Capstone 400C (Presentation)

BLOCKCHAIN POWERED PARKING SOLUTION FOR SMART CITIES

PRESENTED BY

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INTRODUCTION

Addressing Urban Parking Challenges

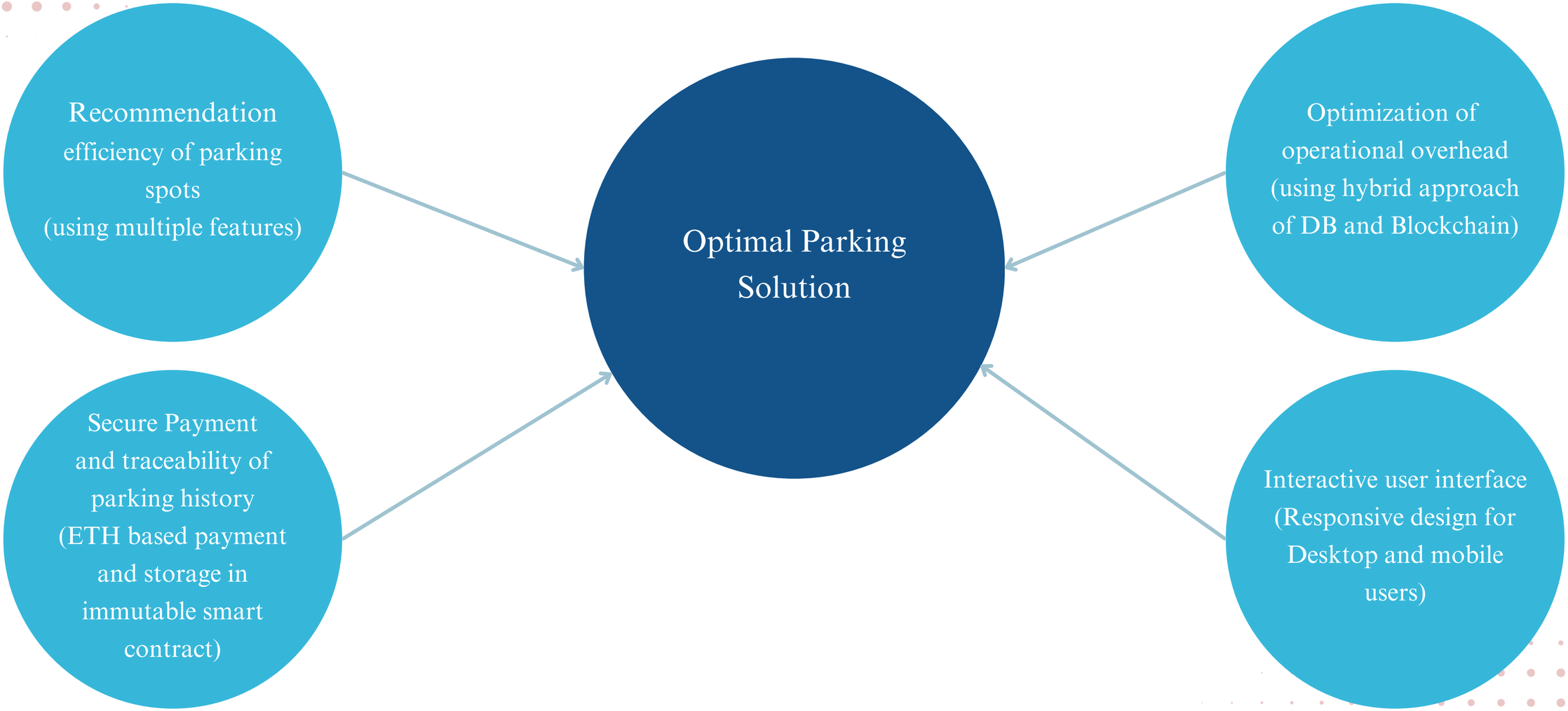
Leveraging Innovative Technologies

Enhancing Economic Growth For Stakeholders

RELATED WORKS

1	2	3	4
PARKCHAIN	**PARKING MANAGEMENT**	**BLOCKCHAIN BASED ARCHITECTURE**	**BSPF: BLOCKCHAIN ENABLED SMART PARKING**
Contributions and Services • Blockchain-based ecosystem • Non-fungible parking tokens (NFT's) • Smart contracts • Real-time surveillance • User-friendly mobile application • Rental Packages	**Contributions and Services** • Consortium Blockchain • Privacy-preserving parking management • Smart contracts for rental • User anonymity • Rental Packages	**Contributions and Services** • Scalability (Layered architecture) • Blockchain powered • Seamless user experience • Rental Packages	**Contributions and Services** • Privacy Protection (Cryptographic Techniques) • Efficiency (Constant time complexity for most operations) • Parking Operations Handling • Rental Packages
Limitations • Privacy Concerns (Public ledger) • High Operational Cost (Due to integration of IOT and Blockchain)	**Limitations** • Limited Scalability (Due to limited nodes) • Single Point of Failure (Every node holds significant responsibility)	**Limitations** • High transaction costs (Gas Fee)	**Limitations** • Computational Overhead • High transaction costs (Due to all data being stored in blockchain)
