

Policy based Cloud Services on a VCL platform

Karuna P Joshi, Yelena Yesha, Tim Finin, Anupam Joshi

Computer Science and Electrical Engineering Department
University of Maryland, Baltimore County
Baltimore, USA

{kjoshi1, yeyesha, finin, joshi}@umbc.edu

Abstract— Managing and delivering virtualized cloud based services is an open challenge. Current research is focused on specific parts like service discovery; composition etc. and there is no holistic view of what would constitute a lifecycle of virtualized services delivered on a cloud environment. We have developed a policy-based integrated framework for automating acquisition and consumption of Cloud services. This framework divides the cloud service lifecycle into five phases of requirements, discovery, negotiation, composition, and consumption. We have also developed a tool to automatically discover, negotiate and consume services from the cloud for a specific use case described by NIST around storage services. It is built upon the service lifecycle ontology that we have developed. We have built the tool using Semantic Web technologies like SPARQL, RDF and OWL to represent and reason about services and service requirements. This paper describes our methodology and the tool we have developed as well as its implementation on VCL platform.

I. Introduction

With the advent of cloud computing, the delivery of Information Technology (IT) services has undergone a paradigm shift. Organizations are increasingly procuring IT components like software, hardware or network bandwidth as services from providers based anywhere in the world. These services are hosted on the cloud and are delivered to the organization via the Internet or mobile devices. The service is acquired and consumed on an as needed basis. In such an environment, multiple providers often collaborate to create a single service for an organization. Cloud services are increasingly based on the composition of multiple component services and assets (technological, human, or process) that may be supplied by one or more providers distributed across the network – in the cloud. Moreover, a single service component can be a part of many composite services as needed. The service, in effect, is virtualized on the cloud. This is becoming the preferred method to deliver services ranging from helpdesk and back-office functions to Infrastructure as a Service (IaaS). The virtualized model of service delivery also extends to IT Enabled Services (ITeS), which typically include a large human element.

A key barrier preventing organizations from successfully using services on the cloud is that they have complex internal policies, as well as legal and statutory constraints that require compliance. Such policies are today enforced on internal resources controlled by the organization. When

acquiring remote services, it requires significant human intervention and negotiation -- people have to check whether a provider's service attributes ensure compliance with their organization's constraints. This can get very complex if the provider is composing services, some of which it gets from other providers. A related issue is the lack of an integrated methodology for service creation and deployment that provides a holistic view of the service lifecycle on a cloud. We have developed a methodology [6] to address the lifecycle issue for virtualized services delivered from the cloud and describe it briefly in section III. This lifecycle provides ontologies to describe services and their attributes. In particular, we used semantically rich descriptions of the requirements, constraints, and capabilities that are needed at each phase of the lifecycle. Policies can be described using the same ontology terms so that compliance checks can be automated. This methodology is complementary to previous work on ontologies, e.g., OWL-S, for service descriptions in that it is focused on automating processes needed to procure services on the cloud. The methodology will enable practitioners to plan, create and deploy virtualized services successfully.

We have developed and implemented a cloud storage service prototype to demonstrate and evaluate our methodology. We used Semantic Web technologies such as OWL, RDF, and SPARQL to develop this tool. The prototype allows cloud consumers to discover and acquire disk storage on the cloud by specifying the service constraints, security policies and compliance policies via a simple user interface. This prototype was developed as part of our collaboration with National Institute of Standards and Technology (NIST). We have integrated this tool with the Eucalyptus [15] and VCL [27] cloud platforms and describe our preliminary results for the same.

II. Related Work

Since cloud computing is a nascent field, there is lack of standardization and there seems to be a need to clearly define its key elements. NIST has released a special publication 800-145 [13] defining cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. One of the key characteristics identified by NIST is that a

cloud service should have the capability of on-demand self-service whereby a consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider. This capability of automatically acquiring a service is currently either missing, or very limited, in most cloud based services. Our methodology aims to make it possible to automatically discover, negotiate/acquire and consume cloud based services.

