The Hague Centre for Strategic Studies

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STRATEGY & CHANGE

SCANNING EMERGING ISSUES OF THE FUTURE: #3

DEVELOPMENTS IN NANOSCALE MEMORY

INTRODUCTION

Research in the production of information storage devices (memory units) at a nanoscale offers exciting new engineering opportunities. New developments in memory technology pave the way for a significant reduction in physical size (more songs on an iPod), an increased data transfer rate (faster downloads), and an increased efficiency in energy usage (longer battery life). New technologies at a microscopic level that operate on molecule structures of materials enable these forthcoming improvements. While most technological fields (e.g. computer science and engineering) experience linear technical progress to some extent, the introduction of engineering techniques at a nanoscale provides researchers with the tools to make exceptional technological breakthroughs.

THE LIMITS OF FLASH MEMORY

Flash memory is currently the most popular computer storage chip in commercial applications. Flash memory technology does not use nanotechnology but saves information by looking at the electric fields that are active or inactive in its components (representing a *bit* in terms of 0 and 1). In doing so, Flash memory does not require power to retain information (i.e. 'non-volatile'). Furthermore, it can withstand strong kinetic impact, particularly when fabricated as a memory card. For these reasons, Flash memory is commonly found in many portable devices such as MP3 players and portable cameras. However, there are several drawbacks to Flash memory: it is relatively slow, unsuited for frequent data erasure, and it is physically limited for size reductions. The high popularity of Flash memory in consumer products now drives new scientific developments to tackle these drawbacks.

Nanoscale memory technologies do not necessarily work by storing information bits by means of an active or inactive electric field. Instead, nanoscale memory technologies are able to explore alternative methods to represent bits for saving information. For example, Swiss researchers at IBM have been working on a nanoelectronic 'racetrack' memory.[1] The proposed technology represents bits on a magnetic nickel-iron nanowire instead of via electrical currents.

TWO MAJOR NANOSCALE MEMORY BREAKTHROUGHS

Two promising research developments are currently taking place that will push memory technology to the next level. First, the new information storage method in the racetrack memory of IBM is said to be 100,000 times faster than current storage systems. Bits that represent information are moved inside the nanowire by using a spin polarized current that can reach speeds of hundreds of meters per second, a dramatic increase in the speed of data transfer compared to current technologies. In addition to its speed, the power consumption of the device is much lower because the racetrack memory does not need to be powered. If this type of memory is globally adopted in computer systems, the order of magnitude for energy reduction could potentially add up to a factor of 300.

Second, researchers at the Lawrence Berkeley National Laboratory and the University of California Berkeley discovered a new class of nano materials suitable for phase-change.[2] Phase-change materials can switch between two states in fractions of a second by exposing it to an electrical current or to laser light. This switching between states allows the storage of bits of information. Because the switching between states occurs so rapidly, it has enormous potential for fast data transfer. Current research is looking into the number of phase-changes that the materials can endure, their sensitivity to temperature (which could be a major drawback for a commercial device), and the various possible geometries for the materials. If successful, this research may offer alternative engineering options for nanoscale memory that may have distinct features from other approaches, such as the racetrack memory. →

SCANNING EMERGING ISSUES OF THE FUTURE: FOCUS AND METHOD

SCANNING EMERGING ISSUES OF THE FUTURE are a series of briefs produced by the Strategy & Change Program. The briefs in the series indentify emerging strategic issues that are relevant for the four themes of S&C: security, technology & innovation, economy & society, and sustainable development (see strategyandchange.nl/).

For each of these issues, we explore policy implications across the four themes. To identify these issues, Strategy & Change employs an innovative approach analyzing a wealth of forward looking resources available the Internet. This process is supported by *Leximancer* text mining software. For a full description of the methodology, please see strategyandchange.nl.

