Secure Energy Trading using Blockchain and Smart Contracts

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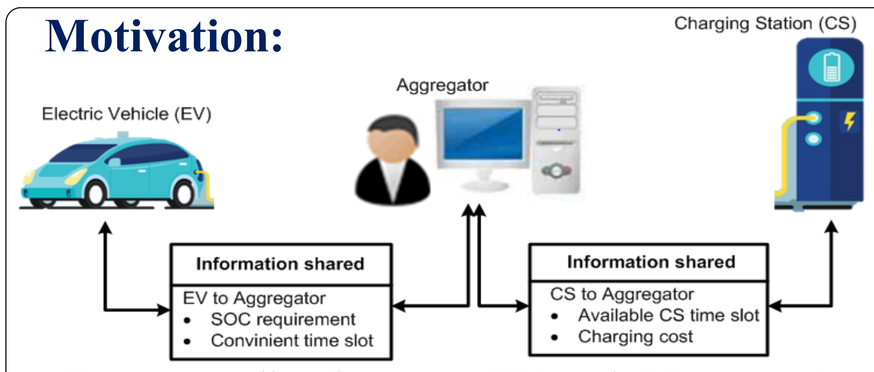
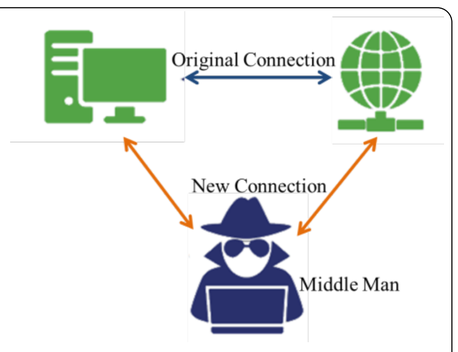
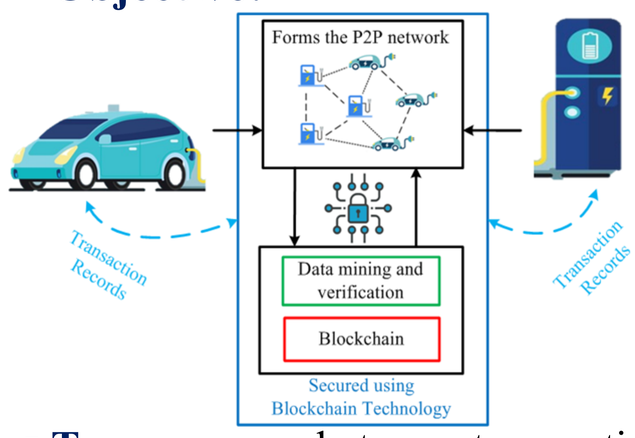
Motivation:

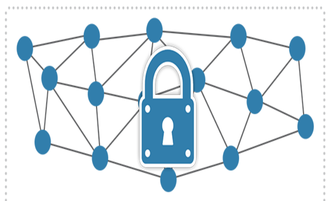




- Energy trading between EV and CS **secure**?
- Aggregator **trustworthy**?
- Energy provided by CS is **reliable** to pay for it?

Objective:





- **Transparency** between two parties.
- A **decentralized** network.
- **Secure** energy trading between EV and CS.
- System **immutable**.

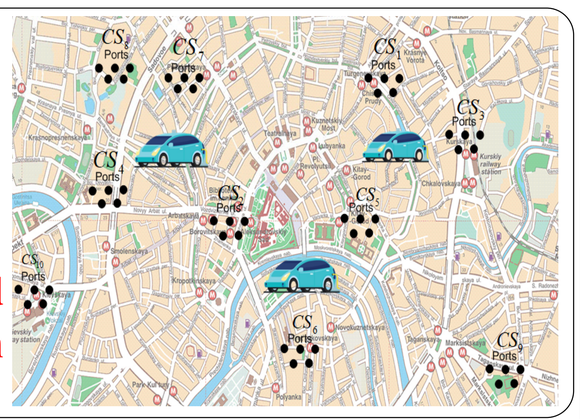
Problem Statement: (1) EVs selecting CS with

