Study of Recommendations For The Best Candidates in a Decision Support System Using Fuzzy Multicriteria Based on Simple Additive Weighting

Sinar Sinurat
Universitas Budidarma
Email: sinurat.sin@gmail.com

Keywords	Abstract
SAW, Fuzzy, FMCDM, Exchange, Labor.	**Abstract.** Recommendations for prospective workers are determined based on the fulfillment of the criteria tested by participants, whereas fuzzy multicriteria based on Simple Additive Weighting are used to process available data to produce participant assessment information that has the potential to be accepted. The multi-criteria-based system shows the accuracy of candidate recommendations according to ranking. The fuzzy set will show the paradigm of handling uncertainty and ambiguity in the behavior of determining candidates effectively and choosing based on Fuzzy Multi-Criteria Decision Making (FMCDM) in the candidate labor market. The argument for selecting the title is adjusted to the Fuzzy Multicriteria decision-making pattern. Improving the quality of determining the workforce that is known by the public in order to train job seekers in both technical and managerial training so that reliable prospective workers are obtained who can compete in the world of work This method is aimed at reducing the large number of unemployed people who continue to grow, so placement of local workers is usually carried out either through the formal or non-formal sectors in order to create new prospective entrepreneurs or even look for opportunities between jobs.

1. INTRODUCTION

Growth in productive age that is ready to compete to fill opportunities to fill existing jobs is faced with an increasing unemployment rate, and the quality of job seekers is still low [1] [3]. Stakeholders can win the competition with several factors that influence many factors, one of which is the human resource factor available in the business entity [3] [4] [5] [6]. The relationship between employers and workers changed drastically after the 1998 reforms, and with the impact of the COVID-19 Pandemic in 2020 until mid-2022, the availability of jobs and the abilities of prospective job seekers are difficult to fulfill. The freedom to voice various complaints such as occupational health and safety conditions, unfair treatment, and low minimum wages can be carried out without fear [1]. [2][3].

The user recommendation system is based on individual profile data, so the system can guarantee the accuracy of the specialization model in the value matrix by not providing individual assessment information. Multi-criteria-based decision support system for accuracy of calculation recommendations in various aspects and criteria provided by stakeholders [7] [8] [9].

As for the research objectives of this prospective workforce recommendation, they are as follows :

1. Helping decision-makers determine the best job candidates in accordance with the specifications and available vacancy formations.
2. To ensure that the results of the selection of prospective employees are in accordance with the criteria determined by stakeholders.
3. To provide a more representative presentation of applicant data
4. For documentation of prospective applicant data and contributions in the world of science and technology.
5. At any time, data and processes can be browsed without changing the value of the applicant for each recruitment process.

The benefit of the recommendation of the best candidate for the best workforce is that it facilitates interaction between stakeholders and decision-makers so that specific recruitment activities are:

1. The submission of decision-making materials can be uniform.
2. The recruitment process is more transparent and attractive.
3. The recruitment process is more interactive.

4. Time and energy efficiency.
5. Improving the quality of the results from recruiting prospective workers.
6. It is possible to do it anywhere and anytime (online).
7. Growing the optimism of applicants and stakeholders about the results of recruitment.
8. Changing the role of decision-makers in a more productive direction

Research Urgency
   The urgency of research carried out in various areas of the teaching and learning process is :
1. Following up on the background explanation of the issue, the urgency of the study is connected to the subject matter, the use of the methodology, and the audience's technical proficiency, which varies according to ability level.
2. A few of the explanatory techniques employed in the study of cryptography have undergone extensive analysis by a number of scholars. The study will combine a number of established guidelines with references in the form of previously published articles from other fields, in accordance with the declared research aims.

2. LITERATURE REVIEW
Labor Exchange
   The labor market is defined as a transaction that brings together stakeholders and prospective workers. Stakeholders in the labor market are prospective labor users. The labor market is held with the intention of coordinating meetings between prospective job seekers and stakeholders or institutions that need workers [1] [2] [10].
   In the framework of activities to meet the needs of manpower by companies, the market for labor candidates can provide a way for companies to fulfill them. Thus, it is not surprising that not only job seekers but also stakeholders benefit from the existence of this market. To create a synergy of conditions between the two parties, namely between labor providers and employers, it is necessary to coordinate and cooperate with all related parties, namely labor providers, labor recipients, and the government [6].

