as a basis for assessing the risk of service providers. The features listed in the dataset is explained in below section.

Pricing Plan – Providers offer pay-as-you-go (usually hourly) plans, monthly pricing plans, "membership" discounts (where the user receives a discount in usage rates in exchange for an extra yearly payment), or any combination thereof. The more options provided, the better, but the pay-as-you-go model is the most interesting stand-alone option, since it allows for more fine-grained usage control. Only the prominently displayed payment plans were considered.

Average Monthly Price – Estimated cost in US$ for a 1 CPU, 2GB RAM cloud server (or the nearest best option), averaged over data centers for companies with location-based pricing, and averaged over Windows/Linux servers. When available, hourly pricing was used, based on 730-hour months. Otherwise, monthly pricing was used. Excludes data transfer costs.

Service Level Agreement (SLA) – The uptime SLA offered (regardless of past performance), in percentage points. The Service Level Agreement is one of the main feature that should be taken care of.

Number of Data centers – The number of data centers offered as a choice when deploying cloud servers. Data centers may be located at many regions by a cloud IaaS providers. The data accessed from the nearest region will be the fastest. This is an important risk element that there is possibility of loss of data if the data centers is two or below.

Certifications – If the vendor has compliance- and security-related certifications, such as PCI or SAS 70. This reflects the trustworthiness of a cloud provider and therefore an important feature to be considered.

Scale Up – If it is possible to scale up individual cloud server instances by adding more memory, extra CPUs or more storage space.

Scale Out – If it is possible to quickly deploy new server instances.

Support – A three-level subjective scale:
Poor – Companies that only offer on-line forums for free; any other support must be paid
Average – Companies that offer a single type of 24x7 support for free (either phone-based or on-line chat), in addition to forums
Extensive – Companies with multiple support offerings included in the base price

Monitoring – Another three-level subjective scale:

Poor – Companies that have no monitoring/alert solutions integrated, requiring the deployment of third-party tools or that extra services be purchased
Average – Companies with very simple integrated monitoring tools (few indicators or no alerting)
Extensive – Companies with very complete integrated monitoring tools offered for no additional cost

APIs – If the company offers APIs to interact with the servers or not. API make the service provider customize their system according their needs and it is provided by leading cloud IaaS providers like amazon.

Free Tier – If the provider has a "free trial" tier that customers can use to test the service.
Supported operating systems – The number of supported operating systems, regardless of version, available as a pre-configured image.

Number of Instance Types – The number of different server configurations available. Some providers offer fully customizable servers in terms of CPU, these are listed as "configurable".

Cost of Outbound Data Transfer – The cost, in US$, for each GB of outbound data sent from the server. Companies that offer a per second (Mbps) connection for free have costs listed as zero.

Cost of Inbound Data Transfer – Same as above, but for inbound data.

By assigning numerical values to all dimensions, putting them into a 0-1 scale and then applying weights, it is possible to rank the providers according to the most desired characteristics.

III. RESULTS AND DISCUSSION

Static Risk Assessment Algorithm

The service provider has to find the best infrastructure provider based on the preferences he has for the cloud features. For this purpose we ask the SP to assign ranks to the features and use multi-attribute decision making algorithm to find the best cloud provider. The algorithm is as follows:

General Description:

Given a set of alternatives A = {A1, A2 . . .} and (somehow expressed) aims or goals of the decision maker(s), find alternative Ai € A that best satisfies the goals.

Input:

A. List of cloud provider's data with attributes - pricing type, average price, sla, datacenters, certifications, scale up , scale out, support, monitoring, api's, free tier, operating system support, instance types, outbound data transfer rate, inbound data transfer rate.

B. Service provider priority for each of the above attribute. (criteria for weightage).

Algorithm:

a. Find maximum and minimum value for each attribute a[i].
b. Convert the attribute value to a score value between 0-1.
c. Find weight w[i] for each a[i] based on the input preference from user.
d. Find the attribute a[i]'s weight by multiplying it with its weight w[i].
e. ∑ wi x ai will be the total score for each attribute.
f. Normalize the total score for each attribute to scale of 0-1.
g. The attribute a[i] with the highest total score is the less risky cloud iaas provider.

