

Article

# Negotiation of Electricity Intention Based on Community Logic System

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## Abstract

In evolutionary computation, distinct clusters that address different subproblems evolve independently of each other, which makes it difficult to exchange genetic information between them. However, a vaguely defined task within one system may be expressed more clearly within another. Effective interaction methods enable subsystems to collaborate more effectively in solving global tasks. By analysing how ambiguous intentions regarding electricity consumption influence actual behaviour in real-world scenarios, we discovered that transaction and negotiation patterns within electricity markets can effectively support this process. By introducing time and third parties, the study presents a semiautomatic, interpretable reasoning community logic system that enables machines to express transaction negotiation patterns. Through formalised operations, it facilitates the conversion of intentions, uncovering hidden relationships within global structures through this liberated form of expression. This paper examines its impact on computational and search paradigms through case studies, enabling collaborative approaches and granularity control via dynamic anchor points, and explores automated peer-to-peer transactions and electricity monetisation within highly abstracted power trading processes.

**Keywords:** negotiation model; community logic system; formal logic; electricity market; smart grid; evolutionary computation; decentralisation; system integration; self-governing community

**MSC:** 68T37

## 1. Introduction

Cooperation between subsystems within complex systems has long posed a challenging problem. In evolutionary computation, the distinct evolutionary processes of different subsystems make it difficult for their experiences to collaborate effectively. Patterns evident within one cluster may manifest more clearly in another, potentially aiding the evolution of that cluster. Exploring cooperation between clusters with differing growth experiences could help optimise the entire system.

Such issues are not confined to systems alone; they are also exceedingly commonplace in social life. Individuals possess distinct experiences and reasoning methods, yet they still collaborate within society. By analysing, abstracting, and formalising the cooperative mechanisms of real-world societies, we can employ mathematical methods to express cooperative patterns across different operational systems, thereby extending them to broader systemic collaboration. Taking the interpretation of user electricity consumption intentions in the power market as an example, this research examines the process by which user



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intentions influence electricity consumption behaviour within power systems. It identifies third parties and time as significant influencing factors.

Research has proposed a community logic system based on propositional logic. By incorporating time and third-party markers, it expresses real-world negotiation and transaction patterns within the logical framework. No longer assuming a global structure, the system permits interactions and cooperation to be described from a local perspective. This study examines the distinctions between community logic system and traditional logic system under this localised approach. Through the free expression of propositional relationships via time and third parties, it enables the uncovering of hidden relationships within global structures. The concept of dynamic anchors is introduced. By establishing anchors across different operational systems, cooperative environments are constructed. This approach enables the straightforward creation of interpretable, locally semi-automated reasoning processes, reducing the costs associated with global assumptions and objectives. Global evaluation functions are constrained through multi-system objectives and negotiation dynamics.

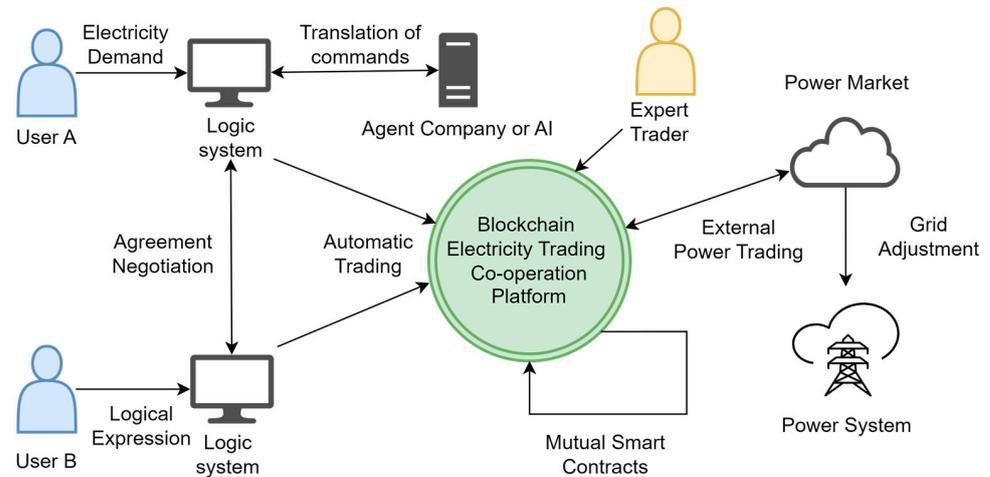
The study further examines the impact of community logic systems on computational modes, presenting natural cooperative and optimisation methods from a local perspective using simple arithmetic examples. This approach allows evolutionary pressures to be transmitted more naturally to global problems. Using parallel computing optimisation as an example, it suggests an evolutionary model in which subsystems naturally adapt to cluster dynamics and discusses how to adjust granularity for collaboration between systems. This allows relationships that are obscured by simplistic global approaches, such as simple mixing, to be uncovered, establishing controllable interaction patterns from localised perspectives. Compared to purely top-down or bottom-up approaches, this allows for a greater variety of perspectives to be selected, thereby enhancing interpretability between systems.

Abstracting the electricity trading process within a community logic system prevents users' electricity transactions from being entirely controlled by third-party agents. Instead, it enables greater flexibility in electricity usage workflows and transaction standards, allowing automated reasoning with machine assistance to reduce costs and adjust granularity as required. Not every step in the process needs to be carried out by the electricity provider alone; certain steps can be handled by other trusted third parties, such as data analytics firms or smart home artificial intelligence (AI). This broadens the entry criteria for electricity trading, enabling third parties with diverse expertise to participate in interpreting intent. During final implementation, electricity transactions only need to comply with a defined standard and be reviewed by a qualified third party [1].

Supported by community logic systems and machine reasoning, and provided that transaction parties establish consensus on trading rules and identify a trusted third party, the abstract outcomes of electricity futures markets can be effectively translated into physical grid operations. This enables the simulation of a peer-to-peer electricity trading system, thereby generating a more efficient electricity market. As shown in Figure 1, individuals, AI, organisations, and blockchain state machines with diverse background knowledge and reasoning logic can all be represented as third parties involved in electricity transactions. The flexibility of the community logic system means that existing electricity trading processes can easily be incorporated into the logical framework for subsequent optimisation.

This also enables the monetisation of electricity, treating it as an abstract currency with certain constraints [2]. This makes it easier for financial experts to integrate into the electricity system, optimise trading rules and models, and establish electricity currency exchanges. Notably, governments can also regulate electricity markets more efficiently through abstract financial policies, thereby facilitating the introduction of clean energy and

reducing carbon emissions [3]. We will analyse the characteristics of this logical model and discuss its potential applications in other domains.



**Figure 1.** Virtual Electricity Market.

This paper makes the following contributions:

This paper identifies the gap between electricity consumption intentions and actual behaviour, analyses the influencing processes, examines the impact of negotiable consumption intentions on the grid alongside issues with existing schemes, abstracts time and third-party involvement as two key factors, and explores potential transaction and negotiation models.

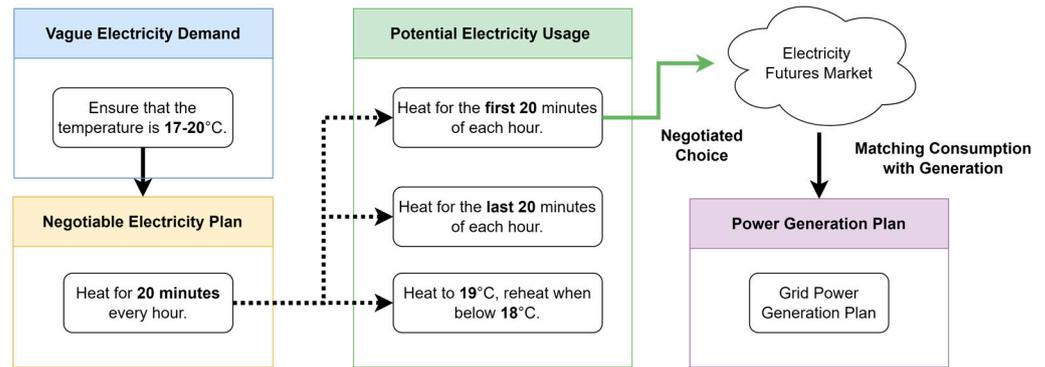
This paper proposes the community logic system, introducing negotiation methods between distinct logical systems in real-world scenarios through the case of electricity markets. Based on traditional logic, it highlights the significant impact of time and third parties on search and computation, presenting an innovative, interpretable, and adaptively co-evolving local semi-automatic reasoning theoretical framework, enabling the discovery of hidden relationships within global structures while adjusting the system's cooperative methods and granularity, and enhancing the effectiveness of collaborative evolution among subsystems.

