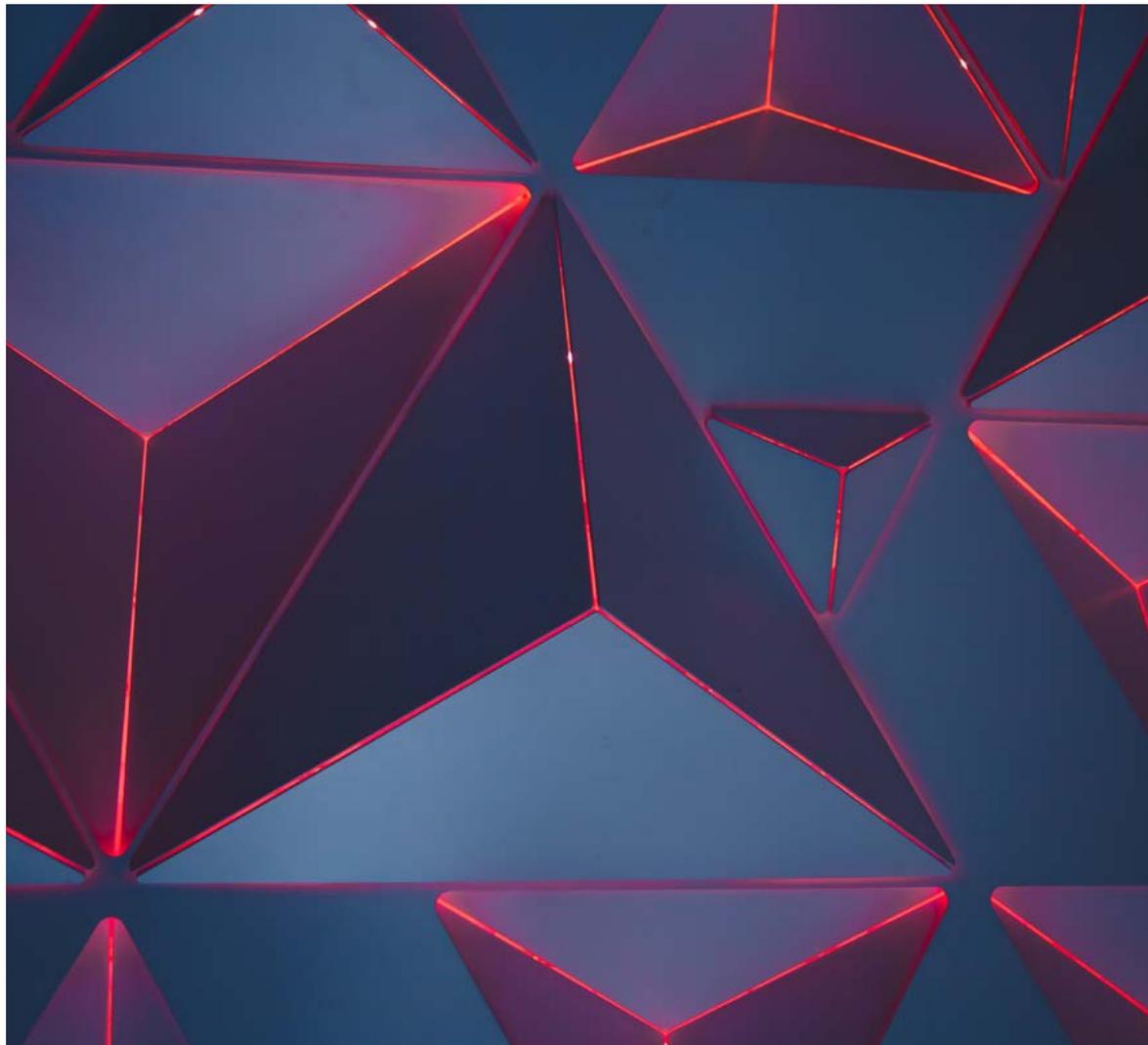
Types of AI hardware patents

Organizations also have to decide what they want to patent. For instance, in Mainland China, industrial and utility model apps could be used to protect the exterior portions of hardware, which is what is externally visible, and Mainland China provides fast routes for this patenting. Design patents can protect against counterfeits that look like the patented product, but work differently. This protection is important for consumer products.

