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SYSTEM FOR EXCHANGING ENERGY

The application relates to a system for exchanging energy between a first exchange device and at least one second exchange device. In addition, the application relates to first and second exchange devices, a method for operating a first and a second exchange device, and a peer-to-peer application.

Charging stations and other (first) exchange devices that are configured to deliver electrical energy to a vehicle as well as other (second) exchange devices are known from the prior art. For example, in the case of a charging station, the vehicle to be charged (or its energy store) can be electrically connected to the charging station via a charging cable. Electrical energy is then exchanged during an exchange process. In the present example, electrical energy in particular is fed from the charging station into the vehicle.

Various solutions are known from the prior art for billing the (energy) exchange process. For example, it can be provided that after the exchange process, a server connected to the charging station performs billing based on the energy amount exchanged and, for example, an agreement between the user of the vehicle and a provider of the charging station. Alternatively, the billing process can be carried out in advance of the exchange process. For example, a sum of money can first be debited from a user's account by a server for a specific energy amount to be charged. The specific energy amount is then charged. WO 2017/032541 A1 discloses a method for exchanging an amount of energy. However, these prior art solutions have various disadvantages. Firstly, a central authority in the form of a server (or multiple servers) is always required. In addition to the high transaction costs that result from a corresponding architecture, another disadvantage of this architecture is that the central authority or the central server manages user data (account data, access data, consumption data, etc.). A constant problem for the central authority is protecting the user data stored on one or more servers from access by unauthorized third parties. In particular, a great deal of security is required to prevent manipulation of, for example, user data, billing information, etc. This in turn leads to higher transaction costs.

Errors can also occur when exchanging electrical energy or when billing the server. If, for example, billing has taken place in advance and a technical error then occurs during the exchange process, it may not be possible to transfer the agreed service or certain energy amount. On the other hand, a technical error can occur in the course of a billing process that is downstream of the exchange process, with the result that a transferred energy amount cannot be billed correctly by a server. Overall, with the systems from the prior art, there is therefore the risk that there may be a discrepancy between the (actual) energy amount delivered and the (actual) energy amount billed.

The application is therefore based on the object of providing a system for exchanging electrical energy between at least two exchange devices, which reliably enables a proper exchange process and in particular prevents a discrepancy between the (actual) energy amount delivered and the (actual) energy amount billed.

According to a first aspect of the present application, the object is achieved by a system, in particular by a system for exchanging electrical energy between at least two exchange devices. The system for exchanging electrical energy comprises at least one first exchange device, at least configured to deliver electrical energy in the form of an (electrical) energy stream to at least one second exchange device that can be connected to the first exchange device during an exchange process. The system comprises at least one first peer-to-peer module associated with the first exchange device, configured to communicate with at least one peer-to-peer application of at least one peer-to-peer network. The first peer-to-peer module is at least configured to receive a token stream during the exchange process, wherein the transmission of the token stream is causable by the second exchange device. The system comprises at least one synchronization module configured to synchronize the energy stream delivered from the first exchange device to the second exchange device with the received token stream during the exchange process.

In contrast to the prior art, the application provides that, during an exchange process. an energy stream and a token stream are exchanged between two exchange devices, in particular under the control of a peer-to-peer application, wherein the two streams are synchronized with each other. The two synchronized streams ensure that the risk of a discrepancy between the (actual) energy amount delivered and the (actual) energy amount billed is significantly reduced.

Furthermore, in contrast to the prior art, according to the application, an exchange process can be carried out in a secure manner by using a peer-to-peer network (i.e., a framework) instead of a central server or a platform, at least a portion (>1) of the peers of the peer to-peer network, performs at least the monitoring, preferably the control of the exchange process. In a peer-to-peer network, high security standards are achieved by preferably all computers (peer nodes or peers) in the network, at least a subset of the peers in the network, monitoring the correctness of exchange processes and/or synchronization processes. Transaction costs can be significantly reduced. No central higher-level platform, server, cloud, etc. is required.

The system comprises at least one first exchange device. The first exchange device is configured in particular to deliver electrical energy. For example, the first exchange device can be connected to a power grid (e.g., public power grid, private microgrid), have at least one electrical generator (e.g., photovoltaic system, wind turbine, etc.) and/or have an electrical energy store (e.g., rechargeable battery), to provide electrical energy. In one embodiment, the first exchange device can be a stationary exchange device (e.g., charging station).

The first exchange device can have at least one controllable first energy exchange module, which can be electrically connected to a second energy exchange module of a second exchange device. For example, a charging cable can be used for the electrical connection. Wireless transmission of the electrical energy can also be provided.

The second exchange device can at least be configured to receive the electrical energy. For example, the second exchange device can have an electrical energy store (e.g., a rechargeable battery) and/or an electrical consumer. The second exchange device can be a mobile exchange device (e.g., an electric vehicle). The second exchange device can preferably be configured for a bidirectional exchange of energy.

According to the application, the electrical energy is transmitted in the form of an energy stream. In the present case, an energy stream is to be understood in particular as meaning that a specific energy amount can be transmitted almost continuously per specific unit of time. In this case, the energy amount (and/or the unit of time) can be adjusted in particular. For example, the energy exchange module can control the energy stream, i.e., modify or adapt it.

In addition, at least one first peer-to-peer module is provided. The first peer-to-peer module is configured to communicate with at least one peer-to-peer application. A peer-to-peer network, in particular at least a portion of the peers of the peer-to-peer network, has the peer-to-peer application. This allows the exchange process to be monitored by the peers in the peer-to-peer network.

The first peer-to-peer module is associated with the first exchange device. For example, the first exchange device can comprise a peer-to-peer module. Each first peer-to-peer module is preferably assigned uniquely to a respective first exchange device. For example, the first peer-to-peer module can be integrated in the first exchange device.

It is also possible for a communication connection to be provided between the first exchange device and a (remotely arranged) first peer-to-peer module which is assigned to the first exchange device. This means in particular that the first peer-to-peer module can communicate and/or act at least on behalf of the first exchange device. For example, the first peer-to-peer module can be formed in part by a separate processing device, such as a mobile communication device (e.g., mobile phone, mobile computer, etc.), or on a remote stationary processing device (e.g., a data centre). In the case of a mobile communication device or a remote stationary processing device, the at least one first exchange device may have a secure communication channel to the processing device (or mobile communication device) of the data centre and the processing device itself may provide a connection to the peer-to-peer network. In one embodiment, the remote processing device may be a "gateway" to the peer-to-peer network. This means that the first exchange device can communicate securely with the peer-to-peer network via the associated first peer-to-peer module and the gateway formed thereby.

In comparison to a client-server network, in which a server offers a service and a client uses this service, this distribution of roles is eliminated in a peer-to-peer network. Each participant in the peer-to-peer network can use a service equally and offer it themselves. In particular, a peer-to-peer network is self-determined and/or self-organized (without a higher-level unit). In the present case, each computer or peer in the peer-to-peer network preferably has a peer-to-peer application.

The first peer-to-peer module is configured to receive a token stream. According to the application, a stream of tokens means that a certain token amount (e.g., x nano-tokens) can be transmitted almost continuously per certain unit of time. A token or a token amount represents a specific (monetary) value. From a technical point of view, a token or a digital unit is present through a transaction signed by cryptographic methods with which a digital unit of account (e.g., cryptocurrency such as Bitcoin, Ether or asset-backed crypto-Euro; ownership token, which represents the value of an asset or other token constructs) between two parties or their wallets or their exchange device. This transaction can be processed via a central eMoney/digital money system or via a decentralized system (e.g., distributed ledger technology, blockchain), which is the variant preferred for this application. In other variants, such a transaction can be encrypted (e.g., zCash, Monero). The token stream, in particular the receipt of the token stream, can be monitored and preferably controlled by the peer-to-peer application. During the exchange process, the energy stream and the token stream can be transmitted essentially in parallel.

In addition, the system according to the application comprises a synchronization module configured to synchronize the token stream and the energy stream in (almost) real time. The synchronization module is configured in particular to bring about a synchronization, that is to say a substantially temporal synchronization, between the delivered energy stream and the received token stream during the exchange process. For this purpose,

the synchronization module can, for example, transmit a control data set to an energy exchange module. Based on the control data set, the energy stream can then be adjusted for synchronization with the token stream. As an alternative or in addition, the token stream can be adapted for synchronization in a corresponding manner.
According to a first embodiment of the system according to the application, the system can comprise at least one second peer-to-peer module assigned to the second exchange device. The second peer-to-peer module can be configured to communicate with the peer-to-peer application of the peer-to-peer network. The second peer-to-peer module can be configured at least to send out the token stream to the first peer-to-peer module. An (encrypted) communication connection between the first and the second peer-to-peer module can preferably be established by means of the peer-to-peer application. For example, a tunnel can be established between the first and second peer-to-peer module. A stream of data or tokens can be transmitted securely and under the control of the peer-to-peer network.
Corresponding to the above statements on the first peer-to-peer module, the second peer-to-peer module can be integrated in the second exchange device or in a separate device, for example a mobile terminal device of the user of the second exchange device.
The system can preferably comprise at least one energy measurement module. The energy measurement module can be configured to measure the energy stream. The at least one energy measurement module can preferably be arranged in the first exchange device and/or the second exchange device. The energy measurement module can be configured at least to measure the electrical energy stream almost continuously. For example, at least one electrical parameter such as (instantaneous) current, (instantaneous) voltage, (instantaneous) active or reactive power, (instantaneous) phase shift, and/or (instantaneous) frequency can be measured during the exchange process. The electrical energy stream, in particular an instantaneous energy stream, can be determined from the at least one measured electrical parameter. The electrical energy stream determined can be made available to the synchronization module for a synchronization process.
Alternatively or additionally, the system may comprise at least one token measurement module. The token measurement module can be configured to measure the token stream. The at least one token measurement module can preferably be arranged in the first exchange device and/or the second exchange device. The token measurement module can be configured at least to measure the token stream almost continuously. In particular, the instantaneous number of tokens received (or sent out) per unit of time can be

detected. A token measurement module can, for example, track a token end transaction and/or query the receipt of tokens (e.g., in a blockchain wallet, a DAG tangle wallet, a payment or state channel, an Interledger or Polkadot transaction, or a blockchained database transaction or database wallet) The determined (instantaneous) token stream can be made available to the synchronization module for a synchronization process.

As has already been described, the system has at least one synchronization module which, for example, can synchronize the two streams on the basis of the detected (instantaneous) token stream and/or the detected (instantaneous) energy stream. According to a further embodiment, the synchronization module for synchronizing the energy stream with the token stream can be configured in such a way that when a change in the token stream is detected, a (corresponding) change in the energy stream is brought about. For example, a corresponding control data set can be transmitted to the controllable first energy exchange module. The energy exchange module can then change the delivered electric energy stream accordingly. For example, if it is detected that the token stream has changed by an amount X%, the energy stream can be changed by a corresponding amount X% (within the allowed physical limits). This can be carried out almost in real time (<10s, in particular <1s).

Alternatively or additionally, the synchronization module for synchronizing the energy stream with the token stream can be configured in such a way that a change in the token stream is brought about when a change in the energy stream is detected. For example, a corresponding control data set can be transmitted to the first or second peer-to-peer module. The peer-to-peer module can then change the delivered token stream accordingly. For example, if the energy stream was detected to have changed by an X% value, the token stream may be changed by a corresponding X% value. This can be carried out almost in real time (<10s, in particular <1s).

According to a preferred embodiment, the synchronization module can be integrated in the first exchange device, such as a charging station. For example, the synchronization module can be formed at least partially by an exchange controller, such as a charging controller, of the first exchange device. If a token measurement module integrated in the first exchange device detects a change in the token current, for example, this can be made available to the charging controller. The energy stream can then be adjusted in accordance with the above statements.

