

การทบทวนวรรณกรรมอย่างมีระบบ: การจัดกลุ่มแบบเคมีนในการขนส่งทางอากาศ

SYSTEMATIC LITERATURE REVIEW: K-MEAN CLUSTERING IN AIR TRANSPORT

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บทคัดย่อ

งานวิจัยเรื่องนี้ มีวัตถุประสงค์เพื่อศึกษาการประยุกต์ใช้การจัดกลุ่มแบบเคมีนในการขนส่งทางอากาศและค้นหาการใช้ตัวแปรในแต่ละวัตถุประสงค์การใช้การจัดกลุ่มแบบเคมีนในการขนส่งทางอากาศ จากบทความทั้งหมด 495 บทความ จากฐานข้อมูลทั้งในและต่างประเทศ เมื่อนำมาทำการทบทวนอย่างเป็นระบบและการวิเคราะห์ห่อภิมาณเหลือบทความทั้งสิ้น 24 บทความ ผลการวิจัยพบว่าการประยุกต์ใช้การจัดกลุ่มแบบเคมีนใน ด้านการขนส่งสินค้าทางอากาศ แท็กซี่ทางอากาศ การจัดการจราจรทางอากาศ สายการบิน ท่าอากาศยาน และ ที่ขึ้นลงของแท็กซี่ทางอากาศ และตัวแปรในแต่ละวัตถุประสงค์การใช้การจัดกลุ่มแบบเคมีนในการขนส่งทางอากาศ ดังนี้ เพื่อสำรวจอุบัติเหตุ/ความเสี่ยง เช่น บุคลากร อุปกรณ์ การจัดการ สิ่งแวดล้อม เพื่อการดำเนินธุรกิจ เช่น น้ำมัน ปัจจัยการบรรทุก ปริมาณการผลิตด้านผู้โดยสาร จำนวนผู้โดยสาร เพื่อการขนส่งทางอากาศ เช่น ปริมาณสินค้าที่ผ่านเข้าออก การเคลื่อนย้ายของอากาศยานที่ขนส่งสินค้า จำนวนสินค้าระหว่างประเทศ เพื่อพยากรณ์การล่าช้าของอากาศยาน เช่น เวลาออกเดินทางจริง เวลาที่ถึงจริง กำหนดเวลาออกเดินทาง กำหนดเวลาถึง เพื่อปฏิบัติการทางการบิน เช่น ความเร็ว ทิศทาง ความกดอากาศ ปริมาณการจราจรทางอากาศขาเข้า-ขาออก และเพื่อการเคลื่อนย้ายโดยสาร เช่น จำนวนผู้โดยสารต่อเดือน จำนวนผู้โดยสารต่อปี ทั้งนี้ยังพบหัวข้องานวิจัยที่น่าสนใจในอนาคต คือ แท็กซี่ทางอากาศและขึ้นลงของแท็กซี่ทางอากาศ

คำสำคัญ: การขนส่งทางอากาศ การจัดกลุ่ม การทบทวนวรรณกรรม เคมีน

Abstract

This research aims to study the application of K-mean clustering in air transport and find variable use in each K-mean clustering purpose. Total 495 articles from Thai and international database after articles are

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Systematic reviews and Meta-Analyses, there are 24 articles remaining. The results found that K-mean clustering was applied in air cargo, air taxi, air traffic management, airline, airport, and vertiport along with variable use in each K-mean clustering purpose as follow, for exploring accident/ risk such as personal, equipment, management, and environment. For business operation such as fuel, load factor, available seat mile, and number of passengers. For cargo transport such as total cargo throughput, freighter aircraft movement, and international cargo. For predictive aircraft delay such as actual departure time, actual arrival time, schedule departure time, and schedule arrival time. For flight operation such as velocity, heading, barometric altitude, daily arrival traffic, and daily departure traffic. For passenger movement such as passenger movement per month and passenger per year. In addition, we found interesting topic in air taxi and vertiport for future research.

Keywords: Air transport, Clustering, K-mean, Literature review

Introduction

Machine learning is a part of Artificial Intelligence (AI) that focuses on developing systems that can learn from data and improve work efficiency from learning. Such learning can enable computer to learn from data then conclude decision on interested issue. Machine learning can divide into 4 categories: Supervised machine learning, Unsupervised machine learning, Semi-supervised learning, and Reinforcement learning. Machine learning also need algorithm in order to command the computer to process such as Neural network, Random forest, and Clustering (IBM, 2021).

