ColorSync 2.0: White Paper (1 of 2) (11/95)

Article Created: 26 June 1995
Article Reviewed/Updated: 28 November 1995

TOPIC ---

This article contains part 1 of the ColorSync 2.0 White Paper.

DISCUSSION --

ColorSync 2.0 Overview

ColorSync 2.0 is a second-generation color management system from Apple Computer, Inc. ColorSync 2.0 will fulfill the promise of desktop publishing-from plain-paper office documents to glossy, high-quality magazines and books–by making available stunning, easy-to-use color.

The Evolution of Color

With the advent of low-cost color printers and other devices, color has become available to a much larger audience. However, a key element has been missing that prevents color from becoming an easy-to-use tool. This missing piece is a system for automatically ensuring color fidelity between devices. ColorSync 2.0 is the crucial piece of technology that will make working with color easy, fast, and consistent. This is accomplished by providing an open architecture and a powerful method for exchanging and matching color information between input devices, displays, applications, and output devices.

ColorSync 2.0 is designed to remove the frustration associated with using color. Different people have different uses for color, ranging from a chart in a presentation to a glossy, six-color annual report. ColorSync 2.0 provides solutions for many of the different uses of color, while delivering an open architecture for those who need special tools.

Business and desktop publishing color users will love the simple plug-and-play nature of ColorSync 2.0. By selecting applications and color peripherals that support ColorSync, such as Apple color displays and printers, they can enable automatic matching of colors between the screen and the printer. ColorSync 2.0 removes the guesswork involved in using color.

ColorSync 2.0 provides powerful tools that are essential in the commercial publishing and prepress markets. High-end users, such as service bureaus, trade shops, and printers, require color solutions that produce the most accurate color reproduction while still supporting existing tools and work flows. ColorSync 2.0 provides one of the fastest, most accurate color-matching systems available on any personal computer system today. And it's an open system, allowing third-party tools to extend its capabilities.

Finally, ColorSync 2.0 offers substantial benefits for developers. Now there's a standard architecture and profile format for color matching on the desktop that delivers the solution that users have asked for. No more decisions about which applications programming interface (API) and profile format to use, or time wasted writing custom routines. The ColorSync 2.0 API provides the most powerful "plumbing" for color management.

Features of ColorSync 2.0

ColorSync 2.0 is more than a simple follow-up to ColorSync 1.0. It has been redesigned based on feedback from customers, developers, and industry experts. While Apple has retained the simplicity of ColorSync, fundamental changes have been made to improve its architecture and performance. Some of the improvements ColorSync 2.0 has to offer are:

• Higher quality, higher performance transformation engine

ColorSync 2.0 provides a default color-matching method (CMM), which transforms color information between documents. This CMM was developed in conjunction with one of the world's leading manufacturers of prepress hardware and software. It provides excellent quality and performance, as well as compatibility with CMMs from other companies.

• Expanded, compatible architecture

The ColorSync 2.0 architecture has been expanded to support a wider array of functions, as well as third-party products, such as alternate CMMs.

• ICC profile compatibility

ColorSync 2.0 supports profiles which conform to the International Color Consortium (ICC) profile specification including ColorSync 2.0 profiles. The ICC profile format is an industry standard, allowing the same device profiles to be used across multiple platforms. In addition, these profiles contain more information than ColorSync 1.0 profiles, enabling higher quality color-matching results.

• Support for PostScript Level 2 devices

The Apple LaserWriter 8.3 driver supports ColorSync 2.0 for printing to color PostScript devices. This allows all devices with ICC-compatible profiles to work with ColorSync 2.0.

• Support for more than four-color devices

ColorSync 2.0 adds support for devices and processes that use more than the four process colors, such as Hi-Fi color printing. This is extremely powerful for prepress users who often have five- and six-color jobs. Support for more than three-color input devices has also been added, allowing for up to eight colors on input and output.

• Increased performance

ColorSync 2.0 is PowerPC native and provides excellent throughput, especially on Power Macintosh machines. Preliminary benchmarks show that ColorSync 2.0, running on a Power Macintosh 8100/80, can transform a 4-inch x 5-inch image at 300 dots per inch (approximately 5.5 megabytes in size) from one color space to another in approximately 5 seconds, more than five times faster than ColorSync 1.0.

• Increased application support

Most of the top publishing applications will offer support for ColorSync 2.0, providing users with a complete solution from start to finish. Every day, more developers are choosing to support ColorSync 2.0.

Hardware and System Requirements

ColorSync 2.0 is system-level software, so no special hardware is necessary. However, ColorSync does require certain baseline hardware and software configurations to perform properly. ColorSync 2.0 is fat binary; it supports both 68000-family and PowerPC processors.