This paper also simulates the process of intention interpretation through the community logic system to enable computer-assisted reasoning while proposing a methodology for constructing electricity markets and exploring potential electricity monetisation. Finally, it indicates the applicability of this intention interpretation model within other systems.

## 2. Electricity Markets, Logical Systems and Evolutionary Computation

Users' intentions regarding electricity consumption do not directly influence the electricity market. Instead, these intentions are expressed through consumption behaviour and predicted by algorithms. However, many of these intentions are negotiable, such as electric vehicle charging and heating requirements. It is not necessary to fully charge electric vehicles every time, nor does heating need to operate at full power. Within certain parameters, the timing, rate and volume of many electricity demands can be adjusted [4–6].

As shown in Figure 2, interpreting users' intentions regarding their electricity consumption enables the transformation of passive, ambiguous demand into proactive, negotiable plans [7]. This facilitates the selection of potential consumption practices through mechanisms such as electricity markets, thereby matching demand with generation more effectively and optimising grid operations [8]. Existing research into users' intentions regarding electricity consumption in relation to power grids has largely focused on case studies, lacking a generalised theoretical framework or methodology [1,9,10].



**Figure 2.** Grid Optimisation Incorporating Electricity Demand.

For the electricity market, we have analysed actual electricity consumption intentions in real-world scenarios, where third parties and time are important influencing factors. Third parties enable users to translate ambiguous intentions into precise, formal expressions without having to provide details of electricity usage scenarios. Trusted third parties not only facilitate reasoning consensus, but also provide compensation when their translations are incorrect [8]. Time is another critical factor: not all problems require immediate resolution, and addressing issues after they occur can sometimes be more effective than trying to prevent them altogether [11].

Users are reluctant to disclose their electricity consumption intentions or adjust their behaviour in response to market fluctuations. Each user possesses their own experiences and reasoning, leading to differing interpretations of the electricity trading process and its implications. Will utilising my electric vehicle as energy storage affect my daily commute?

This makes it difficult for users to establish trust in third-party agents within an oligopolistic market, resulting in low enthusiasm for participating in the electricity market. Existing research seeks credible agents through neighbourhood elections, where neighbours, schools, or government bodies could assume responsibility for electricity markets. Diverse stakeholders will prove crucial in future electricity markets. Value models must incorporate hybrid approaches to navigate varied relationships between prosumers and consumers within energy systems, thereby averting scenarios like the Utility death spiral [12].

The objectives among these roles may adhere to differing value logics. This study attempts to propose a logical model to articulate them, one that interferes as little as possible with the value expressions of distinct roles and ideally facilitates machine-assisted processing. Whether through large models or expert systems, machines may produce reasoning outcomes that fail to meet user requirements, depending on varying value logics and contexts. Yet, as in real life, uncertain or potentially erroneous inferences can be corrected by alternative reasoning. Agreed solutions sometimes prove more effective than resolving every potential issue.

Unlike the pursuit of traditional formal logic, community logic systems do not prioritise the correctness of inferences. Nor are they institutional logic constructs seeking consensus through some globally preset methodology. Divergent value logics within each system may fundamentally undermine institutional logic, or at the very least prevent its utilisation as originally envisaged.

This study attempts to shift perspective by examining each system from a local viewpoint, describing potential system interactions while preserving the freedom of the system's value logic to the greatest extent possible. Institutional logic is treated as consensus reasoning under dynamic anchors, viewing the deductive nature of reasoning through a new lens. It is regarded as fallible experimentation across varying environments, incorporating error correction mechanisms to enable machines to assist users in reasoning about value logic.

Community logic system and its mathematical formalisation also offer fresh insights for evolutionary computation. Certain studies propose observing the entire evolutionary process more comprehensively, preserving effective information from past evolutions through diverse methods for application in future iterations [13]. Community logic system incorporating time and third-party markers enables natural expression of each individual’s position within the complete evolutionary process at every step. This facilitates optimisation while simplifying local analysis, naturally diffusing local influences to the global level and effectively aiding evolutionary scheme design.

Table 1 presents the distinctions and characteristics between the community logic system, automated blockchain trading platforms, and existing electricity trading processes. Compared to systems relying solely on procedural logic and natural transaction logic, the community logic system incorporates local deductibility and global defeasibility [14]. This enables machine-assisted local computations, allowing users to freely adjust granularity, introduce roles from other systems, and deliver more flexible, demand aligned automated solutions.

**Table 1.** Comparison of the Community Logic System with Existing Solutions.

	<b>Blockchain P2P Platform</b>	<b>Existing Transactions</b>	<b>Community Logic System</b>
User Intentions Data	Fixed Expression	Historical Intentions	Free Expression
Process Controllability	High controllability	No controllability	Flexible Workflow Design
Optional Third Party	Power Companies	Power Companies	AI, Friends, Local Communities
Responsible Entity	Users	Power Companies	Combined Solutions
Logical Form	Deductively	Defeasibility	Local Deductively and Global Defeasibility

### 3. Translation of Electricity Consumption Intentions

Users’ electricity consumption intentions do not directly influence the energy market. Instead, these intentions are passively predicted by algorithms based on historical data. Current methods usually forecast future consumption preferences by analysing users’ electricity usage patterns. However, a significant discrepancy exists between actual behaviour and intended consumption, which manifests in two main ways:

1. Certain electricity demands are difficult to predict using historical data. Issues concerning data and privacy rights are also becoming increasingly apparent [15]. Temporary work commitments, travel plans and visitors can all disrupt electricity usage schedules. Such user behaviours may influence consumption preferences and thereby impact the grid. Even if existing algorithms can adjust in real time based on temporary preferences, obtaining this information from users remains challenging. In particular, sudden or planned operational adjustments by large electricity consumers will affect models built on historical consumption data.
2. Certain electricity demands are negotiable. Proactive negotiation helps to control grid fluctuations and enables more precise generation planning [7]. Not all electricity schedules require immediate precision; many preferences are flexible and negotiable, such as electric vehicle charging plans and heating schedules [16]. It is not always necessary to fully charge an electric vehicle; a negotiable margin may exist. Similarly, heating does not need to operate at full capacity continuously; intermittent heating during selected periods may suffice. Beyond basic consumption, considering characteristics such as energy efficiency curves, power factor and charging lifespan enables rational adjustments to be made that can deliver substantial economic benefits. For users employing multi-energy solutions, such negotiation can facilitate support from other energy systems, thereby achieving greater cost savings and carbon reduction [17,18].

Users are reluctant to share their private data regarding electricity consumption intentions, nor are they willing to adjust their usage patterns in response to grid adjustments. This reluctance stems primarily from low returns, which can be attributed to several factors: potential risks, practical and trust-related costs, and low benefits. Interpreting these intentions is complex and cannot be resolved through simplistic idealisation. These factors often intertwine, and existing solutions that address some of them may simultaneously exacerbate others.

Regarding potential risks such as data privacy, we can employ technologies like multi-party secure computation and differential privacy to safeguard data [19]. Alternatively, data could be entrusted to credible local or regional power management centres, where consumption intentions are shared once privacy-sensitive attributes have been removed. Ordinary users lacking technical expertise would need to rely on trusted third-party agents to interpret their intentions or verify the technology. Third-party interests may not fully align with those of users, and establishing trust incurs significant costs. The burden of establishing trust at the data-sharing stage alone is prohibitive, not to mention negotiating actual consumption behaviour. Furthermore, discrepancies between intended electricity consumption and actual consumption behaviour, coupled with unpredictable external influences on electricity usage, further complicate matters. Integrating additional coordination systems would further escalate trust costs, resulting in extremely low returns with current solutions.

Should a logical system enable low-cost expression of these preferences, enhancing automation while integrating solutions and credit systems from domains such as finance and communities, it could introduce more diverse roles. This would permit users to select tailored strategy combinations based on their circumstances, enabling electricity markets to construct suitable schemes for different user characteristics. This dynamic role adjustment enhances the flexibility and efficiency of inter-system cooperation models, enabling controlled market development. It also empowers users to freely select required systems based on their background knowledge and reasoning rules, rather than being constrained by a single system provided by the power grid, thereby reducing inefficiencies.

#### *Potential Electricity Market*

In practice, third parties will typically undertake the effort for issues with substantial benefits and low coordination costs, such as coordinating charging station clusters [5]. However, it proves challenging to develop implementation strategies accessible to the general public for problems with modest benefits and high coordination costs and low yield, such as electricity dispatch plans for electric vehicles [20].

As numerous households acquire solar panels, electric vehicles, and other power generation and storage equipment, users are no longer merely consumers within the electricity market, but have become prosumers [21,22]. The entities that can supply electricity and influence the grid are no longer limited to just a few companies; many potential prosumers can also have an impact. While the influence of individual prosumers may be negligible, their collective impact is significant.

