# Identification scheme and name service in the Internet of Energy

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***Abstract*— The German energy industry is in flux. Renewable energies, unbundling of energy supply chains and increasing competition pressure require innovative approaches to the organization of energy distribution. The Internet of Energy epitomizes the technological framework for the energy market of the future. It allows decentralized control and more efficient use of renewable energy. However its structure and organization is widely unclear. The project "Smart Watts" aims to create a scalable, efficient and secure framework for market communication in the energy sector. First requirement for such an infrastructure is an identification service. The Energy Name Service (ENS) enables the identification of elements within the Internet of Energy and provides the functionality to retrieve additional information on the elements.**

***Index Terms*-- Domain Name System, Information architecture, Smart grids, Standards development, Telecommunication standards.**

## I. INTRODUCTION

Creating more transparency and liberalization on the European Energy Market also means increasing information exchange. An approach and a definition of a standardized communication in the energy industry are required to overcome the challenge of handling enormous information and data interactions. Especially, a time-critical processing of information in smart grids is essential to achieve the aim of providing an efficient and reliable power supply system. To meet these high requirements, powerful information processing systems and common standards for information exchange are mandatory [1].

Within the context of the project Smart Watts (http://www.SmartWatts.de/) an approach for a flexible and scalable ICT infrastructure is developed: the Smart Architecture. Consequently, this approach aims for a reduction of the communication complexity and a unification of data exchange in energy markets. To this end, a series of IT-services are developed that provide basic functionality to enable automated communication between the market participants.

## II. PROBLEM STATEMENT AND OBJECTIVE

The directive for communication of the German Association of Energy and Water Industries (BDEW) requires that "all network-related, organizational and contract-related matters between the parties involved in a business process (in their respective roles) are resolved" [2]. Especially the pre-conditions for the participation in electronic data transfer (EDI) need to be fulfilled:

- The parties have agreed on the parameters for communication
- The parties are obliged to inform other parties about changes in the communication parameters.

The communication parameters contain amongst others the communication channel as well as the addresses for data transfer.

In daily practice, market participants exchange this kind of information manually in an unstructured manner, partly even via telephone. The consequences are poor data quality and subsequently communication issues, especially during the phases of establishing and adapting the communication channels between two or more parties. Furthermore, as the liberalization of the energy sector leads to an increased need for communication, market participants are forced to exchange their communication parameters more often, which will aggravate the problem.

To solve this issue, one objective of the Smart Architecture is to provide a standardized and automated solution for exchanging and updating communication parameters. Market participants shall be able to receive up-to-date information about communication parameters regarding other parties (e.g. data exchange address, URL or E-Mails) through pre-defined, structured queries [3]. Therefore an essential requirement is a sound and clear identification of each market participant as well as their respective resources. Basic component of such an infrastructure is a mechanism for identification, realized by an identification scheme and a corresponding name service.

## III. STATE OF THE ART

In order to collect and identify existing standards that might be of interest for technologies related to power supply, as well as to identify and close gaps in standardization, the German Commission for Electrical, Electronic & Information Technologies of DIN and VDE (DKE) has released "The German Roadmap E-Energy/Smart Grid" [4]. The following section introduces the identified standards and technologies from other domains that are considered relevant for the standardization and automation of communication flows and identification.

### A. *Standards for communication processes*

The most prominent effort to satisfy the need for standardized processes and data exchange formats is a government directive containing a regulated set of standardized processes for market communication (GPKE). It describes the flow of information between different actors and the to be used data types, which are subsets of the EDIFACT format (Electronic Data Interchange for Administration, Commerce and Transport) [5].

GPKE and EDIFACT are complemented by additional standards, i.e. the ESS format provided by ENTSOE which is broadly used for communication with transmission providers. The communication with EDIFACT has the major drawbacks that it is inflexible and the implementation is expensive. Consequently there are recent efforts to establish international standards based on the IEC 61970 (CIM) and IEC 61968 in the German energy sector [6].

### B. *Standards for identification*

Numbering schemes are widely described in the DIN 6763, which explains and defines the different functions a number can have, ranging from being an instrument for identification to classifying the objects it is attributed to [7].

The DIN EN ISO 3166-1 defines three different sets of codes for the names of countries and other geographical regions. The most widely used one is the two-letter alpha-2 set, known from the Internet top-level domains [8].

