BUY VERSUS DEVELOP

A NAND Flash Controller Case Study

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ABSTRACT

The decision to buy or develop any system component is a difficult one. Clearly, the development time and cost is less when using an off-the-shelf component; however, these components attempt to meet the requirements of a main-stream market segment. Outside of those markets, a designer may need to add unique features to solve problems for specialty markets; one example is SSDs for telemetry markets where one critical component is the NAND flash controller. This paper will focus on some of the requirement differences and why it is so important for SSD designers to develop their own controller for these markets.

KEYWORDS

SSD, NAND, flash, controller

INTRODUCTION

Every system design consists of multiple components. When developing a new aircraft or retrofitting an existing program, the designer must integrate several major avionics system components including a data recorder. When developing a data recorder, the designer must integrate different subcomponents including storage such as a Solid-State Drive (SSD). When developing an SSD, the designer must integrate different components including the NAND flash controller.

Each designer faces a decision: is it better to buy the component or develop the component? There are advantages and disadvantages for buying a component; conversely, there are advantages and disadvantages for developing the same component; there is no universal right or wrong answer. Three main criteria for making the decision involve development cost, time to market, and features available in off-the-shelf components; given a specific set of circumstances and requirements, one choice usually wins. This paper will discuss the circumstances and requirements for one critical component in an SSD for telemetry applications: the NAND flash controller.

1. BUY VERSUS DEVELOP OVERVIEW

Every design decision must be evaluated against a set of criteria. The decision to buy versus develop a system component could involve a variety of requirements and conditions. For the sake of brevity, this paper will focus on three criteria specifically: the development cost, the time to market, and features in off-the-shelf components.

1.1 DEVELOPMENT COST

Cost is usually an important factor in any decision, and engineering development cost is no different. Usually the cost to develop a component far exceeds the development cost to integrate a similar off-the-shelf component; however, the recurring costs of a developed component are usually less. Similarly with a NAND flash controller, the development costs can easily exceed the cost of several man-years of work, but the recurring costs will be just the cost of the silicon chip rather the silicon chip plus some vendor's profit margin.

1.2 TIME TO MARKET

Time to market is another important factor in the buy-versus-development decision. If the time to market is too long, customers may not wait for the product. Clearly developing the component will take more time than simply purchasing readily available components. The time to market when developing a new flash controller can be a calendar year or more. Adding additional engineering design resources can shorten the time to market, but additional resources will usually add to the development cost.

1.3 FEATURES

Features differentiate a product and give it a competitive advantage. A majority of off-the-shelf components tend to concentrate on features to satisfy a large market in order to maximize sales of the particular component; the problem is that specialty markets may not need some of these features and, worse, may need additional features not implemented. See figure 1 which shows a hypothetical example of a list of possible features versus the count of customers served by each feature; the middle of the figure illustrates the list of features actually implemented by the vendor to satisfy a large market.

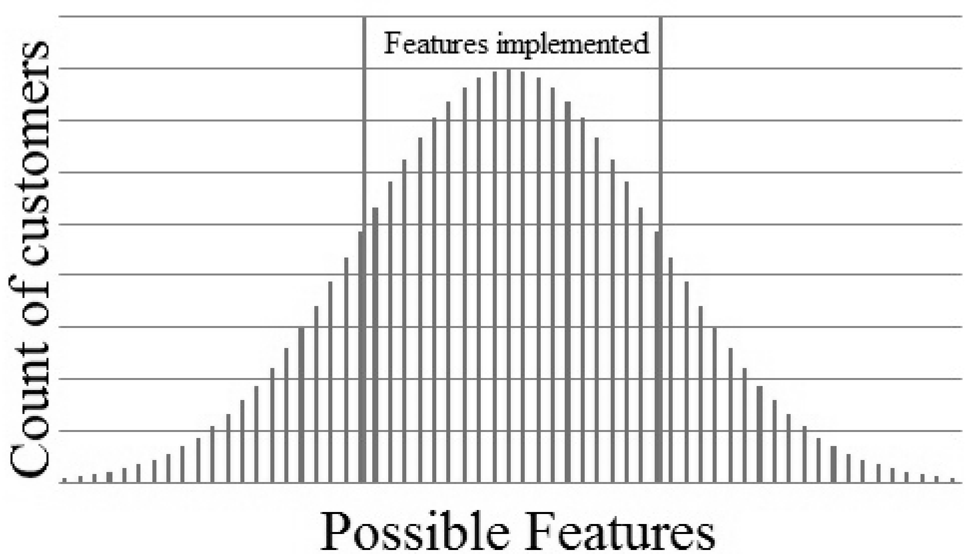

Figure 1: Sample illustration of possible features versus customers served

2. FEATURES OF OFF-THE-SHELF CONTROLLERS

The majority of off-the-shelf NAND flash controller vendors are no different than other component vendors: they cannot practically implement every possible feature, and they aim to implement only those features that satisfy a large market segment. Consequently, they do not have the money or time to implement features for any specialty markets.

