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AfriBit: A People-Oriented Wallet Fostering Financial Inclusion in Kibera

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***Abstract*—For many Western countries, access to a functioning banking system is taken for granted. However, many people in developing countries are still excluded from having a bank account for savings and worldwide money transfers. In the region of Kenya, MPesa has established itself as a mobile financial money service. This service provides a possible solution to mitigate some of the issues of financial exclusion and offers the possibility of accessing mobile banking services. This paper presents AfriBit, a wallet that addresses financial exclusion in Kibera, improves the user experience (UX), facilitates cryptocurrencies adaptation, and provides a feasible alternative to MPesa. AfriBit is evaluated based on a 20-person user study, with a group from Kibera and a group from Switzerland. The study involves real-world scenarios to gather qualitative and quantitative data on the new design changes. Our results have shown that the AfriBit wallet makes it easier to understand the application and solve tasks with less effort.**

***Index Terms*—Bitcoin, Cryptocurrency, Financial Inclusion, Usability, Wallet**

I. Introduction

It is usual in many Western countries to have access to a functioning banking system and a bank account for savings and money transfers. However, this is not always the case in the developing world: Kibera, one of Africa's largest slums, is a major example of financial exclusion [1]. Financial exclusion refers to the inability of certain societal groups to access suitable, affordable, equitable, and secure financial products and services from mainstream providers [2]. In such places, the lack of proximity to banking institutions poses a significant barrier to financial inclusion [3]. Many of the inhabitants of the slums across Africa simply do not have access to a bank account since there is no local bank nearby. Additionally, possessing a government identification document is required, which some African residents may not have [1]. Cryptocurrencies, particularly Bitcoin [4], present a solution toward financial inclusion, but they also introduce new challenges. Cryptocurrencies could eliminate the need for physical banks (and therefore, infrastructural issues) and in addition, protect against inflation. However, the technology introduces significant barriers to populations with limited technological education. In this regard, Kenya introduced a centralized digital currency termed *MPesa*, which is operated by Kenya's largest cellular phone provider Safaricom.

This paper presents *AfriBit*, a mobile Bitcoin Lightning wallet fostering a more inclusive financial system in Kibera. AfriBit presents a refactoring and redesign of an existing wallet, Blink, formerly known as Bitcoin Beach Wallet (BBW) [5], based on missing or unclear functionality. In a partnership with The Ronnie Fund [6], a local Kibera project, requirements were gathered (Section III) by letting the users in Kibera, Kenya, evaluate the existing wallet based on screenshots and provide feedback and feature requests. Two participant groups of ten people each, comprising residents from Kenya and Switzerland, were included in the study. The testing consisted of three tasks based on real-world usage scenarios, emphasizing speed (*i.e.*, how fast users execute tasks) and error reduction (*i.e.*, how many errors or misclicks happened during the tasks). These tasks tested the wallet's interface changes across different application areas and currencies. Quantitative User Experience (UEQ) results show AfriBit's superiority over the initial wallet in different dimensions, such as ease of understanding, reduced effort to complete tasks, attractiveness, and predictability of system behavior.

While not all issues related to financial exclusion can be solved through the use of cryptocurrencies, some problems can be addressed by providing easier access to financial services. In this regard, the use of intuitive interfaces becomes crucial. These can reduce barriers imposed by various factors, such as the illiteracy of certain people, and make financial services based on cryptocurrencies more accessible [7]. Therefore, aspects related to key management, setting up addresses in wallets, and executing transactions, which currently pose technological hurdles for non-technical individuals, can be improved. By enhancing these features to be more user-friendly, it is possible to promote financial inclusion, making these services more approachable and feasible to a wider population [3], [1].

This paper is organized as follows. Section II discusses related work that addresses usability and user experience (UX), as well as the illiteracy aspect. Section III introduces the *AfriBit* prototype and its application scenario. Extensive results and an evaluation are outlined in Section IV, these are complemented by an analysis in Section V, ending in conclusions and future work in Section VI.

II. Related Work

User interface (UI) problems are largely attributed to the inadequate layout of an application interface, lack of guidance for a user, inaccurate information, ambiguous system status, uninformative and poorly designed error messages, and smaller issues such as typos, misaligned color schemes, confusing icons and names [8], [9]. Additionally, the use of technical terms in financial applications is not always clear, but at the same time may be necessary to convey an accurate message to experienced users [10].

Cryptocurrency applications complicate usability problems further because of their unique features, such as understanding blockchain-based transactions and cryptographic key management. Not only are such applications challenging for technology-proficient communities, but technologically inexperienced and illiterate populations might struggle to adopt such solutions, thus hindering financial inclusion.

A. Wallets and Transactions

[9] have conducted a study in which authors have observed that users find it difficult to understand the concept of a *wallet*. There are two types of digital wallets: Custodial and non-custodial. The main difference between the two is who holds and manages the private keys (*e.g.,* third party in case of the former). Custodial wallets improve usability by abstracting technical concepts, while non-custodial wallets frequently expose those terms to a user [11]. [11] note that novice users, people with low technical knowledge or limited motivation, prefer custodial wallets since they are less error prone and convenience is better. Key management is regarded as a burden by such users, which leads to poor usability [11]. Conversely, users confident in managing private keys prefer non-custodial wallets because of their flexibility and functionality to export and import private keys [11]. Advanced users perceive not having such control as a restriction, resulting in intermittent access to their funds [11].