Functions and Benefits of the Labor Exchange
   The prospective labor market has a broad function, both in the economic sector and in other sectors. The functions of the Labor market [1] are :
1. Distribution of job candidates;
2. Get information about the world of work
3. Bring together prospective job seekers and/or institutions that require prospective workers;

   While the benefits of having a labor market are:
1. Assisting prospective workers in obtaining jobs according to their respective fields to reduce unemployment;
2. Helping the community or stakeholders get prospective workers; and
3. Helping the government overcome employment problems,

Basic Decision Support
   Some scientists provide an understanding of decision support according to their point of view and background of thought. According to James A.F. Stoner, the decision is the choice between various alternatives to make a choice. The basis for decision-making has three meanings [9] [11], namely: (1) There is a choice based on logic or consideration; (2) There are alternatives that must be chosen with the best one; And
   There are goals to be achieved and decisions must bring those goals closer. Another definition of decision put forward by Prajudi Atmosudirjo is that a decision is an ending of the thought process related to a problem with a choice based on an alternative. Understanding the decision is obtained through problem solving by selecting one alternative from several alternatives. Based on the explanation of the meaning of the decision, the opinions of experts are quoted regarding the meaning

of making or taking decisions. According to George R. Terry decision making is the selection of alternatives based on certain behavior (behavior) from two or more available alternatives[11][12][9].

Related to this function, the purpose of decision-making can be distinguished as follows: (1) Is singular. Occurs when a decision is made concerning only one problem, meaning that once it is decided, there will be no bias on other issues. (2) is dual. Resulted in affecting more than one problem, meaning that decisions taken while solving two (or more) problems are contradictory or not contradictory. In order to make decisions more directed, it is necessary to introduce elements or components of decision-making.

The elements of decision-making are: (1) Clearly defined decision-making purposes; (2) Identification of alternative decisions to solve problems; (3) Formulation of factors previously hidden or beyond human reach; And (4) Evaluation facilities and equipment or measurable results of decision-making.

Decision Making Subsystem [13], including: a. Data management, including databases with items relevant to formulas that are managed as a database management system (DBMS). b. Model management: an application containing financial models, statistics, management science, or quantitative models that provide system analysis capabilities and related management software. c. Knowledge management, namely as a component that stands alone (independence). The user interface subsystem is a medium or place of communication between users, decision makers, and stakeholders who give orders to decision makers. Meanwhile, George R. Terry mentioned five bases in decision-making, namely: (1) Intuition; (2) Experience; (3) Facts; (4) Authority; and (5) Rationality.

MCDM on Prospective Workforce Recommendation System

Knowledge-based recommendations use user items and items that meet user needs. The obstacle of a knowledge-based approach is the need to acquire a sufficient knowledge base beforehand, but knowledge acquired on a basis to help avoid starting from content-based sparsity pure data problems or collaborative filtering system encounters relying solely on ratings obtained by users [17] A hybrid approach to content-based, collaborative, and knowledge-based filtering in multiple ways A more in-depth analysis of the MCDM recommended representative system surveyed in the previous section shows that the nature of the majority of multi-criteria recommendations can be classified as follows: (1) Content multi-attribute preference modeling; (2) Content multi-attribute search and filtering; (3) Assessment of multiple criteria based on preference elicitation

Simple Additive Weighting (SAW)

The basic concept of the SAW method is to find the weighted sum of the performance ratings for each alternative on all attributes [18] and [9]. The SAW method requires a process of normalizing the decision matrix (X) on a scale that can be compared with all existing alternative ratings.

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{\text{Max } x_{ij}} & \text{Jika } j \text{ adalah atribut keuntungan (\textit{benefit})} \\[2ex] \dfrac{\text{Min } x_{ij}}{x_{ij}} & \text{Jika } j \text{ adalah atribut biaya (\textit{cost})} \end{cases}$$

Where :

Rij = normalized performance rating value; Xij = attribute value owned by each criterion; = the largest value of each criterion; = the smallest value of each criterion; benefit = if the greatest value is the best; cost = if the smallest value is the best; benefit = if the greatest value is the best; cost = if the smallest value is the best; rij is the normalized performance rating of alternative Ai on the Cj attribute; i = 1, 2,..., m, and j = 1, 2,..., n. Preference value of each alternative (Vi) : $v_i = \sum_{j=1}^{n} w_j r_{ij}$

Vi = ranking for each alternative; wj = weight value of each criterion; rij = normalized performance rating value; a larger Vi value indicates that alternative Ai is more selected.

