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Turning Conceptual Modeling Institutional – The prescriptive role of conceptual models in transforming institutional reality

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ABSTRACT

It has traditionally been assumed that information systems describe physical reality. However, this assumption is becoming obsolete as digital infrastructures are increasingly part of real-world experiences. Digital infrastructures (ubiquitous and scalable information systems) no longer merely map physical reality representations onto digital objects but increasingly assume an active role in creating, shaping, and governing physical reality. We currently witness an "ontological reversal", where conceptual models and digital infrastructures change physical reality. Still, the fundamental assumption remains that physical reality is the only real world. However, to fully embrace the implications of the ontological reversal, conceptual modeling needs an "institutional turn" that abandons the idea that physical reality always takes priority. Institutional reality, which includes, for example, institutional entities such as organizations, contracts, and payment transactions, is not simply part of physical reality detached from digital infrastructures. Digital infrastructures are part of institutional reality. Accordingly, the research question we address is: What are the fundamental constructs in the design of digital infrastructures that constitute and transform institutional reality? In answering this question, we develop a foundation for conceptual modeling, which we illustrate by modeling the institution of open banking and its associated digital infrastructure. In the article, we identify digital institutional entities, digital agents regulated by software, and digital institutional actions as critical constructs for modeling digital infrastructures in institutional contexts. In so doing, we show how conceptual modeling can improve our understanding of the digital transformation of institutional reality and the prescriptive role of conceptual modeling. We also generate theoretical insights about the need for legitimacy and liability that advance the study and practice of digital infrastructure design and its consequences.

1. Introduction

Traditionally, conceptual modeling and information systems design based on conceptual models aim to describe (map) physical reality as faithfully as possible [1,2]. The ontological stance underpinning most contemporary conceptual modeling approaches has been characterized as founded in a descriptive view of information systems. The basic assumption is that information systems serve as

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images of reality. Representation theory, for instance, primarily focuses on the descriptive relationship between physical reality and digital infrastructure [3,4]. However, representations serve practical purposes beyond merely describing things [5–7]. These pragmatic functions embedded into information systems influence social interactions and contribute to the processes of societal institutionalization.

Given this background, it is refreshing to see recent publications addressing the limitations of representation theory as a foundation for conceptual modeling [4], acknowledging that we are currently witnessing an "ontological reversal" where CM scripts (conceptual models) also change physical reality. "CM scripts must now permeate more aspects of the IT infrastructure, including physical materials, code, and interfaces. This situation creates avenues for CM scripts to assist with changes between states of physical reality." ([4] p. 281). In this view, digital objects, such as scripts (conceptual models), "execute digital reality within physical reality" ([4], p. 280). For instance, using scripts in wearable devices changes physical reality, such as reminding people to eat more healthily.

According to Recker et al. [[4], p. 270], "physical reality includes not only tangible, material objects (e.g., buildings, cars, products, technologies, people) but also social constructions (e.g., organizations, processes, contracts, relationships) that feature in lived experiences." Moreover, physical reality, which includes institutional entities, and digital reality are seen as detached. They define digital reality as "the aggregation of logical and non-material things and their properties that exist in the computed, digital realm" (ibid. p. 279).

However, similar to the received ontological view mentioned above, a fundamental assumption of the ontological reversal is that physical reality is the only real world (the world we live in), and the relationship between physical reality and the information system is what is of interest. The old assumption only considered the direction of fit from physical reality to the information system and not from the information system to physical reality, which is conceived to be the ontological reversal.

Still, to fully embrace the implications of the ontological reversal, information systems research needs an "institutional turn" away from the idea that physical reality always takes priority. Institutional reality, which includes institutional entities such as organizations, money, and contracts, is not simply a part of physical reality and is not separate from digital reality.

Institutional reality is created by representations (symbols) and is immaterial to its character, which is well recognized in social sciences [8], in philosophy [9–13], and psychology [14]. Institutional reality is constituted by language: "Language is not just the means for describing and classifying institutional reality, language is essential to the creation and maintenance of institutional reality." ([15], p. 16). In institutional reality you make something the case by presenting it as being the case. For instance, this institutional action, which is a declaration creates money: "We, the Bank of America, make it the case […] that Jones has $1000 in his account […] there need be no physical reality to the $1000, other than the representation." ([12], p. 457).

What is crucial is that digitalization is fundamentally transforming institutional reality, not only physical reality [16,17]. In digital banking, any bank statement printout is only a copy of the real institutional entity (the bank account) that exists within a digital infrastructure. The account balance and the money would exist even without a paper receipt, but not the other way around. Digital technology transforms institutional reality by using digital media instead of physical analog media [18]. That is, digitalization turns institutional reality digital.

A computer is based on the notion of a binary digit (bit), 0 or 1, and is inherently of symbolic character. The main function of a computer is to process, retrieve, and store symbols in digital format, although it is undeniable that it also needs to be physically grounded in computational hardware and electricity to process the digits. However, the main function of digital technology is to process symbols used for communication and social interaction; the huge electricity consumption caused by the computational hardware in physical reality is an unwanted side-effect, and is something that we want to minimize [19]. Accordingly, both institutional reality and digital infrastructures are constituted by symbols; by that, digital infrastructures could be a part of, and thus transform, institutional reality.

Additionally, institutional reality and physical reality are distinct realities because they are constituted in different ways. Institutional reality is constituted by symbols and physical reality by matter and energy, although they come together in two ways.

Firstly, physical actions are often regulated and organized by rules and institutional entities. For instance, driving a vehicle (physical action) is regulated by traffic signs (institutional entities) and traffic regulations that give legitimate meaning to the physical action performed. The signs and regulations explain, for example, why the vehicle is driven on the right side of the road. The vehicle and driver should also be properly authorized and identified in order to be allowed to perform the physical actions of driving.

Secondly, institutional actions, such as signing a contract, depend on physical reality because they are performed using sounds, pressing keys on a keyboard, electricity, etc. However, institutional actions are fundamentally symbolic and must be legitimate, conforming to rules, norms, routines, and institutional concepts. Consequently, the physical action that mediates the institutional action should not be confused with the institutional action, which is symbolic and normative to its character. For example, the institutional action of signing a contract could be performed by different physical actions: signing the contract using pen and paper or creating a digital signature. To analyze the practice of signing, one should focus on the institutional actions and entities like authorized signing, the signature, and the contract. Assuming institutional concepts are physically constituted, existing because they possess energy or have a mass and extension in physical space, should not take priority if we want to understand how digital infrastructures shape and change institutional reality.

A digital infrastructure implements routines and schemas that prescribe the structure and behavior of the digital infrastructure and human and digital agents. They use digital infrastructures to perform institutional actions using an institutional language, regulated by software in creating institutional entities, which are stored in registries and exchanged at an unprecedented pace and scale. These are constituent language and non-material entities, and their purpose is to organize society at large. Thus, conceptual schemas prescribe the execution of digital reality within institutional reality because our contemporary digital infrastructures (ubiquitous and scalable information systems) are embedded in and constitute a critical part of institutional reality. A revival of conceptual modeling—embracing the contemporary institutional turn—is motivated by digital infrastructures' constitutive function in society.