In addition to the standard definition of Cloud Computing, NIST has also released the Cloud Computing Reference Architecture document [14] that describes a reference architecture for cloud computing and also the key roles and responsibilities of stakeholders. The authors of this paper were part of the NIST cloud computing reference architecture and taxonomy working group that participated in developing the standard. Our ontology, described in the next section, makes use of the NIST cloud computing standards and definitions.

Current research on cloud or web services so far has been limited to exploring a single aspect of the lifecycle such as service discovery, service composition, or service quality. There is no integrated methodology for the entire service lifecycle - covering service planning, development and deployment in the Cloud. In addition, most of the work is limited to the software component of the service and does not cover the service processes or human agents which are a critical component of IT Services.

Papazoglou and Heuvel [16] have proposed a methodology for developing and deploying web services using service oriented architecture (SOA). Their approach, however, is limited to the creation and deployment of web services and does not account for virtualized environment where services are composed on demand. Providers may need to combine their services with other resources or providers' services to meet consumer needs. Other methodologies, like that proposed by Bianchini et al. [1], do not provide this flexibility and are limited to cases where a single service provider provides one service. Zeng et al. [28] address the quality based selection of composite services via a global planning approach but do not cover the human factors in quality metrics used for selecting the components. Maximilien and Singh [11] propose an ontology to capture quality of a web service so that quality attributes can be used while selecting a service. While their ontology can serve as a key building block in our system, it is limited by the fact that it considers single web services, rather than service compositions.

Black et al. [2] have proposed an integrated model for IT service management. Their model is limited to managing the service from the service provider's perspective. Paurobally et al. [17] have described a framework for negotiation of web services using the iterated Contract Net Protocol (CNP) [21]. However their implementation is limited to pre-existing web services and doesn't extend to virtualized services that are composed on demand. Our negotiation protocol accounts for the fact that the service will be composed only after the contract/SLA listing the constraints is finalized.

GoodRelations [3] is an ontology developed for E-commerce to describe products. While this ontology is useful for describing service components that already exist on the cloud, it is difficult to describe composite virtualized services being provided by multiple vendors using this ontology. Cardoso et al. [24] have described a Unified Service Description Language (USDL) a specification language to describe services from a business, operational and technical perspective.

The Information Technology Infrastructure Library (ITIL) is a set of concepts and policies for managing IT infrastructure, development and operations that has wide acceptance in the industry. The latest version of ITIL lists policies for managing IT services [23] that cover aspects of service strategy, service design, service transition, service operation and continual service improvement. However, it is limited to interpreting "IT services" as products and applications that are offered by in-house IT department or IT consulting companies to an organization. This framework in its present form does not extend to the service cloud or a virtualized environment that consists of one or more composite services generated on demand.

We use Semantic Web techniques for our services lifecycle and prototype development. The Semantic Web deals primarily with data instead of documents. It enables data to be annotated with machine understandable meta-data, allowing the automation of their retrieval and their usage in correct contexts. Semantic Web technologies include languages such as Resource Description Framework (RDF) [9] and Web Ontology Language (OWL) [12] for defining ontologies and describing meta-data using these ontologies as well as tools for reasoning over these descriptions. These technologies can be used to provide common semantics of Service information and policies enabling all agents who understand basic Semantic Web technologies to communicate and use each other's data and Services effectively. The Ontology Web Language for Services (OWL-S) [10] was developed to provide a vocabulary for describing the properties and capabilities of Web Services in unambiguous, computer-interpretable form. OWL-S allows Service providers or brokers to define their Services based on agreed upon ontologies that describe the functions they provide. We have integrated the OWL-S ontology into our ontology.