There are several types of clustering algorithms in Unsupervised machine learning such as K-mean clustering algorithm which in centroid-based clustering (GeeksforGeeks, 2026) is widely used to find non-desired expected output in both patterns and structure of data, it also has goal to cluster identify patterns and relationships in data without prior knowledge of the data. In clustering algorithm K-mean is popular method due to simple to use and efficient in handling large data sets (Gupta, 2025), it can be applied in many areas of research such as image processing, data processing, medical diagnosis, and risk assessment (Ikotun et al., 2023) as well as in area of business research for instance customer clustering (Chitra & Heikal, 2024), document clustering (Buatoom et al., 2020), discount analyze (Zebua et al., 2022), and transportation optimization (Gaon et al., 2025).

Systematic literature review (SLR) is process used for summarize the result obtained from interesting topic which can guide identify gap in research in order to develop future research. Due to the large and increasing number of research studies in K-mean especially in air transport. We are interested to review K-mean clustering in air transport with expected benefit to determine future research guidelines.

Aims

1. To study the application of K-mean clustering in air transport
2. To find variable use in each K-mean clustering purpose
3. To determine future research guidelines

Literature review

Preferred reporting items for systematic reviews and meta-analyses (PRISMA)

PRISMA is design to improve the systematic reviews and provide guide how to completely report why a systematic review was done, what methods were used, and what results were found. PRISMA has a checklist to report standard, ensures all components are reported transparently, and cover key report area. There are also has 4 stages of flow diagram first, identification by record found in database, next screening the duplicate, then record is checked by eligibility criteria, finally report all the meet criteria (PRISMA, 2025).

Related research

Example of systematic literature review: Rix & Ingham (2021) in topic the impact of education selection according to notions of intelligence: A systematic literature review use international database, result found most articles focus on qualitative studies concentrate in impact of education choice on demand and opportunity. Govindan et al. (2022) in topic supply Chain 4.0 performance measurement: A systematic literature review, framework development, and empirical evidence, result found internet of thing (IOT) and big data analytics have the great benefit compared to other industry 4.0. Kavallieratos & Katsikas (2023) in topic an exploratory analysis of the last frontier: A systematic literature review of cybersecurity in space, result found cybersecurity in overall space infrastructure and satellites is being integrate and also research in this field is still increasing. Geske et al. (2024) in topic artificial intelligence as a driver of efficiency in air passenger transport: A systematic literature review and future research avenues, result found it was focused in predictive analytics, resource optimization, safety, automation, and passenger experience. Kotzampasakis (2025) in topic Maritime emissions trading in the EU: Systematic literature review and policy assessment, result found emission trading allow shipping to contribute to EU efforts to achieve its climate targets also in order to achieving emission reduction target excluding maritime shipping would require additional effort from other sectors.

Example of systematic literature review in clustering: Loor-Zambrano et al. (2021) in topic approaches of predictive and clustering methods used in emergency events: A Systematic literature review, result found clustering algorithm can optimize resource allocation and management to solve the problem, regarding to the ability to predict where and when emergencies or natural disaster is neural network. Assef et al. (2022) in topic a review of clustering techniques for waste management, result found K-mean clustering is a popular and preferred technique for cluster analysis for waste management problem. Chaudhry et al. (2023) in topic a systematic literature review on identifying patterns using unsupervised clustering algorithms: A data mining perspective, result found clustering can help to show and extract information efficiently, various data clustering methods, such as segmental clustering and density clustering, have been introduced and used in various fields, such as finance, advertising, and healthcare. Singh & Singh. (2024) in topic a comprehensive review of clustering techniques in artificial intelligence for knowledge discovery: Taxonomy, challenges, applications and future prospects, result found algorithm provide a solution for general clustering, while hierarchical and partitioning approaches have limitations in term of processing speed and throughput. Ruiz, J. G., et al. (2025) in topic cluster of symptoms in kidney failure: A systematic review, result found symptom-based interventions are better than isolated interventions, improving patient quality of life and avoiding adverse events.