Reference [1] S. Jennath et al.,S.Adarsh,Nikhil V.Chandran,R.Ananthan,A.Sabir and S.Asharaf "Parkchain: A blockchain powered parking solution for Smart Cities," Frontiers, vol. 2,2023, doi:10.3389/fbloc.2019.00006	**Reference** [2] J. Hu, D. He, Q. Zhao and K. -K. R. Choo, "Parking Management: A Blockchain-Based Privacy-Preserving System," in IEEE Consumer Electronics Magazine, vol. 8, no. 4, pp. 45-49, July 2019	**Reference** [3] S. Ahmed, Soaibuzzaman, M. S. Rahman and M. S. Rahaman, "A Blockchain-Based Architecture for Integrated Smart Parking Systems," 2019 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), Kyoto, Japan, 2019, pp. 177-182	**Reference** [4] C. Zhang et al., "BSFP: Blockchain-Enabled Smart Parking With Fairness, Reliability and Privacy Protection," in IEEE Transactions on Vehicular Technology, vol. 69, no. 6, pp. 6578-6591, June 2020

MOTIVATION


Recommendation efficiency of parking spots (using multiple features)
Secure Payment and traceability of parking history (ETH based payment and storage in immutable smart contract)
Optimal Parking Solution
Optimization of operational overhead (using hybrid approach of DB and Blockchain)
Interactive user interface (Responsive design for Desktop and mobile users)

OBJECTIVES

Recommendation Model
(Based on min max normalized weighted sum)

Cost Reduction
(Blockchain overhead reduction by storing only necessary
data in blockchain)

Technology Utilization
(Synchronization of DB along with blockchain)

Security Measures
(Transaction traceability and payment using smart contract)

Monetization Management
(Hourly/Monthly
rental packages)

PROBLEM STATEMENTS

1
Choosing features for recommendation model and applying normalization techniques along with weighted sum for efficient recommendation

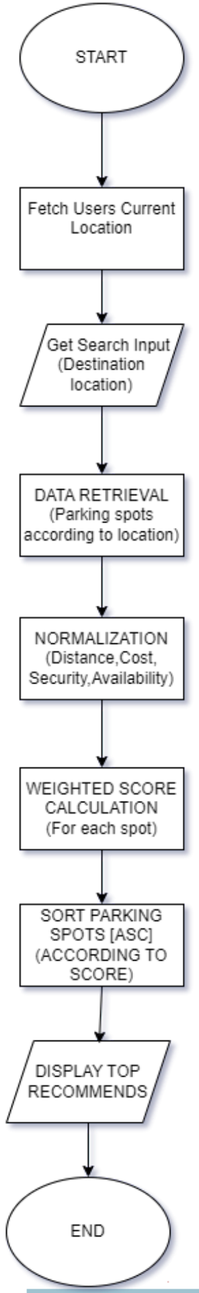
2
Identifying ways to reduce operational overhead by determining the attributes to be stored in blockchain and in database

