From A to B with Ease: User-Centric Interfaces for Shuttle Buses

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ABSTRACT

User interfaces are crucial for easy travel. To understand user preferences for travel information during automated shuttle rides, we conducted an online survey with 51 participants from 8 countries. The survey focused on the information passengers wish to access and their preferences for using mobile, private, and public screens during boarding and travelling on the bus. It also gathered opinions on the usage of Near-Field Communication (NFC) for shuttle bus confirmation and viewing assistance to help passengers stand precisely where the shuttle will arrive, overcoming navigation and language barriers. Results showed that 72.54% of participants indicated a need for NFC and 82.35% for viewing assistance. There was a strong correlation between preferences for shuttle bus schedules, route information (r=0.55), and next-stop information (r=0.57) on mobile screens, suggesting that passengers who value one type of information are likely to value related kinds too.

KEYWORDS

User Interface, Micro-mobility, Shuttle bus, Viewing Assistance

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1 INTRODUCTION

Designers of modern public transportation systems are increasingly recognising the importance of providing personalised and real-time information to meet the diverse needs of passengers. Hoar [7] and Harmony and Gayah [6] highlighted the growing trend towards real-time information systems tailored to individual passengers. Mnasser et al. [10] and Cats and Gkioulou [4] further emphasised the importance of reliability and travel information in reducing passengers' waiting-time uncertainty. As public transit options become more complex, the demand for intuitive passenger information systems is growing, offering passengers customized guidance and updates to navigate networks with ease.

Watkins et al. [15] and Brakewood et al. [2] outlined that real-time information about bus arrivals shown to passengers significantly impacts perceived and actual wait times, hence improving passenger satisfaction. Literature on studying the attitude towards automated mobility concepts like shuttle buses as in Schlichtherle et. al [11] shows itinerary information provided through user interfaces (UIs), and displays influence the choice and usage. Further, Abduljabbar et al. [1] emphasise that micro-mobility options like e-scooters and bike-sharing systems not only enhance the convenience and flexibility of travel but also significantly reduce travel time and environmental impact. Shaheen and Cohen [12] and Campbell et al. [3] provide evidence that micro-mobility solutions can alleviate urban traffic congestion and promote sustainable travel behaviours.

A well-designed UI can facilitate seamless transitions between different modes of transportation within a single journey, enhancing travel satisfaction. Caulfield and O'Mahony [5] discuss public transport information requirements of users, emphasising the need for passenger-centric information systems. Passenger preference towards the type and medium of information is significant for developing effective, user-friendly systems. Since passengers often need to access information quickly and under time constraints, public transportation interfaces must be exceptionally user-friendly and provide easy access to information [8].

User-centred design involves creating interfaces that consider the needs, preferences, and behaviours of bus passengers. Lyons and Urry [9] describe how the evolution of travel times with new information technologies has historically focused on accessibility and ease of use for public transport interfaces.

1.1 Aim of study

The research question of this study was: *What specific information do shuttle bus passengers need, and how do they prefer to access this*

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Figure 1: Scenes generated with (left) Unreal Engine and (right) Dall-E to demonstrate each situation to participants. In the left image, the user uses visual help to determine where to stand before boarding the shuttle bus. Selecting a viewing assistance option on their mobile device shows them exactly where they should stand. In the image on the right, the user examines information on both mobile and public screens before boarding the shuttle bus.

information during their journey? We established the formats of information that are of the most value to passengers, both marketable but common information (e.g., route descriptions and shuttle bus schedules) and less marketable but rather uncommon information (e.g., departure countdowns and accessibility-friendly routes). We studied user preferences for this type of information representation and assessed the preferences on whether these views are presented on mobile devices, private screens, or public displays. We also provided functionalities such as Near Field Communication (NFC) to board and viewing assistance to allow passengers to position themselves exactly where the bus is going to come, which is beneficial in unfamiliar environments.