What we propose radically differs from the traditional view of ontology-based conceptual modeling [1] and the view of conceptual modeling presented by Recker et al. [4], which aim to produce a description of things and their properties as they exist in physical reality. In contrast, conceptual modeling based on the institutional turn focuses on the institutional language and the prescriptive role of conceptual modeling for the design of conceptual schemas and institutional routines, which prescribe how one ought to construct institutional reality. Classifications have real consequences, and when embedded in digital infrastructures, the digital infrastructures become powerful mechanisms for institutional change [20]. The reason is that with digital infrastructure, human agents and digital agents perform institutional actions regulated by software in creating shared institutional entities [21].

Using conceptual modeling to analyze institutional reality aligns with insights by Cornelissen et al. [[22], p. 12], who recognize "the overall promise and potential implications of bringing a stronger communication focus into institutional theory and analysis". Furthermore, our position advances the insights offered by Ocasio et al. [23], who argue that the communicative constitution of categories (classifications) is central to establishing common vocabularies of practice, which we refer to as institutional languages.

In this paper, we explore the consequences of the institutional turn for conceptual modeling and our understanding of digital infrastructure design. The specific research question we address is: What are the fundamental constructs in the design of digital infrastructures that constitute and transform institutional reality?

In answering this question, we show how conceptual modeling offers tools for enabling concise and precise analysis of digital infrastructures and the institutions they implement. In so doing, we show how conceptual modeling grounded in an institutional ontology can improve our understanding of the digital transformation of institutional reality and the prescriptive role of conceptual modeling. We generate theoretical insights about the need for legitimacy that advance the study and practice of digital infrastructure design and its consequences.

2. Theoretical framework

This section introduces relevant theories and develops a foundation for conceptual modeling based on the institutional turn described above. In line with Orlikowski and Barley [24], we suggest that the digital transformations of the organizing of society cannot be understood without considering institutional reality. The concepts of institution and practice stem from institutional theory [25–29], practice theory [30], and speech act theory [9,31]. Habermas [9] and Searle [10,11,13,32] suggest that language is a ubiquitous feature of everyday life that defines the institutional order of institutions. Speech act theory also has a long tradition in information systems research [7] based on the idea that we use information systems to perform symbolic actions [5].

2.1. Institutions and practices

Institutional theory, particularly neoinstitutionalism, is fundamental to management and organization studies [22]. Since the 1960s, recognition of the role of institutions has led to a stream of research that continues to grow [10,11,13,22,25,27–29,32–34]. According to Scott [26], an institution is a social structure that offers organizations and individuals lines of action while, at the same time, controlling them. Thus, institutions constrain social interaction while enabling new kinds of activities, relationships, and practices. Institutions both reflect and constitute society as routinized practices that form the foundation of social structure [30]. Practices connect our doings and sayings with our understandings, the rules we follow, and our intentions. They comprise forms of institutionally meaningful actions that are coherent and established [29], occurring across different times, places, and individuals, making them social [30].

A key element of practices is the language used to communicate and coordinate action [9]. Every institution includes a system of rules, which are upheld through collective intentionality, for example, regulations issued by a state or standards and rule systems agreed by collectives. These rule systems are defined in an institutional language, an artificially designed language consciously devised for communication in a specific field or sector of society. Essentially, the rule system, sometimes called a 'practice lexicon' [35] or 'domain language' in information systems research, is fundamental to the institution. The rules regulate how agents ought to act in the world [36]. To be effective, language must exist in practical use [30]. A key element of practices is the language used to communicate and coordinate action [9]. We use the term "institutional language" to emphasize the coordinative and regulative functions of the practice language.

An *institutional language* consists of vocabulary, definitions, and grammar [25,29]. An institutional language is explicitly defined and maintained by a community of actors, often through a commonly recognized authority. The language is reciprocally defined along with the regulative rules that govern practices within the institution. To understand an institution, one must understand both its institutional language and its regulative rules.

A *regulative rule* is expressed in an institutional language and regulates the social interaction between agents and actors within a practice. Regulative rules [37] stipulate what actions are required, prohibited, and permitted by whom. For instance, a bank customer can use a personal bank account to initiate payment transactions.

Institutional functions [11,38] define bundles of rights and duties that can be assigned to institutional entities (see Section 2.3). For example, to use the regulative rule described above, an agent must know whether to classify someone or something as a customer or a personal bank account. These concepts contribute to the overall coordinating function of the institution [39]. For instance, to understand the concept of a bank customer, one must understand the concept based on bank customers' rights to perform institutional actions in a banking context and the function of a personal bank account in conducting payments and settling debts.

A digital infrastructure that supports agents' social interaction implements an institution (see Section 2.3). Accordingly, to construct a digital infrastructure, designers need to have a clear, shared, and common understanding of the institutional language that constitutes institutional reality. One can obtain such understanding by encoding them into conceptual schemas and institutional routines, which requires conceptual modeling. Conceptual modeling is needed because digital institutions require a formalized institutional language.

2.2. Institutional routines and conceptual schemas

According to Barley & Tolbert [25] institutions rely on *institutional routines* (scripts) and *conceptual schemas.* Institutional routines are recurrent patterns of collective activity ([40], p. 58) within a practice. A routine can be seen as a specific kind of practice [41,42]. While all practices involve recurrent actions that shape and are shaped by social structures [30], routines represent the more habitual and predictable patterns within those practices [43]. They contribute to the stability and legitimacy of organizations, often serving as repositories of knowledge and skills and are, therefore, institutional in their character. However, routines are not static; they are continually enacted and recreated through the ongoing actions of individuals and thus can also be sites of change and innovation within the broader context of practice [42,43].

Institutional routines include both patterns, the routine as a type, and performative aspects [41], the routine as an instance. The pattern aspect is the ideal or schematic form of a routine, the abstract, generalized idea of a routine (ibid. p. 8) that concerns the routine's structure. "The performative aspect of the routine consists of specific actions by specific people in specific places and times" (ibid. 8). This refers to the action aspect of a routine. Each institutional action should conform to a template, a type, called an *institutional action specification*, which regulates the performance of the action, the instances. Action specifications are rules for how to perform actions. Institutional routines prescribe recurrent behaviors in institutional reality. An *institutional routine* includes a set of institutional action specifications and their control flow—the pattern aspect [41]. Notably, practices may develop in unintended and unforeseen ways, creating system workarounds [44]. Emerging practices may then form a basis for redesigning and formalizing new institutional structures and languages [45].

Conceptual schemas are well-formalized representations of the structure of concepts (typifications) within a specific institutional domain (cf. [25,46]). Conceptual schemas are the institution's concepts (its vocabulary), and institutional routines show how to apply those concepts within the routines (the grammar) [25]. Routines and schemas are symbolic and have a prescriptive function [25] in that they prescribe both institutional and physical actions. Agents construct and reproduce institutions by performing actions during social interaction that follow institutional routines, creating new institutional entities and causing effects. A digital infrastructure implements an institution, encoded in institutional routines and conceptual schemas that prescribe the structure and behavior of the digital infrastructure.

2.3. Digital infrastructures

Scott [27] maintains that we use artifacts to mediate institutions. He defines 'artifact' as "material culture defined by human ingenuity to assist in the performance of tasks" ([27], p. 882). According to Lorini et al. [47], such physical artifacts—like road signs, lights, and roundabouts—perform an institutional (normative) function when regulating institutionalized behavior. These artifacts regulate

> "*how fast we can drive; when to stop; when we can cross an intersection; when we can overtake another vehicle; when we must give priority to or when we have priority over other vehicles. All these regulations have been established within an institution,* i.e.*, the highway code, and they have been introduced through the installation of artifacts, which have been designed and built specifically for the purpose of normatively regulating road traffic*." ([47], pp. 185–186)

This specific type of institutional artifact is used to mediate collective intent and deontic powers. However, the institutional artifact is more than the physical thing that mediates its function. Some functions of artifacts depend solely on their physical properties; for example, the ability of a screwdriver to turn screws depends on its physical structure. However, institutional functions are symbolic, and the physical properties of the artifact that mediates them are subordinate [10,11]. For example, a physical traffic sign, i.e., analog media [48], or a digital representation within a navigation system using digital media, can mediate a speed limit.