Alternatively or additionally, the peer-to-peer application can comprise the synchronization module. In particular, the synchronization module can be a software module that can be executed by at least a portion of the peers of the peer-to-peer network (e.g., a smart contract and/or a cryptographic module that uses a synchronization code installed outside of the peer-to-peer network with the peer-to-peer network connects). During an exchange process, a detected token stream and/or a detected energy stream in the form of corresponding measurement data sets can be transmitted at least almost continuously to the synchronization module via at least one peer-to-peer module. The synchronization module is configured in particular to detect a change based on the measurement data sets in accordance with the above statements and to generate at least one corresponding control data set. The control data set can then be transmitted to the corresponding peer-to-peer module. The peer-to-peer module can then adjust the token stream and/or the peer-to-peer module can forward the control data set to the energy exchange module (or a charging controller or the like), for example, in order in particular to adjust the energy stream.

In addition, according to one embodiment, a token conversion module can be provided. The token conversion module can preferably be integrated in the synchronization module. The token conversion module is configured in particular to convert a first token stream or a first token type into a second token stream or a second token type. For example, in the event that two exchange devices (or the respective user) use different token systems/types, the token change module can be used (e.g., shapeshift). For example, a first exchange device may accept token A and a second exchange device may only have token B available. In this case, the token conversion module can convert token B into token A before, after or during the token exchange. For example, the token conversion module can have a wallet in both currencies and carry out the exchange itself as a service or exchange the tokens on third-party marketplaces.

Furthermore, according to a further embodiment, the synchronization module can be connected to at least one control device (or control system) in order in particular to provide synchronization of the energy stream and/or token stream with the control device. The control device can be integrated, for example, in a second exchange device, in particular a consumer (e.g., charging current management and optimization module in a vehicle). As an alternative or in addition, the control device can be integrated into a first exchange device (from a provider), for example as a charging current control and optimization function of an energy provider. The control device can also be a SCADA system or vehicle-to-grid (V2G) system of a network operator for controlling and stabilizing the network operation.

For example, metadata for the system control and/or control data sets can be exchanged via the connection of a synchronization module to a control device. Meta data for system

control comprises, in particular, definitions as to which of the systems takes over the primary control of the charging current, how discrepancies are to be dealt with and/or which boundary conditions exist for the definition of control data sets.
According to a preferred embodiment, the at least one synchronization module can be configured to synchronize the energy stream with the token stream depending on at least one predetermined synchronization criterion. The synchronization criterion can in particular specify the synchronization ratio between energy stream and token stream that is to be at least essentially maintained, i.e., between the energy amount per specific unit of time and the token amount per specific unit of time. For example, if a change in one of the two currents is detected, the synchronization module can perform synchronization according to the synchronization ratio. In particular, during a start phase of the exchange process, synchronization can be set by the synchronization module in accordance with the predefined synchronization criterion and maintained in the subsequent course. A high level of synchronicity between the energy stream and the token stream can be achieved throughout the exchange process.
According to a particularly preferred embodiment, at least one peer-to-peer module may be configured to cause the peer-to-peer application to generate an exchange process agreement module. The exchange process agreement module can be stored by the peer-to-peer application in such a way that the exchange process agreement module is readable by at least a portion (in particular all) of the peers of the peer-to-peer network.
In particular, an exchange process agreement module may be a smart contract. In particular, a monitoring module and/or a synchronization module can be at least part of the exchange process agreement module.
Alternatively or additionally, it can be provided that an exchange agreement can be exchanged as a direct communication message (e.g., via peer-to-peer communication protocols) between two peer-to-peer modules. Such a peer-to-peer module can comprise an exchange process agreement module, which in particular can each have an identity or identifier in the peer-to-peer network. This identity allows the exchange process agreement modules to be authenticated via the use of cryptographic methods and data integrity to be established via the use of hash functions and the storage of hash values in the peer-to-peer network.
The exchange process agreement module can be used to monitor and in particular control the exchange process between a first exchange device (e.g., charging station) and a second exchange device (e.g., electric vehicle). In particular, it can be monitored whether the exchange process is carried out in accordance with data elements that have been

agreed and are stored in the exchange process agreement module before the associated exchange process. If the peers detect a discrepancy, this can be reported immediately and the exchange process can be interrupted or aborted.

The generation of the exchange process agreement module may be effected by at least one peer-to-peer module, such as a first or second peer-to-peer module, for example by transmitting a request message comprising at least one command to create the exchange process agreement module. The request message can be sent by a peer-to-peer module to enable an exchange of energy between the associated exchange device and another exchange device.

In particular, a suitable code and possibly at least one key (e.g., signature) for verifying the sender of a message (e.g., the sending peer-to-peer module and/or the associated exchange device) and/or the authenticity of a message to the peer transferred to the peer-to-peer application or written to the peer-to-peer application by the peer-to-peer module. The exchange process agreement module can be generated between two or more exchange devices or similar entities.

Preferably, after a confirmation message from the (other) exchange device, which can comprise a suitable command and possibly at least one key (e.g., signature) for verifying the sender of the confirmation message, a corresponding exchange process agreement module is generated, preferably after a check by a portion of the peers. In simple terms, each exchange device can search for one or more suitable partners using a peer-to-peer network or the peer-to-peer application and generate an exchange process agreement module using the peer-to-peer application.

According to a preferred embodiment, the exchange process agreement module may comprise at least one of the following data elements:

- at least one identifier of at least one exchange device involved in the exchange process,
- at least one synchronization criterion,
- at least one exchange process start criterion,
- at least one exchange criterion, and
- identifier of the at least one exchange process.

The exchange devices involved in the at least one exchange process can preferably be identified in the exchange process agreement module. For example, each exchange device can be registered in the peer-to-peer application with an identifier (uniquely) associated with the exchange device (or the associated peer-to-peer module). All identifiers of registered exchanges (and other entities) may be stored in a peer-to-peer registry controlled by the peer-to-peer application. The respective identifier can be stored in the exchange process agreement module so that the exchange process can be checked using the identifiers.

Furthermore, the exchange process agreement module can preferably have at least one synchronization criterion (described above). For an exchange process, the synchronization module can at least access the synchronization criterion and, in particular, can control the synchronization in the manner described above.

Alternatively or additionally, at least one exchange process start criterion can be provided. An exchange process start criterion is a criterion by which an exchange process can be started. For example, it can be provided as an exchange process start criterion that the electric energy stream is started first and (e.g., within a definable period of time (e.g., >10s)) the token stream is then started and synchronized with the electric energy stream (e.g., depending on the synchronization criterion). Alternatively it can be provided as an exchange process start criterion that the token stream is started first and then (e.g., within a definable period of time (e.g., >10s)) the electrical energy stream is started and synchronized with the token stream. An exchange process can be initiated in a simple and at the same time secure manner. Advantageously, each generated exchange process agreement module can be provided with a unique identifier.

The exchange process agreement module may comprise at least one exchange criterion. Exemplary and non-exhaustive exchange criteria are the (total) energy amount to be delivered, duration of the exchange process (e.g., desired start and end time), electrical transmission parameters (e.g., max. permissible current, etc.), (financial) amount X for a certain energy amount, the payable by an exchange device (by streaming the token stream), etc.

Further optional data elements comprise at least one wallet address of at least one exchange device involved in the peer-to-peer network and/or a token stream network, an identifier of a control device described above, control criteria, etc.

In addition, according to a further embodiment, the peer-to-peer application can be configured to store at least one exchange process data set via the at least one exchange process in such a way that the exchange process data set can be read by at least a portion of the peers of the peer-to-peer network. For example, after an exchange process, a corresponding exchange process data set can be generated. Alternatively or additionally, it can be provided that an exchange process data set is generated and continuously updated during the exchange process. This makes it possible for at least a portion of the peers to be able to monitor the exchange process, in particular by comparing the previously generated (and readable) exchange process agreement module with the continuously updated exchange process data set. If a discrepancy is detected, the exchange process can be aborted or interrupted.

The exchange process data set can preferably comprise at least one data element from the following data elements:

- at least one identifier of at least one exchange device involved in the exchange process,
- identifier of the at least one exchange process
- exchanged energy amount (so far),
- token amount exchanged (so far).

In the event that the exchange data set is generated and stored after the end of the exchange process, the exchanged or transmitted total energy amount and/or the exchanged or transmitted total token amount can be stored in the exchange process data set. For example, corresponding data elements (previously collected by corresponding measurement modules) can be transmitted from at least one peer-to-peer module to the peer-to-peer application. In the event that the exchange data set is already generated while the exchange process is being carried out, the energy amount exchanged and/or the token amount exchanged can be updated (almost continuously). This makes it possible to check the already exchanged token amount and/or energy amount by at least a portion of the peers during an exchange process.

An exchange data set and/or an exchange process agreement module may be stored by the peer-to-peer application in the peer-to-peer application and/or a storage device controlled by the peer-to-peer application.

As already described, according to a further embodiment, the peer-to-peer application can comprise at least one monitoring module. The monitoring module can be configured at least to monitor the synchronization module and/or the exchange process. At least a portion of the peers of the peer-to-peer network can be configured to execute the monitoring module. For example, the monitoring module can evaluate (instantaneously) detected energy and/or (instantaneously) detected token amounts (e.g., from the data set described above) and an associated exchange process agreement module. For example, previously stored exchange criteria can be compared to the (instantaneously) detected amounts of energy and/or tokens. Electrical energy can be exchanged safely-even without a central authority.

According to an embodiment of the system according to the present application, the peer-to-peer application can be a decentralized register, a distributed ledger or a shared database. The decentralized register can be read by at least every participant in the peer-to-peer network. In particular, all peer-to-peer modules and all peers of the peer-to-peer network can preferably store all information in the peer-to-peer application formed as a register (or in the memory arrangement controlled by the peer-to-peer application) read. All peer-to-peer modules and all other computers or peers in the peer-to-peer network can preferably also send or write messages to the peer-to-peer application. Information can preferably be made accessible to all participants in the peer-to-peer network in a simple manner. This allows a check to be made on the information stored in the remote register, such as exchange data sets or exchange process agreement modules. In particular, each computer in the peer-to-peer network can preferably be configured to check new information, in particular based on older information stored in the peer-to-peer application.

In addition, according to a further embodiment of the system according to the application, each computer or peer of the peer-to-peer network can have the peer-to-peer application. Each computer, at least a portion of the peers, can preferably comprise the complete data content, but at least part of the data content of the peer-to-peer application, in particular of the decentralized register. For example, it can be provided that after a positive verification of new information written in the peer-to-peer application, this is stored by all computers, at least by a portion of the computers. The manipulation security can thus be further improved.

In order to store new information in a tamper-proof manner, the peer-to-peer application can comprise encryption means and/or signature means and/or verification means, for example suitable hash functions. At least one of the aforementioned means can be configured to store in particular at least each generated exchange data set and/or an exchange process agreement module. In particular, it can be provided that the hash function is used to create a link with at least one item of information previously stored in the decentralized register.

Additional data such as inquiries, master, context and/or transaction data of an exchange device or of a user can be stored.

In a particularly preferred embodiment, the peer-to-peer application can be a blockchain or a decentralized ledger, comprising at least two linked blocks. The blockchain technology or decentralized ledger technology is already used for payment using a cryptocurrency such as Bitcoin. It has been recognized that a blockchain can be configured by a special configuration to control at least one exchange process with a synchronization of an energy stream and a token stream between two exchange devices in a tamper-proof manner. The blockchain according to the present embodiment is in particular a decentralized, peer-to-peer-based register in which a plurality of exchange data sets and/or exchange process agreement modules and other messages from exchange device(s) can be logged. As a technical means, a blockchain is particularly suitable for replacing a central authority in a simple and at the same time secure manner. As previously described, the at least one peer-to-peer application may be a decentralized registry, distributed ledger, or shared database configured to store data, e.g., exchange data sets, identifier(s), etc. with certain proofs and/or signatures. In addition to, e.g., identification(s) of registered exchange devices, the decentralized register can store computer code, such as a monitoring module for monitoring and/or controlling an exchange process or a synchronization module for synchronizing two streams. In particular, the code can be invoked by a transaction to the address of the code in the so-called "smart contracts". This code can be processed on the majority of peers of the peer-to-peer network.

