Implementation of Computer Integrated Print Manufacturing (CIPM) in the Graphics Technology Curriculum (GTC)

Nana Poku[1], H. Naik Dharavath[1], & Nilesh N. Joshi[2]

[1]Department of Computer Electronics and Graphics Technology
Central Connecticut State University
New Britain, CT 06050
Email: nana.poku@ccsu.edu; dharavathh@ccsu.edu

[2]Assistant Professor
Department of Applied Engineering and Technology
Morehead State University
Morehead, KY 40351
Email: n.joshi@moreheadstate.edu

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Abstract

This paper discusses the impact of Computer Integrated Manufacturing (CIM) principles on the U.S. printing industry and a demonstration of its applications in the Graphics Technology course curriculum in U.S. schools. Implementation of CIM-based print production technologies in Graphics Technology curriculum is important in order to prepare future graduates of these programs for jobs in a constantly evolving printing industry. The paper covers technologies such as network digital infrastructure and JDF enabled workflow and their inclusion in Graphics Technology educational laboratories. A case study is provided on the ongoing implementation of JDF, DAM, PPF, CAD, MIS, CMW, and CTP technologies in the Graphics Technology laboratory at the Central Connecticut State University. The goal is to provide a comprehensive discussion on the inclusion of various CIPM (Computer Integrated Print Manufacturing) lab modules in the Graphics Technology curriculum, related digital printing devices, and an example JDF enabled workflow. The paper will be of interest to educators in Graphics Technology programs who are planning to introduce CIPM in their laboratories.

Introduction

In the graphics technology industry, a workflow represents a schematic illustration that deals with the real time production of goods and services by utilizing patterns of activities enabled by a systematic organization of analog and digital devices. In this scenario, product content, an image and its color are generated through digital input devices (text/layout/image editing applications, scanners and cameras). The digital information representing the production of a print job is stored in a data file, rasterized into bitmap data and printed (output) by using the cyan, magenta, yellow, and black output (CMYK) digital devices (CTP's, digital printers and printing presses). Upon printing, the printed sheets need to be transformed into finished products and distributed to end-users. Since different digital input/output/finishing devices are involved and each device is driven by its own front-end system to process the print job and finishing, the challenge is to have a reliable job data transfer of the production process across the entire workflow. The job definition format (JDF) data compatible devices (input/output/finishing), front-end systems of workflow (raster image processor), and management information system (MIS) of the business allow us to automate the computer integrated print manufacturing (CIPM) process for high quality work, efficiency and profitability regardless of the type of print job to be produced. Digital print automation requires that the computer aided design (CAD), MIS, the print production process (PPP), and the print-finishing process (PFP) must be merged into the computer integrated manufacturing (CIM) workflow.

This paper discusses implementation and use of digital workflow applications into the Graphics Technology educational laboratories. Literature related to the GTC and the workflow implementation in the curriculum laboratories is lacking. For this study, the approach taken has been to extract the information from vendor's product literature and the notes of on-site or off-site training and the Internet. In addition, information found to be pertinent from the personal communications of vendor trainers and executives were also taken into consideration.

1. Overview

1.1 Computer Integrated Print Manufacturing Workflow

Computer Integrated Manufacturing Workflow (see Figure 1 and 1a) requires a pattern of activities enabled by a systematic organization and the use of analog and digital devices, such as: input/output devices, post-print/finishing devices, digital front-end platforms, web applications, desktop and graphic applications, Internet, and LAN/WAN network components.

Within the major workflow system, area specific workflows (subdivisions) can be housed. For example, Prinergy EVO has the ability to merge or interface with other front-end workflows (or RIP's) or MIS systems, such as: CGS-ORIS, GMG,

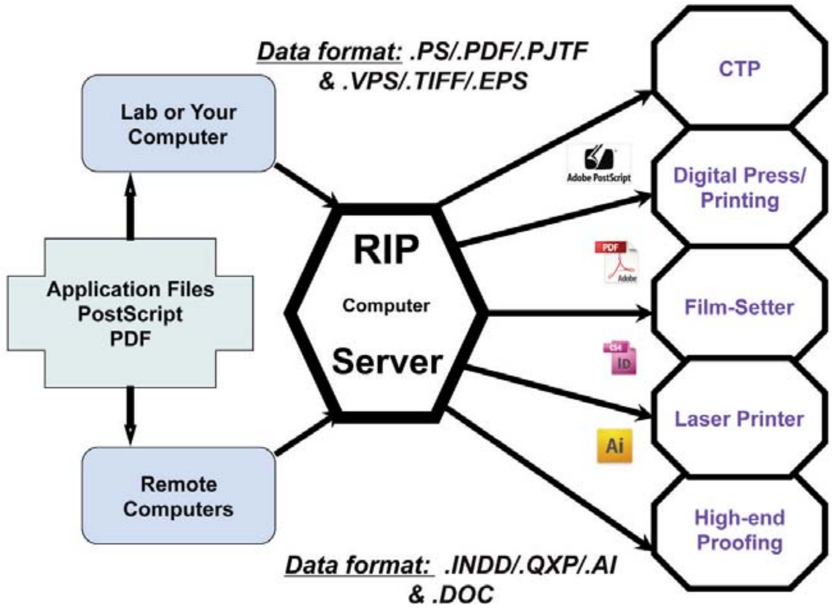

Figure 1: *Schematic Illustration of Low-end Graphic Workflow*

CreoSpire CX_250, Creo IC 307, Metrix or Hiflex. In this type of scenario, limitations could apply to the workflow, due to vendor and brand selection of technologies and platforms, etc. Schnoll (2004) stated that workflow is merely a new page out of a 600-year-old history book. Worklfow issues have surrounded the printing industry since Johannes Gutenberg printed the first bible (Schnoll, 2004). This is an indication that not every printer or academic program can have the ability and resources to implement the CIPM workflow applications/systems into their day-by-day production (or learning) activities (or environment).