For hardware products, the infrastructure that goes with the AI product is also important to protect, as is the use case when the hardware is trained. For hardware features it is worth protecting externally identifiable use cases that are likely to be copied,

and where infringement can be detected. In fact, sometimes as much as two-thirds of the patent portfolio of hardware companies includes enabling software patents, such as compiler techniques and scheduling logic.

That is why companies want to look at a product and technology from different perspectives.



A high influx of small entities are also entering this domain. Those in the top right quadrant of Figure 4 have strong but young portfolios, yet these companies have the potential to disrupt the current market.

Figure 4 illustrates that with many competitors and advancing technology, comprehensive patent analysis, including patent strength,

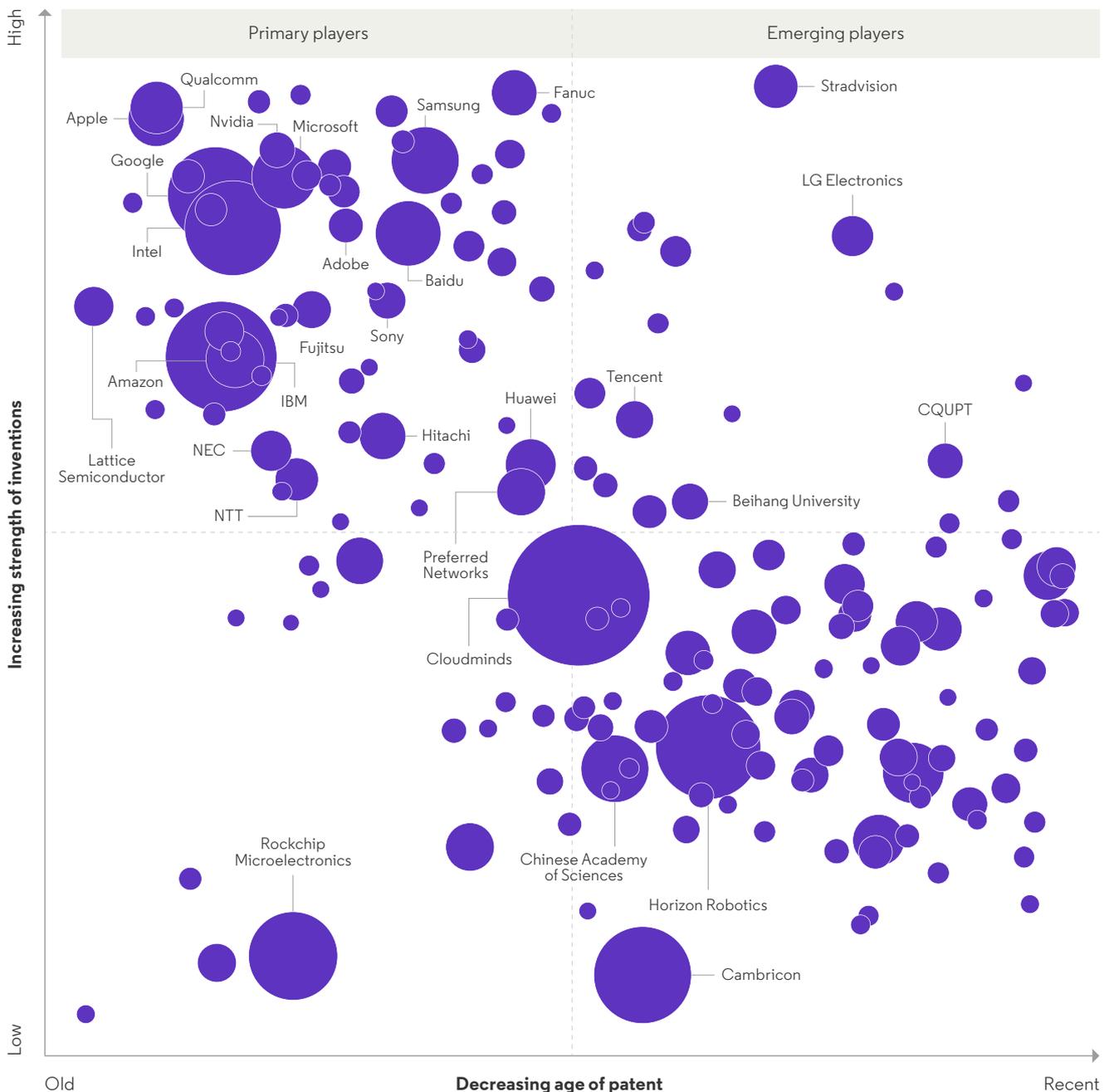
becomes essential. One shortcoming of patent analysis is that simply measuring the volume of patents in a technical field only tells a partial story.