Many studies have sought to maximise direct or indirect user participation in electricity trading, with the aim of optimising power generation and consumption through free market mechanisms [23]. Nevertheless, the majority of end users in the energy sector remain passive participants in electricity markets [21]. This passivity stems from various factors, such as automation, yield rates and trust issues, which collectively discourage user engagement [24]. This makes it difficult for power systems to optimise grid operations based on user intentions.

If we could express the process of translating, interpreting and implementing users' electricity preferences into actual consumption behaviour within a logical system, machines could reason autonomously and negotiate costs more efficiently. Using trusted third parties and transaction models could allow users' preferences to influence the power system more effectively, facilitating more efficient adjustment plans. Some energy communities already use this approach, encouraging users to participate collectively in electricity market transactions through familiar trust networks. This reduces the trust costs associated with introducing third parties and the need for specialised expertise [25].

This interpretation and translation of intentions is not only found in electricity markets, but also pervades everyday life. By analysing the processes involved in interpreting intentions and negotiating in everyday situations, we have identified the critical importance of time and third parties. We have incorporated these factors into a propositional logic system and modified it to create the community logic system. This system is intended to simulate and optimise the real-world process of interpreting intentions within this framework.

#### 4. Real-World Electricity Trading Models and Processes

Before applying a logical framework to describe the process of electricity consumption from intention to actual usage, we will start by analysing the simplest scenario and then progress gradually to more complex situations.

##### 4.1. Issues in the Interpretation of Electricity Intentions

Not all electricity demands are exact. There are numerous adjustable consumption schedules, such as charging plans for electric vehicles and heating schedules for electric heaters. Rather than demanding a fully charged electric vehicle, users often just want enough power to get them to work the next day. Similarly, electric heaters only need to maintain a room temperature of between 18 and 20 °C rather than operating at full power all night. These ambiguous intentions regarding electricity consumption can be interpreted as distinct usage patterns and practices, where charging and heating curves can be adjusted within certain parameters. However, such intentions are often implemented in the most conservative way, by charging at maximum power until the battery is fully charged or by maintaining a constant temperature of 19 °C. Some systems that attempt to optimise their operations struggle to coordinate with external systems and often resort to adjustments based solely on internal information. Examples of this include modifying charging curves to extend battery life or adjusting power output in response to external temperature differences.

The high interpretability costs observed in such scenarios stem from three core issues: incomplete information; conflicting objectives between different systems; and inconsistent inference rules across systems.

##### 1. Incomplete information

For complex systems, these may comprise multiple unrelated or weakly correlated subsystems. During optimisation, indiscriminately considering all information introduces extremely high complexity. Therefore, we must assume causal weightings to enable the system to optimise objectives based on relevant information wherever possible. This assumed global structure may obscure latent relationships, inducing inductive bias that impedes coordinated optimisation and stability among subsystems.

##### 2. Conflicting objectives between different systems

Such issues stem from the decomposition of large objectives and may also arise from the combination of smaller ones. Ideally, we could rationally partition complex systems so that each subsystem contains its necessary information. Such partitioning is constrained

by complexity, and often we lack a global, overarching objective. A favourable state is frequently defined by the combination of multiple local states. This forces us to focus on local objectives, yet when optimising for different goals, intricate causal relationships cause subsystems to influence each other, generating conflicts.

### 3. Inconsistent inference rules across systems

Even when systems possess identical information and objectives, they may not necessarily employ the same methods to optimise those goals. Some algorithms prioritise rapid convergence, while others seek to prevent local optima. Under identical computational resources, they may achieve differing outcomes, and the accumulated experience from these divergent approaches could potentially hinder communication and collaboration between them.

Specifically, electric vehicles only need to focus on serving users and meeting their needs. During charging, electric vehicles collect information about their battery, the charging infrastructure, and the environment. This allows them to optimise charging methods and comprehensively adjust charging strategies. Electric vehicles could perform further optimisations with access to more data. One example would be pre-cooling the cabin based on anticipated usage times. However, optimisation based on limited local information may lead to issues, such as purchasing excessively expensive electricity at commercial charging points [4].

Nevertheless, having sufficient information does not necessarily result in a better understanding of user intent, particularly when several systems are involved. Their differing objectives make coordinated implementation challenging. For the grid, electric vehicle charging and reverse power flow offer superior load-balancing capabilities. Users may be willing to allocate battery capacity for peak shaving and valley filling without compromising normal usage. For automotive manufacturers, reverse charging could cause batteries to degrade more quickly, potentially invalidating warranties. Furthermore, disparate systems with identical objectives may not collaborate effectively. Often, each system operates based on distinct prior knowledge and reasoning rules, resulting in different predictions about the future, even when they are based on the same information. Even if we attempt to express these rules through a common methodology, ignoring the costs of communication and inference, we cannot assume that systems with different rules will understand the reasoning processes occurring within other systems.

However, intention interpretation and collaboration between different entities do occur in real-world scenarios. Our aim is to formulate a universal theory that can express and accelerate this process computationally.

#### 4.2. Interpretation of Intentions in Daily Life

As shown in Figure 2, users may express their fuzzy electricity demands within the logical system. A trusted third party then translates these into more precise formulations, which ultimately become formalised, negotiable electricity requirements. Based on these formalised demands and rules, computers can then search for potential transaction patterns and process the transactions automatically. Users may also form collectives to participate in power system transactions. Members of the same community can leverage existing trust relationships outside the power system by utilising public trusted computing platforms, such as blockchain, to form internal mutual assistance agreements or engage directly in external electricity markets. Once transaction outcomes have been generated in the electricity futures market, the corresponding physical electrical operations can be applied naturally within the power system. By analysing the above cases, we can identify several common patterns in the process.

### 4.2.1. Agent Trust and Translation

In order for machines to assist in the transaction process, vague electricity consumption preferences must first be converted into precise, formalised expressions. Users can either refine these preferences themselves or engage a third party to do so on their behalf. This third party could be an AI, a smart home system or a data company.

As shown in Figure 3, this translation mechanism also supports nesting, enabling users' vague numerical intentions to be progressively refined into concrete trading plans. A user may trust a third party endorsed by the government to interpret their intentions. Rather than listing all possible third parties, the user may simply describe the categories of third parties they find acceptable. The computer then automatically identifies potential third parties, locates them and verifies whether consensus has been reached [26,27].

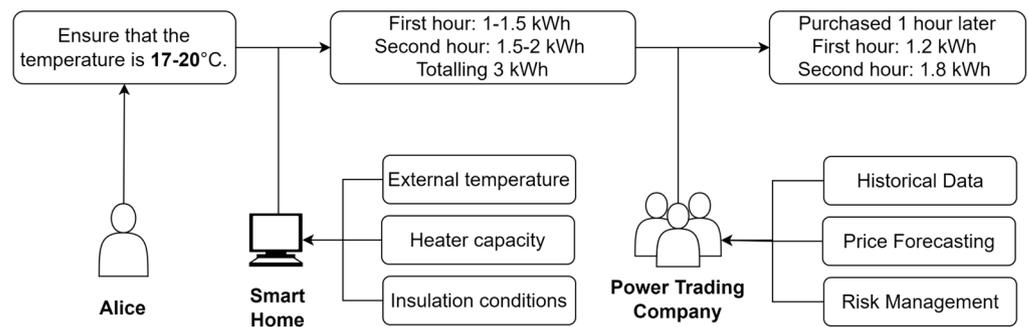


Figure 3. Nested Interpretation.

### 4.2.2. Elastic Demand, Risk and Insurance

Third-party assisted translation reduces user costs and employs unique contextual knowledge to produce more accurate translations of electricity usage intentions [28]. This knowledge can be obtained by analysing users' past intentions or by evaluating the overall environment, thereby generating distinct contextual frameworks and inference rules.

In many cases, it is neither possible nor desirable to standardise the background knowledge and inference rules across all participating parties. The differences between these systems may lead to different interpretations of electricity usage intent translations between users and third parties, something that conventional logic systems strive to avoid. Nevertheless, we should not pessimistically assume that these problems cannot be resolved.

As illustrated in Figure 4, third parties are often responsible for resolving issues with their translations, such as rectifying errors or providing compensation. Electricity trading companies can adjust trading plans or guarantee power supply through insurance mechanisms when transactions fail. This process can be automated, with no cost borne by users.