3
Leveraging technology efficiently to enhance the parking management system for it's end users.

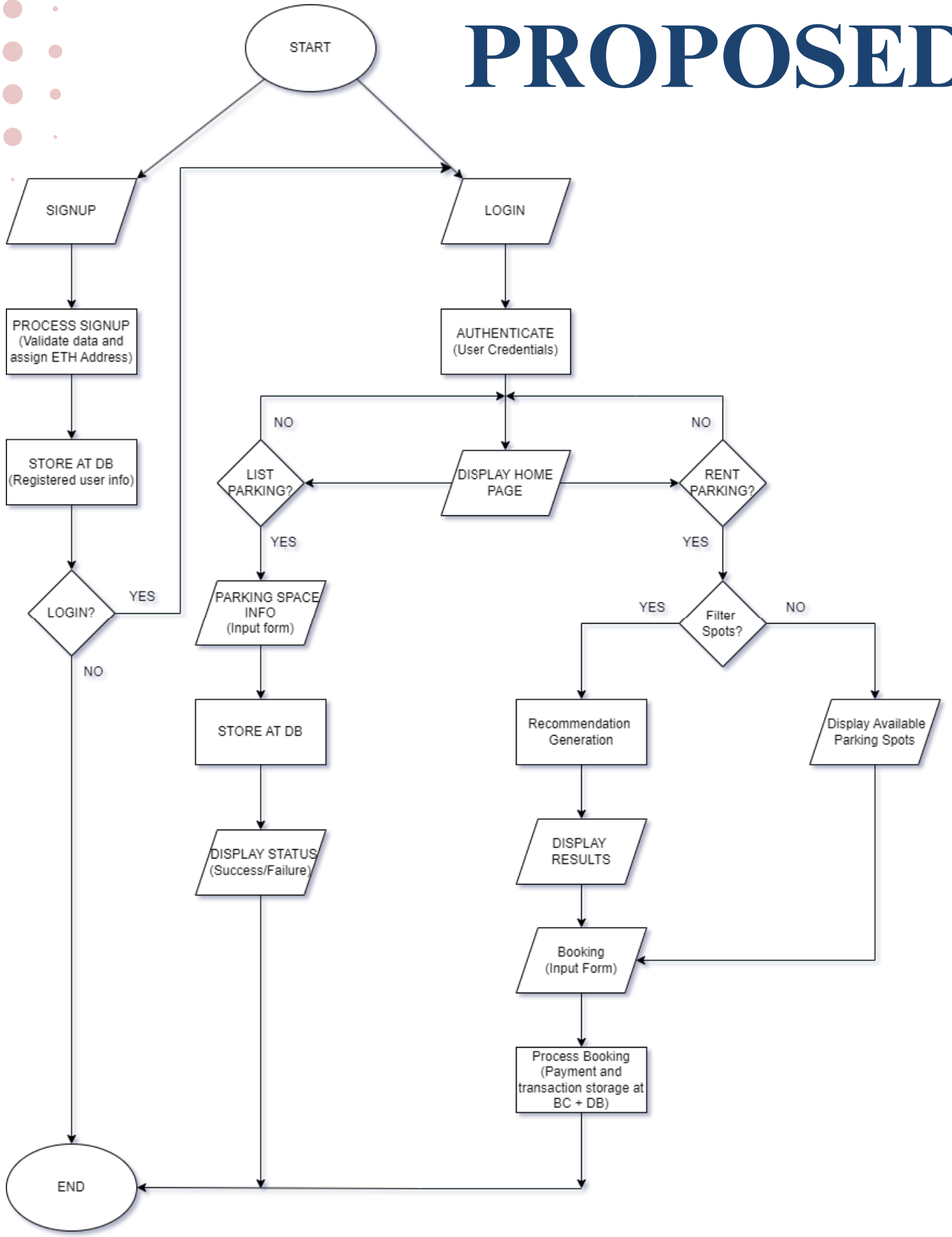
4
Ensuring the security of parking transactions by synchronizing parking data in both blockchain and database while also processing payments through smart contract

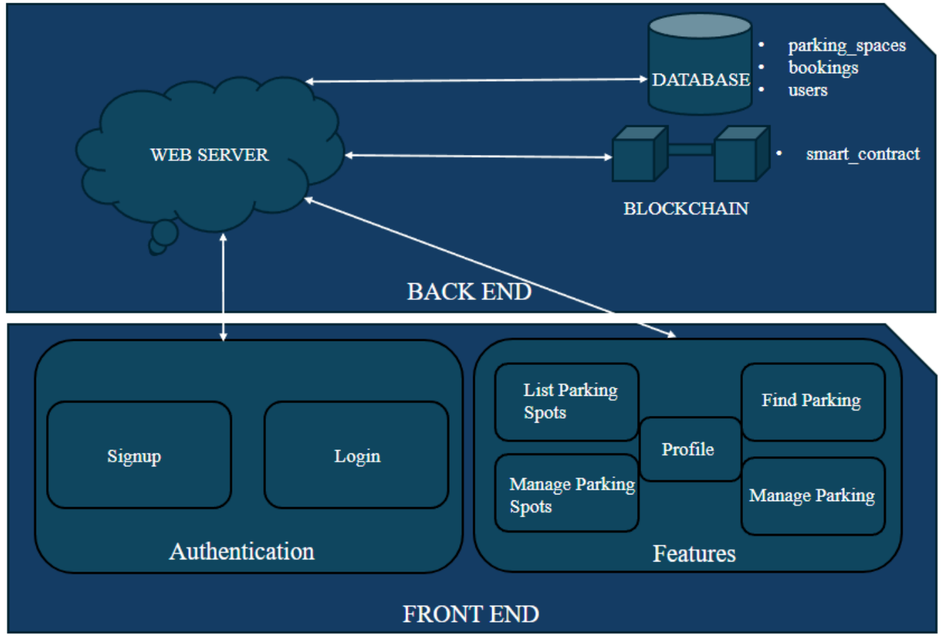
5
Developing strategies to monetize and optimize the utilization of privately-owned empty parking spots to alleviate street parking congestion.

PROPOSED RECOMMENDATION MODEL



PROPOSED SYSTEM





IMPLEMENTATION

Front End	Back End	Frameworks and libraries	Blockchain
• HTML • CSS • Javascript	• PHP • MySQL • Solidity	• Truffle • web3.js	• Ganache (Local blockchain,Private)

Geolocation data are collected using google map and stakeholder preferences are collected through surveys.

