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# Blockchain in Electricity Billing and Settlement System

**Isha Arora[1] and Charu Mathur[2]**

[1]*B.Tech Computer Science and Engineering, PES University, Electronic City Campus, Bangalore, Karnataka, India*
[2]*B.Tech Computer Science, Mody University of Science and Technology, Laxmangarh Rajasthan, India*

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**Abstract -** *The current Electricity Billing and Settlement system is quite flawed. The process uses soiled IT system and inefficient settlement and billing which can result in high transaction costs and operational costs. There are time-consuming reconciliation issues, costly back-office processes and the time period to actually make all the back-end process to happen is enormous.*

*Blockchain technology could reduce transaction costs for trading by making operational processes efficient & by connecting trading between all parties. Trading platforms can eliminate brokers & clearinghouses. Enabling instantaneous settlement of trades via smart contract ensures reduction in costs of payment process and use of smart meters at ground level will simplify the process. This can enrich customer by enabling greater transparency and more fluid system.*

***Key Words*: Blockchain, smart contracts, Electricity billing, settlement, smart meters**

## 1.INTRODUCTION

Blockchain or distributed ledgers are an emerging technology that has taken limelight from various industries including energy companies, various startups, technology firms, finance institutions, the academic forums etc**.** [1] Energy settlement is the process of reconciling the difference between the energy purchased by energy suppliers from generators and the energy sold to the customers. The market participants are incentivized to maintain the balance between their expected demands and energy volumes purchased. The system operator ensures guarantees that the parties not in balance are charged properly. The settlement interaction along these lines assists with keeping up the equilibrium of the network and thus guarantees the safety and the smooth working of the energy organizations. Blockchain technology in this domain can hugely impact how the entire billing and settlement works. It will help to build a more resilient, transparent, Hassle-free, tamper proof system and will automate the system. This will help both the suppliers and generators to directly deal and trade the stated amount of electricity in the given settlement period. This will also ease the operability and accessibility for the end customer, as everything will be done using a mobile app and they will have to pay for the requested load only. Use of smart meters will automatically send the readings and thus it will make the whole process easy and transparent.

## 2. EXISTING WORKFLOW (WITHOUT BLOCKCHAIN)

In the already existing system opted for billing and settlement, following are the key steps how the system works:

- Trades are initiated via a broker.
- The suppliers enter their demand for the settlement period, and the bids are requested to the generators.
- After the above trade is closed, both traders separately enter the transaction details in their respective IT systems.
- Both parties' back offices retrieve the transaction details from their ETRM systems and exchange the data with each other or with the broker, in order to confirm and reconcile the trade.
- The trade is then settled physically through a TSO. It is likewise settled monetarily through a clearinghouse or bank.
- Finally, both actors report the transaction details to the relevant auditors and regulators according to their obligations.
- Electricity generated in power plants is delivered to high-voltage transmission network.
- Electricity supplier is liable for buying power from the discount market, offering it to clients and charging them for the power burned-through.
- Electricity System Operator (National Grid) has the responsibility of balancing the system in real-time and calculates the imbalance amount for each supplier over settlement period and sends out the imbalance (aka. settlement) invoice to the suppliers

### 2.1 Settlement Period and Supplier

Electricity is considered to be generated, transported and consumed in 15 mins chunks known as settlement periods. Each settlement period being settled in isolation from settlement periods around it.

Suppliers assess in advance the demand of its customers for each settlement period and enter into bilateral agreements with Generators ahead of time to cover the essential least expected interest known – known as 'base-load'. Suppliers at that point purchase power in Power Exchanges to meet the expected variation sought after on explicit days known as "shape" to baseload

### 2.2 Generators

In settlement period, generators are relied upon to create power coordinated with the contracted volume and the

Suppliers' clients are required to consume electricity coordinated with the contracted volumes.
They will only move away from their FPNs to accommodate any accepted bids and offers necessary to balance the system.
Nonetheless, in all actuality Generators may create less or greater power and Suppliers' clients may consume unequal power than contracted – these are named as imbalances.

### 2.3 Gate Closure

Contracts can be struck as long as an hour prior to the settlement time frame which the agreement is for this is classified "Gate Closure" for the settlement time frame.

**Prior the Gate Closure:** Generators and Suppliers should tell the System Operator their contracted volumes and their expected generation and demand for the Settlement Period. This is the Final Physical Notification (FPN).

