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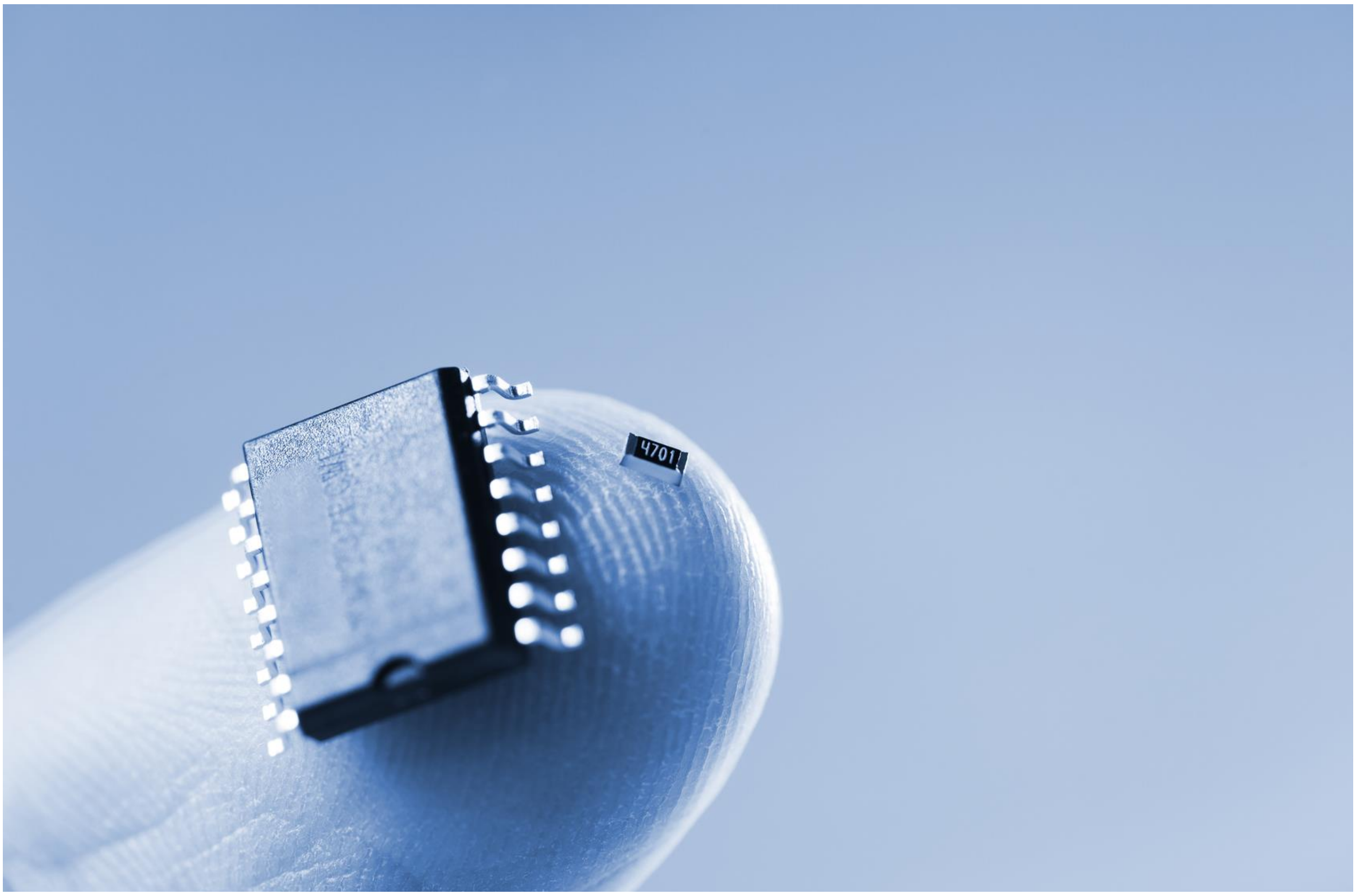


Small wonder: The emergence of nanoscale computer processing

Part of a 30th anniversary series, Sagentia takes a look at some of the key trends in the last three decades and how these breakthroughs in science and technology have impacted the way we live and work today.

A Sagentia
white paper

Small wonder: the emergence of nanoscale computer processing

One of the fundamental shifts over the last 30 years has been the way that processing power has evolved from a reliance on discrete components to increasingly complex multifunctional chips. The result has been inordinately high-performance computing delivered from transistors which are invisible to the eye which have enabled a vast array of game-changing applications for business and consumers. This article takes a look at the major technology developments in this area and then considers how medical diagnostics, manufacturing and industrial processes, as well as consumer applications, have benefitted from a range of embedded applications.