Additionally, organizations filing for a patent need a comprehensive analysis that can adequately determine the strength of inventions and therefore support strategic decision making. The analysis should quantitatively

measure the parameters that act as proxies for motivation, value, impact, validity, and age.

Leveraging insights from in-depth analyses allows organizations to be aware of new players competing in the AI hardware market. Gaining this awareness and visibility informs strategic actions, such as licensing or acquisition.

Figure 4: Entities with Application-Focused AI Hardware



Many organizations in this space are seeking to apply for more patents. Figure 4 shows the entities that have strategies focusing on the benefits of patenting not only products, but also the overarching infrastructure that goes with the AI hardware product and the related hardware manuals.

Given the fast rate of innovation today, patent counsels at organizations need to understand how technology is evolving and how conventional technology is being improved, and then apply legal strategies accordingly. For example, training and

inferencing can require different hardware and have different tradeoffs, so they must be considered in patent strategies.

It is also important to remember that innovations can happen across many different dimensions, which means the same technology improvements can be claimed in different ways when it comes to patents. For additional insights, benchmarks provide useful information into what parameters help distinguish hardware. Professional benchmarks can provide unbiased evaluations of training and inference performance.

Filing for a patent is a strategic decision

To file for a patent, an organization should:



Know what it wants to patent, and in what jurisdictions



Consider future markets for the product



Understand who and where competitors are



Identify where the inventors are because some countries require foreign filing licenses



File internationally (if applicable) to increase patent portfolio value for licensing

Filing strategy by large and small companies

The patent landscape analysis shows that large corporations target multiple jurisdictions with their products and services. This is because they often have established processes, large R&D budgets, and seek to file patents in several jurisdictions for upcoming product releases.

By contrast, money can be a struggle for startups. This is indicated in the analysis as startups usually file a provisional patent with a claim that differentiates the product. Within one year, the company can update the information and file a patent cooperation treaty (PCT) to buy time until it is ready to file for the actual patent.

Companies that are established in this marketplace are typically legacy organizations. They are finding that they are now competing with agile upstarts.

Those operating in crowded environments apply red ocean strategies, as opposed to blue ocean strategies, for marketing. Red oceans represent the known marketplace and companies in existence today, and red ocean strategies are designed to compete for a greater market share in a limited space. Blue oceans are the opposite. They are new or emerging spaces, not crowded by competitors.

When combined with data, analysis, marketing plans, and technical know-how, legal strategies can help garner entry into new markets. They can also help retain leadership and secure a stronghold even in red ocean markets.