**Post the Gate Closure:** The System Operator needs to adjust the system by coordinating with the demand of the settlement period with the physical notification information given by the Generators.

In the event that it anticipates any unevenness, the System Operator will adjust the framework by accepting bids and offers from Generators and Suppliers.

### 2.4 System Operator

The System Operator is responsible for calculating these imbalances and generating the invoices to settle these.

If customers consume more electricity than contracted and, Generators generates less electricity than contracted have to buy the deficit amount from the system at the System Buy Price (SBP)

If customers consume less electricity than contracted and, Generators generates more electricity than contracted have to sell the excess amount to the system at the System Sell Price (SSP)

### 2.5 Challenges in Existing Workflow

There are certain drawbacks of the existing system, thus we propose the new system using blockchain. Length of the settlement and reconciliation process creates uncertainty of costs and revenues for suppliers.

Each party has to enter the information regarding the trade separately in order to confirm the trade which makes it time consuming. As the trade involves third parties such as brokers in order to close the trade, this increases the overall cost. There is a chance of error when the two parties enter and retrieve the information from their back systems. The system is not as transparent and regulators find it difficult to gather the information present regarding each settlement period. [2][3]

## 3. MITIGATING CHALLENGES USING BLOCKCHAIN

**Energy Transacting**: Transactions can be recorded and settled immediately, with no requirement for a delegate and with practically zero requirement for reconciliation since all parties are utilizing a similar stage. Blockchain can possibly empower distributed exchange between end clients. This can eliminate foundational failure like unpredictable price information.
**Global Supply Network**: There are numerous processes between the actual generation and providing it to the client, these means are regularly exceptionally disconnected and siloed, again blockchain will give a straightforward arrangement.
**Regulatory Reporting and Compliance:** Empowering transparency by permitting controllers to safely get to clean, tamper-proof information at the source. Among regulators this would make a standard information design for key spaces of industry, which is something that is essentially inaccessible right now.
**Asset Optimization Across Sectors:** The communication with a huge number of suppliers, vendors, and counterparties drives up intricacy and cost. Blockchain can help organizations screen consistence from their suppliers and eventually decrease costs.

## 4. BENEFITS OF USING BLOCKCHAIN

The blockchain system provides transparency to the entire system and thus contributes to improved visibility, collaboration, and operating efficiency. It also helps in removal of expensive market frictions and intermediaries. It enables more efficient back-office processes. Streamlined regulatory reporting and improved data standardization is also a plus. Creation of new business models and monetization of new blockchain platforms across the industry helps the economic infrastructure as well. The proposed system tends to provide certain benefits over the existing system as stated below:

1. **Billing:** Blockchains, smart contracts and smart meters can understand computerized billing for consumers and appropriated generators. Service organizations may profit by the potential for energy micropayments, pay-as-you-go or payment methods for prepaid meters. [4][5]
2. **Trading and markets:** Blockchain-empowered distributed trading platforms might disturb market operations such as wholesale market management, commodity trading transactions and risk management**.** [6][7]
3. **Automation:** Blockchain could enhance control of decentralized energy systems and microgrids. Adoption of local energy marketplaces powered by localized P2P energy trading or distributed platforms can greatly increase energy production and consumption, also known as behind the meter activities, which can affect revenues and tariffs. [5][6]

4. **Transparency:** Immutable records and transparent processes can vastly enhance auditing and regulatory compliance**.** [4]
5. **Smart grid applications and data transfer:** Blockchains can substantially be used for communication of smart devices, data transmission or storage. Intelligent devices in the smart grid include smart meters, advanced sensors etc. [5]
6. **Grid management:** Blockchain could help in network management of decentralized networks, adaptability services or asset management. Blockchain could arrive at coordinated adaptability in trading platforms. Inexhaustible and Sustainable Energy Reviews and improve flexible resources, which may prompt money-heavy network updates. [5][6]
7. **Security and identity management:** Protection of transactions and security can advantage from cryptographic techniques. Blockchain could protect privacy, data confidentiality and identity management. [7][8]
8. **Competition:** Smart contracts might actually improve and accelerate exchanging of energy suppliers. Improved portability in the market could expand competition and possibly diminish energy tariffs.[9]

