Exploring the role of aggregators in the ecosystem of energy flexibility

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Abstract
This paper aims to explore the role of aggregators in the energy flexibility ecosystem through the lens of an employed framework built on two theories: Information ecology theory and the architectural theory of digital innovation. The framework is initially tested using descriptive data from an organization working as an aggregator in the energy market. The potential of the framework is shown from a combination of these theories and an initial test using descriptions from the aggregator case and its products and services in the context of energy flexibility. By highlighting four integration tasks of sharing, combining, standardizing, and multi-homing, the framework has the potential to explore the role of aggregator within the flexibility ecosystem. This study concludes with three propositions regarding the interaction of the ecosystem actors and the role of aggregators in the creation of flexibility ecosystem that opens up avenues for future studies.

Keywords
Flexibility Ecosystem, Platform Architecture, Aggregator

1. Introduction

The electric power industry is facing many changes due to the utilization of different digital technologies and the emergence of new services for different parts of the power grid system [1]. A major challenge is to consider the increase of electricity demand due to growing electrification and urbanization and at the same time, dealing with limitations in electricity network capacity to transmit and distribute electricity. As a consequence new businesses have emerged to provide services concerned with energy efficiency and flexibility [2, 3], promising to deal with problems associated with flexibility in the electric power industry.

As stated by Karnung and Ramkvist [4], upgrading and renovating the electricity transmission network is a time-consuming process in comparison to solving the congestion problem in a local network, so the importance of flexibility services to control the supply and demand becomes imperative.

The advent of new businesses implies a growing number of actors, including aggregators [5]. Aggregators are entities that pool together small-scale energy resources including but not limited to solar panels, battery storage systems, and heat pumps to create a larger and more flexible energy capacity [6-8]. However, these new actors act in a complex context, and it can be stated that the founding of new actors results in increasing complexities in service, product, and business ecosystems.

Aggregators not only change the ecosystem of the electric power industry but also develop a platform that changes the way flexibility services can be provided [9]. Due to the presence of a platform, the flexibility ecosystem has become a combination of products and services offered by different actors orchestrated by aggregators. Therefore, the integration of various components into an ecosystem is of importance [2, 10].

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On the one side the presence of the platform [2, 11, 12] for flexibility provision and on the other side, the existence of an ecosystem constituted by a combination of products and services each provided by different actors, makes studying the emergence of this ecosystem difficult [13]. It is a question of how to investigate this combination in order to further develop both comprehension and contribution from what could be labeled as an energy flexibility ecosystem. Therefore, in this paper, to explore the role of aggregators in the development of energy flexibility, a theoretical framework has been adopted. The practical usefulness of this framework is that it could in the next step be used as input for future development of services and products in relation to an ecosystem dealing with flexibility challenges in the energy sector.

The framework has been built on two theories: Information ecology theory and the architectural theory of digital innovation. Information ecology theory by Wang [10], elaborates on relationships between part and whole in ecosystems. It grants this study to investigate the products and services within an ecosystem and enables the exploration of digital technologies' role for different types of relationships. The architectural theory of digital innovation by Yoo, Henfridsson [14], on the other hand, deals with the layered modular architecture of digital technologies which instantiates the platform architecture and paves the way to have an architectural perspective when exploring and explaining an energy flexibility ecosystem. We show how these two theories can be combined, and explore the question: What role does an aggregator play in the development of an energy flexibility ecosystem?

This paper will proceed with background information followed by method, presenting the result, discussion and concluding remarks.

2. Background

2.1. Power grid transformation and platforms

Previously, the provision of electricity was based on the centralized structure of power grids. Electricity generation occurred centrally and was transmitted directly to consumers; therefore, no complementary services could be expected. However, there has been a growing trend among companies to offer additional services including auditing, maintenance, and energy efficiency measures [1].

Implementation of a new generation of electricity meters (smart meters) [15], a growing number of distributed energy resources such as photovoltaic systems, wind turbines, etc. [16], and liberalization of the market in some parts of the world [3] are some drivers of new services in the energy sector transforming the traditional power grids.

