Efficient on-line Architectural Scheme for Variable Printing of Mixed One-sided and Two-sided Monochrome or Color Sets

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Abstract

This novel productivity optimization algorithm ia applicable to all jobs - Variable printing as well as book-mode printing applications. A patented lossless scheduling system is described. This concept requires an auto unload sorter-like Limitless Intermixer Module (LIM), which is placed between the printer engine and the finishing device - the number of bins in the LIM is equal to the maximum number of sheets in the duplex paper path. The scheduling technique provides maximum productivity in all cases. This approach is applicable to all two-pass duplex print engines, monochrome or color. This concept can be a modular hardware and software add-on to the existing system.

Our commercialization strategy calls for licensing the patents and additional knowledge to the office equipment and front-end manufacturers.

Introduction

In electrostatographic printing apparatus, wherein images are first created on a photoreceptor in the form of a rotating drum or belt and then transferred to sheets, a key concern is the presence of blank pitches (image-sized spaces) along the drum or belt. The problem with blank pitches is that each blank pitch represents lost productivity. In some duplexing schemes, the number of blank pitches along the belt may be comparable to the number of pitches actually having images on them. In such a situation, not only is the apparatus effectively running at half-speed, but various mechanical parts associated with the drum or belt will be experiencing wear to no productive purpose. Thus, as a general rule, the overall productivity of such printing apparatus is closely related to the number of blank pitches which result in the printing process. A long-standing concern of designers is how to optimize the use of a printing apparatus for situations wherein some desired prints are simplex and others are duplex. The fact that each duplex print has to be printed essentially twice causes a significant systemic problem with maintaining optimal or near-optimal operation of the entire printing apparatus. One simple solution, for example, would be to run every sheet along the duplex path, regardless of whether it is a simplex or duplex print, and in the case of each simplex print simply print nothing on the back side. While this solution is easy to implement, it provides the disadvantages of unnecessarily decreasing the output speed of the whole system. Another solution is to maintain duplex prints which are awaiting printing on the back sides thereof in a special buffer tray, until the system becomes available for printing the back sides of each sheet in sequence. The key disadvantage of this system is that a significant probability of error exists (a sheet may have the incorrect back side image placed thereon), and also the relatively intense handling of each print sheet in and out of the buffer tray substantially increases a likelihood of mechanical misfeed which will cause loss of job integrity. Both such problems tend to result from the fact that sheets typically cannot be fed out of the buffer tray reliably. Even with a buffer tray, a fairly sophisticated scheduling system is required.

These systemic problems are common to variable printing ar book-mode printing applications. Variable printing applications have fewer originals and the run length is one whereas book-mode printing may have many originals and the run length is also quite large. In the current scheduling schemes mixed originals containing simplex and duplex originals suffer productivity losses since the blank side of a simplex original is also printed unnecessarily to keep the sequencing in order.

U.S. Pat. No. # 5,655,208 and another pending patent disclose a general overview of mixed simplex-duplex printing system for variable printing and book-mode printing applications.

The Intermixing Architecture (Patent # 5,655,208)

