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A Literature Survey On Automated Teller Machine Cash Demand Analysis And Prediction In Financial Sector

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ABSTRACT
ATM is one of the most pressing issues in today's banking system. The popularity of a bank will decline if an ATM has a lack of cash, and this will lead to increased costs for the bank and a decrease in customer use of ATMs. In order to ensure which neither a consumer's transaction is refused due to the ATM being out of cash, nor the bank's profit potential is squandered, each ATMs cash must be well stocked. Managing the quantity of currency in an ATM is critical to any bank's ability to serve its customers. For the most part, banks use third-party cash management firms to keep ATMs topped up on a regular basis. They're doing a study to see whether analysis of the data and Machine Learning (ML) can be used to supplement the present system's mathematical capabilities. Hence, this paper provides a survey on researches of predicting the proper amount of ATM cash replenishment to ensure that the bare minimum of cash is always present until the next refill. ATMs daily cash limit is relatively a time series phenomenon but it is has difficulty in prediction. There'll be no client unhappiness as a result of an ATM cash out issue is addressed by employing a data driven technique to estimate the proper quantity for each ATM or set of ATMs, an ATM replenishment prediction machine learning approach.

KEYWORDS: ATM cash prediction, Machine learning approaches, Time series, Cash demand prediction, Replenishment amount, Cash out.

I. INTRODUCTION

Financial Institutions, through technology Machines, help to enable consumers to access and withdraw money their account without the assistance of a bank teller or staff are known as Automated Telling Machine (ATM). As customers use the ATM for their cash needs, it is essential part of banks to keep sufficient cash available in ATMs. Automated Telling Machine (ATM) cash replenishment is a well-known concern in banking business. It is necessary to reduce the number of ATMs that are out-of-cash and the period ATMs are unavailable to customers, in order to increase customer satisfaction. Many banks now contract with cash-in-transit providers to handle the cash management associated with automated teller machines. Armoured vehicles and people are used by cash in transit (CIT) businesses to execute ATM replenishment strategies that they have determined. It is possible for clients of multiple banks to do basic financial transactions using certain

ATMs. About 2.5 times as many Automated Teller Machines were installed throughout the globe in the previous decade.. Cash replenishment optimization is a well-known issue in ATM management, and it primarily focuses on the frequency and amount of cash that should be put into an ATM during each money replenishment period. Many institutions now use cash-in-transit (CIT) providers to handle the cash from automated teller machines (ATMs). Additionally, CIT corporations employ their own resources, including armoured vans and staff, to execute cash replenishment at ATMs of on-site or off-site. Now-a-days, advanced ATMs support both cash withdrawals and cash deposits, while traditional ATMs only allow cash withdrawals. As a result of the ATM replenishment plan, which includes operational expenses and opportunity costs, as well as service levels, the number of replenishment actions and the average cash inventory in ATMs will affect both costs and service levels.

II. LITERATURE REVIEW ON ATM CASH REPLENISHMENT

In designing model for predicting the cash needs of ATMs within a network for a single financial institution, Long-Short Term Memory (LSTM) Recurrent Neural Networks (RNN) were shown to perform better for this challenge when compared to our technique. The dataset utilised for this research was made up of the transactions made at seven ATMs in Karachi, Pakistan, between June 2013 and December 2015. Using the Symmetric Mean Absolute Percentage Error (SMAPE), the results of the trials may be reported [1]. Time Series Model for ATM is based on the ARIMA approach and uses time series data (TASM4ATM). The replenishment data from 2040 ATM is used to train the software. The model is compared to Recurrent Neural Networks and Amazon's Deep AR model. Predicting ATMs may be done in two ways: a single ATM and a cluster of ATMs[2]. Predicting the ATM cash replenishment amount is one such difficulty, ensuring that the minimal quantity of cash is always present before the next replacement. There'll be no client unhappiness as a result of an ATM that is always cash filled. For this issue, the Root Mean Squared Error (RMSE) of the Long Short-Term Memory (LSTM) model is 132.53, which is positive. They expect to cluster ATMs based on transaction patterns and cash demand similarities in order to predict a cash supply. It is possible to utilise a basic model to service a large number of ATMs in this manner [3]. When considering replenishment expenses as well as stock-outs, an ideal restocking strategy aims to reduce overall money holding and customer discontent costs to a minimum. The replenishment approach takes into account the fact that future financial needs are not known at the outset of the planning process. Rather than making point forecasts, they employ prediction intervals to account for unknown future cash needs, and then apply robust optimization and linear programming to address the issue of replenishing currency. Retroactive ATM cash withdraw data is used to assess the effectiveness of various refilling strategies [4].

