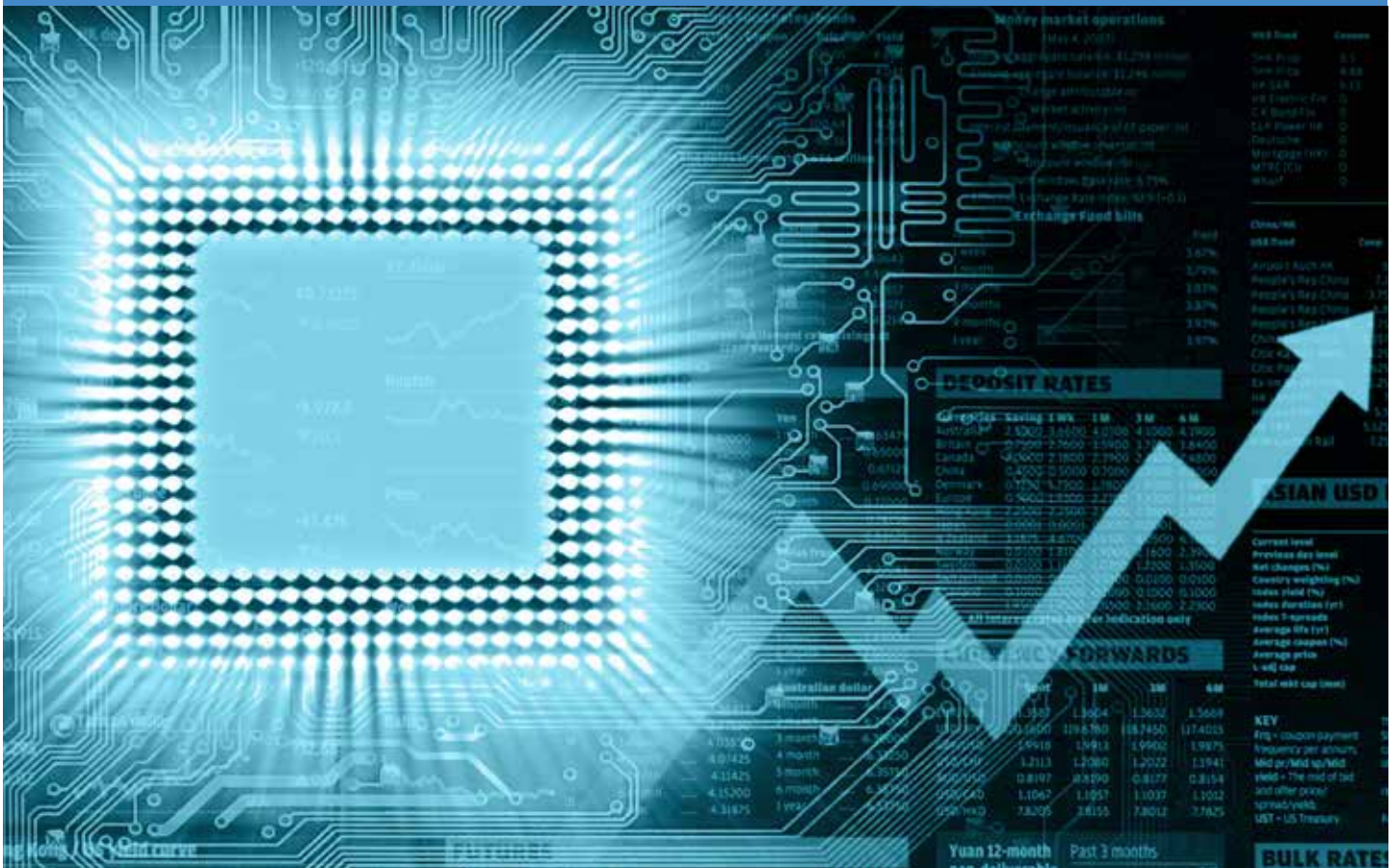