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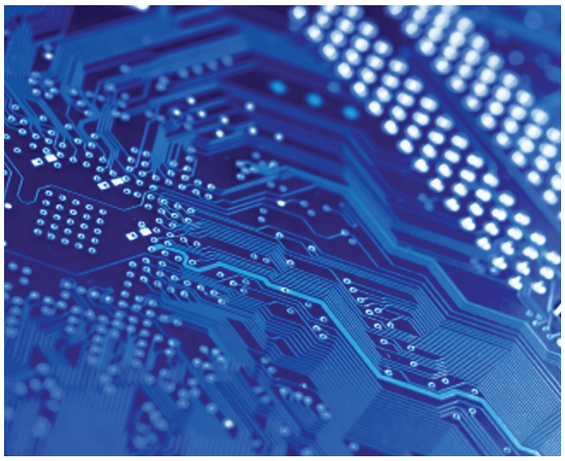

SPEEDING UP WORK AT LOWER ENERGY COSTS

New types of engineering techniques, tools and methods at a nanoscale to produce information storage devices will impact the reduction of the physical size of memory units, the data transfer rate, and the efficiency in energy usage. In turn, these improved features will have an impact on other larger processes. First, the decreasing size of memory units allows other nanoscale devices to carry out increasingly intelligent operations. For instance, small memory units allow computer circuits to store their system state, save sensory data or carry out sophisticated algorithms. This offers new opportunities for the type of operations that nanoscale devices are able to perform. For instance, it allows longer and more autonomous 'missions'. Examples of such operations include nanoscale medical bots that operate autonomously in the human body to carry out complex medical procedures. Alternatively, environmental decontamination nanobots may venture into contaminated areas to actively engage and neutralize hostile particles.

Second, a faster data transfer rate will increase the productivity of businesses, organisations and individuals. Nowadays a computer boots up in at best three minutes but usually the process takes much longer. The booting process takes time because the computer's storage device, usually the hard disk, has to transfer the operating system to the computer's Random Access Memory (RAM). This transfer is required because RAM cannot save information when it is unpowered. With superfast nanoscale memory (such as with the 100.000 times faster racetrack memory) this process could be far more effective. Booting up a computer could be done in a matter of seconds, data transfer from a hard disk to USB device could be instantaneous, and internet data transfers could dramatically enhance user experiences, increasing efficiency in business processes that reduce operating costs.

Third, in a world that is increasingly dependent on energy consuming technologies, the development of energy efficient hardware is getting renewed attention.

Nanoscale memory chips may make a contribution to an increasingly sustainable world because they offer faster load times and therefore consume less energy. This may have a bigger impact than one initially anticipates. Globally, the energy consumed by computing and electronics amounts to 6% of total energy consumption and this number is expected to increase to 15% by 2025.[3] Energy consumption of hardware could be drastically reduced by a factor of 300 with the development of nano memory.

A NEW RISK

While nanoscale memory devices have their merits, they may also introduce new risks. New memory units may further pressure privacy issues as individuals, organisations and government are increasingly able to monitor various processes and save data. It may be hard to keep track of this data because it is so abundant and potentially unprotected. Once data (or the nanoscale memory units in general) is lost out of sight, data is expected to spread rapidly due to the growing interconnectivity of many devices and the popularity of social networks. As a result, challenges will emerge to securely store and safeguard all kinds of data, including corporate and governmental intelligence. If the incidents with Wikileaks are any guide, future information will likely surface more easily into the public.

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1 SWISS RESEARCHERS WORKING ON NANOELECTRONIC 'RACETRACK' MEMORY, NANOWERK, 15-11-2010, HTTP://WWW.NANOWERK.COM/NEWS/NEWSID=19005.PHP

2 NANO-PARTICLES COULD OFFER NEW TYPE OF FLASH MEMORY, TG DAILY, 17-09-2010, HTTP://WWW.TGDAILY.COM/TRENDWATCH-FEATURES/51591-NANO-PARTICLES-COULD-OFFER-NEW-TYPE-OF-FLASH-MEMORY

3 SWISS RESEARCHERS WORKING ON NANOELECTRONIC 'RACETRACK' MEMORY, NANOWERK, 15-11-2010, HTTP://WWW.NANOWERK.COM/NEWS/NEWSID=19005.PHP