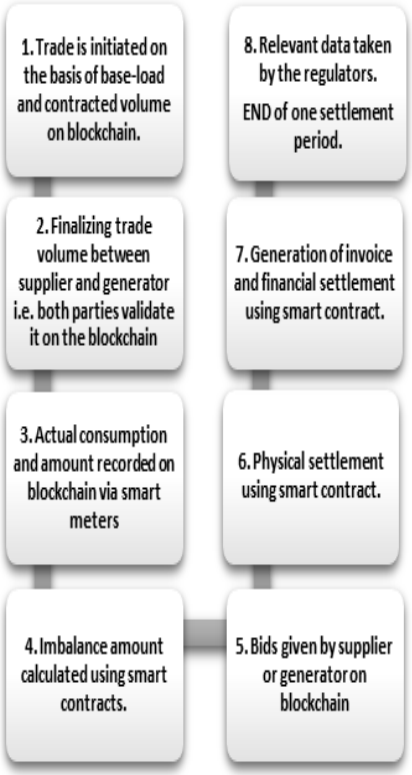
## 5. VALUE ADDED FOR KEY STAKE HOLDERS

This can reduce the transaction costs for trading by making operational processes more efficient. Blockchain-based trading platforms can eliminate the need for brokers and clearinghouses. By enabling the instantaneous settlement of trades, will reduce the costs of payment processing and accounting by executing a smart contract.

## 6. PROPOSED WORKFLOW USING BLOCKCHAIN

The proposed solution offers significant advantages above the already existing technology. All the advantages that the blockchain offers are depicted in our proposed solution. Following is the workflow of the new proposed system.

1. Firstly, the trade is initiated on the basis of base-load and contracted volume on blockchain.
2. Following initiation, the trade volume between supplier and generator is finalized which both parties validate it on the blockchain.
3. Next, the actual consumption and amount are recorded on blockchain via smart meters.
4. After the actual consumption has been registered using smart meters, the imbalance amount is calculated using smart contracts.
5. Later, bids are given by the supplier or generator on the proposed system using an easy-to-use interface which works on blockchain
6. Succeeding all the above steps, physical settlement using smart contract is done. Physical settlement is the actual consumption and generation of electricity taking into account the balance amount as well.
7. At last, generation of invoice and financial settlement using smart contract is done.
8. Later the relevant data is taken by the regulators.
9. This marks the end of one settlement period.




## 7. HOW IT WORKS

**Initializing**: Trade initiated on the basis of base-load and contracted volume and finalizing trade volume between supplier and generator i.e. both the parties will validate it on blockchain.

**Processing Imbalance**: Actual consumption is recorded on the blockchain via smart contracts that in turn was recorded using smart meters. Later, the imbalance amount is calculated using smart contracts. The bids given by supplier or generator is taken into account.

**Bidding**: Bids and offers are put forward by the suppliers and generators for the particular settlement period and the transaction and bids are recorded and executed by smart contracts itself.

**Settlement**: The physical settlement of energy and financial settlement along with the generation of invoice is done by smart contracts for each settlement period.

**Data Accumulation**: The relevant data is taken by the regulators for further use and generation of data sets. This marks the end of one settlement period.

## 8. PROTOTYPE OF THE PRESENTED SOLUTION

Prototype of the proposed solution depicts the overall flow of the process of billing and settlement. The solution will be

implemented using a mobile application. There will be three different login screens and credentials for each supplier, generator and customer.

The working of the supplier and generator will be nearly same. The difference will be that supplier will be requesting for bids to the generator and generator will be advertising those bids in order to be selected by the supplier for the given settlement period.

The customer will be able to send the demand to the supplier, and will pay the bill through the mobile app for the purchased units.

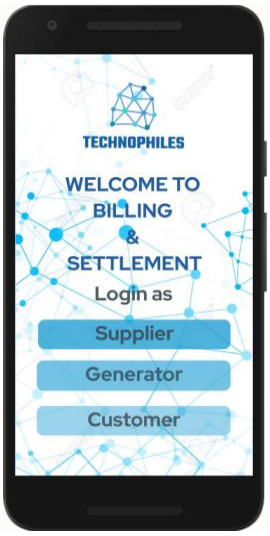



**Fig-1: Home Screen**

The Home screen shows- Supplier, Generator and Customer. Clicking on each will redirect to the respective login page. (Fig-1).

