PRINT PRODUCTION WORKFLOW SYSTEMS: AN ALGORITHMIC IMPLEMENTATION

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Abstract— An innovation in technology has always ignited change for the people. Such changes have not only forced business processes to adopt new technology but also to change the business processes as well. The same has been seen in the print industry. Due to new concepts in technology and increasing use of internet, the industry is facing major challenges and one such challenge is survival. It is evident that run lengths for print is decreasing. But at the same time new opportunities are arising that includes embracing web-to-print, workflow systems and MIS for business survival and growth. This paper discusses such aspects of print industry and proposes a new cloud based print workflow model (PrettyPrint) that can leverage benefits to the print providers. The algorithms for the proposed model are illustrated and discussed.

Keywords— Algorithm, Cloud based print workflow, Print production workflow, Small scale print providers, Web-to-print

1. INTRODUCTION

There has been drastic change in the specified printed products market. It is expected that by 2020 there will be more such changes. Print industry cannot withstand with the idea 'the way it is always going to be'. There is a need for the Printers to think about and rethink about their business processes, products and services they deliver. This includes adoption of new innovative business ideas and also to rethink about the company culture they are practicing [1]. There have been great differences created for the print industry due to technological advancements, internet advantage to people, and the changing trends and demands of customers. Though one cannot deny the fact that there has been decline in demand for print, but at the same time print players in the market those who have adopted and embraced technological changes and have studied customers mind-set are doing well.

The internet revolution has made drastic changes about the mindset of people towards print media requirements. Though at the same time traditional method of reading from printed version still exists but at the same time there has been rise towards using e-version of books, magazines and other reading material. Not everyone is comfortable to read electronic books and novels but for the print providers it has become the necessity to offer electronic version of books and magazines for their consumers. The need to embrace technology and to integrate it with their workflow is the need of the hour for the print providers.

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2. RELATED WORK

The print industry has been facing lot of changes due to Internet revolution. The way traditional media and communication was used has changed. The three major reasons for the changes in current printing industry relate to - Workflow digitization, Technology integration and Changing demands. The print industry now uses electronic delivery of files and has adopted automated workflow processes. The industry uses integrating "hybrid" printing by combining different reproduction processes since many print jobs are complex with specialized coating or printing requirements. Printing production now shifts closer to the point of distribution as printing trends move away from being press-centric to printer-centric [2, 3].

Print industry has seen that Adobe PDF (Portable Document Format) workflow allows the standardization required to take full advantage of a digital workflow for print. Further, the introduction of JDF (Job Definition Format) has added advantage to print service providers. The JDF has helped to make the workflow visible to MIS used in print organization [4, 5].

Due to rapid changes in print industry, there is increasing demand for print automation. It has been realized that without automation of print workflow the organization survival will become questionable. There have been many print solution providers in the market to cater such needs. Print workflow solution providers are need of the present time for any print organization to gain business growth and to survive in the market [6].

Web-to-print systems are advancing towards marketing materials such as promotional mailers, membership card programs, etc that are capable to handle personalization and distribution [7]. Many print providers have adopted web-to-print solutions because of the acute demand for fast production turnaround time for various print jobs, and to reach out to customers in an easy way [8]. Info-trends have conducted a research to know about information about the penetration rate of web-to-print. The findings in their report highlight that 46% of print providers have adopted and invested in some form of such web-to-print solutions [9, 10]. The research by the Global Industry Analysts (publishers of worldwide market research), reveals in their report "Web to Print: A global strategic Business Report", that the global web-to-print market will reach \$869 million by 2017 [9, 10].

Print industry has now adopted Print Fulfillment Software for their automation needs. Print Fulfillment Software refers to the process of warehousing online printing items by a method of receiving orders, gathering the items for order, packing, shipping, and confirming that the order is full. Print fulfillment software can help a business print large quantity of marketing materials, business cards, gift cards, and other unique printing problems that can't be done in-house. Print fulfillment tools can act as a solution for all of a business's needs, or only for large or unique projects. Companies can focus their efforts on more important aspects of their business and not worry about business printing. Some print fulfillment tool differences include type of printing projects, size of printing order, and needs for photo manipulation tools to be built into the product, marketing features, and scalability [11].

Some of the examples of Print Fulfillment Software are [11, 12]: Vistaprint, PrintOS, ProShop, Printfection, Printful, Blurb, CafePress, PaperCut, GotPrint, CorePrint, Pressero, Mediaclip HUB.

Most of this Print Fulfillment Software is organization specific and used as customized solutions for print providers. The changes in print industry due to various factors have been adopted by many print providers. Further, there is a need to peep into the critical needs of print providers those who work at small scale.

3. PrettyPrint – THE PROPOSED PRINT PRODUCTION WORKFLOW

The print service providers can be categorized into two categories - Small Scale Print Providers (SSPP) and Large Scale Print Providers (LSPP). They have been categorized on the basis of print job volume and the size of infrastructural set up used by them. The printing process includes three important management aspects - Prepress management, Print management and Post-press management.

