uCash: ATM Cash Management as a Critical and Data-intensive Application

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Abstract: Distributed cloud databases wrapped with streaming analytics modules provide nowadays quick response to increasingly demanding real-time applications, relying on fast analytical and online processing of enormous amounts of data or very frequently updated. However, time-critical applications, dealing with sensitive data, typically run on mainframes, cannot fully benefit from existing solutions. Such applications can be found in Banking, Financial Services and Insurance (BFSI) industry, one notable being the ATM cash management. The paper presents uCash, an ATM cash management system, running on top cloud analytics appliances, which can be hosted insite. The proposed system allows data processing and Key Performance Indicators (KPIs) calculation and communication among diverse actors, resulting in highly efficient cash management over large ATM networks.

1 INTRODUCTION

Even in the digital age, cash remains an essential component of the payment system, being the largest retail payment category by number of transaction for transactions under $10 (Reserve Bank of Australia, 2017). During the last few years, in their attempt to achieve mobility to better serve their customers, banks across the globe are investing on next-generation ATMs, featuring advanced capabilities and offering customers the ability to perform more types of financial transactions than the ones are currently handled by customer service representatives. This will create a whole new perspective of the user ATM experience, also increasing the spatiotemporal heterogeneity of the cash demand and the data produced by the ATMs, derived from the new business value propositions of these new ATMs (ATM Industry Association, 2018). Additionally, as user mobility increases, so does the complexity of predicting the expected user withdrawal and deposit transactions volumes.

Banks and financial institutes nowadays face significant challenges in managing effectively ATM replenishment, based primarily on static prediction algorithms. This results in high cash-out rates in certain ATMs, while having excess leftover cash in other ATMs, returned to banks. Accordingly, ineffective cash management in ATMs leads to considerable customer dissatisfaction due to delays until reloading empty ATMs, as well as complex and expensive cash logistics to reload the network.

Ideally, smart cash management should be able to catch cash demand, affected by external factors and not easily predictable, as e.g. the monthly salaries/pensions. For example, an ATM, located on the same level of a large shopping Mall as a store with special discounts for a single day only, could have increased cash flow. Also, cash demand in ATMs close to social events is expected to be higher than usual. Moreover, ATM traffic could be affected by combined factors, such as weather and location. Indicatively, ATMs close to beaches/seaside might realize increased demand during warm and sunny days or cash demand could decreased for any ATM during cold days. Another dependence can be found at seasonality, e.g. ATM cash demand is expected to grow during the days before bank holidays.

In this context, appropriate cash management is bound to ultra-fast analytics over huge datasets,

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produced by large interconnected ATM channel networks. Business objectives mandate for the capability of processing complex queries over thousands of columns of operational data, created by thousands of ATMs in the order of seconds.

On the other hand, strong data privacy and security requirements renders ATM cash management too critical to rely on existing clouds.

In this paper, ultra-fast ATM Cash Management system (uCash) is presented as a critical application, running on top of cloud analytics appliances, providing scalable operational databases, ultra-fast streaming analytics and/or big data analytics, while ensuring high availability. The proposed system is able to identify both expected and unexpected changes in external factors affecting cash withdrawal from ATMs. To this, the proposed system relies on streaming information received from ATM channels, the social media, cooperating retailers, social trending sites, the weather, financial services or other sources are properly exploited. Also, uCash should be smart enough to identify short- or long-term changes, affecting cash demand from ATMs, in order to feed accordingly the cash logistics.

The rest of the paper is organized as follows. Section 2 presents a general overview of the considered inputs. Section 3 introduces the uCash Architecture and Section 4 concludes the paper.

2 uCash SYSTEM DESIGN

uCash is intended for optimizing cash allocation in banks' ATM network, in order to minimize cash out events, excess cash left in low-demand machines, while increasing customers' satisfaction. So, it will provide the tools to interested parties to make decisions related to their responsibilities, communicate them to interested endpoints and visualize/share amounts to multiple parties simultaneously, thus enhancing communication among them, access to data and minimizing processing/communication latency or overhead. In brief, uCash will support cash demand prediction and cash allocation in a bank ATM network, based on advanced Big Data and Stream Processing analytics, while facilitating access to both data and processed results for eligible users.