Table 1*Details of Year for Searching, Number of Articles Found and Database in Related Research*

Authors	Year for searching	Articles found (Percent)	Qualified articles (Percent)	Database				
				ACM Digital	IEEE Xplore	ScienceDirect	Springer	Others
Assef et al. (2022)	2001 - 2020	428 (100)	61 (14.25)					✓
Chaudhry et al. (2023)	2002 - 2023	698 (100)	143 (20.49)	✓	✓		✓	✓
Geske et al. (2024)	2015 - 2022	238 (100)	62 (26.05)			✓		✓
Govindan et al. (2022)	2017 - 2022	1,155 (100)	178 (15.40)			✓		
Kavallieratos & Katsikas (2023)	2009 - 2023	107 (100)	66 (61.68)	✓	✓	✓		
Kotzampasakis (2025)	2009 - 2024	249 (100)	51 (20.48)			✓		✓
Rix & Ingham (2021)	1944 - 2021	4,303 (100)	85 (1.96)			✓		✓
Ruiz, J. G., et al. (2025).	2022 - 2023	46 (100)	8 (17.39)					✓
Singh & Singh. (2024).	1999 - 2024	282 (100)	84 (29.79)	✓	✓	✓	✓	✓
Loor-Zambrano et al. (2021)	2015 - 2020	2,867 (100)	50 (1.74)		✓	✓	✓	✓

From table 1 first column shows name of author(s) in each article, second column shows year of starting year and ending year of searching, third column shows number of articles found before apply the criteria in parentheses shows the percentage, fourth column shows number of articles found after apply the criteria parentheses shows the percentage, last column shows the database of acquired article.

Research Methodology

This document research use PRISMA (Figure 1) by start with define research objectives and define inclusion & exclusion criteria (Table 2). Next, we will use keyword for searching strategy as “Transport” AND “Clustering” to find total of article then “Air transport” AND “Clustering” to find related article range in Thai database (Thai Digital Collection/ Thai Journals Online) and international database which written in English language (Emerald insight/ ScienceDirect/ IEEE Xplore/ Springer/ ACM Digital/ Hindawi/ MDPI). Then qualify all articles which match the established criteria and define topic of interest (in Table 4: Year, Continent, Application, Clustering for). After that analyze each qualified article. Finally conclude for objective and present obtained data by table and graph.

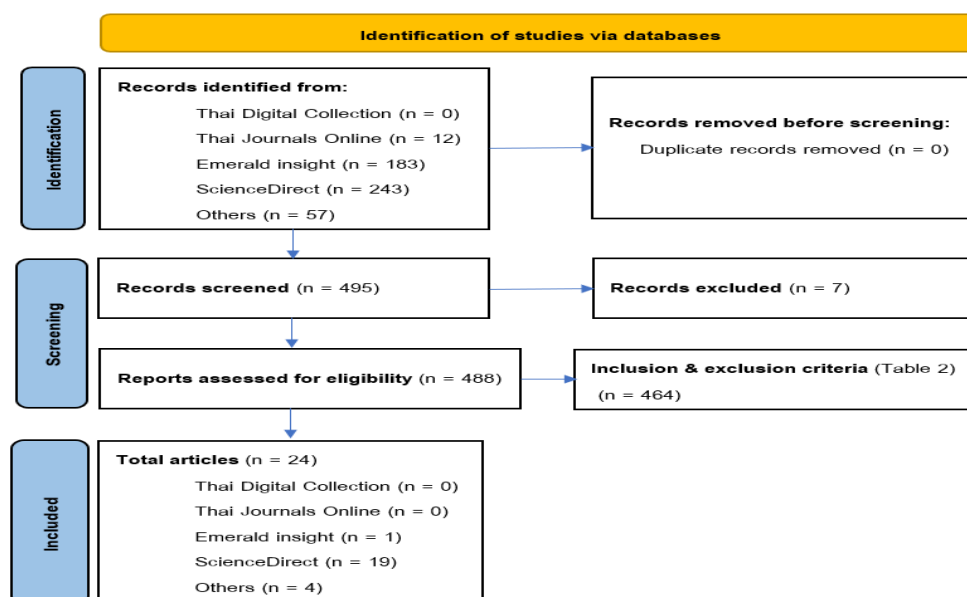
Table 2

Inclusion & Exclusion Criteria

Inclusion criteria	Exclusion criteria
Research article	Conference/ Thesis/ Final research report
Subject areas in social science/ business management	Not open access
Year between 2015 – 2025	Article on other clustering
K-mean clustering in air transport	Article in other language

Figure 1

The PRISMA Approach.