Predicting NN5 cash needs using support vector machines (SVMs) as the most promising machine learning approach. This study's major objective is to predict NN5 time series utilizing support vector regression, followed by calculating Root Mean Square Error. Clustering is used in ATM cash prediction pre-processing to enhance the RMSE, according to unsupervised learning (clustering)[5]. Use of the scenario for tackling particular banking problems, such as maximising ATM demand and projecting contact centre and cash centre workload is discussed [6]. When replenishment falls on a weekend or holiday, security agencies' fees go substantially. Using the suggested technique, the operation of replenishment may be controlled in order to reduce the cost of replenishing in a dynamic cash demand situation. Using our suggested technique, they were able to lower ATM operating costs compared to the current state-of-the-art cash demand forecast systems, as shown by experiment results [7]. Minimum cost routes are established in accordance with time limitations and population coverage limits for ATMs refilled. For each of the 237,604 people who have used an ATM in the real world, they've produced a fresh set of synthetic data and evaluated it against the real-world data collected from up to 98 of those ATMs. When the Population Coverage Requirements vary, our findings for real-life cases show considerable variances in the cost of restocking ATMs in seven major Dutch cities [8].

ATMs serve as a point of contact between banks and their actual consumers. Renouncing interest is heightened when currency is kept in a tangible form. Customer satisfaction, on the other hand, need a financial reserve. A cost function for replenishment optimization is proposed in this study, which shows that daily cash withdrawals are predictable. Experiments have shown that the suggested model significantly reduces idle balance [9]. Using the planned technology, banks will be able to refill ATM currency more precisely than ever before. With this approach, banks may lower the amount of interest paid to the Central Bank by analysing the withdrawal patterns of each ATM and predicting the quantity of currency notes that need to be replaced in the ATM [10].

Customers and banks avail benefit from the increased usage of ATMs, especially in cash access from their accounts. Despite this, banks face higher ATM administration expenses. Cash replenishment optimization is a well-known issue in ATM management, and it primarily concerns how often and how much cash should be fed into an ATM during each cash replenishment period [11]. By balancing these elements, ATM replenishment optimization may be achieved. By arriving a balanced amounts of cash in ATMs, will decrease customer satisfaction as well as increase revenue to bank. To avoid an out-of-money issue, the needed quantity is always available and to solve the ATM cash replacement issue, there are two steps: estimating the daily amount of withdrawals, and determining the best timetable for replenishing the ATMs' cash. They presume that an accurate prediction for money withdrawals is provided in this work [12].

ATMs grouped together to handle a variety of functions are known as a cluster. Colonial-ized areas like business districts, hospitals, and so on are most prominent. The following methods for replenishing ATMs with cash are used: a) to reduce the value of fake money b) increase the likelihood of financial gain c) as a means to better satisfy clients. In order to determine the total norm volume of transactions of each ATM and construct a detachable cluster model for each group, divide the ATMs into two aggregate groups (high range transaction quantity or low range transaction amount) using historical data spanning six-month periods [13]. For ATM cash replenishment, banks seek to save resources while still accommodating the varying needs of their customers.. The daily cash replenishment of individual ATMs was previously modelled using an exponential weighted moving average approach. As the number of variables increases, these techniques may not function as effectively. The ATM cash replenishment process may be predicted based on the present cash demand using evolutionary computing approaches. As a stand-alone method or in combination with an intelligent strategy, the aforementioned may be achieved[14]. These parameters may be tweaked to keep replenishment, storage, and lost-sale expenses to a minimum. Fuel expenses and driver salaries are examples of replenishment costs, which are incurred when ATMs need to be restocked. It's possible that the ATM's holding charges reflect interest that would have been earned if the money had been held elsewhere. Finally, they refer to lost-sales costs as the expenses incurred when an ATM is unable to provide the required amount because one or more denominations have been depleted [15].

