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Solid state-based emulation is a sustainable option

Replacing a failing storage device with a solid state-based drive that uses the same physical connector, interface protocols and memory maps is a sustainable option, advocates **Brian McSloy**

Data storage media such as magnetic (floppy) and magneto-optical (MO) disks, magnetic tapes and even early HDDs are, from a technical industry viewpoint, things of the distant past. However, many systems that were designed in the distant past, incorporating what was then 'state-of-the-art' storage devices and media, are still in use today and must provide several more years of service.

For instance, in the military and aerospace sectors, radar systems, simulators, automatic test equipment and computers are in use that were built more than 40 years ago and are based on pre-PC mini and industrial computers. Some airlines are using Airbus A320 aircraft that had their maiden flights back in the 1980s, when a floppy disk was the primary means of data transfer.

In the telecom sector, legislation mandates that legacy services must continue to be offered, regardless of their commercial viability. Accordingly, digital access cross connect systems, private automatic branch exchanges and other infrastructure from the 1980s and 1990s must remain operational.

Old favourites

Perhaps the most ironic continued use of yesteryear data storage technology is within the semiconductor industry, where some fabs use tools that accept file transfers (for process recipes, for instance) only by floppy disk.

Some types of removable media are still available, albeit increasingly hard to come by. As the moving parts of mechanical drives start to fail, new replacements are simply not available and refurbished second-hand drives, when they can be found, carry short warranties.

In the interests of sustainability and keeping the host system operational for as long as possible, the practical solution is to replace the failing storage device with an emulator, a solid state-based drive that uses the same physical connector, interface protocols and memory maps as the failing drive. Taking the swap-in replacement route means the host system needs no modifications and being solid state, reliability is greatly improved (and with a lower power requirement). Also, if fitted with an Ethernet port, the new drive can be networked, which opens a whole new world of possibilities.

As for the choice of storage media to use in the emulator, an industrial class compact flash (CF) card is the ideal choice, particularly where the end application still requires the memory to be removed.

Industrial CF provides high endurance and longer-term availability than its commercial equivalent. Other considerations include capacity, performance and memory wear. For example, multi-level cell is higher capacity, but slower and has less endurance than single-level cell, although memory access will still be faster than with the old drive. As it is program-erase cycles that cause flash memory wear, the correct selection of CF card is important, with the choice mainly dependent on the write frequency and the required device capacity.

Copy that

A popular way of connecting computer peripherals was the small computer system interface (SCSI). Many storage

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device types adopted this interface including floppy, MO, tape and HDD.

The interface was standardised in 1986 as the SCSI parallel interface 8-bit wide, single-ended bus. The SCSI standard evolved through a number of iterations, doubling the number of data lines to 16 and incorporating differential signalling, allowing the transfer rate to significantly increase, before finally being superseded by the serial attached SCSI interface.

The word ‘standardised’ must be taken with a pinch of salt as there was, particularly in earlier implementations, a level of incompatibility that has to be catered for in any emulator. Other interfaces were launched that do not incorporate the full standard, retaining just the SCSI command protocol or the SCSI architectural model, for example.

Within SCSI there are a number of standard mode pages and a set number of vendor-unique ones. The latter tend to be used by host systems to determine if the drive is valid or not. This practice was adopted by host system OEMs Compaq and HP, for example, in the 1980s and 1990s when many storage devices were developed for a specific host’s chassis. *Figure 1* shows a Fujitsu HDD manufactured in the 1990s to fit a 1980s’ design for an IBM host computer. The HDD is the size of a shoebox and has a standard 50-pin connector for data and control, and a four-pin Molex connector for power. The positions of the connectors would be such that they mate only with corresponding connectors in the host’s chassis.

This looseness of the SCSI standard also meant drive OEMs, such as CDC Control Data, Seagate, Quantum, Fujitsu and Connor, could implement SCSI in slightly different ways to make their solutions proprietary.