Transformation has not been without challenges [2] particularly with growing electrification and urbanization that have caused an increase in electricity consumption [17]. The distribution and transmission parts of power grids are the Achilles heel of smart service provision due to the limited capacity of the grid network and the long process of renovating and upgrading this part [4]. As a result, many businesses attempted to solve the grid congestion by providing energy efficiency and flexibility services [3].

That is one of the reasons for the growing number of business models aiming to provide energy flexibility [3] as a solution to reduce the overload on the network and simultaneously benefit the consumer by reducing the consumption cost. Flexibility is a service that leads to changes in the pattern of electricity consumption due to the price-based inventive [18] or/and as a response to the peak load of electricity in the grid [19].

Energy flexibility is a service that can be provided in different ways. For instance, suppliers by providing the spot price for the consumer encourage them to change their consumption behavior due to the creation of price incentives. Thus, the consumers have the possibility to adjust their electricity consumption according to the cheapest electricity price in a day and reduce their energy expenses [6]. However, the advent of a newly added actor to the power grids recognized as aggregators has enabled platform-based flexibility which means the platform matchmakes [20] between the supply side and demands side. Grid networks need to eliminate the potential congestion and consumers desire to benefit from the cheapest possible electricity. Therefore, the platform acts as an intermediary between grid-side actors and consumers.

In the energy context, platforms are defined in different ways depending on the context or application of the studies. For example, Ardolino, Saccani [21] stated that service platforms seek to create a mixture of products and services for efficiency improvement and cost reduction. Similarly, emphasizing the service-providing aspect of platforms in the energy sector, Idries, Krogstie [2] draw on different definitions [e.g., 21, 22] and introduce service platform as a "modular structure that contains both tangible and intangible resources that ease and facilitate the interaction between actors and resources (p.4)". Menzel and Teubner [12], by accentuating the multi-sided aspect of platforms [13] defined a green energy platform as "the study of digital platform markets that either facilitate the trading of energy from renewable sources or enable the integration of renewable energy into the energy system" (p. 457). Kloppenburg and Boekelo [11] in addition to considering the platforms as the main driver of the dynamics (e.g., complexities, challenges, etc.,) adopted a sociotechnical perspective [13] and defined platforms as "digital spaces where users can communicate and interact with each other and get (temporary or permanent) access to products, services, or more broadly 'resources' provided by peers or organizations" (p.68). Despite not providing a specific definition for a platform, Ma, Clausen [23] depicted the importance of the ecosystem aspect of a platform when studying a particular type of business model in power grids. As shown in table 1, the constructive components of these platform definitions include service and product, business actors, or a combination of these three, implying that although platforms create their ecosystem, this ecosystem can exist at different levels (e.g., service and product level, business level).

Table 1
Summarizing the platform definitions in the energy sector

Authors	Context or application	Components of platform
Ardolino, Saccani [21]	Service	Service and product
Idries, Krogstie [2]	Service	Business actors, service and product
Menzel and Teubner [12]	Green energy, marketplace	Product and service
Kloppenburg and Boekelo [11]	Communication	Business actors, service and product

This highlights the need for a multilevel perspective to investigate the platform and its surrounding ecosystem. Such an approach allows us to comprehend how various components of the platform, including services and products, are provided by different actors forming the flexibility ecosystem.

In the following section, we will explain the theoretical lens adopted for this study to further elaborate on our approach.

2.2. Information ecology theory

Using the information ecology theory, Wang [10] explains how the relationship among actors dealing with innovation mimics the ecological ecosystems. By drawing on ecological and information perspectives, Wang introduced the information ecology theory which expands the comprehension of the ecosystem as an organizational form for digital innovation. Information ecology theory aims to explain the part-whole imbalance- focusing on actors and their actions and relationships and forgetting the ecosystem as a whole- that undermines the integration between parts and the whole ecosystem and specifies the role of digital technology in ecosystems. To do so, applying the holon concept [24], Wang [10] explained the dual behaviors of elements of an ecosystem as a part and whole simultaneously. "Nodes on the hierarchical tree which behave partly as wholes, or wholly as parts, according to the way you look at them [24]". Holarchy here refers to the hierarchy within which the holons are located. In relation to explaining the emergence of a business ecosystem from its subordinates Wang [10] proposed four tasks that need to be considered, namely: sharing, combining, standardizing, and multi-homing.