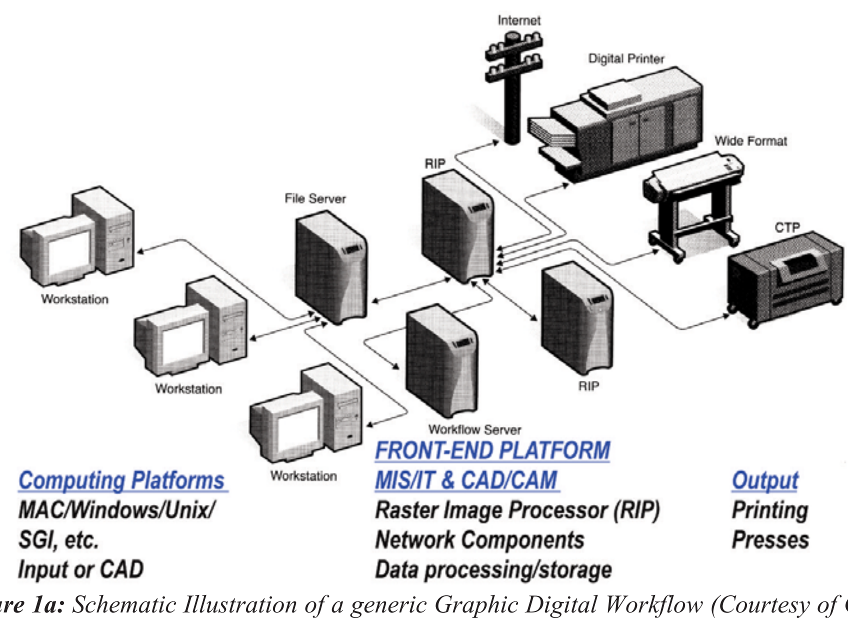

Figure 1a: *Schematic Illustration of a generic Graphic Digital Workflow (Courtesy of GATF)*

Majority of printing companies, in all sizes, have made the concept of "CIPM workflow" a top priority in their day-to-day production operation. The personal experiences of touring of the graphics technology educational programs across the country show a different scenario. Not every graphics technology program houses a CIPM workflow system in their academic laboratories. This is due to the cost and investment associated with acquiring such technology and application (see Figures 1 and 1a).

Presstek Direct Imaging (DI) was the first company to pioneer the first offset press to offer on-press imaging; the Heidelberg GTO DI used first-generation Presstek imaging on a Heidelberg GTO press platform. In 1993, the imaging was upgraded to the first laser diode based on-press imaging technology. In 1993, the technology was first demonstrated at the Printing Laboratory at the Rochester Institute of Technology, Rochester, New York. In order to image plate on-press, a workflow system was needed. However, the invention of Computer to Plate (CTP) by Creo (Kodak) was the starting point of digital workflow concept (Schnoll, 2004). The goal of the CIPM workflow is the ability to address all the factors for any printed piece in an open, well-defined but flexible manner that can be handled by the computing and front-end platforms (Walter, 2005). For many printing companies and academic graphics technology laboratories, the CIPM workflow has arrived and it is within the reach. The complex and critical challenge is ease of implementation and training. Older technology must be replaced with new digitally driven front-end platforms in order to have a successful implementation and use.

1.2 Computer Integrated Print Manufacturing (CIPM)

Computer Aided Design (Image Capturing, Design and Prepress Layout) production is an integral part of CIPM. The goal of CIPM is a total automation of an entire printing company without much human intervention or labor. In reality, this goal is conceivable. The CIPM workflow has many dynamic parts, starting with software and hardware components of the CIPM (Schnoll, 2005). Schnoll continues to focus on implementation of new digital workflow with legacy equipment, and systems that are often restrictive and frustrating (2005). Dr. Bohan (2005) indicated that CIPM, enabled with job definition format (JDF), is going in the right direction but is not there yet. So, today are we there yet? JDF enabled CIPM is still a difficult task with old legacy equipment. Many academic laboratories are equipped with legacy technology. The newer technologies and systems are available with JDF enabled front-end platforms.

Modern graphics technology products are manufactured in a heterogeneous environment. A number of departments, individuals, and systems can be involved in the production process. These new technologies of JDF enabled CIPM and applications are available in every production area of CIPM (prepress, press, post-press, distribution, and MIS, etc.). Workflow processes within these production and management areas are quite challenging. An effective digital workflow of CIPM consists of these stages: The CAD area (see Figure 2) in which design elements (color, text and images) are assembled according to the job specifications. The job planning process begins with carefully inspecting the job and planning it with more cost effectiveness. Depending upon the type of application to be used for the job plan, at the planning stage, opportunities will be there for planner (or prepress technicians) to create page imposition layout, finishing job ticket, and output job data. Additional options may be available to merge the job contents with the plans in a JDF format. Also, planner or technical person can export (and or export) the job (JDF file) to the front-end platform of CIPM device. This device can be a digital press, proof, CTP, or a digital printer. Finishing data in JDF format can also be sent to finishing devices, which are part of CIPM. Lastly, the management information system (MIS) area is responsible for collecting the cost associated with job from the customer. For example, Metrix 2011 software from the Litho Technics is capable of performing the above stated functions.