EXPERIMENTAL EVALUATION

(CHOOSING THE RECOMMENDATION ALGORITHM)

ASPECTS	1 BORDA COUNT	2 DECISION RULES	3 MIN-MAX WEIGHTED SUM (Choosen)
Description	Combines rating of multiple voters into a single value.	Decides the list of items based on constraints on one or more parameters	Calculates final score based on normalized values and assigned weight on parameters
Time Complexity	O (N x M)	O (N x M)	O (N x M)
Space Complexity	O (N x M)	O (N x M)	O (N x M)
Flexibility	Limited, may not reflect varying importance of preferences	Strict, may not reflect the intensity of preferences well	Highly flexible, allowing consideration of criteria importance

SAMPLE DATA SET FOR EVALUATION

Parking Spot ID	Distance (Km)	Cost (bucks)	Availability (Parking Slot)	Security (Facilities)
PS-1	1	8	2	**CCTV**
PS-2	1.5	6	4	**GUARD**
PS-3	2	12	1	**INDOOR,GUARD**
PS-4	0.8	10	3	**CCTV,GUARD, INDOOR**
PS-5	1.2	9	2	**CCTV,INDOOR**
PS-6	1.8	7	5	**GUARD**
PS-7	1.3	11	1	**CCTV**
PS-8	0.9	8	4	**INDOOR,GUARD**

EXPERIMENTAL EVALUATION
(COMPARISON OF RECOMMENDATION ALGORITHMS)

ASPECTS	BORDA COUNT	DECISION RULES	MIN-MAX WEIGHTED SUM (Used)
Point Calculation	$P = N - rank + 1$ Where : N = number of spots rank = criteria specific rank P = criteria specific points Final point = Summation of all P Rank spots (DESC)	1.Assign rules 2.Assign ranking for each criteria 3.Assign points based on ranking 4.Aggregate points 5.Rank spots (ASC)	1.Calculate norm for each criteria $(x\text{-}min)/(max\text{-}min)$ 2.Calculate weighted sum for each spot $\sum(weight * norm)$ of all criteria 3.Rank spots (ASC)
Recommended Parking spots	1. Spot 8: 25 points 2. Spot 4: 24 points 3. Spot 2: 20 points 4. Spot 5: 19 points 5. Spot 6: 19 points 6. Spot 1: 19 points 7. Spot 7: 12 points 8. Spot 3: 11 points	1. Spot 8 (Total points: 11) 2. Spot 4 (Total points: 12) 3. Spot 2 (Total points: 15) 4. Spot 5 (Total points: 16) 5. Spot 6 (Total points: 16) 6. Spot 7 (Total points: 23) 7. Spot 1 (Total points: 24) 8. Spot 3 (Total points: 25)	Spot 1: Total Score = 0.291 Spot 8: Total Score = 0.420 Spot 2: Total Score = 0.441 Spot 5: Total Score = 0.483 Spot 4: Total Score = 0.500 Spot 7: Total Score = 0.504 Spot 6: Total Score = 0.691 Spot 3: Total Score = 0.733

SURVEY QUESTIONS

S/N	Question	Category
1	**Are you a potential renter or rentee ?**	**Stakeholder and Preference**
2	**What features are most important to you when choosing a parking spot ? (Select all that apply)** 1.Cost 2.Distance 3.Security 4.Availability 5.Rating	**Stakeholder and Preference**
3	**How frequently do you use parking services ?** 1.Daily 2.Several times a week 3.Once a week 4.Occasionaly 5.Rarely	**Economic Effect**
4	**How much would you be willing to pay per hour/month for a convenient parking spot ?**	**Economic Effect**

S/N	Question	Category
5	**How do you currently find parking spots ?** 1.Circle the area until finding a spot 2.Use a parking app	**Environmental Effect**
6	**Do you believe that having access to real-time parking availability can reduce traffic congestion in your area ?** 1.Yes 2.No 3.Unsure	**Environmental Effect**
7	**Do you believe better managed parking spaces can positively impact community interactions ? (e.g., by reducing stress and frustration)** 1.Yes 2.No 3.Maybe	**Social Effect**
8	**Do you believe improved parking availability can benefit local businesses ? (e.g., increased customer foot trafic)** 1.Yes 2.No 3.Unsure	**Social Effect**