The RFC 3986 "Uniform Resource Identifier (URI): Generic Syntax" defines the URIs generic syntax and describes its grammar, which allows an implementation to analyze the common components of a URI reference. It further contains guidelines and security considerations for the use of URIs on the Internet [9].

The RFC 2141 "URN Syntax" determines the canonical syntax for Uniform Resource Names (URNs). Latter are lasting resource identifiers designed to make it easy to map other namespaces into URN [10].

### C. *Notation standards*

The ISO/IEC 14977 introduces "Extended BNF", a syntactic meta-language based on Backus-Naur Form (BNF). The form and symbols of the syntactic element, as well as the general layout and the terminal-characters representation are described in this document [11].

### D. *Name service related standards*

The RFC 1034 "Domain names – concepts and facilities" introduces the Domain Name System (DNS), by explaining the domain style names, as well as their use for Internet mail support and the protocols used to implement domain name facilities [12]. This is further explored in the RFC 1035 "Domain names – implementation and specification", which describes the details of the domain system. It builds upon the RFC 1034 and goes on to explain standard queries, responses and the Internet class RR data formats [13].

The RFC 2181 "Clarifications to the DNS Specification" proposes solutions to problems encountered with the specification of the Domain Name System. It examines issues such as the definition of Time to Live (TTL) and the distinction between authoritative and canonical names, amongst others [14].

| Nr. | Requirement |
|---|---|
| R1 | *Separation of identification and location*<br>The identificator of an object needs to be independent from its actual location:<br>- Information about an object can be stored at multiple locations<br>- If the location of an object changes, the identificator shall stay the same |
| R2 | *Separation of identification and access mechanism*<br>Access to an object at a specific location may be limited by the location itself, but not by the identification scheme (e.g. a file stored on a server may be accessed via ftp or http). The identification scheme therefore shall not contain coding about the access mechanism. |
| R3 | *Surjective unambiguity*<br>An identificator shall always reference to only one object, but an object may have multiple identificators. |
| R4 | *Persistence*<br>The reference from an identificator to an object shall last for the lifecycle of the object to avoid maintenance effort and potential errors. |
| R5 | *Mapping of object types*<br>A typology of the to be supported objects shall be integrated into the identification scheme. |
| R6 | *Consideration of existing object terms*<br>Existing terms and names for objects shall be integrated into the identification scheme to avoid parallel terminology. |
| R7 | *Data security*<br>The identificator shall not give hints or conclusions about not-public information of the referenced object. Non-public information may only be available through respective access mechanisms. |

**Figure 1: Requirements for a name service**

The RFC 4501 "Domain Name System Uniform Resource Identifiers" (URI) defines a URI scheme for DNS data. As the scheme focuses on the data stored in the DNS, the URI can be used even when the DNS protocol is not used directly [15].

The Dynamic Delegation Discovery System (DDDS) is an abstract algorithm described in four parts, consisting of the RFCs 3401-3404. It is used to support dynamically configured delegation systems {Internet Society (ISOC)

#801}. The RFC 5890 and 5891 are part of a collection that describes the usage context of Internationalized Domain Names for Applications (IDNA). While the RFC 5890 contains the major definitions and specification of the document framework, the RFC 5891 determines the protocol mechanism itself [16].

## IV. Research Approach

For the development process of the identification scheme and name service, requirements engineering methodologies were used. The aim was to develop a practical solution; therefore the focus was on the market demands. As a first step, requirements towards the identification scheme were identified from the overall objective to provide an automated solution for exchanging communication parameters as well as from different regulated GPKE processes and use cases in the energy sector [17]. These requirements were specified, validated and complemented together with experts from the energy sector. In total, seven different requirements were gathered that are described in Figure 1.