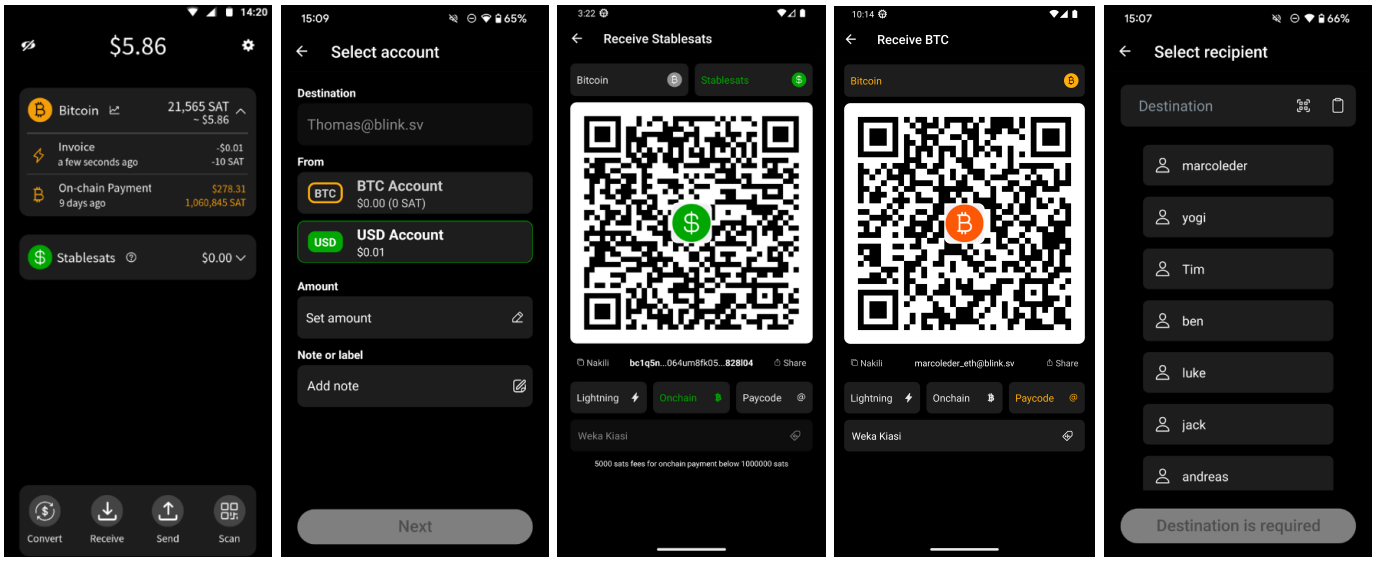
The challenge for a user starts at the wallet setup process when a user is presented with a seed phrase and required to store or memorize it for wallet recovery purposes. Novice users tend not to understand how important their backup phase is and struggle with the recovery mechanism later [12]. The lack of guidance during the setup process results in an entry barrier for some users because they could not create a wallet in the first place. [9] advises designing cryptocurrency wallets similarly to existing online banking and payment systems. It has been shown that users tend to be more cautious when dealing with new systems [9]. Therefore, making users feel familiar with the application flow is vital. The difficulty in achieving this is that cryptocurrency wallets inherently rely on another set of functionalities compared to traditional finance management applications. Cryptocurrency transactions differ from traditional financial transactions and represent another area where poor usability contributed to a misunderstanding of fundamental principles. Current applications leave users confused about the state of their transactions, and *pending* status is often misunderstood [9], [8]. This is because a user is commonly unaware of the underlying concept, such as that an already broadcasted transaction cannot be canceled, and expects transactions to be reversible [9]. Therefore, it is essential to display transactions immediately for the user, regardless of whether they have been confirmed or not [8].

When sending transactions, users frequently face a lack of fee structure transparency and confusion on how transaction fees influence the speed of confirmation and how those are calculated in the first place [12], resulting in a negative impact on the wallet usability [9]. Additionally, most applications lack the functionality to resubmit a transaction, which often blocks a user from submitting any further transactions due to a still pending previous transaction[13]. Customizable transaction fees, that allow users to choose the transaction processing speed, were reported to contribute to better usability [9]. Such flexibility enables not only to reduce user errors, but also to minimize financial losses [9]. Since such mechanisms could potentially confuse a novice user, [9] propose to use different user interfaces based on their experience level to improve overall UX.