2.1 Input and Output Streams

Figure 1 presents the input and output streams considered for the uCash system. Specifically, input streams include:

Figure 1: Inputs and outputs of the uCash System.

ATM Data: Information extracted by the ATMs can provide useful insights, regarding cash demand as well as potential temporal patterns. The ATM stream will include the cash balance for every ATM, along with accompanying info, such as the id of the ATM, its location, the amount of money inserted at replenishment, as well as the timestamp of operations. As ATM data are useful on a real-time basis, but no critical changes are expected within seconds, an update rate in the order of minutes is considered adequate.

Social Events: Social events may potentially affect the cash demand, especially in case of ATMs located close to the events' area. So, information about events taking place in short time in close locations may provide significant insights to cash demand predictions. In order to facilitate the prediction process, it is assumed that less popular events or events quite far from the ATM's area do not affect the ATM traffic, so they are not considered as input data. Specifically, the social events of interest:

- Collect a number of likes higher than a predefined threshold T_ℓ;
- Have number of attendees higher than a predefined threshold T_a;
- Take place on the same or the next day;
- Are close to the ATM area.

Social Trends: Current trends can provide useful insights on collective user behaviours, revealing potential correlations of everyday trends with ATM cash demand. So, uCash will consider the most popular social trends (hashtags) for a specific location as potential influencers of ATM cash demand.

Weather: Weather may impact on consumers' activities. In this perspective, rainy, sunny, warm or cold days could reveal, at some extent, people's willingness to socialize -and thus potentially withdraw cash- or stay at home. Information of

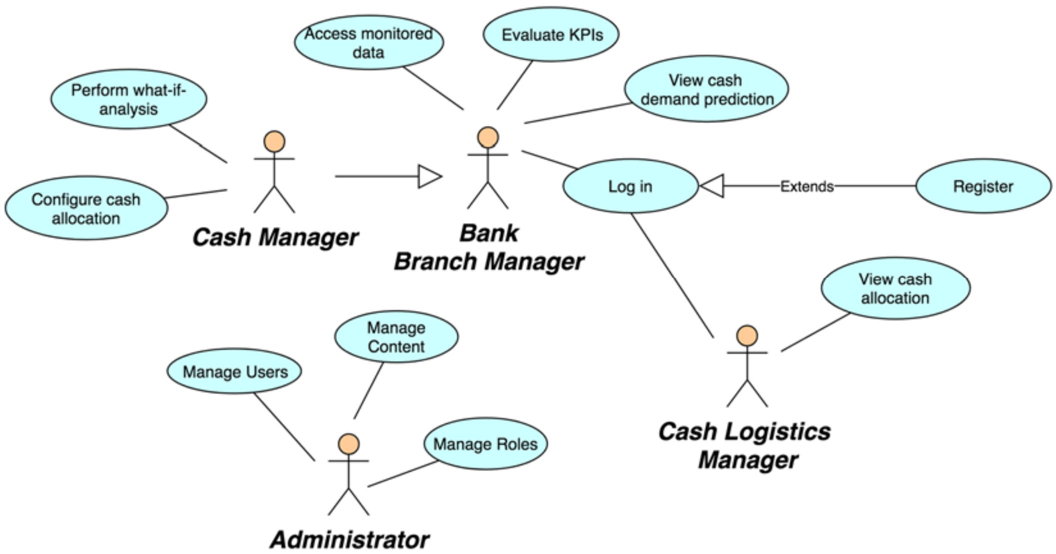

Figure 2: The uCash Use Case diagram.

interest refers to the weather forecast for the next 3 days, including the weather conditions' characterization (such as clear, rain, partly cloudy, snow, sunny, etc.).

Retailers' Discounts: The ATM traffic can be significantly affected by discounts announced by retailers having physical stores in close proximity with ATMs. uCash will offer an API to cooperating retailers to submit their sales or discounts.

These individual input streams with diverse dataset characteristics (such as frequency rates) are subject to pre-processing, which aggregate and synchronize diverse inputs, producing the system's input stream in a format favorable to Machine Learning (ML). Thus, the final input dataset is constructed as unstructured raw data with 1754 features with update frequency in the order of second.