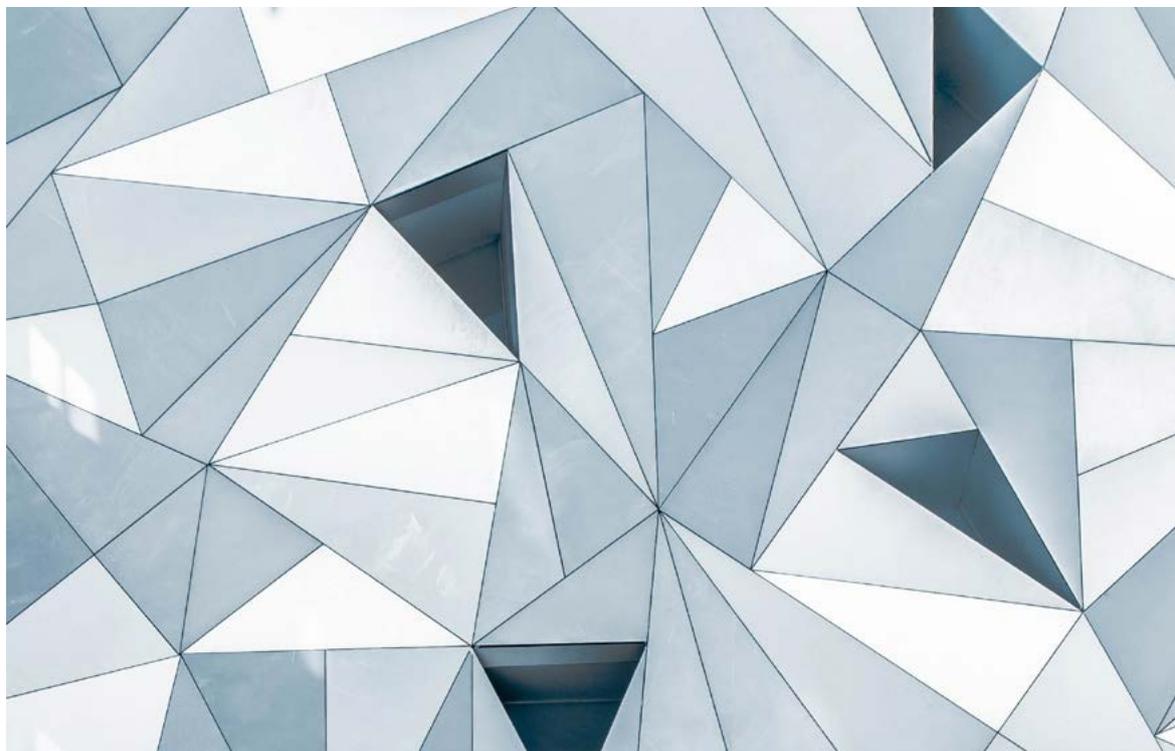
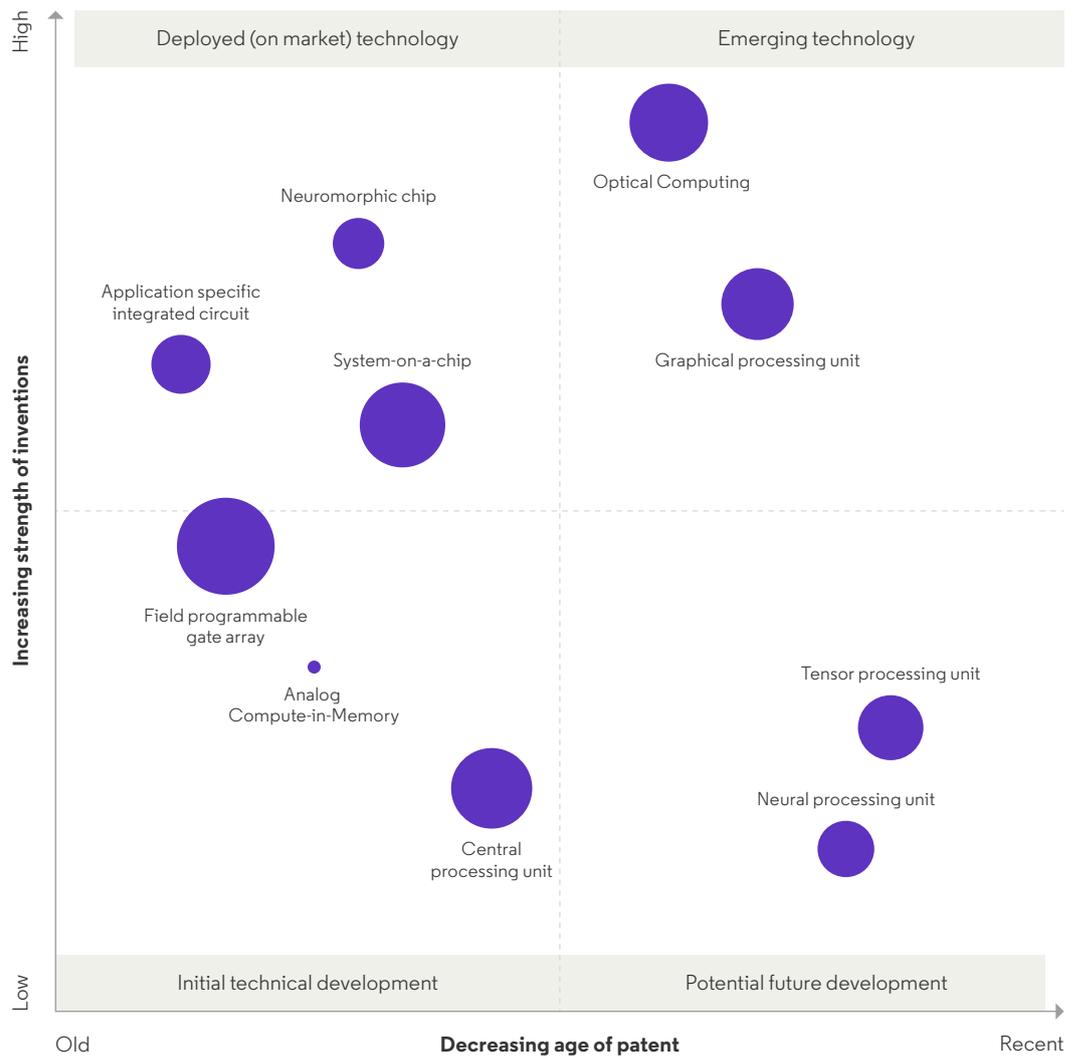