Sharing refers to the intra and inter-circulation of data, knowledge, information or any other required sources essential for the survival of the ecosystem among the actors. Combining implies the process in which different elements of actors mix with one another. Standardizing refers to standards followed by the actors, de facto or de jure [10]. Multi-homing is observed when an actor or actors is present in more than one ecosystem [25]. For example, the presence of the software developer in the iOS and Android ecosystem [26] shows that actors do not necessarily provide services to only one ecosystem. This study assumes the components in the service and product level as parts and the case organization ecosystem for energy flexibility as a whole. Utilizing this theory and the incorporated tasks helps to understand the ecosystem emergence from the components in the service and product level.

2.3. Architectural theory of digital innovation

Despite having four tasks for the emergence of an ecosystem in mind, it is still unclear how different services and products constitute the architecture of the flexibility platform. For this reason, we suggest adopting the layered modular architecture of digital innovation theory [14]. This theory is compatible with the architectural definition of platform since platforms are considered as the instantiation of layered modular architecture [27]. In other words, Digital platforms possess layered and modular technology architectures, which operate within an ecosystem [28]. These platforms have the ability to orchestrate technological components to promote co-innovation and collaboration among various ecosystem actors [28]. Therefore, our framework will be able to explain integration tasks through the interaction of product and service components in the ecosystem.

Synthesizing two concepts of the layered architecture of digital technology [29] and the modular architecture of physical products [30], Yoo, Henfridsson [14] proposed the architectural theory of digital innovation to introduce it as a new organizing logic of digital innovation. The architectural theory of digital innovation consists of four layers of device, network, service and content. The device layer is where machinery and logical capability exist. Network refers to communication components (e.g., transmitters, network standards, etc.) of digital technologies. Service deals with the application functionality and content which is the place of different data and graphical elements for the user. Moreover, modularity on the other hand refers to the degree to which a product is decomposed to its constructive entities [30].

The combination of layering (layered artefacts) and modularity changes the logic of the top-down design of a product which is nested and fixed to a bottom-up logic [31, 32] where the bottom layer of the stack (i.e., device and network), constitute a relatively stable core which is not quickly changeable and the upper layers of the stack (i.e., service and content) which are considered as the periphery layers where the developers by data manipulation can change it often [33]. Figure 1 shows these layers horizontally where the bottom layers and top layers are located on the left and right sides respectively.

Such architecture allows a separation between the hardware and software that helps digital and physical components to be mixed in different ways [34]. For example, considering google Maps, this service can be combined in various types of devices such as phones, computers, cars, etc., and does not belong to a specific type of device (i.e., product agnostic) [14].

2.4. Preliminary conceptual framework

For constructing the framework, this study adopts a sociotechnical definition of platform [13]. This definition refers to platforms as technical elements including software and hardware distributed in different layers of platform architecture and associated organizational processes and standards among ecosystem actors [13]. In this definition, hardware and software make up the architecture of the platform [14] which are present on the service and product level of holarchy. Organizational processes and standards respectively reflect the business actors at the business level of holarchy [10]. Thus, Information ecology comprises the social and architectural theory of digital innovation elucidates the technical part of the definition.

Four tasks of sharing, combining, standardizing, and multi-homing drive the emergence of ecosystems by facilitating actors' collaboration. However, these tasks fail to explain how actors achieve flexibility through the platform. For instance, the term "sharing" is too vague to specify what exactly is being shared to enable the platform's functionality. To address this gap, it is necessary to integrate the tasks into the platform architecture, allowing for a clear understanding of the role played by each layer of the platform and the services and products provided by different actors.

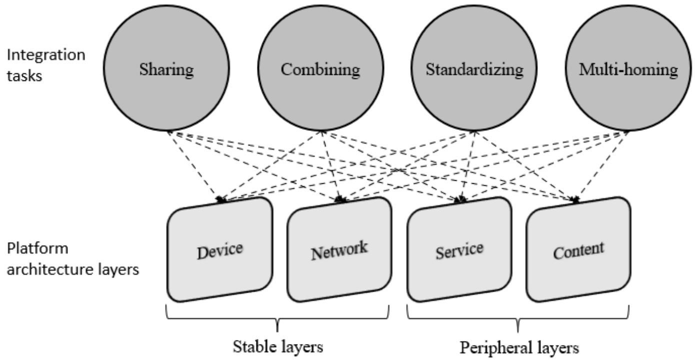

Figure 1: The preliminary theoretical lens: Explaining four tasks of ecosystem emergence through the platform architecture