2 METHOD

The study was conducted through an online survey featuring scenes generated in Unreal Engine [1] or Daal-E [2] (see Figure 1). It was administered via Google Forms (see section 6). It involved 52 participants who were recruited through social media channels. The participants were required to be at least 18 years old. All participants provided informed consent before taking part in the survey. This study was approved by the Ethical Review Board of Eindhoven University of Technology. The survey collected data on:

- **Demographic information:** Age, gender, and current country of residence.
- **Frequency of travelling on a shuttle bus and use of micro-mobility:** How often do the participants use buses and micro-mobility options such as e-scooters and bicycles?
- **Preference for viewing assistance and NFC:** Do the participants find the viewing assistance and NFC necessary for navigating unfamiliar environments or overcoming language barriers?
- **Preferences for obtaining information before the journey on a shuttle bus:** The type of information participants want to receive on mobile or public screens before starting their journey. Participants were given ten different options to select from and were also asked for any additional suggestions they may have.
- **Preferences for obtaining information during the journey on a shuttle bus:** The type of information participants want to receive on mobile, private, or public screens during the journey. Participants were given ten different options to select from and were also asked for any additional suggestions they may have.

[1]https://www.unrealengine.com, last accessed: 19.06.2024.
[2]https://openai.com/index/dall-e-2, last accessed: 19.06.2024.

3 RESULTS

After discarding the response from a respondent who did not give consent, answers from 51 (12 females and 39 males) respondents were analysed. The mean age of the respondents was 28.6 years (SD = 5.1 years). The responses came from eight different countries, with the largest number of respondents from The Netherlands (n = 16), Germany (n = 15), India (n = 13), USA (n = 2), Norway (n = 2), Japan (n = 1), Syria (n = 1) and People Republic of China (n = 1). Anonymised data is provided in section 6.

3.1 Respondents' Use of Micro-Mobility, Public Bus, Viewing Assistance, and NFC

Respondents provided brief information about how often they commute on current public buses and micro-mobility options. According to the survey, 29.4% of respondents use the bus 1–2 times per week, 3.92% use it 3–4 times per week, 11.8% use it 5–6 times per week, 7.84% use it 7 or more times per week, and 47.1% do not use it at all. The survey found that 29.4% of respondents utilise micro-mobility choices daily, while 21.6% never use them, 17.6% use them once a month to once a week, 13.7% less than once a month, 9.8% 4-6 days a week, and 7.84% 1-3 days a week.