SURVEY SUMMARY

Category	Summary
Stakeholder and Preference	• Our Survey findings suggest most of the rentee's prefer cost and security as highest priority (94%) followed by availability (88%) and distance (76%) . The least importance was given to reviews (35%) . • Most of the user base consists of rentees (76.5%) while renters are the remaining (23.5%) .
Economic Effect	• Our findings suggest most people use parking services several times a week (35.3%) while daily usage stands up to (29.4%). Occasional users counts at (23.5%) and people who use parking services once a week or rarely stands at (5.9%) . • In most cases , rentee's are willing to pay 3000tk per month or 50tk per hour .
Environmental Effect	• Most of the rentee's currently find parking spots by circling an area (64.7%) while the remaining user base use parking apps to find parking spots (35.3%) . • Majority of the rentee's agree that having real-time parking availability can reduce traffic congestion in their area (76.5%) while the rest of them are unsure about it (23.5%) .
Social Effect	• Our findings suggest all the rentee's believe better managed parking facilities can help improve community engagement by reducing stress and frustration (100%) . • Majority of our stakeholders believe that improved parking availability can help local businesses (88.2%) while the rest of them are unsure (11.8%) .

ADVANTAGES OVER EXISTING WORKS

Private Blockchain

- Access control
- Reduced attack surface
- Instant mining
- Enhanced privacy

Efficient Recommendation System

- Recommendation of parking spots are generated based on various parameters that are normalized and weighted (distance,cost,security, availability)

Reduced Operational Overhead

- Reduced GAS FEE usage by using Database alongside Blockchain

CONCLUSION

This project optimizes empty parking spots to reduce street congestion using a blockchain-powered platform with dynamic pricing and secure transactions. Key achievements include enhanced security, reduced search time via a recommendation system, and a user-friendly interface. Future work will focus on reducing costs, improving algorithms, ensuring scalability as well as integration of various payment gateways. This project is a significant step towards smarter and more efficient urban parking solutions.

THANK YOU

We are now open to questions !

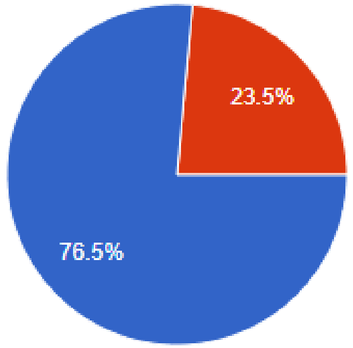
Demo: https://youtu.be/bylZd9DPaaQ

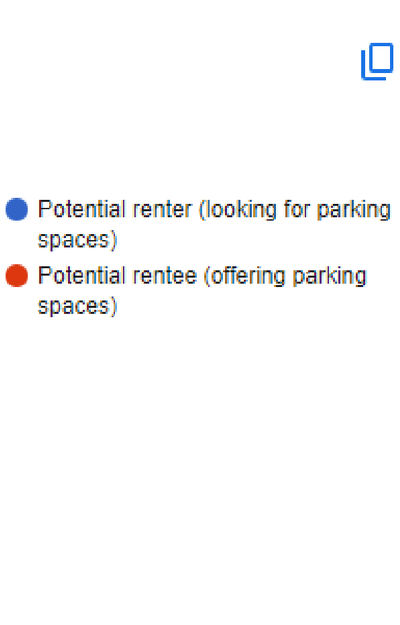
STUDY ON THE EFFECTS OF THE PROPOSED MODEL

(STAKEHOLDERS AND PREFERENCES)

Are you a :