| Approach | R1 | R2 | R3 | R4 | R5 | R6 | R7 |
|---|---|---|---|---|---|---|---|
| IPv6 | ○ | ◑ | ● | ◔ | ● | ○ | ● |
| Telephone numbers | ◔ | ◑ | ◕ | ◕ | ◔ | ○ | ● |
| E.164 Number Mapping (ENUM) | ○ | ◕ | ● | ◔ | ● | ◔ | ● |
| Lightweight Directory Access Protocol (LDAP) | ◕ | ◕ | ◕ | ◕ | ● | ◑ | ● |
| OpenID | ◑ | ◑ | ● | ● | ◕ | ◑ | ● |
| Electronic Product Code (EPC) | ◑ | ◕ | ◕ | ◔ | ● | ◔ | ◑ |
| Metering Code | ◔ | ◑ | ● | ● | ○ | ◑ | ◕ |
| VDEW/BDEW-Code | ◕ | ◕ | ● | ● | ◑ | ◑ | ◕ |
| Uniform Resource Identifier (URI) | ◕ | ◕ | ● | ◑ | ◑ | ◕ | ◑ |
| ETSO Identification Coding Scheme (EIC) | ◔ | ◑ | ● | ● | ◕ | ◑ | ○ |
| Domain Name Service (DNS) | ● | ◕ | ◕ | ◑ | ● | ◕ | ● |

**Figure 2: Requirement fulfillment grade of approaches**

As a second step, existing approaches for identification schemes from other domains were examined (see section III). The goal was to identify potential solutions that are suitable for this field of application, i.e. that can be applied directly or at least be adapted. For this study, 11 existing schemata were examined such as IPv6, OpenID (OpenID Authentication 2.0 and extensions) [18], Electronic Product Code (EPC) [19] and Domain Name Service (DNS), but also energy-sector-specific schemas as the ETSO Identification Coding Scheme (EIC). These schemas were evaluated against the defined requirements. The summary of this evaluation is displayed in Figure 2.

The result was that none of the examined identification schemas fulfills all requirements and therefore can be directly adapted. Nevertheless some approaches were identified that could be used as a basis, especially the DNS and the EPC. Also the specific terminology from the energy-sector-specific schemas needs to be considered.

## V. Identification Scheme

Based on the evaluation of existing approaches, an identification scheme for the "Internet of Energy" has been developed and will be introduced in the following section. The identification scheme itself is specified analogous to a Unified Resource Identifier (URI) as in RFC 3986 and allows Latin letters, numbers and a set of special characters [9].

### A. *Syntax*

The alphabet of allowed characters includes all upper- and lower-case Latin letters, numbers from zero to nine, the special characters dash ("-"), underscore ("_") and tilde ("~") and finally the dot ("."). A character string further aggregates those atomic elements with the exception of the dot, where the dot acts as a separator of strings.

An identifier <id> hence consists of two strings concatenated with a separator as indicated in Figure 3. The two components <instance> and <scheme> will be further explained in section B "Semantics of the identifier".

| Element | Rep. | Construction |
|---|---|---|
| Character | <char> | {a-z}, {A-Z}, {0-9}, {-, _, ~} |
| Separator | <separator> | {.} |
| String | <string> | <char> \| <char><string> |
| Identifier | <id> | <instance>.<scheme> |
| Attributes | <attributes> | "type:"<string> \| "class:"<string> \| "region:"<string> |

**Figure 3: Syntactic elements of the identification scheme**

The attributes are required for attribute-references. As Figure 3 shows, an attribute consists of an attribute designation and an attribute value separated through a colon (":"). Attributes are separated by a semicolon (";"). The possible values for the three kinds of attributes are given in Figure 4 and explained in section C "Semantics of attributes".

| Attribute | Value |
|---|---|
| region | *Any Alpha-2 code in compliance with DIN EN ISO 3166-1 in its most recent version* |
| class | {person, element, service, group, actor} |
| type | *Depends on values of region and class* |

**Figure 4: Possible values for attributes**

### B. *Semantics of the identifier*

As indicated, the identifier consists of two components <instance> and <scheme> separated by a dot.

<scheme> allows for specifying the name space in which the identifier is allocated. Different schemes are listed within the DIN SPEC, although additional ones might be added if propagated accordingly. Examples are the Serialized Global Trade Item Number (SGTIN) as specified by GS1 and represented by the scheme “sgtin” or the German Value Added Tax Identification Number which is assigned to all commercial actors by the German tax authorities represented by the scheme “vatin” [20].

<identifier> hence has to be constructed accordingly to the Syntax as specified as well as to further restrictions by the used scheme, for example “DE919357421” for an enterprise.