SPARQL Protocol and RDF Query Language (SPARQL) is the query language for RDF that has been standardized by W3C [18]. SPARQL can be used to express queries across diverse data sources, whether the data is stored natively as RDF or viewed as RDF via middleware. It has capabilities for querying required and optional graph patterns and their conjunctions and/or disjunctions. SPARQL also supports value testing and altering of results. The results of queries can be results sets or RDF graphs. A SPARQL abstract query is defined in [18] as a tuple (E, DS, R) where E is a SPARQL algebra expression, DS is an RDF Dataset and R is a query form.

A SPARQL endpoint is a conformant SPARQL protocol service as defined in the SPARQL Protocol for RDF (SPROT) specification [22]. It enables users (human or

other) to query a knowledge base via the SPARQL language. Results are typically returned in one or more machine-processable formats. Therefore, a SPARQL endpoint is mostly conceived as a machine-friendly interface towards a knowledge base. Both the formulation of the queries and the human-readable presentation of the results should typically be implemented by the calling software, and not be done manually by human users. We have used the Joseki [5] server to simulate the SPARQL endpoint for our tool.

III. Lifecycle of Cloud Services

We have developed a methodology which integrates all the processes and data flows that are needed to automatically acquire, consume, and manage services on the cloud. We divide this IT service lifecycle on a cloud into five phases. In sequential order of execution, they are requirements, discovery, negotiation, composition, and consumption; and are illustrated in figure 1. We have described these phases in detail along with the associated metrics in [6]. We have developed the ontology for the entire lifecycle in OWL 2 DL profile, [7]. This ontology has been used in the development of the Smart Cloud Services tool described in the next section.

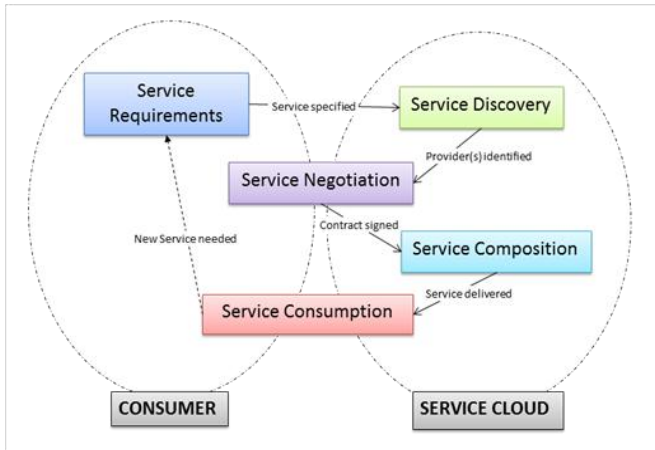


Figure 1: The IT service lifecycle on a virtualized cloud comprises five main phases: requirements, discovery, negotiation, composition and consumption

A. Service Requirements Phase

In this phase, the consumer details the technical and functional specifications that a service needs to fulfill along with the organizational policies for the providing agent, data quality policy and security policies for the service. Service compliance policies such as required certifications standards to be adhered to, etc. are also identified. Depending on the service cost and availability, a consumer may be amenable to compromise on the service quality. Functional specification describe in detail what functions/tasks should a service help automate. The technical specifications lay down the hardware, software, application standards, and

language support policies to which a service should adhere. Once the consumers have identified and classified their service needs, they issue a Request for Service (RFS). This request could be made by directly contacting a few service providers for their quotes. Alternatively, consumers can use a service discovery engine or service broker on the cloud to procure the service.

B. Service Discovery Phase

Service providers are discovered by comparing the specifications listed in the RFS. The discovery is constrained by functional and technical attributes defined, and also by the budgetary, security, compliance, data quality, and agent policies of the consumer. While searching the cloud, service brokers can be employed. The broker engine queries the service providers to match the service data and security policies, compliance needs, functional, and technical specifications; and returns the result with the service providers in priority order. Sbodio et al. [20] and Paliwal et al. [25] have presented semantic approaches for service discovery which can be incorporated in our methodology.

One critical part of this phase is service certification, in which the consumers will contact a central registry, such as UDDI [19], to get references for providers that they narrow down to.