As a result of digitalization, digital infrastructures are powerful and increasingly important mediators of institutions and institutional actions. We recognize three constituents of digital infrastructures: the digital institutional entity, the software, and the digital agent, which we further define and explain below.

2.3.1. Digital institutional entities

Institutional entities such as organizations, customers, debts, money, insurance, taxes, and contracts are not physical things (Natural Kinds) with mass and extension in physical space. Nor are they directly created through physical actions. Increasingly, institutional entities only exist digitally in digital infrastructures that mediate (carry) the institution [6]. Some key characteristics of a digital institutional entity are that it:

- is digitally mediated
- is created using an institutional language at a specific time
- is created with digital media and has a media trace
- conveys meaning

- has an institutional identity
- represents rights.

Based on Searle's [49] notion of 'deontic power' and Hohfeld's [50] classification, we use the term 'right' when referring to claims, privileges, and powers. An institutional entity has a claim on another institutional entity if the second entity is required to act in a certain way for the benefit of the first entity. Conversely, the second entity is said to have a duty to the first. A privilege means that an institutional entity can act if it is free to carry out its action per the institution. Power is the ability of an institutional entity to create or modify claims, privileges, or powers.

An institutional entity can be grounded in a physical entity or another institutional entity. Grounding is a relationship between entities that expresses existential dependencies. Physical grounding means that an institutional entity needs to be associated with a physical thing or biological human being to come into existence. For example, a resident is grounded in a human being, or a contract is grounded in a piece of paper. Sometimes, however, there is no such need; an institutional entity can come into existence without being grounded in a human being or a physical thing ([10], p. 16; [15], p. 20). For example, an organization exists only by social convention and is not grounded in any biological or physical structure. An organization does not possess physical properties such as weight, height, length, or breadth and is not an aggregation of human beings [51].

Institutional grounding means that an institutional entity needs to be associated with another institutional entity to come into existence. For example, to create a new bank customer within a bank registry, the entity must be grounded in a resident in the digital census registry. We define a *digital institutional entity* as one created, accessed, identified, and recorded via digital media within an institutional context.

2.3.2. Software and digital agent

A piece of *software* is a sequence of symbolic instructions telling a computer what to do [52]. Routines and conceptual schemas are encoded in software,[1] which can govern the institutional actions of digital and human agents. In institutional theory, agency traditionally defaults to human agency. Agency that is the capability to perform actions does not require the cognitive capabilities of human beings in institutional contexts [51]. Institutional actions could also be performed by digital agents. A digital agent is an autonomous artifact that can perform institutional actions guided by some collective intentionality [53–55]. Digital agents process information and create institutional entities, acting on behalf of declaring parties identified as institutional entities (e.g., a bank) responsible for the institutional actions made [51]. Digital agents, without intrinsic consciousness, can make legally effective declarations of intent. Accordingly, a digital agent must be identified and authorized to act on behalf of institutional entities (Fig. 1).

Accordingly, we posit that a *digital agent* is an information processing entity regulated by software, physically grounded in computational hardware, executed when activated [56], and acting on behalf of a digital institutional entity that is institutionally grounded in a legal entity. Digital agents are thus assigned rights. A *Legal Entity* is an institutional entity legally liable for its institutional actions [51]. In other words, the digital infrastructure enables and restricts social interaction among human and digital agents regulated by the institution.

2.3.3. Digital institutional action

Digital infrastructures possess both structural and performative properties. The digital artifacts described above are used to perform digital institutional actions. An *institutional action* is carried out to create, modify, or delete institutional entities to evoke institutional effects. For example, a human agent handing in a university application performs an institutional action. Institutional actions are grounded in physical actions, such as tapping on a keyboard. However, they are primarily symbolic of their character. Physical capability alone is not sufficient for performing institutional actions. The agent must be appropriately authenticated and authorized to perform institutional actions [57]. However, actions in physical reality also contribute to the reproduction of the institution. For instance, after the student has been enrolled, he will physically attend on-campus courses. But, as the human agent's physical actions are regulated by institutional entities, the human agent has to prove that he has been given a student identity, that is "count as a student", otherwise he has no right to physically attend on-campus courses.

An *institutional process* is a sequence of institutional actions that gives rise to institutional effects. For example, a university enrollment process creates a student institutional entity, which provides a human agent with the right to participate in education. Each institutional process should conform to a *routine* that regulates how the institutional process should be performed. While institutional routines prescribe behavior, they always leave wiggle room for the agent enacting a process – the performative aspect of routines.

Software and conceptual schemas encode the routine patterns, and digital agents performing institutional actions enact these structures. They also dynamically create new institutional entities that dynamically alter the software that regulates it. Digital agents are executed at computational hardware, which are physical things related to an institutional thing. From an institutional perspective, an institutional thing is an institutional entity that can have privileges and is physically grounded in a physical thing. Physical things, in turn, can have specializations, such as computational hardware. For digital infrastructures, we omit other specializations in physical things; see Fig. 2.

[1] Routines and conceptual schemas are not necessarily encoded in software; they could be written on paper as well.

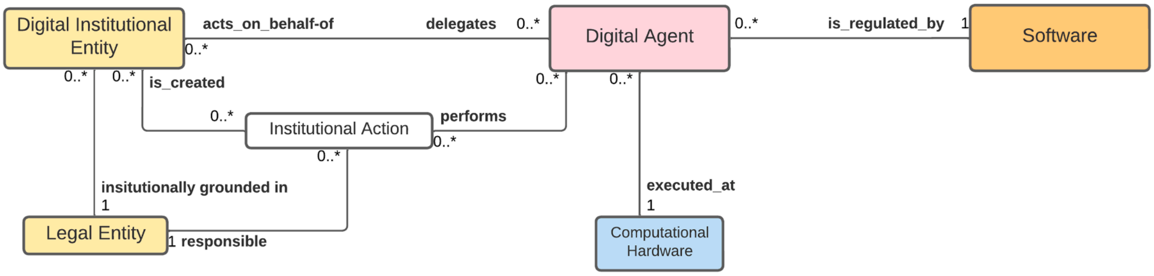

Fig. 1. The parts of digital infrastructures: digital institutional entities, digital agents, and software.