The large scale print providers can manage all the above aspects in their well established print production unit. But the small scale print providers cannot manage all the three aspects due to limited resources and investments. The small scale print providers take the printing jobs from the clients and only perform the pre-press part of the job. This is because pre-press task can be performed on computers by using tools and some software like Adobe Photoshop, In Design or Corel Draw. Once the print job is ready and approved, the same is handed over to third party print provider for printing. Small scale print providers cannot afford costly printing machines (e.g. Heidelberg) and they are dependent of large scale print providers to complete their job. The pre-press is completed on time, but the print does not always meet the deadlines as the small scale print provider is dependent on third party. Moreover, the print cost may also vary depending upon the type of machinery set-up by the third party print provider.

The adoption of Cloud is growing as a necessity for the business players in the market. It is the need of the recent times to understand Software-as-a-service (SaaS) model and cloud computing in the context of printing firms as these technologies can be applied to boost the business and achieve cost efficiencies, effectiveness and desired productivity [13].

The Cloud-based Print Workflow Model (PrettyPrint) has been proposed in this study that will benefit B2B transactions between SSPP and LSPP. The general block diagram for the proposed Cloud based Print Workflow Model is given in Figure 1[14].

Fig. 1 General Block Diagram of proposed Cloud based Print Workflow Model [14]

The concept behind proposed Cloud-based Print Workflow Model is that the SSPP should be able to submit the print ready job on a web solution deployed on the cloud. On this web portal, the SSPP and various LSPP should be registered to use this portal.

Once the print job is submitted on this web solution by SSPP then according to the preference of job type the web portal will tag this job to a registered LSPP for completion. This tagging of the job to LSPP will be based on the minimum job queue of the LSPP at that time. Thereafter, the LSPP will approve the job. The approved job will be completed and the delivery will be done to the SSPP.

This web solution will be managed by a third party. The web portal will bridge the gap between SSPP and the LSPP for performing B2B transactions. The proposed model will be beneficial to the print providers on many aspects. The proposed Cloud-based Print Workflow model is a new concept in web-to-print services. The initial registration process on Cloud has been shown in the Figure 2.

Fig. 2 Initial Registration Process [14]

Fig. 3 'PrettyPrint' - Proposed Cloud-based Print Workflow Model [14]

The registration on cloud-based web portal is mandatory for the SSPP and LSPP so that the print job transaction can be managed. The web portal may charge some fees

towards using its services. The details of SSPP and LSPP will be recorded in the database of the web portal. The detailed proposed Cloud-based Print Workflow model is shown in Figure 3.

4. ALGORITHMIC IMPLEMENTATION

The algorithm has been developed for the newly proposed cloud-based print workflow model for the print providers. The algorithm performs the core aspect of the new model. Using the web based tool *Print Job Tagger (PJT)*, the tagging of job is automatically performed for the print ready job submitted by the SSPP. The algorithm designed for this purpose is given below:

JOB-PREPARATION ()

1. ► Fetch a unique job ID
jobID ← GET-JOB-ID ()
2. ► Get the job type from the client (SSPP)
jobType ← GET-SSPP-JOBTTYPE ()
3. ► Get the list of available Large Scale Print Provider (LSPP) with the given jobType and assign SSPP preferences
jobPref1 = GET-PREFERENCE-LIST (jobType)
jobPref2 = GET-PREFERENCE-LIST (jobType)
jobPref3 = GET-PREFERENCE-LIST (jobType)
4. ► Get the deadline
jobDeadline = GET-SSPP-DEADLINE ()
5. ► Get priority number for the job
jobPriority = GET-PRIORITY (jobDeadline)
6. ► Upload the job file
jobFile = GET-SSPP-JOBFIL ()
7. ► Submit the job with the given parameters, with last parameter set to NULL specifying the list of LSPP who rejected the job
JOB-SUBMIT (SSPP_ID, jobID, jobType, jobPref1, jobPref2, jobPref3, NULL)

Description: The JOB-PREPARATION algorithm represents that when a new job has to be submitted then unique jobID is fetched. Once the jobID has been fetched then the SSPP specifies the job type. The next step is to assign the preferences by SSPP for the job. Up to three preferences can be assigned by SSPP for the choice of LSPP. The SSPP needs to specify the deadline for the job. Further, the print ready job file has to be submitted. The submitted job shall be stored on the cloud database in order of the priority number. In case two jobs with same priority number are encountered, then FCFS shall be used to break the tie. In this manner the SSPP will submit print ready job.