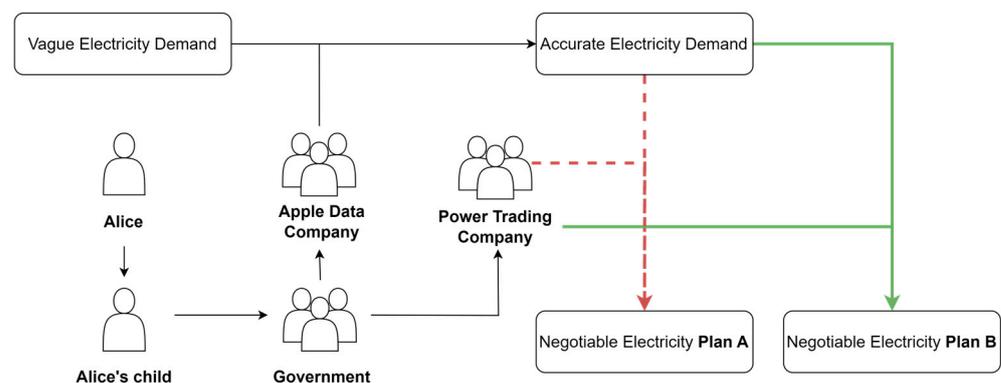


Figure 4. Unperceived Agent Reinterpretation.

### 4.2.3. Dispute Shelving and Dispute Resolving

Any issues that arise, whether now or in the future, can be resolved at a later date. This tolerant approach to errors allows for greater freedom when collaborating with multiple systems. This methodology can be employed to address future issues and resolve past disputes.

Disagreements between systems need not hinder cooperation. Disputes can be set aside, resolution methods agreed upon and new, conflict-free consensus environments established. Any new problems arising from past disagreements can be addressed as they emerge.

Under this approach, there is no need for full integration of all systems. First, we establish a coarse-grained collaborative environment, then refine the granularity as required to allow for flexible adjustment.

### 4.2.4. Consensus in Peer-to-Peer Transactions

In transactions, we require a certain degree of consensus and follow specific agreements or rules. The process of reaching this consensus can be automated using computing. By describing these agreements or rules, it is possible to reach consensus effectively through methods such as secure multi-party computation.

Reaching consensus may involve taking the intersection of mutually agreed-upon rule sets, or describing acceptable rules without listing them all explicitly. We may engage a third party to help define acceptable protocols and rules, trusting either its computational outcomes or the rules it endorses.

As shown in Figure 5, a third party can facilitate the reaching of consensus or even become the consensus itself. It is easy to imagine two users swiftly completing an electricity transaction due to their shared trust in the same power company. Questions such as how to find consensus paths or identify optimal routes can be resolved more quickly within logical systems through algorithms.

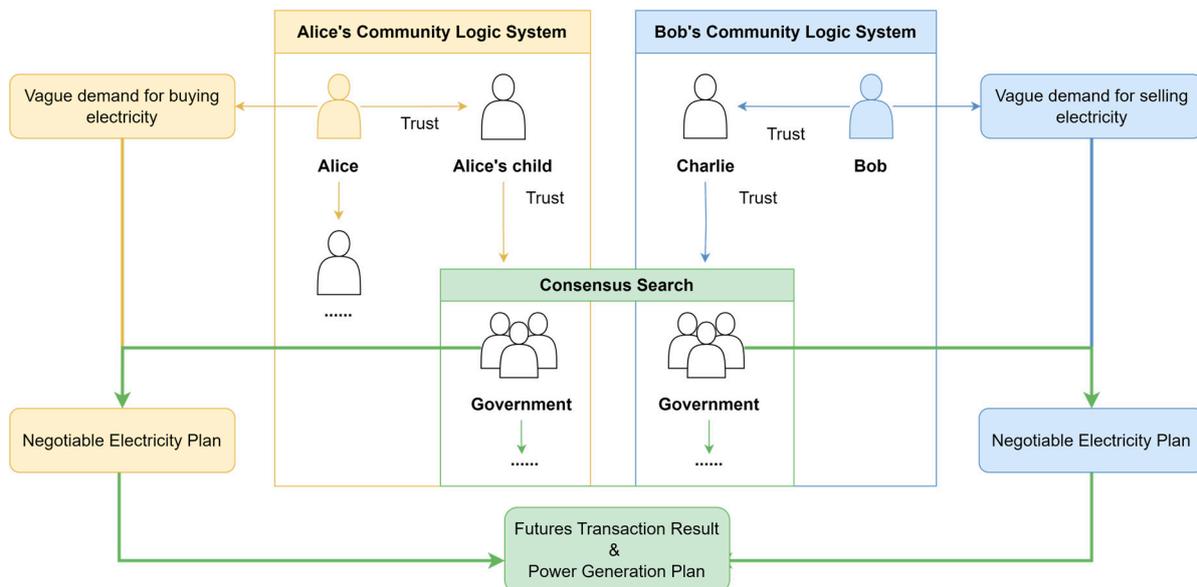


Figure 5. Consensus Third-Party Transaction.

## 5. Community Logic System

Classical propositional logic cannot be directly applied to the aforementioned model. Given that each individual's value logic differs, and reasoning processes and information are not fully transparent, constructing a comprehensive, all-encompassing logical system

proves challenging. Moreover, the assumptions and inductive biases inherent in such a global logical system may be subject to revision at any time. Should inconsistencies in the definition of certain concepts be discovered within a subsystem, the entire logical framework risks fundamental disruption.

This paper seeks to shift perspective, describing logic through partial systems while questioning the assumptions and biases of global logical frameworks. We consider the emergence of problems, employing mechanisms for dispute shelving and resolving to describe and address them, dynamically adjusting the anchors of negotiation and cooperation. Building upon propositional logic systems, we propose a community logic system grounded in partial perspectives. It introduces time and third-party markers, naturally delineating distinct systems while establishing temporal-based global relationships. The proposed meta-modification operator renders operational system updates feasible. This enables the transaction patterns and characteristics discussed earlier to be effectively examined within the community logic system, clearly describing how subsystems employ these negotiation modes. We shall demonstrate this through simulated case studies.

5.1. Definition of the Community Logic System

Time and third parties play a significant role in the transaction process. Our aim is to design a logical system that can describe the abstract characteristics identified in the above process. This research uses the community logic system, which is an extension of the classical logic system [29].

Classical logic comprises a set of inference rules (**Z**) and a set of initial propositions (**I**). During the process of reasoning, any new knowledge must satisfy the conditions within **Z** [30]. To introduce time and third parties into the formal system, the community logic system introduced three changes. Table 2 lists the symbols used in the text:

Table 2. Explanation of Symbols.

Indices	Definition	Operators	Definition
<i>T</i>	<b>Timing</b> of propositions	$\neg p$	<b>Not p</b>
<i>u</i>	Propositions by any <b>user</b>	$ST(a, \varphi_a, b)$	Alice <b>sends</b> $\varphi_a$ to Bob
<i>a, b, c</i>	User <b>Alice, Bob, Charlie</b>	$GF(b, \varphi_a, a)$	Bob <b>gets</b> $\varphi_a$ from Alice
Sets	Definition	$p \rightarrow q$	Proposition <b>p infers</b> proposition <b>q</b>
<i>Z</i>	The set of inference rules in formal system	$\alpha(p)[q]$	When <b>p</b> , modify the set of rules <b>Z</b> according to <b>q</b>
<i>I</i>	The set of propositions in formal system	$p \rightarrow End$	When <b>p</b> , end the operation
Propositions	Definition		
$\varphi$	Arbitrary propositions		
<i>e, p, q, r, x</i>	Propositions		

- **Time and third parties**

The community logic system introduces a time superscript and a reasoner subscript for each proposition and rule.

$$p^{T+1 \text{ to } T+10} \rightarrow q \tag{1}$$

When **p** exists in the time **T + 1 to T + 10**, **q** can be reasoned.

- **Send to and get from operators**

To express the interaction between different user logic systems, the community logic system introduces **Send To** ( $a, \varphi_a, b$ ) and **Get From** ( $b, \varphi_a, a$ ) operators.

**Send To** operator  $ST(a, \varphi_a, b)$ , means **a** sends proposition  $\varphi_a$  to **b**.

**Get From** operator  $GF(b, \varphi_a, a)$ , means **b** gets proposition  $\varphi_a$  from **a**.

- **Meta-operator**

Occasionally, a system may modify its operational rules in response to external conditions. Consequently, the community logic system introduces the meta-operator  $\alpha(\mathbf{p})[\mathbf{q}]$  (When  $\mathbf{p}$ , modifies the set of rules according to  $\mathbf{q}$ ):

$$\alpha(\varphi_a \wedge \neg\varphi_b \rightarrow Clash)[Share\ more\ information] \tag{2}$$

### 5.2. Automatic Reasoning of Intentions

Users can express their electricity consumption intentions directly within the community logic system. These propositional statements can then be converted into formalised expressions either through third parties or directly. The logic system will also automatically receive external information and perform reasoning. It will update the user’s logic system state via sensors by adding propositions to set  $I$ . The computer may also automatically attempt reasoning by conducting transactions and searches to determine the next valid electricity consumption plan state.

