CSE 564 Project Report Phase 1

Team 07

Team Member Names:

1. Chi Ao, Chen
2. Jean Johnson
3. Hana Almuallem
4. Dominic Baker
5. Aryan R. Suthar

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1. Customer Problem

1. 1. Student Dissatisfaction

1. 1. 1. Long Waiting Time [1]

- Students would need to wait for shuttle a much longer time
- student lose their patience in taking shuttle

1. 1. 2. Crowded Shuttle [1]

- Students can't find seats during peak hours
- Crowded environment makes students uncomfortable

1. 1. 3. Lack of feedback system [5]

- Lack of a system for students to provide feedback on shuttle services.
- Student complaints are not addressed promptly, leading to recurring issues.

1. 1. 3. Lack of Communication [5]

- Students do not receive notifications about shuttle delays or cancellations.

1. 2. Inefficient Shuttle Dispatching

1. 2. 1. Lack of responsiveness [5]

- Shuttle can't respond to accident quickly
- Shuttle schedule can't respond if there's a huge event in school

1. 2. 2. Lack of Real-Time Information [2]

- Students can't get real-time shuttle information
- Unable to predict shuttle arrival times
- No collection or analysis of shuttle usage statistics to improve services.

1. 2. 3. Poor Route Design [4]

- Unreasonable route design leads to detours
- Students need to spend more time reaching their destination

1. 2. 4. Poor Coordination with Other Transport Services [4]

- Shuttle schedules do not align with public transport timings.
- Missed opportunities to collaborate with ride-sharing services for better coverage.

1. 3. Waste of Resources

1. 3. 1. Environment impact [3]

- Inefficient usage of shuttle caused extra pollution
- The pollution might provoke resident's anger

1. 3. 2. Operation Costs [4]

- School needs to spend more money due to inefficient dispatching
- This would also affect the overall sustainability of the whole shuttle system.

1. 3. 3. Human Resource [4]

- Drivers' work schedules are unreasonable
- High work pressure on drivers affects service quality

1. 3. 4. Maintenance Costs [5]

- Poor maintenance leads to frequent shuttle breakdown
- Untimely maintenance increases costs
- Takes more time to classify the data in traditional shuttle system
- Shuttles do not employ energy-saving measures, increasing operational costs.

1. 3. 5. Underutilized Shuttle Capacity [1]

- Shuttles run with very few passengers during non-peak hours
- More drivers than needed during low demand periods, leading to inefficiency.

1. 3. 6. Inefficient Scheduling [4]

- Some shuttle routes overlap, leading to redundant services.
- Shuttle schedule not based on actual demand, causing inefficiencies.

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[1] T. Arabghalizi and A. Labrinidis, "Data-driven Bus Crowding Prediction Models Using Context-specific Features," *ACM/IMS Transactions on Data Science*, vol. 1, no. 3, pp. 1–33, Sep. 2020, doi: https://doi.org/10.1145/3406962.

[2] "Real-Time Bus Arrival Prediction: A Deep Learning Approach for Enhanced Urban Mobility," *Arxiv.org*, 2024. https://arxiv.org/html/2303.15495v3 (accessed Sep. 22, 2024).

[3]W. Austin, G. Heutel, and D. Kreisman, "School Bus Emissions, Student Health, and Academic Performance," *National Bureau of Economic Research*, Mar. 01, 2019. https://www.nber.org/papers/w25641

[4]A. Sharma, "Advancing School Bus Routing: A Machine Learning Approach for Enhanced Efficiency, Safety, and Sustainability." Accessed: Sep. 28, 2024. [Online]. Available: https://www.ijfmr.com/papers/2022/6/16031.pdf

[5]M. W. Raad, M. Deriche, and T. Sheltami, "An IoT-Based School Bus and Vehicle Tracking System Using RFID Technology and Mobile Data Networks," *Arabian Journal for Science and Engineering*, Nov. 2020, doi: https://doi.org/10.1007/s13369-020-05111-3.