It is understood that a (smart contract) code or processing logic can be stored and executed in so-called "crypto conditions" of the Interledger Protocol (ILP). This means that not all code has to be stored in a smart contract, like Ethereum smart contract.

In a further embodiment, the (smart contract) code can be stored and executed on a decentralized calculation marketplace (e.g., Ethereum Computation Market, Trubit, Golem, Cryplets Microsoft).

In another embodiment, computer codes of an external computing device controlled by the peer-to-peer application may comprise algorithms for distributed cognitive analysis, artificial intelligence, or machine learning. Analytics and learning can be shared with other devices and shared, aggregated and further analysed via the peer-to-peer application. For example, these algorithms can be applied to optimize an exchange process.

A decentralized register can be read by at least a portion of the participants in the peer-to-peer network. In particular, each computer node (peer) and each registered entity/device (by means of the respective peer-to-peer module) can comprise the peer-to-peer application. The decentralized register, at least the public part (i.e., without private contracts), can at least be read by every participant in the peer-to-peer network. In particular, all peer-to-peer modules and all other computers of the peer-to-peer network can preferably read all information in the peer-to-peer application, which is designed as a register. It is preferably also possible for all peer-to-peer modules and all other computers in the peer-to-peer network to send or be able to send messages to the peer-to-peer application. A message or transaction sent to a smart contract may initiate execution of smart contract code (e.g., monitoring module, synchronization module, etc.) while using data stored in the smart contract. For example, receiving measurement data associated with an exchange may start execution of the monitoring module, as described above.

The peer-to-peer application can be built on the following elements: peer-to-peer network with consensus system/protocol, data structure, Merkle trees, public key signatures and/or Byzantine fault tolerance. It can replicate data according to a consensus principle. It can be auditable and traceable.

Information can preferably be made available to all participants in a simple manner. This may allow verification of information stored in the remote registry or codes executed in the remote registry. More preferably, each computer (peers) in the peer-to-peer network can be configured to check new information, in particular based on older information stored in the peer-to-peer application. In addition, the at least one monitoring module and/or the at least one synchronization module can be monitored by at least a portion of the peers of the peer-to-peer network, preferably by all peers. A manipulation of such a module can thus at least be prevented.

In addition, at least one peer, preferably each peer, can comprise the complete data content, but at least part of the data content of the peer-to-peer application, in particular of the decentralized register. For example, after a positive check of information written in the application or, for example, after a positive registration of an exchange device in the peer-to-peer application, this information can be stored by all peers, at least by a portion of the peers. For example, after the generation of an exchange process agreement module and/or after a successful registration of an exchange device, the exchange process agreement module or the (new) identifier can be stored by at least a portion of the peers, preferably by all peers of the peer-to-peer network. The protection against manipulation for the data stored in the peer-to-peer application can be further improved as a result. An exchange process and/or a synchronization process can be securely controlled.

In order to store new information (e.g., from an IoT device, such as a measurement device) in a tamper-proof manner, the peer-to-peer application can comprise encryption means and/or signature means and/or verification means, with at least one of the encryption means and/or the signature means and/or verification means configured to store data such as an exchange process agreement module, etc. In particular, a hash function can be used to establish a connection with at least one item of previously stored information in the decentralized register. Other data, such as request messages, ordinary, contextual and/or transactional data of an entity can be stored.

The peer-to-peer application can be formed by a Directed Acyclic Graph (DAG). A directed acyclic graph, like IOTA or Tangle, means that blocks (or nodes of the graph) are coupled to each other via directed edges. "Direct" means that the (all) edges (always) have the same direction in time. In other words, it is not possible to go back. Finally, acyclic means that loops do not exist.

In further embodiments of the peer-to-peer application, the blockchain can be a "permissionless" or "permissioned" blockchain. In one case, the blockchain can be a public, consortium, or private blockchain.

In a further embodiment, the peer-to-peer application can be formed by several peer-to-peer networks, in particular blockchains, which are connected via mechanisms such as "side chains" or smart contracts. A peer-to-peer node, or peer, can execute one or more blockchain client(s).

The peer-to-peer application data can be stored on the decentralized ledger technology and/or the decentralized ledger steers (encrypted) data storage via the Internet and preferably in the decentralized data storage, object storage or database, such as e.g., an Interplanetary File System (IPFS) or Storj or in a distributed blockchain database (e.g., BigChainDB or database hashed with Cryptowerk functions). Access to encrypted data to third parties can be managed via an authorization module, which can be formed as one or more smart contract(s) in the blockchain.

As already described, tokens from a peer-to-peer network can be frozen and transferred to a blockchain-enabled database, for example. This means users can have a second 'wallet' in this database. Transactions between users or their wallets can be carried out as high-performance database transactions. After a certain time has elapsed or the entire transaction has ended, the result can be written back to the original peer-to-peer network.

As an example of running multiple blockchains, an IoT blockchain, such as DAT tangle, can be used to securely collect IoT data and place it on a second peer-to-peer network, such as BigchainDB, as input to perform transactions save.

In addition, data feeds can be provided by the peer-to-peer application (so-called "smart oracles"). Data feeds may provide additional data about an exchange from at least one additional source. For example, further weather data and/or power grid status data can be provided by a meteorological provider and/or a further grid status provider. Data can be received from trusted sources and stored in the peer-to-peer application or stored on a decentralized data storage arrangement via the peer-to-peer application.

Information between peers can be exchanged through a peer-to-peer messaging system.

This means that a peer can send a message to another peer to convey information or trigger an action. Messages (e.g., measurement data, synchronization data or control data) can be signed, hashed, time-stamped and/or encrypted in plain text. This means that not all data exchanged between peers has to be stored on the peer-to-peer application.

In a further embodiment, the at least one peer-to-peer network can be formed by a multiple peers and a peer-to-peer module, such as the first peer-to-peer module of a first exchange device, a second peer-to peer module of a second exchange device, etc. A peer-to-peer module can only be configured to communicate with the plurality of peers. In other words, the peer-to-peer module is not a peer of the peer-to-peer network, but only a participant. Such a peer-to-peer module does not comprise the peer-to-peer application, but only provides an interface module, such as an application programming interface (API), and a decentralized application for communicating with the peers of the peer-to-peer network or with the peer-to-peer application, such as a blockchain or a smart contract of a peer-to-peer application. For example, such a peer-to-peer module can either send plain text or encrypted information or create a secure connection (e.g., tunnel) to another peer-to-peer module (e.g., to transmit a token stream) in order to communicate with the peer-to -peer module or the peer-to-peer network to communicate. This enables the required computing power of the peer-to-peer module to be reduced.

In one embodiment of the peer-to-peer network, there may be only one validating peer or a full node, e.g., only one node may be configured to perform a validation process, such as an exchange or a synchronization process, and one or more observing (or monitoring) peers. An observing peer may validate some transactions to establish a level of trust, but it does not validate all transactions performed by the validating peer.

In another embodiment, the peer-to-peer module can be one of the peers. In this case the peer-to-peer module comprises at least part of the peer-to-peer application. In particular, the peer-to-peer module can preferably comprise the entire data content of the peer-to-peer application or access the information stored in another peer. For example, the peer-to-peer module can be a so-called "light node" or a decentralized application (DAPP) that is (fixedly) connected to a remote peer.

It is noted that in the present case, according to an embodiment, the peer-to-peer module comprises at least one API configured to communicate with the peer-to-peer application. In addition to the API, the peer-to-peer module comprises a decentralized software application that comprises local algorithms that are at least configured to collect data such as B. measurement data, and to transmit it to the peer-to-peer application via the API.

The decentralized application "Dapp" is at least configured to process and transmit the data.

The data is preferably signed or encrypted or can be transmitted to a peer or another peer-to-peer module via a cryptographically secured tunnel or a secured Internet connection. In a further embodiment, the peer-to-peer application itself is implemented in the peer-to-peer module, i.e., the peer-to-peer module is a peer of the peer-to-peer network that the decentralized application, which comprises API and peer-to-peer application.

Data and transactions stored on the blockchain do not provide "transactional privacy". Transactions between pseudonyms can (often) be stored in plain text on the blockchain. In some cases, the data stored on the blockchain is encrypted and the keys can be manipulated through the blockchain. Transactions between pseudonyms are stored in clear text on the blockchain. Secure transactions or computer code executions can be achieved using cryptographic tools such as "zero knowledge" (zk) proofs or "zk Succinct Non-interactive Arguments" (zk-SNARK). Transactions or algorithms are divided into two parts: a smart contract over the blockchain and a private contract. A data protection protocol ensures data privacy and code execution accuracy (SNARK verification is done via the on-chain smart contract). Private job computation can be performed by a set of peers, off-chain computers, or in a measured launch environment or secure hardware enclave for attestation and sealing, not controlled by other software code running on the devices is running, can be manipulated. In an alternative embodiment, secure multi-party computing (sMPC) systems can be used for transaction privacy. Examples of privacy preservation protocols and calculations are HAWK and MIT Enigma.

With zero knowledge (zk proofs), the parties can see that the algorithm is running correctly in a private contract, but the input data is not shared with the parties. In addition, selective privacy can be provided by releasing keys to decrypt transactions for reporting and auditing purposes.

To securely deliver code and/or data into a device, a trusted execution environment such as Intel SGX or TPM or Direct Anonymous Attestation Module can be integrated with a peer-to-peer module.

Other cryptographic methods can also be used to create transactional privacy (e.g., ring signatures, stealth addresses or Pedersen commitments).

Similarly, in a further embodiment, a particularly large peer-to-peer network can be divided into two or more (physical or logical or dynamic virtual) clusters. For example, in a corresponding peer-to-peer network, validation (of a subset of transactions) can only be performed by the members of a cluster (a subset of peers, e.g., splitting a blockchain to improve scalability). In another embodiment, the peer-to-peer application may be formed using multiple blockchains. These blockchains are connected via frameworks such as "sidechains" or smart contracts or Interledger protocols.

Another aspect of the application is a first exchange device for exchanging electrical energy with a second exchange device. The first exchange device comprises at least one (first) energy exchange module, at least configured to deliver electrical energy in the form of an energy stream to the second exchange device, which can be connected to the first exchange device, during an exchange process. The first exchange device comprises at least one first peer-to-peer module associated with the first exchange device, configured to communicate with at least one peer-to-peer application of at least one peer-to-peer network. The first peer-to-peer module is configured to at least receive a token stream during the exchange process. The first exchange device comprises at least one synchronization module configured to synchronize the energy stream delivered by the first exchange device to the second exchange device with the received token stream during the exchange process.

The first exchange device according to the application can in particular be a charging station. The system described above can comprise at least one first exchange device according to the application.

Another aspect of the application is a second exchange device for exchanging electrical energy with a first exchange device. The second exchange device comprises at least one energy exchange module, at least configured to receive electrical energy in the form of an energy stream from the first exchange device, which can be connected to the second exchange device, during an exchange process. The second exchange device comprises at least one second peer-to-peer module associated with the second exchange device, configured to communicate with at least one peer-to-peer application of at least one peer-to-peer network. The second peer-to-peer module is configured at least to send out a token stream during the exchange process. The second exchange device comprises at least one synchronization module configured to synchronize the token stream delivered by the second exchange device to the first exchange device with the received energy stream during the exchange process.

The second exchange device according to the application can in particular be an electric vehicle. The system described above can comprise at least one second exchange device according to the application.

Yet another aspect of the application is a method for operating an exchange device, in particular a previously described first exchange device. The method comprises:

- delivering energy in the form of an energy stream from a first exchange device to a second exchange device that can be connected to the first exchange device during an exchange process,
- receiving a token stream during the exchange process by a peer-to-peer module, and
- synchronizing the energy stream with the received token stream during the exchange process.

The method according to the invention can preferably be used to operate a previously described system. Alternatively or additionally, the method can comprise synchronizing the energy stream and token stream with at least one (additional) control device of a consumer, provider or network operator, as described above.