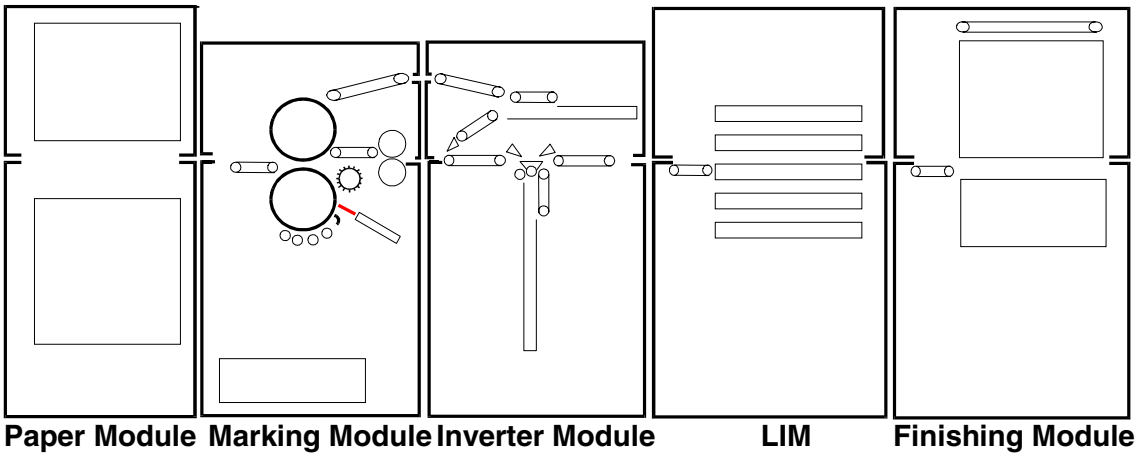

FIGURE above is a simplified elevational view showing the relevant parts of a duplex printing apparatus, on which the system of the present invention may operate; The various modular units, such as Paper Tray, Marking Module, Duplex-Inverter Module, Limitless Intermixer Module (LIM) and Finisher Module is shown.

The additional LIM hardware module as shown between Inverter Module and minimizes the number of blank pitch spaces within the schedule. for all jobs including variable printing jobs According to the present invention, wer provide a method for scheduling a sequence of images created by the marking module for a mixed simplex or duplex printing job. The elevational view of the paper path of an on-demand printing apparatus is shown which is capable of simplex or duplex output. The particular architecture shown is for an electrostatographic printer, but the principle of the invention could apply equally to other types of image-creation technologies, such as ink-jet printing.

Duplex loop as shown is typically in the form of a racetrack which is capable, by means of friction, static electricity, vacuum, or other means, of retaining a plurality of sheets thereon, thereby retaining a particular sheet until it is time for the sheet to receive an image on the side of the sheet facing outwardly from the belt of the duplex loop.

To create a duplex print, that is, a print having one desired image on one side thereof and another desired image on the other side thereof, it is necessary to make the other side of the sheet available to the photoreceptor drum or belt, by causing the other side of the sheet to face outward while the sheet rides on the outside of duplex loop. For this purpose there is provided along the duplex loop a device generally indicated as inverter. The basic purpose of inverter is to pick off a sheet from duplex loop which has an image already placed on the outward-facing side. In brief, inverter operates by temporarily removing the sheet from the duplex loop, feeding it in one direction, and then re-feeding it back onto the duplex loop.

Thus, for a duplex print, the creation of the front-side image by imager must be spaced by a fixed time period from the creation of the back-side image on the same sheet; this time difference is ultimately dependent on the size of the sheet relative to the overall length of the duplex loop. In a practical application of a duplex printer, an operating parameter which is more useful than the timing between the production of particular images is the number of "pitches" along the length of either the photoreceptor belt or the duplex loop. A "pitch" is a length of the duplex loop or photoreceptor belt corresponding to an image of the size to be printed, such as 8.5.times.11 inches or "A4". For example, a typical practical length of a duplex loop can be four pitches; that is, for letter-sized images to be printed, the duplex loop is of a length wherein four such images, or four such sheets, could be retained on the duplex loop at a particular time along the circumference thereof. What this also means is that duplex loop is capable of, in effect, temporarily storing up to five such sheets at a time between the time any individual sheet receives an image on one side thereof and gets ready to receive an image on the other side thereof. This "capacitance" of the duplex loop will of course have a direct effect on

the number of bins in the LIM. If a larger size print, such as 11.times.17 inches, is desired to be printed, the effective capacitance of duplex loop will be lower, such as two or three pitches, because only two or three such large sheets could be retained along the circumference of duplex loop at a particular time. Given the physical parameters of a duplex-capable printing apparatus including LIM, which is situated between the printing engine and the finishing module, let us now discuss the specific scheduling techniques according to the present invention.

Duplexing Efficiency Let us assume that the duplex loop is 4. Let us consider a monochrome duplex printer without LIM where the jobs are a mixture of simplex and duplex originals ("mixplex"). In an all duplex book-mode printing job, the machine can print four front-sides then four back-sides of the odd pages followed by even pages and so on and no blank pitches are incurred. But now suppose the first page is duplex and the next three are simplex. The machine will either create pages out of sequence or many blank pitches will be added to keep the order in printing.