### C. *Semantics of attributes*

As already elaborated, three kinds of attributes exist. <region> is a tribute to the variety of terms of reference in different nations and allows for the identification of the involved country. It is coded as a DIN EN ISO 3166-1 Alpha 2. The attribute <class> details the object behind the identifier. Possible values for <class> are explained in Figure 5. <type> depends on the values of <class> and <region>. The DIN SPEC gives an overview over possible combinations and their types but is not to be considered a final solution. It rather has to be adapted for new applications.

| Value | Description |
|---|---|
| Person | - any natural person or corporate entity along with legal capacity<br>- the ability to contract plays a central role in legal transactions in the Internet of Energy |
| Element | - physical and logical element of the Internet of Energy with no ability to contract<br>- important criterion is seclusion: objects of this class are identifiable by itself |
| Service | - provides a specified functionality<br>- identical services can be offered by various service providers using the very same ID<br>- new IDs emerge from small variations of the services<br>- use of services usually by means of ICT |
| Actor | - person acting within a range who is assigned to a specific role<br>- legal distinction between person and role required<br>- ID-scheme: 2-tuple [person, role] |
| Group | - consists of an arbitrary number of the aforementioned objects<br>- groups can be grouped once more into pure and mixed groups and can be part of other groups |

**Figure 5: Possible values for the attribute *class***

### D. *Functions of a directory service*

Based on the specified identification scheme different services can be published in order to allow for the application in an ICT infrastructure. In Figure 6 five functions, called references in this context, are listed and explained.

## VI. IMPLEMENTATION AND EVALUATION

The creation of the identification schema was executed within a DIN SPEC process. In this process also aspects of implementation were considered. Those further explain the concept of the identification schema in terms of a name service.

### A. *DIN SPEC PAS-process*

Deutsches Institut für Normung e.V. (DIN; in English, the German Institute for Standardization) is the German national organization for standardization and Germanys ISO member body. It offers different levels of standardization activities, of which a DIN SPEC PAS (Publicly Available Specification) is the least normative one. A proposal is made public and interested parties are invited to join the committee. In contrast to a DIN norm not all relevant inflicted parties have to be involved in the specification process, further a full consensus within the committee is not necessary.

| Reference | Description |
|---|---|
| Attribute | - supplementary characterization of objects that are to be identified<br>- allows for characterization into <region>, <class> and <type> |
| Mapping | - redelivers alternative identifiers of other identification schemes to an arbitrary identifier of an identification scheme<br>- unique mapping: while in different identification schemes there can be equivalences to the inquired identifier, there exists only one equivalence per identification scheme |
| Responsibility | - redelivers to an identifier <X> of the classes *element, service, group* or *actor* an identifier <Y> of the class *actor*<br>- *actor* <Y> is assigned to information and services of object <X><br>- further information on <X> can be directly inquired from <Y> |
| Actor | - to an identifier of the class *actor* this function redelivers the identifier of that *person* which is behind the *actor*<br>- if an identifier of the class *actor* is inquired, all *actors* registered for this *person* are returned |
| URI | - redelivers one or more URIs to an arbitrary identifier<br>- contains direct information, provides or describes a service |

**Figure 6: References in the directory service**

A DIN SPEC allows the evaluation of specification in the industry as it is publicly available and taken into consideration for a norm after three years after release.

### B. *Realization of a name service*

Analogous to the DNS the ENS does not hold information about past or future conditions. It therefore only provides information that is valid at the time of the request.

As detailed before, the ENS acts analogous to a DNS. An implementation in parallel to an existing DNS would imply a new root-structure and therefore is not recommended. Hence the specification further elaborates the incorporation into an existing DNS.

The deployment of an ENS uses NAPTR (Naming Authority Pointer) Resource Records according to RFC 3401 – 3404 for its functionality. Such a NAPTR Resource Record links the included identifier (*Domain* in Figure 7) with additional information (*RegExp* in Figure 7). The ENS must allow for multiple NAPTR Records per domain and provide all those records to any request containing the domain.