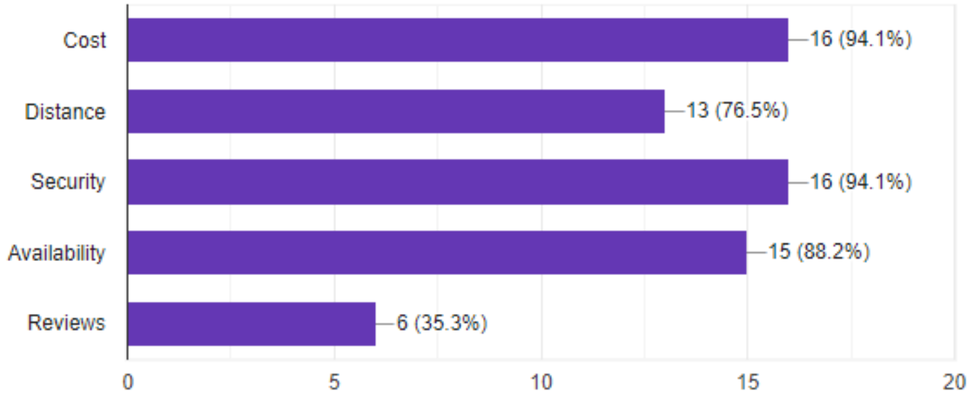
17 responses





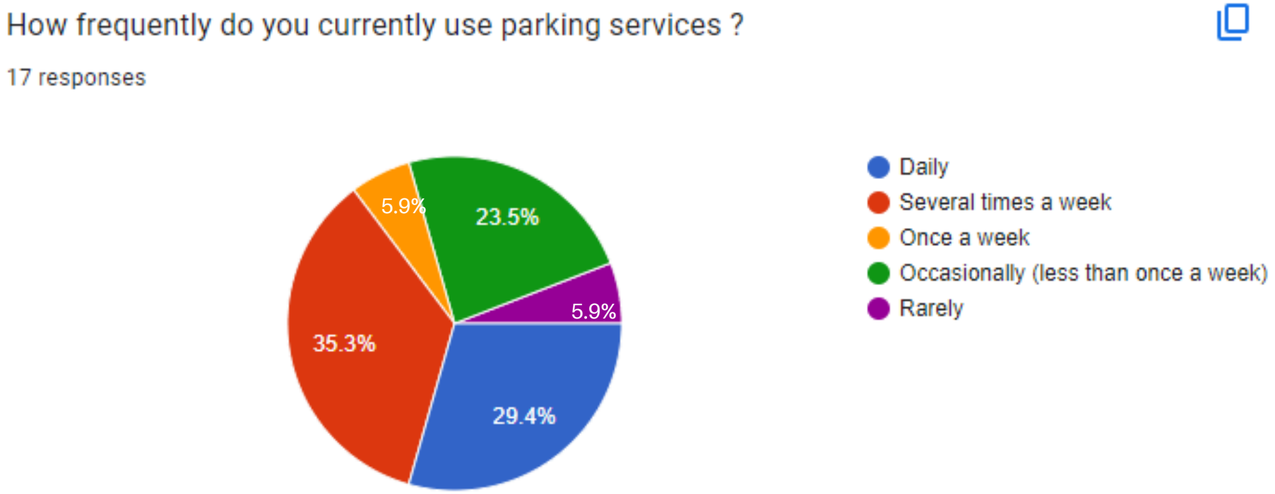
What factors are most important to you when choosing a parking spot? (Select all that apply)

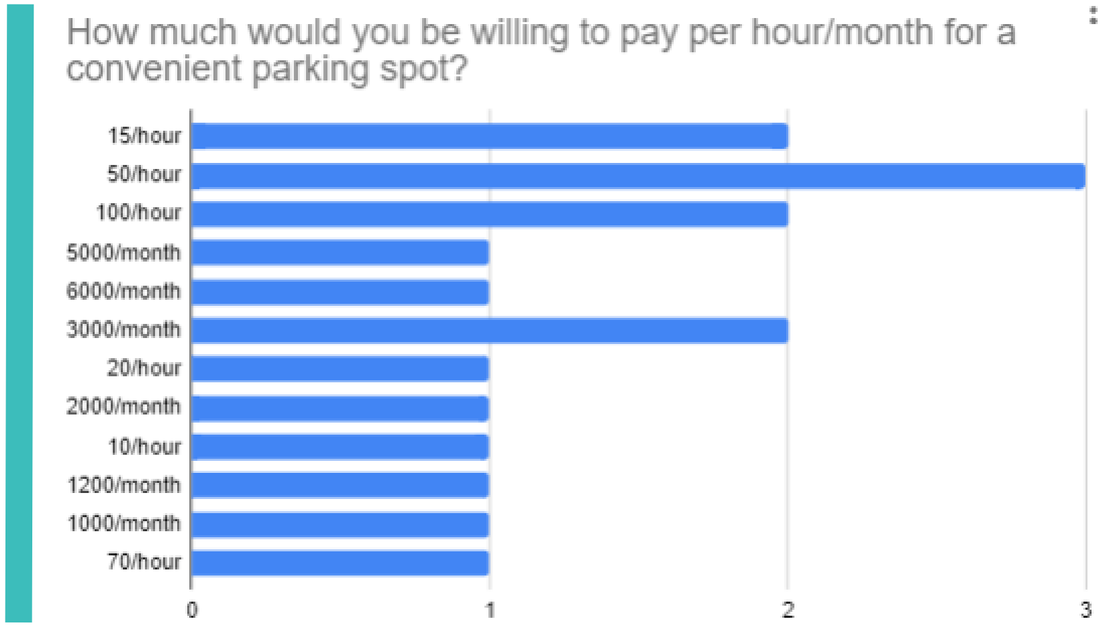
17 responses



STUDY ON THE EFFECTS OF THE PROPOSED MODEL

(ECONOMIC EFFECTS)