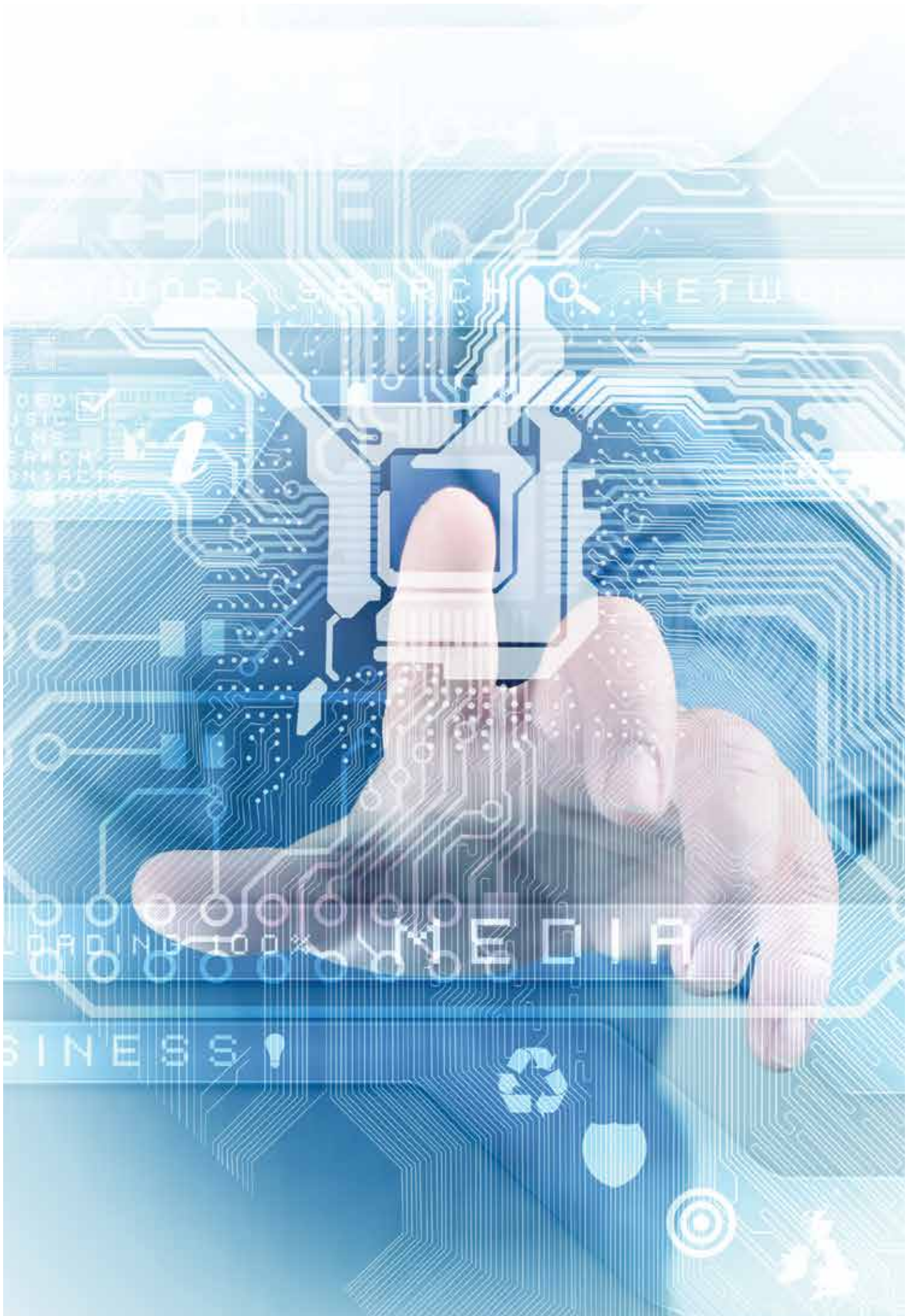


