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Smart Bill Splitter with Expense Tracking

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Abstract

The rapid increase in shared financial activities among individuals in scenarios such as travel, accommodation, and social gatherings has created a need for efficient expense management systems. This paper presents a Smart Bill Splitting with Expense Tracking system that integrates intelligent computation techniques, optical character recognition (OCR), and real-time data synchronization to streamline group expense management. The proposed system enables users to input expenses manually or via automated receipt scanning, apply flexible bill-splitting strategies including equal, percentage-based, and custom divisions, and visualize financial data through interactive dashboards. Furthermore, a graph-based debt simplification algorithm minimizes the number of transactions required for settlement, thereby enhancing efficiency. The system is implemented using modern technologies such as Firebase Firestore, SQLite, and Razorpay APIs, ensuring scalability, reliability, and secure transaction handling. Experimental evaluation demonstrates that the system significantly reduces manual errors, improves transparency, and enhances user experience in collaborative financial environments.

Keywords: Smart Expense Management; Bill Splitting System; Expense Tracking; Optical Character Recognition (OCR); Debt Simplification; Graph-Based Optimization; Financial Analytics; Firebase; Razorpay Integration; Mobile Application Development.

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Introduction

With the rapid growth of digital transactions and group-based activities such as travel, dining, and shared living, managing expenses among multiple individuals has become increasingly complex. Traditional methods like manual calculations or basic note-taking often lead to errors, lack of transparency, and confusion among participants.

To address these challenges, this work introduces a smart bill splitting and expense tracking system that automates financial management within groups. The system integrates modern technologies such as cloud storage, Optical Character Recognition (OCR), and real-time synchronization to simplify expense recording and sharing.

Unlike conventional approaches, the developed system provides flexible expense division methods, including equal, percentage-based, and customized splitting. Additionally, it incorporates an optimized debt simplification mechanism that reduces unnecessary transactions between users. This improves both efficiency and user experience while ensuring accurate financial tracking.To overcome these limitations, the proposed Smart Bill Splitting with Expense Tracking system introduces a comprehensive, automated, and intelligent solution that integrates modern technologies such as Optical Character Recognition (OCR), cloud computing, and graph-based optimization.

The overall working of the system is divided into the following structured steps:

Step1: User Authentication and Group Creation The process begins with secure user authentication, where individuals register and log in using Firebase Authentication services. After successful authentication, users can create new groups or join existing groups where shared expenses will be managed. Each group acts as an independent financial environment containing members, expenses, and transaction records.

Step2: Expense Entry and Data Acquisition Once inside a group, users can add expenses either manually or by using OCR-based receipt scanning. In the OCR approach, users capture an image of the bill, and the system automatically extracts key details such as total amount, date, and expense category. This reduces manual effort and minimizes input errors.

Step3: Expense Validation and Categorization After data acquisition, the system validates the entered or extracted information to ensure accuracy and consistency. Expenses are then categorized into predefined groups such as food, travel, utilities, or miscellaneous. This categorization supports better organization and enables detailed financial analysis.

Step4: Bill Splitting Mechanism The validated expense is processed using flexible bill-splitting logic. Users can choose between equal splitting, percentage-based distribution, or custom-defined contributions. The system calculates individual shares dynamically and ensures that the total distributed amount matches the original expense.

Step5: Balance Computation and Update Following the splitting process, the system computes the net balance for each participant by comparing their contributions and liabilities. Each user's financial position is updated in real time, indicating whether they owe money or are entitled to receive payment.

Step6: Debt Simplification and Settlement Optimization To reduce the complexity of multiple transactions, the system applies a graph-based debt simplification algorithm. In this approach, users are represented as nodes and financial obligations as weighted edges. The algorithm analyzes the network of debts and eliminates redundant transactions by identifying optimal settlement paths. This ensures that the minimum number of transactions is required to settle all balances efficiently.

Step7: Payment Processing and Settlement Execution Once the optimized settlement plan is generated, users can complete transactions directly through the application using integrated payment gateways such as Razorpay. The system securely processes payments and updates transaction statuses in real time.

Step8: Notifications and Real-Time Updates The system utilizes Firebase Cloud Messaging to send real-time notifications regarding new expenses, pending payments, and completed settlements. This ensures that all users remain informed and engaged throughout the process.

Step9: Data Visualization and Financial Insights Finally, all expense data is presented through interactive dashboards and charts, enabling users to analyze their spending patterns, track category-wise expenses, and monitor outstanding balances. These insights help users make informed financial decisions and improve overall expense management.