Minimum requirements:
- A 68020 or later processor, or
- A PowerPC 601 or later processor
- System 7.1 or later
- A hard disk drive
- A system with a minimum of 5 megabytes of RAM
- Color display with 8-bit or higher color support
- ColorSync 2.0 (or ICC-compatible) profiles for installed peripherals
- A supporting printer driver, such as the Apple LaserWriter 8.3 version driver

Compatibility

ColorSync 2.0 is backward-compatible with ColorSync 1.0. This means that any application, driver, or CMM that implements ColorSync 1.0 will function normally with ColorSync 2.0 installed. In addition, ColorSync 2.0 supports the International Color Consortium (ICC) profile standard. This ensures that devices with ICC profiles are compatible with ColorSync 2.0.

QuickDraw GX versions 1.1 and later integrate ColorSync 2.0 for color-matching functions. Users of QuickDraw GX have the added benefit of accurate color matching.

ColorSync 2.0 will be available with several Apple products, including peripherals, computers, and system software updates. Look for the ColorSync logo on popular applications and peripherals. ColorSync 2.0 will be available from on-line services such as eWorld and AppleLink.

As it has done with other system extensions in the past, Apple will offer developers the option of licensing ColorSync 2.0 for applications they are developing that may benefit from ColorSync 2.0.

Why Is Color Management Needed?

Why don't the colors on the display match the colors that come out of the printer? How come digital proofs look different from film proofs? There are many reasons, based in complex color science, why the appearance of a color image is difficult to predict. In many ways, communication in color has problems similar to those with communication in languages. Each device is like a person, speaking his or her own language. When one device that speaks French attempts to communicate with another device that speaks Japanese, there is a breakdown, and the message isn't communicated. What's needed is an interpreter that is capable of interpreting the language as well as the dialect, to ensure that the message is properly communicated.

There are two basic concepts to understand when working with color. The first is how devices reproduce color, and the second is how desktop devices communicate in color.

Each device that is capable of reproducing color has a range of colors that it can accurately reproduce, better known as the gamut. Each type of device, such as a display or printer, has a unique gamut. A device's gamut is a subset of a larger standard area of color, known as a color space. Different types of devices work in different color spaces. For example, displays work in a different color space than do printers. It is important to understand the impact that gamuts and color spaces have on color reproduction and the types of work that are being produced on the desktop. This is easily illustrated by a familiar problem: The colors selected on a display may be much brighter and more saturated than the color that comes out of the printer. The reason for this may be that the color selected on the display is in gamut for the display, but is not in gamut for the printer. The gamuts of desktop devices, such as displays and printers, are relatively small when compared with the visible spectrum of light.

The second problem exists in the method that desktop devices communicate with each other. Before the evolution of desktop publishing, special-purpose, computer-based systems were used for many of the tasks involved in color publishing. These were known as color electronic publishing systems, or CEPS. CEPS offered many benefits over the traditional processes of color printing, such as improved quality and accuracy, and a complete solution from a single vendor. However, they required an enormous investment in equipment and training, as well as functionality limited to a single task for each computer. These factors limited the widespread use of color, leaving it in the control of experts.

The desktop publishing revolution delivered tools that reduced the complexity and cost of publishing. And a single desktop computer could perform a wide variety of tasks. Today color is used more widely than ever before. Quality color devices, such as color printers and scanners that were previously extremely expensive, now cost less than $500.

Suddenly the tools for the in-house creation of color documents quickly became available and easy to use. However, a new set of problems reduced their power and effectiveness. With these new tools came incredible creative power, providing designers and artists with the ability to electronically manipulate color data themselves. However, in practice these tools required an unrealistic level of training and expertise due to the inherent complexity of color. So while color seemed within reach, it was in fact still as far away as ever. If high-quality color was to reach the masses, either the user's knowledge about color had to increase or the tools had to incorporate this knowledge.

Device-Dependent Color

Why is color so complex? As discussed before, each color device has a range of colors that it can accurately reproduce. The problem occurs when a color that was specified on one device is reproduced on a different device. This is a common occurrence when working with color on the desktop. A color is selected based upon what it looks like on the screen, such as a deep, rich blue. The color that appears on the printer, however, is much less saturated than the color that was specified on the display. The gamuts of the two devices are different, and no translation has occurred between the two. Color in this case is device dependent–the desired appearance of color depends on its being reproduced on a particular device.

Many of the new software and peripherals that became color-aware were manufactured by different companies. So it was common to have a scanner, display, and printer from three different manufacturers, as well as image manipulation and page layout software from different software vendors. But none of these devices communicated in the same language of color. The tools and power of CEPS were now available to anybody for a fraction of the cost. But the continuity that brought the entire system together, the solution that a CEPS provided, was missing. How could these elements be enabled to work together?

In addition, the users of desktop systems, the graphic artists and designers, lacked the color expertise that prepress experts had accumulated. The tools they used were not equipped with the understanding of how color was delivered to different devices, so they failed to deliver a comprehensive solution. The color expert needed to become an integral part of the system.

The Color Management Wave

The color spaces typically used by devices are made up of the additive or subtractive primary colors. The additive colors, red, green, and blue (commonly referred to as RGB), are used by all color displays and many scanners. The subtractive primaries, cyan, magenta, and yellow, with the addition of black1 (commonly referred to as CMYK or process colors), make up the color space used by output devices, as well as some scanners. The two color spaces also have many areas that do not overlap.