When actors within the ecosystem aim to collaborate, their interactions occur within one or more layers of the platform. This assumption is based on the understanding that the platform serves as the foundation for both grid sides and consumers to benefit from energy flexibility services. Consequently, the platform acts as an aggregated base where actors come together. Thus, if an actor participates in the flexibility ecosystem, its role will be reflected in the platform architecture. Thus, this framework addition to enabling the explanation of the connection between the parts (products and services) and the whole (flexibility ecosystem), delineates how the flexibility ecosystem as a whole emerges through the interactions among the parts.

3. Method

This study started with reviewing literature on digital servitization, digital platforms in the energy sector, aggregators and demand-side flexibility services. As shown in section 2.1, the ecosystem of energy platforms including energy flexibility platforms can be defined in multilevel including product, service and business levels. The first challenge was to identify a theoretical lens that is suitable for exploring and explaining what is ongoing regarding the development of a flexibility platform and the surrounding ecosystem. Therefore, to inform this study in terms of data collection and analysis, two theoretical lenses were adopted: information ecology theory and architectural theory of digital innovation as building blocks for the framework. The Information ecology theory provided us with the following four tasks: sharing, combining, standardizing and multi-homing. These tasks serve this study by visualizing the possible interaction among the ecosystem components in order to create a flexibility ecosystem. While the architectural theory of digital innovation provided us with the perspective of layering (layered artefacts) and modularity that instantiate the flexibility platform architecture. Therefore, these two theoretical lenses enabled this study with a multilevel perspective to investigate the flexibility ecosystem. To execute the first test, we decided to have a case of an organization acting as an aggregator in the energy sector. To do so, different companies related to the context of the research were identified. The initial selection of companies was delimited to the energy flexibility services directly and indirectly associated with single households.

For finding an initial case which suit the ambition of testing the framework two resources were used: Färegård and Miletic [18] by introducing the actors (aggregators) and their role in energy flexibility in Sweden and Crunchbase.com by providing the search and filtration options for searching organizations. Among possible organizations, one was selected as an initial case test for the suggested framework. Due to privacy concerns regarding the next stages of our research with the case organization, the name of the company is anonymized. Therefore, we will refer to this company as AnAgg throughout this paper.

Upon selection of the case organization, the necessary data was collected to explore the role that an aggregator plays in the flexibility ecosystem. The data we use consists of information gained from the organization's website and information material the organization uses for marketing its product and services. Additionally, 20 documents from the Svenskakraftnät [35] (TSO) webpage were collected to supplement the AnAgg data, providing insight into the structure of the Swedish flexibility market and the ecosystem actors involved in providing flexibility services. These documents include meeting reports, summaries and presentation slides shown in meetings of flexibility ecosystem actors.

To analyze the data, this study employed document analysis [36] to identify the actors involved and their respective products and services, thus shaping the service and product level of the holarchy. Subsequently, each component at the service and product level was analyzed against the layered modular architecture framework to identify the constructive elements of the energy flexibility platform. After establishing the roles of each service and product component in integration tasks, this study further explained each task by utilizing different layers of the layered modular architecture of digital technology [14].

AnAgg is a Swedish-based aggregator which specializes in digitalizing and optimizing energy systems by providing smart energy services and required products for citizens and power grid operators. By leveraging the pre-existing electricity and district heating infrastructure, the company focuses on enhancing cost-effectiveness and improving home comfort for end consumers and simultaneously helping the power grid actors by reducing grid congestion when it is needed. The service and product scope of this company is shown in table 2.

These services target two customer categories: electricity consumers' side (service types 1, 2, 3) and grid operators' side (service types 4, 5).

For the consumer side, AnAgg offers an energy optimization service and a corresponding product which is a smart thermostat. These thermostats utilize automated temperature control in buildings. By gathering data on external factors such as outside temperature and electricity spot prices, customers can potentially save some percentages annually on their energy expenses. The thermostats consist of wireless hardware connected to an undisclosed company's cloud, allowing users to control them conveniently through a mobile application or web platform.