By structuring the system into these well-defined steps, the proposed solution ensures a seamless, transparent, and efficient workflow for managing shared expenses. The integration of intelligent algorithms, automation techniques, and user-centric design significantly enhances the reliability and usability of the system, making it suitable for real-world financial collaboration scenarios.

Problem Statement

Despite the availability of various expense management tools, many existing solutions fail to address key challenges associated with shared financial activities. Manual expense tracking is inherently error-prone, often leading to incorrect calculations and confusion regarding individual contributions. In group scenarios, the complexity increases as multiple transactions occur simultaneously, making it difficult to maintain accurate records and track outstanding balances. Additionally, existing applications often require continuous internet connectivity, lack intuitive interfaces, or do not provide advanced features such as automated data extraction and intelligent debt optimization.

Another significant challenge is the lack of transparency in expense distribution, which can result in disputes among users. The absence of efficient mechanisms to minimize the number of settlement transactions further adds to the inconvenience. Therefore, there is a critical need for a comprehensive system that automates expense tracking, ensures accurate and fair distribution of costs, and provides clear and actionable insights into financial data. The proposed system aims to address these challenges by integrating advanced technologies and intelligent algorithms to deliver a robust and user-centric solution.

Proposed System and Architecture

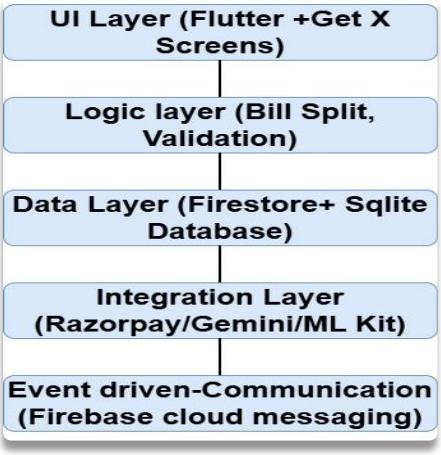

Fig. 1. *Layered Architecture of the Smart Bill Splitter and Expense Tracking System*

The proposed system is designed using a multi-layered architecture that ensures modularity, scalability, and efficient data processing. The User Interface Layer serves as the interaction point between the user and the system, providing an intuitive and responsive platform for entering expenses, viewing summaries, and managing groups. This layer is developed using Flutter, enabling cross-platform compatibility and a seamless user experience.

The Logic Layer forms the core of the system, where all computational processes are executed. This includes expense validation, bill-splitting calculations, categorization of expenses, and execution of the debt simplification algorithm. The layer is designed to handle complex scenarios efficiently, ensuring accurate and consistent results.

The Data Layer is responsible for storing and managing all relevant information, including user profiles, group data, expense records, and transaction histories. Firebase Firestore is utilized for cloud-based storage, providing real-time synchronization across devices, while SQLite is used for local storage to enable offline functionality. The Integration Layer connects the system with external services such as OCR modules for automated receipt scanning and Razorpay APIs for secure payment processing. The use of an event-driven communication model allows different components of the system to interact efficiently, ensuring flexibility and ease of future enhancements.

Literature Survey

The concept of expense management systems has gained significant attention with the rise of digital transactions and collaborative financial activities. Various researchers and developers have proposed solutions to simplify shared expense tracking, yet several limitations still exist in terms of automation, accuracy, and optimization.

Early studies on expense sharing primarily focused on basic record-keeping and manual calculation approaches. These systems allowed users to log expenses and divide costs equally among participants. However, such methods lacked flexibility and often resulted in inaccuracies when dealing with unequal contributions or complex group scenarios.

With the advancement of mobile and cloud technologies, modern applications such as Splitwise introduced automated expense tracking features. These platforms enabled users to record transactions, split bills, and monitor balances in real time. Despite their usability, they often depend heavily on manual data entry, which can lead to user errors and reduced efficiency.

Recent research has explored the integration of Optical Character Recognition (OCR) to automate data extraction from receipts. OCR-based systems reduce manual input by capturing expense details directly from images. While this approach improves convenience, challenges such as inaccurate text recognition and dependency on image quality still affect performance.

In addition, several studies have applied graph-based models to optimize debt settlement among users. These approaches treat participants as nodes and transactions as edges, enabling the identification of optimal settlement paths. Such techniques significantly reduce the number of transactions required, thereby improving efficiency in group financial management. However, many existing implementations do not integrate this feature seamlessly with real-time systems.