III. ATM CASH DEMAND FORECASTING – SURVEY SUMMARY

Sl. no	Paper title	Author	Technique used	Findings (Result)	Remarks
1.	ATM cash prediction using time series approach	Rafi et.al	VAR-MAX model is built for each ATM based on transaction data, which is then used to predict future ATM performance.	RMSE of 358950.12 was established by comparing the outcomes of identical ATM datasets across 2.5 million transactions.	Need very long time
2.	Towards optimal ATM cash replenishment utilizing time series analysis	Rafi et.al	Using the ARIMA technique to time series data, this paper presents an ARIMA Time Series model for ATMs (TASM4ATM). Six banking organisations' ATM back-end refill data was used in this inquiry.	In comparison to the other models examined, the suggested model generated an average of 7.86/7.99 MAPE / SMAPE errors on individual ATMs and 6.57/6.64 on clusters of ATMs.	inaccuracy
3.	A LSTM Based Model for Predicting ATM	Azad et.al	adopting a data-driven method for the estimate of the proper quantity for	Determining the appropriate quantity of cash to have on hand for	Inefficient prediction

	Replenishment Amount		each ATM or a set of ATMs, a machine learning technique	transactions is a difficult subject.	
4.	Optimal ATM replenishment policies under demand uncertainty. Operational Research	Ekinci et,al	Rather than creating point estimates, they use robust optimisation using linear programming to cope with unexpected future cash demands.	Uses prediction intervals to allow for uncertainty in future demand predictions while determining the best replenishment quantities for many ATMs belonging to the same bank. Robust optimization problems are handled to reduce maximal regrets.	Implementation cost is high
5.	Clustered support vector machine for ATM cash repository forecasting	Jadwal et.al	The 'k-means' clustering approach was used to cluster ATMs in order to perform the clustered SVM for ATM cash repository. The mean square error (rmse for ATM clusters is used to compare this error to the efficiency of a simple baseline Svm Classifier model.	When ATMs were grouped before applying SVR, the RMSE was reduced. When comparable ATMs are clustered into ideal clusters, machine learning algorithms may be trained more effectively, resulting in more accurate forecasts.	Prediction error is high
6.	Predicting Time Series in the Banking Sector Using a Machine Learning Pipeline	Gorodetskaya et.al	Maximising ATM demand and anticipating call centre and cash centre load may both be accomplished using the scenario that	It is being investigated if the scenario produced can be used to solve particular banking activities in order to increase company efficiency, including maximising demand	Need very long time

			has been constructed.	for ATMs and anticipating the load on the contact centre and cash centre.	
7.	Optimal ATM Cash Replenishment Planning in a Smart City using Deep Q-Network	Kiyaei et.al	Deep Q-Network replenishment is used to regulate ATM cash replenishment operations to reduce refill costs in a dynamic cash demand environment where the cash demand fluctuates daily.	In order to obtain Cash demand dynamic status is learned by using a deep learning component and an action-value function is learned by using a Q-learning component. However, in the true execution of the system, the two components are combined as a single unit.	Computational complexity is greater
8.	ATM cash replenishment under varying population coverage requirements	Chiussi et.al	The population coverage of the refreshed ATMs and the length of each route are used to create a list of minimum-cost routes.	Since the PCRs varies in seven main Dutch cities, there are substantial discrepancies in restocking ATMs in real life.	Data organisation is difficult
9.	ATM Cash Flow Prediction and Replenishment Optimization with ANN	Serengil et.al	ATMs serve as physical interfaces between banks and their consumers. Renouncing interest is piqued when tangible currency is stored.	They'll demonstrate the predictability of daily cash withdrawals and provide a cost function for optimising replenishment	Inefficient prediction
10.	ATM Cash Replenishment Prediction Analyzing and	Abeygunawardene et.al	Automated Teller Machines (ATMs) at banks have made deposits and	With this approach, banks may lower the amount of interest paid to the	Prediction error is high