Results

After searching article from database and criteria mentioned above, found in table 3 that there is no article qualify in Thai database, mean while in international database we found in Emerald Insight 1 article from 183 articles (0.35%), ScienceDirect 19 articles from 243 articles (7.82%), and other 4 articles from 57 articles (7.02%). So, we have total 24 articles from 495 articles (4.84%).

Table 3

Articles Found in Database

Database	All article from database (Percentage)	All article qualifies with criteria (Percentage)
Thai Digital Collection	0 (0.00)	0 (0.00)
Thai Journals Online	12 (100)	0 (0.00)
Emerald insight	183 (100)	1 (0.35)
ScienceDirect	243 (100)	19 (7.82)
Others	57 (100)	4 (7.02)
Total	495 (100)	24 (4.84)

Table 4

Article Obtained

NO.	Author(s)	Year	Continent	Application	Clustering for
1	Mayer	2016	Europe	Airport	Cargo
2	Marta	2017	Europe	Airport	Passenger
3	Urban et al.	2018	Europe	Airline	Business operation
4	Migdadi	2019	Asia	Airline	Business operation
5	Budd et al.	2021	Europe	Airline	Passenger
6	Gao	2021	North America	Airport	Passenger
7	Liu et al.	2021	North America	Air traffic mgt	flight operations
8	Magdalena & Bouzaima	2021	Europe	Airline	Business operation
9	Pérez-Campuzano et al.	2022	Europe	Airline	Business operation
10	Kong et al.	2023	Asia	Airport	flight operations
11	Zhang et al.	2022	Asia	Airport	Delay
12	Renold et al.	2023	Europe	Airline	Business operation
13	Wei et al.	2023	Asia	Airport	Delay
14	Chandra et al.	2024	Asia	Air traffic mgt	flight operations
15	Devos et al.	2024	Europe	Airline	Passenger
16	Ersoz & Ucler	2024	Asia	Airline	Business operation
17	Hirabayashi et al.	2024	Asia	Air traffic mgt	flight operations
18	Passarella et al.	2024	Asia	Airport	flight operations
19	Kamsing et al.	2025	Asia	Air traffic mgt	Environment
20	Petit & Ribeiro	2025	Europe	Vertiport	Business operation
21	Puente & Lange	2025	Europe	Air cargo	Business operation
22	Senthilnathan et al.	2025	Asia/ North America	Air taxi	Business operation
23	Wang et al.	2025	Asia	Airport	Accident/ Risk
24	Wendel et al.	2025	Europe	Airline	Business operation

Table 4 informs article obtained in air transport be K-mean clustering in the first column shows Year, Continent, Application, and Clustering for, respectively. The analysis of this table is show in figure 1-4.

Figure 2

Frequency of Articles Between Year 2015 – 2025

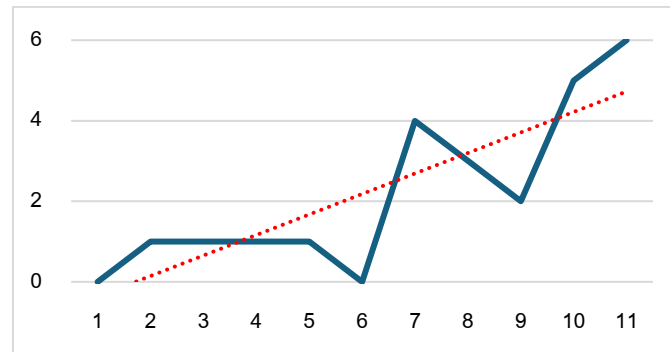


Figure 2 horizontal axis: 1 means year 2015, 2 mean year 2016, until 11 means year 2025. Vertical axis is frequency of articles each year. Year with the least research article (no research passed the criteria) are year 2015 and 2020. The year with the most research is 6 articles in year 2025.