(i) optimal distance

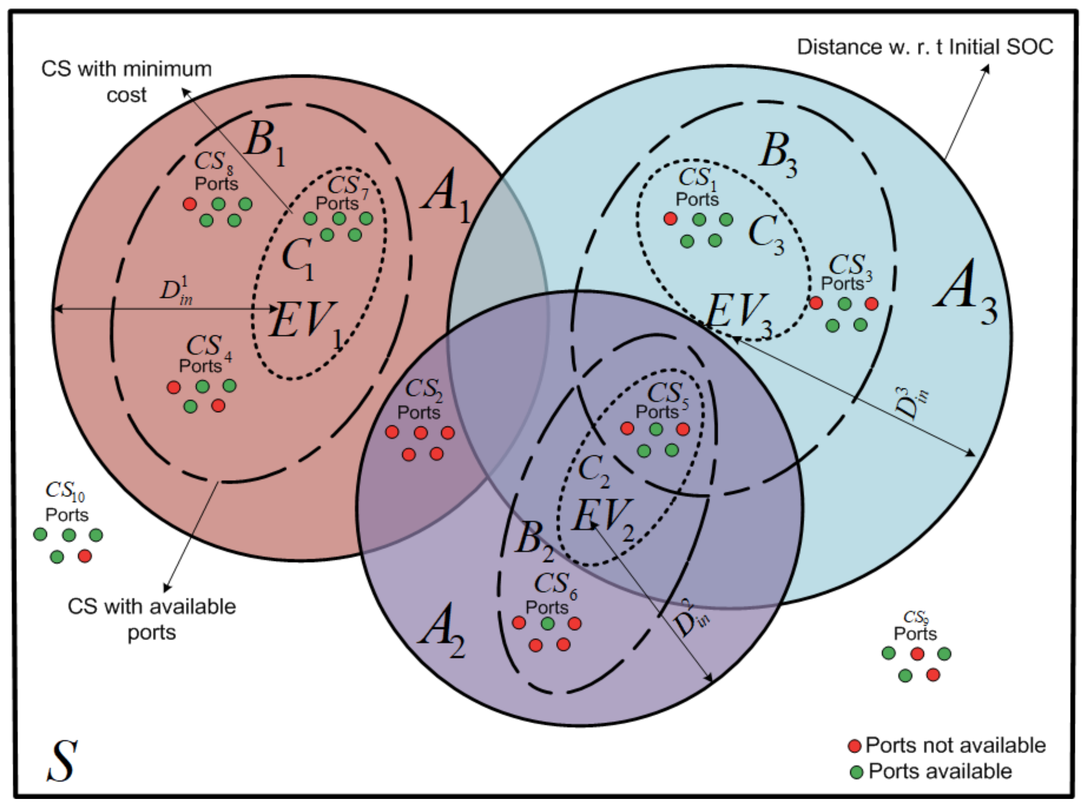
(ii) availability of ports

(iii) minimum cost

(2) Securing energy information and transaction details using blockchain through smart contracts

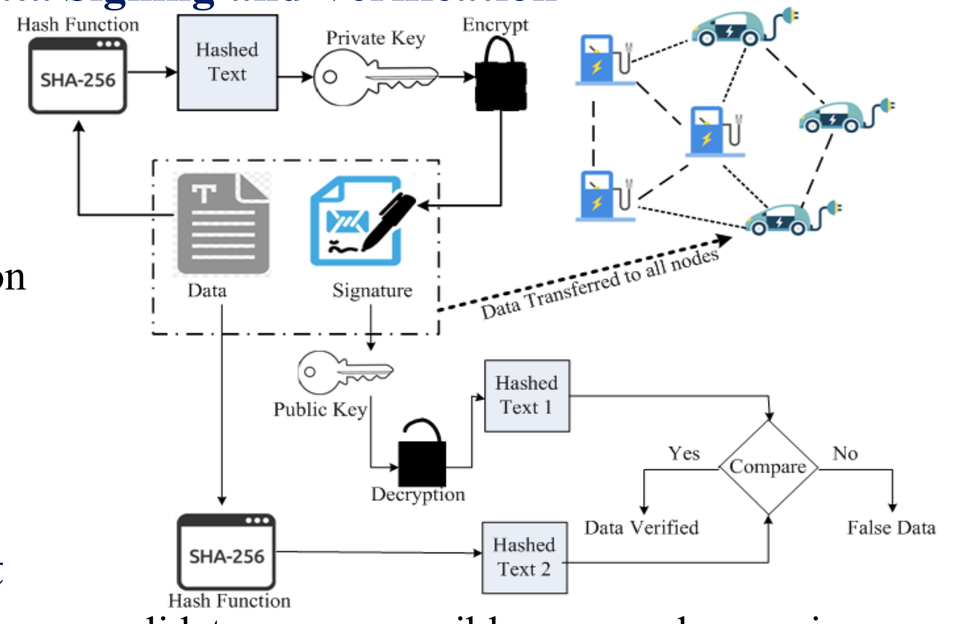


Representation of Problem Formulation



Blockchain: Data Signing and Verification

EVs and CSs → P2P network → Node information → Hashed → Broadcasted



Smart contract

- Smart contract ⟶ validates ⟶ possible proposed scenarios.
- Contract ⟶ satisfied ⟶ transaction is succeeded