HARDWARE ACCELERATION IN FINANCIAL MARKETS

A step change in speed





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Faster is more profitable in the front office

Banks, brokers and funds have continued to invest in improving their execution latency in order to maintain or improve profitability. Firms have focused on every element of the execution chain - faster software, lower latency networks and hardware located closer to trading venues. To the extent that profitability remains correlated with faster speed, firms will need to search for more fundamental approaches in order to retain competitive advantage.

Faster could also be safer

Increased regulation governing firms' risk management responsibilities has increased the importance of calculating the value and potential losses of financial portfolios. Traditional software based solutions value a firm's portfolio of trades and manage its risk in a batch process at the end of the day. Firms that can maintain an accurate intraday or near-real-time view of the risk in its portfolio will be able to leverage the full potential of its collateral whilst meeting stringent risk management requirements.

The next evolutionary step in financial systems will see elements of the software solution replaced with hardware to provide the speed required

Programming at the hardware level enables optimal parallel processing by removing the architectural constraints of a traditional CPU and its operating system layers. Therefore, hardware solutions can significantly accelerate computational performance of mathematical models, such as risk algorithms. A hardware platform is fully deterministic, allowing complete test coverage reducing operational risk. Additionally, replacing multiple processors with a parallel hardware solution may reduce the number of cards in a rack, reducing CAPEX and OPEX.

Hardware acceleration provides a step change in processing capability through true parallel processing

Hardware¹ allows mathematical computations to be implemented at a low-level with an optimum customised parallel architecture, removing overhead from control, the operating system, interfaces and interrupts. Therefore, performance can be orders of magnitude faster than traditional software systems. The functionality is highly deterministic and completely repeatable reducing operating risk.

A hardware platform reduces latency over a software implementation through its parallel architecture

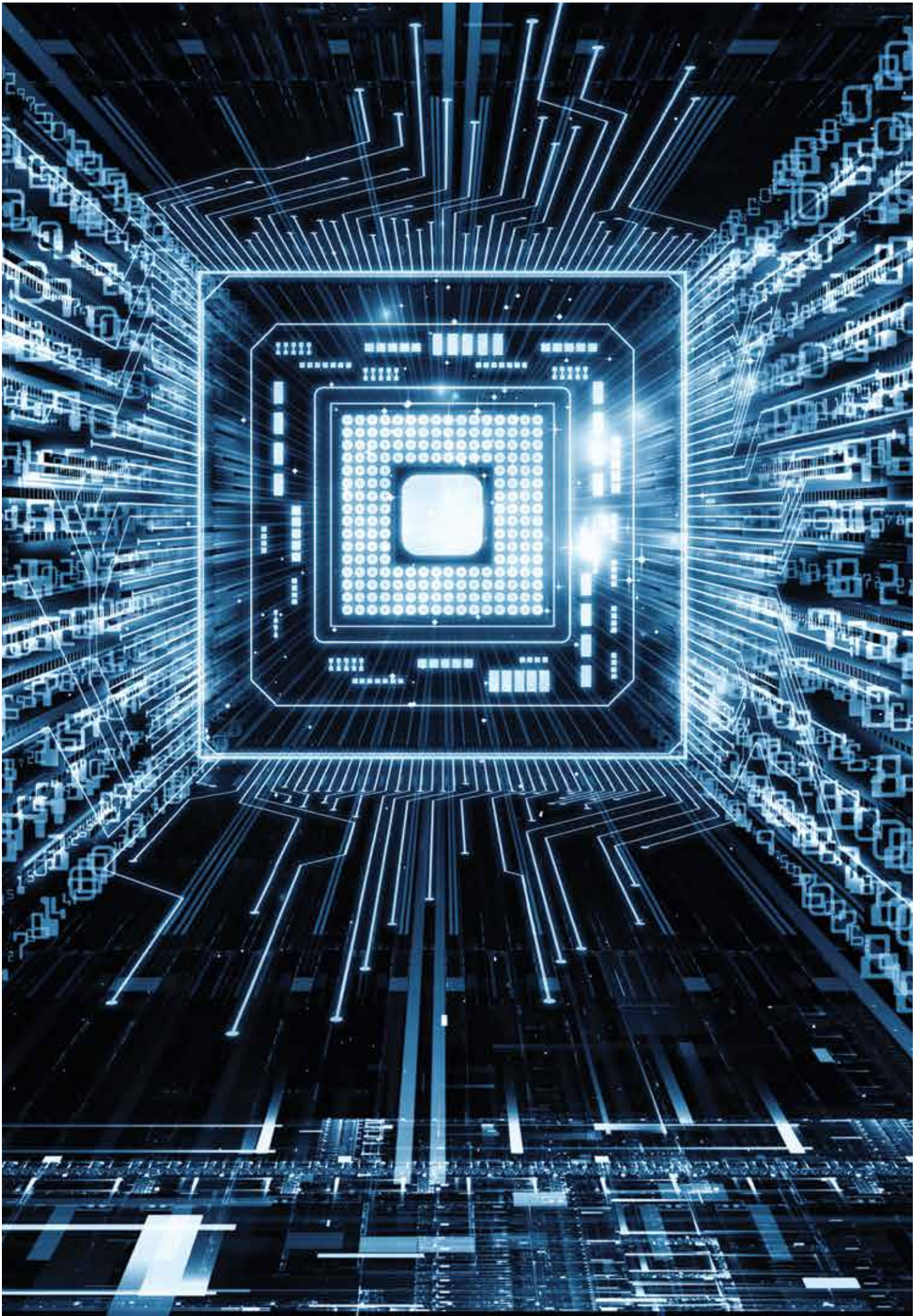
If an algorithm can be broken down into a set of tasks that can be processed in parallel it can be accelerated using a hardware solution instead of software. This is due to multiple functional blocks being processed simultaneously on an optimised bespoke parallel platform without the constraints of a serial program counter or fixed processor architecture, as found in a software platform. This parallel processing means that a hardware solution is fast. Really fast. Much faster than that of the equivalent software implementation.