B. Illiteracy

[14] have conducted a study in Ethiopia and observed that illiterate users have difficulty using mobile banking applications. [15] have found that understanding the conceptual model of users can be explored best by utilizing an ethnographic approach. The study highlights not only the barriers in naming and language but also shows why Bitcoin and its applications are not understood correctly [15]. One of the critical aspects is an application interface that leverages verbal instructions [14]. Such design did not improve the usability for illiterate audience, but only emphasized the barrier of translating verbal instructions to manual action [14]. For example, placement of items such as *Left* and *Bottom* have shown to be easily misunderstood, but could be addressed with the use of visuals (e.g., images) [14]. However, [14] points out that the use of icons is not always beneficial because it is harder to draw abstractions with diagrams and signs. Additionally, seeing icons and imagery of unknown items for the first time results in difficulty in interpreting them. The best example is the menu-based interfaces, which were reported to be highly confusing for novice users [14].

When looking at the existing interfaces of MPesa, it relies on the menu-based systems with hierarchical navigation. Considering the perspective of an illiterate user, such an interface is not favorable and difficult to use [14]. To address the usability problem, [14] proposed the use of photographs that illustrate the local currency notes, since currency notes are easy to distinguish based on size and color.



(a) (b) (c) (d) (e)

Fig. 1: AfriBit Screens: (a) Home, (b) Send Confirmation, (c) Receive USD, (d) Receive BTC, (e) Send to a Contact

III. AfriBit Wallet

AfriBit improves the usability and UX of Blink [5] while addressing two main requirements for better financial inclusion: (i) Simplifying the user interface considering the illiteracy aspect and (ii) adding support for Swahili, the local language of Kenya. These user requirements were collected on-site in Kibera, in cooperation with the company sideXchange [16], by asking users to evaluate the existing wallet and provide feedback regarding its functionality.

A. Prototype Design & UI Improvements

Since AfriBit addresses the usability and UX of an existing wallet Blink [5], the backend infrastructure is adopted as is. The backend service relies on the Galoy managed node to ensure the system's reliability, security, and interoperability and facilitate connectivity to the lightning network [17].

The wallet enables users to have on-chain Bitcoin and off-chain Bitcoin Lightning transactions, as well as convert cryptocurrency to conventional currency (USD) without undergoing the Know Your Customer (KYC) process first. This is facilitated by the use of a synthetic USD on the Bitcoin mainnet, namely Stablesats [18]. Thereby, the mobile wallet offers users a mechanism that addresses Bitcoin volatility by providing a hedge against future changes in BTC to USD exchange rate through the use of Bitcoin bank (here Galoy and the managed node). Thus, allowing users the benefits of a stable USD-denominated currency without needing existing bank access [18].

AfriBit addresses a range of usability and UI issues and improves the wallet's UX. The implemented changes are as follows:

- **Icons:** Bitcoin icon library was utilized instead of native Galoy icons to ensure the icons are well-known, can be universally understood across different cultures and languages, and are not ambiguous in their meaning.
- **Navigation:** To reduce the reliance on a hierarchical menu structure, the bottom navigation bar was removed, and the user interaction flow was remodeled.
- **Color scheme:** Icons and UI elements follow a consistent color scheme. Additionally, the transactions were displayed in the corresponding color of the currency (*e.g.*, orange for Bitcoin, green for USD) to enable users to have appropriate associations between currency and color.

Furthermore, the following changes were made to the UI of the main application screens.

1) Home Screen: In the home screen, the bottom navigation bar was removed to reduce the data-ink ratio (*i.e.*, ratio of elements in a visual representation to the total elements used [19]) and effectively convey the information to the user. Action buttons - convert, receive, send, and scan - moved to the bottom of the screen, improving accessibility of the elements. *Transactions* were grouped based on their corresponding *account* information (Figure 1 (a)), thus satisfying the UI design principle of proximity from the Gestalt laws [20]. The "hide" icon hides the account and transaction balances to improve user privacy.

The number of displayed transactions depends on the screen size and allows the use of the application on mobile devices with small touch screens, as shown in Figure 2 (a) and (b). Additionally, values were highlighted in the respective currency color scheme (*e.g.*, Bitcoin transactions shown in orange). This is particularly important for the home screen, where account information is clickable and displays the transaction history, as shown in Figure 2.

2) Confirmation Screen: Instead of navigating a drop-down menu, a user can see all the accounts at once and select the desirable account by tapping on it (Figure 1 (b)). The layout informs a user of the current account balance, and the title reflects the account selection. A visual border around the selected account was also implemented for better display. The color of the border is consistent with the selected currency (*e.g.,* green for USD, as shown in Figure 1 (b)).

3) Receive Money: The color scheme to reflect the selected currency was implemented to provide a user with a visual distinction between currencies (Figure 1 (c) and (d)). Additionally, the scaling of the displayed elements was improved to address the needs of a smaller device, and the screen title reflects the chosen method for receiving funds. To save more space on the screen, the destination address was moved to the same line as *copy* and *share* buttons. For consistency, users can set the received amount through the *Paycode*. Since the Paycode option is only available for Bitcoin, selecting this option automatically switches the currency to Bitcoin. Once the Paycode option is selected, the option to switch to other currency is omitted.