The output streams include a set of KPIs and cash demand prediction. In more detail:

Cash Demand: The cash demand is extracted by the difference in cash balance, not including the amount of bank replenishments over a desired period of time for a desired ATM.

$$D(t_1, t_2) = B(t_1) - B(t_2) - \sum_{t=t_1}^{t_2} R(t)$$

where $D(t_1, t_2)$ is the cash demand during the period $[t_1, t_2]$, $B(t)$ the cash balance at the ATM of interest at time t and $R(t)$ the amount of refills at time t.

Cashout: An (operational) cashout is defined as the event in which an ATM runs out of money or its balance equals to 0. Its duration is defined as the period of time since the cashout took place (balance equal to below $T_c < T_B$), until the next replenishment.

$$Cashout\ is\ true\ \ for\ \ T_{\text{Cashout}} = t_2 - t_1$$

where $B(t) < T_B$ for $\forall t \in [t_1, t_2]$

$B(t)$ the cash balance at the ATM of interest at time t and

T_B the balance threshold below which the ATM is considered to realize a cashout.

Unavailable ATMs: The number of ATMs realizing a cashout over desired time period.

$$N_{ATM}(\exists t \in [t_1, t_2]: cashout(t) = true)$$

where N_{ATM} the number of unavailable ATMs within the period $[t_1, t_2]$.

ATM Downtime: The total duration of cashouts at a desired ATM over desired period of time.

$$T_{ATM}^{Down} = \sum_{\substack{t=t_A \\ B(t)<T_B}}^{t_B} t$$

where $B(t)$ the cash balance at the ATM of interest at time t and T_B the balance threshold below which the ATM is considered to realize a cashout.

Leftover Cash: "Leftover cash" is defined as the ATM balance at the time of replenishment. The KPI provides the total amount of leftover money for a desired ATM over a desired period of time.

$$Leftover = B(t)$$

$$for\ refill(t) > 0\ and\ t \in [t_1, t_2]$$

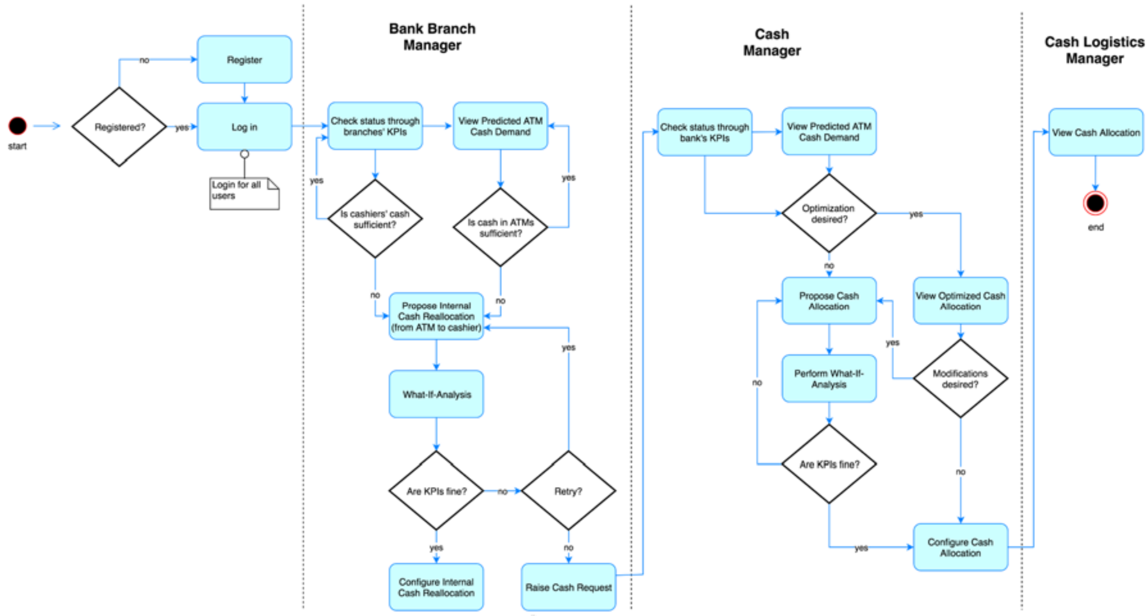

Figure 3: The uCash activity diagram.

where $B(t)$ the cash balance at the ATM of interest at the time t of refill.