Yet another aspect of the application is a method for operating an exchange device, in particular a previously described second exchange device. The method comprises:

- receiving energy in the form of an energy stream from a first exchange device that can be connected to the second exchange device during an exchange process,
- sending out a token stream during the exchange process by a second peer-to-peer module, and
- synchronizing the energy stream with the received token stream during the exchange process

The method according to the invention can preferably be used to operate a previously described system.

Yet another aspect of the application is a peer-to-peer application for a peer-to-peer network. The peer-to-peer application comprises at least one synchronization module configured to synchronize an energy stream delivered by a first exchange device to a second exchange device with a token stream received from the first exchange device, the transmission of which is effected by the second exchange device, during an exchange process.

The devices and modules described above can be formed at least partially by software and/or at least partially by hardware components. In particular, the peer-to-peer application can be a computer program.

As already described, a peer-to-peer module is configured to provide access to the peer-to-peer network. For example, the peer-to-peer module can send tokens or initiate token transactions from a wallet associated with the peer-to-peer module (or its user) and/or check the receipt of a token in the wallet.

The tokens can be sent and/or received directly on the peer-to-peer network and/or via another mechanism (or peer-to-peer network), such as side chains, payment or state channels, trusted computing systems, Polkadot, Interledger Protocol transactions or blockchained databases, such as BigchainDB. The peer-to-peer module can, for example, be connected to such a technology in order to send tokens and/or check for receipt.

In addition, the sending of tokens can be linked to at least one condition. An example of a condition is receiving readings or counts. A comparison of token stream with measurement data can take place via the synchronization model.

So that the synchronization module can trust (possibly external) measuring or counting devices, it is conceivable for these measuring or counting devices to be integrated into a further peer-to-peer network. This additional peer-to-peer network can be used to guarantee the integrity and authenticity of data from (possibly third-party) measuring or counting devices.

It is conceivable that an exchange device is equipped with multiple peer-to-peer modules or that a peer-to-peer module of an exchange device is connected to multiple peer-to-peer networks.

Examples of a token or the value of a digital unit are cryptocurrencies such as Bitcoin or Ether or IOTA tokens, ownership shares in assets, physical assets, real estate, art, intellectual property, a company or other forms of assets, loyalty/bonus system/gaming system units, units for promises of access or use (e.g., use of a facility or access to data), or other comparable constructs.

The owner of a token can only spend it once. In an energy exchange system, for example, an energy provider can exchange their energy for such a token, which then represents equivalent value for the provider. Such a token can be generated, managed and exchanged in a peer-to-peer network or a peer-to-peer application − e.g., on a blockchain, a DAG Tangle or a blockchained database. A user (e.g., human, machine or (software)application) of a peer-to-peer network can have a public identity or identifier in the peer-to-peer network. This can be linked to access to a digital wallet. Such a token is exchanged between digital wallets, which can be connected to a peer-to-peer module, for example.

Furthermore, a token can be exchanged between entities as a direct transaction in the peer-to-peer network. In peer-to-peer networks, an exchange can take place, for example, in the form of transaction rates that enable the exchange of two or more tokens between two entities or users via a chronological sequence (e.g., DAG tangle).

Alternatively or additionally, a token can be frozen (locked) in the peer-to-peer network under at least one specific condition and, for example, exchanged outside of the peer-to-peer network (possibly in several steps and at higher transaction rates). After a given time, the result of such an exchange is written back to the peer-to-peer network as one (or more) transactions using cryptographic methods such as signatures. Examples of such mechanisms are side chains, payment or state channels, trusted computing systems, Polkadot or Interledger protocol transactions.

The Interledger Protocol, for example, allows the use of crypto conditions, for example to carry out an exchange under certain conditions (e.g., if-this-then-that).

According to such a mechanism, tokens from a peer-to-peer network can also be frozen and transferred to a peer-to-peer storage arrangement or database. This means that users can have a second 'wallet' in this database into which tokens can be transferred. Transactions between users can then be carried out as high-performance database transactions. This means that in such a peer-to-peer database, in particular a blockchain database, a large number of tokens with a very small value (e.g., amounts in the sub-Euro cent range) can be efficiently exchanged between users. In one embodiment, such a token can already be generated in the peer-to-peer database.

As already described, the exchange of a large number of tokens between two (or more) exchange devices over a defined period of time can be called token streaming. This means that a token with a defined value unit is exchanged between the exchange devices or users per unit of time. This exchange extends over two or more time units.

As already described, an exchange device can be registered in the peer-to-peer application. In particular, in a further embodiment exchange devices can be registered in a synchronization module and control register in the peer-to-peer application with at least one property or attribute. Exemplary and non-exhaustive attributes are supported mechanisms for token streaming, usable synchronization module (e.g., including identifier), wallet to be used, reputation or quality of technical parameters, supported communication and/or dialogue protocols for connecting control devices and/or synchronization modules and/or supported control and/or synchronization mechanisms.

In one embodiment, a synchronization module can be integrated in each of the two exchange devices. In this case, communication can be established between the two synchronization modules. The synchronization modules can exchange information about the synchronization mechanisms, preferably in a dialogue protocol. The dialogue can be carried out via a peer-to-peer communication protocol, for example. In particular, this dialogue can be used to determine which is the primary synchronization module (i.e., the one in charge) for controlling the token and energy stream, how the start phase is to be handled, what happens in the event of discrepancies and/or how a discrepancy is to be dealt with (e.g., if the secondary synchronization module has different readings across its detectors than the primary synchronization module). It can also be regulated how to proceed if, for example, a token stream is stopped or cannot be adjusted due to technical faults. The exchange devices can then agree, for example, that the financial transaction is carried out using other mechanisms (e.g., escrow payment using a smart contract, or pre- or post-payment). Otherwise, both token and energy streams will be stopped.

So that the dialogue between the synchronization modules of the exchange devices can come about and in particular the exchange process can be started (quickly), an existing protocol can be used (e.g., according to ISO 15118) or the exchange devices/synchronization modules can query the synchronization module and control register in order to detect data set identifiers, reputations and synchronization or control mechanisms of the other exchange device. This can be advantageous to perform optimization in a system comprising many exchange devices.

It is understood that the subject matter described here is also applicable to other exchange systems. Examples are exchange systems via pipeline systems for fluid media, such as gases or liquids, exchange systems via pipeline systems for granular media, exchange systems via robot systems for objects of the same type (e.g., metal or plastic parts of the same type).

The features of the methods, systems, devices, peer-to-peer applications and computer programs can be freely combined with each other. In particular, features of the description and/or of the dependent claims, even with complete or partial omission of features or part features of the independent claims, alone or freely combined with each other independently, can be inventive. The invention is defined by the appended claims.

There are now a multitude of possibilities for designing and further developing the system according to the application, the method according to the application, the device according to the application and the peer-to-peer application according to the application. For this purpose, reference is made, on the one hand, to the claims dependent on the independent claims, and, on the other hand, to the description of exemplary embodiments in conjunction with the drawings. In the drawing:

Fig. 1 shows a schematic view of an exemplary embodiment of a system according to the present application;

Fig. 2 shows a schematic view of a further exemplary embodiment of a system according to the present application;

Fig. 3 shows a schematic view of a further exemplary embodiment of a system according to the present application;

Fig. 4 shows a schematic view of an exemplary embodiment of a peer-to-peer application according to the present application;

Fig. 5 shows a schematic view of a further exemplary embodiment of a system according to the present invention;

Fig. 6 shows a diagram of an exemplary embodiment of a method according to the present invention.

In the figures, the same reference signs are used for identical elements.

Figure 1 shows a schematic view of an exemplary embodiment of a system 100 for exchanging electrical energy. The system 100 comprises a first exchange device 102. The first exchange device 102 is configured at least to output electrical energy or power. The first exchange device 102 can preferably be configured for a bidirectional exchange of energy.

The first exchange device 102 can, for example, be connected to a power grid (not shown) – or an energy store or generator – in order to at least deliver electrical energy. It goes without saying that two or more energy sources can be provided. In the present case, the first exchange device 102 has at least one first energy exchange module 106, configured to deliver electrical energy to at least one second exchange device 104 that can be electrically connected to the first energy exchange module 106. For example, an electrical line 114 (e.g., a cable) can be provided. It goes without saying that the electrical energy can also be transmitted wirelessly. The electrical line can be arranged between the first energy exchange module 106 and a second energy exchange module 108 of the second exchange device 104 for at least one exchange process.

The first energy exchange module 106 is configured to transmit electrical energy in the form of an energy stream 130 to the second exchange device 104, in particular the second exchange module 108, during an exchange process.

The second exchange device 104 can be, for example, an electrical consumer and/or an electrical storage device or at least have an electrical consumer and/or an electrical storage device. It goes without saying that the second exchange device 104 can also have at least one electrical generator or can be connected to at least one electrical power source.

An essential difference to a system known from the prior art is that no central authority is provided in the system 100. In the present case, the system 100 has at least one peer-to-peer network 122 or a computer-to-computer network 122. The peer-to-peer network

122 comprises a large number of peers 126.1 to 126.3 (also called nodes or computers). It goes without saying that more than the three peers 126.1 to 126.3 shown can be provided. In the present case, a peer-to-peer network 122 is characterised in that each respective node and/or participant is preferably connected to each other respective node and/or participant. This can take place over a wireless or wired network. For example, the Internet can be used.

In addition, the peers 126.1 to 126.3 are configured as equal peers 126.1 to 126.3, which makes them different to a conventional server-client structure.

The illustrated three peers 126.1 to 126.3 (each) comprise a peer-to-peer application 124. As can be seen, the same peer-to-peer application 124 is implemented on each peer 126.1 to 126.3. The peer-to-peer application 124 can preferably be a public register 124 that can be viewed by all participants (not only the peers) of the peer-to-peer network 122. Each peer 126.1 to 126.3 preferably comprises the (entire) public register 124. Provision can also be made for only part of the register to be provided on a peer. In a particularly preferred embodiment, the peer-to-peer application 124 can be a blockchain 124.

It can also be seen that in the present case a first peer-to-peer module 110 is assigned to the first exchange device 102. In particular, the first peer-to-peer module 110 is integrated in the first exchange device 102 in the present exemplary embodiment. In the present case, a second peer-to-peer module 112 is assigned to the second exchange device 104. The second peer-to-peer module 110 is presently integrated in the second exchange device 104.

A peer-to-peer module 110, 112 is configured to communicate at least with the peer-to-peer network 122, i.e., the peers 126.1 to 126.3 of the peer-to-peer network 122. In other words, a peer-to-peer module 110, 112 or the exchange device 102, 104 corresponding to this peer-to-peer module 110, 112 is at least a participant in the peer-to-peer network 122. In this case, each participant in the peer-to-peer network 122 preferably knows all participants in the peer-to-peer network 122.

In the present case, an exchange process, in particular a synchronization process of an exchange process described below, can be monitored (and/or billed) by at least a portion (>1) of the peers 126.1 to 126.3, preferably all peers 126.1 to 126.3, by means of the peer-to-peer application 124.

A communication connection 116 (e.g., via a wireless and/or wired communication channel) can be established between the peer-to-peer modules 110, 112 at least during an exchange process. The electrical line 114 (e.g., a charging cable) can preferably also comprise the communication channel. In particular, a tunnel can be produced. At least during the exchange process, the first peer-to-peer module 110 receives a token stream 128.

At the start of the exchange process, for example, an identifier and/or a configuration of at least one exchange device involved can be exchanged via this communication channel (e.g., with token streaming mechanisms, synchronization modules used).

The token stream can also be carried out via a so-called partition-tolerant peer-to-peer network (e.g., IOTA DAG tangle). In a partition-tolerant peer-to-peer network, clusters of peer-to-peer networks can exist that (temporarily) have no communication links with each other. Token streaming and validation of the transactions can be performed in this cluster and synchronized with the main peer-to-peer network ("mainnet") at a later point in time if necessary. Due to the temporarily missing communication connections, this cluster is to be understood as an offline case. This cluster can be formed by at least one peer-to-peer module for the two exchange devices and a communication channel between the two exchange devices. In the cluster, IoT data can be validated and authenticated and tokens can be exchanged.