4) Send Money: The contact list is displayed by default to enable a user to select a contact to send money to (Figure 1 (e)). The search bar allows the user to filter the contacts and applies an automatic suggestion of the name. The user can also select a contact from the list by directly clicking on the contact located in the list. The selected element is visually highlighted for clear distinction of a selected contact for a user.

B. Implementation

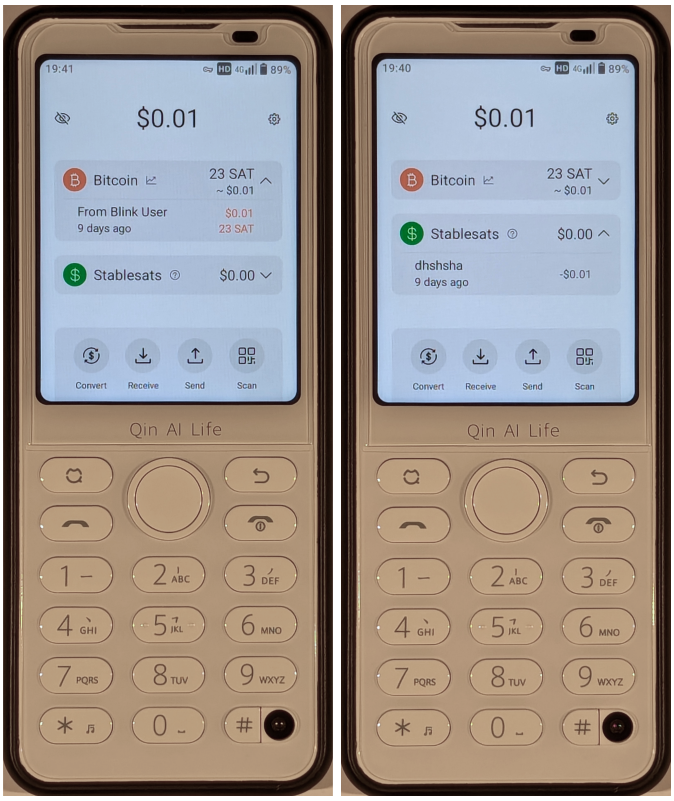
The AfriBit[1] is based on the open-source Galoy mobile wallet (Blink) [21] application. The application is developed for Android-based mobiles and utilises Typescript, i18n React Native front-end library[2] and GraphQL[3]. Necessary terms were translated to Swahili language using the generative AI model gpt-4-0613 by OpenAI[4] and the correctness of the translation was confirmed by a native Swahili speaker.

The new implementation expanded the clickable area with *hitSlop* React functionality around the main elements of the application on all screens [22]. Thus, allowing the application to perform expected functionalities, even when inaccurate touch input occurs.

IV. Results and Evaluation

The AfriBit wallet was evaluated based on the user testing sessions. Two participant groups were formed of ten people, one comprising residents of Kibera, Kenya, and another students from Switzerland. Each participant examined both Blink wallet and improved AfriBit wallet, always starting with the Blink application first. To imitate the illiteracy

[1]https://github.com/AfriBit-wallet/galoy-based
[2]https://react.i18next.com/
[3]https://graphql.org/
[4]https://openai.com/



(a) (b)

Fig. 2: AfriBit Home Screen on Small Mobile Device: (a) BTC Transactions, (b) USD Transactions

in the Switzerland-based participant group, the wallet language was set to Swahili. Doing so served as a proxy for the Swiss participants, who had no experience in reading or writing Swahili. Testing sessions were screen recorded to enable evaluation of UI changes and whether those allowed users to complete tasks faster and with reduced error rates. Additionally, observations were gathered from the video material, and direct feedback from the participants was collected through a survey (outlined in the Appendix A).

The testing scenario was designed to satisfy the following requirements:

- The tasks should be as close to real-world scenarios as possible;
- Participants should incur as little fees and spend as little time as possible;
- To test the effectiveness of the UI changes, the tasks must span areas of the application that were altered;
- To evaluate the changes in the visually distinctive coloring of the two currencies, the tasks should include the use of both currencies.

As a result, participants were asked to complete three tasks in order: (i) receive a payment of 10,000 sats via the Lightning Network; (ii) convert 5,000 sats to Stablesats; and (iii) send 1 USD in Stablesats to the user *marcoleder*. After completing the tasks for both wallets, the participants were asked to fill out usability questionnaires (refer to

Appendix F and G in [23]) for Blink and AfriBit wallets. The questionnaire design was based on the Usability Experience Questionnaire (UEQ) from Laugwitz *et al.* [24].

A. Quantitative Results

Analysis and interpretation of the results from the UEQ survey are facilitated by the provided Excel data analysis tool file [25]. The mean, standard deviation, and confidence level of each wallet are depicted in Table I, and the graphical representation thereof in Figure 3, with the addition of showing the whole confidence interval for interpretation.