Using color science, Apple developed a methodology to address the problem of device-dependent color. The fundamental solution was to create device-independent color, or colors that are not dependent on any particular device. The idea is to use color spaces that represent the entire range of visible colors as translation spaces. This means that any color that is selected on a display is in the gamut of this neutral color space. In 1931, the CIE (Commission Internationale d'Eclirage) established standards for a series of color spaces that represented the visible spectrum–60 years before the arrival of desktop color!

The CIE color spaces form the foundation of device-independent color for color management. Many of these spaces, such as CIE XYZ and CIE Lab, are widely used in desktop color management systems today. These color spaces, along with several other pieces that will be described in the following sections, together form a system for managing and matching colors.

Device Characterization, Device Calibration, and Gamut Mapping

In order to accurately render colors from one device's color space to another, some resource must exist that describes each device's color capabilities. Today's systems use profiles. Profiles are basically dictionaries that contain data on a specific device's color information, including its gamut, colorants, and modes of operation. These profiles are created by color scientists working with highly sensitive measuring devices called spectrophotometers. The resulting measurements are input to a custom software package that uses several complex algorithms, the result of which is a profile. This process, known as device characterization, must be repeated to refine the profile until quality results are generated.

It is important to recognize that a device profile represents that device in its factory condition. In reality, devices of the same type will deviate, resulting in inconsistencies, and may require device calibration. This process is much simpler than device characterization, and should be performed on a regular basis to ensure accuracy.

The profiles are then used by a color transformation engine, or a color matching method (CMM). The CMM translates data from one device's colors to another, via an independent color space. The CMM receives the necessary information from the profiles, so that it can accurately transform a color from one device to another. The result is color that is consistent from device to device. It is not possible to have perfect color matches between devices due to differences in each device's gamut. For example, many of the deep, saturated blues and greens that appear on a display cannot be reproduced by printers using the CMYK ink set.

In this instance, the CMM must perform gamut mapping, a process by which the next closest reproducible color is selected. Most matching systems offer several gamut-mapping methods, or rendering styles. Because the use of color varies from business graphics to photographic reproduction, the rendering intent of a color must be specified to produce the best possible results.

In the late 1980s, a number of leading color technology companies developed systems for color desktop publishing applications. These were commonly known as color management systems, or CMSs. The first CMSs promised to solve the problem of unmatched colors across desktop color devices. These pioneers took the first steps in creating a solution. However, these systems lacked key features, which resulted in poor acceptance by users.

One of the fundamental problems that prevented widespread adoption of early color management systems was the fact that each was implemented using a different architecture. In order to perform color-matching functions, an application manufacturer would have to select one system and then make specific calls to it. However, because there was no common color management framework for applications to use, each application had to use a unique system, with no compatibility between profiles and no consistency among the results.

Because no single system was widely adopted, all of the systems failed to provide a satisfactory solution. From a user's perspective, there was no guarantee that peripherals and applications would all work together to provide a complete work flow with consistent results. And because each system was proprietary, users couldn't exchange files, like profiles, with users of different systems.

These early CMSs primarily addressed only the prepress market. In fact, they provided high-end tools that were very similar to the CEPS systems, but ran on the desktop. They didn't intend to provide a solution for less experienced users of color, such as graphic artists and designers or business users. So color still required expertise and continued to be difficult to use.

New and Improved ColorSync

To address many of the issues surrounding color use, Apple Computer introduced ColorSync 1.0 in 1993. The goal of ColorSync was to provide a common architecture for color-management systems. ColorSync 1.0 was an important first step toward a solution, but it did not completely meet customer needs in certain key areas. The API lacked the necessary prepress functionality for high-end users. The profile format was structured in such a way that it did not contain enough data for higher quality transformations. These elements resulted in somewhat limited developer adoption. Without widespread application and driver support, there were limited vehicles to use ColorSync 1.0. Based on input from end-users and developers, Apple returned to the drawing board to redesign ColorSync. The result is a greatly refined solution, ColorSync 2.0.

Begin_Table

Differences Between ColorSync 1.0 and 2.0

	ColorSync 1.0	ColorSync 2.0
Profiles:	ColorSync 1.0	Apple Supplied ColorSync 2.0 or third-party ICC-compatible profiles
PowerPC Native:	Yes*	Yes
Channel Limit:	Up to 4	Up to 8
CMMs:	ColorSync 1.0 Default CMM	ColorSync 2.0 Default CMM and third-party CMMs
LaserWriter Driver Support:	None	Apple LaserWriter 8.3

End_Table

* Note: ColorSync 1.0.5 is PowerPC native.

ColorSync 2.0 greatly improves on the three key elements of ColorSync: the ColorSync API, the Apple Default CMM, and ColorSync 2.0 (or ICC-compatible) profiles.

Article Change History:
11 Aug 1995 - Reformatted to make more readible on the World Wide Web.
28 Nov 1995 - Removed illegible characters.

Keywords: <None>

==

19960215 11:05:19.00
Tech Info Library Article Number: 18020