If a consumer finds the exact service within their budgets, s/he can begin consuming the service immediately upon payment. However, often the consumer will get a list of providers who will need to compose a service to meet the consumer's specifications. The consumer will then have to begin negotiations with the service providers. Each search result will return the primary provider who will be negotiating with the consumer.

C. Service Negotiation phase

The service negotiation phase covers the discussion and agreement that the service provider and consumer have regarding the service delivered and its acceptance criteria. The service delivered is determined by the specifications laid down in the RFS. Service acceptance is usually guided by the Service Level Agreements (SLA) that the service provider and consumer agree upon. SLAs define the service data, delivery mode, agent details, quality metrics, and cost of the service. While negotiating the service levels with potential service providers, consumers can explicitly specify service quality constraints (data quality, cost, security policies, response time, etc.) that they require.

At times, the service provider will need to combine a set of services or compose a service from various components delivered by distinct service providers in order to meet the consumer's requirements. The negotiation phase also includes the discussions that the main service provider has with the other component providers. When the services are

provided by multiple providers (composite service), the primary provider interfacing with the consumer is responsible for composition of the service. The primary provider will also have to negotiate the Quality of Service (QoS) with the component providers to ensure that SLA metrics are met.

The key deliverable of this phase is the service contract between the service consumer and service provider. The SLA is a key part of this service contract and will be used in the subsequent phases to compose and monitor the service. Another deliverable of this phase are the service sub contracts between the service provider and component (or dependent services) providers. The QoS are the essential part of the service sub-contracts and are used in the consumption phase to monitor service performance.

D. Service Composition phase

In this phase one or more services provided by one or more providers are combined and delivered as a single service. Service orchestration determines the sequence of the service components.

E. Service Consumption/Monitoring phase

The service is delivered to the consumer based on the delivery mode (synchronous/asynchronous, real-time, batch mode etc.) agreed upon in the negotiation phase. After the service is delivered to the consumer, payment is made and

the consumer then begins consuming the service. In a cloud environment, the service usually resides on remote machines managed by the service providers. The provider is responsible for managing and monitoring the service. In this phase, consumer will require tools that enable service quality monitoring and service termination if needed. This will involve alerts to humans or automatic termination based on policies defined using the quality related ontologies. The Service Monitor measures the service quality and compares it with the quality levels defined in the SLA. This phase spans both the consumer and cloud areas as performance monitoring is a joint responsibility. If the consumer is not satisfied with the service quality, s/he should have the option to terminate the service and stop service payment.

The composite service is made up of human agents providing the service, the service software, and dependent service components. All the three elements, agents, software, and dependent services, must be monitored to manage the overall service quality. For the service, software providers have to track its performance, reliability, assurance, and presentation as they will influence customer's satisfaction rating (CSATs). Since the dependent services/components will be at the backend and, will not interface directly with the consumers, the service provider only needs to monitor their performance. We have proposed a framework to manage quality based on fuzzy-logic for such composed services delivered on the cloud in [8].

Figure 2: User Interface for Smart Cloud Service allows users to specify the service constraints using drop down lists and generate a Request for Service (RFS).

IV. Smart Cloud Services Tool

We have developed a prototype for automatically acquiring cloud based services. This tool is based on the lifecycle described in the previous section and uses the ontology that we have developed for the same. It demonstrates the capability that cloud users will have in the future to automatically acquire cloud services. This tool allows users to define a range of values for their constraints and so accommodates for scenarios where the users may not have finalized their requirements.

For the prototype we considered a simple Storage service, as a representative scenario for Infrastructure as a Service (IaaS), whereby users can store their files/data in the cloud. It consists of a web interface (Figure 2) that enables cloud users to easily define the service policies and constraints by choosing predefined values from dropdown fields. The tool then discovers the services that will match the specified policies. A Cloud-provider end server process interprets the policies specified by the user(s) and establishes Service Level Agreements (SLAs) by the process of negotiation. A virtual instance of the service based on the SLA is created on the cloud platform.