TABLE I: UEQ Survey Result Statistics

		Blink			*AfriBit*		
Scale	**N**	**Mean**	**STD**	**CL**	**Mean**	**STD**	**CL**
Attractiveness	20	1.85	1.06	0.46	2.20	0.83	0.37
Perspicuity	20	1.50	1.16	0.51	2.24	0.52	0.23
Efficiency	20	2.16	0.75	0.33	2.64	0.43	0.19
Dependability	20	1.88	0.85	0.37	2.46	0.45	0.20
Stimulation	20	2.20	0.95	0.42	2.70	0.57	0.25

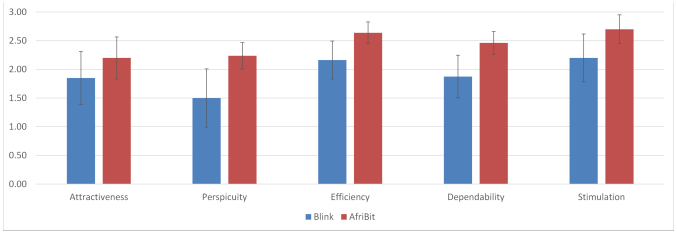


Fig. 3: UEQ Survey Results Graphic

Based on Schrepp *et al.* [26] guidelines on how to interpret the results shown in Figure 3, we conclude that the AfriBit wallet excels in its pragmatic quality, making it easier to understand the application (*perspicuity*), solve tasks with less effort (*efficiency*), and predict the behavior and states of the system better (*dependability*).

B. Task Completion Time

This section quantitatively supports the aforementioned findings and statistically contrasts the time measurements of both wallets. After the conversion of the time measurements in the format *SS:FF* to a standardized format in seconds and milliseconds *SS.MS*, the standard deviations were calculated. In addition to the calculation of the standard deviation of the whole scenario, the individual task standard deviations, as well as the standard deviations per group, were calculated.

The raw data in seconds and milliseconds and the corresponding standard deviations for the Blink wallet are presented in Table II. Table III respectively represents the raw data in seconds and milliseconds, and the corresponding standard deviations for the AfriBit wallet. The measurement data from the tables is the basis for further statistical analysis. The data points were imported and evaluated in R. The data of Task 1 in *set amount time* for the Kibera group is missing due to the reasons mentioned in Section IV-C3.

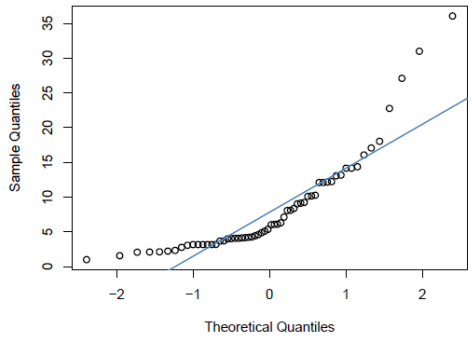
TABLE II: Blink Time Measurements

Time in seconds [s]	Home screen time			Set amount time		
Task	1	2	3	1	2	3
Kibera group	2.37	5.00	3.03	N/A	15.50	14.03
	4.37	IOS	6.67	N/A	IOS	6.10
	1.37	10.40	3.03	N/A	7.13	3.33
	9.23	1.27	5.33	N/A	22.77	3.50
	4.03	3.07	3.03	N/A	error	5.03
	4.00	6.00	15.00	N/A	34.07	11.10
	5.07	IOS	13.03	N/A	IOS	11.13
	2.10	3.20	4.00	N/A	12.10	3.03
	3.97	13.43	4.73	N/A	4.23	4.67
	4.70	4.10	5.87	N/A	7.47	4.33
Task Std. dev	2.16	4.10	4.24	N/A	10.54	3.95
Group Std. dev		3.60			8.21	
Swiss group	65.17	39.23	31.00	23.30	8.30	4.20
	16.27	IOS	27.27	13.23	IOS	5.20
	28.30	17.17	23.00	35.17	11.13	2.30
	17.13	1.20	23.10	45.23	7.27	2.10
	70.03	14.10	19.23	21.20	34.23	5.00
	41.43	8.30	3.33	20.27	9.43	1.20
	21.43	9.13	14.23	16.03	11.47	2.03
	24.37	20.13	4.47	11.03	7.07	1.47
	16.37	16.20	16.40	19.17	9.17	8.33
	14.47	19.47	14.33	8.30	3.27	2.37
Task Std. dev	20.65	10.60	9.03	11.26	8.95	2.24
Group Std. dev		15.67			11.07	
Scenario Std. dev		14.09			10.06	

