Toward a SLA-Based Marketplace for Digital Commercial Print Providers

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Abstract

We present our efforts at enabling a marketplace based on service level agreements (SLAs) for commercial print businesses, where print services can be queried, combined and searched in an automated way. Although SLAs have been an active research area in the computer networking domain, the technical and legal challenges in other industries have hindered the growth of SLAs. We believe that medium and large sized commercial print providers will profit from SLA-based marketplace as it will promote automation and better utilization of resources. We discuss the issues in incorporating SLAs in the existing commercial print workflows. We then present a protocol for negotiating SLAs among the print service providers and consumers. The negotiating protocol has support for offers as well as counter-offers. We then discuss our ongoing efforts for a prototype implementation of a SLA-based marketplace wherein we use two open source frameworks: 1) WSAG4J - for negotiating print services; and 2) Ptolemy II - for designing and analyzing print services. With these technologies, we will be able to hook up a large number of digital commercial print providers on to the SLA-based marketplace.

Introduction

The current Internet of today will become an Internet of services, where each service will operate independently of other services and each service will be interoperable, i.e. the service interface (to the external environment) would be separate from service implementation. Service oriented architectures (SOAs) are clearly a step in that direction [JS05]. SOAs are already replacing the existing workflows in a wide range of industries with loosely coupled services that have explicitly stated service aspects like service quality, service deliverables, etc., primarily because the consumers of such services want a guarantee on the quality and reliability of the offered services. A *SLA-based marketplace* provides a venue where services can be advertised, queried or combined [SH09, BWR$^+$]. The commercial print industry is still far from being an Internet of services.

The commercial print industry as a whole is very big in revenue (over 100 billion dollars [pap09] in US) but at the same time various print service providers (PSPs) compete mainly on price with very low margins and low capital utilization rates. Many of the existing workflows use knowledge accumulated by individuals over a period of time. The implicit knowledge creates workflows which are: 1) tightly coupled 2) not agile 3) have under utilized capacities. The number of printed pages is declining (in North America) [PRI10] and there is pressure on the commercial print businesses to reduce inefficiencies in their workflow. This has sped up the efforts to automate commercial printing workflows and maximize the utilization rates of the resources in the workflow.

Incorporating SOAs in commercial print workflows will change the current workflows into a set of loosely couple services. The current order agreements will change to service level agreements (SLAs) [Ver04], which not only mention the functional aspect of a service such as service deliverables but also the non-functional aspects such as service quality. But to effectively utilize the SOA capabilities across a range of provider, we will need a SLA-based marketplace for commercial print providers. In this paper, we describe the issues in creating a functional SLA-based marketplace for digital commercial print businesses.

Terminology

We introduce the terminology for readers who are not familiar with the SLA-related terminologies used in computer networking. A *provider* is one who offers a service and a *consumer* is one who uses that service. In a services world, a *user* can play both the roles, but those roles are exclusive in any relationship. A service level agreement (SLA) is a formal agreement between a consumer and a provider and details: 1) the type of service to be provided; 2) the quality of service; 3) a way to address issues if service quality is not meeting expectations. *SLA parameters* are the building blocks for various SLA aspects. *Service level objectives* (SLOs) are an aggregation of SLA parameters together with their permissible ranges to set the expectations for both the provider as well as the consumer of that service. A *quality of service* (QoS) is a metric used to measure the quality of service offered to the consumer. The *SLA negotiation* is a process by which consumers and providers of a service come to an agreement, usually with multiple rounds of offers and counter-offers from the involved parties. The *SLA negotiation protocol* defines a structured way for doing SLA negotiations.

In the context of commercial printing, the consumer provides content, normally in PDF, and a *print service provider* (PSP) prints the content or provides services that helps in printing the contents. A *print artifact* is the end result of a provided print service. The print artifact can range from soft artifacts such as rendered PDF to physical artifacts such as books or even signages and displays used in departmental stores. In this paper, we follow the terminology from Kipphan [Kip06] to talk about print and various printing processes but we restrict ourselves to digital printing.