Figure 5: Current technology landscape



Securing patents for use cases

Patents are not only for products, services, or technologies.

Several large companies have patents for their use cases:

- **Amazon** has patented speech, voice assistance, autonomous unmanned aerial vehicles.
- **Intel** has a patent for object recognition using 3D image data; estimating the states of an autonomous device; model-for-scene reconstruction using a convolutional neural network; image and video processing for recognition applications; and neuromorphic applications.
- **Nvidia** obtained a patent for visual sequence learning using neural networks; adaptive driver assistance systems (ADAS); self-driving cars using automatic image analysis for security systems; and smart real-time language translations in video chat applications.

Advancing AI hardware into the future

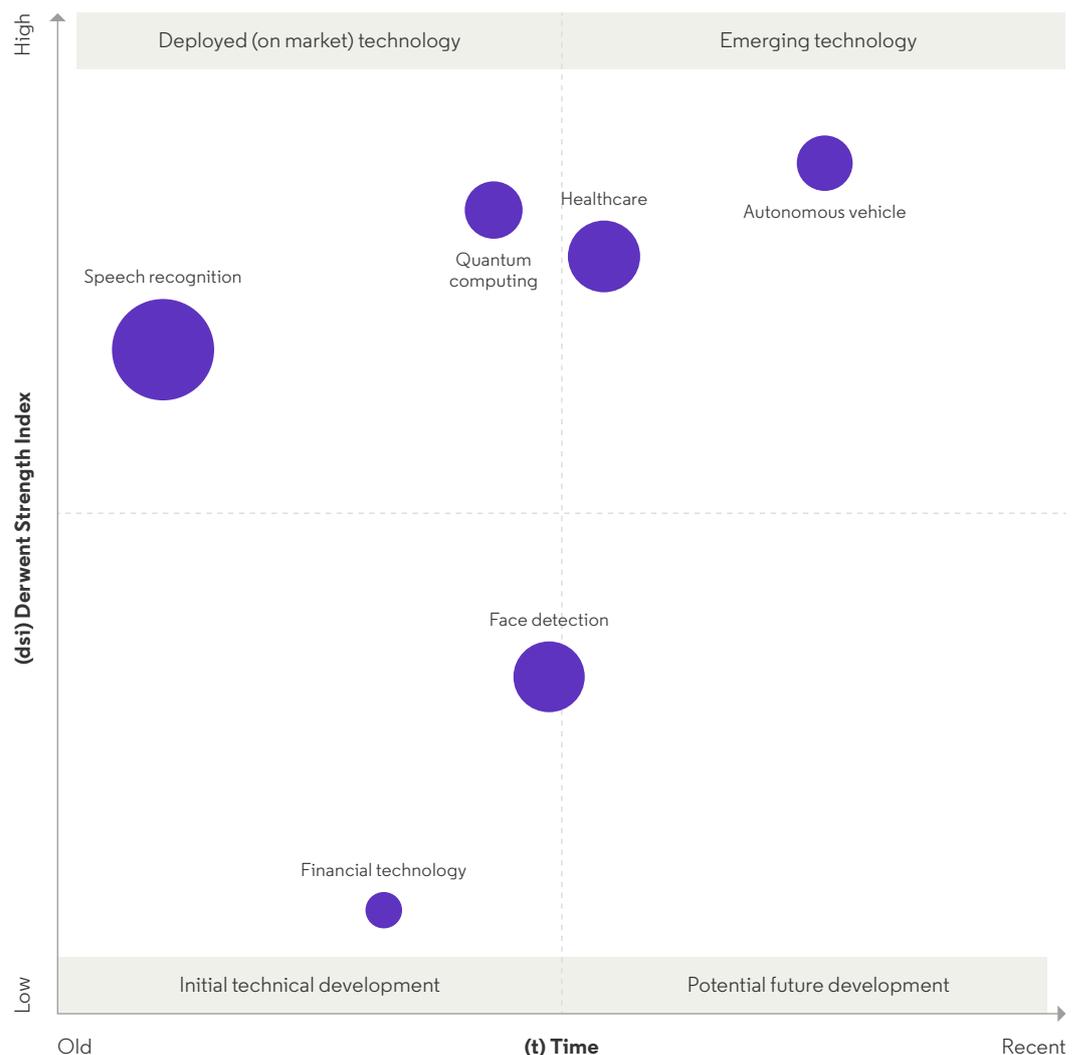
An additional strategy for monitoring innovation is to look at the technical categories and monitor changes in development for emerging players and potential disruption. Figure 5 features the technology overview, showing domains are moving toward optical computing and improvements in graphical processing units.