	forecasting Cash For ATMs In Order To Optimise the Replenishment pro cess		withdrawals of cash more easier for consumers who visit the establishment.	Central Bank by analysing the withdrawal patterns of each ATM and predicting the quantity of currency notes that need to be replaced in the ATM.	
11.	Dynamic programming solution to atm cash replenishment optimization problem	Ozer et.al	The proposed method uses matrix chain multiplication by mapping the matrices to the daily ATM cash requirements.	Assuming accurate projections of withdrawal amounts are available, we concentrate our efforts on determining the best time to refill our bank accounts with cash.	inaccuracy
12.	Comparison of Integer Linear Programming and Dynamic Programming Approaches for ATM Cash Replenishment Optimization Problem	Ozer et.al	Assume that ATM cash needs have previously been forecasted in a trustworthy manner. Authors suggest a dynamic programming approach after providing linear programming-based techniques.	The objective is to come up with a replenishment strategy that keeps the ATM stocked with cash and keeps the cost of replenishment as low as possible for a certain number of days, loading fees, and interest expenses.	Implementation cost is high
13.	ATM Cash Replenishment with Clustering Series.	Vishwakarma et.al	ATMs should be clustered according to withdrawal trends, and LSTM aids in the reduction of unused cash without negatively impacting the user	The LSTM architecture is designed to maximise the demand for ATM cash based on daily estimates for the following 31 days. Logistics costs and	Computational complexity is greater

			experience by predicting future cash requests and recommending the most optimal locations	underflow predictions are taken into account.	
14.	Evolutionary computing applied to solve some operational issues in banks	Krishna et.al	ESO techniques may be used to handle bank operational problems such portfolio management, bankruptcy forecasting, FX price forecasting, gridlock resolution, and ATM cash replenishment.	Some operational problems in banks may be solved with the use of evolutionary and swarm optimization methods, which provide global or near-global optimum answers.	Prediction error is high
15.	Replenishment and denomination mix of ATM with dynamic forecast demands	van der Heide et.al	According to our findings, the operating expenses of administering an ATM may be lowered by 21% or €153.77 per Atms per month average by using the time-varying denomination mix.	ATMs may be able to provide clients with the option of choosing their own combination of denominations or letting the ATM do the work for them. As an alternative, one might use a heuristic, which is a less time-consuming strategy	inaccuracy
16.	Determinants of Automated Teller Machine Loading Demand Requirements in Sri Lankan Cash Supply Chains	Perera et.al	To develop a prediction model for a specific ATM, regression analysis or time series analysis may be employed; the latter technique is suggested.	There are a number of unpredicted social and cultural elements that might influence ATM cash withdrawal decisions.	Prediction error is high

17.	ATM Cash Management as a Critical and Data-intensive Application	Velivasaki et.al	Using current big data & streaming analytic technologies, an ATM cash management application may be built on top of them. Taking use of their capabilities while also addressing specific application requirements and delivering value to the Banking and Financial Services Insurance application space.	Changes in external variables impacting ATM cash withdrawals may be detected by the proposed method in both anticipated and unexpected ways.	Implementation cost is high
18.	An averaging approach to individual time series employing econometric models: a case study on NN5 ATM transactions data	Cedolin et.al	Using aggregated time data from an ATM network, it suggests a viable decision-making method. this study is to improve the ATM cash demand forecasting problem's computing efficiency**.**	By locating the cluster of ATMs where the aggregated series' forecasting results are suitable, the goal is to reduce the predicted number of ATMs**.**	Need very long time
19.	Data-Driven Cash Replenishment Planning of Recycling ATMs with Out-of-Cash and Full-of-Cash Risks	Zhou et.al	Utilizing sales and inventory data, the model established in this study can estimate replenishment schedules and amounts, lowering costs and raising service levels.	To estimate the safety stock and replenishment amount, the model provides a standard level of service for all ATMs. A significant future expansion to this study is a combinatorial	Data organization is difficult

				optimization issue that occurs when considering various service levels for several ATMs.	
20.	Automated teller machine replenishment policies with submodular costs	Zhang et.al	They built an MDP model and used dynamic programming to infer many structural characteristics of the best strategy.	They used a real-world dataset of 139 ATMs, which included daily cash withdrawal data going back 20 months. With better service, they were able to demonstrate via a numerical research that index policy may save costs by 35% – 40%	Computational complexity is greater