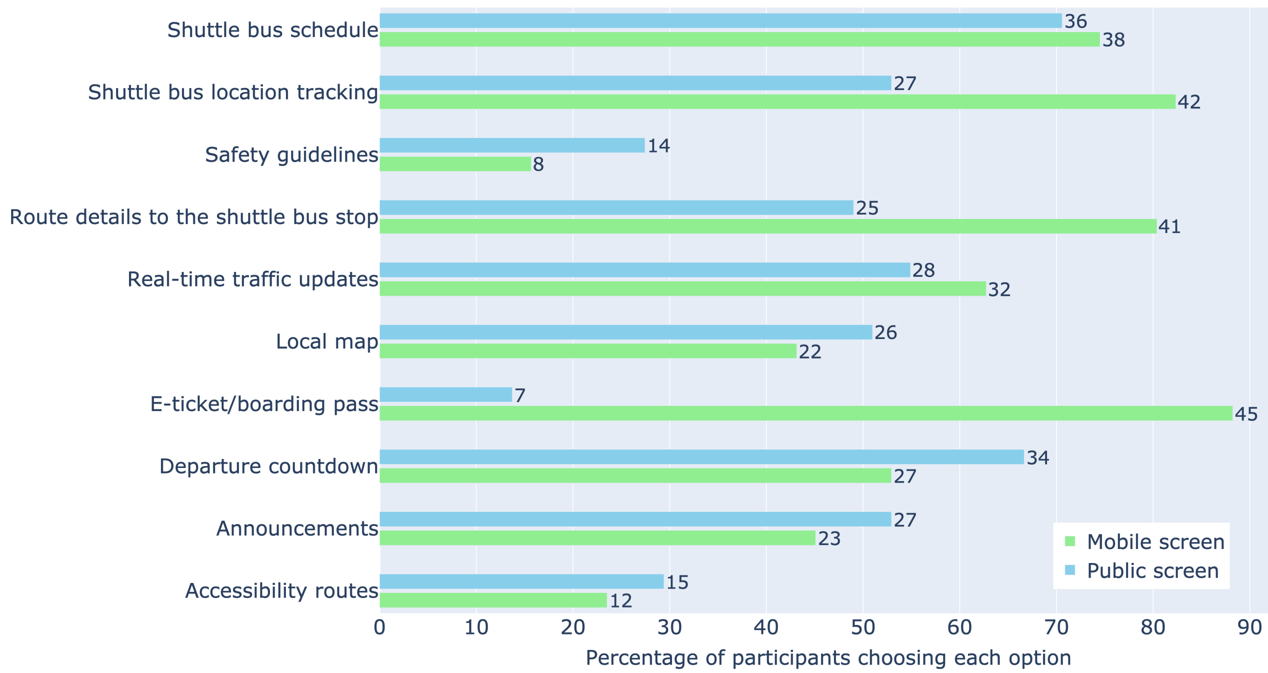

Figure 2: Choices of respondents on what information should be shown before boarding the shuttle bus on a mobile and public screen.

In addition, the survey included preferences for viewing assistance and NFC function. According to the data, 66.67% of respondents support using viewing assistance, with 15.69% strongly agreeing that it is vital while travelling to a new place, 11.76% neither agreeing nor disagreeing and 5.88% disagreeing. Furthermore, 60.78% of respondents supported NFC for simplicity of navigation and shuttle bus confirmation. 11.76% strongly agreed on the use of NFC, 17.65% neither agreed nor disapproved, and 9.8% disagreed.

3.2 Respondents' Preferences for Information Before and During the Shuttle Bus Journey

Figure 2 shows the responses of the participants about what information should be shown before boarding the shuttle bus. The analysis of participants' preferences for information displayed on mobile and public screens reveals distinct trends. Participants showed a notable preference for receiving dynamic and real-time travel information, such as shuttle bus location tracking (82.35%) and route details to the shuttle bus stops (80.39%), on mobile screens rather than public screens. A feature like departure countdowns (66.67%) also garnered higher public screen preferences. Information types with more balanced preferences, such as real-time traffic updates, shuttle bus schedules and local maps, were noted as useful for both screen types.

Mobile screens were slightly more preferred for personalised information like accessibility routes (29.41% vs. 23.52%) and announcements (52.94% vs. 45.09%), where preferences were evenly split compared to public screens. Safety guidelines (27.45% vs. 15.68%) were also preferred on public screens, while e-tickets/boarding passes (88.23% vs. 13.72%) were significantly preferred on mobile screens over public screens.

Figure 3 shows the responses of the participants about what information should be shown on a mobile, private and public screen after boarding the shuttle bus. The participants expressed a strong preference for displaying next-stop information on public screens (90.19%). Route information and public transportation connections garnered significant preferences for both public screens (72.54% and 66.67%) and private screens (70.58% and 64.70%). Mobile screens were notably preferred for personalised recommendations (54.90%), notifications (62.74%), and language translators (49.01%).

Weather updates and safety protocols were more commonly preferred on private screens (45.09% and 52.94%) compared to mobile screens (21.56% and 35.29%) and public screens (23.53% and 47.05%). Accessibility information showed a significant preference for mobile screens (49.0%), followed by private screens (33.3%), and was least preferred on public screens (21.56%).

The correlation matrix analysis (see Figure 4) provides detailed insights into participants' preferences for information displayed on mobile and public screens during preboarding and during the journey. A strong correlation (r = 0.57) was found between shuttle