One chip: many functions

These days, transistors – the fundamental building block of computer chips – are minute at just 14 nanometres. That's so small that it's possible to fit over 100 million of them onto the head of a pin. Each one runs 4000 times faster than they did 30 years ago and uses 5000 times less energy. Over the same period their price has dropped by a factor of 50,000.

With the rapid development of microprocessor technology and increasing transistor densities more and more functions have been integrated onto a single chip. Even when Gordon Moore predicted in 1965 a doubling in chip performance every year for the next decade (revising it at the end of that decade to a doubling every two years for the foreseeable future), it's doubtful that even he could have imagined what is possible today. The speed at which new feature sizes below 14 nm are introduced is slowing as the fundamental limits of traditional CMOS technology is reached and quantum effects have to be considered. To continue improving performance with CMOS nodes 3D packaging and 3D integrated circuits are allowing vast numbers of transistors to be placed into smaller and smaller packages.

Working in parallel

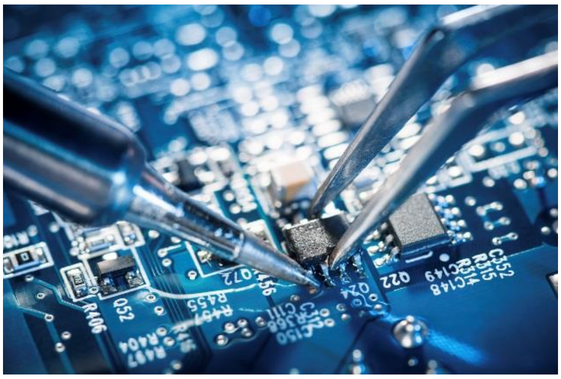
More transistors per chip means more computer power and more power creates electronic systems with vastly greater functionality and performance than has ever been possible before. The arrival of microscopic transistors, smaller than even the Ebola virus, has made it possible to use the extra chip space to duplicate their existing circuitry and create multiple processors in one which are then able to work on tasks simultaneously.

Such 'multi-core' parallel processing in which a single physical processor contains the core logic for two or more processors opened up new opportunities for massively improving performance and power consumption even further.

Sagentia has developed processing platforms for the oil and gas industry which provide 200 TeraFLOPS of computing power using the latest 8 core digital signal processors in combination with 28nm feature size FPGAs. This amount of computing power was unprecedented 30 years ago. The first CRAY supercomputer was introduced 30 years ago and reached a peak processing speed of just 160 MegaFLOPS.

Superchips

The advent of ‘system on a chip’ technology raises the bar again on what can be achieved. Incredibly small form factors combined with immense computer power result from putting the microprocessor, graphic processing unit, modem, memory and peripherals onto a single chip. Consuming much less space and power than a traditional circuit board, SoC ‘superchips’ are a key enabler for connected devices and the Internet of Things.



Paulo Pinheiro, Head of Electronics, Software and Systems, Sagentia adds “Work in the non-invasive pre-natal testing arena is a good example. Data generated by Next Generation Sequencing (NGS) machines can now be aligned to the human genome at rates in excess of a million DNA sequences per minute using standard consumer Personal Computers (PCs). This allows this type of analysis to be performed in decentralised point of care environments rather than by dedicated super computers”.

With the ability to make chips increasingly smaller and ever more powerful finally starting to plateau, integrated circuits (IC) are becoming more specialised. Custom-built ICs focus the available resources on exactly the task in hand and dedicate all their compute-power to a defined set of activities.

However much is still being done by the world’s IT firms to guarantee the future for Moore’s law. The Economist (March 2016) reports on a number of initiatives to move performance on again including optical communication and the use of light instead of electricity to connect transistors and work to develop better memory technologies and new kinds of fast, dense, cheap memory.

There’s perhaps no surprise that over the last 30 years, advanced processing of the kind described, has contributed to significant breakthroughs. We now take a look at some of the applications.

Transforming markets

All this processing power has, and continues to, transform industries.

Industrial applications: enabling intelligent measurement

Embedded micro-processing systems are being increasingly used across the automotive sector in engine control, fleet tracking, safety systems, infotainment and fuel management. Vehicle to vehicle communication to improve safety and reduce accidents are proving an insight of things to come. Relying heavily on network and vehicle-based computing and communication systems, recent trials by the US National Highway Safety Administration and the SafeSpot project funded by the EC are just two examples.