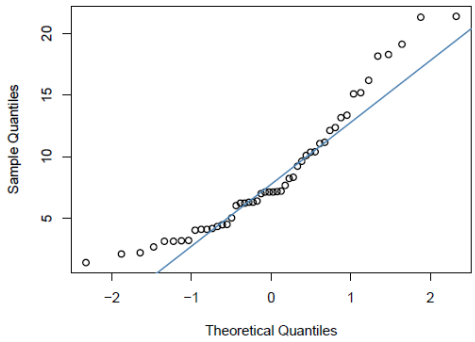
TABLE III: AfriBit Time Measurements

Time in seconds [s]	Home screen time			Set amount time		
Task	1	2	3	1	2	3
Kibera group	14.17	3.17	12.23	N/A	7.67	4.17
	9.23	22.77	3.17	N/A	6.30	4.50
	4.17	3.70	2.77	N/A	5.03	4.33
	4.87	4.60	3.67	N/A	9.63	2.67
	2.23	4.03	3.17	N/A	6.40	3.13
	8.37	4.07	3.07	N/A	18.17	19.13
	4.13	5.37	2.13	N/A	16.20	6.23
	12.10	4.43	2.33	N/A	6.30	13.17
	5.10	6.10	3.17	N/A	12.13	13.37
	3.20	3.17	1.57	N/A	21.33	4.47
Task Std. dev	4.02	5.91	3.05	N/A	5.78	5.63
Group Std. dev		4.53			5.82	
Swiss group	14.17	31.00	13.07	8.23	11.07	2.10
	8.10	9.03	9.13	6.03	7.00	3.17
	36.07	7.13	6.03	9.23	7.17	4.03
	17.07	10.17	4.00	12.37	8.33	7.20
	10.10	8.07	1.00	7.13	6.23	3.20
	6.30	4.27	2.07	10.40	11.17	1.40
	27.10	14.37	16.07	21.40	10.37	3.13
	18.03	4.20	2.10	7.13	18.30	2.20
	10.27	6.07	13.17	10.10	7.13	4.10
	12.17	12.10	4.07	15.10	15.20	4.10
Task Std. dev	9.27	7.85	5.42	4.63	3.95	1.60
Group Std. dev		8.29			4.85	
Scenario Std. dev		7.21			5.23	

Before conducting statistical hypothesis tests, both the data from the Blink measurements and from AfriBit, were checked for being normally distributed using QQ-plots [27], as shown in Figure 4 and Figure 5 (for the full evaluation refer to [23]). The first column refers to the *home screen time*, whereas the second column shows the *set amount time*. The QQ-plots visually indicate that the data is not normally distributed, since the data points do

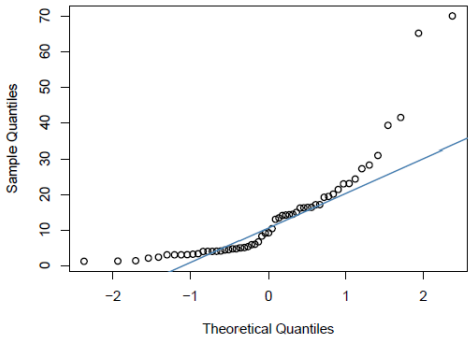


(a)

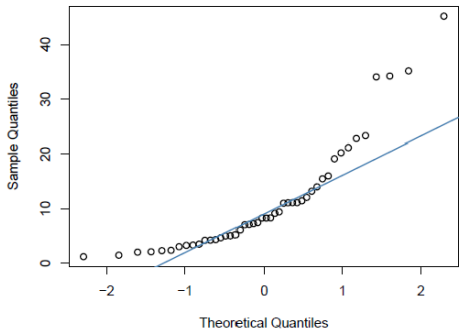


(b)

Fig. 4: AfriBit QQ-Plots, Both Groups (Home Screen Time)



(a)



(b)

Fig. 5: Blink QQ-Plots, Both Groups (Set Amount Time)

not closely follow the normal distribution line. To confirm this observation graphically and numerically, Shapiro-Wilk tests [28] were conducted to test for normality. A Shapiro-Wilk test's null hypothesis states that the data is normally distributed, which is the hypothesis to be tested against [28]. Thereby, six Shapiro-Wilk tests were conducted per wallet; four spanned each group in the respective screen scenario, and two represented the overall scenarios. All the Shapiro-Wilk tests resulted in a p-value of less than 0.05, meaning the null hypothesis can be rejected. Hence, the data does not follow a normal distribution, which can be attributed to the relatively small sample size and the outliers prominently occurring at the upper end of the spectrum.

C. Qualitative Results

The assessment, whether UI changes lead to a better UX:

1) UI: Based on observations, users knew immediately that Lightning was selected for the first task when opening the *receive money* screen. Thus, the new UI conveyed the state to the user correctly. However, the screen to convert from Bitcoin to Stablesats was not as intuitive, with users assuming that the section with the top two accounts was used for conducting the swap. This highlights the need for better highlighting the swap direction and where user input is needed.

Most participants had issues understanding the topmost section on the screen for converting between two currencies. The direction of the swap was not clear because the icon had both arrows pointing up and down. However, most users read this section top-down, meaning that the top account is the account to send *from* and the bottom one to *receive*. Users could not anticipate the general interaction flow, and most were unaware they had to set the amount the same way when receiving funds. Additionally, participants did not realize the keyboard on the same converting screen was clickable. This can be due to the grayed-out buttons do not indicate they can be clicked. Furthermore, buttons lack visual signifiers (*e.g.,* outline or shape) indicating the functionality. Since the input field also lacks any signifiers, some participants assumed they were first required to select the input field. However, the design selects the input field by default, and buttons are always clickable.