To avoid complex algorithmic issues, we will not describe how the computer specifically arrives at the next valid state. The vast majority of algorithms can be applied to this reasoning process. The community logic system only guarantees that the computed state is valid and can serve as a reasonable next state. That is to say, ensuring the deducibility between the two states.

For example, when an electric vehicle connects to a home energy management system, the community logic system updates the electric vehicle’s status proposition ( $e$ ) and carries out electricity purchases and sales according to predefined trading strategies. Equation (3) illustrates the process of system ( $I$ ) updates.

$$\begin{aligned} I_u^T &= \{EV\_Charge\_Level = 50\text{ kWh}; Sell\_Price\_Threshold = 40\text{ p/kWh}\} \\ Z_u^T &= \left\{ \begin{array}{l} \mathbf{If} \quad (EV\_Charge\_Level > 20\text{ kWh}) \\ \mathbf{and} \quad Sell\_Price\_Threshold > 35\text{ p/kWh}) \\ \mathbf{then} \quad (sell\ 10\text{ kWh}) \end{array} \right\} \\ I_u^T \text{ and } Z_u^T &\rightarrow I_u^{T+1} \\ &= \{EV\_Charge\_Level = 40\text{ kWh}; Sell\_Price\_Threshold = 40\text{ p/kWh}\} \end{aligned} \tag{3}$$

### 5.3. Third-Party Agency Reasoning

Rather than expressing their intentions in formalised, computable terms themselves, users can trust the results originating from third-party systems. The community logic system can describe how these systems translate intention propositions and how operations continue based on the outcomes. Equation (4) illustrates the process by which users ( $u$ ) trust the result ( $q$ ) after submitting proposition ( $p$ ) to a third party ( $v$ ).

$$\begin{aligned} I_u^T &= \{p_u : "I'm\ going\ to\ the\ office\ tomorrow"\} \\ Z_u^T &= \{ST(u, p_u, v); \varphi_v \rightarrow \varphi_u\} \\ I_u^{T+1} &= \left\{ \begin{array}{l} p_u : "I'm\ going\ to\ the\ office\ tomorrow" \\ q_v : "Ensure\ EV\ power\ is\ above\ 20\ kWh" \end{array} \right\} \\ I_u^{T+2} &= \left\{ \begin{array}{l} p_u : "I'm\ going\ to\ the\ office\ tomorrow" \\ q_v \rightarrow q_u : "Ensure\ EV\ power\ is\ above\ 20\ kWh" \end{array} \right\} \end{aligned} \tag{4}$$

This translation can also be nested, enabling users to trust data companies that are endorsed by trusted groups. Often, third parties not only introduce new propositions but also update the user’s set of inference rules  $Z$ . Meta-operation modifiers  $\alpha$  can express modifications to the logical rules  $Z$ .

As we have not specified a particular method of operation, the third party is abstract and need not express its operational process within the user’s logical system. This allows various third parties, such as AI, human intuition, blockchain and other state changes, to be incorporated into the community logic system for analysis. This also means that the community logic system no longer has the formal logical consistency of classical logic. A state may be invalid yet remain undetected due to the sequence of operations, undisclosed logic, or propositions of the third party.

This uncertainty can be resolved through other forms of uncertainty. When issues arise, we can have faith that the system will eventually provide solutions, even if we cannot predict them. These solutions may come not only from problem-solving methodologies [31], but also from arbitration outcomes delivered by third parties.

5.4. Reasoning from the Future

Community logic systems do not guarantee the accuracy of the outcomes of reasoning, which could cause potential issues. However, if problems can be resolved within manageable parameters, selecting solutions at a later date is acceptable.

In the case of insurance systems, it is impossible to predict the timing or scope of every future occurrence. Although policy terms specify compensation limits, significant fluctuations could deplete funds for all beneficiaries. This approach carries inherent risks, yet it is a reality and effectively resolves problems.

We will demonstrate the critical role of time in resolution methods using the community logic system. In the following example, Alice and Bob attempt to reach a consensus on  $r$ .

In the real world, we often encounter environments that are far more complex, where computational contexts may conflict, and where constraints and information may be incomplete or outdated. In such environments, consensus may only be reached at a later date.

$$\begin{aligned}
 Z_a^{T+1} &: \{p_a \rightarrow r_a\} \\
 I_a^{T+1} &: \{\neg p_a^T\} \\
 Z_b^{T+1} &: \{p_b \rightarrow r_b\} \\
 I_b^{T+1} &: \{p_b^{T+1}\}
 \end{aligned}
 \tag{5}$$

In the event of a conflict, we can use a third-party agent to update the computational environment and enable Alice to trust the latest result, even if it is not from Bob but from Charlie instead.

$$\begin{aligned}
 Z_b^T &: \{p_b \rightarrow r_b, GF(b, p_c^{T+n+1}, c)^n, ST(b, p_c^{T+n+1}, a)^n\} \\
 I_b^{T+1} &: \{p_b^{T+1}\} \\
 I_b^{T+2} &: \{p_b^{T+1}, p_c^{T+2}\} \\
 I_a^{T+3} &: \{\neg p_a^T, p_c^{T+2}\} \\
 Z_a^{T+1} &: \{p_a \rightarrow r_a, \alpha((\varphi_c^{T+n} \wedge \neg \varphi_a^{T+x}) \&(n > x)) [remove \varphi_a^{T+x} \ \& \ add \varphi_a^{T+n} ]\} \\
 I_a^{T+4} &: \{p_a^{T+2}, p_c^{T+2}\}
 \end{aligned}
 \tag{6}$$

When computing consensus, a single machine can trust external propositions. This reduces the cost of maintaining a local computing environment and eliminates the need to bear losses independently.

5.5. Complex Consensus

When multiple systems collaborate, achieving consensus is both crucial and complex. Before we can define consensus, we must conduct a basic analysis. In this study, we examine users seeking consensus to conduct virtual electricity transactions.

We regard the process of achieving consensus as the construction of a virtual computational environment. This involves first establishing correspondences between propositions in two logical systems and then performing joint reasoning. Define these correspondences as anchor points.

$$\begin{aligned} Z_a^T &: \{p_a \rightarrow r_a; \varphi_a \wedge \varphi_b \leftrightarrow \varphi_{a \wedge b}\} \\ I_a^T &: \{p_a\} \\ Z_b^T &: \{q_b \rightarrow r_b; \varphi_a \wedge \varphi_b \leftrightarrow \varphi_{a \wedge b}\} \\ I_b^T &: \{q_b\} \end{aligned} \tag{7}$$

According to the virtual computational environment of the two parties, we construct  $Z_{a \wedge b}^T$  and  $I_{a \wedge b}^T$ , and the abort condition of the operation is the existence of  $r_{a \wedge b}$ . Below is a possible arithmetic path:

$$\begin{aligned} Z_{a \wedge b}^T &: \{p_a \rightarrow r_a; q_b \rightarrow r_b; \varphi_a \wedge \varphi_b \leftrightarrow \varphi_{a \wedge b}; \exists r_{a \wedge b} \in I_{a \wedge b}^{T+n} \rightarrow End\} \\ I_{a \wedge b}^T &: \{p_a, q_b\} \\ I_{a \wedge b}^{T+1} &: \{p_a, q_b, r_a\} \\ I_{a \wedge b}^{T+2} &: \{p_a, q_b, r_a, r_b\} \\ I_{a \wedge b}^{T+3} &: \{p_a, q_b, r_a, r_b, r_{a \wedge b}\} \rightarrow End \end{aligned} \tag{8}$$

In this approach, as long as both parties reach a consensus, it is not necessary for a third party to be involved in reaching this consensus in order to use the third party’s logical system. A time synchronisation system periodically broadcasts the current time. As long as both parties acknowledge this, they can use the time synchronisation system’s logical system to ensure time without third-party participation in consensus negotiation.

When discussing the differences between consensus systems, we referenced dispute shelving and resolving. Systems can control the granularity of information sharing and cooperation.