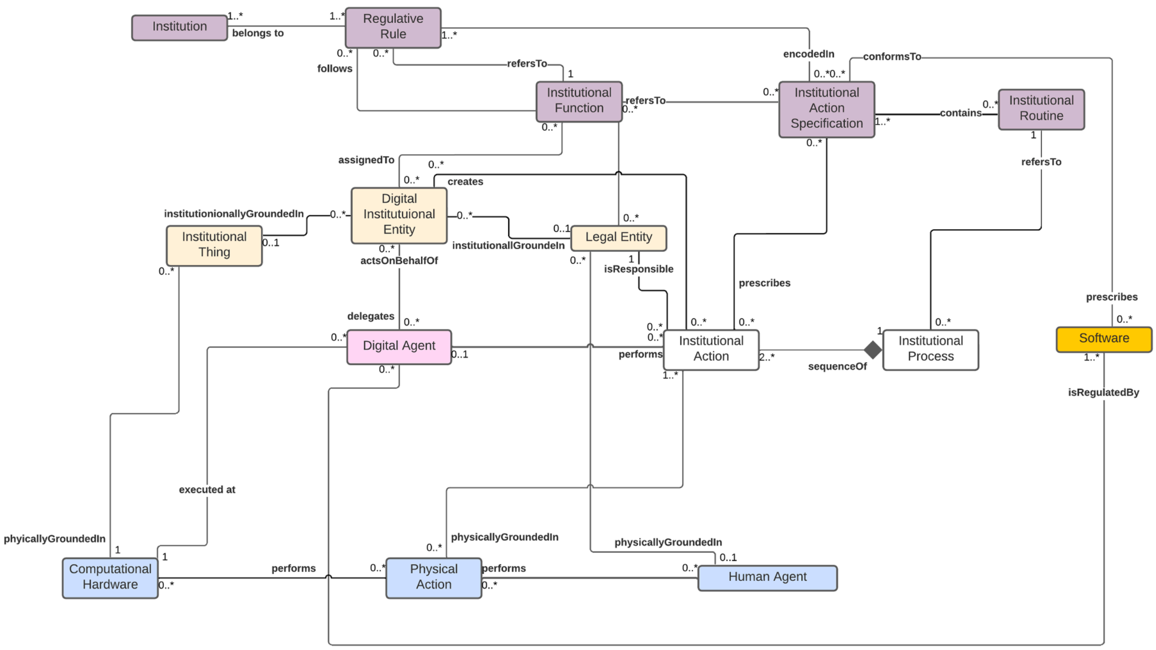

Fig. 2. A conceptual model of the basic institutional concepts defined in Sections 2.1 through 2.3.

2.4. Summary

In this section, we have developed a foundation for conceptual modeling of institutional reality. The most important institutional concepts of this foundation are described in Sections 2.1 (Institutions), 2.2 (Institutional routines and conceptual schemas), and 2.3 (Digital infrastructures). These institutional concepts are illustrated together in the UML class schema of Fig. 2. We will use these concepts in the next section to analyze the institutional language of open banking.

3. Modeling institutional reality – analyzing institutional language and rules through conceptual modeling – the example of open banking

In this section, we illustrate the use of the framework. We do this by analyzing an institutional language in the case of open banking. We chose this case because it illustrates how digital infrastructures are part of institutional reality and, therefore, are changing institutional reality, which can easily be overlooked if focusing primarily on the physical reality.

3.1. Introduction to the modeling case

Institutional languages are critical instruments for designing and managing digital institutional realities. Therefore, designers and managers of digital institutions must have a clear and shared understanding of institutional languages. This section shows how such an understanding can be achieved with conceptual modeling. The reason behind the PSD2 regulation is that since 2007, "the retail payments market has experienced significant technical innovation, with rapid growth in the number of electronic and mobile payments and the emergence of new types of payment services in the marketplace, which challenges the current framework" ([58]. p. 36).

The PSD2 Directive is designed to adapt the legal framework accordingly. The purpose of PSD2 is to contribute to legal certainty, competition, and the development of an integrated internal market. Another objective is to strengthen consumer protection, security of payment transactions, and protection against fraud. PSD2 is typical of how institutional systems are changed and transformed today. New services and innovations emerge bottom-up, which challenges the institution and requires language development within it. New regulative rules and institutional concepts must be developed to define new institutional functions, typically in laws and directives such as Directive 2015/2366 [58]. Moreover, based on these institutional constructs, new conceptual schemas and institutional routines are needed for digital infrastructure design. These constructs are often found in standards such as The Berlin Group [59] standard.

Open banking is an institution that provides third-party financial service providers with access to bank customers' transactions and accounts. When designing new institutional entities, software, and digital agents of the open banking digital infrastructure, a designer needs to analyze what is meant by the institutional language used and regulative rules defined in the PSD2 directive [58], as well as the accompanying Berlin Group standard [59], which prescribe the schemas and institutional routines to be used in digital infrastructure design.

In the analysis, we disentangle the relationship between the institution and digital infrastructure and show how one can unpack the black-boxed digital infrastructure using conceptual modeling. We model a conceptual schema in the form of several class diagrams and an institutional routine in the form of a sequence diagram. The resulting diagrams clearly and explicitly represent the concepts and institutional routines of open banking and how these constructs should be implemented in the digital infrastructure. To show how the institutional language of open banking can be analyzed and interpreted in terms of the foundation sketched out in Section 2, the class diagrams (Figs. 4, 5, 6, and 8) are stereotyped according to Fig. 2.

3.2. Modeling digital institutional entities – analyzing PSD2 institutional entities

The PSD2 directive contains regulations for new services to be operated by Third-Party Payment Service Providers (TPP) on behalf of a Payment Service User (PSU). A TPP can offer payment services through which an individual or an organization (a PSU) can transfer money held in accounts in a financial organization. To provide the new services, a TPP needs to access the PSU account, which is maintained by an Account Servicing Payment Service Provider (ASPSP), usually a bank. These are institutional functions defined in the directive and the standard.

As shown in Fig. 3, an ASPSP must provide an interface (called a "PSD2 compliant Access to Account Interface," a.k.a. an "XS2A Interface") to its accounts to be used by a TPP for accesses that are compliant to and regulated by the PSD2 directive. A PSD2 institutional entity is participating in PSD2-compliant payment services. PSD2 institutional entities are created using an institutional language, can exercise rights, have an identity, and are created, accessed, and identified digitally.

A TPP is an authorized provider of payment and account services within the open banking context, institutionally grounded in a financial organization, which is stereotyped as a legal entity. A PISP (Payment Initiation Service Provider) is a TPP that can initiate a payment transaction; an AISP (Account Information Service Provider) is a TPP that can provide information about accounts and their transactions; and a PIISP (Payment Instrument Issuing Service Provider) is a TPP that can confirm that available funds exist for a payment transaction. A PSU should be institutionally grounded in a customer to an ASPSP, private or corporate, and a customer is stereotyped as a legal entity. The ASPSP is an account service provider, institutionally grounded in a financial organization.

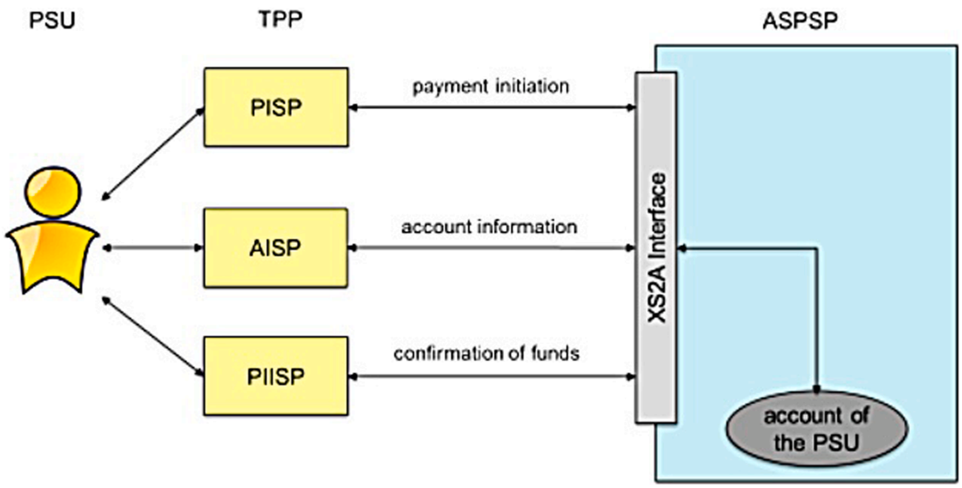

Fig. 3. PSD2 institutional entities [59].