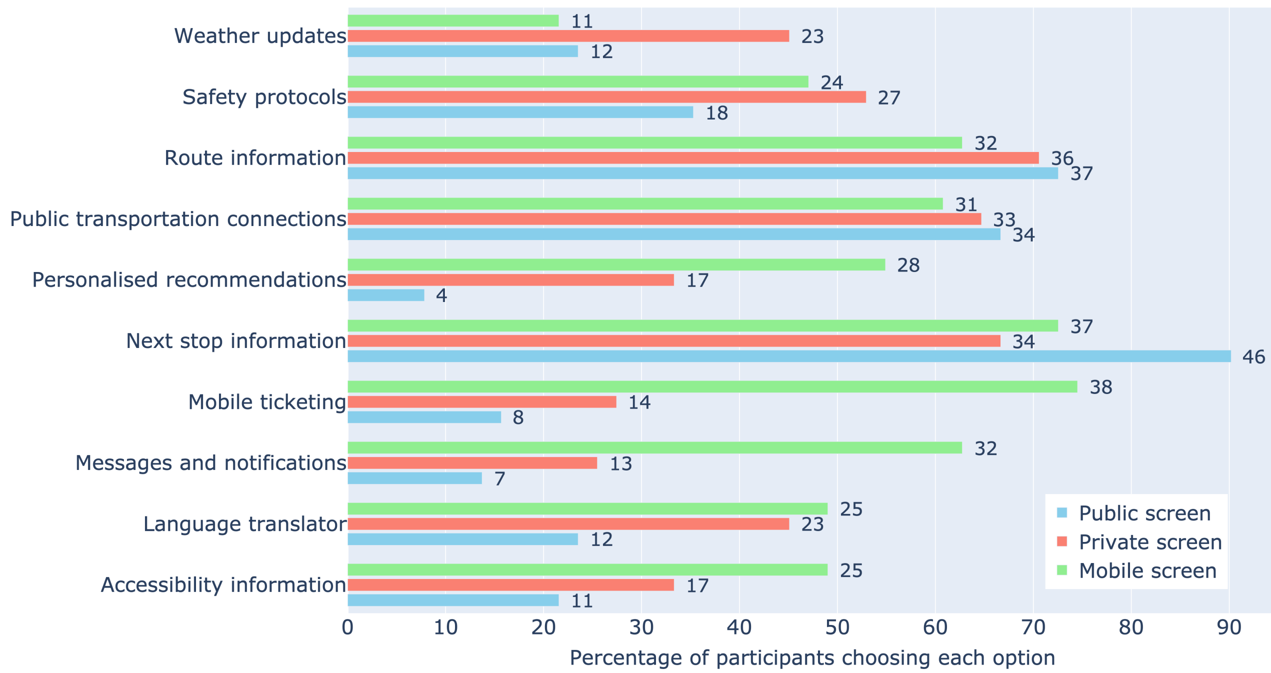

Figure 3: Choices of respondents about what information should be shown after boarding the shuttle bus on a mobile, private and public screen.

bus schedules and route information on mobile screens, indicating that users who prioritise schedule information also value detailed route information. Similarly, a correlation (r = 0.55) exists between shuttle bus schedules and next-stop information on mobile screens. Cross-screen correlations reveal that shuttle bus location tracking on public screens and real-time traffic updates on mobile screens (r = 0.25) are moderately correlated. Additionally, e-ticket/boarding pass information on mobile screens correlates with accessibility routes on public screens (r = 0.24).

3.3 Additional features recommended by participants

Some of the key suggestions from the participants are as follows:

- **Mobile screen before boarding:** Occupancy of the shuttle bus, platform number, bus stops along the route, possible delays, vehicle number, next bus departure time, and routes of each shuttle arriving soon at the stop. Additionally, there should be an option where users can input their destination, and the app shows whether an arriving shuttle will be going there.
- **Public display before boarding:** Occupancy of the shuttle bus, cancellation status, and bus number.
- **Public screen during journey:** Displays expected delays, total travel time, and upcoming stops.
- **Private screen during journey:** Option to set a personal stop for the bus to halt, along with access to more detailed information than what is displayed on the public screen.
- **Mobile screen during journey:** Estimated time of arrival and any possible delays.

4 DISCUSSION

The preference for public screens for dynamic, real-time, and critical travel information, such as shuttle bus location tracking and route details, suggests that public screens are suitable for urgent, location-specific updates. Users appreciate the visibility of such updates in public spaces, enhancing the transportation experience. The balanced preferences for real-time traffic updates and local maps indicate that both mobile and public screens are versatile for these purposes. The preference for personalised information on mobile screens highlights the need for convenience and accessibility for users with specific needs.