### 8.1 Supplier

The login screen shows the username and password for the registered supplier (Fig-2). The Welcome page shows base load & contracted volume can be entered explicitly. Validation is being done on blockchain. Transaction button redirects to the previous transactions, details show the account info & OK redirects to bids (Fig-3).

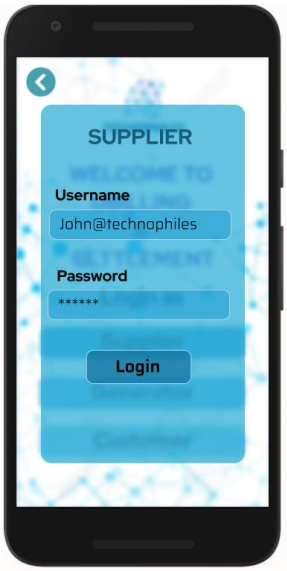



**Fig-2: Supplier Screen**


**Fig-3: Welcome Screen for Supplier**

The entire execution of each element will be done by the smart contracts in the back-end. Transaction button on top left shows the previous transactions list (Fig-4). On clicking, it redirects to a list a previous transaction. The clickable tab redirects to complete transaction details (Fig-5). The details button show account information (Fig-6).

Actual consumption is recorded from customer and the settlement is calculated automatically by smart contracts. The supplier requests bids to the generator (Fig-7 and Fig-8). The bids are then received for the settlement period by the generators and any one can be accepted (Fig-9). Finally, the selected bid details are displayed along with the name of the generator (Fig-10).

After the bid has been selected, the details of the final transaction is displayed (Fig-11). Finally, on clicking confirm the Transaction has been successfully recorded. (Fig-12)