In a preferred embodiment, the cluster can be defined before the transaction, identities and public keys can be stored in the peer-to-peer modules, and tokens can be frozen on the mainnet with cryptographic conditions. In addition, a mechanism can be defined for the cluster, according to which the tokens in the cluster can be exchanged. Should the communication connection be interrupted later (offline case), tokens can be exchanged in the cluster. Since the tokens are frozen on the mainnet, so-called “double spending” can be ruled out. If the cluster is online again at a later date, the result of the token streaming is synchronized with the mainnet.

The second peer-to-peer module 112 causes the token stream 128 to be delivered. In the present case, the second peer-to-peer module 112 sends out the token stream 128. In other variants it can be provided that the second peer-to-peer module 110 controls a separate module and the separate module sends the token stream (under the control of the second peer-to-peer module 112) to the first peer-to- peer module 110.

In addition, the system 100 shown comprises a synchronization module 120. In the present case, the synchronization module 120 is integrated in the first exchange device 102. In other variants, the synchronization module 120 can also be integrated in another device (e.g., second exchange device, telecommunication components, control authority of several exchange devices or a central system for exchange device infrastructures, such as charging networks). The synchronization module 120 is configured to synchronize the energy stream 130 delivered by the first exchange device 102 to the second exchange device 104 with the received token stream 128 during the exchange process.

As has already been described, an energy stream is characterised in that a certain energy amount (e.g., a certain current, a certain power, etc.) is transmitted (almost continuously) per unit of time. This can also be referred to as "energy streaming". A token stream can be formed in a corresponding manner. This can also be referred to as "token streaming".

The synchronization module 120 is presently coupled to the first energy exchange module 106 and in particular to the first peer-to-peer module 110. The synchronization module 120 may comprise at least one detection means (not shown) to detect at least one change in the token stream 128. The synchronization module 120 is configured in particular for synchronizing the energy stream 130 with the token stream 128 in such a way that, when a change in the token stream 128 is detected, a corresponding change in the energy stream 130 can be brought about. For example, if it is detected that the token stream 128 has reduced, a corresponding reduction in the energy stream 130 can be effected. For example, the synchronization module 120 can transmit a corresponding set of control data to the first energy exchange module 106.

For example, if the token stream 128 is detected to have increased, a corresponding increase in the energy stream 130 may be effected. In the event that an increase in the energy stream 130 cannot be further increased because the maximum permissible transmission rate has been reached, the synchronization module 120 can additionally be configured to transmit corresponding information to the second exchange device 104. For example, this can be done using the peer-to-peer modules 110, 112 or by other means. Alternatively (or additionally), the first peer-to-peer module 110 can be configured to effect the sending of a further stream of tokens to, for example, the second peer-to-peer module 112 in order to send or “stream” the excess tokens back. The excess tokens can also be stored in an “escrow” and returned, for example, at a later point in time or after the exchange process has ended.

The synchronization process will be described in more detail below. It should be noted that the synchronization module 120 can be formed at least partially by a controller (e.g., charging controller of a charging station) of the first exchange device 102.

Figure 2 shows a schematic view of a further exemplary embodiment of a system 200 for exchanging energy. In the present case, system 200 is a charging system 200 for charging vehicles 204. To avoid repetition, essentially only the differences from the exemplary embodiment according to Figure 1 are described below. For the other components of the system 200, reference is made in particular to the embodiments above. In this exemplary embodiment (and also in the following exemplary embodiments), only one peer 226 of the peer-to-peer network 222 is shown for the sake of a better overview. It is understood that the peer-to-peer network 222 has a large number of peers. In the present case, the first exchange device 202 is a charging station 202. The charging station 202 comprises a charging module 206 as the energy exchange module 206. It goes without saying that two or more charging modules can be provided. The charging module 206 is configured to charge an electric vehicle 204, in particular the rechargeable electric storage device of the electric vehicle 204. The second exchange device 204 is therefore an electric vehicle 204 in the present case. For example, a charging cable can be used as the electrical line or connection 214.

In the present case, the charging module 206 comprises an energy measurement module 236, configured to measure a delivered (or received) energy stream 230. In particular, an almost continuous measurement of the delivered energy stream 230 can be carried out. In addition, the first peer-to-peer module 210 comprises a token measurement module 234 configured to measure the received (or delivered) token stream 228. In particular, an almost continuous measurement of the received token stream 228 can be performed.

In addition, the second peer-to-peer module 212 is connected to a token module 232 (e.g., wallet). Tokens can be stored in the token module 232. The token module 232 can be formed, for example, with a wallet linked for the exchange process in the peer-to-peer network 222 and a Dapp. A continuous, discrete token stream (or token transfer transactions) from the wallet of the second exchange device to the wallet of the first exchange device can be controlled via the Dapp. This can be individual transactions or a transaction rate. During an exchange operation, the token module 232 may provide the token amount required for the exchange operation. The second peer-to-peer module 212 then sends the tokens as a token stream to the first peer-to-peer module 210. The token amount in the token module 232 is reduced accordingly. Or it may increase when an energy stream streams from the second exchange device to the first exchange device in the case of bidirectional charging. That is, energy and token streams can reverse. The synchronization module is able to synchronize these reverse streams.

In the present embodiment, the detected measurement data sets are transmitted to the peer-to-peer network 222, in particular the peer-to-peer application 224, by the first peer-to-peer module 210. In the present case, the peer-to-peer application 224 has a synchronization module 220, in particular in the form of a software module 220 (e.g., smart contract). The synchronization module 220 receives the measurement data sets almost in real time, evaluates the corresponding measurement data almost in real time and carries out synchronization almost in real time in accordance with the above statements (see Figure 1).

Since the synchronization module 220 is integrated in the peer-to-peer application 224 in the present exemplary embodiment and is therefore executed by a plurality of peers 226 during an exchange process, the synchronization process can be reliably monitored. Manipulations and in particular discrepancies between energy stream and token stream can be detected and reported. In particular, the synchronization can (generally) comprise aborting the exchange process when a manipulation or discrepancy is detected.

It goes without saying that the first exchange device 202 can also have a token module, for example in order to store the tokens received therein. The token amount may increase accordingly. It also goes without saying that the peer-to-peer application 224 can comprise and in particular monitor token modules, for example each assigned to different users. Finally, it goes without saying that the second exchange device can also have an energy measurement module and/or token measurement module.

It should be noted that the previous statements can easily be transferred to other systems or exchange devices.

Figure 3 shows a schematic view of a further exemplary embodiment of a system 300 for exchanging energy. The system 300 is presently a charging system 300 for charging vehicles 304, but can be transferred to other exchange systems in a simple manner. To avoid repetition, essentially only the differences from the exemplary embodiments according to Figs. 1 and 2 are described below. For the other components of the system 300, reference is made in particular to the embodiments above.

Firstly, in the present exemplary embodiment – in comparison to the previous exemplary embodiments – the first peer-to-peer module 310 is a peer or node of the peer-to-peer network 322. Furthermore, in the present case (only) the second exchange device 304 in the form of a vehicle 304 comprises the at least one synchronization module 320. The synchronization module 320 (e.g., smart contract or an embedded controller or a central system) is connected in particular to an energy measurement device 342.

The energy measurement device 342 is configured to measure the electrical energy received at least during the exchange process. The measurement data are made available to the synchronization module 320. In the present exemplary embodiment, the synchronization module 320 adjusts the delivered token stream 328 based on the received energy stream 330. The synchronization module 320 is configured in particular for synchronizing the energy stream with the token stream 328 in such a way that a change in the token stream 328 is brought about when a change in the energy stream 330 is detected.

For example, in a starting phase of the exchange process, provision can be made for the energy stream 330 to be increased up to a maximum energy stream (which can be agreed in advance, for example). In particular, the synchronization can comprise the corresponding increase in the token stream up to the corresponding maximum token stream (which can be agreed in advance, for example). Alternatively, in the start phase of the exchange process, the token stream can first be increased and the synchronization can comprise a corresponding increase in the energy stream. The same can also be provided in the exemplary embodiments described above.

As can also be seen from Figure 3, the peer-to-peer application 324 in the present case comprises a monitoring module 340 configured to monitor the synchronization module 320 and/or the exchange process. At least a portion of the peers 326.1, 310 of the peer-to-peer network 322 can be configured to execute the monitoring module 340. In particular, measurement data can be transmitted from the peer-to-peer modules 310, 312 to the peer-to-peer application 324 and evaluated by the monitoring module 340 (e.g., a software module that can be executed by a plurality of peers). For example, the measurement data can be compared to data items pre-stored in an exchange process agreement module, as will be explained in more detail below.

Additionally, the system 300 presently comprises at least one storage arrangement 346 controlled by the peer-to-peer application. Data may be stored in a peer-to-peer application 324 and/or in a (readable) storage arrangement 346 controlled by peer-to-peer application 324. Preferably, the storage arrangement 346 comprising a plurality of decentralized storage units 348 may be a decentralized database system (such as IPFS) or a decentralized object store (such as storj) or a decentralized distributed database (such as BigchainDB) which is controlled by the peer-to-peer application 332. For example, details about all registered devices may be stored in the storage arrangement 346.

Tokens can also be used in wallets in a blockchain database (e.g., BigchainDB) or these tokens can be transferred from another blockchain to these wallets using cryptographic processes. Exchange devices can have a wallet in this database. Token streams can then be performed as transactions in this database.

In addition, the synchronization module can be mapped in the blockchain database via so-called crypto conditions. For this purpose, the IoT data of the measurement modules (safe in terms of data integrity and authenticity by using the peer-to-peer network) can be transferred to the database and stored. The crypto conditions process the IoT data from the energy measurement modules and control the token stream. If tokens are used up, the token stream comes to a standstill.

Furthermore, according to other variants of the present application, at least one off-chain computing device (not shown) can be provided, which can be controlled by the peer-to-peer application 324. An off-chain computing device may provide algorithms, cognitive analytics, machine learning, and/or artificial intelligence (AI) to optimize, for example, the exchange process, particularly the charging process.

In one embodiment (not shown), a synchronization module can be connected to a control device (not shown) of a consumer, provider and/or network operator. In this embodiment, the control device cannot, for example, control the energy stream, but (possibly via the synchronization module) a token stream, which then in turn controls the energy stream.

Price signals can also be sent to a synchronization module as (dynamic) synchronization criteria. If prices change, the energy stream can be adjusted while the token stream remains the same. The advantage is that dynamic pricing can be translated directly into changing energy streams. For this purpose, a synchronization module can, for example, have a price for tokens or an energy stream conversion module.

Figure 4 shows a schematic view of an exemplary embodiment of a peer-to-peer application 424 according to the present application. The peer-to-peer application 424 is in particular a register that can be viewed or read by the participants in a peer-to-peer network and into which messages are written and/or sent by devices or participants in the peer-to-peer network from which messages can be read. In a preferred embodiment, the peer-to-peer application 424 can be a blockchain 424.

In the following, in the more detailed description of the present exemplary embodiment, it is assumed that the peer-to-peer application 424 is a blockchain 424. However, the following explanations can easily be transferred to other peer-to-peer applications.

The blockchain 424 is formed from at least one block 451 to 455, preferably a large number of blocks 451 to 455 linked to each other. The first block 451 can also be called a genesis block 451. As can be seen, a block 453, 455 (apart from the first block 451) relates to the respective previous block 451, 453. A new block can be created by a computationally intensive process (e.g., so-called “mining” or by a corresponding process) and in particular can be made available to all participants in the peer-to-peer network.

The present blockchain 424 is configured in particular to receive messages from a peer-to-peer module of a participant in the peer-to-peer network, such as a first peer-to-peer module of an exchange device, and to store this message in the blockchain 424. In particular, a new message can be stored in the current block 455 of the blockchain 424 and made available. Due to the design of a blockchain 424 as a public register 424, the message of a peer-to-peer module can be read by preferably all participants in the peer-to-peer network and thus checked in particular.