IV. ATM CASH DEMAND FORECASTING USING TIME SERIES APPROACH

When employing a time series technique to anticipate ATM cash flows, statistical models like auto regression, regression-averaging, and vector auto regression-averaging with exogenous variables (VARMAX) are all used. Information is divided 71/29 for training and testing in our technique, which is highly unlikely to be divide at a proportion greater than 29/71 for training and validation in the normally specified way. Previous methods used a Moving Average (MA) technique, which is not a viable way to make information stable. Information differentiation is used in our technique to cope with a similar issue: "Computes the distance between a Data Frame component and another Data Frame element" [26]. To eliminate the trend and bring the series to a stable, differencing and power conversions are frequently employed [25]. (P, d, q) is a norm used in the ARIMA model, where'd' is the amount of integrations (i.e., differentiations) necessary to make information stable. ARIMA models may then be applied to time series information that has been stable using the Moving Average initially. In order to use ARIMA, researchers used the original information to build a model and then predicted the outcome. To put it another way, it's found that the findings are good enough to go forward.

Automated Teller Machine cash demand forecasting requirements have been set for developing and developed countries alike, regardless of economic condition. ATM cash demand has been forecasted using a number of methods, depending on the severity of the ATM industry. A clustered ATM can get accurate withdrawal quantities based on similar weekly withdrawal patterns using an artificial neural network based on time series. General Regression Neural Network is regarded the best option for anticipating the demand for ATM cash. [16]. Cash demand and possible temporal trends may be gleaned from the data gleaned from ATMs. Cash balance information, such as the location, amount entered upon replenishment, and date, will be included in the ATM stream. Each ATM's cash balance will also be included.There are no important changes predicted in the ATM data in the next few seconds, thus an update pace of a few minutes is acceptable [17].

Researchers present decision-making techniques that use aggregated ATMs time series. By selecting the cluster of ATMs where the aggregate series' forecasts are appropriate to use. They hope to minimise the ATM Cash forecasted by independent modelling approaches. Automatic moving average and seasonal SARIMA are used to fit time series data. The use of averaged time series simplifies the forecasting procedure for each ATM. It is feasible to discover ATMs that may be projected using this strategy by averaging data[18]. ATMs that enable cash deposits and withdrawals are replenished in a particular (s, S) inventory model, with two safety stocks, one for out-of-stock and one for full-stock risks, which determines the ATM locations that must be supplied each day and the amount of money that must be replaced [19], [20] and to develop an ATM replenishment strategy for a bank with a large number of ATMs. The goal is to reduce the costs of replenishments and cash outs, taking account the economy of scale involved with restocking cash several ATMs at once.. Restocking costs often rise when a third-party provider is engaged for cash replenishment schedule design approach for financial institutions. To determine which ATMs to refill, the replenishment scheduling took into consideration the total cash inventories at all ATMs, as well as the demands of the network and the associated expenses.

V. TRENDS IN ATM CASH FORECASTING MANGEMENT

a) Notion of Artificial Intelligence

In the future, computers may be able to learn from their mistakes and enhance their effectiveness with artificial intelligence (AI) (including forecast or robot control). The degree to which some replies closely resemble the correct ones serves as a measure of precision. Data science has seen a surge in interest in artificial intelligence (AI) in recent years, particularly in the diagnosis of cardiovascular illness. [21], software architecture is built [22], and the discovery of recurring design patterns [23]. Guided, unsupervised, and evolutionary learning are all types of artificial intelligence (AI) methodologies.

b) Supervised Learning

It's also known as learning from exemplars and is a form of AI approach in which the proper answers (targets) are given to a training collection of instances and the methodology is then generalized so that it responds appropriately to any input. Techniques like Support Vector Machines as well as Lazy Learning and Neural Networks are included in this group. All of these methods use a unique algorithm.

c) Unsupervised Learning

There is no supervisor, and all they have is input information, in this group. Identifying the patterns in the input is the goal. The input space has a design that makes some patterns appear more frequently than others, and they want to observe what occurs in the input space on average and what fails to. This is known as computation in statistics. Grouping, Pearson Correlation, and Anomaly identification are 3 of the most common methods in this group, and they all make use of probabilistic, deterministic and timed-transition automation.

d) Evolutionary Learning

To find the best solution to the issue, these methods imitate the process of natural progression. A population of remedies may be steadily improved by using the benefits of options with varied levels of fitness. There are several evolutionary algorithms, including Genetic Algorithm, Particle Swarm Optimization (PSO), and Artificial Immune Systems (AIS), that focus on optimization (AIS).

e) Other Techniques

Some studies utilized a strategy for information retrieval that did not adhere to the categories indicated above, thus they included them in this category. Statistical and dimensionality minimization and quantitative optimization, a mathematical methodology, were applied in these methods.

f) Hybrid Techniques

Data mining methods exist for each of the previously listed categories, but many researchers choose to integrate these approaches in order to come up with a new strategy or a solution to various portions of their issue. As a result, a number of studies have been placed under this "Hybrid" category.