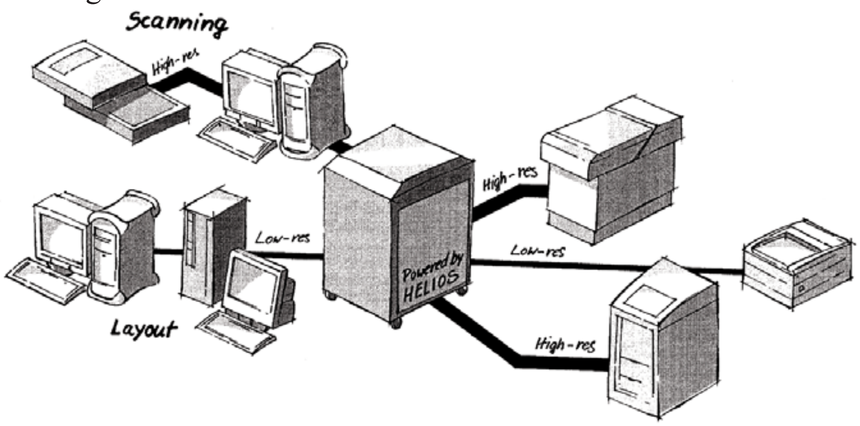

Figure 2: *Schematic Illustration of CAD (Courtesy of Helios)*

1.3 XML and a Document

Extensible Markup Language (XML) is a markup language for encoding documents containing structured information. Structured information contains the content as well as its meaning. The content can be in the form of words, photos, tables, etc. Different documents have different structures. Structural markup identifies structures in a document. XML uses markup tags (words surrounded by '<' and '>') to describe document structures. Countless numbers of applications are currently being developed that make use of XML documents. In addition to traditional documents, XML file format can be used for various e-business applications, metadata applications, and for display on wireless computing devices.

1.4 CIP 4/Job Definition Format (JDF)

The International Cooperation for the Integration of Processes in Prepress, Press and Postpress (CIP4) is a Standard Development Organization which is registered with the U.S. Department of Justice and the Federal Trade Commission. It is a global nonprofit organization established in Switzerland. It has representatives in several countries. The goal of CIP 4 is to develop standard XML based job ticket called the Job Definition Format (JDF) for workflow management of the graphic industry. CIP4 works with vendors, consultants and end-users in print technology, Graphic Arts industry, and related sectors. CIP4 standards cover a variety of equipment, software, peripherals, and processes (2012, cip4.org). Currently, a majority of device manufacturers (equipment vendors) and software developers are integrating the CIP 4/JDF standards within the frond-end system of MIS, input, output, and finishing devices. Many older front-end systems cannot handle the XML data if embedded into production formats, such as: PDF, PostScript, and PJTF, etc. CIP 4 and its partners strongly believe in having a common production language/technical standard – JDF.

1.5 Job Definition Format (JDF)

The JDF is a technical standard designed to facilitate information exchange between different applications and systems in the graphic arts industry. It describes JDF files as well as a job messaging format (JMF) based on XML over HTTP. It is successor to pre-existing partial solutions, such as CIP3's Print Production Format (PPF) and Adobe Systems' Portable Job Ticket Format (PJTF). The integration of commercial and planning applications into the technical workflow is made easier by the JDF system. As more and more vendors (including media, design, graphic arts, on-demand and e-commerce companies) accept the JDF standard, it will ensure benefits such as greater portability between different platforms and their integration with Internet-based systems to create seamless workflows.

Custom automation and system integration projects in the printing industry are generally very expensive. JDF can help bring the cost of automation down by ensuring that printers of all sizes and other equipment have access to automation on a common platform. With a JDF-based print production workflow, organizations don’t need to reengineer an already automated process every time they purchase new equipment as long as the new equipment supports JDF.

2. Rationale of Graphics Technology Education

Graphics technology education is one of the oldest fields, in the print manufacturing industry and its content is constantly changing due to rapid advancements and trends that are taking place in industry. Graphics technology has been a part of educational institutions since its invention in the 14th century, and it continues to meet the needs of a progressive industry (Daily, 2000). Marshall (2000) stated that two common goals of technology-based educational programs across the country are to increase enrollments and to offer a curriculum that is both current and relevant. Technological developments in the graphics technology industry are currently changing many of the job descriptions, thereby creating a greater need for a qualified and skilled workforce. Graphics technology companies and educators need to integrate technological and managerial changes into the curriculum to prepare the future production workforce and managers for industry. Wilson (2001) stated that the graphics technology industry is in a constant technological flux. He also stated that industry input is needed to make sound curricular decisions for technology-based educational programs to meet employers' expectations and to increase graduates' technical competency.

Childress & Gillispie (1999) stated that the graphics technology industry offers a host of career opportunities including management, sales, technical, art, customer service, and more. Graphics technology graduates from a technical or community college qualify for an entry-level or a technician position in industry. Similarly, graduates of a four-year or university-level graphics technology program qualify for entry-level supervisory management-trainee, or middle-management positions (Flecker & Groff, 1998). A review of course catalogs from universities/technical colleges offering graphics technology programs revealed that graphics technology curriculum covers both theoretical and practical content in the areas of print management, prepress, press/printing, and print finishing or bindery. Flecker & Groff (1998) indicated that the depth of course content taught to students may be different from institution to institution and program to program. This is due to the level of the programs and the status of the institutions. Denny & Harmon (2000) indicated that any type of education plays a critical role in society and allows an individual to develop the knowledge and skills necessary to capture economic opportunities and thus increase his or her income. Additionally, education plays a critical role in building a modern market-based economy and raising the standard of living (Denny & Harmon, 2000).