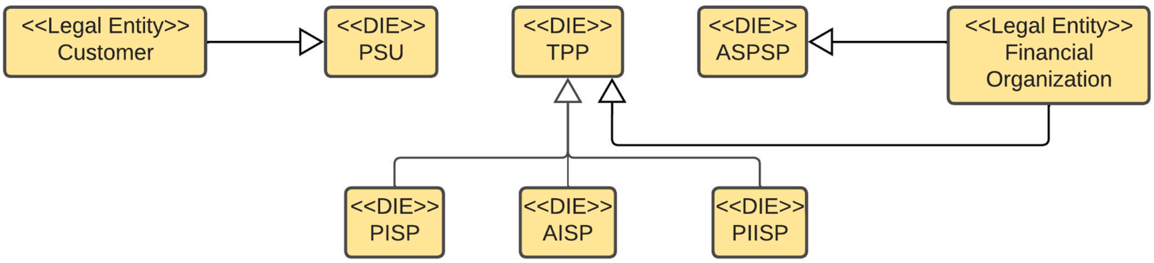

Fig. 4. PSD2 Third-Party Payment Service Providers (TPP), Account Servicing Payment Service Providers (ASPSP), and Payment Service Users (PSU) modeled as digital institutional entities and their relationship towards legal entities.

3.3. Modeling software – analyzing PSD2 API and application

A TPP can provide payment services to PSUs. For example, a TPP service may allow a PSU to transfer money between two accounts. Realizing such a service requires software provided by the TPP (called a TPP Application). A TPP Application would typically include instructions for how to authenticate and authorize a PSU and provide account information. As a TPP does not control the PSU's accounts, it only acts as a mediator and needs access to the accounts maintained by an ASPSP. To obtain this access, TPP Applications need access to software provided by an ASPSP that can read and update accounts and transactions. An ASPSP offers access to the accounts maintained in its systems through so-called ASPSP Applications, which are pieces of software that provide digital banking functionality, such as initiating payments, authenticating, authorizing, giving access to balance information about accounts, and reading transaction details. The TPP uses ASPSP Applications to provide banking services. Thus, a TPP gets access to the functionality offered by an ASPSP employing TPP Applications that use ASPSP Applications provided by the ASPSP. ASPSP Applications with related functionality can be grouped into an XS2A Interface according to the XS2A Interface Specification in The Berlin standard (2018). This also facilitates the management, publication, and discovery of the ASPSP Applications, see Fig. 5. An ASPSP may then use this as a basis for the implementation of its XS2A Interface to comply with the PSD2 directive.

When implementing and publishing its ASPSP Applications, an ASPSP must adhere to several regulative rules defined in the PSD2. This is to ensure that different ASPSPs provide uniform naming and access, and consistent semantics to their ASPSP applications to facilitate communication within a digital infrastructure. The Berlin standard (2018) introduces the notion of an API Access Method to express and organize these rules, which works as a template for ASPSP Applications. An API Access Method specifies a name and a specification of its semantics. Such a specification could involve determining correct payment details, such as legitimate account numbers and amounts to debit an account, see the first row of Table 1.

Furthermore, an API Access Method partially specifies how an ASPSP API conforming to it can be located. Technically, this is done by specifying an Endpoint that is to be part of the URL at which to access the ASPSP API. Finally, an API Access Method specifies the HTTP method to be used, which tells whether a corresponding API is about creating, reading, updating, or deleting institutional entities. Some API Access Methods are mandatory, meaning an ASPSP must support them according to The Berlin standard [59]. We model this by the attribute Condition, which can take on the values 'optional' or 'mandatory' (see Table 1). The HTTP method and Endpoint are not part of the standard *per se* but instead of another standard, namely the HTTP protocol.

From an institutional perspective, an API Access Method is an Institutional Action specification because it encodes parts of the logic of the institution of open banking as defined by PSD2. Thus, it is an institutional construct, not just a technical one. Accordingly, the designer of an ASPSP Application must ensure that it conforms to the institutional language and the regulative rules of the institution.

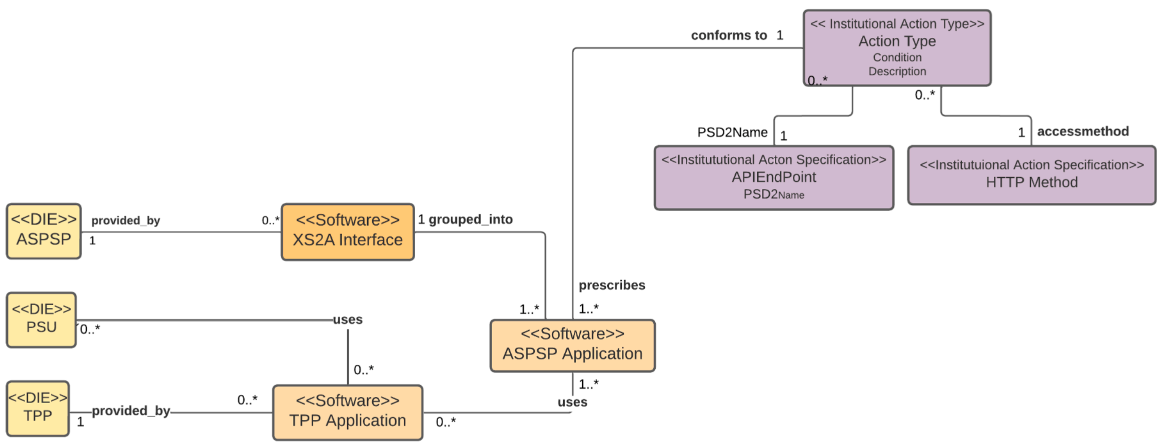

Fig. 5. PSD2 software.

Table 1
Example of API Access Methods of PSD2 ([59], p. 18).

Endpoints	Method	Condition	Specification
Payments/{payment-product}	Post	Mandatory	Create a payment initiation resource addressable under {paymentId} with all data relevant to the corresponding payment product. This is the first step in the API to initiate the related payment.
Payments/{paymentId}	Get	Mandatory	Read the details of an initiated payment
Payments/{paymentId}/status	Get	Mandatory	Read the transaction status of the payment

Fig. 5 summarizes how digital institutional entities can access PSD2 software provided by other digital institutional entities via XS2A interfaces.

3.4. Modeling digital agents – analyzing PSD2 digital agents

An ASPSP does not provide access to its software by letting TPPs discover and download the code of its ASPSP Applications. Instead, an ASPSP provides a digital agent, called an ASPSP agent, that TPPs can invoke. An ASPSP agent is an information processing entity regulated by an ASPSP Application, executed by computational hardware, and acting on behalf of an ASPSP, which is responsible for its institutional actions. As the ASPSP Application is installed and runs on this computational hardware, it can perform institutional actions, such as identifying, authorizing, and regulating other agents. Thereby, the digital agent can act on behalf of a digital institutional entity, e.g., it can exercise rights such as signing contracts and giving consent to various actions if the institutional entity is grounded in a legal entity.