JOB-SUBMIT (SSPP_ID, jobID, jobType, jobPref1, jobPref2, jobPref3, jobPriority, rejectList)

1. ► Initially set the LSPP_List array to NULL
LSPP_List ← NULL
2. ► If none of the preferences is given by the SSPP, then list of all available LSPP with the given jobType is fetched
if jobPref1 = NULL and jobPref2 = NULL and jobPref3 = NULL
then LSPP_LIST ← GET-LSPP-LIST(jobType)
3. ► If first preference is given by the SSPP, then it is added to LSPP_List array at first location
if jobPref1 != NULL
then LSPP_LIST[0] ← jobPref1

4. ► If second preference is given by the SSPP, then it is added to LSPP_List array at second location
if jobPref2 != NULL
 then LSPP_LIST[1] ← jobPref2
5. ► If third preference is given by the SSPP, then it is added to LSPP_List array at the third location
if jobPref3 != NULL
 then LSPP_LIST[2] ← jobPref3
6. ► Job is being sent to the server for allocation and a feedback is returned from the server
jobFeedback ← JOB-ALLOCATE (LSPP_List, rejectList, SSPP_ID, jobID, jobType, jobPriority, jobFile)
7. ► If the feedback received from the server is “ACCEPT”, then an acceptance mail is send to SSPP, otherwise list of available LSPP is again checked and if the LSPP list is not empty, then the job is again submitted recursively. If both the conditions fail, then a rejection mail is sent to SSPP.
if jobFeedback = “ACCEPT”
 then SEND-MAIL (SSPP_ID, “Acceptance Mail”)
else if LSPP_LIST != NULL
 then JOB-SUBMIT (SSPP_ID, jobID, jobType, jobPref1, jobPref2, jobPref3, rejectList)
else
 SEND-MAIL (SSPP_ID, “Rejection Mail”)

Description: The JOB-SUBMIT algorithm represents that the initial LSPP_LIST array is set to NULL. If no preference has been specified by SSPP depending upon the job type all available LSPP are fetched. Otherwise, as per the given preference by SSPP the corresponding LSPP are added to the LSPP_LIST array. This is followed by sending the submitted job to server for job allocation. Depending upon the feedback from the server, an email will be sent to the SSPP. In case the response from server is ACCEPT then acceptance email will be sent to SSPP. Otherwise the process is repeated until the LSPP_LIST is not empty. In case the LSPP_LIST is also empty then server responds with REJECT message and accordingly rejection email will be sent to SSPP.

JOB-ALLOCATE (LSPP_LIST, rejectList, SSPP_ID, jobID, jobType, jobPriority, jobFile)

1. ► Removes all LSPP ID's from LSPP_LIST which are present in rejectList array
for i ← 0 to length[rejectList] – 1
 ► Search an rejected LSPP from LSPP_LIST array
 loc ← SEARCH (LSPP_LIST, rejectList[i])
 if loc != –1
 ► Removes an element from LSPP_LIST array from the location loc
 then REMOVE-LSPP (LSPP_LIST, loc)
2. loc ← 0
3. ► Get the waiting time from the first LSPP job scheduler
min ← GET-JOB-SCHEDULER-WAITING-TIME (LSPP_LIST[0])
4. ► Finding LSPP with minimum waiting time
for i ← 1 to length[LSPP_LIST] – 1
 t ← GET-JOB-SCHEDULER-WAITING-TIME (LSPP_LIST[i])
 if t < min
 then min ← t
 loc ← i

5. ► Job request mail is being sent to LSPP and the response (acceptance / rejection) is received
response $\leftarrow$ SEND-JOB-REQUEST-MAIL (LSPP_LIST[loc], SSPP_ID, jobID, jobType, jobFile)
6. return response

Description: The JOB-ALLOCATE algorithm defines how the job allocation is managed. Initially the algorithm will remove all those LSPP ID's from the LSPP_LIST that are found in rejectList array. The rejectList array will include LSPP ID's of the service providers that have rejected the print job of SSPP. The algorithm searches the rejected LSPP from the LSPP_LIST array and removes the element from LSPP_LIST. After this the minimum waiting time from LSPP job scheduler is obtained as per the LSPP_LIST. The job request email will be sent to LSPP along with the job details of SSPP and the response will be received. This response is returned.

SEARCH (A, item)

1. for $i \leftarrow 0$ to $\text{length}[A] - 1$
if $A[i] = \text{item}$
then return i
2. return -1

Description: The SEARCH algorithm will be used for performing search for LSPP_LIST.

REMOVE-LSPP (LSPP_LIST, loc)

1. for $i \leftarrow \text{loc} + 1$ to $\text{length}[A] - 1$
 $A[i - 1] \leftarrow A[i]$
2. $\text{length}[A] \leftarrow \text{length}[A] - 1$

Description: The REMOVE-LSPP algorithm will be used to remove the LSPP from LSPP_LIST those who have rejected the job submitted by SSPP.

5. CONCLUSIONS

The print industry is ruled by technological advancements, changing business patterns and the changed customer requirements. The print providers those who have embraced the technological advancements and adopted new way of doing business are surviving and doing well. Web-to-print solutions have resulted in multi fold advantages to the print providers and the clients. Faster job completion, customer satisfaction, quick delivery are some of them. In the changing print industry environment still the dependency of small scale print providers for their print jobs on large scale print providers has some limitations. The small scale print providers face late delivery of their print jobs that results in late delivery of product to their customers.

Due to limited resources and investment it becomes necessity for small scale print providers to be dependent on third party for their print jobs to be completed. The proposed new cloud based print workflow model (PrettyPrint) will ease out the problem for small scale print providers and at the same time will open good business advantage to large scale print providers as well. The paper has discussed the algorithmic implementation aspects of the proposed print workflow model. Further, it is required to be discussed how the proposed model will benefit the print organizations for business growth and customer satisfaction.

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