Lewis (1996) stated that, like other manufacturing industries, the graphics technology industry also requires trained and educated employees to keep the industry growing profitably. Currently, the United States printing industry is going through a radical reorganization of its workplace due to technological developments in every segment of the industry (Faiola, 1999). Due to these changes, there has been an increased demand for an educated and skilled workforce with up-to-date technical competencies. This demand is due to technological changes in digital prepress, management practices, color management, and digital printing areas of the industry (Lewis, 1996). According to several published reports, the printing and publishing industry is in desperate need of qualified and skilled workers at every level. As the graphics technology industry begins to replace older technology with new, digitally-driven technologies for the purpose of efficiency in print production, profit gain, and to meet the demands of the various market segments, the type of employees' skills also needs to change. New technology is often difficult for many older industry workers to adopt, especially with the rapid changes that have occurred over the past ten years in the industry. Modern graphics technology education can prepare an individual to cope with industry advancements (Faiola, 1999). Graduates with modern graphics technology education and skills are, and will be, in greater demand than ever before in one of the fastest growing industries in the United States.

3. Graphics Technology and the Power of Partnership

Recently Central Connecticut State University's (CCSU) Graphics Technology program is undergoing a revamping with the development of new courses, revision of curriculum and establishment of new laboratories, such as: Digital Workflow, Digital Proofing/Printing, Color Management and Control, Graphic Management Information Systems, and Mobile Laboratory for the Radio Frequency Identification (RFID) in the Print/Packaging Logistics. The undergraduate degree program, which prepares graduates for careers in printing and associated industries, is one of the most competitive in the nation.

In the spirit of CCSU's commitment to continuous improvement, the graphics technology program continues to revise its curriculum and course content. The program laboratories house several technologies to be used by students in the program. The facilities can be classified as a full-fledged commercial print operation. As such, the new curriculum requires development of new laboratories, acquiring of new technologies, and development of new laboratory learning modules and activities for students. Graphics technology program's successful efforts to secure industry donations will contribute to establishing the finest laboratories for the program. The following paragraphs explain the major donations (hardware/software) the university is expected to receive in near future that will significantly impact digital workflow, color management, and production management areas in the Graphics Technology curriculum.

Prinergy EVO 5.1.00 from Kodak Graphic Communications Company, Burnabay/Rochester, British Columbia/New York. The Kodak Prinergy Evo Workflow is a JDF enabled powerful solution for controlling prepress production (CTP and Proofing) with outstanding performance and output quality. Built on proven Prinergy Workflow PDF processing technology, Prinergy Evo Workflow features advanced preflighting, normalizing, color management, trapping, and optimizing. With an intuitive user interface, self-training, and support, Prinergy Evo Workflow provides easy, efficient operation with an ongoing low cost of ownership. Modular and scalable, it is a flexible workflow system that helps streamline processes and reduce the costs of production. This system allows to communicate (data transfer) with GMG (proofing RIP), Metrix2011 (job planning), and Creo IC307 Print Controller (Creo Color Server) of Konica-Minolta bizhub C6000 Digital Color Press. Efforts are in progress to have an updated version of Prinergy Evo Connect, so that it can be merged with Hiflex MIS System.

Metrix 2011 from LithoTechnics, New South Wales, Australia. Metrix is an intelligent, automated job planning/imposition system used by industry estimators, CSRs, and prepress operators. It is used as a production management system in the GCM program's computing laboratory at the university. Metrix has become the printing industry standard for automated and integrated production planning and imposition; as such, it is a tool that students need to learn and master. LithoTechnics' generous donation enabled students and faculty to practice and perform computerized production management activities while learning how Metrix integrates with MIS, prepress, and post-press systems and processes. Metrix is fully JDF-enabled (xml based Job Definition Format) on both the input (MIS) and output side (prepress and post-press), and LithoTechnics has been a full CIP4 (International Cooperation for the Integration of Processes in Prepress, Press, and Postpress Organization) member since the company's founding. This donation provides a priceless experience for students in the post-press and estimating classes, enabling them to experience the production management workflow—from print job planning to print finishing—as performed in today's industry, as well as understand how this contributes to high quality work, efficiency, and profitability. Without the Metrix application, job planning would require the application of manual techniques using paper and pencil.

Hiflex MIS System from Hiflex Corporation, Aachen, Germany/Asland, NY. Hiflex Print MIS Software supports all business processes in the graphics technology industry. Hiflex Software is represented worldwide and available in 15 languages. HIFLEX is the Global Technology Leader in Printing Web2Print and MIS and the only system that actually uses JDF in real work integrations. It uses the Drupal Open Source Content Management System for our Webshop System. Hiflex will be used in the Graphics Technology program to teach MIS concepts such as: Web2Print, Estimating, Customer Service & Order Entry, Scheduling, Costing, Invoicing, Purchasing, Inventory, Data-Collection and Integration to Prepress, Press, Postpress, Mailing and Delivery.

GMG Color Management and Proofing Workflow Software by GMG Color, Germany will be used by the graphics technology program's digital color proofing and color management laboratories. This application will become a standard digital color proofing workflow application for the Graphics Technology program. GMG application consists of multiple components (modules) for color proofing workflow management, such as Color Proof, Proof Control, and Color Server. The GMG application will allow students to print digital color proofs more accurately than before, regardless of device capabilities. A color proof is a prototype of a final print reproduction; it represents how a final printed piece would look. It also ensures that the proof being printed meets industry standards, such as GRACoL, SWOP, and SNAP. Accurate or facsimile color control from beginning to end in a printing or imaging process is essential for quality output (display or printed). The new resources that will be brought into the laboratory will allow students to perform color management activities, such as digital color proofing, device emulation, device calibration, and control. The laboratory will also be able to facilitate onsite training and consulting for industry personnel. Integration of the new tools and activities will be a major asset to the graphics technology curriculum at CCSU.