Similarly, a TPP provides a digital agent, called a TPP agent, that PSUs can invoke. A TPP can give a TPP agent the power to perform institutional actions on its behalf. Thus, a PSU that wants to use a TPP Application of a TPP communicates with a TPP agent that acts on the TPP's behalf. Fig. 6 models the PSD2 view of how digital agents can carry out institutional actions on behalf of digital institutional entities regulated by software and executed on computer which is identified as a host. A host in this institutional context is an institutional thing identified with a domain name, which is an institutional identifier that have the privilege to be recognized and securely accessed on the Internet.

3.5. Modeling institutional routines – analyzing PSD2 flows

The conceptual schemas in Figs. 4, 5, and 6 model the institutional entities, digital agents, and software of a digital infrastructure. However, it is also required to model how social interaction should be performed using a digital infrastructure. In other words, the conceptual schema needs to be complemented with a process or interaction model.

Fig. 7 shows an example of an institutional routine in PSD2 called a flow, which is modeled in a UML Sequence diagram, which describes how a payment initiating process (an institutional process) should be performed based on the PSD2 directive and the Berlin Group standard. A flow is an institutional routine, which consists of a set of action specifications, a control flow, and a set of PSD2 roles. The labels of the arrows between the PSD2 roles TPP and ASPSP in the diagram of Fig. 7 should be names of action specifications as defined in the Berlin Group standard [59], e.g., 'Request for payment details' and 'Request Create Authorization.'

Carrying out institutional actions according to the PI flow creates an institutional entity, the payment transaction. These actions change the balance of the account of the PSU and the account of the receiver of the payment transaction (two other institutional

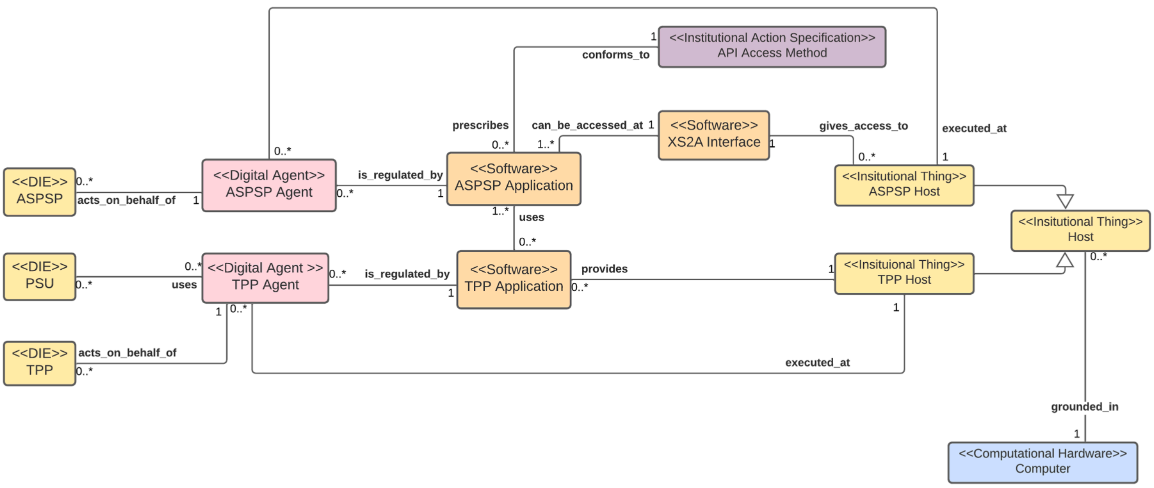

Fig. 6. Digital agents.

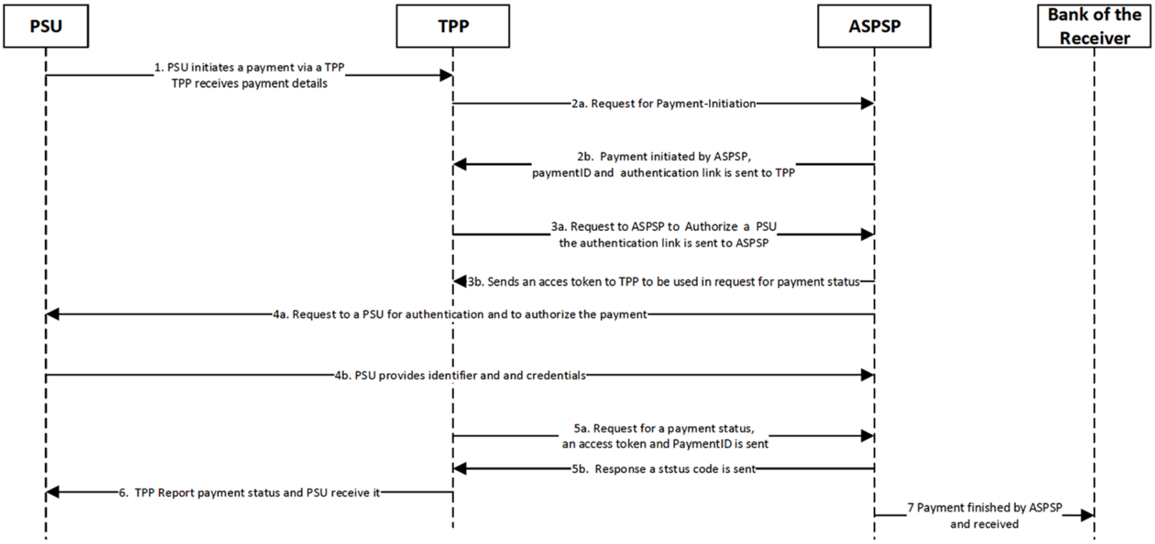

Fig. 7. A payment initiating flow used for prescribing a payment initiating process according to PSD2.

entities). The action specifications involve prescribing correct payment details, such as legitimate account numbers and amounts, e.g., the account number 999999999 and the amount of 1000 to be debited from the account. The transaction also needs to be inserted in the transaction ledger. This requires that a unique identifier value, e.g., Transaction:883838838394, is assigned to the transaction. Another rule requires that values for several compulsory attributes must be provided (e.g., the date 2024–02–02 and time 12:00 of the transaction).

Authentication rules are another example of institutional rules. Authentication is the process of verifying that a human agent or digital agent is who it claims to be. The PSD2 directive [58] prescribes the use of Secure Customer Authentication (SCA)-compliant identification methods (step 4 in Fig. 7). SCA uses two-factor authentication, which means providing an identifier and possessing credentials, such as a payment card or phone, or inherence, e.g., a fingerprint. The PSD2 also assumes that the exchange of institutional entities through Request-and-Response pairs is carried out according to another standard, the REST API protocol [60]. Within PSD2, every request for the exchange of institutional entities must follow authorization using the OAuth 2.0 protocol [61]. This protocol is based on exchanging an access token used in a session. A session is an institutional process, a sequence of Request and Response institutional actions, during which the digital agents exchange the temporal access token. The digital agent issuing the access token is the ASPSP agent, and the session token is given to the TPP agent, which permits the agent access to the accounts of the TPP.

3.6. Summary

In summary, the models (the class diagrams in Figs. 4, 5, and 6 and the sequence diagram in Fig. 7) show the institutional character of the digital infrastructure by emphasizing the institutional language and how it should be used in the digital infrastructure where the social interaction is performed. Consequently, the digital infrastructure should be understood from an institutional perspective rather than as computational hardware.