A significant preference for e-tickets/boarding passes on mobile screens points to the need for accessible travel credentials. Safety guidelines preferred on public screens emphasise the importance of making critical safety information widely visible. The preference for displaying next-stop information on public screens underscores the need for visible updates for efficient travel planning. Preferences for route information and public transportation connections on both public and private screens highlight the need for accessible navigation details during the journey. Mobile screens are preferred

	Pre-Pub: Accessibility routes	Pre-Pub: Announcements	Pre-Pub: Departure countdown	Pre-Pub: E-ticket/boarding pass	Pre-Pub: Local map	Pre-Pub: Real-time traffic updates	Pre-Pub: Route details to the shuttle bus stop	Pre-Pub: Safety guidelines	Pre-Pub: Shuttle bus location tracking	Pre-Pub: Shuttle bus schedule
Pre-Mob: Shuttle bus schedule	0.18	0.08	-0.13	0.10	0.15	0.10	0.21	-0.14	-0.01	0.21
Pre-Mob: Shuttle bus location tracking	-0.04	-0.02	0.00	0.04	0.06	0.10	0.15	0.17	0.18	0.04
Pre-Mob: Safety guidelines	0.31	0.19	0.19	0.14	0.32	0.17	0.33	0.34	0.19	0.16
Pre-Mob: Route details to the shuttle bus stop	0.21	0.13	0.07	0.20	0.21	0.15	0.29	0.08	0.13	0.11
Pre-Mob: Real-time traffic updates	0.14	0.00	0.23	-0.05	-0.03	0.36	0.11	0.20	0.25	0.21
Pre-Mob: Local map	0.05	0.19	0.03	0.23	0.30	0.15	0.18	-0.00	0.19	0.13
Pre-Mob: E-ticket/boarding pass	0.24	0.14	-0.13	-0.03	0.25	0.04	0.24	0.22	0.02	0.30
Pre-Mob: Departure countdown	0.26	0.29	0.17	0.03	0.25	0.25	0.22	0.14	0.21	-0.01
Pre-Mob: Announcements	0.28	0.22	0.14	-0.02	0.26	0.11	0.29	0.33	0.22	0.24
Pre-Mob: Accessibility routes	0.25	0.06	0.20	0.05	0.08	0.41	0.01	0.18	0.15	0.26

	On-Mob: Accessibility information	On-Mob: Language translator	On-Mob: Messages and notifications	On-Mob: Mobile ticketing	On-Mob: Next stop information	On-Mob: Personalised recommendations	On-Mob: Public transportation connections	On-Mob: Route information	On-Mob: Safety information	On-Mob: Weather updates
Pre-Mob: Shuttle bus schedule	0.12	0.12	0.11	0.17	0.55	0.10	0.45	0.57	0.28	0.09
Pre-Mob: Shuttle bus location tracking	0.15	0.04	0.18	-0.03	0.18	0.10	-0.06	0.28	0.13	0.12
Pre-Mob: Safety guidelines	0.22	0.01	0.33	0.13	0.27	0.28	0.13	0.22	0.24	0.30
Pre-Mob: Route details to the shuttle bus stop	0.39	0.19	0.33	0.16	0.25	0.35	0.31	0.33	0.27	0.26
Pre-Mob: Real-time traffic updates	0.19	0.19	0.16	-0.08	0.25	0.36	0.13	0.25	0.16	0.11
Pre-Mob: Local map	0.25	0.02	0.02	0.06	0.09	0.31	0.29	0.34	0.45	0.22
Pre-Mob: E-ticket/boarding pass	-0.01	0.24	0.10	0.35	0.32	0.04	-0.04	0.22	-0.02	0.04
Pre-Mob: Departure countdown	0.30	0.22	0.17	0.17	0.12	0.25	0.13	0.17	-0.13	0.11
Pre-Mob: Announcements	-0.02	0.06	0.21	0.26	0.03	0.19	-0.08	-0.04	0.33	0.20
Pre-Mob: Accessibility routes	0.29	0.29	0.24	0.22	0.13	0.41	0.16	0.33	0.13	0.16

Figure 4: Correlation matrix. The prefix in the names of variable: Pre-Mob: Information required preboarding (mobile screen), Pre-Pub: Information required preboarding (public screen), On-Mob: Information required during journey (mobile screen).

for personalised recommendations, messages, notifications, and language translators, reflecting the desire for immediate access to critical information.

