Proceedings of the 2014 Winter Simulation Conference
A. Tolk, S. Y. Diallo, I. O. Ryzhov, L. Yilmaz, S. Buckley, and J. A. Miller, eds.

END-TO-END INDUSTRIAL PRINT EQUIPMENT RECOMMENDATION AS A SERVICE

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ABSTRACT

Rather than just evaluating price/performance of the discrete pieces of equipment, industrial print service providers (PSPs) are working (without automated tools) to put together well matched, flexible solutions since any mismatch in capabilities or capacities will greatly reduce ROI. This design challenge is made more difficult by the variety of equipment suppliers offering multiple devices with similar functionality yet no standard vocabulary for comparison. An automated way to reason out the best combination of equipment is needed. It needs to provide a good comparative study and also address capability and capacity matching questions so that solution architects can recommend the right solutions to the PSPs. We profile here our approach and a prototype tool named Production Designer, which is based on an open source electronic design automation toolkit Ptolemy II that selects the right candidate configurations based on static and dynamic behavior of the system and the desired business objective.

1 PROBLEM STATEMENT

Industrial printing solution architects are increasingly being asked questions such as "Upgrading to the faster press will definitely help me with one client but the upgrade will leave me with excess capacity. Should I do more short runs of large books or larger runs of small books with the excess capacity, and what system components provide me with the best return and/or most flexibility?" These kinds of questions are not all printing press specific but rather specific to the intended application and the decisions that are made upstream from printing press about the downstream finishing equipment. For example, for a booklet application (process flow shown in Fig. 1), batching scheme will determine whether a 1-plow fold or 2-plow fold is needed, the output from folder/cutter combination will determine whether signatures are stacked 1-up or 2-up and that will determine the throughput for binders. Moreover, for a booklet application, there are 5-6 different finishing steps and each supplier may have 4-5 different pieces of equipment to be considered. Thus, we are left with a design space of 20-30 different equipment combinations in the finishing space alone. Winnowing of unsuitable candidates manually or with semi-automated Excel based tools from this design space is tedious, application-specific and does not scale well when considering various demand, resource and operating policy what-ifs.

2 OUR SOLUTION

The vast variety of equipment specifications and the formats in which they are specified create a lot of unstructured information. An automated tool has to ingest all these unstructured information before any reasoning can be done on the specifications. Our solution comprises two stages: in Stage I, we algorithmically analyze the equipment configurations which are infeasible with the given inputs as shown in Figure 2. We have developed syntax and a vocabulary that allows us to give a structure to this unstructured information. The syntax of the specifications is geared towards consumption by Ptolemy II – our simulation engine (Eker et al. 2003). Additionally, we have developed a framework to model a piece of equipment and its interactions with the upstream and downstream equipment. Each machine's capability is described as a set of attribute-value pairs but without any attribute namespace conflicts. A machine's transformation of an input to an output is modeled as symbolic expressions. Any necessary constraints on inputs and outputs are modeled as boolean constraints. Unsatisfiability of any one constraint leads to an infeasible equipment configuration. In Stage II, we use equipment configurations which pass the filter from Stage I (coupled with other equipment and factory information) to generate multiple scenarios, which are then concurrently simulated using the cloud compute and storage infrastructure as shown in Figure 4. Figures 5 and 6 show the various financial and production metrics synthesized from the multiple scenarios. Our tests on Stage II show that the cloud service can be offered at a low monthly price.

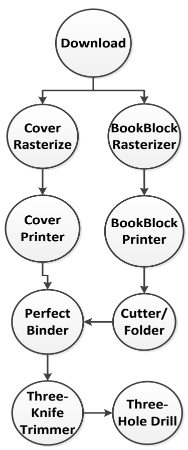

Figure 1: Booklet Flow

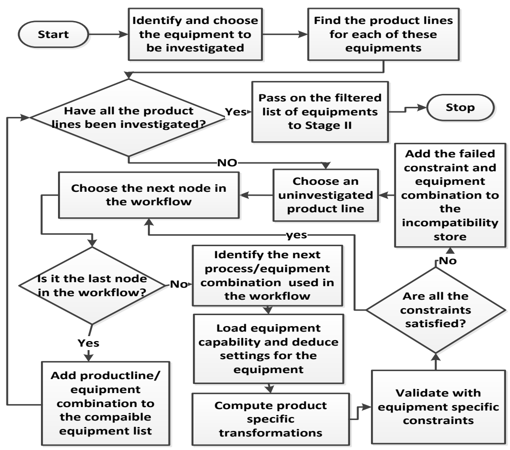

Figure 2: Stage I

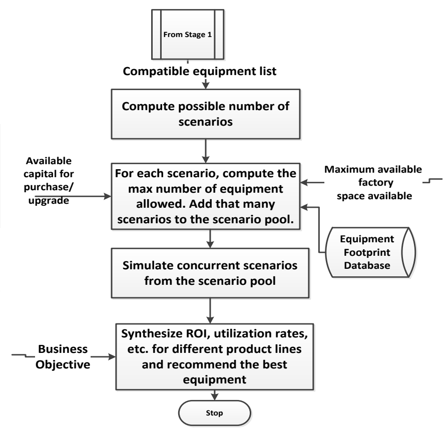

Figure 3: Stage II

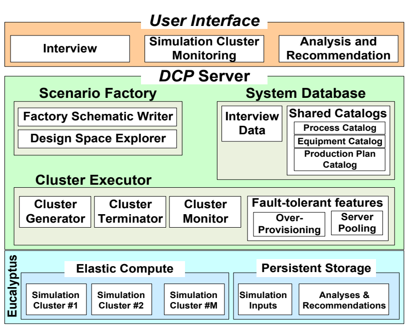

Figure 4: Cloud architecture

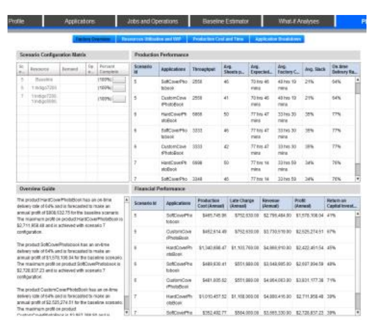

Figure 5: Scenario metrics

Figure 6: Resource utilization

ACKNOWLEDGMENTS

Many colleagues in Hewlett Packard have contributed to and supported this work including Michael Reasoner, Craig White, Eviatar Halevi, Jun Li and Eric Hoarau and Narayan Krishnan.

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