The highlight of an account in the sending process reduced the risk of sending the wrong currency, with only four people having sent from the wrong account in the AfriBit wallet compared to eight people in the Blink wallet. Additionally, all participants could select a contact from the contact list, highlighting the benefits of well-known workflows.

Lastly, in both wallets, the green tick animation after executing an action helps interpret the feedback that the action has succeeded. Many participants perceived it as a sign of success and did not check for the balance change or transaction history afterward.

2) Icons: The new icons in the AfriBit application were not always well perceived. Participants stated that the new icons were associated with *download* or *email inbox*, which was not the goal of using the certified Bitcoin icons [29]. This observation applies to all the wallet functions except the convert icon, which was identified to be more intuitive. Nevertheless, all participants were able to identify the function of each icon and were able to execute the tasks accordingly.

3) Accessibility: It is important to note that Task 1 resulted in missing data points for Kibera participants. Instead of stating that the participants should *receive* a payment, the participants should have been asked to *request* a payment. Highlighting the importance of used terms further, the use of Swahili language for Switzerland-based participants revealed the confusion about the term *ada*, which means *fee*, when sending funds. There is a need for a method to convey information about the fee structure in a non-text way, such as a graphical representation, to address potential misunderstandings. Moreover, cryptocurrency terms (*e.g.,* Lightning) were also found to be unclear to the participants, resulting in an inability to distinguish between the two networks. Similar terms for the different currencies extended the confusion further, with *sats* (small fraction of a Bitcoin) perceived as the same as *Stablesats* (synthetic USD). Additionally, participants struggled with associating Stablesats with USD, since the interface in the account selection only differentiated between USD and BTC and did not mention Stablesats.

Warnings that relied heavily on text (*e.g.,* "You have never sent money to this address") were also found to be problematic, resulting in various interpretations and led to confusion.

The use of percentage buttons on the conversion screen was unclear to most novice participants unfamiliar with online banking or cryptocurrency wallets. This resulted in either risk-averse behavior or an exploitative approach from the participants. However, experienced users who knew the functionality behind those buttons proceeded without hesitation.

Lastly, a few users did not feel confident about whether they were on the right screen of the application when completing the tasks, which resulted in more frequent switching between screens. Providing additional guidance to the users, for example, with the use of a progress bar in the sending process, could help to resolve the issue.

D. Questionnaire Feedback

At the end of each questionnaire, the participants were asked if they had any additional feedback to enable them to elicit thoughts and inquiries not covered by the UEQ. As a result, participants expressed the need for features and UI improvements for the Blink wallet, such as providing a button for IOS-based wallets to exchange Bitcoin to Stablesats. Other considerations included a combination of send and scan interactions on the home screen and the addition of icons to the text fields.

For the AfriBit wallet, the feedback was more inclusive and diverse. A critical point raised by one participant was that he could not find the drop-down of the transactions, whereas Blink directly showed him this information without the need for input. However, this user seems to be the only one facing this issue, as the number of verified transactions via the history was 34 in Blink and 35 in AfriBit, suggesting that the change in the user interface did not drastically affect the number of verified transactions. Interestingly, most Kibera participants wished for the app to be more colorful. Some Kenyan users described the use of color as inadequate or even as sad. Additionally, one of the Swiss participants noted that the colored action button at the bottom of the screen was more appealing than the black/white button in the AfriBit wallet.

One participant gave valuable insight and noted that the app should be more informative and explain the technical terms. Feedback from a Kibera group participant highlighted that being familiar with the terms helped make the application easy to use. Since this feedback aligns with the findings from the quantitative analysis, we can conclude that the user's familiarity with the terms influences the successful use of the application.

Participants also brought up general points unrelated to new features or UI changes that needed improvement. These included the fact that the percentage buttons were confusing when sending and that it would be beneficial to have visual feedback (such as a cursor) when inputting the amount.

V. Analysis

To see whether the participants exhibited a learning effect, the time it took to set the amount in the Blink application was compared to the AfriBit wallet. The two-sided Wilcoxon rank sum tests with continuity correction were performed and statistically analyzed. As a result, the analysis showed no difference between the two wallets, with none of the groups exhibiting a statistically significant difference. This result is surprising, as we expected users in the AfriBit wallet to be faster when completing the tasks for a second time. Thus, with all p-values yielding that the completion of the set amount tasks in both wallets does not differ significantly, it can be concluded that for no group a learning effect is present. The important conclusion of the user study of the set amount of time is that no participant group exhibited a statistically significant learning effect.

To analyze the task completion time, the recorded time measurements from the Blink wallet home screen were compared against AfriBit, and statistically evaluated. The one-sided Wilcoxon rank sum tests with continuity correction tested if the time it took to complete the tasks in the Blink wallet was greater than in the AfriBit wallet, whereas the results showed that this statement can be disproved for the Kibera group with a p-value of 0.3926, but not for the

Swiss group. The considerations of previous experience with the Blink wallet apply here, indicating that the UI changes in the AfriBit wallet did not lead to a difference in time for experienced users. However, the Swiss group with a p-value of 0.0001329 showed that the time it took to complete the tasks using the Blink wallet was significantly greater than using the AfriBit wallet. This could be attributed to the fact that most of the Swiss users participating in the study had little to no experience with the Blink wallet or any other Bitcoin mobile wallet. As mentioned previously, the difference in time needed to complete the tasks can not be accredited to the learning effect, as no statistical difference in time could be determined for screens that have stayed consistent throughout both applications. Therefore, a consideration could be that the AfriBit wallet UI is more appealing to new and inexperienced users.