The goal is to make a replacement drive that can be switched for the failing one and for the host system not to notice.

In terms of designing the interface protocol into an emulator, it is necessary to account for any tweaks the host system might require. This information may be available online, but the most reliable method to determine it is to interrogate a working drive, even a refurbished one.

Another option is reverse engineering. This involves taking a logic analyser to the end application and placing it in-line between the host system and the legacy drive and recording the control and data lines. The timings will need to be reproduced in firmware and microcontrollers are available that lend themselves well to the task. For example, the Atmel Smart SAM9XE is based on the integration of an ARM926EJ-S processor with fast ROM, RAM and flash, and has a wide range of peripherals. It also embeds an Ethernet MAC and a multimedia/SD card interface.

Figure 1: A Fujitsu HDD manufactured in the 1990s to fit a 1980s’ design for an IBM host computer

An emulator for virtually any 1980s’/1990s’ drive can be built around a suitable microcontroller, a suitable interface driver, some glue logic and power devices, and result in a relatively compact, low-power unit. *Figure 2* shows a 2.5-inch solid state SCSI (50-pin connector) drive with dual CF cards, which means data can be mirrored. The inclusion of an Ethernet port means the emulator can be networked and provide functionality the original drive never could.

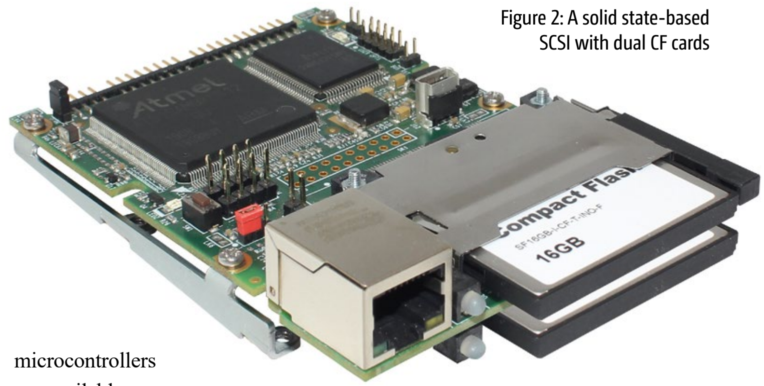

Figure 2: A solid state-based SCSI with dual CF cards

Once an emulator exists as a replacement it should be plain sailing – but will it be? Legacy drives are for the most part based on logical blocks, where the exact encoding of the data onto the disk is handled internally by the storage device (that is, HDD, tape), but for some classes of device, such as ESDI (enhanced small disk interface) or floppy, the encoding has to be implemented within the storage device’s firmware. This is a complex operation that can be achieved only by reverse engineering the particular implementation, including detailed low-level examination of the format written to the media, which sometimes varies across the surface.

What also needs to be considered is what the host system expects to be written to the drive or media before it is installed. The drive may therefore need to be formatted, in much the same way a USB stick needs to be formatted to at least FAT32 for use with Windows. Some hosts will expect a new drive to be filled entirely with logic zeros, others will require the old data to be present on the new drive. This can be a problem, as some drives will have become very fragile over time. Great care must be taken not to cause loss of data during investigation or replacement.

Moving target

ESDI and IDE (also known as Parallel ATA or PATA) can be emulated too and emulator OEMs have created firmware libraries that reside in each emulator.

Obsolescence is a moving target, and there are systems in use today that have already had their original drive replaced with an emulator that has subsequently become obsolete too. Accordingly, emulators can keep legacy systems operational, improve reliability, reduce power and support new features if required, but they must themselves be subject to obsolescence management.

Drives with high-speed serial interfaces (for example, SATA) are more complex than SCSI, ESDI and IDE, and are now heading towards obsolescence. Emulator technology will need to change very soon, with the use of FPGAs and more powerful microcontrollers, which provide greater flexibility and shorter development programmes. In addition, the emulator’s PCB must be capable of catering for higher signal speeds. ❑

About the author

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