Multiple types of color measuring devices (Colorimeters and Spectrophotometers) as well as Device Profile Creation applications by the X-Rite Corporation, Grand Rapids, MI, and additional similar types of devices and applications by the Data Color Corporation, Zurich, Switzerland will be brought into the laboratory. Students will utilize such devices and software applications to create device profiles in order to communicate accurate color data among various input (scanner), display (monitors), and output devices (printers). Device profiles consist of colorimetric data of a color creation or display or printing device.

Also, the laboratory received multiple copies of color quality (print quality) management applications (SPC applications), such as Gamut Vision (iMatest), ColorThink-Pro (Chromix), SpotOnPress (Alder Technologg), IDEALinkCurve (IDEAlliance), and Taskero Universe ColorPath Verified (Fujifilm), Proof Pass from ColorMetrix, and Remote Director for Soft proofing, etc. These industry-specific applications interact with various types of color measuring devices and applications, enabling students to inspect and analyze device profiles as well as predict the intended reproducible color on a particular device and determine the expected deviation (ΔE) of a color between input versus output color-producing devices. In addition, these applications allow students to analyze the printed colors (combination of paper, ink, and toner) to confirm with industry standards in order to determine the quality of color printing standards.

4.0 The Graphic Technology Academic Laboratory

Over a period of two to three years, donations of workflow applications will be fully implemented into the curriculum. In addition to Adobe-CS application, multiple dedicated servers and front-end platforms will be installed to run and drive workflow applications and output devices. For example: The Metrix 2011, GMG, Creo IC307 Controller, and ProofPass from ColorMetrix, and Konica-Minolta C6000 bizHub Digital press. The curriculum is a full-fledged curriculum, delivering courses in the areas of pre-media, high-end image capturing, new media publishing, press, post-press, color management MIS, management and distribution.

4.1 Pre-media

In the pre-media courses students will utilize high-end image capturing devices and Adobe-CS applications as part of their CAD activities (see Figure 3). Students will use color managed workflow, and as such, the color settings within the applications of pre-media must be very similar from area to area. Majority of the activities include combining the design elements of text, color, and graphics to prepare the final layout of the job (or project) for further processes. Further steps may require to .JDF files by using Metrix applications. Students will utilize a wide variety of output devices (low-end to high-end) for printing related activities. These devices will be accessed through GMG & Creo IC307 Colr Server workflow system, in which the output templates (hot folders or watched folders) allow students to drop, process, and output the job (paper proofs or CTP) on respective output devices. Depending upon the final destination (proof or plate), the workflow resources transfer the rasterized data to respective front-end platform of the device from which the image carrier or paper proof (or printing) will be produced. The laboratory utilizes GMG front-end for Roland proofer, and Creo IC307 Controller for digital printing on Konica-Minolta C6000 press.

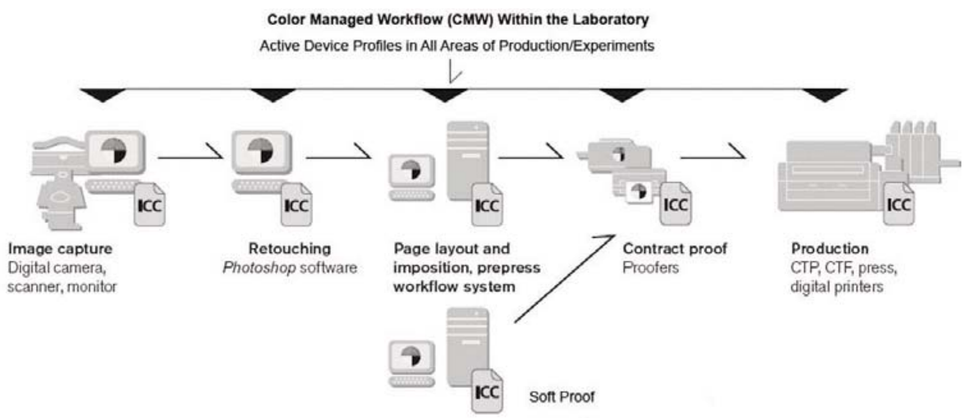

Figure 3: *Schematic Illustration of pre-media Laboratory (Courtesy of Kodak)*

4.2 Color Management and Control

Color can be viewed as a science where the optical aspects of color are quantitatively analyzable and measurable. The human eye, however, perceives color more subjectively, which poses a challenge at times for the print and image reproduction industry. Color Management Workflow (CMW) of the Graphics Technology laboratory will use a set of hardware tools and software applications working together to create accurate color between various devices: input, display, and output. A Color Management System (CMS) consists of device profiles (or characterization of devices) which control and document the working performance of the scanner, monitor, and the printer. A device color transformation engine (Color Management (matching) Module (method) or CMM) is one that interprets the color data between the scanner, display, and the printer. The gamut compensation mechanism of the CMS addresses differences between the color capabilities of input, display and output devices. The Profile Connection Space (PCS) is a device independent color space through which all color transformation occurs from one device-dependent color space to another (see Figure 4). The PCS is based on the spaces derived from CIE color space. Apple ColorSync supports two of these spaces: L* a* b* and XYZ. The color conversion from device-dependent color space to device-independent color space is achieved by the use of PCS. The device color characterization file (profile) passes in and out of the PCS to complete the transformation. The PCS is the central hub of the CMS in which a particular color value is considered absolute and not subject to interpretation.