Hardware solutions can be more deterministic than software, reducing functional risk and making testing easier

A well designed implementation of an algorithm in hardware is deterministic, ie, it is predictable and repeatable, without the occurrence of random events within its processing paths. This allows full test coverage because there are a finite number of operating states, and hence there is a lower risk of functional errors. Therefore, a hardware solution allows 100% test coverage giving high confidence in the output integrity from this type of implementation.

Hardware solutions have been proven in the telecoms industry and are now being adopted by leading edge financial firms. These solutions are also being assessed by trading venues and market data vendors who don't want to be left behind in the arms race.

1. Hardware in this case refers to synchronous re-configurable electronic logic circuitry as provided by field programmable gate arrays (FPGAs)



Opportunities to increase trade volumes and implement effective real-time risk functions exist for trading firms, execution venues and market data vendors

Examples where hardware solutions are being considered to accelerate front and back office functions include:

- 1 Parsing of incoming orders and generating outgoing order/trade confirmation using protocols such as the Financial Interface eXchange protocol (FIX) and FIX Adapted for Streaming (FAST) could benefit from parallelisation and deterministic processing.
- 2 Proprietary APIs can be accelerated by keeping them on the same FPGA device as external APIs, avoiding external interfaces with high-latency data exchange and indeterminate functionality.
- 3 Pre-trade volume, price or collateral checks could benefit from hardware acceleration to remove the latency that would otherwise be introduced by the increasing rigour that regulators require in these checks.
- 4 The matching engine can be accelerated with a parallel architecture to perform the order matching function, aggregation calculations for best bid and offer volumes, bait generation and the management of complex order (eg, icebergs).
- 5 Processes that take hours to calculate the value, loss scenarios and standard deviation of financial portfolios can be accelerated to give near-real-time risk information to support trading decisions.