The Vision

We believe that the current digital commercial print marketplace will evolve into an Internet of services; where services can be queried or combined with another service. This will ensure a better utilization of PSP's capability. A PSP may not have all the capabilities to process an order. On the other hand, many of these PSPs have a special relationship with their customers as well as

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other PSPs. Thus, instead of rejecting a customer order for the lack of capability, a PSP may elect to use its access to the SLA-based marketplace to find a way to fulfill the customer's order. The customer will be oblivious of the PSP chain used to fulfill his complete/partial order. But such chains should also come with guarantees such as the quoted price, quality and delivery times will be met. This scenarios is described in Fig. 1, where a customer has placed an order which can only be partially fulfilled by the provider. Instead of rejecting the order, the PSP uses its access to three other PSPs to complete the entire order. The bidirectional arrows in the Fig. 1 represent the SLAs. The arrows intersected by the shaded portion denotes SLAs which a PSP has made with other PSPs to fulfill an order.

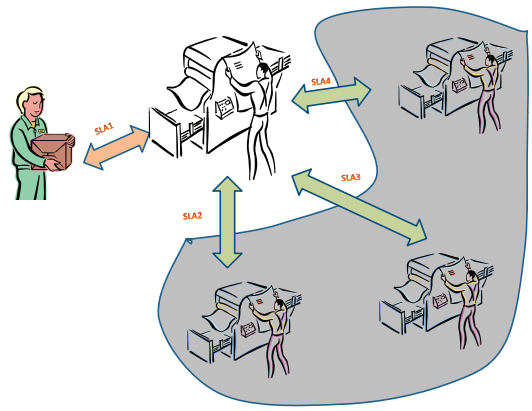

Figure 1. *Different Customers and Fulfillment of Orders*

The Challenges

The SLAs initially come into the picture in the order acquisition and quote process for the existing workflows, but for SOAs they span the entire printing workflow - if each stage or even each process in the digital commercial printing is treated as a service [ZLD+11]. For instance, if a commercial print business wants to use compute resources from outside for rendering an image, *i.e.* conversion of an image from JPG format to bitmaps, then SLAs will come into the picture at the prepress stage. On the other hand, if a PSP wants to outsource printing to a different provider then SLAs come into picture at the printing stage whereas if he decides to outsource cutting to a different provider then SLAs come into picture in the postpress stage.

Although, there are informal SLAs currently used at various UK universities to advertise printing services [linb, lina, linc], but we believe the current technological infrastructure has to evolve to accomplish the above vision. For a fully functional SLA-based marketplace, various SLA support infrastructure should also be in place, namely SLA negotiation protocols, SLA monitoring tools, etc. But we foresee many challenges as we implement the vision we set out earlier. In the next few sections, we look at some of the critical issues in a SLA-based marketplace. We discuss: 1) how the existing customers will be supported in a SLA-based marketplace; 2) how PSPs will negotiate on various SLAs; 3) the challenges in measuring and specifying the print artifact quality.

Handling the Different Types of Customers

A SLA-based marketplace would enable partial fulfillment of orders at each and every step in the existing workflow. A key challenge is to model how the existing users will interact with an SLA-enabled workflow. Today, the customers of a PSP come from three distinct categories: 1) Individual customers 2) Print Brokers 3) Other PSPs.

The individual customers have one to one discussions with a PSP. They directly talk to a PSPs sales department on their orders. The print brokers are typically order aggregators and negotiate a rate for a set of jobs with a PSP's sales department. They take a percentage of the cost from each of the order initiators as their profit. Lastly, PSPs may have outsourcing relationships with other PSPs. These PSP either have special equipment or provide capabilities that a PSP may not have. The individual and PSP customers are shown in Fig. 1.