Output:

The optimal cloud infrastructure provider.

The risk assessment algorithm follows the following steps. It firstly Finds the maximum and minimum value for each attribute A[i]. Let us take the attribute "cost" for illustration in all the steps. Minimum value of cost is 39.99 for Godaddy and maximum value of cost is 273.6 for Gogrid. Secondly the attribute value for each provider is coverted to a score value between 0-1. In this case the highest cost is considered to be 1 and the lowest cost is considered to be 0.All other values are lies in the range 0-1.Simply put the values are normalized with the formula

$$Normalized\ (e_i) = (e_i - E_{min})/(E_{max} - E_{min}) \quad \text{.....(1)}$$

where , E_{min} = the minimum value for variable E
E_{max} = the maximum value for variable E
If E_{max} is equal to E_{min} then Normalized (e_i) is set to 0.5.

Next Find weight w[i] for each a[i] based on the input preference from user. For example if the user gives preference of 8 out of 10 for cost. To illustrate for the sake of simplicity let us consider there are only two attributes cost and SLA and the user gives 2/10 for SLA. So the weight for cost as 0.8 and Sla 0.2. Next Find the attribute a[i]'s weight by multiplying it with its weight w[i]. The weight of cost here for Amazon will be 0.704641813. The weight for cost is 0.8. Attribute weight = A[i] x W[i] which is 0.704641813*0.8 and equals 0.5637134504. Similarly find for all the attributes. ∑ Wi *ai will be the total score for each provider. The ∑ Wi * Ai for Amazon will be 7.25344. Normalize the total score for each attribute to scale of 0-1 by using equation 1 .The provider with the highest total score is the least risky or optimal cloud infrastructure provider.

Score Comparison

PROVIDER	SCORE
Rackspace	0.7716998554816161
OpSource	0.7537902466895209
Amazon ec2	0.6967493026147744
Softlayer	0.6111009864219937
Hosting.com	0.6064083820662769
Hosting.com	0.6064083820662769
Terremark	0.602322334812126
BitRefinnery	0.5897417153996102
NephoScale	0.533704795993816
GoDaddy	0.502744883040935 7
GoGrid	0.46847222222222223
ReliaCloud	0.4644247412112657

IV. CONCLUSION

The cloud risk analysis tool is implemented successfully. The system provides risk assessment framework for the Cloud Providers to assess the less-risky cloud provider. The framework is beneficial for end-users and service providers approaching the cloud to deploy and run services, as well as infrastructure providers to deploy and operate those services. User friendly interfaces are provided. The less risky provider is suggested correctly by the application using the multi-valued decision making algorithm

A full-fledged application can be developed based on the prototype, with dynamic data. The risk analyzing dataset can be modeled into a repository for public use and update so that data is updated and reliable. Web Services API calls can be integrated to the system for the dynamic updation of the dataset. The desktop application can be enhanced to work on mobile platforms as well. This tool can be integrated to the cloud operating systems like Open Stack or Eucalyptus to dynamically assess the risk of failure of an IP.

V. REFERENCES

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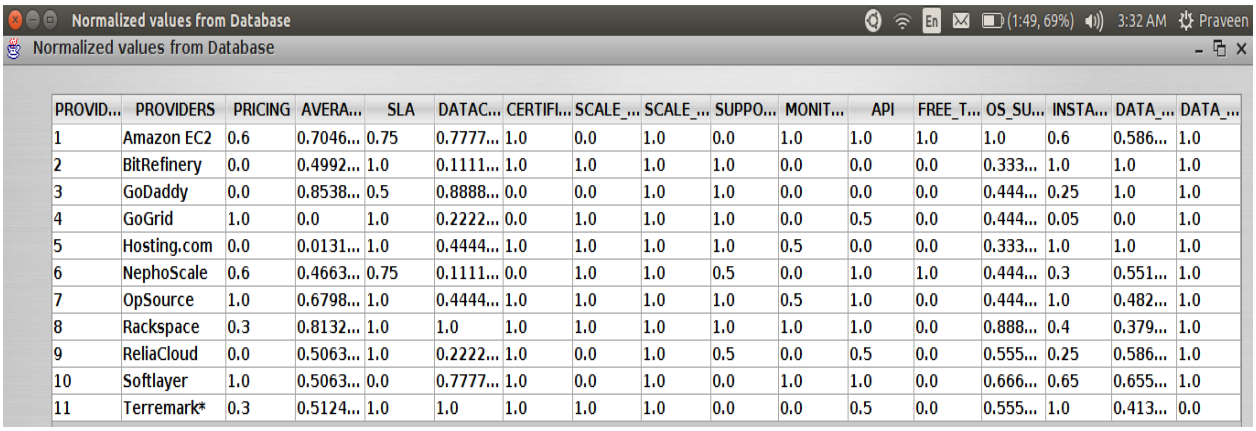
Appendix A