It has to be noted that taking both groups of the home screen scenario together and comparing them across the two wallets, the p-value of 0.01562 is statistically significant, providing evidence that the Blink UI takes participants longer to complete the given tasks' home screen time. All the above-mentioned statistical results align with the findings from the UEQ analysis, where the AfriBit wallet scored better in all categories (as mentioned in Section IV-A and shown in Figure 3).

VI. Considerations

This paper presented AfriBit, a mobile wallet facilitating financial inclusion in Kibera, Kenya and providing a feasible alternative to MPesa. First, existing cryptocurrency wallet and user requirements had been collected and analyzed locally in Kibera, leading to proposed changes to the UI. The resulting design changes were incorporated into AfriBit, allowing the execution of the three fundamental operations of MPesa (depositing, sending, and receiving money). The quantitative evaluation of the results and user study contribute to the overall understanding of the problem and the proposed solution. In addition, the UX improvement proposed in AfriBit has been incorporated into the existing Blink wallet as *BLIP 16 - display recently used contacts for quick send* [30].

Nonetheless, more extensive fieldwork, testing sessions, or even the public roll-out of the AfriBit wallet in the Apple App Store and Google Play Store need to be considered to provide a basis for future improvements. As such, AfriBit can only be evaluated entirely by gathering long-term insights into adoption, transaction volume, and further feedback and analysis.

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APPENDIX

USABILITY OF AFRIBIT WALLET*

You just completed the think-aloud evaluation of the AfriBit application. In your think-aloud walkthrough, you executed three tasks. You were given the information that one bitcoin equals 100 million sats prior to executing the tasks:

1) Receive a payment of 10000 sats via the lightning network. Confirm that you received the amount in the transaction history.
2) Convert 5000 sats to Stablesats. Confirm that the converion was successful (in the transaction history).
3) Send 1 USD in Stablesats to the user marcoleder. Confirm that you were deducted the amount in the transaction history.

For anonymity you are allowed to use a pseudonym as your name, but use the same name for both evaluations. This will allow us to compare your opinion from AfriBit wallet to Blink. All material gathered (screen recording, audio, transcript and the answers to these questions) will only be used for the research purpose. The results will not be sold to any third party.

1) Name, Age, Location
2) Do you have experience with Blink or any other bitcoin mobile wallet? (Rank from 1 as no experience to 7 as excellent experience)
3) Considering your complete knowledge and experience about the user interface, how was your experience? (Rank from 1 as annoying to 7 as enjoyable)
4) How was the interface structure overall? (Rank from 1 as cluttered to 7 as organized)
5) How was it to navigate between the different screens? (Rank from 1 as complicated to 7 as easy)
6) The system used technical terms (e.g., BTC, stablesats, lightning), how were the terms? (Rank from 1 as not understandable to 7 as understandable)
7) How was the importance of the information shown on the home screen? (Rank from 1 as inferior to 7 as valuable, figure omitted)
8) How was the organization of information (e.g., text, numbers) on the home screen? (Rank from 1 as bad to 7 as good)
9) How was the hierarchical ordering of the accounts and transactions section on the home screen? (Rank from 1 as impractical to 7 as practical, figure omitted)
10) How did the visual placement of functions (e.g., buttons, icons) allow you to execute your tasks on the home screen? (Rank from 1 as inefficient to 7 as efficient, figure omitted)
11) How was the placement of the payment function? (Rank from 1 as unpredictable to 7 as predictable, figure omitted)
12) How did you identify the function for Task 1 (receive)? (Rank from 1 as slow to 7 as fast, figure omitted)
13) How did you identify the function for Task 2 (convert)? (Rank from 1 as slow to 7 as fast, figure omitted)
14) How did you identify the function for Task 3 (send)? (Rank from 1 as slow to 7 as fast, figure omitted)
15) For executing the tasks you used three functions, how was it to understand what the functions do? (Rank from 1 as difficult to learn to 7 as easy to learn, figure omitted)
16) How secure were you in predicting the outcome of the functions? (Rank from 1 as not secure to 7 as secure)
17) The system sometimes prompts for action (pressing buttons), how were these prompts? (Rank from 1 as confusing to learn to 7 as clear, figure omitted)
18) The system sometimes prompts for input (text), how were these prompts? (Rank from 1 as obstructive to learn to 7 as supportive, figure omitted)
19) How was it to interpret the feedback of the system? (Rank from 1 as does not meet expectations to 7 as meets expectations)
20) How was the use of color in the system? (Rank from 1 as unattractive to 7 as attractive)
21) If you have any comments or remarks, please, specify them.

*__Note:__ the survey has been adapted for a consice display of information.