Categorizing them is important since the proofing workflow is different for each of these categories. For example, PSPs require that proofing be done in *advance* of any orders, at least for typical print artifacts which form a bulk of their orders. Individual customers typically require proofs but only *after* an order has been placed. These differences will have to be reconciled in a SLA-based marketplace either by a service tailored to the type of the customer or by giving a uniform service which abstracts away from the actual type of the customer.

Implementing Automated SLA Negotiations

We mentioned earlier that there are three different types of commercial print customers. The basics of the SLA negotiation process remains the same for these different customers but there are subtle differences. In case of PSP customers, the SLA negotiations will become more of a machine-to-machine interaction. In particular, the PSP customers will have more explicit details about how a job should be set up, what colors to use, etc. and can be fully automated to a large extent. The negotiations here can be protracted with multiple rounds of offers and counter-offers. In case of print brokers and individual customers it might be either machine-to-machine or human-to-machine interaction. The negotiations in case of print brokers or individual customers (mostly humans) will be short since humans like to reach a settlement faster and in as few rounds as possible.

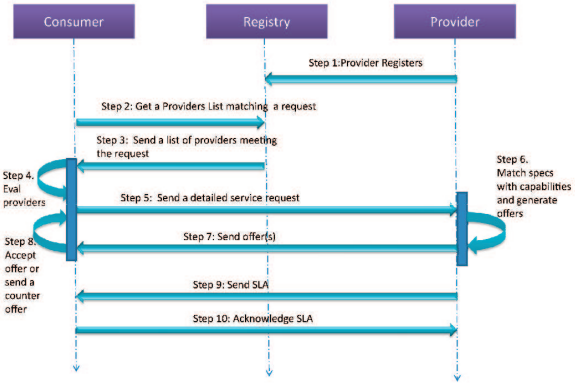

Figure 2. *SLA Negotiation Protocol*

For the SLA marketplace, the main interaction events leading to a creation of a SLA are shown in Fig. 2. The interaction steps are described below:

- In Step 1 a provider registers himself and the offered service(s) in a registry.
- In Step 2 customers request for services and a list of providers are sent to the customers in Step 3. Based on the information provided by the consumer, one or more providers can provide the same service.
- In Step 4, which is an optional step, a consumer may rule out service providers which do not meet a certain criteria. For example, not located locally (geographically).
- In Step 5 - 8 a SLA is selected based on the the client's needs and sent to client to fill up details regarding the order. This could be a multi-stage negotiation with offers and counter-offers.
- In Step 9 a consumer and a provider have agreed on the details and the consumer is sent a SLA to confirm.
- In Step 10 the provider sends a confirmation to the consumer acknowledging the SLA.

In machine-to-machine interactions as well as human-to-machine interactions, we believe measuring and quantifying the quality of a print artifact will be an important consideration. The next section discusses the various aspects of measuring quality of a print artifact.

Measuring and Specifying An End -to-End Print Artifact Quality

A key component of SLAs for commercial print is the notion of print artifact quality. But note that print artifact quality is a sum of the quality of the individual stages, not just print quality. Thus, for instance, finishing stages also contribute to the print artifact quality. The QoS will be defined at each stage and for each process used in that stage. For example, the proof as well as the final artifact quality will be measured on an agreed quality metric. But that brings the question of how can we measure the print quality. Existing literature from RIT and others [RC], [CR07], [Eer10], [Met10] have surveyed the print quality issues in the digital printing. Even if we focus on the print quality, it is not straightforward to measure and quantify print quality. Readers should note that a print is composed of image and texts and other graphic arts. Image quality in itself is a significant and growing research area as demonstrated by some of the recent papers [FG10, PBB+10, Eer10].

In digital print we have additional considerations, for instance, each printed page can have different contents; thus a hard proof might not be representative of the actual printed product. Then there are also color related issues which crop up in variable data printing – mostly related to the how variable data (images) gets obscured by the background color [Ber05]. There are still advanced scenarios where its not clear what the right approach is. A case in point is a photo calendar where images are personalized with individuals' name embedded in the image.