3.   METHODS

Processing Stages

Several stages of data processing that will be carried out are :

1. Collecting a number of references in the form of journals related to Fuzzy multicriteria, Decision Making, recommendation systems,
2. Collect data on the Exchange of prospective workers.
3. Analyzing data for the Simple Additive Weighting process sourced from the internet as research material.
4. Analyze and build application models for data usage in point 2.
5. Build databases and relationships between tables according to the tools used.
6. Compile algorithms and compile coding by the user.
7. Implement system design, conduct testing, and draw conclusions.
8. Make a report.

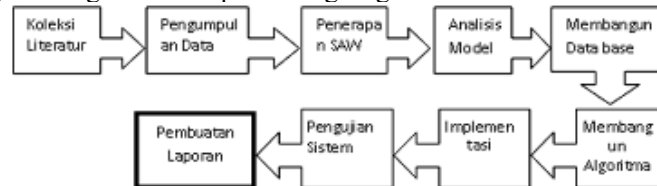The following is a diagram of the processing stages:

Figure 1. The Processing Stages

Design Requirements Applicants

The form of the application form first synchronizes the employment relationship with the level of knowledge or education of the candidates based on work agreements that have elements of work, wages, and orders. Rights and obligations in employment relations can be distinguished by [16]: (1) Work Norms: Rights and obligations of employers/owners and prospective employees through laws and regulations; (2) Working Conditions: Rights and obligations of employers and prospective employees that have not been regulated in law. Arrangement of working conditions includes: (1) Clarity of rights and obligations for employers and prospective employees; (2) Realization of calm work. Calm work contains the following elements: (1) Guaranteed rights for all parties; (2) Resolving disputes that arise at a later date; and (3) Strike action is not used to impose will. The arrangement of rights and obligations is distinguished as follows: (1) Minimum macro: laws and regulations (Work Norms); (2) Microconditional (terms of work) in the form of individual and collective Proper regulation of rights and obligations if regulated in law means that it does not need to be negotiated and is coercive in nature, meaning that if it is not carried out, it is punishable by imprisonment and or fines for: (1) Working time; (2) Overtime pay; (3) Time off and leave; (4) Minimum Wage ; (5) Occupational Safety and Health (K3).

The form for filling in the application form for the front page and the back page that must be filled in by prospective applicants is :

Figure 2. The Form For Filling In The Application

4. RESULTS AND DISCUSSION

Criteria and Weight

The Fuzzy criteria are in the following table, and each criterion will be weighted with six fuzzy numbers, namely very low (SR), low (R), medium (S), middle (T1), high (T2), and very high (ST), as shown in the following diagram.

Kriteria	Keterangan
C1	Usia saat ini
C2	Status perkawinan
C3	Pendidikan terakhir
C4	Pekerjaan saat ini
C5	Pengalaman kerja

For the weighting of the data in the first table and the sample of prospective applicants, three (3) candidates were taken for the sample for FMCDM using the SAW method, as shown in the second table below.

Bilangan Fuzzy	Nilai
Sangat Rendah (SR)	0
Rendah (R)	0.2
Sedang (S)	0.4
Tengah (TT)	0.6
Tinggi (T2)	0.8
Sangat Tinggi (ST)	1

No	Nama	Usia	Status Kawin	Pendidikan Terakhir	Pekerjaan Saat ini	Pengalaman Kerja
1	A1	19	Belum	SMU	Karyawan Mingguan	1 tahun
2	A2	22	Belum	S 3	Karyawan Dalaman	1 tahun
3	A3	27	Kawin	S-1	Karyawan Tetap	5 tahun

Application of Simple Additive Weighting (SAW)

Based on the selection steps to determine scholarship recipients using FMCDM with the SAW method, the following are carried out:

1. Provide an alternative value (Ai) on each specified criterion (Cj).

   a. Age: The age variable consists of four fuzzy numbers, namely very young (SM), young (M), moderate (S), and old (T), as shown in the following diagram and table.