Figure 3

Frequency of Author(s) in Each Continent

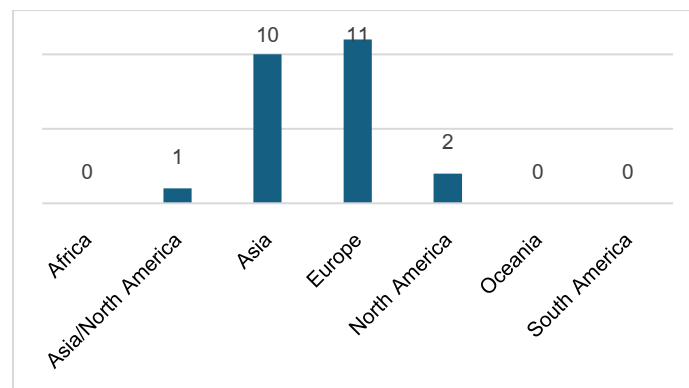


Figure 3 horizontal axis shows continent. The most frequency of author(s) is 11 author(s) from Europe, the lowest frequency of author(s) is 0 author(s) (no author) from Africa, Oceania, and South America.

Figure 4

Frequency of Application in Air Transport K-Mean Clustering

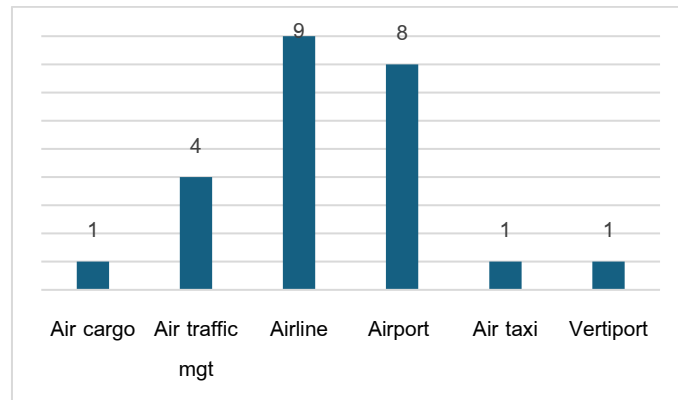


Figure 4 horizontal axis shows application in air transport. The most frequency of application in air transport by K-mean clustering is 9 in Airline, the lowest frequency of application in air transport by K-mean clustering is 1 in air cargo, air taxi, and vertiport.

Figure 5

Frequency of Clustering Purpose

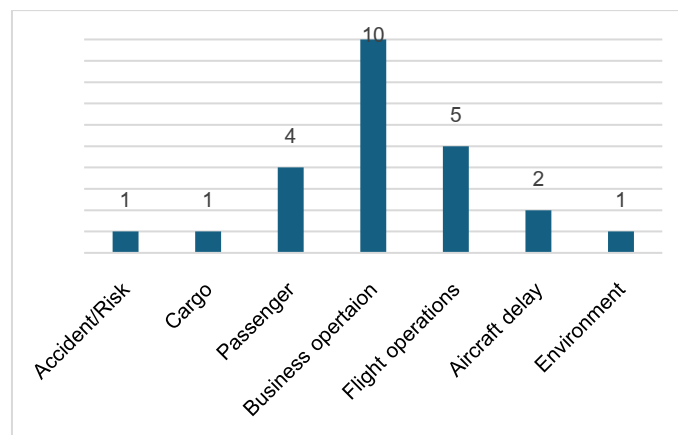


Figure 5 horizontal axis shows clustering purpose. The most frequency in air transport by K-mean clustering purpose is 10 is Business operation, the lowest frequency in air transport by K-mean clustering purpose is 1 in Accident/ Risk, Cargo, and Environment.