2.2 uCash Use Case Analysis

The uCash system involves the following actors:
The **Bank Branch Manager.** The main responsibilities of the Bank Branch Manager which will be primarily enhanced via the ATM Cash Management system are the following:

- Ensuring there is adequate cash for each of the tellers and automated teller machines.
- Developing forecasts, financial objectives and business plans.
- Monitoring branch targets.
- Reposting to head office

The **Cash Manager.** The main responsibilities of the Cash Manager which will be primarily enhanced via the ATM Cash Management system are the following:

- Organizing daily cash administration.
- Timely matching cash application and disbursements.
- Monitoring cash transactions to ensure that bank account balances to the report and any unusual items are investigated.
- Forecasting, monitoring and tracking cash flow on preferred basis.
- Preparing cash flow reports
- Maintaining security and confidentiality of financial records.

The **Cash Logistics Manager.** The main responsibilities of the Cash Logistics Manager which will be primarily enhanced includes the organization of cash distribution.

(ATM Cash Management System) Administrator. The Administrator will be able to manage access of specific user types to the ATM Cash Management system data.

2.2.1 Use Case Diagram

The UML use case diagram is presented in Figure 2. The use cases considered are analyzed as follows.

Log in: The user should be able to log in the uCash application, to access personal or their user type related data.

Register: The user should be able to register in the uCash application, according to their user type.

Access Monitored Data: The user should be able to visualize both historical and real-time input datasets input datasets in a user-friendly way, e.g. diagrams allowing for configuration enhancing readership (e.g. sorting, filtering, etc.). Access to datasets might be restricted per user type (actor).

Evaluate KPIs: The user should be able to visualize in a user-friendly format the KPIs calculated out of input datasets, based on their field of expertise revealed from user type (actor). Configuration of visualization format should be possible to facilitate user's perception of data.

View Cash Demand Prediction: The user should be able to visualize in a user-friendly format predictions of the cash demand in the ATMs of their interest, based on actor type.

Configure Cash Allocation: The user should be able to verify or change cash allocation proposed by the system.

Perform What-If-Analysis: The user should be able to perform what-if-analysis of custom cash allocations changes, showing effects on KPIs of interest.

View Cash Allocation: The authorized user should be able to visualize optimized cash allocation to ATMs on demand.

Manage Users: The authorized user should be able to manage users' registration, validate or disapprove their account.

Manage Content: The Administrator should be able to manage the content shown for each user type.

Manage Roles: The Administrator should be able to manage the content shown for each user type.

2.2.2 Operations Analysis

The sequence of operations is presented in the activity diagram of Figure 3. In more detail, the process is the following:

- After sign-in, the Bank Branch Manager checks the availability of cash for both ATMs and cashier.
- If the cash is not enough, the Bank Branch Manager may try to perform some cash reallocation between the two channels (ATMs and cashiers), after what-if-analysis, based on predicted cash demand.
- The Bank Branch Manager may make several tries, checking resulting KPIs before actually performing cash reallocation or she may raise a cash request.
- The (central) Cash Manager may automatically optimize cash allocation or she may prefer to do this manually, after performing what-if-analysis of potential allocation schemas.
- Even when selecting automatic cash allocation optimization, the Cash Manager will evaluate the result and propose any modifications, if desired, after proper what-if-analysis.
- Having decided about the cash allocation, the Cash Manager eventually configures cash allocation.

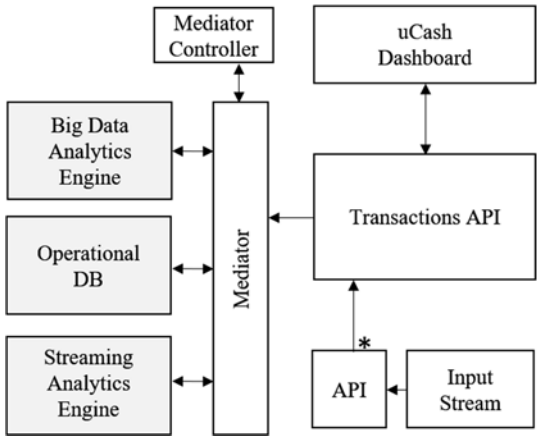

Figure 4: The uCash architecture.