A. Prototype Architecture

We used Semantic Web technologies to build the front end of our prototype as they are platform independent and inter-operable. We used SPARQL, Jena Semantic Web framework [4] and the Joseki software [5], which is an HTTP engine that supports the SPARQL Protocol and the SPARQL RDF Query language, to develop the prototype. The prototype mirrors the service lifecycle described in section III and uses the service lifecycle ontology that we have developed and the OWL-S ontology. In addition to these two ontologies, we also created an OWL ontology to describe the technical and security policies for the prototype. We have incorporated actual enterprise policies related to data storage and security that are practiced by large organizations. We have used the policies defined in the use case 3.9 [26] identified by the NIST cloud computing initiative.

The smart cloud services tool consists of four main components as illustrated in Figure 3.

- **Web-based user interface:** enables users to define their service requirements as well as specify the data, security and compliance policies that the service should meet. After specifying the service values, the users can press the ‘Request for Service (RFS)’ button to generate a machine readable RFS (step (1) in figure 3) that is specified as an RDF document. Figure 2 illustrates the RFS in a RDF/XML format.
- **Cloud Service Broker:** Uses the RFS generated by the user interface to discover services that will match the specified policy constraints (step (2) in figure 3). This component also executes the program to enable automated SLA negotiation (step (3) in figure 3) and sends the final SLA for approval (step (4) in figure 3).

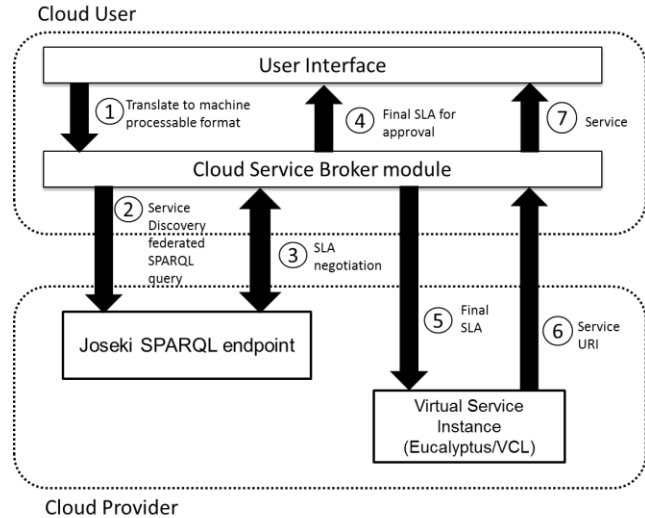


Figure 3: Smart Cloud services prototype architecture

- **Service Endpoint:** The service endpoint component simulates a service provider providing the service. It contains a list of all available services and their service attributes (like cost, availability, etc.). We created a SPARQL endpoint using Joseki. Since the Joseki server allows multiple service definitions, we used it to simulate both multiple services provided by the provider as well as multiple instances of a same service.
- **Cloud Platform:** For the cloud-end processes, we use the Eucalyptus Cloud [15] which is an open source cloud platform and the IBM Virtual Computing Lab (VCL) [29] platform. Both these platforms have been installed in our research lab. The final approved SLA is generated in a machine readable RDF format and is sent to the cloud platform (step (5) in figure 3). The virtual instance of the requested service is generated and (step (6) in figure 3) and the URI of the service is returned to the user (step (7) in figure 3).

B. Web-based User Interface

Users can specify their service requirements as well as the data, security and compliance policies that the service should meet using an easy to use web-based interface (Figure 2). There are four main categories of service attributes – core service attributes, data/security policy attributes, compliancy policy attributes and Cloud instance attributes. We describe these in detail below.

Each field in the interface has an associated ‘Help’ description that describes the attributes and enables users to determine which option to select. The fields in each section are placed in descending order of priority. The priority was determined in conjunction with our NIST collaborators. This tool allows users to define a range of values for their constraints and so accommodates for scenarios where the users may not have finalized their requirements.