Table 2
product and service portfolio of AnAgg

Type of service	Customer segment	Functions
Service type 1	Single family house	Electricity consumption optimization
Service type 2	Single family house	Electricity consumption tracker
Service type 3	Condominium associations, Property owners	Electricity consumption distribution via individual metering and billing
Service type 4	Condominium associations, Property owners, district heating companies	Control and optimization of properties' heating system
Service type 5	District heating companies, power grid operators (DSOs and TSO)	Power load control and optimization of district heating network

For the grid side, AnAgg has collaborated with more than 70 energy companies, offering them grid optimization services. These services aid in balancing the peak loads on the electricity grid. Designed for large-scale management and optimization of electricity grids, including both electricity and district heating, grid optimization service incorporates predictive tools and AI to facilitate the coordination between energy producers and consumers. For instance, when there is insufficient power in the grid, AnAgg can temporarily reduce building temperatures to address the situation.

4. Results

In this section, the result of the study including four tasks of sharing, combining, standardizing, and multi-homing associated with the emergence of a flexibility ecosystem will be explained.

4.1. Sharing

Starting from the sharing task, we found that this task is carried out mainly by the device and network layer of the platform. In the device layer, the most common devices include smart meters, depositors, controllers (heat pump connectors), gateways (data transmitters) and heat pumps. Sharing by these devices refers to the presence of the required device to enable the service provision for AnAgg. The mentioned components need to be shared among the users so that they can use the energy efficiency and potential flexibility in the later stage. Among these devices, smart meters and heat pumps are newly added devices that are provided by DSOs and heating system companies respectively. By default, households possess these two components. Therefore, it cannot be a concern for AnAgg in terms of the distribution of components in the device layer. The presence of these devices functions as the required infrastructure [22] that facilitates building the flexibility services.

In the network layer, sharing happens for transmitting data among different actors involved in energy flexibility. The interaction between the consumers and AnAgg in the network layer takes place with the help of the gateway component. Gateway receives the required data including current interior temperature, desired consumer temperature, and home energy conservation from the consumer side and transfers it to the AnAgg database. For this communication, AnAgg uses its own radio network [37] and as such eliminates the need for Wi-Fi. Similarly, AnAgg takes control of heat pumps by sending control signals to the gateway and the controller turns this signal into an actionable command for the heat pumps. Balance responsible parties and suppliers are the actors influenced by aggregators' business [38]. Despite this importance, it is not clear what are the communication channels between AnAgg and these actors and whether the communication takes place in real-time or not. Therefore, the communication between these actors in the network layer of the platform needs further investigation.

4.2. Combining

The platform architecture features the combining task at layers of device, network, service, and content. In the device layer, combing implies the physical compatibility of devices. The importance of combing in the device layer was observed in frequent questions on the AnAgg website in this regard. The compatibility of smart meters and the heat pumps with the devices AnAgg provides was a concern for consumers. Currently, various types of heat pumps in different brands are supported by AnAgg and even in the rare case of incompatibility, some customization services are possible to enable offering flexibility service. This wide compatibility coverage for heat pumps and smart meters makes the collaboration between AnAgg, DSOs (smart meter providers) and heating system companies possible.

Combining at the network level represents the process in which the sensor data is aggregated and transferred to the service layer via the communication protocols [39]. These protocols are a set of rules that must be followed when exchanging information between different entities [40]. Wang [10] explained how the combining task is a programming attribute of digital technology [41, 42] due to the possibility of using boundary resources [43] such as applying application programming interfaces (APIs) in platforms. AnAgg provides open APIs that enable third parties to use the sensorial data for different purposes [44] which basically makes the development of various services possible [45-47]. It seems the role of APIs in developing and expanding ecosystems is prominent since they facilitate the creation of new applications [43].