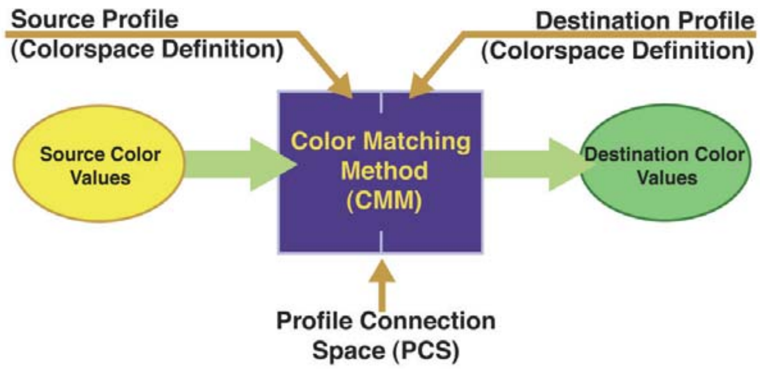

Figure 4: *Schematic of PCS of CMS (Courtesy of Adobe Systems, Inc.)*

The International Color Consortium (ICC) was formed in 1993 by seven industry members (Adobe, Agfa, Apple, Kodak, Microsoft, Sun Microsystems, and Silicon Graphics) to define the standards for color device characterization (Adams & Weisberg, 2000). Today, the ICC represents more than 70 industry and honorary members (ICC, 2009). This device characterization is presented in terms of specially formatted files, which have come to be called profiles. Unfortunately, the use of color management systems has not yet solved all of the problems of color reproduction (Fleming & Sharma, 2002), such as: acceptance of linear colors, reproduction of neutral gray-balance, rendering and intents. It has however, made possible the quantification of problems. As always, in quality control, with quantification comes the ability to control, and with control, quality management becomes possible (Fleming & Sharma, 2002).

4.3 The 4 C's of CMS or CMW

To implement the CMS successfully, all the devices (monitor, scanner or digital camera, and printer or printing press) which are used for printing and imaging purposes must be calibrated, characterized (profiled) and their color capabilities (RGB and CMYK) must be converted into an independent color space (CIE L* a* b* space). A calibration process means standardizing the performance of the devices according to the device manufacturer specifications so that the results of the devices are repeatable. A profiling process (or characterization) refers to colorimetric assessment of the device color performance and creating an ICC (International Color Consortium) profile specific to that device. The characterization process requires CMS hardware tools and software. Characterization of the devices is converted into an ICC profile file format. It communicates measured color output of devices in response to known output. Conversion refers to translating a color image data from one device color space to another device space. It is also known as color transformation. Control, the fourth C, means the user of CMW must monitor and analyze the use of the CMW process through the use of statistical process control (SPC) tools in order to avail the benefits of the CMW.

Color management as a workflow activity simplifies and improves the reproduction accuracy of color images from device to device. When appropriately used in the print process, a CMS will assist the student in delivering accurate output colors regardless of device color capacities with the use of proper gamut mapping techniques. Students will utilize CMW to produce ISO 12647-7 certified digital color proof with a color deviation within the established ISO standards for GRACoL proofs or ISO 126476-7 proofs (see Figure 5). Upon printing the proofs, their proofs will be measured to determine the pass/fail criteria. The measured colorimetric values will be stored into Fuji's Taskero process control color server, which will also allow students to access the colorimetric data remotely over the web or over the web in the laboratory.

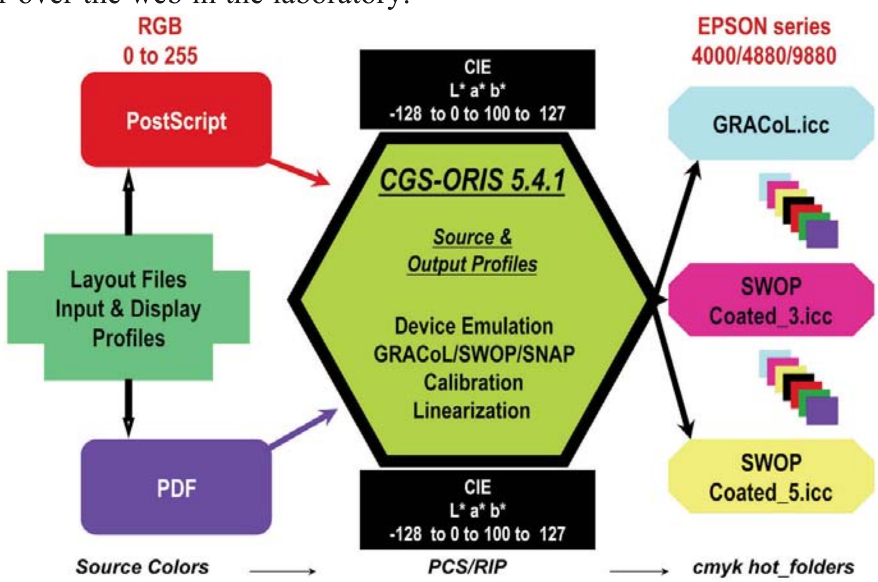

Figure 5: *Schematic Illustration of Color Managed Certified Color Proofs – ISO 12647-7*

4.4 Management Information System (MIS)

The students of Postpress, Estimating and Planning, Customer Service, and Practicum courses will utilize this laboratory. Over the network, students will be able to access the data (job content) storage server, the Metrix 2011, Graphics Technology curriculum activities will include job planning, JDF imposition layout creation, JDF data file for proofing, and for printing. JDF data file of finishing (trimming or cutting) can also be created and transferred to the JDF enable paper cutter in the laboratory. JDF finishing data file can be created by using the Metrix 2011 software. Additionally, upon planning the job, students can also prepare tentative cost (job quote and estimating worksheets) of the print job by using the stated applications. Students will also gain hands-on experience of creating production department, cost centers, and tabulating the cost of equipment hourly rate (BHR) and materials and task costs.