1) CORE Attributes

The Core attributes include the mandatory attributes that the service provider should meet.

1. **Storage size:** defines the storage size (in Giga Bytes / Tera Bytes units) that the consumer wishes to procure on the cloud.
2. **Service Cost:** This attribute refers to the price consumers are willing to pay for the service. The service cost will vary depending on the other attributes specified by the cloud user and so the service is searched on a range of costs as opposed to a specified price.
3. **Data Preservation/Backup:** specifies the data backup requirements.
4. **Service Availability:** This field specifies the minimum level of service availability consumers expect from the service provider.

2) DATA/SECURITY POLICY Attributes

The data and security policy attributes specify the policies of the consumer organization with regards to their data on the cloud. The policies that we selected are specific to the NIST cloud computing User case 3.9 [26]. The priority of each policy was determined by our NIST collaborators and the fields were positioned in the tool in decreasing order of their priority. The attributes in this section are listed below.

1. **User authentication mechanism:** specifies whether FIPS 140-2 is to be supported by the cloud provider or not. NIST issued FIPS (Federal Information Processing Standard - Publication 140-2) is a U.S. government computer security standard used to accredit cryptographic modules.
2. **Data Encryption:** specifies if the consumer wants the data to be encrypted when stored on the cloud.
3. **Data Location:** specifies the constraint the consumer may have regarding the location of the cloud.
4. **Data Deletion:** enables consumer to specify their data deletion policies for the cloud – whether the data is deleted or merely made inaccessible, secure wipe is supported or not. While in the cloud environment it may be difficult to ensure the intended data deletion; adding this policy to the Service SLA will make the cloud provider liable if the deletion method specified is not followed. So the onus to ensure appropriate data deletion procedure will be on the cloud provider and not the cloud user.
5. **Virtual Machine (VM) separation:** specifies whether the cloud provider supports separate Virtual Machines to store consumer's data on the cloud. Some

organizations may desire separate Virtual Machines on the cloud to ensure more security.

6. **Interface for a storage specification:** The consumer can specify in their requirements whether they want SOAP protocol or REST (Representational state transfer) interface support.

3) COMPLIANCE POLICY Attributes

In the tool we have included two compliance policies specified by NIST and majority of the US federal agencies. They are listed below. The compliance policy constraints have lower priority than the data/security policy constraints and hence are relaxed after cloud instance constraints, but before the data/security constraints during service negotiation.

1. **Trusted Internet Connection (TIC):** Trusted Internet Connection initiative is mandated in an OMB (Office of Management and Budget) Memorandum (M-08-05) meant to optimize individual external connections, including internet points of presence currently in use by the Federal government of the United States.
2. **CC Evaluation Assurance Level (EAL) levels:** The Evaluation Assurance Level (EAL1 through EAL7) of an IT product or system is a numerical grade assigned following the completion of a Common Criteria security evaluation, an international standard in effect since 1999. This attribute accepts EAL number from 1 to 7.

4) CLOUD INSTANCE Attributes

If consumers have specific requirements of the Cloud instance, they can specify the RAM size, CPU speed and number of cores dedicated to the requested service. The Cloud Instance policy constraints have the lowest priority and hence are relaxed first during service negotiation.

C. Cloud Service Broker

The Cloud Service Broker component helps procure the service that best matches the user specified requirements and constraints. After generating the RFS, users press the 'Discover Services' button to search for services that match the RFS constraints. The tool generates federated SPARQL queries based on the selections on the screen. This query runs across multiple SPARQL endpoints and retrieves a list of matching services residing on that endpoint. If a query matching all the constraints is found, it is displayed on the screen. Otherwise, the user is advised to begin service negotiation by selecting the Negotiation button.