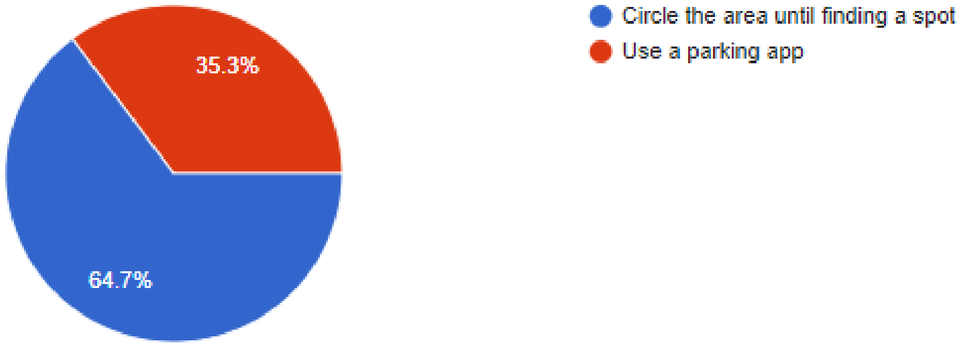


STUDY ON THE EFFECTS OF THE PROPOSED MODEL

(ENVIRONMENTAL EFFECTS)

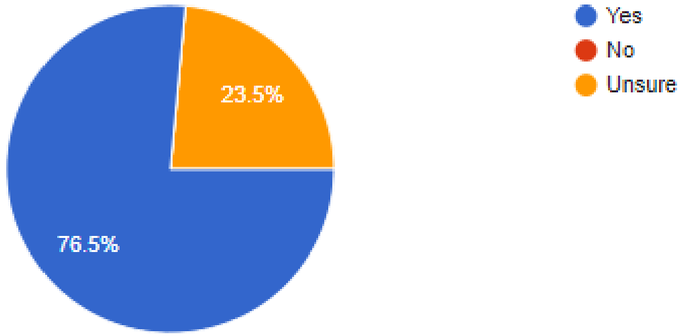
How do you currently find parking spots ?

17 responses



Do you believe that having access to real-time parking availability can reduce traffic congestion in your area?

17 responses

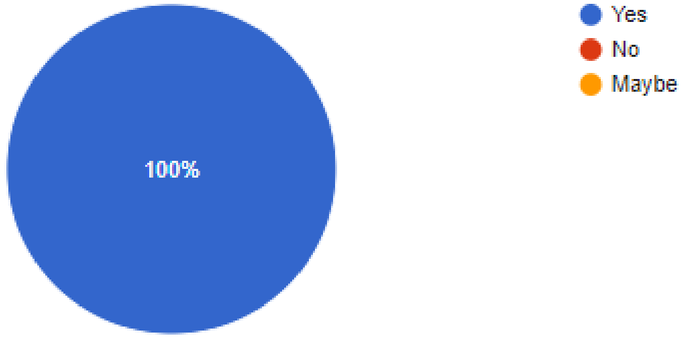


STUDY ON THE EFFECTS OF THE PROPOSED MODEL

(SOCIAL EFFECTS)

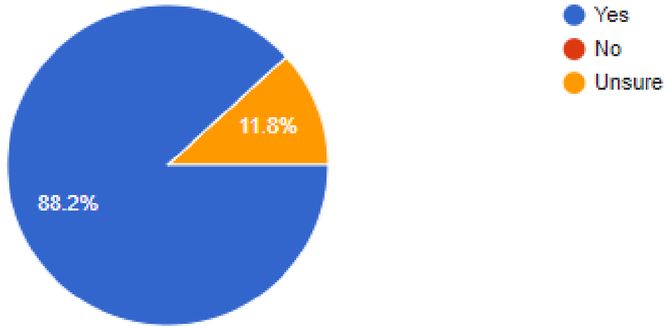
Do you think better-managed parking spaces can positively impact community interactions (e.g., by reducing stress and frustration) ?

17 responses



Do you believe improved parking availability can benefit local businesses (e.g., increased customer foot traffic) ?

17 responses



COMPARISON WITH EXISTING WORKS

ASPECTS	1 PARKCHAIN	2 PARKING MANAGEMENT	3 BLOCKCHAIN BASED ARCHITECTURE	4 BSPF: BLOCKCHAIN ENABLED SMART PARKING	5 BLOCKCHAIN POWERED PARKING SOLUTION FOR SMART CITIES
Type of Blockchain	Public	Consortium	Decentralized (specifics not provided)	Decentralized (specifics not provided)	Private
Recommendation of Parking Spots	Real-time recommendations based on IoT data and blockchain transactions	Real-time recommendations based on blockchain transactions	Likely real-time recommendations, details not specified	Recommends parking spots based on location-based range queries	Real-time recommendations based on various parameters (e.g. distance,cost,security,availability)
Data Storage	IoT data stored on blockchain	Combination of blockchain and off-chain database	Likely a combination of blockchain and database, specifics not provided	Uses blockchain for secure data storage	Combination of blockchain and database