Table 5*Variable of K-Mean Clustering in Each Purpose*

Purpose	Author(s) (Year)	Variables
Accident/ Risk	Wang et al. (2025)	Personnel and equipment / Management / Environment
Business operation	Urban et al. (2018). Migdadi (2019).Magdalina & Bouzaima (2021). Pérez-Campuzano et al. (2022) . Renold et al. (2023). Ersoz & Ucler (2024). Petit & Ribeiro (2025). Puente & Lange (2025). Senthilnathan et al. (2025). Wendel et al. (2025)	Product / Infrastructure / Financial / Fuel / Energy / Pricing / Alliance / Load factor / Available seat mile / Yield per passenger / Total operating fleet / Airspace / Drone payload / Vertiport working hour / Capacity of vertiport / Total cargo flight / International flight / Domestic flight / Average flight per day / Number of passengers
Cargo	Mayer (2016)	Total cargo throughput / Cargo work load units / Freight aircraft movement / International cargo
Aircraft delay	Zhang et al. (2022). Wei et al. (2023).	Actual departure time / Actual arrival time / Schedule departure time / Schedule arrival time / Geographical location / Runway operational capacity / Flight operations
Environment Flight operations	Kamsing et al. (2025) Liu et al. (2021). Kong et al. (2023). Chandra et al. (2024). Hirabayashi et.al. (2024). Passarella et al. (2024)	Velocity/ Heading/ Barometric altitude/ Month Miles-in-trail (MIT) / Airspace flow programs (AFP) / Special activity airspace (SAA) / Daily arrival traffic / Daily departure traffic / Daily total traffic
Passenger	Žambochová (2017). Budd et al. (2021) Gao (2021). Devos et al. (2024)	Passenger movement per month / Passenger per year / Age / Gender / Employ status / Attitudes towards air travel / Airport experience

Table 5 inform variable of K-mean clustering in each purpose in Accident/ Risk, Business operation, Cargo, Delay, Environment, Flight operations, and Passenger.

Conclusion and Discussion

From the first objective to study the application of K-mean clustering in air transport, we can find in figure 4 K-mean clustering is applied in air cargo, air taxi, air traffic management, airline, airport, and vertiport. The second objective to find variable use in K-mean clustering purpose, we can find in table 5 there are a lot of variables used such as personnel and equipment/ management/ environment in purpose of exploring

accident/ risk. Fuel/ load factor/ available seat mile/ total cargo flight/ number of passengers etc. in purpose of business operation. Total cargo throughput/ cargo workload units/ freighter aircraft movement/ international cargo in cargo transport. Actual departure time/ actual arrival time/ schedule departure time/ schedule arrival time in predictive aircraft delay. Velocity/ heading/ barometric altitude/ month in environment emission. Daily arrival traffic/ daily departure traffic/ daily total traffic in flight operation. Lastly Passenger movement per month/ passenger per year/ age etc. in passenger movement.

In figure 2 frequency of articles between year 2015 – 2025 is an upward trendline, its consistency with Ray (2025) said K-mean is 7 out of 10 in machine learning algorithm in 2025 and Bajpai et.al. (2025) said K-means is one of the most popular and effective partitional clustering algorithms, it is not surprising why the trendline is upward. Figure 3 frequency of author(s) in each Continent the first one is in Europe and Asia is follow behind in second one its consistency with Jsoncrew (2025) said the current leaders are the top countries by coding skills are China, Russia and Poland. Figure 4 frequency of application in air transport K-mean clustering is airline, its consistency with Transportation & logistic international (2025) said in 2025 is the surpassing of five billion passengers - a 6.7% increase compared to 2024 and Airports council international (2025) said from 2024 to 2043, global passenger traffic is projected to grow at a compound annual growth rate in this two-reason author(s) may see the opportunity to conduct research for responding to mentioned trend. Figure 5 the most frequency in air transport by K-mean clustering purpose is business operation, its consistency with Metcalf (2025) said the importance of business operations are efficiency, sales, profit, and customer satisfaction then author(s) may see opportunity to conduct research for responding to that reason.

We have found interesting topic from Senthilnathan et al. (2025) in air taxi by applied K-mean clustering for business operation focuses on determining optimal locations for establishing electric vertical take-off and landing air taxi infrastructure sites in urban cities. From Petit & Ribeiro (2025) in vertiport by applied K-mean clustering for business operation to analyze on the implementation of a middle-mile delivery, urban air mobility network by identifying optimal locations for vertiports.

Suggestion, from this research we should focus more detail in air transport along with other algorithm such as Random forest, Neural networks, Naive Bayes etc. and also focus in air transport accident. Finally, future research should be in area of clustering for air cargo, air traffic management, airline, and airport area by using variable in table 5 along with new variable should add narrow research gaps and achieve new knowledge. Moreover, air taxi and vertiport should be in area of clustering about passenger's segmentation, air route, related infrastructure, and location to obtain new knowledge.

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