Cloud-based architectures have further enhanced the scalability and accessibility of expense tracking systems. By storing data on remote servers, users can access and update financial records from multiple devices. However, reliance on constant internet connectivity and concerns related to data security remain important considerations.

Overall, existing solutions provide a strong foundation for managing shared expenses but lack a unified system that combines automation, intelligent optimization, and real-time analytics. The proposed system addresses these gaps by integrating OCR-based data acquisition, flexible bill splitting mechanisms, graph-based debt simplification, and interactive visualization, thereby offering a more efficient and user-friendly solution for collaborative financial management.

Methodology

The methodology adopted for the proposed system involves a structured workflow that ensures efficient and accurate expense management. The process begins with user authentication, where individuals register and log in securely using Firebase Authentication services. Once authenticated, users can create or join groups to manage shared expenses collaboratively.

Expenses can be added either manually or through OCR-based receipt scanning, where the system extracts relevant information such as amount, date, and category from captured images. The extracted data is validated and processed by the system before being stored in the database. The bill-splitting mechanism is then applied, allowing users to choose between equal distribution, percentage-based allocation, or custom-defined shares.

Following the calculation of individual contributions, the system updates user balances in real time and applies a graph-based optimization technique to minimize the number of transactions required for settlement. The final results are presented through interactive dashboards, which display detailed insights into spending patterns, category-wise distribution, and outstanding balances. This systematic approach ensures accuracy, efficiency, and enhanced user experience.

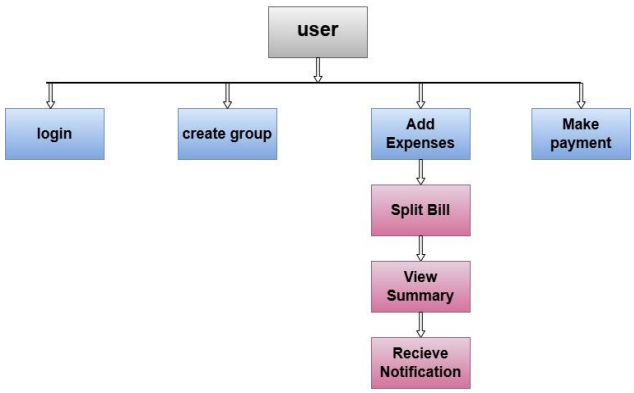

Fig. 2. *Smart Bill Splitter Workflow*

Algorithm

1. Bill Splitting Logic: In the developed system, expense distribution is handled dynamically based on the selected method. For equal splitting, the total amount is divided evenly among all participants. In percentage-based splitting, each user is assigned a specific share, and

the system calculates the corresponding amount automatically. Custom splitting allows users to manually define individual contributions. All calculations are validated to ensure the total distributed value matches the original expense.

2.Debt Optimization Approach: The system applies a graph-based technique to simplify financial settlements. Each user is treated as a node, and their balances are represented as weighted connections. By analyzing net balances, the system reduces unnecessary transactions and determines the most efficient way to settle debts with a minimum number of payments.

3. Expense Processing Mechanism: All expense entries, whether manual or OCR-based, are verified before storage. The system categorizes expenses into predefined groups, enabling better organization and analysis. Data is then stored in both cloud and local databases to ensure availability and consistency.

4.Payment Handling Process: Secure payment processing is achieved through integration with payment gateway APIs. The system manages transaction initiation, verification, and status updates while maintaining proper records for reliability and tracking.

5.Notification Mechanism: Real-time updates are provided using cloud messaging services. Users receive notifications for new expenses, pending settlements, and completed transactions, ensuring continuous awareness of financial activities.

6.Insight Generation Module: The system also includes a basic analytics component that evaluates historical expense data to provide useful insights. This helps users understand spending behavior and make better financial decisions.

Data Analysis and Visualization

The system incorporates advanced data visualization techniques to present financial information in a clear and intuitive manner. Interactive charts and graphs are used to display category-wise expense distribution, monthly spending trends, and individual contributions within a group. These visual representations enable users to quickly understand their financial behavior and identify areas for improvement. Real-time dashboards provide up-to-date information, ensuring that users always have access to the latest financial data. The use of visual analytics not only enhances user experience but also supports informed decision-making.