### 5.5.1. Dispute Shelving

Consensus can be reached at various levels between two systems. When setting up a consensus computing environment, it is not necessary to share everything.

$$\begin{aligned} Z_a^T &: \{p_a \rightarrow r_a; \varphi_a \wedge \varphi_b \leftrightarrow \varphi_{a \wedge b}\} \\ I_a^T &: \{p_a\} \\ Z_b^T &: \{\neg p_b \rightarrow r_b; \varphi_a \wedge \varphi_b \leftrightarrow \varphi_{a \wedge b}\} \\ I_b^T &: \{\neg p_b\} \end{aligned} \tag{9}$$

Although there may be conflicts between  $\neg p_a$  and  $p_b$ , these conflicts may not affect transactions. Therefore, the computing environment can be constructed using shallow consensus, whereby only the result  $r$  is shared rather than the method of obtaining it.

$$\begin{aligned} I_a^{T+1} &: \{p_a, r_a\} \\ I_b^{T+1} &: \{\neg p_b, r_b\} \\ Z_{a \wedge b}^{T+1} &: \{\varphi_a \wedge \varphi_b \leftrightarrow \varphi_{a \wedge b}; \exists r_{a \wedge b} \in I_{a \wedge b}^{T+n} \rightarrow End\} \\ I_{a \wedge b}^{T+2} &: \{r_a, r_b\} \\ I_{a \wedge b}^{T+3} &: \{r_a, r_b, r_{a \wedge b}\} \rightarrow End \end{aligned} \tag{10}$$

We can refer to the process of excluding propositions from the consensus computing environment as dispute shelving. Problems caused by shallow consensus can also be resolved using dispute resolving methods.

### 5.5.2. Dispute Resolving

A dispute may be triggered by differences in reasoning and understanding of the same proposition, future changes, or any number of other factors, and may be raised by one party. Various strategies can be employed to resolve such disputes. Rather than stopping directly, we can break the logic chain down further to identify the conflicting parts and attempt to create inference rules by bypassing the conflicting steps.

$$\begin{aligned} Z_a^T &: \{x_a \rightarrow p_a; p_a \rightarrow r_a\} \\ Z_b^T &: \{x_b \rightarrow \neg p_b; \neg p_b \rightarrow r_b\} \\ Z_{a \wedge b}^T &: \{x_{a \wedge b} \rightarrow r_{a \wedge b}\} \end{aligned} \quad (11)$$

In this process, systems can bypass the conflicting  $p$  and  $\text{non-}p$  to construct the inference rule for  $x$  to  $r$  directly.

While the two systems may differ in their interpretation at the intermediate level, they are entirely consistent at the deep and shallow levels. By shelving and resolving disputes, we can adjust the scale of the computing environment to reach a consensus. The following are the cases that  $x$ ,  $p$  and  $r$  may represent:

$$\begin{aligned} x &: \text{"User is going to work tomorrow"} \\ p &: \text{"User is 15 km from the work"} \\ \neg p &: \text{"User is not 15 km from the work (20 km)"} \\ r &: \text{"20 kWh is plenty"} \end{aligned} \quad (12)$$

Consensus is a highly complex concept; no matter how it is defined, it seems to differ from our intuitive understanding of consensus. Discussion of this issue may touch upon philosophical definitions, which we will briefly cover in future chapters.

For now, we simply regard it as propositions inferred from the anchor points and the constructed consensus environment. By modifying these anchor points, systems can alter the level of cooperation. Naturally, consensus will also shift at different levels of cognitive granularity (i.e., anchor points adjustment).

## 6. Time, Third Parties and Computational Patterns

Time and third parties provide a more general relationship between propositions and operations. When all possible times and third parties are exhaustively enumerated, the community logic system degenerates into standard propositional logic. This implies that when designing algorithms, it is essential to consider utilising the additional information provided by time and third parties. More significantly, the very act of exhaustively enumerating all propositions and rules is not straightforward; it encompasses certain implicit operational patterns.

Compared to standard propositional logic, the introduction of time and reasoner labels creates additional inter-propositional relationships, facilitating co-evolution between different logical systems. Reasoner subscripts link concepts with the same name, implying potential similarities and differences between propositions and rules, as well as the logical consistency of reasoners with the same name. This natural division arises when multiple logical systems exist, particularly when dealing with uncountable and indescribable third-party underlying logics, where such associative information is essential.

The intrinsic meaning of temporal labelling is both more natural and more intricate. Compared to the symbolic expression of computational processes, introducing time more naturally expresses the relative operational sequence of subsystems collaborating with external systems [32], generates positions within global computations and implies underlying causal relationships. This makes it easier to break down computational processes, allowing

for parallelisation and other optimisations. Notably, certain issues encountered in existing operations can be resolved in subsequent ones, enabling self-referential implementation. For example, a random fluctuation could introduce an unpredictable offset in variables with each execution. This offset can accumulate over time and be self-corrected based on the operational state of the algorithm.

6.1. Case Studies of Community Logic System Applications

The multi-system negotiation search model could offer advantages when time and third parties are introduced. Consider a parallel charging task involving eight electric vehicles awaiting charge, grouped into three groups (A, B, C) based on departure order: A1, A2, B1, B2, B3, C1, C2, C3.

The three departure groups depart sequentially, with vehicles within the same group departing simultaneously, striving to complete each departure group’s charging task as swiftly as possible. If the next departure group’s tram completes charging before or simultaneously with the preceding group (an inverse pair), this incurs a 1-point penalty. Each forward pair increases the score by 1 point. For each additional charging cycle required, 5 points are deducted. The overall score for  $B1^{T+1}, A1^{T+2}$  is  $-1$ , and the overall score for  $A1^{T+2}, B1^{T+3}$  is  $-4$ .

Assuming each electric vehicle has identical charging times, each subsystem remains unaware of the total number of global tasks. Knowing the sequence of tasks in phases A, B and C improves the subsystem’s score. During each round, a subsystem can adjust its operational strategy based on information shared from external systems. Such search and adjustment processes are finite and incur costs; in this case study, they are simply represented by the number of trams participating in the optimisation. The optimal outcomes for the eight tasks from A1 to C3 are as follows:

$$A1^{T+1}, A2^{T+1}, B1^{T+2}, B2^{T+2}, B3^{T+2}, C1^{T+3}, C2^{T+3}, C3^{T+3} \tag{13}$$

All Phase A tasks are completed at time  $T + 1$ , Phase B tasks at time  $T + 2$ , and Phase C tasks at time  $T + 3$ . The total score is 21 points. (Correct order: 21 points; reverse order: 0 points; timeout: 0 points).

Consider that three electricity supply producers exist which initially assign the following outcomes at random:

$$\begin{aligned} a &= \{A1^{T+1}, B1^{T+4}, C1^{T+5}\} \\ b &= \{A2^{T+2}, B2^{T+3}, C2^{T+4}\} \\ c &= \{B3^{T+1}, C3^{T+2}\} \end{aligned} \tag{14}$$

The overall task outcome is:

$$A1^{T+1}, B3^{T+1}, A2^{T+2}, C3^{T+2}, B2^{T+3}, C2^{T+4}, B1^{T+4}, C1^{T+5} \tag{15}$$

The total score is  $-1$  point (correct order: 15 points; reverse order:  $-6$  points; timeout:  $-10$  points). In this hypothetical scenario, we will discuss how to apply trading patterns.

6.1.1. Cooperative Negotiation

During the optimisation phase, System A negotiates with System B by sharing a computational environment controlled by both parties, which involves performing rearrangement.

$$\begin{aligned} a &= \{A1^{T+1}, B1^{T+4}, C1^{T+5}\} \\ b &= \{A2^{T+2}, B2^{T+3}, C2^{T+4}\} \end{aligned} \tag{16}$$

After System A and System B shared all information, both parties reorganised their respective computational environments based on their respective objectives.

$$\begin{aligned} a &= \{A1^{T+1}, B1^{T+3}, C1^{T+4}\} \\ b &= \{A2^{T+2}, B2^{T+3}, C2^{T+4}\} \end{aligned} \tag{17}$$

At this point, the negotiation cost is the number of elements in the computational environment, which is 6.

### 6.1.2. Agent Trust

When System A collaborates with System B, it stops sharing extensive environments and instead starts sharing small ones, thereby placing direct trust in its policies.

$$\begin{aligned} a &= \{A1^{T+1}\} \\ b &= \{A2^{T+2}\} \end{aligned} \tag{18}$$

Following the shared environment, System B will adjust its operations to:

$$b = \{A2^{T+1}\} \tag{19}$$

The negotiation cost at this point is 2. This self-adjustment method allows subsystems to adapt quickly to global changes, rather than updating incrementally based on predefined patterns within the system.