Job planning activities will enable students to create multiple types of data files. Upon creation of JDF file with job contents, it can be transferred via workflow systems to a respective output device (ROLAND, KONICA-MINOLTA C6000 PRESS) front-end platform for output purpose. The most exciting part of this laboratory is that the applications (Metrix2011 & Hiflex) which will be available will allow students to create the job plan for printing and cutting JDF data from a single work station, without others intervening. This is the foundation to computer integrated print manufacturing (CIPM). As the demand for the printing volume goes down, the only way a printer can remain in the competitive business is by having print automated workflow. Print automation will be the key to fast set-up, less human intervention, and doing business more accurately and efficiently. The complete print automation requires that the business must adapt to the JDF enabled workflow systems for CIPM, CMW, CTP, DAM, and MIS, etc. (see Figure 6). CIPM requires the facilities of the production to be very modern and capable of handling multiple data formats. JDF enabled devices and front-end platforms are the key for successful implementation of JDF workflow (see Figure 7).

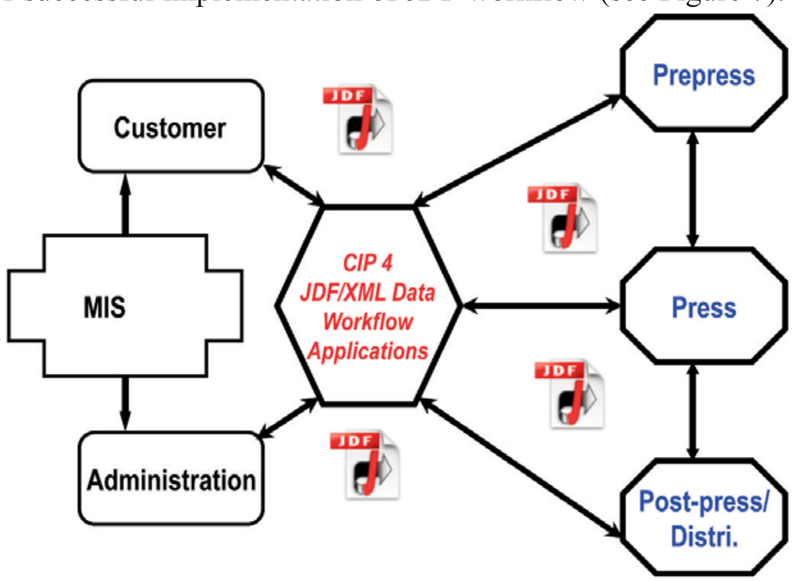

Figure 6: *Schematic Illustration of CIP 4 Complete Print Automation*

The JDF enabled workflow will allow us to have a reliable business communication among all the parties involved. Also, JDF enabled CIMP will allow us to connect and communicate with the input, output, and finishing devices of front-end platforms. JDF is more than a PJTF data file. Software applications such as Metrix, Hiflex, Kodak Preps, Kodak business link, etc. have abilities to create JDF data file, so that the user can transfer the data to respective devices or front-end systems or MIS, etc. Graphic technology laboratories at CCSU will have the JDF abilities, and the future workforce will be JDF enabled (see Figure 7).