In a SLA-based marketplace there will be these different notions of acceptable quality based on the kind of print artifact being produced. The acceptable tolerances for the print quality defect attributes will vary across the service providers, but there will be a uniform way of quantifying the defects and there will be more explicit mention of what is an acceptable/rejectable quality of print artifacts in the SLAs.

Simulation and Implementation of a SLA-Based Marketplace

There are many more issues which we believe are an important input in SLA design. The SLA parameters that we came up for digital commercial print are shown below. Note that it is still a work in progress and only a few attributes of the SLA are shown.

- Contact details of the provider
- Contact details of the consumer
- Third party arbitration details
- Order details
  - Order ID
  - Order quantity ⋮
  - Actual print artifact delivery date (given by the provider)
  - Print artifact delivery shipping method (given by the consumer)
- Agreed print quality metrics (depends on the print artifact)
- Depth of SLA nestings
- Criteria to restrict service provider in case of partially fulfilled orders

Note that both the consumer and the provider have responsibilities in the SLA, which are not shown here due to space restrictions. The consumer has the responsibility of providing a proof approval within a given time frame, whereas a provider has the responsibility of agreed upon product within the agreed time frame. Any delay in consumer providing proof details may lead to re-negotiation of an SLA, possibly affecting the various SLA parameters. Furthermore, there are apparent constraints between the various SLA parameters. For example, the latest proof approval date cannot be later than the latest print artifact delivery date.

The current implementations of the negotiation protocols have followed two different frameworks: OGSA (Open Grid Service Infrastructure) framework under the purview of the GGF (Global Grid Forum) and WSRF (Web Services Resource Framework) [spe06] under the purview of the Organization for the Advancement of Structured Information Standards (OASIS). Both the implementations are compliant with WS-Agreement specification [ACD+07], developed by the GRAAP-WG (Grid Resource Allocation and Agreement Protocol Working Group) of the OGF (Open Grid Forum).

We plan to implement and test our implementation of negotiation protocols on WSAG4J [RWZ10] - a toolkit based on WSRF framework. The toolkit is a Java implementation of WS-Agreement and allows for multi-round negotiations, a key feature missing in WS-Agreement. The implementation provides enough hooks so that domain specific details can be plugged in easily. Figure 3 show the protocol and the software stack used in the implementation.

A key part in this implementation would be integration with a simulation environment Ptolemy II [EJL+03], an open source electronic design automation toolkit, where we can simulate a PSP operations as shown in [ZLHD09]. This would help us create SLAs which truly reflect a PSPs manufacturing capability and

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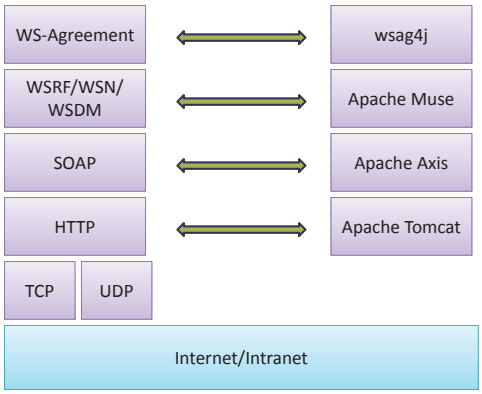

Figure 3. *WSAG4J: Protocol and Software Stack*

equipment availability as well as create and investigate a simulated SLA-based marketplace. We are also investigating a formal framework to reason about the various interactions in a SLA-based marketplace.

Conclusions

We argued that adoption of SOA in digital commercial print will promote a set of loosely coupled services as a replacement for traditional workflows. To discover and use these services, a SLA-based marketplace and supporting infrastructure will be needed. We outlined a few challenges and the possible ways to tackle them.

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