Different types of messages can be processed and/or stored in the present blockchain 424, for example within a smart contract (algorithm and/or storage on the blockchain) (and/or outside of the blockchain 424). As previously described, the blockchain 424 may be configured to generate an exchange process agreement module 454. The generation and design of an exchange process agreement module 454 is shown below by way of example.

For example, prior to the exchange process, such as a charging process, a second peer-to-peer module associated with a vehicle to be charged or its user (or its identity and wallet) can initiate the generation of an exchange process agreement module. The exchange process can then be carried out based on the data elements generated and stored in the exchange process agreement module. In particular, the generation can be initiated by sending a request message 450 to the peer-to-peer application 424.

A request message 450 can comprise the following data elements, for example:

Identifier(s):	at least one identifier of the requesting second exchange device and/or at least one identifier of a (desired) first exchange device (e.g., specific charging station),
Synchronization criterion:	criterion (e.g., ratio or ratio range between token and energy stream, primary synchronization module in the case of two synchronization modules, protocols to be used, etc.), which must be observed during the exchange process when performing the synchronization
Exchange process start criterion:	start criterion of the exchange process
Exchange criterion:	criterion that must be met or adhered to during or after the exchange process.

It is understood that a request message 450 can have fewer data elements and more data elements. In addition to an identifier for a desired first exchange device, geographic coordinates can also be specified, for example, in which a first exchange device is to be located.

As an exchange process start criterion, it can be specified, for example, that an energy stream or a token stream must be started first. The stream that is still to be initiated can then be synchronized with the previously started stream in accordance with the synchronization criterion. In addition, a start time or a start time range can be specified. The start value of a token amount per unit of time and/or the start value of an energy amount per unit of time can also be specified as the exchange process start criterion.

Furthermore, at least one exchange criterion, preferably several exchange criteria, can be specified. For example, an indication of quantity, such as the energy amount that is desired by the second exchange device, can be specified as an exchange criterion. The request message 450 can also comprise a time specification, for example about the future period in which the energy transmission is to take place. A transaction criterion can also be specified as an exchange criterion. This may be a criterion that will be met by the second exchange device to generate an exchange process agreement module. In other words, the transaction criterion can indicate the token amount (which can correspond to a certain monetary value) that the second exchange device wants to pay for the desired energy amount.

It goes without saying that other criteria can also be specified. Further details can be, for example, a time stamp, a signature of the sender of the message, an identifier for the message and other transaction criteria, such as details about the desired type of generation or consumption, distance from the exchange device, etc.

Another message 452 can be an acceptance message 452. In this exemplary embodiment, the acceptance message 452 can be generated by the first peer-to-peer module of the first exchange device and, in particular, can be transmitted to the peer-to-peer application 424. This can be done in particular after the request message 450 has been read.

An acceptance message 452 can have the same or at least similar data elements as an associated request message 450. Additionally, the acceptance message 452 may comprise a reference to a previous request, such as the identifier of the request message 450, for example. For example, in relation to a request message 450, an acceptance message 452 can list that a specific and desired energy amount can be supplied for the future period for the transaction criterion offered. The identifier of the first exchange device and a synchronization criterion can also be specified.

Request messages and/or acceptance messages can also be exchanged directly between the exchange devices. Preferably, via a peer-to-peer communication protocol.

The energy amount can be a subset of the requested amount. The time specification can be a partial time specification. A lower/higher transaction criterion can also be specified. If an acceptance message 452 comprises only a subset of the requested energy amount and/or token amount, partial time specification, and/or a lower/higher/different transaction criterion, or the like, the acceptance message 452 may be referred to as a counter-offer message. This can be accepted by the second exchange device by means of a further acceptance message. Based on this, at least one peer-to-peer module can cause the peer-to-peer application to generate an exchange process agreement module.

In particular, there can be multiple request messages and/or acceptance messages. Each exchange device can provide specifications according to which at least one exchange process agreement module can be generated. In a preferably automatic, for example iterative, process, each request message can preferably be assigned an acceptance message that corresponds as optimally as possible. The blockchain 424 may be further configured to generate an exchange process agreement module 454 based on the messages and effecting the exchange devices.

It is understood that the generation of an exchange process agreement module 454 can also be initiated by a first peer-to-peer module.

An exchange process agreement module 454 may be stored within a smart contract 454 in a block 455. A smart contract may comprise computer program code (code for short). In particular, in the exchange process agreement module 454, the exchange of a specific energy amount and a specific token amount, which may correspond to a specific price, may be agreed upon between the at least two exchange devices.

In addition, the blockchain 424 can comprise a synchronization module 420. The synchronization module 420 is configured to synchronize the energy stream and the token stream with each other during an exchange process, in particular based on the data elements (synchronization criterion, exchange process start criterion) stored in an exchange process agreement module 454.

A monitoring module 440 can be configured to monitor the synchronization process. For example, the monitoring module 440 can derive from provided token measurement data and provided energy measurement data and the readable exchange process agreement module 454 whether the criteria stored in the exchange process agreement module 454 are being met. This can make manipulation significantly more difficult.

In addition, an exchange process data set 456 may be stored in the peer-to-peer application 424. An exchange process data set 456 can comprise the following data elements in particular:

Identifier(s): at least one identifier of at least one exchange device involved in

	the exchange process and/or identifier of an associated exchange process agreement module 454,
Energy amount:	amount of electrical energy exchanged
Token amount:	exchanged token amount

For example, the corresponding data elements may be transmitted from the respective peer-to-peer modules to the peer-to-peer application 424 after the corresponding exchange operation and stored as an exchange operation data set 456. Alternatively or additionally, the conversion price (conversion of energy amounts to token amounts, discrete units (discrete size of the smallest energy or token stream packets), etc.) can be stored as a data element, for example.

The monitoring module 440 may then review the exchange process based on the exchange process data set 456 and the associated exchange process agreement module 454, for example. If discrepancies are found, this can be published in the peer-to-peer application 424. If necessary, further measures such as a subsequent correction or the like can be initiated.

Preferably, the exchange process data set 456 can be an exchange process data set 456 that can be updated during the exchange process (in particular in real time). In this case, the exchange process can be evaluated in particular by the monitoring module 440 during the exchange process. It is possible to monitor the exchange process almost in real time. If a discrepancy or manipulation is detected between the data elements of the updatable exchange process data set 456 and the previously generated exchange process agreement module 454, appropriate measures (e.g., correct, cancel, etc.) can already be initiated during the exchange process.

As already described, the synchronization module can alternatively or additionally be integrated in at least one exchange device and/or a separate device.

In particular, the peer-to-peer application 424 is configured to store the stored data/messages in a tamper-proof manner. This is essentially done in that, through the entire peer-to-peer network, for example an exchange process agreement module 454 can be verified by the cumulative computing power of the entire peer-to-peer network.

Preferably, at least the messages/data described above, such as the exchange process agreement module or the exchange process data set 456, can be hashed together in pairs in a block 453, 455 of the blockchain 424 using a Merkle tree. In particular, only the last hash value, the so-called root hash, can be noted as a checksum in the header of a block. Then the block can be concatenated with the previous block. Chaining the blocks can be done using this root hash. Each block can comprise in the header the hash of the

entire previous block header. This allowed the order of the blocks to be clearly defined. In addition, the subsequent modification of previous blocks or the messages stored in the previous blocks can also be (practically) ruled out, since in particular the hashes of all subsequent blocks would also have to be recalculated in a short time.
It goes without saying that the modules/data sets etc. mentioned above can also be combined with each other, at least in part. For example, the exchange process data set may be stored in an exchange process agreement module. It is also understood that at least a portion of the data can be stored in a memory arrangement as described above.
As described above, the peer-to-peer application may also comprise a synchronization engine and controller register (not shown). Instead of a linear blockchain, a DAG tangle or a blockchain database or a lightning or state channel network or a blockchain integration technology, such as Interledger Protocol or a combination of the peer-to-peer technologies mentioned, can also be used.
Figure 5 shows a schematic view of a further exemplary embodiment of a system 500 according to the present application. To avoid repetition, essentially only the features differing from the exemplary embodiments according to Figures 1, 2 and 3 are described below.
The system 500 shown in a greatly simplified manner comprises seven entities 502.1, 502.2, 504.1, 504.2, 526.1, 526.2, which in particular comprise and/or form peers of a peer-to-peer network 522. Each peer can provide or comprise a peer-to-peer application (not shown), for example the blockchain 424 according to Figure 4.
In the present case, two first exchange devices 502.1, 502.2, for example charging stations, and two second exchange devices 504.1, 504.2, for example electric vehicles, are provided. Furthermore, a plurality of peers 526.1, 526.2 can be formed in the form of other computing devices 526.1, 526.2.
In the present example, two different types of peers or node computers 502.1, 504.1, 526.1 or 502.2, 504.2, 526.2 are shown. All of the peers 502.1 to 526.2 are comprised in the peer-to-peer network 522. In the present exemplary embodiment, however, only a portion of the peers 502.1 to 526.2, in this case the peers 502.1, 504.1, 526.1, check the validity of the messages/data/modules stored in the peer-to-peer application. In particular, only a portion of the peers 502.1, 504.1, 526.1 are configured to run exemplary modules, such as a monitoring module or a synchronization module.
Provision can also be made for only a portion of the peers to store the entire peer-to-peer application and/or for only a portion of the peers to execute the smart contract algorithms. Since the validation/check can involve a considerable amount of computing effort, it can

be advantageous for reasons of efficiency if only a portion of the peers 502.1, 504.1, 526.1, in particular particularly powerful peers 502.1, 504.1, 526.1, carry out the validation. Here, powerful means, in particular, high computing power. In other words, a valid entry in the peer-to-peer application, such as a blockchain, is assumed here if (only) a portion of the peers 502.1, 504.1, 526.1 have come to a positive result of a verification process. It is understood that only a single peer, in particular a particularly powerful peer, can carry out the validation.

Likewise, in an alternative embodiment (not shown), it can be provided that a particularly large peer-to-peer network can be divided into two or more clusters. With a corresponding peer-to-peer network, for example, validation can only be carried out by the members of a cluster.

Furthermore, in an embodiment (not shown) it can be provided that a control device of the provider, user or network operator or central control systems for exchange module infrastructures are connected to the peer-to-peer network.

Figure 6 shows a diagram of an exemplary embodiment of a method according to the present application. In a first step 601, an exchange process agreement module can be generated, for example in accordance with the previous statements (see, for example, Figure 4). In particular, details about an exchange process to be carried out between a first exchange device and a second exchange device can be stored in the exchange process agreement module.

In a next step 602, the exchange process can be carried out. This can comprise a plurality of sub-steps which are carried out essentially in parallel with each other. During step 604, a stream of energy may be delivered from a first exchange device via an electrical connection to a second exchange device, particularly according to the generated exchange process agreement module. In other words, in step 604, the second exchange device may receive an energy stream from the first exchange device.

In parallel with this, a second exchange device can cause the transmission of a token stream to the first exchange device (step 605), as previously described. In other words, in step 605 a token stream may be received from a first peer-to-peer module.

At step 606, the energy stream may be synchronized with the token stream by causing the energy stream to change (correspondingly) upon detection of a change in token stream, or by causing the token stream to change upon detection of a change in energy stream, as previously described.

Here, at step 603, after the exchange, an exchange process data set may be stored in the peer-to-peer application. In particular, the corresponding measurement data can be transmitted to the peer-to-peer application.

As previously described, step 603 may be a sub-step of step 602. In addition, the exchange process and/or the synchronization module or the synchronization process can be checked in at least one checking step (not shown).