Example

Category	**Amount (₹)**
Food	4000
Travel	3000
Utilities	2000
Others	1000

Pie Chart

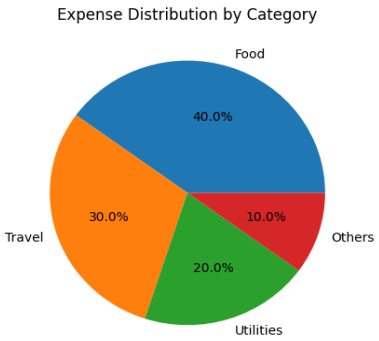

Fig. 3. *Expense Distribution by Category*

Explanation

The data visualization module presents expense distribution using graphical representations such as pie charts. The above figure illustrates the category-wise distribution of expenses within a group, where food expenses constitute the largest share at 40%, followed by travel at

30%, utilities at 20%, and other expenses at 10%. This visualization helps users quickly identify major spending areas and analyze their financial behavior. Such insights enable better budgeting decisions and improve overall financial transparency among group members.

Implementation

The implementation of the proposed system is carried out using a combination of modern technologies that ensure efficiency, scalability, and reliability. The frontend is developed using Flutter, which provides a responsive and visually appealing user interface. Firebase services are utilized for backend functionalities, including authentication, cloud storage, and real-time database management. SQLite is used for local data storage, enabling offline access to essential features. The integration of OCR technology allows automated data extraction from receipts, while Razorpay APIs facilitate secure payment processing. The system follows clean architecture principles, ensuring modularity, maintainability, and ease of future enhancements.

Results and Discussion

The developed system demonstrates significant improvements in managing shared expenses compared to traditional methods. The automation of expense tracking and bill splitting reduces manual effort and eliminates calculation errors. The graph-based debt simplification algorithm effectively minimizes the number of transactions required for settlement, improving efficiency. User feedback indicates high satisfaction with the system's ease of use, accuracy, and performance. The integration of visualization tools further enhances the user experience by providing clear and actionable insights into financial data.

Fig. 4. *Expense Splitting Result with Individual Balance*

Table 1. User Expense Settlement and Net Balance Summary

User	Paid	Owes	Net balance
A	1200	300	+900
B	0	300	-300
C	0	300	-300
D	0	300	-300

The system successfully performs accurate expense splitting and balance calculation among group members. The results clearly indicate individual contributions and outstanding balances, ensuring transparency. The graphical representation further helps users understand spending distribution. Overall, the system reduces manual effort and simplifies financial management in group scenarios

Future Scope

The proposed Smart Bill Splitting with Expense Tracking system demonstrates strong potential for further enhancement and scalability through the integration of advanced technologies and additional features. One of the key areas for improvement lies in the enhancement of

Optical Character Recognition (OCR) capabilities. By incorporating more accurate and robust OCR models, the system can achieve higher precision in extracting data from diverse bill formats, including handwritten receipts and low-quality images, thereby reducing dependency on manual corrections. Furthermore, implementing advanced machine learning-based OCR solutions can enable automatic categorization of expenses and intelligent detection of anomalies in billing data.

Another important direction for future development is the introduction of a fully functional offline mode. Enhancing offline capabilities using local databases and synchronization mechanisms would allow users to add and manage expenses without requiring continuous internet connectivity. Once the device reconnects to the internet, data can be seamlessly synchronized with cloud storage, ensuring consistency and reliability. This feature would significantly improve usability in areas with limited network access.

In addition to these improvements, the system can be extended by integrating more sophisticated Artificial Intelligence (AI) techniques to provide personalized financial insights, predictive expense analysis, and smart budgeting recommendations. The inclusion of voice-based expense entry and chatbot assistance can further enhance user interaction and accessibility. Expanding payment gateway support beyond existing integrations would enable more flexible and secure transaction options for users across different platforms.

Moreover, the application can be scaled to support larger groups and enterprise-level expense management by incorporating role-based access control, advanced reporting tools, and multi-currency support for international usage. Security enhancements such as biometric authentication and end-to-end encryption can also be implemented to strengthen data protection. Overall, these future enhancements aim to transform the system into a comprehensive, intelligent, and globally adaptable financial management platform.

Conclusion

The Smart Bill Splitting with Expense Tracking system provides a robust and efficient solution for managing shared financial activities. By integrating intelligent algorithms, OCR technology, and real-time data visualization, the system addresses the limitations of existing methods and enhances transparency, accuracy, and user experience. The proposed solution is scalable and adaptable, making it suitable for real-world applications in various collaborative environments. Future work may focus on expanding AI capabilities, improving offline functionality, and integrating additional payment gateways to further enhance the system's capabilities.

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