A.1. Dataset Table

This is the cloud infrastructure provider comparison table

Provider	Pricing	Average Price / Month (US$)	SLA	Datacenters	Certifications	Scale Up	Scale Out	Support	Monitoring
Amazon EC	Pay-as-you-go or Year + Discount	80.81	99.95%	7	Yes	No	Yes	Poor	Extensive
BitRefinery	Monthly	137	100%	1	Yes	Yes	Yes	Extensive	Poor
GoDaddy	Monthly	39.99	99.90%	8	No	No	Yes	Extensive	Poor
GoGrid	Pay-as-you-go or Monthly	273.6	100%	2	No	Yes	Yes	Extensive	Poor
Hosting.cor	Monthly	270	100%	4	Yes	Yes	Yes	Extensive	Average
NephoScal	Pay-as-you-go or Year + Discount	146	99.95%	1	No	Yes	Yes	Average	Poor
OpSource	Pay-as-you-go or Monthly	87.6	100%	4	Yes	Yes	Yes	Extensive	Average
Rackspace	Pay-as-you-go	51.1	100%	9	Yes	Yes	Yes	Extensive	Extensive
ReliaCloud	Monthly	135.05	100%	2	Yes	No	Yes	Average	Poor

Normalized Data Set



PROVID...	PROVIDERS	PRICING	AVERA...	SLA	DATAC...	CERTIFI...	SCALE_...	SCALE_...	SUPPO...	MONIT...	API	FREE_T...	OS_SU...	INSTA...	DATA_...	DATA_...
1	Amazon EC2	0.6	0.7046...	0.75	0.7777...	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	0.6	0.586...	1.0
2	BitRefinery	0.0	0.4992...	1.0	0.1111...	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.333...	1.0	1.0	1.0
3	GoDaddy	0.0	0.8538...	0.5	0.8888...	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.444...	0.25	1.0	1.0
4	GoGrid	1.0	0.0	1.0	0.2222...	0.0	1.0	1.0	1.0	0.0	0.5	0.0	0.444...	0.05	0.0	1.0
5	Hosting.com	0.0	0.0131...	1.0	0.4444...	1.0	1.0	1.0	1.0	0.5	0.0	0.0	0.333...	1.0	1.0	1.0
6	NephoScale	0.6	0.4663...	0.75	0.1111...	0.0	1.0	1.0	0.5	0.0	1.0	1.0	0.444...	0.3	0.551...	1.0
7	OpSource	1.0	0.6798...	1.0	0.4444...	1.0	1.0	1.0	1.0	0.5	1.0	0.0	0.444...	1.0	0.482...	1.0
8	Rackspace	0.3	0.8132...	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.888...	0.4	0.379...	1.0
9	ReliaCloud	0.0	0.5063...	1.0	0.2222...	1.0	0.0	1.0	0.5	0.0	0.5	0.0	0.555...	0.25	0.586...	1.0
10	Softlayer	1.0	0.5063...	0.0	0.7777...	1.0	0.0	1.0	0.0	1.0	1.0	0.0	0.666...	0.65	0.655...	1.0
11	Terremark*	0.3	0.5124...	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.5	0.0	0.555...	1.0	0.413...	0.0

Assignment of Weights