The NAND flash controllers typically support several different NAND flash vendors. In addition, the NAND flash controllers support several different generations and geometries of NAND flash. These features allow the SSD designer to pick and choose the NAND flash that works best for their system architecture and corporate business processes.

Due to the widespread use of these off-the-shelf NAND flash controllers, they are well tested in a variety of host system environments. However, these host environments are usually main-stream systems, and not the systems typically found in specialty markets such as telemetry.

The NAND flash controllers are normally quite fast, and release firmware and new silicon frequently to keep up with customer's next generation demands for more speed.

3. REQUIREMENTS OF TELEMETRY CUSTOMERS

These off-the-shelf NAND flash controllers normally do not satisfy the specific needs of the telemetry market segment. Telemetry customers may require special security and erase features, custom commands beyond those found in standards documents, adaptability to unique host system environments, reduced speed to conserve power, and long-term availability and BOM control.

3.1 SECURITY AND ERASE

One feature of security and erase not found in most off-the-shelf NAND flash controllers is the special erase procedures required to sanitize or declassify the contents of a storage device such as an SSD. Some examples of the sanitize procedures include NSA/CSS Manual 9-12 and RCC-TG IRIG 106-13. Another feature not found is being able to erase the entire contents of a 1 TB SLC SSD in less than 10 seconds.

Some telemetry applications require special certification that may involve implementing extra commands, code inspection, and other laboratory testing. Some examples of certification include FIPS 197, FIPS 140-2, and NIAP Common Criteria Protection Profiles.

3.2 CUSTOM COMMANDS

The standards bodies define the commands that must be implemented to insure compatibility among many different devices and hosts. However, it is impossible for these commands to satisfy all possible requirements. Some unique telemetry systems may require custom commands to implement special sanitize procedures and/or replace legacy storage devices. The off-the-shelf NAND flash controller vendors almost certainly will not spend the effort to implement such commands.

3.3 ADAPT TO SPECIFIC HOST SYSTEM

In addition to the custom commands, some telemetry host systems have very unique characteristics. Sometimes the host interface chips were developed rather than bought, and may not implement the full interface specification. In addition, some cabling systems may not support the latest speeds. In these situations and others, the SSD must adapt to the specific host system requirements - possibly reducing interface speeds and/or modifying the SSD's interface to the host system.

3.4 POWER THROTTLING

Reducing the interface speed may also reduce power consumption on the SSD; the faster the SSD moves data, the more power it consumes. Some applications run off of special power or batteries; consequently, the power system cannot afford to provide 10 or more Watts of power to the SSD alone. Another area to throttle could be the erasing of all NAND flash; if there is no requirement for 10-second erase times, and the system is limited on power, the SSD could possibly erase slower and consume less power.

3.5 LONG-TERM AVAILABILITY

Many telemetry systems are designed for production runs over several years; if a component changes, the requalification efforts could be costly and time consuming. Therefore, these telemetry designers seek components that have long-term availability. The designer does not want to purchase components from the local electronics store where the firmware and revision on the SSD will most likely change frequently. Off-the-shelf NAND flash controllers are also subject to frequent changes with the main-stream markets pushing for newer feature sets, faster silicon, and lower cost.

CONCLUSION

The design decision of whether to buy or develop a component in a system can be a challenging one. Usually the system designer will evaluate the advantages and disadvantages of each in categories such as development cost, time to market, and features available in off-the-shelf components.

The NAND flash controller in an SSD designed for telemetry applications can be such a component on which SSD designer must decide whether to buy or develop. Clearly, an off-the-shelf NAND flash controller will have a smaller development cost, and shorter time to market. However, the features in these off-the-shelf components may not work for this specialty market; most NAND flash controller vendors are not interested in custom features for a small market opportunity.

With over 20 years of experience in solid-state storage, SMART High Reliability Solutions believes we had only one choice: we must invest the development cost and development time into designing our own NAND flash controller to satisfy the needs of this complicated telemetry environment.

NOMENCLATURE

Flash: A non-volatile memory device using an array of transistors each with a floating gate to store a charge

GB or Gigabyte: 10^9 bytes

HDD or Hard-disk drive: Traditional storage device using rotating, magnetic platter.

MLC or Multi-Level Cell: A flash technology which stores more than one bit per transistor cell using more than two voltage levels on the floating gate; most commonly referred to two bits per cell using four distinct voltage levels

NAND: A high-density flash device usually with defect blocks marked by the factory; read and write operations must be done at a page level (several kilobytes), and erases done at an erase block level consisting of several of pages

SATA or Serial ATA: A storage bus interface where the data is transferred serially rather than through parallel data wires as in previous generations.

SLC or Single-Level Cell: A flash technology which stores one bit per transistor cell using two distinct voltage levels on the floating gate

SSD or Solid-State Drive: Storage device typically using the same form factors as traditional hard disk drives, but without the moving parts

TB or Terabyte: 10^{12} bytes