Participant suggestions emphasise the need for comprehensive, real-time information across various platforms, highlighting diverse passenger needs. For mobile screens before boarding, participants desired occupancy data, platform numbers, route stops, possible delays, vehicle numbers, next bus departure times, and routes of arriving shuttles, with an option to input destinations for convenience. This shows a demand for detailed, customisable information to enhance trip planning and reduce uncertainty. Key information for public displays before boarding includes bus occupancy, cancellation status, and bus numbers, indicating a preference for transparency and informed decision-making. Onboard, public screens should show anticipated delays, time estimates, and next stops, emphasising the need for real-time updates. Private screens after boarding should allow setting personal stops and accessing detailed information, while mobile screens after boarding should display estimated arrival times and potential delays, demonstrating the need for continuous, personalised updates. These preferences suggest passengers value detailed, personalised information and real-time updates, leading to a user-centric transportation system. Implementing these features can enhance user satisfaction by providing a smoother, more predictable, and enjoyable travel experience.

The correlation matrix (see Figure 4) analysis provides insights into participants' preferences for information on mobile and public screens, preboarding and onboarding. Strong correlations were found between preferences for shuttle bus schedules, route information, and next-stop information on mobile screens, indicating that those who value one type likely value-related information. Cross-screen correlations, such as between accessibility routes on mobile routes and real-time traffic updates on public screens, indicate consistent preferences across mobile and public screens.

5 CONCLUSION

The survey results indicate a strong preference among users for having real-time updates, route guidance, and shuttle bus schedules readily available on their personal devices. This suggests that personal devices play a crucial role in providing timely and context-based information, enhancing the user experience by facilitating seamless navigation from departure to destination. Conversely, safety guidelines and local maps were more frequently preferred on public displays, indicating that certain types of information are better suited for shared viewing. This highlights the importance of strategically distributing information across different types of screens to maximise usability and user satisfaction.

The high acceptance of viewing assistance and NFC features, as mentioned in subsection 3.1, underscores the potential of these technologies to improve the ease of navigation and confirmation processes in shuttle bus systems. Integrating these features into the UI design can significantly enhance user convenience and operational efficiency. Furthermore, participants suggested several additional features, such as occupancy information, detailed delay and traffic information, and personalised route information. These recommendations indicate a need for a comprehensive and adaptable UI that can cater to various passenger needs and travel scenarios.

Overall, the findings from this study provide valuable insights for designing user-centric transportation systems. By aligning the UI features with user preferences, it is possible to create more intuitive and supportive travel experiences for automated shuttle bus passengers.

6 LIMITATIONS AND FUTURE WORK

This study was conducted with a relatively small and homogeneous sample population, with 96.15% of participants aged between 21 and 34 years old. Future research may aim to include a more diverse demographic to capture a broader range of preferences and behaviours. This will involve expanding the survey to cover different age groups, geographical locations, and cultural backgrounds to ensure that the findings are representative of a wider population.

Additionally, the current study focused on a single journey scenario, where participants travelled from the office to home. Future work can explore multiple scenarios to understand how different contexts influence UI preferences, such as travelling in a new city where the language or culture is different. By comparing participants' choices across various travel contexts—like commuting to work, travelling for leisure, or attending events—we can gain deeper insights into the adaptability and versatility of the UI.

Moreover, this study relied on participants selecting their preferred UI features from a list without interacting with actual interfaces. To address this limitation, future research will involve the development and deployment of interactive prototypes using mixed reality (MR) simulations developed in a virtual environment, as shown in Subramanian et. al [14]. These prototypes will simulate real UI elements on both mobile and public displays combined with virtual environments. Conducting the surveys by immersing the participants in a virtual environment enhances their involvement with defined scenarios and thereby will improve the effectiveness of the participants' feedback as explained by Subramanian in [13]. Usability testing with these prototypes will provide more accurate feedback on the effectiveness and user satisfaction of the proposed features.

Finally, integrating advanced technologies such as augmented reality (AR) for route visualisation and ensuring seamless collaboration between personal devices and public displays will be explored. This will not only enhance the user experience but also ensure that the UI can cater to various needs and preferences dynamically.

In addition, future work will specifically focus on automated shuttles to understand the unique needs and preferences associated with this mode of transportation. By addressing these aspects, future work will aim to provide a more comprehensive understanding of user needs and preferences, leading to the design of more effective and user-centric transportation interfaces.

SUPPLEMENTARY MATERIAL

The questionnaire used in the survey and the anonymised responses are accessible at https://doi.org/10.4121/76432912-37c4-4603-97e7-9cabbaba653e. The code that reproduces the figures and the tables is available at https://github.com/Shaadalam9/shuttle-boarding.

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