### 6.1.3. Dispute Shelving

Negotiations between systems frequently encounter conflicts and fail to adhere to locally optimal outcomes.

$$\begin{aligned} a &= \{A1^{T+1}, B1^{T+3}, C1^{T+4}\} \\ c &= \{B3^{T+1}, C3^{T+2}\} \end{aligned} \tag{20}$$

Following negotiations between System A and System C, the theoretically optimal outcome should be as follows:

$$\begin{aligned} a &= \{A1^{T+1}, B1^{T+2}, C1^{T+3}\} \\ c &= \{B3^{T+2}, C3^{T+3}\} \end{aligned} \tag{21}$$

However, as System A has already negotiated with System B, the outcome for System B is:

$$b = \{A2^{T+1}, B2^{T+3}, C2^{T+4}\} \tag{22}$$

Adjusting the system would inevitably result in the formation of the reverse pair  $C1^{T+3}$  and  $B2^{T+3}$ . Therefore, System A opted not to make any adjustments, thereby shelving the dispute. System C will be adjusted as originally planned. At this point, the charging sequence is:

$$A1^{T+1}, A2^{T+1}, B3^{T+2}, B2^{T+3}, B1^{T+3}, C3^{T+3}, C1^{T+4}, C2^{T+4} \tag{23}$$

The total score is 12 points. (Correct order: 19 points; reverse order: -2 points; timeout: -5 points).

### 6.1.4. Dispute Resolving

To address the above issues, if we believe that operations have encountered certain limitations, we may consider adjusting the constraints on negotiation costs to allow multiple systems to share a large-scale environmental rearrangement. For example, systems A, B and C could share phases A and B.

Dispute shelving and dispute resolving describe the approaches to managing these conflicts. These processes allow us to effectively adjust the granularity of negotiation and cooperation, thereby controlling the negotiation cost per generation.

This approach holds broad applicability for coordinating electricity consumption among multiple subsystems through negotiation. By facilitating multiple rounds of negotiation and exchange, it yields more optimal electricity trading outcomes, permitting each subsystem to adjust its behaviour according to its own optimisation objectives. This enables the optimisation of more complex electricity markets [33], whilst also allowing for the dynamic adjustment of anchor points and negotiation scopes as required, thereby enhancing the controllability of the evolutionary process.

### 6.2. Community Logic System and Computational Models

By abstracting these logical steps into mathematical operations and introducing time and third parties, we can describe the cooperative patterns between systems and construct global operations from local perspectives.

Consider a fundamental operational process  $S$ , expressed as follows:

$$S : (a + c) \times b \div d \tag{24}$$

For example, adding markers to each computational step within process  $S$  naturally prescribes the order of operations over time, rather than relying on a global description of the computational sequence. This allows subsystems to adjust their local computations independently without considering their impact on global properties.

Assume two systems  $S1$  and  $S2$ , occupying variables  $a, b$  and  $c, d$  respectively. Within a general evolutionary paradigm, these systems require joint expression and evolution within the global system. With the help of community logic systems, it is easier to express them from a local perspective:

$$\begin{aligned} S1 &: a_{S1}^{T+1}, b_{S1}^{T+5}; +^{T+2} \\ S2 &: c_{S2}^{S1+3}, d_{S2}^{S1+7}; \times^{T+4}, \div^{T+6} \end{aligned} \tag{25}$$

$S2$  trusts  $S1$ 's computational sequence and adjusts its own operations accordingly. Compared to traditional computational expressions, this approach offers greater freedom in subsystem partitioning and more naturally expresses the relationships between different systems. For multi-subsystem tasks, strongly correlated tasks can be naturally aggregated through time-stamping, agent trust mechanisms and similar methods. Systems can also establish checkpoints at different levels of detail to categorise tasks. For example, different evaluation functions can be assigned to expressions that aggregate every three, five, or seven subsystems, thereby making the transmission of evolutionary pressures more controllable.

More generally, given that computational functions can vary between systems, the ability to freely select anchor points allows content to be compared, analysed and transferred across different mathematical frameworks and systems.

Consider the negotiation of consensus between two complex systems. Initial time  $T$ , hierarchical correspondences, and other similar factors can all serve as reference anchor points. While these systems may exhibit similar behaviour at both the macro and micro levels, different construction methods can make finding mid-level correspondences chal-

lenging. In such cases, dynamically adjusting these reference anchor points facilitates the consensus search and cooperation between the systems.

Such dynamic adjustments can be made by employing dispute shelving, namely by switching anchors through the meta-operator  $\alpha$ . For instance, this can rectify invalid operations and tolerate differing system variables and computational methods, thereby seeking abstract consensus.

Where unification proves challenging, dispute resolving can be used to adjust the comparative perspective between two systems, whether top-down, bottom-up or at the same level. Depending on the anchor point, the comparative perspective can be switched freely.

By expressing computational processes via community logic systems, the granularity of two complex systems can naturally align through dynamic anchors. This greatly assists in exploring inter-system relationships and enhances interpretability between systems.

### 6.3. Community Logic System and Parallel Optimisation

Following the rejection of the global scheme, time and third-party elements are our minimal modifications, enhancing the system's freedom in information processing and enabling natural optimisation through relevant data.

In parallel evolutionary optimisation, each processing stream is regarded as an independent subsystem. We use delay and reference symbols to represent the computational positions of these subsystems within the global system.

Each processing stream maintains its own cluster and possesses an evaluation function representing a subtask that occupies local variables. Subsystem processing streams can optimise tasks independently. After a certain number of iterations, the subsystems merge to compute the global evaluation function. Once the relationships between variables have been identified, the variables occupied by each subsystem are redistributed based on the references and delays between different tasks.

Each sub-cluster generates distinct building blocks during its evolutionary process, offering different perspectives on the same problem. Ambiguous tasks within one system may be precisely resolved within another. Certain system divisions may result in overly tight coupling between two subsystems, causing mutual interference and hindering local convergence. The community logic system provides a representation method with considerable flexibility by incorporating time and reasoner labels. Collaborative approaches that consider dynamic anchor reasoning enable the most flexible control over interactions between systems from a local perspective.

This allows relationships that were previously latent within the system design and constrained by its architecture to be expressed and revealed. Rather than defining potential system structures in advance, we allow the system to discover them naturally through its evolution. This approach is highly effective when dealing with complex systems whose structures are difficult to define.

More generally, during system updates and integration, information can be introduced into the system in a granular manner using methods such as agent trust, dispute shelving and dispute resolving.

The correspondences between the old and new systems can be expressed and controlled naturally, and the granularity of information fusion can be regulated through dynamic anchors, such as by adjusting the correspondence of subsystem evaluation functions. Resource allocation across different systems for distinct sub-tasks can also be generated naturally. Omitted or simplified relationships between systems can be discovered within another system, enabling the full leveraging of each system's strengths. This natural expression of task structure allows the evolutionary process to consider fusion granularity and avoid confusion caused by mismatches in information granularity during system integration.

By employing community logic systems to naturally partition and express variable relationships, algorithms can reveal relationships that are obscured by global structural constraints. This approach reduces the limitations imposed by global structures on the granularity of correspondence and interaction, enabling flexible adjustments as required.

#### *6.4. Applicability of the Community Logic System*

At first glance, it seems that global optimisation could be achieved in this simple scenario by a single large system. However, when considering factors such as time costs and facilitating parallelisation, multiple subsystems conducting local searches may collaborate more efficiently than a single large system. Furthermore, subsystems may not be evaluated solely by a large system; rather, they must demonstrate their effectiveness across multiple tasks. Even for a single task, the consensus algorithms used by different systems may differ. Additional scoring criteria further complicate global optimisation.

This approach offers novel solutions to problems that cannot be described globally. Rather than designing a top-level coordination system, we allow each system to define its own objectives and link multiple goals through negotiation.

Crucially, clusters designed under this philosophy can freely adjust granularity. The depth and breadth of each negotiation can be tailored to requirements, while individual permissions and cost metrics can vary.

Community logic gives us almost infinite freedom: each subsystem can establish its own subjective negotiation evaluation methods without considering global implications at every turn. The weighting of the different evaluation systems governing smaller systems can be dynamically adjusted according to the situation, with these adjustments propagating naturally throughout. Often, numerous partial descriptions are just as effective as an overall description.

This case study provides valuable insights into the variety of challenges involved in addressing problems where local descriptions can easily be constructed, but global algorithms are difficult to develop. Examples of such problems include multi-traveller issues, scheduling and planning. Community logic system provides an effective entry point in scenarios where generating a unique evaluation system is challenging, consensus is weak and cooperative strategies are complex. Unlike a single global model, we can adjust computational processes based on the negotiation costs of different systems, select the appropriate level of detail, and control the search process. When tackling complex, collaborative tasks involving multiple systems, community logic system and its proposed cooperative models can significantly reduce the complexity of constructing global patterns. Starting from individual systems and designing negotiation and adjustment mechanisms makes cost-controlled global optimisation achievable.