Finally, the Cash Logistics Manager is able to view the configured cash allocation, in order to allocate cash to ATMs accordingly.

3 uCash ARCHITECTURE

uCash is aimed to exploit fast analytical and streaming processing capabilities of third-party frameworks, providing useful insights inferred through a number of KPIs calculated over large amounts of historical data or over frequently updated streams. As uCash constitutes a critical system, running on top of streaming and big data analytics engines, it realizes a modular, micro-services oriented architecture, able to easily integrate with third party solutions. The uCash architecture is depicted in Figure 4, in which uCash components appear in white color, while third-party components are colored in grey.

The main components of the uCash architecture include APIs for every input stream, the Input Streams Orchestrator, the Transactions' API, the uCash dashboard, the Mediator and the Mediator Controller.

Input API(s): These components are responsible for retrieving data from the input streams and providing them to the Transactions API.

Transactions API: This component is responsible for receiving and providing data or KPIs from/to interacting components. It receives the input data and forwards them to the Operational Database to be persisted, while it asks the analytics components (Big Data Analytics Engine and Streaming Analytics Engine) for KPIs, as properly defined queries, and provides them to the Dashboard.

Mediator: This component acts as an adaptation API, hiding the heterogeneity of third-party applications. It is responsible for making queries a) over streaming data, such as those involving moving windows, as well as retrieving the results, and b) over historical data, as well as retrieving the results. This component will not provide any intelligence in query processing, but it acts as a mediator between third-party components and uCash, requesting KPIs and transferring the results.

Mediator Controller: This component controls the mediator in the sense that it triggers KPIs' retrieval from the corresponding components.

uCash Dashboard: This component is responsible for authentication and authorization of users of different types, as well as for providing role-based access to content. Moreover, this component incorporates the User Interface (UI) functionality of uCash.

Following this modular architecture, uCash uses the Mediator to easily integrate with existing analytics systems. In the architecture of Figure 4, three external components are considered:

- An operational database, understood as a scalable database adequately supporting ACID (Atomicity, Consistency, Isolation, and Durability) properties for operational and analytic workloads and can scale in the three Vs of Big Data (Volume, Velocity and Variety).
- A scalable Big Data Analytics Engine, capable of processing fast analytical multidimensional queries over high-volume and variety streaming data.
- A scalable Streaming Analytics Engine, able to process fast continuous queries over high-frequency, volume and variety streaming data.

Indeed, uCash can work with a subset of the external components and can easily integrate existing, new or updated components.

4 CONCLUSIONS

uCash has been presented as a data-intensive and critical application. The aim of the design is to derive an ATM cash management application on top of existing big data and streaming analytics platforms, best exploiting their capabilities, while covering application specific needs and adding value to the targeted BFSI application domain. To this end, the design methodology includes specifications related to big data and streaming analytics (such as the input dataset and the KPIs), as well as the specification of the architecture.

Notably, the architecture allows the reception of specified input dataset and its pre-processing, if needed, while having the logic to ask the appropriate components to apply streaming or batch analytics over the operational or the historical data. In brief, the specified application adequately covers analytics over both operational and historical data, as well as functionalities of operational databases.

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REFERENCES

ATM Industry Association, 2018. *Business Value Propositions for Next Generation ATMs.* [Online] Available at: https://www.atmia.com/files/committees/consortium-for-next-gen-atms/bvps-for-next-generation-atms-published.pdf

Investopedia, 2017. *Gross Profit Margin.* [Online] Available at: http://www.investopedia.com/terms/g/gross_profit_margin.asp

Investopedia, 2017. *Price Elasticity of Demand.* [Online] Available at: http://www.investopedia.com/terms/p/priceelasticity.asp

Reserve Bank of Australia, 2017. *Reserve Bank Bulletin,* Sydney: s.n.