Keterangan:
• SM = Sangat Muda;
• M = Muda;
• S = Sedang;
• T = Tua.

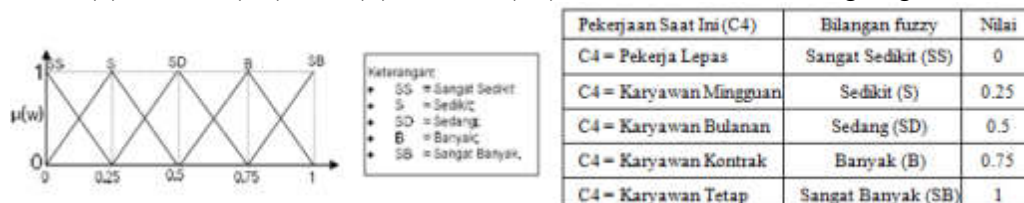| Usia (C1)	Bilangan fuzzy	Nilai
Usia <= 15 Tahun	Sangat Muda (SM)	0.25
Usia <= 20 Tahun	Muda (M)	0.5
Usia <= 30 Tahun	Sedang (S)	0.75
Usia >= 31 Tahun	Tua (T)	1
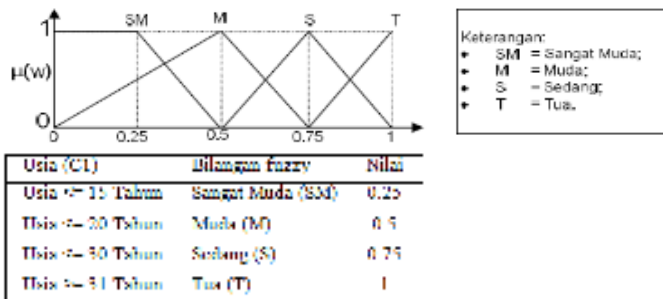
   b. Marital status The marital status variable consists of four fuzzy numbers, namely low (R), moderate (C), high (T), and very high (ST), as shown in the following diagram and table.

Keterangan :
R = Rendah
C = Cukup
T = Tinggi
ST = Sangat Tinggi

| Status Perkawinan (C2)	Bilangan fuzzy	Nilai
Kawin	Rendah (R)	0.25
Pernah Kawin Punya Anak	Cukup (C)	0.5
Pernah Kawin Tidak Punya Anak	Tinggi (T)	0.75
Belum Kawin	Sangat Tinggi (ST)	1

   c. Final Education: the last educational variable consists of five fuzzy numbers, namely very little (SS), a little (S), moderate (SD), a lot (B), and a lot (SB), as shown in the following diagram and table.

Keterangan:
• SS = Sangat Sedikit
• S = Sedikit;
• SD = Sedang;
• B = Banyak;
• SB = Sangat Banyak;

Pendidikan Terakhir (C3)	Bilangan fuzzy	Nilai
C3 = Tidak Sekolah, Lulus SD, SMP	Sangat Sedikit (SS)	0
C3 = SMTA	Sedikit (S)	0.25
C3 = Diploma-1 - Diploma III, Akta	Sedang (SD)	0.5
C3 = Strata-1, Strata II	Banyak (B)	0.75
C3 = Strata-III	Sangat Banyak (SB)	1

   d. Current Job. The current job variables consist of five fuzzy numbers, namely very little (SS), a little (S), medium (SD), a lot (B), and a lot (SB), as shown in the following diagram and table.

Keterangan:
• SS = Sangat Sedikit
• S = Sedikit;
• SD = Sedang;
• B = Banyak;
• SB = Sangat Banyak;

Pekerjaan Saat Ini (C4)	Bilangan fuzzy	Nilai
C4 = Pekerja Lepas	Sangat Sedikit (SS)	0
C4 = Karyawan Mingguan	Sedikit (S)	0.25
C4 = Karyawan Bulanan	Sedang (SD)	0.5
C4 = Karyawan Kontrak	Banyak (B)	0.75
C4 = Karyawan Tetap	Sangat Banyak (SB)	1

e.   Work experience is in the first table, and work suitability ratings are in the second table. The work experience variable consists of five fuzzy numbers, namely very low (SR), low (R), sufficient (C), high (T), and very high (ST), as shown in the following diagram.
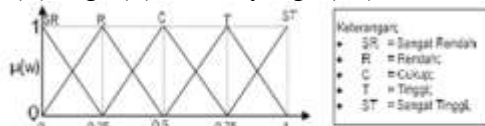
Pengalaman Kerja (C5)	Bilangan fuzzy	Nilai
C5 < 1 Tahun	Sangat Rendah (SR)	0
C5 = 1 – 2 Tahun	Rendah (R)	0.25
C5 = 3 - 5 Tahun	Cukup (C)	0.5
C5 = 5 – 10	Tinggi (T)	0.75
C5 >= 11 Tahun	Sangat Tinggi (ST)	1