The class diagram in Fig. 8 summarizes the essential concepts of the institutional language of open banking, along with its implementation in the digital infrastructure. The institution is modeled at the top and consists of institutional functions, regulative rules, and institutional action specifications. The sequence diagram in Fig. 7 shows how these concepts are used and related in an institutional routine, which is also a part of the institution.

The Digital Infrastructure modeled in the middle of Fig. 8 implements the institution. In the case study of PSD2, this is modeled as:

- Digital institutional entities, each of which is assigned based on the PSD2 roles (institutional functions).
- Software regulated by API Access Methods, which are institutional action specifications. In turn, the software regulates the digital agents.
- Digital agents that act on behalf of digital institutional entities, which must be recognized as legal entities. The digital agents perform institutional actions within a session, an institutional process.

These are the concepts of the institutional language, i.e., institutional constructs constituting institutional reality, which is different from physical reality. Physical reality is modeled at the bottom of Fig. 8. Legal entities could be physically grounded in human agents. Institutional actions are physically grounded in physical activities. Computational hardware is modeled as a computer.

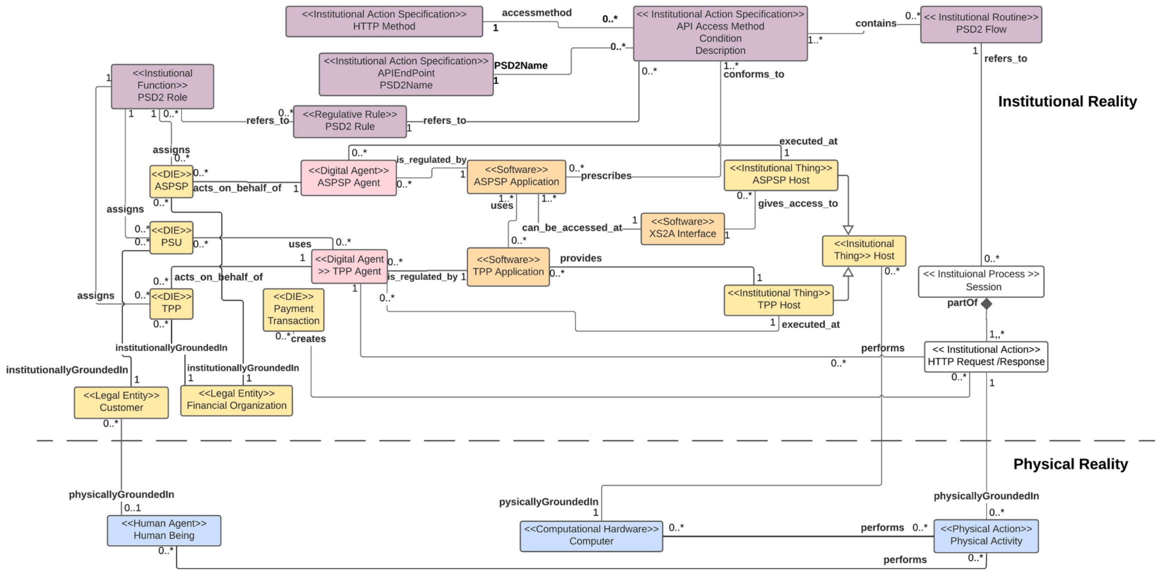

Fig. 8. [21]A conceptual model of the essential concepts of the institutional language of open banking using the basic concepts of Fig. 2 as stereotypes

4. The institutional design of digital infrastructures

In the following, we highlight four critical takeaways for the institutional design of digital infrastructures.

4.1. *Digital infrastructures are changing institutional reality*

Digital infrastructures are changing institutional reality because human and digital agents use these to perform institutional actions using an institutional language. Software regulates the actions in creating institutional entities, which are exchanged at an unprecedented pace and scale. The development of the institution of open banking and its related digital infrastructure is an example of how the institutions of society change because of digitalization. The Directive (EU 2015/2366) [58] introduces new institutional concepts and regulative rules. These regulative rules and concepts have been encoded into conceptual schemas and institutional routines in standards such as the Berlin Group standard, and designers of digital infrastructures should comply with these institutional specifications.

4.2. *Analyzing the institutional context of digital infrastructures*

Digital infrastructure design should therefore involve analyzing institutions [16,62,63]. The PSD2 directive case shows that regulations and standards, such as the Berlin Group standard, prescribe rules for legitimate ways of acting in institutional reality. Compliance with regulations and standards is increasingly important, e.g., in the digital payment landscape [64]. Designing digital infrastructures, in general, is, to a great extent, about analyzing, interpreting, creating, and implementing regulations and standards to develop a new 'institutional normative order' ([65], p. 324). Such design requires knowledge about how regulations and standards ought to be implemented into digital infrastructures. Conceptual modeling is a valuable tool for acquiring the necessary understanding.

4.3. *Digital agency*

Since digital agents increasingly perform institutional actions, it is crucial to understand the notion of digital agency from an institutional perspective [21]. Recker et al. [66] describe digital agency as a "material agency." In doing so, they assume that digital objects possess versions of cognitive functions typically associated with humans, such as perceiving, reasoning, learning, and interacting. Digital agents have this capability because they can produce and consume scripts (i.e., conceptual models).

However, as we have illustrated through our models and analysis of open banking, it is not the cognitive capabilities of digital agents that are of interest for institutional reality; it is the capability of making legitimate institutional actions by digitally creating new institutional entities [51]). For example, a digital agent representing a TPP could initiate a payment transaction. Indeed, digital agents could perform institutional action by representing legal entities [67]. As illustrated by the open banking (PSD2) case, institutional actions are performed mainly by digital agents: the TPP agent on behalf of the TPP and the ASPSP agent on behalf of the ASPSP. Only the PSU involves human agency, and only the human agent performs institutional actions using its own institutional identity. However, this is only the case where the PSU is a private person.

The ability to perform institutional action is decisive for agency in institutional contexts. The deciding criterion is that the external behavior of digital agents can be attributed to the declaring party, which has to be a legal entity [51]. Suppose the digital agent is delegated to perform institutional actions on behalf of legal entities. In that case, there must be adequate legal protection to ensure the legal consequences can be affected (see the autonomy risk below). For instance, in open banking, it must be transparent which legal entity has delegated the power to the digital agent to perform the payment.

To fulfill the responsibilities, designers must show how regulative rules have been implemented in the digital infrastructure. For example, consider the PSD2 directive,

"The account information service provider shall: (a) provide services only where based on the payment service user's explicit consent" [58] (Article 67). This directive should be implemented through the institutional action specification "Request to PSU to authorize the transaction", which is modeled in the sequence diagram of Fig. 7 (Action type 3a). The institutional routine and the action specifications prescribe that the legal entities accountable for the digital agents ensure that the PSU must be authenticated and authorized by the ASPSP and must give consent once approved. Therefore, it should be transparent how the "Request to PSU to authorize the transaction" has been implemented in the ASPSP application. Consequently, the ASPSP application's user interface must be designed to make clear that the PSU is authorizing the digital agent of the ASPSP to perform the payment. Minimizing liability risks challenges designers to find methods that make digital institutional actions transparent and secure, which requires conceptual modeling based on an institutional turn.

In summary, the interplay between digital agents, institutional processes, legal entities, and transparency shapes the landscape of digital agency within institutional contexts. Designers must navigate these complexities to create secure and transparent digital infrastructures.