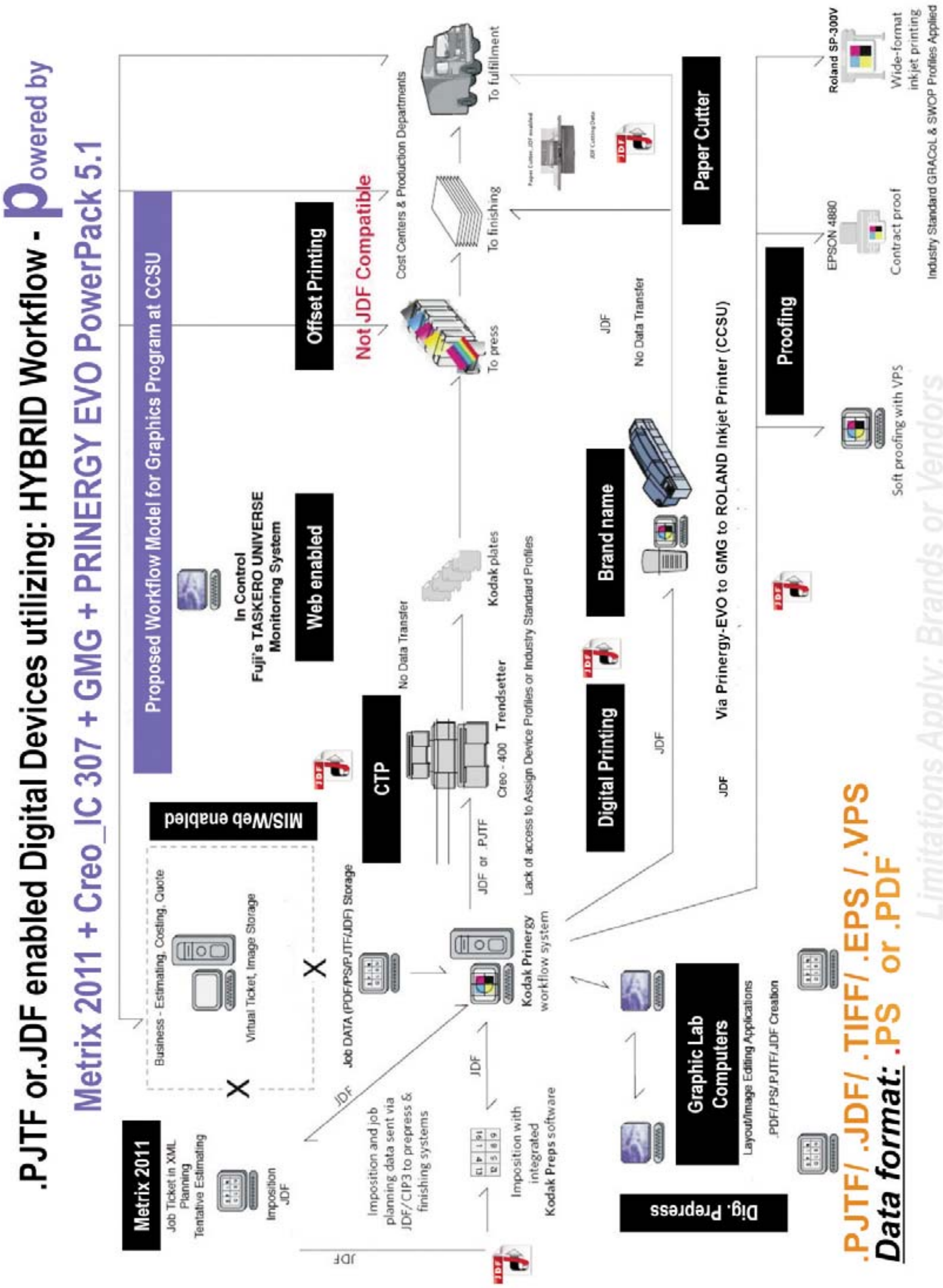

Figure 7: *JDF enabled Workflow of the Graphics Technology Laboratory (Powered by Metrix 2011, Creo_IC307, GMG and or CGS-ORIS and PRINERGY EVO PowerPack 5.1*

Summary

Integration of the new tools and activities in the Graphic Digital Workflow will be a major asset to the Graphics Technology curriculum at CCSU thanks to the vendors and donors contribution of technology and applications. For the students in the program, being able to experience the workflow for job planning, proofing, plating, CIPM, and MIS as it happens in the industry, and seeing how this contributes to quality work and efficiency, will be invaluable. The program prepares students to be managers who are leaders, motivators, communicators and well equipped to deal with business issues ranging from policy information to production efficiency. In the spirit of CCSU's commitment to continuous improvement, the program continues to revise its curriculum and course content. As the graphics technology industry replaces older technology with new, digitally-driven technologies for the purpose of efficiency in print production, profit gain and to meet the demands of the various market segments, employees' skills also need to change. The industry is constantly changing because of technological advancements, necessitating a more educated, skilled and technically competent workforce. CCSU graduates from the program will be prepared, thanks in large part to the generous donations.

Modern graphic technology has evolved from the craft oriented field towards a manufacturing and engineering technology merged with informational technology/networking applications, computer programming/scripting, quality engineering, and color science, demanding faster turnaround of print jobs and greater color reproduction control among the devices used in the print and imaging industry. This is of importance to the graphics technology educator, as the tools used to control those interface are increasingly software applications of the front-end platforms of the devices that invite the knowledgeable student to execute the print job more efficiently and accurately. In seeking to empower our students to better understand the CIPM techniques, JDF, DAM, PPF, CAD, MIS, CMW, and CTP technologies, the graphics technology laboratories allow students to experience analog print and digital printing manufacturing in a laboratory environment, similar to, what a student would encounter upon entering into the workplace. Hence, for a student to consistently deliver a quality print and execute the job plan, managing and controlling color from the input device to multicolor output device is a major concern for the graphic communication and imaging educator. Advancements in science and engineering, however, have allowed print and image professionals to apply scientific research methods across prepress, pressroom, and quality control. Applying these methods with our students will heighten their recognition as to the importance of proper workflow and education. While we already educate students as to how each family of devices tends to create and produce color differently—input and output devices produce colors differently because they depend on their own color capabilities—the challenge for us is to convey management of color and CIPM consistency across the entire workflow.

Industry is in a constant change, and the curriculums need to be geared to reflect these changes. A graduating student with graphics technology education must equip themselves with the following technical competencies for digital workflow and printing management: evaluate various input and output devices, develop skills in use of graphic applications, identify various front-end platforms, implement and use of color managed workflow, and identify the digital data file format and DAM. Additionally, students must also develop competencies in plant administration and production management, develop or interpret market research, and have ability to evaluate impact of new technologies on the business. Since the use of digital workflow is very critical for reduction in wastage, production efficiency, future workforce abilities in implementing digital workflow management, digital communications, MIS, job planning & JDF are essential.

Technological developments in the areas of electronics, computers, lasers, and computer integrated manufacturing techniques, science and engineering are radically changing the structure of the traditional printing industry. Due to these technological developments, significant changes are continuing in the printing industry, and thus demand a skilled workforce with up-to-date technical competencies. Research studies on technical competencies are required to make sound curricular decisions for technology-based graphic arts educational programs. New developments in industry should be integrated into the curriculum so that both graduates and industry can benefit. Finally, industries and educators must work cooperatively to better promote education, as well as make efforts to enhance the current curriculums and educational programs. Without the cooperative effort of these groups, industry may face a serious workforce shortage.

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