In the service layer, the success of energy flexibility will be materialized when the services both for the grid actors and the consumers are appreciated. Having an inadequate number of consumers using service type 1, or the lack of grid actors' cooperation (service type 4 and service type 5) means that the benefit of services will be restricted to the consumer side (energy optimization and cost saving) and deprive the grid actors to reduce the congestion or control the pick prices. Moreover, in line with the sharing task in the network layer, the possibility of conflict of interest between the grid actors, AnAgg, and consumers increases if the provision of flexibility service disrupts the activities of any actor. For instance, regarding the relationship between aggregator and balance responsible parties, any consumption deviation caused by what AnAgg carries out from the forecasted electricity consumption by the BRPs leads to an unexpected imbalance in the grid for which BRPs are responsible [38]. Additionally, this deviation can impose risks to suppliers' business since changing the households' consumption (increasing or decreasing) disturbs suppliers' contracts with electricity market parties (e.g., generators) and obliges them to compensate financially [48]. These examples show the importance of combining tasks in the service layer to prevent providing counterpart services in the grid.

Finally, the combining task is reflected in the content layer when the data related to providing services are displayed for different actors. In our case, only the content for the consumers is observable since AnAgg provides mobile applications that function as an interface with which consumers interact. The content layer seems to be provided by AnAgg and the role of other actors in creating the content layer is not observed. In addition, it is not clear whether AnAgg provides a similar interface for other grid actors to monitor the status quo of service provision.

4.3. Standardizing

Standardizing is prominent in the device, network, and service layers of the platform. In the device layer, standardizing facilitates the condition for interoperability of the devices that work together. Standardizing the device layer is not performed by AnAgg but this company leverages it for different physical connections. For instance, having an outdoor sensor in the heat pumps is an enabler for flexibility provision since AnAgg uses this sensor to control the heat pumps. This is one of the de facto standards that is followed by many heating system companies and AnAgg uses it.

Similar to the combining task, APIs play a role in the network layer for standardizing. AnAgg defines different protocols for developers who use AnAgg APIs. For instance, AnAgg's API supports JSON format via HTTP. This matters for developers to ensure that their applications send the requests in a compatible format. Specifying the API's format enables developers to implement encoding and decoding functionality in their application code to ensure that data is correctly formatted when it is sent and received via the API. Another example of a defined protocol is seen in datetime format which is based on ISO 8601:2004 as a universal format for representing dates and times.

Standardizing the network layer is a means of enabling platform generativity by establishing interoperability between devices and facilitating the introduction of new services through the network. This standardization allows for the decoupling of physical components from digital components. For example, if consumers terminate their contract with AnAgg, the network layer can serve as an intermediary between the devices installed by AnAgg and the new services offered by other companies. In this way, the new service layer can leverage the existing infrastructure [49], ensuring compatibility and continuity.

In the service layer, an example of utilizing standards for service provision is the functional requirements set by the Swedish Energy Markets Inspectorate (Ei) for smart meters [15]. Unlike previous examples, this standard is considered de jure because it mandates that all electricity meters must be replaced by a specific deadline to meet these functionalities. AnAgg, a company, leverages the standard functionalities of smart meters to offer services. For instance, since the smart meters can provide consumption data every 15 minutes, AnAgg's tracking system (service type 2) receives this data and presents it to consumers, allowing them to monitor their consumption. As a result, the standards defined for smart meters enable AnAgg to capitalize on them and provide a new service to consumers.

4.4. Multi-homing

Multi-homing in an ecosystem occurs in different scenarios and involves utilizing different components and actors. One scenario is when AnAgg enables the participation of other components in its own flexibility ecosystem. As such, AnAgg as the platform provider, orchestrates multiple ecosystems. One instance involves including heating systems as a new component within the flexibility ecosystem. Heat pumps, despite not being part of the flexibility ecosystem previously, become a valuable resource for flexibility when they are controllable by AnAgg. Another example is enabling other services that might need AnAgg APIs such as peer-to-peer flexibility trading service [50]. Multi-homing in these two examples occurs in the device and network layer respectively.

In a different scenario, smart meters provided by Distribution System Operators (DSOs) play a routine role in collecting electricity consumption data and facilitating billing services. However, these smart meters can also be utilized by AnAgg for their flexibility services, creating multi-homing between the two ecosystems. In this scenario, DSOs enable AnAgg to use their device and data network as seen in service type 2 when connected to the smart meter and make the data transmitted by the smart meter readable to the consumer.