Alternatif	Kriteria				
	C1	C2	C3	C4	C5
A1	0.5	1	0.25	0.25	0.25
A2	0.75	1	1	0.5	0.25
A3	0.75	0.25	0.75	1	0.75

Based on the data presented above, it is converted into a decision matrix X with the following data :

$$X = \begin{vmatrix} 0.5 & 1 & 0.25 & 0.25 & 0.25 \\ 0.75 & 1 & 1 & 0.5 & 0.25 \\ 0.75 & 0.25 & 0.75 & 1 & 0.75 \end{vmatrix}$$

2.   Determine the weight value for each participant that will be received in the following table.

Kriteria	Bobot	Nilai
C1	Sedang (S)	0.4
C2	Sedang (S)	1
C3	Tinggi (T2)	0.8
C4	Sedang (S)	0.4
C5	Sangat Tinggi (ST)	0.4

So that the weight value (W) is obtained with the data :
W = [0.4 1 0.8 0.4 0.4]

3.   Normalizing the X matrix into an R matrix based on the SAW equation yields:
   a.   The age of the applicant is included in the cost attribute :

$$r11 = \frac{Min\{0.25 : 0,5 : 0.75 : 1\}}{0.5} = \frac{0.25}{0.5} = 0.5 \qquad r21 = \frac{Min\{0.25 : 0.5 : 0.75 : 1\}}{0.75} = \frac{0.25}{0.75} = 0.33 \qquad r31 = \frac{Min\{0.25 : 0.5 : 0.75 : 1\}}{0.75} = \frac{0.25}{0.75} = 0.33$$

   b.   For marital status included in the cost attribute:

$$r12 = \frac{Min\{0.25 : 0.5 : 0.75 : 1\}}{0.25} = \frac{0.25}{0.25} = 1 \qquad r22 = \frac{Min\{0.25 : 0.5 : 0.75 : 1\}}{1} = \frac{0.25}{1} = 0.25 \qquad r32 = \frac{Min\{0.25 : 0.5 : 0.75 : 1\}}{0.25} = \frac{0.25}{0.25} = 1$$

   c.   For the last education included in the attribute advantage (benefit),

$$r13 = \frac{0.25}{Max\{0;0.25;0.5;0.75;1\}} = \frac{0.25}{1} = 0.25 \qquad r23 = \frac{1}{Max\{0;0.25;0.5;0.75;1\}} = \frac{1}{1} = 1 \qquad r33 = \frac{0.75}{Max\{0;0.25;0.5;0.75;1\}} = \frac{0.75}{1} = 0.75$$

   d.   For current work, it is included in the cost attribute.

$$r14 = \frac{Min\{0.25 : 0,5 : 0.75 : 1\}}{0.25} = \frac{0.25}{0.25} = 1 \qquad r24 = \frac{Min\{0.25 : 0.5 : 0.75 : 1\}}{0.5} = \frac{0.25}{0.5} = 0.5 \qquad r34 = \frac{Min\{0.25 : 0.5 : 0.75 : 1\}}{1} = \frac{0.25}{1} = 0.25$$

   e.   For the average value of applicants included in the attribute advantage (benefit).

$$r15 = \frac{0.25}{Max\{0;0.25;0.5;0.75;1\}} = \frac{0.25}{1} = 0.25 \qquad r25 = \frac{0.25}{Max\{0;0.25;0.5;0.75;1\}} = \frac{0.25}{1} = 0.25 \qquad r35 = \frac{1}{Max\{0;0.25;0.5;0.75;1\}} = \frac{1}{1} = 1$$