2. Stakeholders

2.1. ASU

- Have a system that can be used to monitor and issue buses to stations
- Able to detect when to use more or less buses depending on time of day
- Improve the ability for students to reach their goal location in a reasonable amount of time
- Keep track of who enters their shuttles in case of emergency

2.2. Students

- Improved system that allows them to reach their goal location in a reasonable time
- Allows them a combust system that allows them to feel safe when standing at the shuttle location
- Improve time for them to arrive to class on time
- Allows them to see how many people are located at the shuttle location.
- Allowing them to avoid over crowdedness
- Allows the students to leave an alert if there's a lot of people on a particular shuttle

2.3. Parents

- Could be able to monitor their child location based on camera feedback
- Ease of mind that their child is having a reliable transportation system
- Could possibly view the area where their child would be waiting at

2.4. Drivers and Staff

- Optimized schedule to reduce stress
- Predictable workloads
- Improved job satisfaction
- Reduced Idle times
- Better work life balance
- Better coordination with maintenance team to for earlier maintenance based on usage

2.5. Transport Authorities

- Optimizing resource allocation
- Ensuring customer satisfaction
- Adhering to local transport regulations

2.6. Shuttle Service Operators

- Efficient fleet management
- Reducing operational costs,
- Minimizing fuel consumption
- Enhancing service reliability

2.7. Technology Providers

- Continuous improvement of predictive systems
- Maintaining service contracts
- Providing new features to improve service reliability

2.8. Local Government and City Planners [8]

- Improving public transport efficiency
- Achieving sustainability goals through better use of transport resources
- Economic growth and job creation
- Improving equity and access
- Address city growth and density

2.9. Data Scientists and Analyst

- Access to accurate data
- Ensuring that data-driven decisions improve operational efficiency
- Algorithm Optimization to fine tune model
- Improve scalability and performance
- Better reports and visualization of the data

2.10. Private Sponsors and Investors [8]

- Return on investment through efficient operations
- Reduced costs
- Potentially higher rider satisfaction leading to more usage
- High growth potential

2.11. Environmental Groups

- Reduction in emissions through optimization bus deployments
- Supporting sustainability goals
- Encouraging green transportation

2.12. Smart City Initiatives

- Utilizing shuttle service data for broader smart city application
- Optimizing traffic flow
- Reduce urban congestion
- Improving quality of life

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[8]Bucchiarone, A., Battisti, S., Marconi, A., Maldacea, R., & Ponce, D. C. (2020). Autonomous shuttle-as-a-service (ASaaS): Challenges, opportunities, and social implications. *IEEE Transactions on Intelligent Transportation Systems*, *22*(6), 3790-3799.

3. Key Operational Concepts

3. 1. Facilitating student success

3. 1. 1. Optimized bus scheduling

- Optimized bus schedules based on crowd patterns.
- More buses during peak hours.
- Faster reaction to incidents including road blocks & accidents.

3. 1. 2. Better campus connectivity

- Students can be on time across ASU campuses.
- Accommodate diverse work hours for faculty.
- Enable cross-campus collaborations among students.
- Enable access to ASU events across campuses.

3. 1. 3. Maximize student comfort

- Reduced wait times during extreme weather.
- Reducing stress of unexpected delays.
- Encourage students to attend class.
- Avoid delays and inconsistencies in bus schedule.

3. 2. User Interaction and Feedback

3. 2. 1. Intuitive interface.

- Easy to use interface for better user satisfaction [3].
- Effortless navigation for positive experience.
- Enhanced communication with clear visuals & real time alerts.
- Personalization options to tailor for individual users.

3. 2. 2. Information sharing for better planning.

- Real time seat occupancy status tracked and published to users [4].
- Real time schedule change notifications published.
- Enhanced communication to drivers and staff operating shuttle service.

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[3] M. N. Islam, "Towards Designing Users' Intuitive Web Interface," *2012 Sixth International Conference on Complex, Intelligent, and Software Intensive Systems*, Palermo, Italy, 2012, pp. 513-518,

[4] Vidyasagaran, S. R. Devi, A. Varma, A. Rajesh and H. Charan, "A low cost IoT based crowd management system for public transport", 2017 International Conference on Inventive Computing and Informatics (ICICI), pp. 222-225, 2017.

3. 2. 3. Privacy and Anonymity

- Camera sensors won't implement face recognition.
- Any personal identifiable data captured by system is removed.
- Optional data collected won't be linked to user.

3. 2. 4. Optional Data Collection for Improvement.