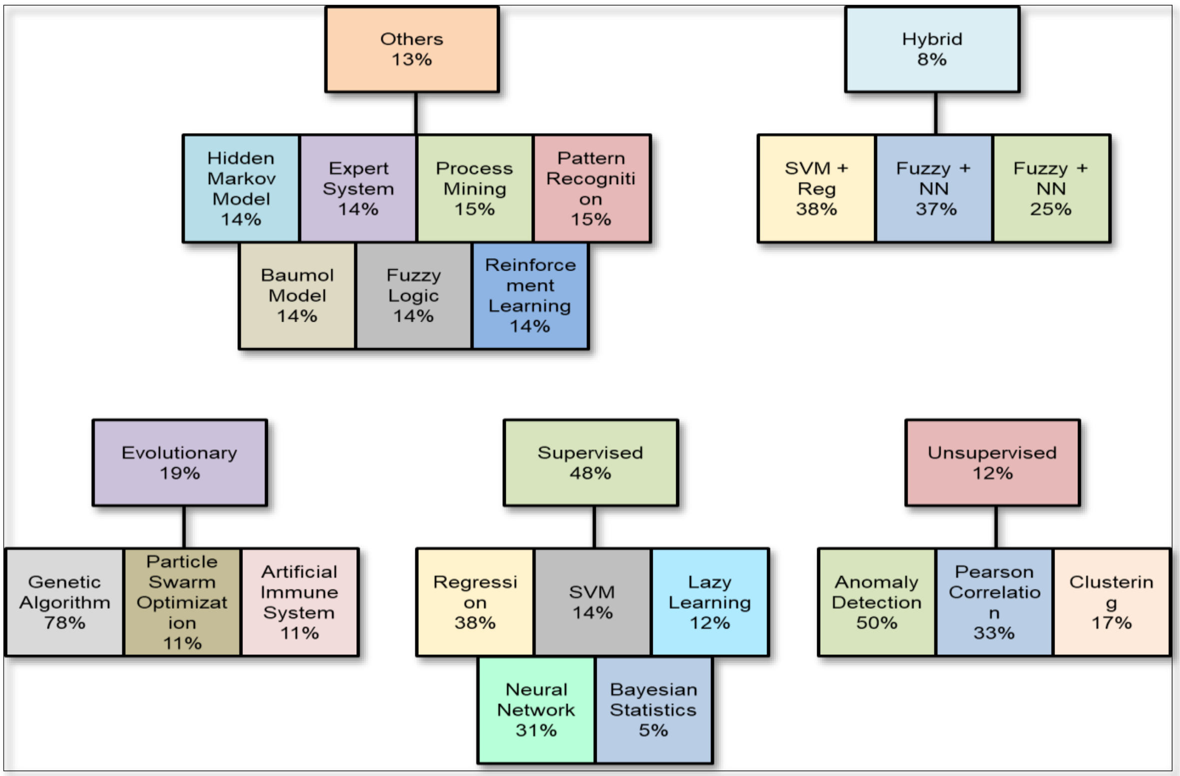

Figure 2.Rate of AI technique classification employed in ATM supervision [24]

VI. CONCLUSION

As more and more banks increase their ATM networks across the globe and voluminous transactional growth is recorded due to 'On-Us' and 'Off-Us' transaction, most regulators of countries show their special attention to make ATMs are functional, available to customers 24X7 and fully enabled with cash dispensing as per customers' demand. More monitoring is being exercised during the exigency time span like the present COVID lock-down (on and off extensions). Customer satisfaction and Return on Investment of ATM assets may be improved by using the reasonably good methodology, on ATM cash management. Clustering ATMs based on transaction patterns and cash demand similarities will be used to estimate cash demand in the future.

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