# Cloud computing decision-making using a fuzzy AHP approach

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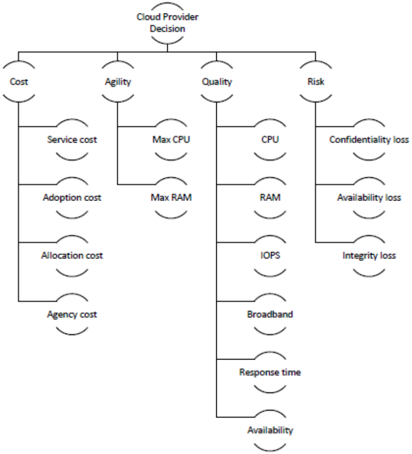
The World Conference on Intellectual Capital for Communities

# Providers Distribution

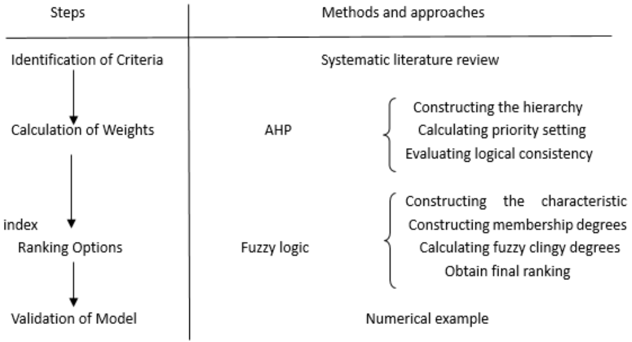
Providers Distribution (NASA)

# Identification of Criteria




Hierarchy

# Research Model




Research model

# AHP

Let $C = \{c_i | i = 1, 2, \cdots, n\}$ be the set of criteria. The results of the pairwise comparison on n criteria can be summarized in a $(n \times n)$ evaluation matrix A in which every element $a_{ij}$ is the quotient of weights of the criteria.

$$A = (a_{ij}), (i, j = 1, \cdots, n) \quad (1)$$

The relative priorities are given by the right eigenvector $\mathcal{W}$ corresponding to the largest eigenvalue $(\lambda_{max})$.

$$A\mathcal{W} = \lambda_{max}\mathcal{W} \quad (2)$$

# Fuzzy Logic

The fuzzy decision theory is used to solve uncertainty of human decision-making problems. Let $P = \{p_j | j = 1, 2, \cdots, m\}$ be the set of alternatives, $\mathcal{W} = (w_1, w_2, \cdots, w_m)^T$ be the set of weights of criteria $C = (c_1, c_2, \cdots, c_n)$. $S_{ij} = f(c_i, p_j)$ is a characteristic index value of $c_i$, $i = 1, 2, \cdots, n$ corresponding to $p_j$, $j = 1, 2, \cdots, m$. Each alternative can be used to correspond to the n criteria, so we can get a $m \times n$ characteristic index matrix.

$$S = \begin{pmatrix} s_{11} & s_{12} & \cdots & s_{1n} \\ s_{21} & s_{22} & \cdots & s_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ s_{m1} & s_{m2} & \cdots & s_{mn} \end{pmatrix} \quad (3)$$

# Fuzzy Logic

All membership functions are defined to be linear and divided into two types:

- The larger value is better

$$r_{ij} = \begin{cases} 1 & s_{ij} > s_{ip} \\ (s_{ij} - s_{if})/(s_{ip} - s_{if}) & s_{if} \leq s_{ij} \leq s_{ip} \\ 0 & s_{ij} < s_{if} \end{cases} \quad (4)$$

- The smaller value is better

$$r_{ij} = \begin{cases} 0 & s_{ij} > s_{ip} \\ (s_{ip} - s_{ij})/(s_{ip} - s_{if}) & s_{if} \leq s_{ij} \leq s_{ip} \\ 1 & s_{ij} < s_{if} \end{cases} \quad (5)$$

# Fuzzy Logic

$r_{ij}$ is the membership function of $p_j$, $j = 1, 2, \cdots, m$ that corresponds to $c_i$, $i = 1, 2, \cdots, n$. $s_{if}$ and $s_{ip}$ are lower limit and upper limit. If there isn't upper limit $s_{ip} = max_{j\in(1,2,\cdots,n)} s_{ij}$, if there isn't lower limit $s_{if} = min_{j\in(1,2,\cdots,n)} s_{ij}$. With function (4) and (5), we can transform the characteristic index matrix (3) to the membership degree matrix (6):

$$R = \begin{pmatrix} r_{11} & r_{21} & \cdots & r_{m1} \\ r_{12} & r_{22} & \cdots & r_{m2} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix} \quad (6)$$

# Fuzzy Logic

On the basis of the maximum membership degree principle, we can obtain the following ideal option :

$$\bar{G} = (r_{11} \vee r_{12} \vee \cdots \vee r_{1n}, r_{21} \vee r_{22} \vee \cdots \vee r_{2n}, \cdots, r_{m1} \vee r_{m2} \vee \cdots \vee r_{mn})^T$$
$$= (g_1, g_2, \cdots, g_m)^T$$

$\vee$ is a max operation. The fuzzy clingy degree is

$$N(p_j, \bar{G}) = 1 - D_w(p_j, \bar{G})$$

where $D_w(p_j, \bar{G})$ is the weighted distance. Then:

$$N(p_j, \bar{G}) = 1 - \sum_{i=1}^{m} w_i(g_i - r_{ij}) \ \ (j = 1, 2, \cdots, m) \tag{7}$$

# Data

Cloudscreener dataset provides information and standardized metrics related to various aspects of the performance of cloud computing technology. It provides a comprehensive set of indicators which helps to understand the variance of cloud performance.

# Results

Because of legal concerns, we anonymize the providers names and refer to them as A to H. A.1 is one of the data center locations

| Ranking | Provider | Index |
|---|---|---|
| 1 | A.8 | 0.638455 |
| 2 | A.4 | 0.619122 |
| 3 | A.6 | 0,616346 |
| 4 | A.5 | 0.536647 |
| 5 | A.7 | 0,52856 |
| 6 | E.1 | 0.518421 |
| 7 | A.9 | 0,516338 |
| 8 | E.2 | 0.506845 |
| 9 | B | 0,495442 |
| 10 | A.1 | 0,45991 |

# Conclusion

- The research findings show that the proposed fuzzy logic theory and AHP method present a well-structured architecture and a high degree of computational power.
- Such a systematic methodology to compare and rate cloud providers can make a significant impact and create healthy competition among cloud providers.
- We believe that our decision model is a significant step toward analyzing the process of cloud provider selection.

# Future Research

- Our model is currently focused on cost, performance, agility and risk, thus does not include extensive qualitative aspects that may influence cloud computing decision, future research will focus on this topic.
- As time goes by, providers update their infrastructure and there will be more cloud providers entering the cloud market, we will update and compare more cloud providers in the future.

# Thank you for your attention!

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