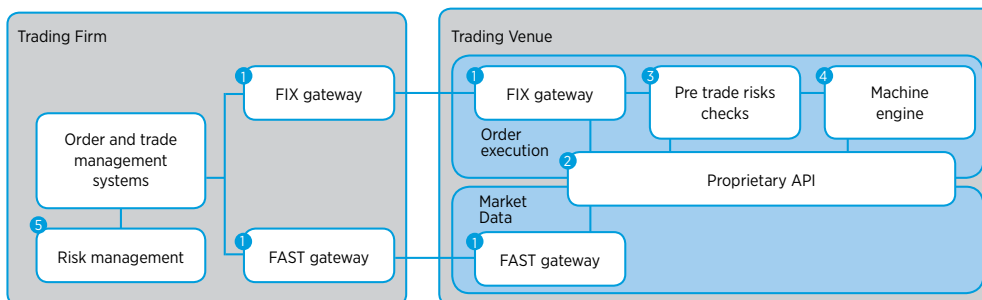
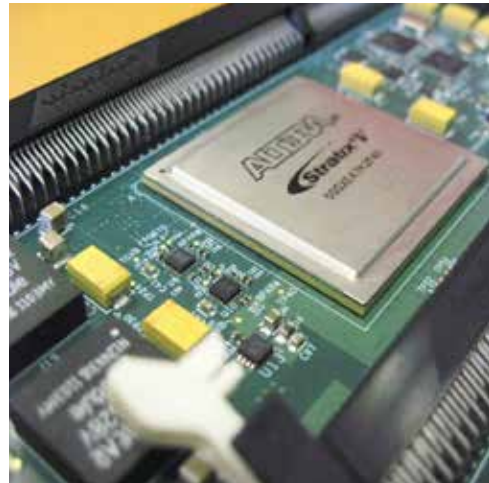


DIAGRAM 1

The diagram shows the typical application for hardware acceleration in front and back office trading and risk management systems.



IMAGE

ALTERA 'Stratix V'
FPGA chip'

Firms should embrace hardware acceleration at the earliest opportunity

Improvements to highly demanding processes like portfolio valuation should reduce the capital buffers needed to support trading portfolios. Rapidly valuing portfolios will allow quicker scenario testing to become possible as input variables are flexed. The potential reduction in regulatory capital charges could be very significant.

The opportunity to reduce portfolio valuation times is one way in which increased processing speed can help financial firms. However, the technology is new and requires a different skill-set to software development. Solutions are typically specific to the needs of individual firms and there are very few organisations that have real practical capability in developing hardware accelerated solutions.

PA can help you achieve business advantage through hardware acceleration

PA has a proven track record in applying hardware acceleration solutions.

- We have a team of experts in implementing complex, high-throughput solutions on Field Programmable Gateway Array (FPGA) platforms supported by a wider team of technical and business analysts. We also have close working relationships with FPGA vendors (including Altera and Xilinx) and are advanced users of their flag-ship FPGA devices. We also have strategic working relationships with card vendors and IP providers, allowing us to build complete systems with market leading hardware

- We have implemented hardware acceleration solutions in wireless telecoms applications to accelerate systems which are analogous to those in the finance sector. The consumer pull for increased data over mobile networks has resulted in step-changes in the data-rates seen over 3G and 4G cellular networks. PA has implemented solutions in the latest standards and has used the acceleration provided by FPGAs to achieve this – for example, we increased the peak performance of a 4G system from 30Mbps in software to 150Mbps in FPGA (this was achieved without any optimisation activity, and a further 2x performance increase could be expected with this optimisation)
- We have devised ways in which some software configuration can be maintained within an FPGA architecture, to allow efficient in-house maintenance of key algorithms where required
- We have developed a prototype for portfolio valuation to prove the benefits of hardware acceleration in Financial Services. More information can be provided about this on request.

Working with your business and technical teams, we can:

- Help you define the business problem that needs acceleration and the business benefits that could be achieved
- Identify the hardware acceleration options
- Develop a suitable implementation approach
- Establish an effective support regime
- Build and embed a support capability within your firm.

To help you improve speed whilst reducing risk and cost, contact PA Consulting Group.

We are an employee-owned firm of over 2,500 people, operating globally from offices across North America, Europe, the Nordics, the Gulf and Asia Pacific.

We are experts in energy, financial services, life sciences and healthcare, manufacturing, government and public services, defence and security, telecommunications, transport and logistics.

Our deep industry knowledge together with skills in management consulting, technology and innovation allows us to challenge conventional thinking and deliver exceptional results with lasting impact.

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