Introducing time allows subsystem negotiations to follow a natural operational sequence and adjust global operations. Including third parties allows the system to adapt its negotiation strategies. During the evolution of the system, it is possible that certain pivotal central communication systems will emerge. These systems will prioritise sharing information with others over computational adjustments. This will influence the computational patterns of the entire group through the operations of central nodes. Compared to random nodes, negotiating with central nodes is more efficient. It is important to note that not every task is completed by a single individual, which highlights the critical importance of introducing third parties.

## **7. Energy Communities and Electricity Monetisation**

### *7.1. Community Logic System and Automated Electricity Trading*

Although existing household users are treated as prosumers within the electricity market, they often require third-party assistance to participate due to factors such as

background knowledge and revenue considerations. This makes it difficult for them to control how their intentions are interpreted and explained, and subsequently influence the market [34]. Issues including data security and misaligned interests between users and third parties reinforce this passive role and reduce the incentive for other third parties to engage with the electricity market [35].

Expressing the process from electricity intent to consumption behaviour within a community logic system increases the flexibility of the electricity market, introducing more participants and trading models than the existing market allows [36].

This expands the flexibility of the electricity market and enables computers to accelerate reasoning to a certain extent, reducing costs. Once time and third parties are incorporated, the vast majority of real-world trading models can be described, analysed and optimised within the system. Integration with different systems facilitates more controllable automated electricity trading.

### *7.2. Energy Communities and Peer-to-Peer Electricity Markets*

Energy communities are a key approach to achieving decarbonisation and energy autonomy. The introduction of the community logic system makes it easier to develop the concept of energy communities [37,38].

Third-party trust issues can be solved by leveraging trust established within other systems. Energy communities utilise neighbourhood trust to elect council members to assist in translating electricity consumption preferences. In existing cases, these trusted nodes may be public institutions such as hospitals or schools.

Abstract third parties formed by multiple entities can also be introduced into the logic system. Users may trust a consortium chain developed by several entities because they consider its state changes to be reliable and trust its operational outcomes. Similarly, energy communities can establish autonomous collectives based on trusted platforms, such as blockchain, which cooperate under protocols supported by the community logic system [28]. This includes generating internal coordination mechanisms that prevent any single user from suffering significant losses due to external electricity price volatility, by prioritising collective internal transactions at an agreed average price during extreme conditions [39,40].

Conducting an abstract analysis of electricity trading hides the underlying details and makes it possible to create a peer-to-peer electricity market at the user level.

### *7.3. Electricity Monetisation and Monetary Policy*

Developing precise models of electricity transmission that account for losses, reserves and other factors enables us to devise unique trading rules and models for electricity transactions. This simplifies the process, delineates distinct roles and enables greater participation from electrical engineers and financial traders within the electricity market. Once sufficiently abstracted, electricity can be regarded as a form of currency governed by specialised trading rules, thereby establishing a more efficient electricity market. Users, power companies and agents can trade futures in this market. Once transactions are confirmed, power is transmitted within the grid, enabling natural energy allocation through free trade.

This incentivises and enables smaller nodes to actively participate in the electricity market, transforming electricity demand from random consumption patterns within a given timeframe into negotiable plans within defined parameters. This gives the electricity market greater flexibility to adjust and creates trading windows. As the market evolves, it will be possible to introduce more complex and extreme strategies, such as negotiating the use of private electric vehicles as energy storage devices.

#### 7.4. Trust and the Rights Transferred, from Government to Friends

Setting aside specific identities, our trust in third-party agents is founded upon an expectation that they will behave in certain ways. We trust governments to uphold fairness and shield the majority from energy hazards; we trust friends to select dependable suppliers, thereby securing our electricity supply. These divergent trusts among different actors forge complex social interactions. Two users' shared trust in an agent simplifies their transaction process; two traders' differing trust in prices enables counterparty arrangements. Such varied trust is both present and indispensable.

Based on this trust and belief, we cede our rights and adjust our actions to achieve better outcomes. We assign distinct functions to different roles: our friends may assist with childcare, while government officials administer our pension schemes. Through the actions of perceived third parties, the system can delegate tasks and collaborate with other systems to resolve issues.

As an entity that commands broad and strong trust, the government can provide fundamental public services and maintain the market. It can model the power system precisely, construct transaction control platforms, oversee evidence preservation and regulate equipment. Furthermore, the government can regulate the electricity currency trading market through policy or participate in it directly. For instance, it could adjust taxes on power sources to gradually achieve carbon neutrality, or intervene directly in transactions to prevent disruptive events, such as black swans, from damaging the electricity market. It could also adjust grid development according to circumstances to ensure electricity safety. These are the actions users expect from the government as a robust public entity [3,41,42].

The electricity market requires more diverse participants. Introducing roles from different systems enables users to adjust their rights of concession, permits greater freedom in user behaviour, and builds a more complex and robust electricity market [12]. Moreover, the abstraction applied by the community logic system allows for computer acceleration, thereby reducing costs.

These responsibilities are dynamic; our trust in different entities and our understanding of their operational logic evolve over time. Should we perceive a third party capable of substituting another's actions through certain behaviours to further our objectives, we may alter our conduct and modify the rights we cede.

Consider a simple case: if each individual possessed a private large model capable of translating any language into a form more comprehensible to them, it is not difficult to imagine its function as a personal secretary, assisting in translating one's own expressions and acting as an intermediary for communication. This would enable cooperative models requiring complex negotiation and communication costs, while also granting greater freedom to third-party roles and introducing more intricate and variable patterns of inter-system collaboration. Leveraging computing power to reduce cooperation costs or establishing novel cooperative frameworks like blockchain systems, the community logic system provides a sound theoretical framework for describing such patterns.

## 8. Future Perspectives

In Section 3, we examined issues in the interpretation of intentions and summarised them as three problems: incomplete information; differing objectives between systems; and different reasoning rules across systems.

While these three problems may appear isolated, they are in fact related in complex ways. If information is incomplete, can requirements be met by sharing information? Similarly, if reasoning rules differ, can we assume the meaning of information remains constant?

The answer is no, but not entirely. If we deny all information invariance outright, a complete rejection of all information invariance would render it impossible to establish any reasonable comparative methodology between systems, leaving all optimisation efforts without foundation. In a community logic system without anchors, each system operates in isolation and cannot reason based on external information.

Therefore, interaction between systems necessarily depends on a degree of information invariance, embodied by anchors. By fixing the meaning of information and establishing relationships between systems, these anchors enable flexible adjustments. Interpretations of the same proposition by different systems can serve as fixed anchors or be adjusted dynamically as required. The community logic system provides a clear framework for interaction between systems, enabling collaboration methods and granularity to be adapted based on different anchors.

Time and third parties essentially describe reasoning about what is unknown outside the system. The introduction of these unknowns makes the meta-modifier  $\alpha$  critically important. This could allow us to move beyond templates and reflection with our abstraction levels, resulting in a non-deterministic, locally semi-operable abstraction.

Based on this, how exactly do systems collaborate? How are partial, semi-operational expressions realised within a global context? At what level do systems achieve consensus and mutual understanding? How do subsystems adaptively co-evolve within a system cluster? Exploring these questions requires a deeper understanding of systems and information. We argue that this relates to Wittgenstein's theory of language games, particularly with regard to describing how language changes [43]. This issue will be explored in subsequent research.

More broadly, the community logic system is an abstraction of human cooperation. Integrating this interpretative approach to intent with diverse fields such as artificial intelligence and blockchain technology has significant potential [44].

## 9. Conclusions

This paper analyses how users' intentions regarding electricity consumption generate behaviour that impacts the power system. It conducts an in-depth analysis and abstraction of this process, identifying key issues within this transformation. Drawing upon real-world transaction models, time and third parties exert a critical influence on this process.

The community logic system is employed to express this process and effective transaction models, facilitating the participation of diverse algorithms and accelerating the process while reducing costs. Building on this foundation, the paper analyses transaction models applicable to existing power trading processes and their automation. It examines and abstracts concepts such as transactions and consensus. It then explores the impact of these models on algorithmic search patterns and discusses construction methods for energy communities, peer-to-peer electricity markets, and electricity monetisation. It also discusses potential future research directions for the community logic system, which has significant application potential in a variety of fields.

The community logic system provides a general theory and framework for constructing inclusive and scalable electricity markets. This enables users to participate in electricity market transactions naturally and intuitively. Existing transaction processes can easily be expressed within the logic system for analysis and optimisation, thus making future electricity market transactions centred on negotiable demand feasible. This free, formalised method of mathematical expression also enables a collaborative approach to be applied across diverse systems, revealing hidden relationships obscured by global assumptions. It dynamically adjusts collaboration methods between systems, establishing a new paradigm for interpretability and negotiation. This enhances cooperation between different sys-

tems, enabling the expression and control of third-party-based collaborative evolution and time-based self-evolution through dynamic anchors.

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