So that the R matrix

$$R = \begin{vmatrix} 0.5 & 1 & 0.25 & 1 & 0.25 \\ 0.33 & 0.25 & 1 & 0.5 & 0.25 \\ 0.33 & 1 & 0.75 & 0.25 & 1 \end{vmatrix}$$

4. Carry out the ranking process using the equation :

$$v_i = \sum_{j=1}^{n} w_j r_{ij}$$

where: V_i=ranking for each alternative; w_j=weight value of each criterion; r_{ij}=normalized performance rating value; The selected v_i value indicates that alternative A_i is more selected. So :

$V1 = (0.4)(0.5) + (1)(1) + (0.8)(0.25) + (0.4)(1) + (0.4)(0.25)$; $V2 = (0.4)(0.33) + (1)(0.25) + (0.8)(1) + (0.4)(0.5) + (0.4)(0.25)$
$= 0.20 + 1.00 + 0.20 + 0.40 + 0.10 = 1.90$ $= 0.13 + 0.25 + 0.8 + 0.20 + 0.10 = 1.48$
$V3 = (0.4)(0.33) + (1)(1) + (0.8)(0.75) + (0.4)(0.25) + (0.4)(1) = 0.11 + 1.00 + 0.60 + 0.10 + 0.40 = 2.20$

5. The applicant's data value with the largest value is in V3, so that the 3rd participant is the alternative chosen as the selected employee, namely Name of Candidate for Workforce = A3, Age = 27 Years, Marital Status = Married, Last Education = Strata-1, Employment Status Currently = Permanent Employee, Work Experience = 5 Years; Further descriptions are shown in the following table :

No	Nama	Usia Pelamar	Status Kawin	Pendidikan Terakhir	Pekerjaan Saat ini	Pengalaman	Hasil Akhir
1	A1	0.5	1	0.25	0.25	0.25	1.90
2	A2	0.75	1	1	0.5	0.25	1.48
3	A3	0.75	0.25	0.75	1	0.75	2.20

Whereas when the final results are the same, what determines is the highest weighted value according to the table above for each prospective employee who will be recruited or accepted.

Design Logic
The Use Case diagram of the applicant data recommendation system and its processing in the first and second diagrams shows the state of the process so that it can be used for each search.
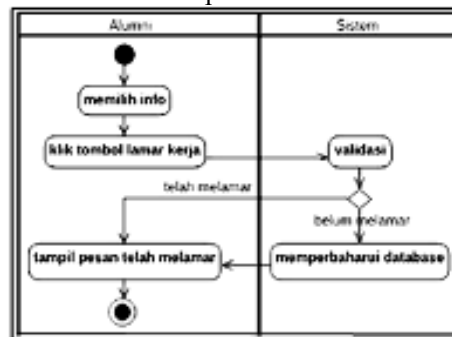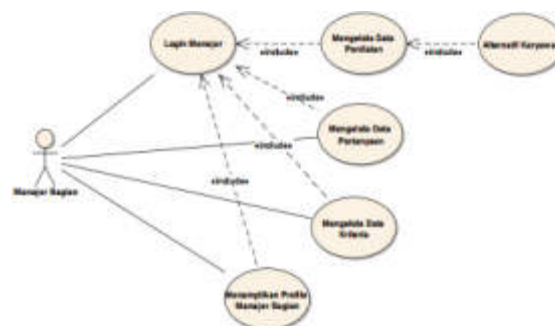

Figure 3. Design Logic

Figure 4. Use Case diagram

5. CONCLUSSION

Based on the point of view of a decision support system, a number of assessment criteria contained in the discussion allow it to be developed with other criteria in accordance with the formation of stakeholder needs. Based on the results of calculations with SAW, where the reference criteria are the applicant's age, marital status, last education, job when applying, and work experience, an employee with the highest ranking will be selected who will get the first opportunity to be recruited. Based on SAW calculation with applicant data, the candidate with the highest ranking is A3, Age is 27 Years, Marital Status is Married, Last Education is Strata-1, Current Job Status is Permanent Employee, and work experience is 5 years. Based on the analysis during the research phase, several suggestions are needed for the development of this research in the future, including : The stakeholder appraisal party for the assessment can be developed according to the formation of criteria according to the needs during the employee recruitment period. The calculation process with FMCDM using the SAW method seems to need to consider the behavior of applicants to allow for projections of certain positions.

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