The users press the 'Negotiate and Finalize SLA' button to begin service negotiation. The tool iteratively relaxes the requirements one by one and generates a new SPARQL query to search the service endpoints. The order of constraint

relaxation for this prototype was determined by the NIST team that was collaborating with us who specified the priority of each constraint in the RFS. After each constraint relaxation, the tool executes the new SPARQL query to discover services that match the new constraint set. When a service match is found, the tool returns the service details of that service along with a list of constraints not met. The consumer can finalize the SLA by accepting the service that best matched the constraints. The final SLA (figure 4) is generated as a RDF file and is in machine readable format.

The user next clicks the ‘Compose Services on the Cloud’ button to compose the desired service.

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@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>.
@prefix xsd: <http://www.w3.org/2001/XMLSchema#>.
@prefix itso: <http://ebiquity.umbc.edu/ontologies/itso/1.0/itso.owl>.
@prefix dc: <http://purl.org/dc/elements/1.1/>.
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix stg: <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owl>.
  <http://localhost/SLA>
<http://ebiquity.umbc.edu/ontologies/itso/1.0/itso.owlExpected_Begin_Date_of_Service> " 1-1-2012\r\n";
  <http://ebiquity.umbc.edu/ontologies/itso/1.0/itso.owlService_Cost_Constraint> " 0 ";
  <http://ebiquity.umbc.edu/ontologies/itso/1.0/itso.owlService_Location_constraint> " global ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlauthentication> " FIPS 140 2 supported ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlavailability> " 95 ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlbackup> " Weekly ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlcloud_instance_cores> " 4 ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlcloud_instance_size> " 1073741824 ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlcloud_instance_speed> " 1GHz ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owldataavailability> " data archived ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlEncryption> " No Encryption ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlstorage> " 1073741824 ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlstorage_interface> " SOAP WSDL ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlTIC_connection> " TIC Compliant ";
  <http://www.cs.umbc.edu/~kjoshi1/storage_ontology.owlVMseparation> " VM separation ".

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Figure 4: The finalized SLA is stored as a RDF document (N3 format)

D. Service Composition and Consumption on the Cloud

When the user clicks the Compose button, a Virtual Machine is created on the cloud environment. The finalized SLA is referred to by an automated routine when launching the virtual machine. This URI of the service is then returned to the end user to begin consuming the service. By clicking on the Launch Service button, the consumer is directed to the service URI on the cloud environment.

To interface our tool to a cloud system we chose Eucalyptus [15], an Infrastructure as a Service (IaaS) cloud solution and IBM Virtual Computing Lab (VCL) [29] platform. Smart Cloud services tool and the cloud platforms were installed on separate machines. Due to security reasons, the cloud installation had no direct internet access and no direct access to the tool. The only way to communicate between the two systems was through an intermediate node called Bluegrit which is a 116 core PowerPC cluster managed at UMBC.

The software to manage the interaction between our tool and the cloud platform is written in Perl and, due to the layout of the system, resides on the Bluegrit cluster. When the user presses the ‘Compose Services’ button on the tool, a remote connection is established with the Bluegrit cluster and the Perl code that parses the SLA RDF file (figure 4) is executed to find the suitable cloud configuration. If all the criteria are met, the software launches an instance of the configuration and reports back the IP address of the newly launched instance to the tool.

v. Conclusion and Future Work

In this paper we have described an integrated methodology to automate IT services lifecycle on the cloud. To the best of our knowledge, this is the first such effort, and it is critical as it provides a holistic view of steps involved in deploying IT services. Our methodology, described in section III, complements previous work on ontologies for service descriptions in that it is focused on automating the processes needed to procure services on the cloud. The methodology can be referenced by organizations to determine what key deliverables they can expect at any stage of the process. We also hope that it will enable the academia and the industry to be on the “same page” when referring to IT services on the cloud. The Smart Cloud Services tool successfully demonstrated how our methodology can be used to significantly automate the acquisition and consumption of cloud based services thereby reducing the large time required by companies to discover and procure cloud based services. We are in the process of releasing this tool to multiple users to analyze how this scales up. As part of our ongoing work in this area, we are also working on improving the integration of this tool with the VCL cloud platform and automate it such that the cloud platform configuration is transparent to the end user.

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