Appendix

CO	CO Description	Knowledge Profile (K)	Complex Engineering Problem (EP)
CO7	**Assess** and **address** the sustainability and impact of the capstone project in societal and environmental contexts	**Sustainability and Impact**: The project reduces traffic congestion and emissions by optimizing parking space usage, contributing to environmental sustainability. It provides economic benefits by enabling monetization of unused spaces and improves quality of life by reducing parking search times. **Ethical Responsibility**: Ensures secure and transparent transactions using blockchain, protecting user data and maintaining public trust.**[K7]**	**EP2 : Range of Conflicting Requirements :** The project addresses conflicts between security/transparency (blockchain) and user-friendliness, as well as balancing dynamic pricing for affordability and profitability. **EP5: Extent of Applicable Codes :** The project operates beyond traditional engineering codes due to its innovative use of blockchain, adhering to blockchain security and data privacy principles while complying with local parking regulations. **EP6: Extent of Stakeholder Involvement and Conflicting Requirements :** Involves diverse stakeholders such as parking spot owners, renters, urban planners, and authorities. Addresses their conflicting needs through features like dynamic pricing, real-time tracking, and navigation app integration. Stakeholder surveys ensure the platform meets varied requirements effectively.

Appendix

CO	CO Description	Knowledge Profile (K)	Complex Engineering Problem (EP)
CO8	**Apply** professional and engineering ethical principles and practices for the implementation of the capstone project	The project applies professional and engineering ethical principles by ensuring user data privacy and security through blockchain technology, which provides secure, tamper-proof transactions. Transparency and trust are fostered via smart contracts that guarantee clear, immutable terms. Dynamic pricing models balance affordability for users with profitability for owners, ensuring fairness. The platform enhances public safety by reducing traffic congestion and potential accidents through optimized parking usage and real-time tracking. It supports sustainability by minimizing the need for new parking infrastructure and lowering emissions, adhering to environmental standards. Additionally, the project complies with local parking regulations, demonstrating professional integrity while innovatively implementing blockchain technology.**[K7]**	

Appendix

CO	CO Description	Knowledge Profile (K)	Complex Engineering Problem (EP)
CO9	**Work effectively as an individual and a team member for successful completion of the capstone project**	The project upholds ethical principles by ensuring data privacy and security through blockchain technology, which guarantees tamper-proof transactions. Transparency and trust are maintained with smart contracts, while dynamic pricing ensures fairness between users and parking spot owners. By reducing traffic congestion and accidents through real-time parking optimization, the project enhances public safety. It supports sustainability by minimizing new infrastructure needs and lowering emissions, aligning with environmental standards. Furthermore, the project complies with local regulations, showcasing professional integrity in the innovative use of blockchain technology.	

Appendix

CO	CO Description	Knowledge Profile (K)	Complex Engineering Problem (EP)
CO10	**Write effective reports and design documentation, and make effective presentations of the outcome of the capstone project**		**EA1: Range of Resources :** Utilizes diverse resources including Google Maps, MySQL, PHP, HTML, CSS, JavaScript, Solidity, and stakeholder surveys. **EA2: Level of Interaction :** Addresses complex interactions between technical, engineering, and societal issues by integrating blockchain with web development and ensuring regulatory compliance. **EA3: Innovation :** Showcases innovative use of blockchain for decentralized parking solutions with features like smart contracts, real-time tracking, dynamic pricing, and peer-to-peer sharing. **EA4: Consequences to Society and the Environment :** Reduces traffic congestion and emissions, promotes efficient use of urban space, and enhances public safety, addressing significant societal and environmental impacts. **EA5: Familiarity :** Operates beyond traditional engineering standards by using blockchain, while ensuring compliance with legal and regulatory standards in parking and urban management.

Appendix

CO	CO Description	Knowledge Profile (K)	Complex Engineering Problem (EP)
CO11	**Conduct economic analysis and cost estimation; and apply appropriate project management processes in the development life cycle of the capstone project**	In the development life cycle of the capstone project, an economic analysis and cost estimation were conducted to ensure financial viability. The project utilized cost-effective resources such as open-source software (MySQL, PHP, Solidity) and free data sources (Google Maps). Dynamic pricing models were analyzed to maximize profitability for parking spot owners while maintaining affordability for users. Project management processes, including agile methodologies, were applied to streamline development, ensure timely delivery, and manage resources efficiently. Regular stakeholder meetings and iterative feedback loops were employed to align the project with user needs and market demands, ensuring a cost-effective and well-managed development process.	

Appendix

CO	CO Description	Knowledge Profile (K)	Complex Engineering Problem (EP)
CO12	**Prepare to take part in independent and life-long learning for adapting emerging technologies for the solution of the complex computer science and engineering problems**	The capstone project emphasizes the importance of independent and lifelong learning to adapt to emerging technologies. By integrating blockchain, smart contracts, and real-time data tracking into the parking solution, the project showcases a commitment to staying updated with cutting-edge advancements in computer science and engineering. Continuous learning was facilitated through research, online courses, and practical experimentation with new technologies. This approach not only solved complex engineering problems but also prepared the team for future challenges, fostering an environment of ongoing education and technological adaptation.	