| Field | Content | Comment |
|---|---|---|
| Domain | <domain> | Requested identifier as domain |
| TTL | <ttl> | *As in RFC 3401 - 3404* |
| Class | IN | Mandatory (for Internet) |
| Type | 35 | Mandatory (for NAPTR) |
| Order | <order> | *As in RFC 3401 - 3404* |
| Preference | <preference> | *As in RFC 3401 - 3404* |
| Flags | <flags> | *As in RFC 3401 - 3404* |
| Service | <function> | Function of ENS to be used by request |
| RegExp | !^.*$!<info>! | Additional information for identifier |
| Replacement | . | *As in RFC 3401 - 3404* |

**Figure 7: NAPTR Resource Record in the ENS**

The content of the fields *TTL*, *Order*, *Preference*, *Flags* and *Replacement* are not relevant for the ENS and therefore left to the specification of RFC 3401 – 3404. On the other hand *Class* and *Type* have mandatory values as shown in Figure 7.

The different references as specified by the identification schema (see Figure 8) can be retrieved from the ENS through different functions, which are represented in the field *Service* of the NAPTR Resource Record.

| Reference | Content of field *Service* |
|---|---|
| Attribute | ioe+attr |
| Mapping | ioe+idmap |
| Responsibility | ioe+resp |
| Actor | ioe+actor |
| URI | ioe+uri |

**Figure 8: Representation of references in field *Service***

The full DIN SPEC further defines mapping rules for the different contents to allow for a consistent and reliable resolution of requests.

### C. *Resolution of an ENS request*

The ENS acts as a part of an existing DNS and therefore is transparent towards it. NAPT Resource Records provided by the ENS are only distinguishable from those maintained by the DNS by their mapping to the ENS-root ("ioe.eu"). To minimize communication and coordination overhead between the operator of the ENS and other operators within the embedding DNS, the concept of "deep delegation" is applied. This is done as described in the following.

After requesting the *Actor*-reference, the inquirer receives the information, that *Actor* (<id>) is responsible for the *requested object* (<domain>). It therefore is able to concatenate that information to create another request to the ENS: <domain>.<id>.ioe.eu. Next step would be to retrieve available services and information about the object. This is done by requesting the *URI*-reference.

A practical example for the application of the ENS could be an energy-supplier, who needs to request the consumption data of a specific grid connection user (ioe:person:3) from a metering data provider (ioe:person:2). The sequence for this request would be:

1. ENS request (ioe:person:3)
2. ENS response (ioe:person:2:person:3)
3. ENS request (ioe:person:2:person:3)
4. ENS response (https://ioe.mdl.de/data-request.wsdl)

Subsequently the WSDL-file delivered in step 4 can be evaluated (i.e. for interface information, method for authentication). Afterwards the consumption data can be accessed according to the WSDL information.

This structure allows for an efficient administration of objects in the internet of energy. Actors in the Smart Architecture who need to manage their own entities have to perform a one-time registration process and afterwards can register additional persons or IDs within the ENS easily.

### D. *Evaluation through open feedback*

Evaluation of the developed concepts was done through an open feedback phase as part of the DIN SPEC process. This led to an overall sum of 61 comments and requests for change, issued by seven institutions.

The comments included on the one hand hints about missing definitions (e.g. "The definition of object class is missing") and outdated/updated standards (e.g. "RFC 2915 is obsoleted. Please refer to the actual RFCs 3401, 3402, 3403, 3404). On the other hand they included recommendations on how to enhance the initial draft of the identification scheme further (e.g. "Since 'object type' is most probably a refinement of 'object class', 'type' should be a subclass of 'class').

Of those comments, the majority of 55 comments were incorporated to further refine the specification two were partially included and four could not be addressed within the scope of the DIN SPEC.

## VII. CONCLUSION AND NEXT STEPS

With the ENS a concept has been developed and specified that allows for the basic organization of elements in a smart grid. It suffices the enlisted requirements and enables a scalable and flexible infrastructure. Through the open character of a DIN SPEC, the results are made public to be fostered by the industry.

In parallel activities within Smart Watts, possible business models for the operator of such a name service and the adjacent infrastructure are being developed, ranging from provides of access to the infrastructure to service and consultation firms. These are evaluated in different scenarios for the energy industry.

Next steps include addressing the comments of the evaluation phase that were outside the scope of the first DIN SPEC: aspects of security. The ENS explicitly excludes security considerations and focuses on the identification of objects. A recently initiated second DIN SPEC will go into further detail on a concept for roles based access control for the energy industry.

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