DK/EP 3662429 T3

System til udveksling af energi

Patentkrav

1. System (100, 200, 300, 500) til udveksling af elektrisk energi, der omfatter:
   - mindst én første udvekslingsanordning (102, 202, 302, 502.1, 502.2), der i det mindste er indrettet til at afgive elektrisk energi i form af en energistrøm (130, 230, 330) til mindst én yderligere udvekslingsanordning (104, 204, 304, 504.1, 504.2), der kan forbindes med den første udvekslingsanordning (102, 202, 302, 502.1, 502.2), under en udvekslingsproces,
   - mindst ét første peer-to-peer-modul (110, 210, 310), som er tilordnet den første udvekslingsanordning (102, 202, 302, 502.1, 502.2), og som er indrettet til at kommunikere med mindst én peer-to-peer-applikation (124, 224, 324, 424) i mindst én peer i et peer-to-peer-netværk (122, 222, 322, 522),
   - hvor det første peer-to-peer-modul (110, 210, 310) i det mindste er indrettet til at modtage en tokenstrøm (128, 228, 328) under udvekslingsprocessen, hvor udsendelsen af tokenstrømmen (128, 228, 328) kan bevirkes af den yderligere udvekslingsanordning (104, 204, 304, 504.1, 504.2), og
   - mindst ét synkroniseringsmodul (120, 220, 320, 420), der er indrettet til at synkronisere energistrømmen (130, 230, 330), der afgives fra den første udvekslingsanordning (102, 202, 302, 502.1, 502.2) til den anden udvekslingsanordning (104, 204, 304, 504.1, 504.2), med den modtagne tokenstrøm (128, 228, 328) under udvekslingsprocessen, hvor synkroniseringen omfatter, at der bevirkes en i det væsentlige tidsmæssig synkronisering mellem den afgivne energistrøm (130, 230, 330) og den modtagne tokenstrøm (128, 228, 328) under udvekslingsprocessen,
   - hvor den i det mindste ene peer-to-peer-applikation (124, 224, 324, 424) er indrettet til lagring af mindst ét udvekslingsprocesdatasæt (456), der omfatter en udvekslet energimængde i den afgivne strøm og/eller en udvekslet tokenmængde i den modtagne tokenstrøm, hvor den udvekslede energimængde og/eller den udvekslede tokenmængde næsten opdateres kontinuerligt, via den i det mindste ene udvekslingsproces, på en sådan måde at udvekslingsprocesdatasættet (456) kan læses af i det mindste en del af peers (126, 226, 326, 310) i peer-to-peer-netværket (122, 222, 322, 522), hvor den allerede udvekslede tokenmængde og/eller udvekslede energimængde

kontrolleres ved hjælp af delen af peers under udvekslingsprocessen, idet der foretages en sammenligning af et forinden genereret udvekslingsprocesaftalemodul med det kontinuerligt opdaterede udvekslingsprocesdatasæt, hvor udvekslingsprocessen standses eller afbrydes ved detektion af en afvigelse ved udvekslingsprocessen.

2. System (100, 200, 300, 500) ifølge krav 1, hvor
   - systemet (100, 200, 300, 500) omfatter mindst ét yderligere peer-to-peer-modul (112, 212, 312), som er tilordnet den yderligere udvekslingsanordning (104, 204, 304, 504.1, 504.2), og som er indrettet til at kommunikere med peer-to-peer-applikationen (124, 224, 324, 424) i peer-to-peer-netværket (122, 222, 322, 522),
   - hvor det yderligere peer-to-peer-modul (112, 212, 312) i det mindste er indrettet til at udsende tokenstrømmen (128, 228, 328) til det første peer-to-peer-modul (110, 210, 310).

3. System (100, 200, 300, 500) ifølge krav 1 eller 2, hvor
   - systemet (100, 200, 300, 500) omfatter mindst ét energimålemodul (236, 342), der er indrettet til at måle energistrømmen (130, 230, 330),

   og/eller
   - systemet (100, 200, 300, 500) omfatter mindst ét tokenmålemodul (234), der er indrettet til at måle tokenstrømmen (128, 228, 328).

4. System (100, 200, 300, 500) ifølge et af de foregående krav, hvor
   - synkroniseringsmodulet (120, 220, 320, 420) til synkronisering af energistrømmen (130, 230, 330) med tokenstrømmen (128, 228, 328) er indrettet på en sådan måde, at der ved detektion af en ændring af tokenstrømmen (128, 228, 328) bevirkes en ændring af energistrømmen (130, 230, 330),

   og/eller
   - synkroniseringsmodulet (120, 220, 320, 420) til synkronisering af energistrømmen (130, 230, 330) med tokenstrømmen (128, 228, 328) er indrettet på en sådan måde, at der ved detektion af en ændring af energistrømmen (130, 230, 330) bevirkes en ændring af tokenstrømmen (128, 228, 328).

5. System (100, 200, 300, 500) ifølge et af de foregående krav, hvor synkroniseringsmodulet (120, 220, 320, 420) til synkronisering af energistrømmen (130, 230, 330) med tokenstrømmen (128, 228, 328) er indrettet afhængigt af mindst ét synkroniseringskriterie.

6. System (100, 200, 300, 500) ifølge et af de foregående krav, hvor
   - mindst ét peer-to-peer-modul (110, 112, 210, 212, 310, 312) er indrettet til at bevirke en generering af udvekslingsprocesaftalemodulet (454) ved hjælp af peer-to-peer-applikationen (124, 224, 324, 424),
   - hvor udvekslingsprocesaftalemodulet (454) af peer-to-peer-applikationen (124, 224, 324, 424) gemmes på en sådan måde, at udvekslingsprocesaftalemodulet (454) kan læses af i det mindste en del af peers (126, 226, 326, 310) i peer-to-peer-netværket (122, 222, 322, 522), og
   - hvor udvekslingsprocesaftalemodulet (454) særligt omfatter mindst ét dataelement ud af følgende dataelementer:
     - mindst én identitet for en udvekslingsanordning (102, 104, 202, 204, 302, 304, 502.1, 502.2, 504.1, 504.2), der medvirker i udvekslingsprocessen,
     - mindst ét synkroniseringskriterie,
     - mindst ét startkriterie for udvekslingsprocessen,
     - mindst ét udvekslingskriterie.

7. System (100, 200, 300, 500) ifølge et af de foregående krav, hvor
   - udvekslingsprocesdatasættet (456) desuden mindst mindst én identitet for en udvekslingsanordning (102, 104, 202, 204, 302, 304, 502.1, 502.2, 504.1, 504.2), der medvirker i udvekslingsprocessen.

8. System (100, 200, 300, 500) ifølge et af de foregående krav, hvor
   - peer-to-peer-applikationen (124, 224, 324, 424) omfatter mindst ét overvågningsmodul (340, 440), der er indrettet til at overvåge synkroniseringsmodulet (120, 220, 320, 420) og/eller udvekslingsprocessen, og
   - i det mindste en del af peers (126, 226, 326, 310) i peer-to-peer-netværket (122, 222, 322, 522) er indrettet til at udføre overvågningsmodulet (340, 440).

9. System (100, 200, 300, 500) ifølge et af de foregående krav, hvor
   - peer-to-peer-applikationen (124, 224, 324, 424) er et decentralt register eller en distribueret database, og
   - peer-to-peer-applikationen (124, 224, 324, 424) særligt er en blockchain eller en decentral ledger.

10. System (100, 200, 300, 500) ifølge et af de foregående krav, hvor tokenstrømmen er en bestemt tokenmængde, der næsten kan overføres kontinuerligt.

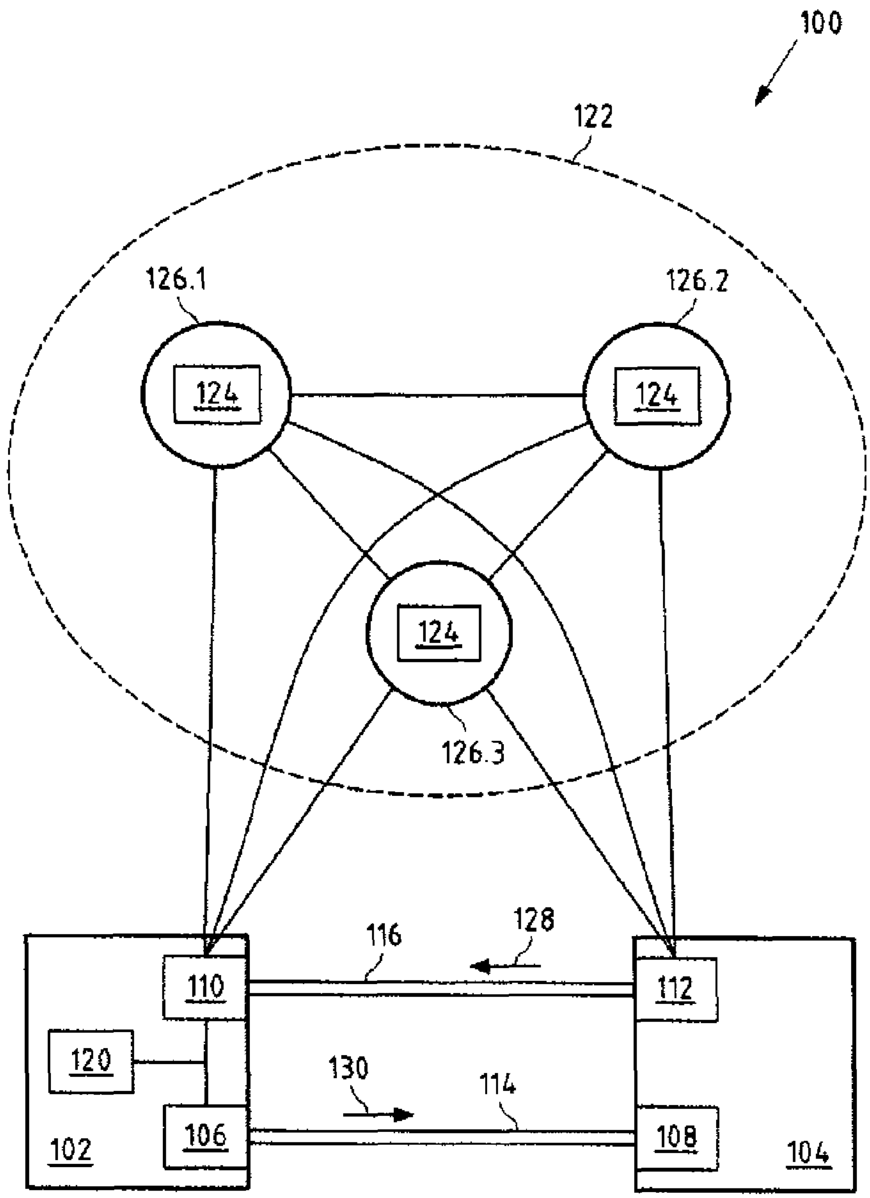
100
122
126.1
126.2
124
124
124
126.3
116
128
110
112
120
130
114
106
108
102
104