5. Discussion and concluding remarks

In this paper, a framework combining information ecology theory and architectural theory of digital innovation is employed to explore the role of an aggregator in the flexibility ecosystem. The data relationship between platform architecture and four tasks is shown in Figure 2. Combining and standardization are two critical tasks that seem to be more significant when it comes to the creation of an energy flexibility ecosystem. Although we admit that it needs more investigation to prioritize the importance of each task, it has been observed that the involvement of platform architectural elements, including device, network, service, and content in these two tasks, can signify the importance of these two tasks.

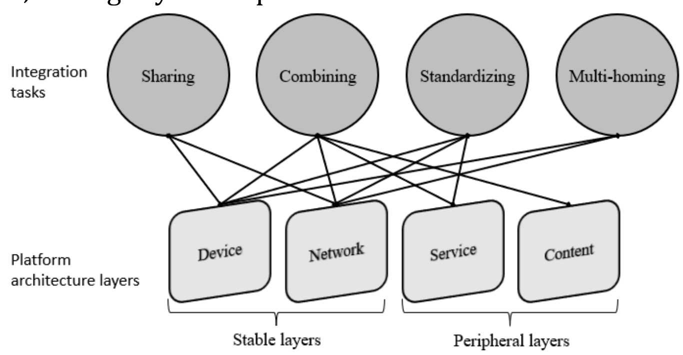

Figure 2: Ecosystem emergence framework for AnAgg

The discussion will proceed with three key points. Each point will be accompanied by a corresponding proposition, highlighting avenues for further investigation.

Firstly, the device and network, as shown in Figure 2, are associated with all four tasks. This implies that establishing an ecosystem relies heavily on the collaborative efforts of actors within these two layers. On the other hand, the weaker connection between the service and content layer with ecosystem tasks indicates that AnAgg has more autonomy in forming these platform layers. Correspondingly, we pose proposition 1:

Proposition 1: The platform for energy flexibility relies more on the interaction of ecosystem actors for its stable core, while peripheral parts depend more on AnAgg as an autonomous actor.

Secondly, we emphasize that despite functioning as an independent aggregator, AnAgg exhibits dependencies in various tasks when constructing its platform architecture. For instance, in the standardization process, AnAgg relies on the standards set by other actors to introduce new services to the platform's service layer. Consequently, exploring the interdependencies and autonomy of AnAgg within the flexibility ecosystem becomes a topic of interest. Understanding these dependencies holds significant importance. For instance, if AnAgg heavily depends on external actors for the multi-homing task, which pertains to the device layer of the platform, the platform's future becomes reliant on the availability and actions of providers of those devices. This dependency becomes more critical when the network layer (such as in data sharing or combining) becomes reliant on other actors or potential new intermediaries, which potentially pose risks to consumer privacy. Therefore, investigating these dependencies within the flexibility ecosystem becomes crucial. Proposition 2 summarizes this point as follows:

Proposition 2: AnAgg, functioning as an aggregator, exhibits varying degrees of dependency and independence across different tasks that impact the construction of platform architecture.

Thirdly, there needs to be more clarity surrounding data sharing (sharing task) and the combination of service and content (combining) within the flexibility ecosystem. We have identified this as a significant issue because the platform's inability to carry out these tasks across the ecosystem effectively can lead to potential conflicts of interest among the actors involved. To provide flexibility services, it is essential to establish a close connection between the supply and consumer sides. This means that flexibility should offer a solution for managing electricity consumption on the demand side, such as peak clipping and load shifting [38], to benefit power grid actors. Simultaneously, it should consider consumer preferences, such as indoor temperature, in order to optimize electricity usage. In such a scenario, the ability to have (near) real-time communication between technological components on the consumer side and electricity market actors, including suppliers, becomes crucial.

Likewise, the provision of flexibility services by AnAgg relies on collaborative interactions with other grid actors whose service offerings are impacted by AnAgg's business. It is crucial to address this lack of clarity to ensure the proper functioning of the ecosystem. This ends up in proposition 3:

Proposition 3: Sharing data and combining service and content in the platform affects the ecosystem's functionality by eliminating the potential conflict of interest.

The next step in acknowledging the potential of this framework and further exploring the role of an aggregator in a smart grid ecosystem, an investigation of the propositions would be fruitful.

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