In the book-mode with large run length, the machine with LIM will print four images of the first page followed by the back side images of the second page and shoot these four sheets into bins 1, 2, 3 & 4 of the LIM, followed by four simplex images of sheet number 2 and shoot these four sheets into bins 1, 2, 3 & 4 of the LIM, followed by four simplex images of sheet number 3 and shoot these four sheets into bins 1, 2, 3 & 4 of the LIM followed by four simplex images of sheet number 4 and shoot these four sheets into bins 1, 2, 3 & 4 of the LIM. Thus no blank pitches are incurred.

In the variable printing mode with run length of 1, the machine with LIM will print four images of the first page for customers 1, 2, 3 & 4 followed by the back side images of the second page of the respective customers and shoot these four sheets into bins 1, 2, 3 & 4 of the LIM, followed by four simplex images of sheet number 2 for customers 1, 2, 3 & 4 and shoot these four sheets into bins 1, 2, 3 & 4 of the LIM, followed by four simplex images of sheet number 3 for customers 1, 2, 3 & 4 and shoot these four sheets into bins 1, 2, 3 & 4 of the LIM followed by four simplex images of sheet number 4 for customers 1, 2, 3 & 4 and shoot these four sheets into bins 1, 2, 3 & 4 of the LIM. Thus no blank pitches are incurred.

It can be stated that in a four pitch duplex loop print engine, a printer with 4 bin LIM can output any combination of mixplex pages in correct sequence without any blank pitches or lost productivity.

Mixed Color with black & white: A somewhat similar problem can occur when printing mixed color and black and white. Quite a few printer can print black & white four times faster than single color (black). Also, most of these printers are capable of printing one A3 or two A4 on the transfer drum or belt.

In a job with mixed monochrome or color pages, it is advantageous that the pairs of A4 images on transfer drum or belt are both monochrome or color to assure maximum productivity. If a color and monochrome pages are printed together, a monochrome page takes four times as long since it can be sent to output until all four passes of color on the adjacent page has been transferred. A LIM can help here as well since only pairs of monochrome or color pages will be printed together and sent to the LIM. Thus proper sequence can be maintained at maximum productivity.

RIP Efficiency: Another advantage of the LIM concept for book-mode printing applications is in RIP efficiency and RIP cost. For a four-bin LIM, the RIP could run at one-fourth the speed that would be required if each page was printed in sequence. The use of the LIM could be important in high-end color printers, where the RIP is often a technical bottleneck . In lower cost machines, the LIM can probably lower the cost of the RIP further.

Integrity of Variable Data: Another major advantage of the LIM is the assurance of job integrity for variable data jobs. Variable data printing poses a special problem, as for example, in a billing or checking statement, customer one receiving a page from the statement of customer two's account will be unacceptable. Currently, very expensive image pattern recognition and matching schemes are used to assure job integrity of variable data applications.

With LIM, all the sheets for customer#1 go inti bin#1 of the LIM and so on. Since, each bin has a paper sensor, it is every easy to determine through machine control logic whether the sheets for customer #1 were received in bin# 1 and so on.

Finishing Efficiency: Another advantage of the LIM is the finishing efficiency due to the fact that additional buffer bins in the LIM provide more time for finishing operation and no blank pitches have to be introduced in the system to pause for finishing operations.

Other advantage of LIM algorithm relates to simple algorithm for job recovery, larger time window for image dependent fuser temperature control or simpler sheet dependent finishing operations, as for example, scoring, envelope feeding etc.

LIM requires extra physical space. However, it is possible to stack LIM vertically and reduce the footprint with intelligent architectural design.

Test Results

The mixplex algorithm with LIM is quite straight-forward. However, the implementation is dependent on individual print engines. At this time printer companies are being approached for feasibility implementation. Depending on the application, in variable printing mode, productivity improvement of over 50-75% can be achieved.

Conclusions

When we combine these advantages of LIM, we find that the mixplex solution using LIM has many system advantages including lower overall cost and higher systems efficiency.

References

US Patent # 5,655,208 Modular multi-function image-forming apparatus for printing mixed sided and mixed color copy sets

Biography

Ravi Sahay has extensive experience as a management consultant in the areas of electronic imaging, printing, publishing and document management. He holds a master's degree in Electrical Engineering as well as master's degree in Business Administration. Ravi has worked for Xerox Corporation as a Systems Engineer, Strategic Planner and New Product Development Manager. He holds seven U.S. patents on Xerographic machines and two patents are pending. He can be reached by email at rsahay@aol.com.