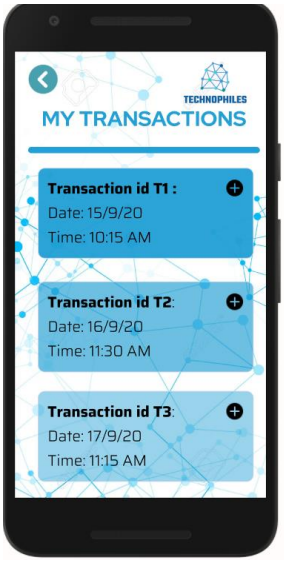



**Fig-4: Previous Transaction**

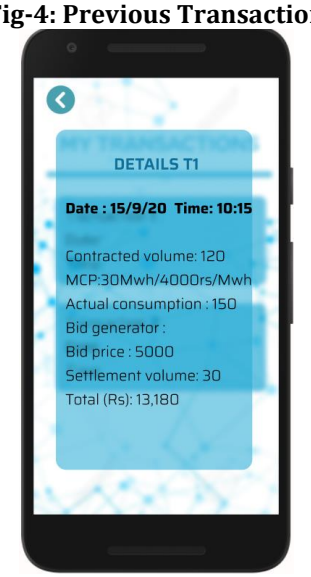



**Fig-5: Transaction details**

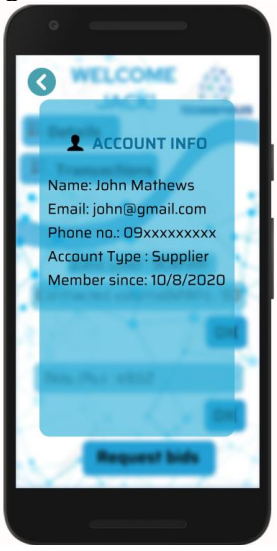



**Fig-6: Details button**


**Fig-7: Requesting Bids by the supplier**


**Fig-8: Requesting generators**

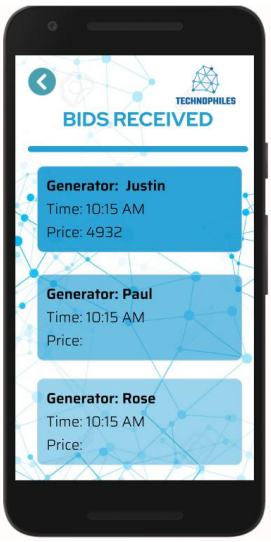



**Fig-9: Bids received**

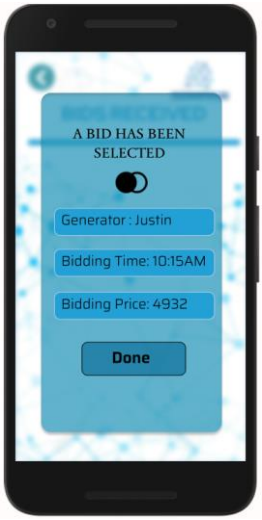



**Fig-10: Bid selected**

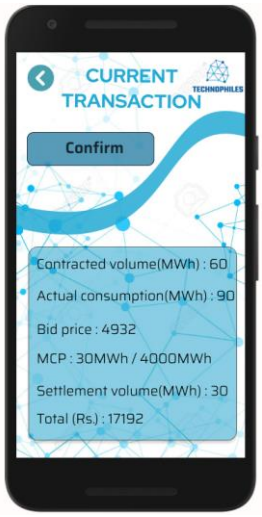



**Fig-11: Current transaction**

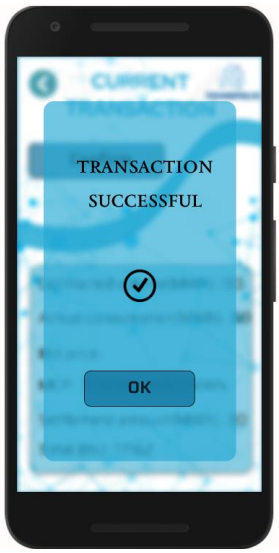



**Fig-12: Transaction Successful**

## 8.2 Customer

The customer will be able to send the demand to the supplier, and will pay the bill through the mobile app for the purchased units. Given below are the screens of work for the customer interface after logging in as customer.

The login page appears for the customer which redirects to welcome screen (Fig-13 and 14). On clicking OK, it sends the demand to the supplier (Fig-15). The Details button show the account information (Fig-16). The previous bill button redirects to list of previous bills of the customer (Fig-17). On clicking each Bill number separately, it shows in detail description (Fig-18). After clicking bill generated option, the screen on the left appears, having all the relevant details about current transaction. Finally, the transaction is successful. The process happens on blockchain itself (Fig-19 and 20).