As a result of the fast pace of AI adoption, understanding the AI hardware space is essential for high-tech companies looking to enter this space or that want to stay ahead of competitors by protecting their patents.

Being innovative is essential for companies' success, and this success requires organizations to be fully aware of other patents in order to identify market gaps.

Ongoing monitoring of technical categories will reveal which ones become stronger and disruptive, and which ones never gain traction and become old and weak. As shown in Figure 6, organizations can expect future AI applications, which will most likely be driven by AI hardware, to include more autonomous vehicles, quantum computing, new healthcare applications, new speech and face recognition applications, and more.

Figure 6: Future AI applications



A competitive landscape timeline

Organizations that use Clarivate services can expect:

- **Day 1:** Gain a clear understanding of the technology marketplace, such as who is present, where is the most activity taking place geographically, who are the strong portfolio holders, what are the main sub-technologies for trends, and where are the whitespaces.

- **Day 30:** Select key players from the technology landscape and compare the customer's portfolio to that of their peers. This provides a comprehensive benchmarking study to provide a clear understanding of competitor focus and trends.

- **Every 3 months:** Set up quarterly competitor watches to monitor competitor patent activity, to help inform decision making and receive notification of possible infringement.

Uncover answers with Clarivate

Getting analytic insights into the AI hardware ecosystem is difficult, yet it is essential for businesses competing in this area. Specialized data insights reveal what hardware is on the market, how it is being applied, where it is heading in the future, and how it supports AI.

The AI hardware space is popular and trending. Emerging startups want to identify their niche and get patent protection quickly for differentiating features. Some of these companies are considering options to partner with larger players, using off-the-shelf technology, and joining industry consortiums.

Meanwhile, large organizations want to build their competitive advantage, enhance their AI hardware portfolios, and maintain or grow their market share. All organizations, both large and small, should protect all avenues of their AI hardware products, including open source, trade secrets, manuals, and code.

An organization can “landscape” a competitor's products or an innovation space and use that intelligence to inform its own strategy. Oftentimes, when companies enter a new product line, they perform analysis or seek an external review of their freedom to operate. By working with the Clarivate Patent Research team, organizations can access the data needed for a comprehensive patent landscape to identify potential partners, or where there is an opportunity to launch a new technology.

Clarivate offers services that are:

- Tailored to inform multiple audiences
- Highly visual for clarity, underpinned by expert practitioner knowledge
- Structured to focus on answering questions with easy-to-use output
- Able to increase the exploitation of under-used data sources, such as the Derwent Patent Citation Index
- Inclusive of benchmarks, including the Derwent World Patents Index, for added insights

By unifying data, tools, and services across all data classes, Clarivate can help customers in any industry unlock the full potential of their intellectual property across the entire innovation lifecycle and successfully navigate today's complex and often unpredictable global innovation landscape.



About Clarivate

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