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Simulation as a cloud service for short-run high throughput industrial print production using a service broker architecture

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ABSTRACT

Evaluating end-to-end systems is uniquely challenging in industrial/commercial printing due to a large number of equipment combinations and customization needed for each customer and application. Moreover any mismatch in capacities may render multi-million dollar investments to zero returns on investment. Simulation can help foresee changes on the shop floor when demand changes. Providing a library of components that can be assembled together is the usual approach used by many simulation vendors which still leaves a simulation engineer in the loop to make it usable. We detail our experiences on implementing a prototype (private) cloud service using service broker architecture and a dynamic model generator. The service broker handles the heterogeneity associated with demand and equipment configurations whereas the dynamic model generator customizes a generic model based on inputs from the user. This helps avoiding rewiring of simulation models on each engagement. The schema and the necessary front and back-end codes all reside in the cloud and, therefore, users pay on a per use basis without worrying about the upgrade/update of software at their end. The service supports multi-tenancy which results in low costs per user and provides sharing of resource information yet restricting access to proprietary workflows and policies. A typical run costs a very small amount, which is affordable for even small-sized PSPs. We show the utility of our work in the context of educational book publishing to evaluate equipment changes needed when the current lumpy order demand stream changes to a highly fragmented demand stream. We also discuss how our work can be extended to several other domains such healthcare, transportation, 3D printing.

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1. General introduction

Printing is one of the ways in which digital information can be converted into a physical format. When a printing facility serves multiple customers with multiple print products then the facility becomes a print service provider (PSP). Though many print facilities and operations can be termed as PSPs, in this paper we restrict ourselves to high throughput industrial print facilities, which are characterized by very high volume demand (thousands of printed products per day), high throughput equipment (more than 40,000 feet of paper per hour), worker shifts all day and night and multiple million dollar equipment. A typical workflow in a PSP is summarized below and detailed steps are also shown in Fig. 1 [41]:

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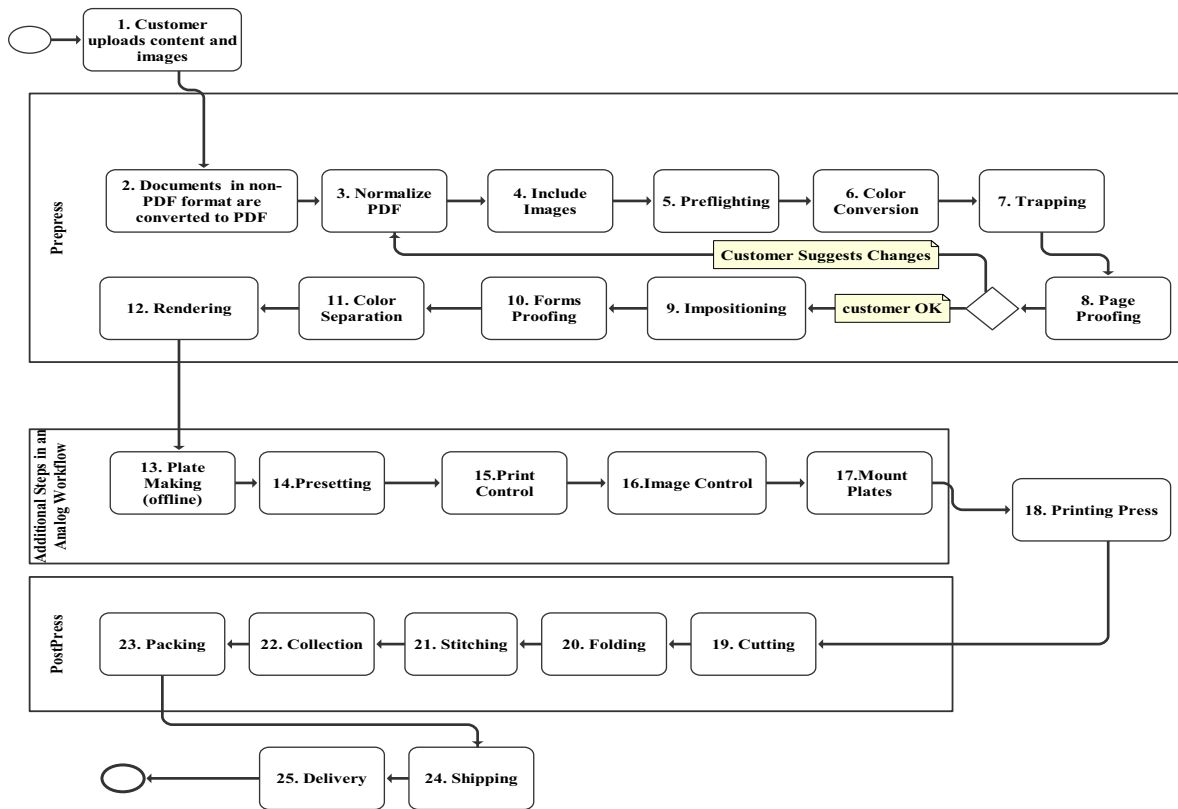


Fig. 1. Analog and digital workflow.

1. Gather order information and customer supplied content (Steps 1 and 2).
2. Pre-process content (convert all PDFs to v1.4) and do various checks such as color, paper layout, and registration (Steps 3–7).
3. Create a proof (Steps 8–10) and ask customer for feedback.
4. If all OK, proceed to Step 11. If not OK, make necessary changes and restart the prepress process (go to Step 3).
5. Add production information (batching information) and rasterize the content (Step 12).
6. Print the rasterized content (Analog workflow will have Steps 13–18; digital workflow will only have Step 18).
7. Do post-press steps such as cutting, folding, and stitching (Steps 19–21).
8. Gather, package and ship print products (Steps 22–24).
9. Delivery of the printed product (Step 25).

The above steps are illustrated for digital commercial/industrial print. For analog commercial/industrial print, Steps 13–17, which are costly and time consuming, are completely eliminated from the workflow. Moreover, over the last two decades, digital printing has slowly, but surely, replaced analog printing for many applications due to advancement in printing quality, color accuracy, and cost effectiveness for the shorter runs. This does not mean that analog printing is going to go away. For certain applications, analog printing will continue to be cost effective.

The demand profile has also played a key role in this transition. For example, Precision Printing, a PSP based in UK, has reported an astounding more than 200% increase in number orders per day but a 99% decrease in average value of the order as it moved from analog to a mix of analog and digital printing as shown in Table 1. The data for this table has been compiled by the author from an article published in [1].

Table 1
The effect of change of demand on a PSP.

Parameter	Before 2005	After 2005
Configuration	All Analog Presses	Digital + Analog Presses
Turnover	\$8M	\$19.2M
Average orders/day	45	10,000
Avg. order value	\$795	\$3.68

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