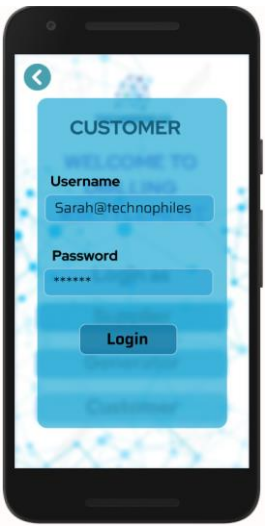



**Fig-13: Login Screen**

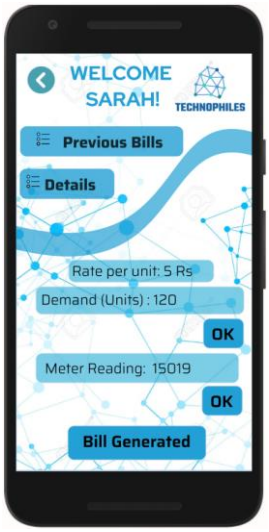



**Fig-14: Welcome Screen**

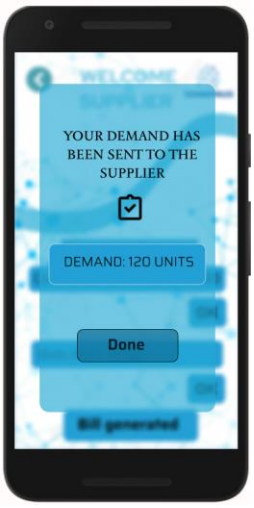



**Fig-15: Demand sent**

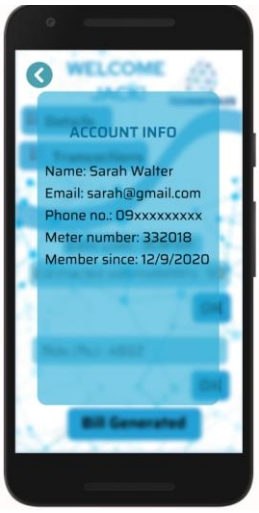



**Fig-16: Account Information**

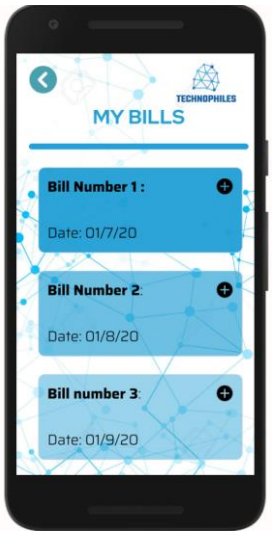



Fig-17: Previous Bills

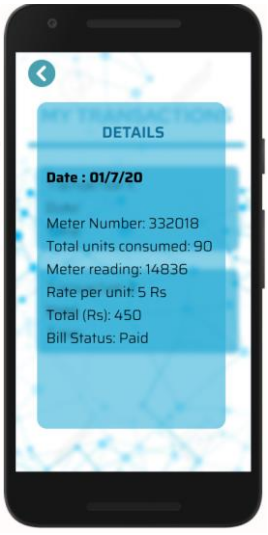



Fig-18: Details of bills

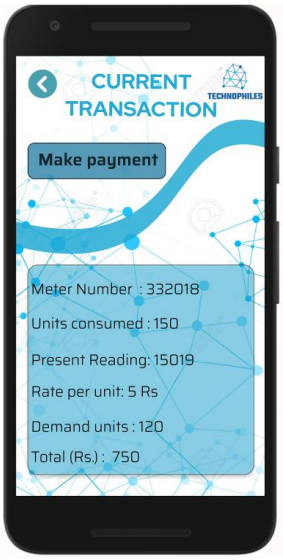



Fig-19: Current Transaction

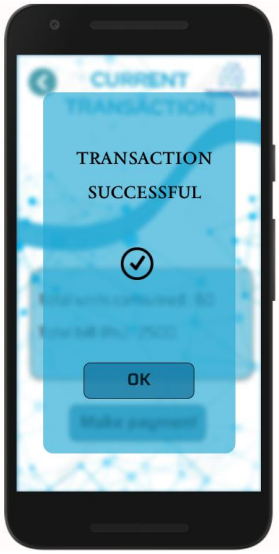



Fig-20:Trans. Successful

### 8.3 Generator

The working of the supplier and generator will be nearly same. The difference will be that supplier will be requesting for bids to the generator and generator will be advertising those bids in order to be selected by the supplier for the given settlement period.

## 9. CHANGED MARKET ROLES

Changed market jobs will be that the meter operators would at this point don't need to gather and record information themselves, as all utilization and exchange information would be traded naturally and precisely through blockchain innovation and smart meters. (smart contracts). Also, all energy consumers will become balancing group managers. Energy consumers would have to submit their own demand forecasts to the relevant network operator.

## 10. LONG TERM GROWTH POTENTIAL

Thus, it is expected to add business value to the structure and market models of energy markets in which a traditional utility or supplier plays the role of business facilitator. Also, the creation of Internet of Values i.e. towards a universal space where values and value-related interactions can be represented in a structured way along with decentralization

## 11. FUTURE OPPORTUNITIES

Introduction of cryptocurrency for internal energy trading within the closed energy ecosystem can be proposed to make the proceedings even more smooth. Use of peer-to-peer trading can be encouraged in the later stage of the project to provide a choice for dealing with other consumers directly, using the surplus produced.

## 12. SCALABILITY

The billing and settlement process itself involves entire electricity grid ecosystem and the interaction between each player. This project needs to be done on a large scale itself as it revolves around the backbone of modern economy

## 13. CONCLUSIONS

There are time-consuming reconciliation issues, costly back-office processes and the time period to actually make all the back-end process to happen is enormous in the existing electricity billing and settlement system. Blockchain technology could reduce transaction costs for trading by making operational processes efficient & by connecting trading between all parties. Trading platforms can eliminate brokers & clearinghouses. Enabling instantaneous settlement of trades via smart contract ensures reduction in costs of payment process. Can enrich customer by enabling greater transparency and more fluid system. The proposed system will be easier to operate as all the processes can be handled through a smartphone application. All the players that are involved in the system including the end user, supplier, generator and retailer will have a transparent and easy -to-use interface. This will reduce the hassle by a great amount and will automate the entire billing and settlement system.

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