Fig.1

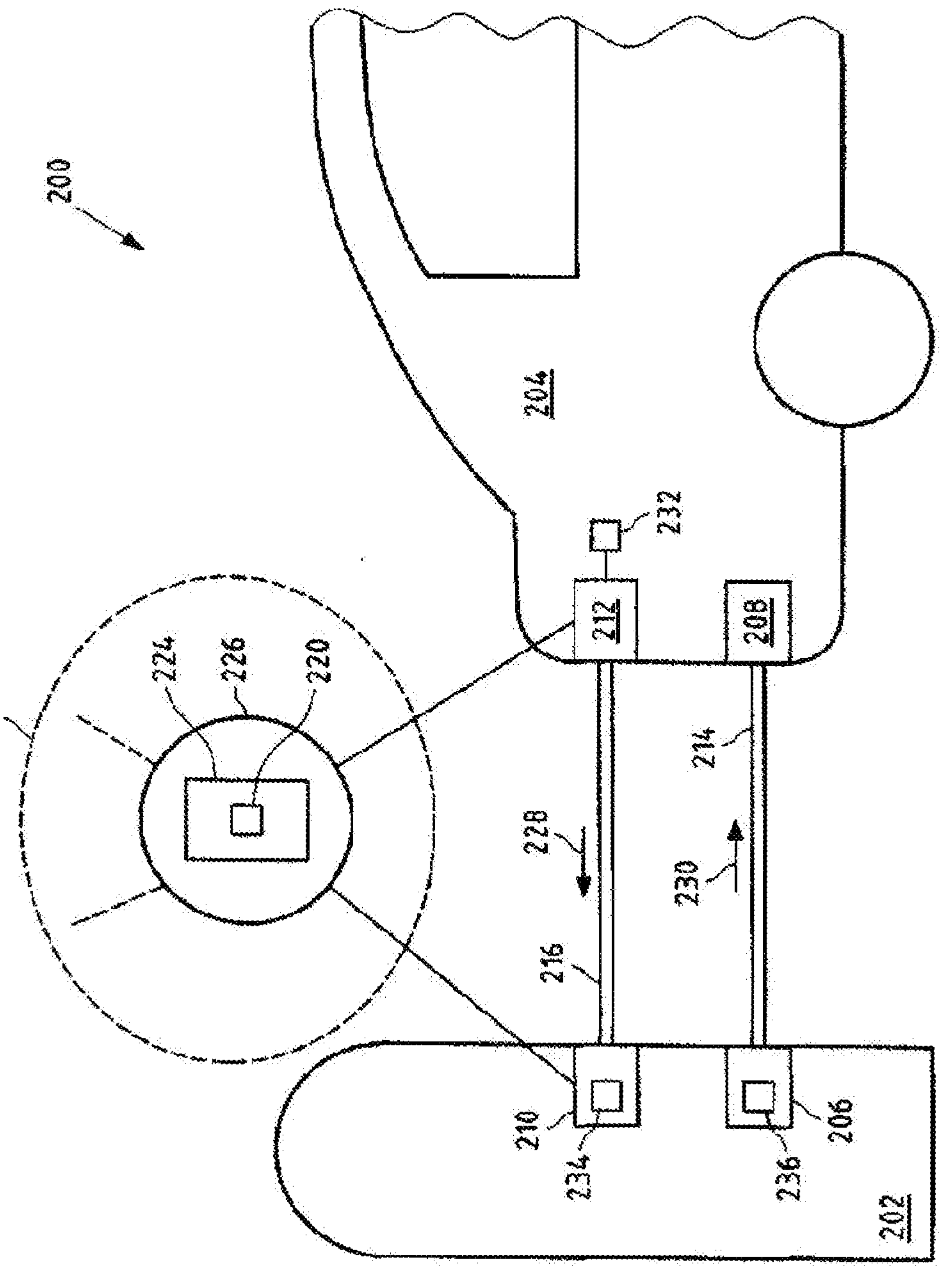
200
204
232
212
208
222
224
226
220
228
230
214
216
210
234
206
236
202

Fig.2

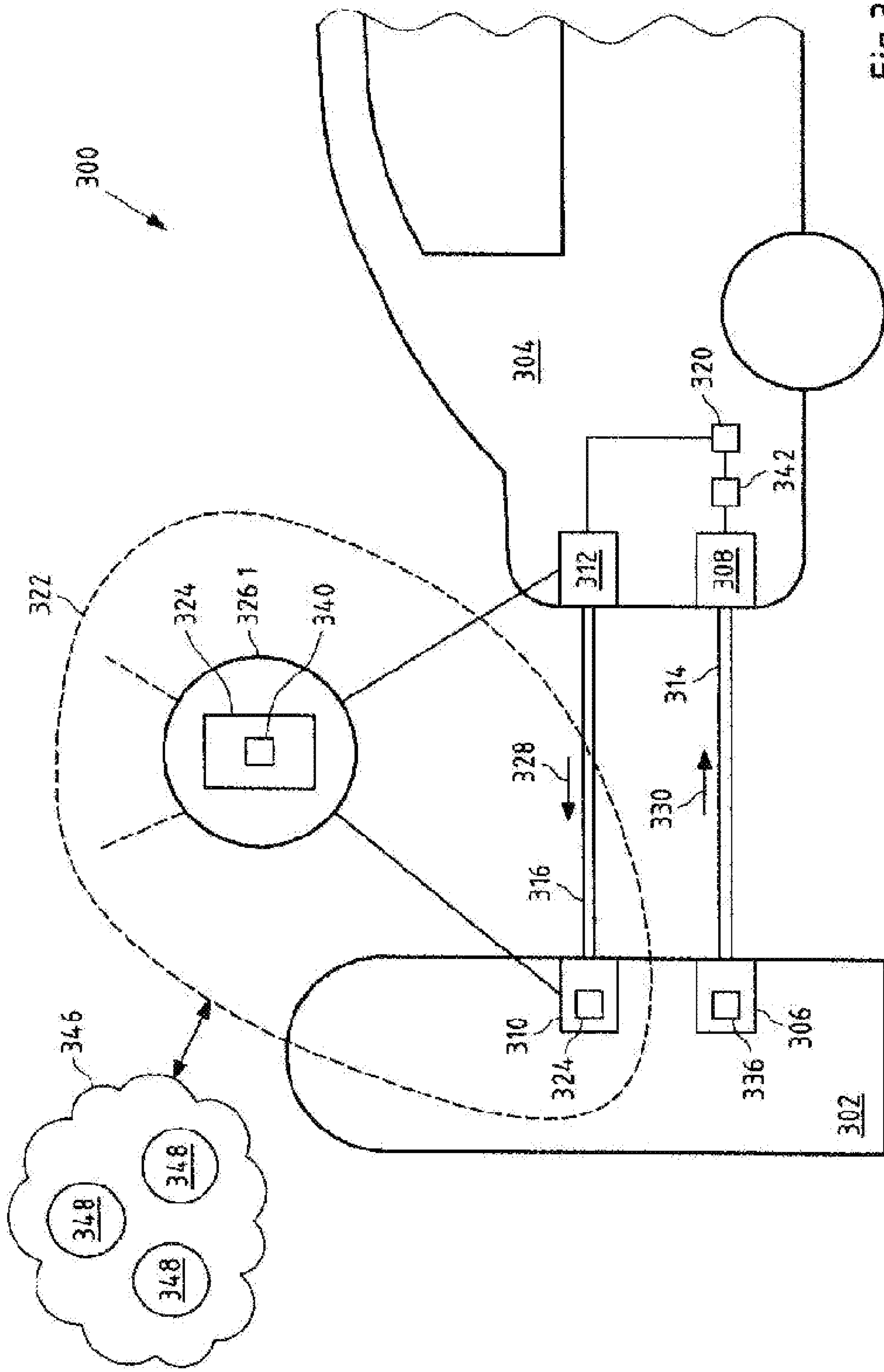
300
304
320
342
312
308
322
324
326
340
314
328
330
316
310
324
336
306
302
346
348
348
348

Fig.3

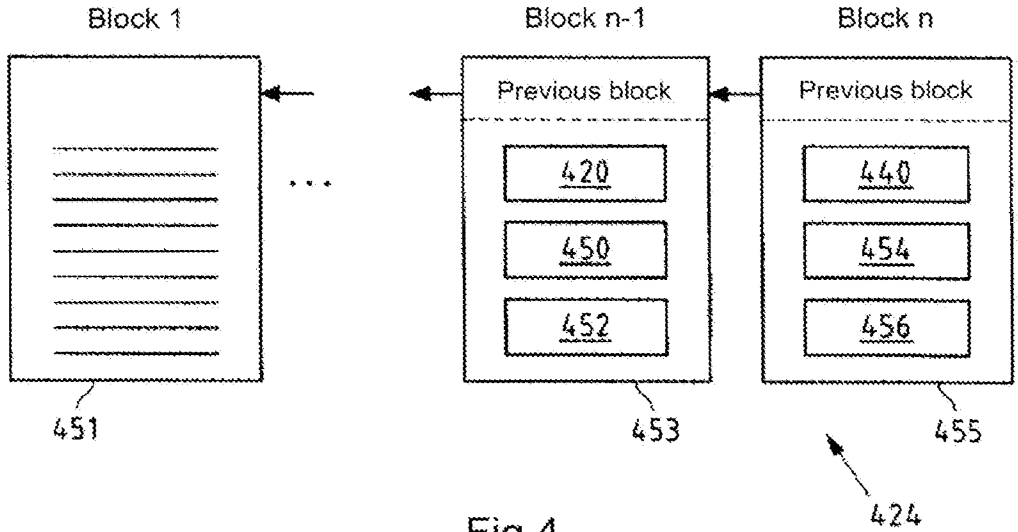
Block 1
Block n-1
Block n
Previous block
Previous block
420
450
452
440
454
456
451
453
455
424

Fig.4

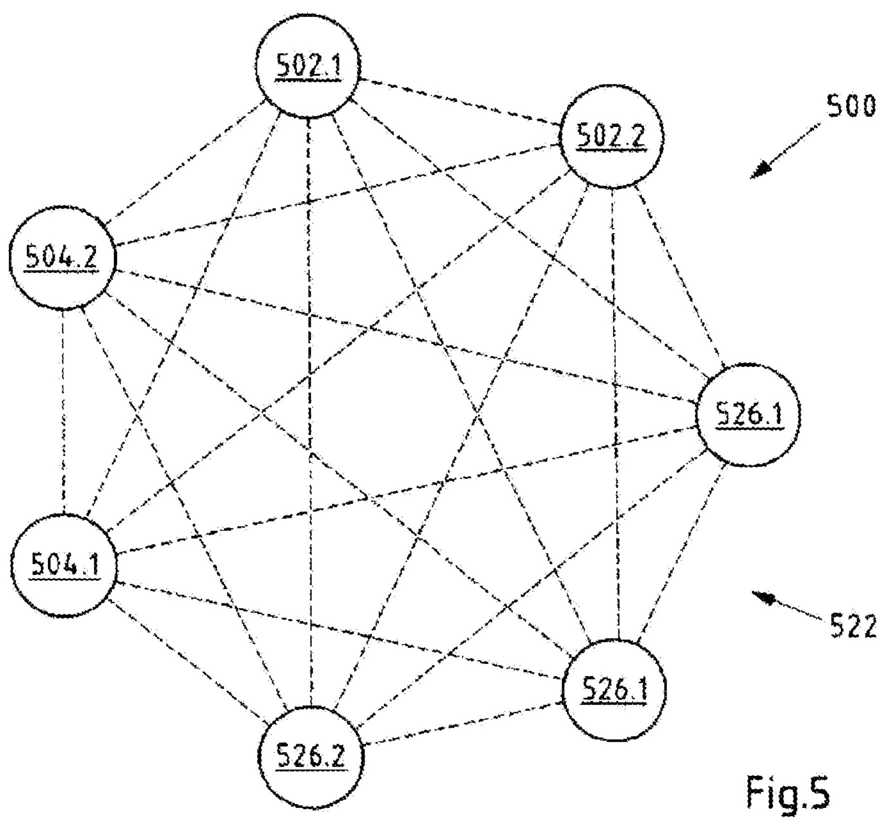
502.1
502.2
504.2
526.1
504.1
526.1
526.2
500
522

Fig.5

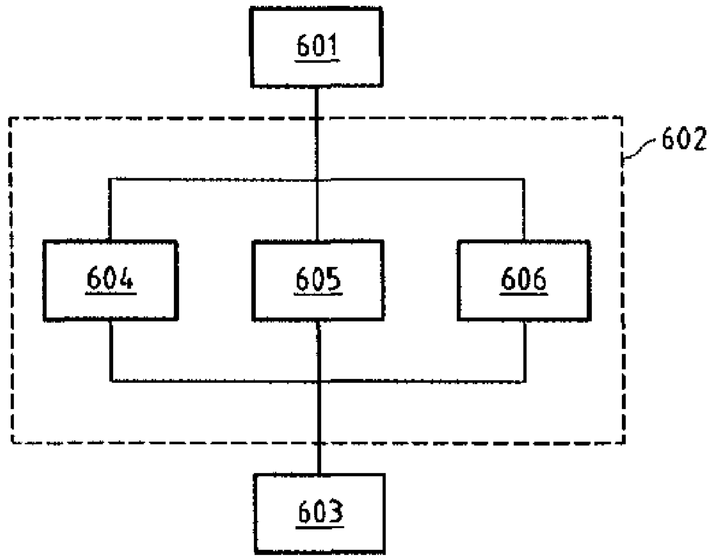

Fig.6