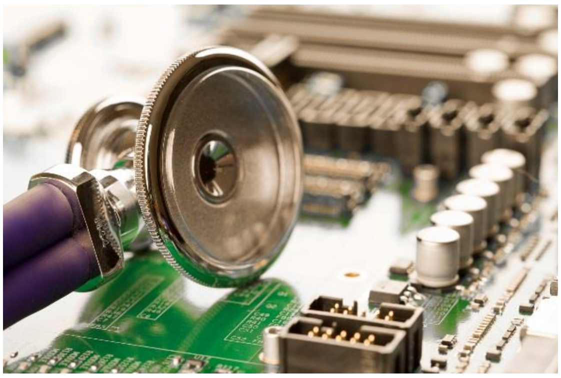
Alun James, CTO of Sagentia's Commercial Business expands "Our work for Stingray Geophysical, who are developing subsea, fibre-optic, seismic sensor arrays, in order to optimise yields from oil and gas reservoirs, is a great example of how the availability of powerful processing in miniature have helped to arrive at new solutions and better outcomes. The terabytes of data per second generated by one array is equivalent to several Europe to-US transatlantic internet cables and yet the processing required sits in an electronics rack containing just a few circuit boards".

The use of sensors in industrial automation to measure parameters such as pressure, temperature, force and flow and their associated processes is becoming widespread. Low cost computing and low cost sensors provide huge opportunities in the area of condition monitoring, precision control, instrumentation and flow management.

Cost and space pressures on the factory floor have led to the use of single chip embedded controllers which are able to integrate with a number of systems and allow for rapid development of control systems. Intelligent sensors with on board data processing capabilities will be able to refine data and help to contribute to 24/7 continuous production and reduced downtime.

Medical use: embracing the advantages of miniaturisation

By radically reducing chip size and increasing performance, the semiconductor industry has opened up new opportunities in the medical sector. Advanced processing has contributed to significant breakthroughs in medical electronics. For example miniature, ultra-fast, low-power medical imaging systems such as chip-on-tip endoscopy and lab-on-chip systems for point of care diagnostics. In turn these emerging applications have helped to accelerate the trend to miniaturisation and ignited additional pressures on micro-manufacturing, micro-electromechanics and microfluidic technologies.



Lab on chip devices are transforming what can be achieved in the field. In 2004, engineers at Berkeley miniaturised fluorescent microscopy onto a chip for use in the field. The H1N1 flu pandemic of 2009 resulted in rapid development of microfluidic chips which have been used for the diagnosis of flu, where immediate diagnosis is critical. We've now seen nanoscale transistors so small they can be used to penetrate cell membranes with the possibility of their use to fight bacteria or cancer.

System on chips have found an immediate application in the area of implantable devices as well as minimally invasive surgery which, by definition, imposes constraints on the size, weight and shape of the device or instrument being used. Breakthroughs in patient comfort and aesthetics have been made as medical implants have become smaller.

Major steps forward in the area of 'wearable personal health systems' have also occurred leading to patient-centric eHealth solutions. Wireless body sensors measure, process and wirelessly report various physiological, metabolic and kinematic biosignals non-invasively such as ECG, body temperature, SpO_2 and blood pressure to tele-health providers.

Such a development enables personalized, long-term and real-time monitoring of chronic patients. Wireless remote monitoring can also integrate with patient medical records and coordinate nursing or medical support.

Consumer markets: small is beautiful

Whilst embedded processors are extending Internet connectivity to the tiniest of devices, the commoditisation of chips will continue to drive connectivity and the Internet of Things, leading to smarter homes and an increasingly intelligent world. In the realm of wearables, ARM predict much more prolific use as well as what they call – 'an extension beyond the wrist'. There is a seemingly insatiable desire for compact, portable, smarter devices.

Chris Covey, VP Industrial, Sagentia Commercial comments "Nanoscale processing has substantial application in the 'smart home' space, as our work with AppKettle's wireless kettle has demonstrated. Remote monitoring and control of household appliances was largely unaffordable ten years ago, whereas now processors are cheap and powerful, enabling frugal use of data networks and the reliable delivery of valuable metrics and functionality. Appliances are becoming truly smart; IoT has moved well beyond a wirelessly connected network of sensors".

The applications remain diverse and deep

Microprocessing will continue to provide high-performance computing power to areas where it has not been possible. The opportunities for bringing new functionality to existing areas and products or creating entirely new ones are endless.

Massive technological shifts in computing matched with the increased availability, high-power and low cost of micro processing will continue to define our environments and the way we live and work.

Sources:

http://www.sme.org/memagazine/Article.aspx?id=8589938946

Intel fun facts sheet http://download.intel.com/newsroom/kits/22nm/pdfs/22nm_Fun_Facts.pdf http://www.economist.com/technology-quarterly/2016-03-12/after-moores-law

http://www.nhtsa.gov/About+NHTSA/Press+Releases/2015/nhtsa-will-accelerate-v2v-efforts

http://www.safespot-eu.org/

http://spectrum.ieee.org/semiconductors/processors/25-microchips-that-shook-the-world

About Sagentia

Sagentia is a global science, product and technology development company. Our mission is to help companies maximise the value of their investments in R&D. We partner with clients in the consumer, industrial, medical and oil & gas sectors to help them understand the technology and market landscape, decide their future strategy, solve the complex science and technology challenges and deliver commercially successful products.

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