Cost Function for Charging

Assumed as pre-defined values

SOC required to EVs

$$C_P = \beta + \frac{1}{\sum_{t=0}^{k} \alpha_k}\left[\left(SOC_{des}^{i} \times P_{SOC}\right) + \left(X_{req}^{i} - X_{nom}^{j}\right)^2\right]$$

nominal rate of charge by the CS

$$X_{req}^{i} = \frac{SOC_{des}^{i}}{T_p}$$

the time period of EV waiting at CS

- β: the nominal value
- $\sum_{t=0}^{k} \alpha_k$: charging port status
- SOC_{des}^{i}: the desired SOC
- P_{SOC}: price per SOC
- X_{req}^{i}: rate of charge required by the EVs

Updated Cost function with possible scenarios

Penalty factor P,

$$delay = |T_d - T_a| \leq T_{threshold}$$

- T_d: Actual arrival time
- T_a: Time of arrival
- $T_{threshold}$: Threshold value of delay

$$T_a^i = \frac{D_{in}^i}{V_a^i}$$

- D_{in}^i: Initial distance to CS
- V_a^i: Average speed

$$P = K \times delay$$

Reward factor R,

$$C_{left} = |SOC_{des}^{i} - SOC_{prov}^{i}| \leq SOC_{threshold}$$

- C_{left}: Charge not provided
- SOC_{prov}^{i}: SOC provided by CS
- $SOC_{threshold}$: Threshold value of charge

$$R = Q \times C_{left}$$

Where, K and Q are scalar factors

$$C_P = \beta + \frac{1}{\sum_{t=0}^{k} \alpha_k}\left[\left(SOC_{des}^{i} \times P_{SOC}\right) + \left(X_{req}^{i} - X_{nom}^{j}\right)^2\right] + P - R$$

Selection of CS with proposed Blockchain framework

No. of CS	Distance			Ports								Cost Function	Selected CS		
	EV_1	EV_2	EV_3	P_1	P_2	P_3	P_4	P_5	EV_1	EV_2	EV_3		EV_1	EV_2	EV_3
CS_1	0	0	1	0	1	1	1	1			4	$C(P_{T_1})$			CS_1
CS_2	1	1	0	0	0	0	0	0	0	0		$C(P_{T_2})$			
CS_3	0	0	1	0	1	0	1	1			3	$C(P_{T_2})$			
CS_4	1	0	0	0	1	1	1	0	3			$C(P_{T_4})$			
CS_5	0	1	1	0	1	0	1	1		3	3	$C(P_{T_5})$		CS_5	
CS_6	0	1	0	0	1	0	0	0		1		$C(P_{T_6})$			
CS_7	1	0	0	1	1	1	1	1	5			$C(P_{T_7})$	CS_7		
CS_8	1	0	0	0	1	1	1	1	4			$C(P_{T_8})$			
CS_9	0	0	0	1	1	1	1	0	4			$C(P_{T_9})$			
CS_{10}	0	0	0	1	0	1	1	0	3			$C(P_{T_{10}})$			

Conclusions

- Proposed a blockchain and smart contract based secure EV charging scheme
- The integrity of the system ↑↑
- Security of information exchange ↑↑

References

1. G. Liang, S. R. Weller, F. Luo, J. Zhao, and Z. Y. Dong, "Distributed blockchain-based data protection framework for modern power systems against cyber attacks," IEEE Transactions on Smart Grid, pp. 1–1, 2018.
2. S. Nakamoto, "Bitcoin: A peer-to-peer electronic cash system," 2008.

Publications

Poster is based on the following papers presented at:

1. U. Asfia, V. Kamuni, A. Sheikh, S.Wagh, and D. Patel "Energy Trading of Electric Vehicles using Blockchain and Smart Contracts" **17th European Control Conference (ECC'19), Italy, 2019**.
2. V. Kamuni, U. Asfia, S. Sutavani, A. Sheikh, and D. Patel "Secure Energy Market against Cyber Attacks using Blockchain" **6th International Conference on Control, Decision and Information Technologies (CODIT), Paris, France, 2019**