**Small Computing Devices**

**The Impact of Single-Board Computers, Microcontrollers, and the Internet of Things**

With the microprocessor revolution of the early 1970s came increasingly smaller computer technology. Moore's Law predicted a future of computer sizes which must have been unimaginable for early computer scientists working with punch cards on mainframe installations a mere decade or two previously. The world's first single-board computer, that is, a computer built onto a single printed circuit board, was produced in 1976. The MMD-1 boasted a 2MHz processor with 2Kb of RAM. While extremely slow and primitive by today's standards, it was a major milestone in the evolution of computer technology, and a glimpse of what was to come in the following decades.

**What does it do?**

The current state of single-board computers makes the high-end models almost indistinguishable from laptop computers, at least when compared on technical specifications. Minus a keyboard, monitor, and case, models such as the Udoo x86 Ultra and the LattePanda4G/64GB nevertheless rival the computing power of many laptop computers in a device which can easily fit in one's hand. Current state-of-the-art single-board computers have enough processing power to run Windows 10 and GPUs which can output 4K resolution.

While the highest-end single-board computers are in many ways the equal of laptop computers, they are atypical. The most well-known single-board computer, and one of the most popular computers in the world, is the Raspberry Pi. The most recent model, the Raspberry Pi B+, includes a quad-core 1.4 GHz processor, 1 GB of RAM, four USB 2.0 ports, and HDMI output. Neither overpriced nor overpowered, it is a typical example of the current generation of single-board computers.

Single-board computers are not typically used as desktop/laptop replacements; they are primarily designed to be utilitarian learning tools for computer science and engineering, particularly for students and children to learn programming and develop simple IT applications. They can also be used to function as home media servers, games consoles (running Android or Linux), simple web servers, or mini-PCs.

Another small computing device in a similar vein is the Arduino single-board microcontroller. While not a full computer, it contains many essential components for use in IT projects. Similar to the Raspberry Pi, the Arduino is also primarily used as a learning tool for students and hobbyists. Because of the sensors and actuators featured on the Arduino board, they are commonly used in small projects for detecting temperature, motion sensing, and controlling simple robots. However, they can be used in a large range of other applications. They can be used to upload data to the Internet, or to receive data from sites such as Twitter to display different output.

As time passes, and the technology advances, we can expect to see small computing devices becoming even smaller, more powerful, and cheaper. Smaller sizes of the devices themselves means we can expect to see greater proliferation, and more and more "dumb" household objects becoming absorbed into the Internet of Things. Therefore, we can expect that most ordinary people will own and operate more of these embedded "smart" devices as they become more and more commonplace, especially around the home. Cleaning robots will become cheaper as the market grows, voice-activated doors and other objects will become easier to build and install, and it may become more common to see otherwise ordinary objects, such as houseplants and furniture, with social media pages advising their owners about their condition.

The continually-decreasing size and increasing power of electronic components which drives the laptop industry will likewise impact the small computing device industry. Moore's law predicts that the number of transistors in an integrated circuit doubles approximately every two years; this has held relatively true since the 1970s. Devices can be expected to become smaller, more powerful, and more affordable.

**What is the likely impact?**

The increase of connectivity and automation in parallel with the increase in the computing power of small computing devices, combined with advances in mobile communications such as 5G, will lead to more information from more sources being delivered to the end user in faster times.

We are likely to see changes inside the home, where home security data could be readily and easily accessible by anyone with a smartphone. Information such as temperature control or home surveillance footage will be available with greater accuracy. Other automation such as remote or RFID-based light control may also become more commonplace.

The most obviously-affected users will be the hobbyists and creators. As the market for small computing devices increases, demand increases and so prices will fall. IT can be expected that the field for creating and producing projects with these devices will also increase.

Other people likely to be affected by these developments will be users with disabilities. Increased sensor-based computing and automation will have a huge variety of applications for users who are unable to walk, type, or access certain areas of the home. While actuated doors, storage ages and movement-activated lights may be a fun toy for most users, they may be essential to comfortable, autonomous living for users who are, for example, confined to wheelchairs.

There is always a fear that with greater automation comes job redundancy. While this may be true to some extent, however I don't believe it will be a great concern with regards to small computing devices. Small computing devices primarily operate on very small scales, such as uploading small amounts of data at intervals, or opening and closing doors. The increased demand for small computing devices is far more likely to create jobs, as we can expect to see an increased demand for workers in building the devices, logistics, and tech support in this industry.

**How will this affect you?**

Day to day, the visible effects of this advance in small computing devices wouldn't be obvious: the embedded nature of these devices keeps them "out of sight, out of mind". The way it is most likely to affect me, and other technology enthusiasts, is in the growing affordability of using these devices as learning tools. As a hobby, developing smart devices with small computing devices seems like the world of science fiction come to life. The main barrier to beginning any new hobby is typically the financial cost; as the cost decreases, the temptation to purchase, tinker with, and create smart objects around the home will become more appealing. The educational value of experimenting with these devices would be a great feature to put on any CV.

Apart from the clear benefit of having experience with small computing device projects, I would benefit by having the completed projects themselves. There are any number of possibilities for projects to create: home surveillance with real-time security footage accessible by smartphone; home weather stations to check the temperature in my home neighbourhood; emergency assistance tools for my parents in their retirement; a voice-activated home media system. With enough imagination, and some assistance from blueprints and guides from the Internet, anyone with the motivation will be able to create an endless variety of projects.

The essential purpose of small computing devices is to increase connectivity in many different contexts; the possibility of greater connectedness with family and friends is undoubtedly a great benefit to all involved. Emergency assistance devices becoming easier to develop and install in order to aid elderly relatives would seem to be an obvious effect of this technology.

The future of small computing devices may represent the next great advance of technology. From fun but frivolous projects to life-changing tools of assistance, the development of small computing devices heralds an exciting, customisable future of technology.

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