- Collect travel window from students & staff.
- Allow drivers to input availability of their schedule.
- Collect failure to board information from students & staff.
- Use data collection for system improvements.
- Responsiveness to feedback from users build trust among users.

3. 3. Cost-effective Solution

3. 3. 1. Predicts the right number of buses, to minimize cost.

- Detect and track the crowd data at the bus stop [5].
- Predict crowd based on historical crowd data and past trends using AI [6].
- Dispatch the right number of buses to save cost.

3. 3. 2. Low-cost development

- Initial development done by students along with faculty
- Required hardware is inexpensive.
- Use open-source and free tools to save on costs.
- Leverage existing frameworks for faster development.
- Build the solution on Cloud for low capital cost and scalability.

3. 4. Positive Environmental and Social Impact.

3. 4. 1. Reduce the environment impact.

- Reduced carbon footprint by optimizing the number of buses.
- Students provided the carbon footprint data to show the impact of public transport.
- Track the carbon footprint for shuttle system for better planning.
- Robust public shuttles can promote public transport for new students [7].
- Minimalist sensor usage to reduce electricity waste.

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[5] Y. Xie, J. Niu, Y. Zhang and F. Ren, "Multisize patched spatial-temporal transformer network for short- and long-term crowd flow prediction", IEEE Transactions on Intelligent Transportation Systems, vol. 23, no. 11, pp. 21548, 2022.

[6] M. Z. Malik, S. Nazir and H. U. Khan, "Artificial Intelligence Based System on Enhancing the Capabilities of Transport System: A Systemic Literature Review," 2023 IEEE Symposium on Industrial Electronics & Applications (ISIEA), Kuala Lumpur, Malaysia, pp. 1-6, 2023

[7] P. HORAŽĎOVSKÝ, S. KOZHEVNIKOV and M. SVÍTEK, "Dynamic Public Transport in Smart City using Multi-agent system," *2019 Smart City Symposium Prague (SCSP)*, Prague, Czech Republic, 2019, pp. 1-5, 2019

3. 5. Collaboration with other Transport Systems.

3. 5. 1. Co-ordinate schedules across city.

- Partner with local transit services for schedule sharing and updates.
- Consider the local transit schedule when scheduling shuttles.
- Align local transit pick-up and shuttle bus drop-off timing & vice versa.
- Reduce waiting times across multiple transit services.

3. 5. 2. Data sharing for better service.

- Share data from across transport modes & providers.
- Analyze trends in data from local transit for crowd analysis [8].
- React to real-time updates of service disruptions, incidents & delays.

3. 5. 3. Improving shuttle stop location

- Collect data from students and faculty
- Cross reference information with existing route to consider new stops.
- Public transport services can pick better stops in student areas.

3. 6. Sustainable and Long-Running Product.

3. 6. 1. Future-Proof Solution.

- Accommodate additions of new shuttles to the fleet.
- Solution should be flexible to accommodate shuttles of difference capacity.
- Solution must be scalable to handle increasing user base and fleet.
- Adapt to new needs and wants of students' and drivers.

3. 6. 2. Equal opportunities for all students.

- Improved accommodation for students with disabilities.
- Accessibility for students without their own vehicles to different campuses.
- Easy affordability for students and faculty.
- Safe option for international and out-of-state students to travel.

3. 7. Co-ordination for ASU Events.

3. 7. 1. Schedule Adjustments.

- Solution must provide easy integration with ASU for event co-ordinations.
- Extend shuttle service hours to accommodate events.
- Event registration data can be integrated with the dispatcher system.
- Anticipate an increased crowd and adjust the schedule.
- Publish event-specific notifications to user on schedule changes.

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[8] S. Lyapin, D. Kadasev and N. Voronin, "Application of Digital Control Approaches in Solving Transport Planning Problems in Road Transport," *2023 5th International Conference on Control Systems, Mathematical Modeling, Automation and Energy Efficiency (SUMMA)*, Lipetsk, Russian Federation, 2023, pp. 894-898

3. 8. Valuable Data Insights for ASU.

- Data captured by the solution can contain valuable insights.
- Data such as shuttle ridership, peak times can be leveraged for analysis.
- Insights from data used to improve class schedules, event planning.

4. Conclusion

4. 1. Overview

4. 1. 1. Student Dissatisfaction

- Long waiting times during peak hours.
- Shuttles are often overcrowded, making it hard to keep services running on time, especially during busy hours.
- No real-time information pertaining to the arrival of buses.
- There is no real consistency of schedules, with constant delays.

4. 1. 2. Stakeholders Needs

- Effective Shuttle operations become efficient and reliable.
- Economical utility for ASU and students alike.
- Accountable and transparent.
- Better user experience and communication.
- Positive environmental impact.

4. 1. 3. Operational Challenges

- Overcrowding on some routes, while others are underutilized.
- Unresponsive dispatching to changing conditions.
- Wasteful utilization of resources.
- Higher maintenance costs, since wear and tear are more than it ought to be.

4. 1. 4. Potential Solutions

- Use data-driven algorithms to predict demand and adjust schedules accordingly.
- Real-time information, on-board feedback mechanisms, user-friendly interface.
- Minimize unnecessary journeys; route optimization; energy-efficient technologies.
- Carbon emissions reduction, shift to public transport, exploitation of alternative renewable energy sources.
- Also, the transport system is focused on data privacy-not storing it as personal information, and face recognition is also avoided.
- Anonymized data helps make the transport system safer by reducing privacy risks and providing valuable information.

4. 2. Limitation of Resources (Open Issue 1)

4. 2. 1. Constraints of Resources

- Lack of Shuttle buses during peak hours.
- Drivers' shortage means fewer shuttles running and longer waiting times.
- Delays and inconvenience for students due to buses break down.
- Rising fuel costs makes it expensive to run the shuttles.

4. 2. 2. Addressing Limitations

- Figuring out the need of more buses and drivers to meet the demand.
- Insufficient maintenance resources like lack of personnel or facilities.
- Lack of parking spaces at the bus stops.

4. 3. Unexpected roadblocks & Accidents (Open Issue 2)

4. 3. 1. Non-Contingent Planning

- No plans for situations like road closures, accidents or bad weather.
- Non-accurate traffic monitoring leading buses to delay.
- Need to develop alternate route plans instance of emergency.

4. 3. 2. Improvement in Incident Response

- Need better communication tools for buses and dispatch centers to stay in touch.
- Emergency response training for the drivers and staff members.
- Partnering up with the emergency responding agencies for more quicker response.
- Keep a track of previous incidents and try to prevent them from happening again.

4. 4. Parking Lot

4. 4. 1. Storage Tracking

- Monitor the boot storage capacity of each shuttle in real time.
- Provide the real-time information of storage occupancy of shuttles to the students.
- Using the data to optimize routing and scheduling of shuttles.

4. 4. 2. Student Reservation System

- Allow students to reserve seats on shuttles in advance.
- Analyze the reservation patterns to optimize scheduling and resource allocation.
- Keep the students informed about the overcrowding and seat availability.

4. 4. 3. Autonomous & Fuel-efficient Shuttle Buses

- Electric or hybrid vehicles for fuel efficiency and energy-efficient infrastructure.
- Explore the potential benefits and challenges of implementing self-driving shuttles.
- Keeping in mind about the safety and regulatory implications of auto-shuttles.
- Track and report carbon footprint for measuring sustainability progress.

5. Appendix A: Credit Sheet

Team Member Name	Contributions
Chi Ao, Chen	1. Participating in discussions for topic selection 2. Discussing group-raised issues with the professor 3. Identifying Customer Problems part
Jean Johnson	1. Participating in discussions for topic selection 2. Discussions with professor on aspects of the problem. 3. Requirement elicitation from students using campus shuttles. 4. Identifying Operational Concepts for the solution.
Hana Almuallem	1. Participating in discussions for topic selection 2. Requirement elicitation and discussion with professor 3. Requirement elicitation from students using campus shuttles 4. Identifying Operational Concepts for solution
Dominic Baker	1. Participating in discussions for topic selection 2. Identifying the stakeholders for the project 3. Asked questions for professor.
Aryan R. Suthar	1. Participating in discussions for topic selection. 2. Discussing group-raised issues with the professor. 3. Handling Conclusion part of the project. 4. Addressing problem’s overview and their potential solutions. 5. Addressing open issues and parking lots.