4.4. Liability risks

Teubener [51] suggests that digital agency poses three new liability risks: (1) *the autonomy risk*, which has its origin in stand-alone "decisions" taken by the digital agents; (2) *the association risk*, which is due to the close cooperation between human and digital agents; and (3) *the network risk* that surfaces when digital agents interact with other digital agents in digital infrastructures. Regulations and digital infrastructure design must manage these liability risks.

One can manage the autonomy risk [51] by law by granting legal status to the digital agent to act on behalf of the legal entity, making the legal entity liable for the actions performed by the digital agent; essentially, what legislations in the USA and EU are now implementing. Accordingly, the conceptual model in Fig. 1 associates institutional action with a digital institutional entity, which has to be institutionally grounded in a legal entity. The digital infrastructure must implement such delegation of rights and duties.

The second risk, the association risk [51], can be managed by recognizing the human-digital association as a focal entity. Sometimes, the interactions between the digital and human agents cannot be reduced to the individual actions of the human agent or those of the digital agent. For instance, when the human agent uses their PSU identity to authorize the payment transaction in interaction with the ASPSP digital agent (Fig. 7, Action type 4a and 4b). Contract law offers a model for dealing with such hybrids, emphasizing the common purpose of exchange between the parties. It produces concrete legal consequences for interpreting contractual declarations and whether, and to what extent, a breach of contract has occurred. The contract can bring the hybrid of human and digital agency to bear in legal terms. Furthermore, one can manage the hybrid risk within the digital infrastructure using strong customer authentication (SCA), which PSD2 requires. If SCA is not used, the PSU cannot be held liable. If SCA is used, both the human and the digital agent can be held responsible if something goes wrong [68].

Finally [51], there is a network risk when several digital agents interact within a digital infrastructure, which can be managed by access tokens, as described in Fig. 7. Suppose a digital agent (e.g., the TPP agent) needs to access institutional entities (e.g., accounts) on behalf of a user (e.g., the PSU). It could acquire this right through an access token provided by an authorizing digital agent (e.g., the ASPSP digital agent) (Fig. 7, action type 3b). However, to get the token, the client agent (e.g., the TPP agent) must also identify itself by providing a client ID and a client secret (action type 3a) to the authorization digital agent (e.g., the ASPSP agent).

Managing liability risks impacts digital infrastructure design significantly and can be highly complex. There is a need for conceptual modeling based on an institutional turn to sort out which entity is liable. This requires the ability to securely assign institutional identifiers to institutional entities and human and digital agents in order to authorize them to perform institutional actions and be able to sort out who is liable when damage occurs.

In summary, managing liability risks in digital agency involves granting legal status to digital agents, recognizing human-digital associations, and implementing secure interactions within digital infrastructures. Designers must adeptly navigate these intricacies to ensure transparent and accountable systems.

5. The institutional turn in conceptual modeling

In this section we discuss why a revival of conceptual modeling of information systems—involving a contemporary "institutional turn" is required. We maintain that the institutional turn is motivated by the constitutive function that institutional languages mediated by digital infrastructures have in society. The institutional turn is essential for understanding how institutional reality and

[2] All digital agents can perform Institutional Actions HTTP Request/Response, but only the TPP Digital Agent Request/Response is shown for space reasons.

digital infrastructures are constituted. According to Searle [11], the basic linguistic constructs of institutional reality are institutional entities, because they are used for creating and distributing powers, privileges, claims and duties.

"By creating institutional reality, we increase human power enormously. By creating private property, governments, marriages, stock markets and universities, we increase the human capacity for action prodigiously." ([11], p. 24)

Recent surveys of the past decades of research on conceptual modeling [69,70] identified a dominant stream of work addressing the theoretical foundations of conceptual modeling. Within this stream, "notable theories include a general ontology, such as the BWW (Bunge-Wand-Weber) [2] or UFO (Unified Foundational Ontology) [71,72]. These theories typically assume a materialistic view of reality. That is, all entities to be modeled are material in nature" ([70], p. 26).

The purpose of foundational (general) ontologies such as BWW and UFO are to provide a coherent framework for modeling the fundamental constructs of reality. Using ontology as a foundation for conceptual modeling assumes that ontology can help us better understand how reality is constituted. UFO and BWW are the two most dominant ontologies; however, both struggle in modeling constitutive parts of institutional reality such as institutional entities and identity [70]. Accordingly, in Sections 5.1 and 5.2 we will describe the assumptions made in UFO and BWW about institutional identities and institutional entities and compare these with the institutional turn.

The notion of entity and identity is a central issue for conceptual modeling, which is also recognized in UFO and BWW. Without a clear understanding of identity, the formulation of any conceptual framework becomes uncertain, as entities inherently rely on their identity conditions. Identification requires both qualitative and individual identity [73,74]. It involves classification, that is, grouping entities that share similarities and delineating them from entities that fall under other concepts (qualitative identity), and among entities that fall under the same class we need to be able to distinguish between individual entities (individual identity).

5.1. The BWW ontology and institutional reality

The BWW ontology, which is the basis for representation theory mentioned in the introduction, maintains that, the fundamental pillar for conceptual modeling is, "identifying the things in a domain is a prerequisite to our eliciting the remaining semantics–for example, the attributes that are important, the relationships that exist among things, and the classes used to generate a view of the domain" ([1], p. 505–506).

Eriksson & Ågerfalk [6][3] showed that different models result if the modelling is based on a property-based conception of identity compared to an institutional one. They used the Bunge-Wand-Weber principles, which embrace a property-based view of identity to point out how this type of ontology sidesteps the notion of institutional identity. As a consequence, they found that typical institutional entities such as vehicle owners, which can be 'corporate owners' or 'person owners,' are challenging to model, because a common vehicle owner class makes no sense, according to the BWW guidelines. There is simply no common physical property or set of properties (qualitative identity) between corporations and persons to form a common owner class. The BWW ontology also assumes that a unique set of physical properties could be used to provide individual identity. However, if somebody was to lose a limb, would it not still be the same person? It was also difficult to see what the unique physical properties of a corporation were. A corporation, which is a typical institutional entity, would have an institutional identifier such as a unique corporate name or number. However, names or numbers of corporations are not part of the conceptual model because identifiers have no significance for modeling the world according to the BWW guidelines [1].

In contrast to the BWW ontology, the institutional turn underscores how institutional identifiers (individual identity), such as an owner number, is assigned when entities are created (instantiated). Identity is not provided by things with unique physical properties that already exist and have an identity in physical reality. Additionally, in institutional reality, qualitative identity is not defined by properties but decided based on institutional function. An institutional function defines bundles of rights and duties that can be assigned to institutional entities when they are instantiated (see Section 2.3). For instance, to understand the concept of a vehicle owner, one must understand it based on the owners' duty to have traffic insurance for the vehicle, pay road tax and road tolls, which are common duties for all vehicle owners in the institutional context [6].

5.2. UFO/OntoUML and institutional reality

OntoUML is a modeling language where UML has been extended by using basic principles and categories from UFO. Accordingly, we start with discussing UFO in Section 5.2.1 and using OntoUML in Section 5.2 to present a conceptual model.

5.2.1. UFO

In line with BWW, UFO maintains that a central issue for conceptual modeling is the notion of identity. OntoUML assumes that "there is no entity without identity" ([75], p. 5), and if incompatible principles of identity apply to the same individual, then it cannot be a viable entity.

UFO assumes another principle of identity compared to BWW, which solves the problem that the identity is dependent on a set of physical properties. In UFO, identity is provided by substance sortals, "A principle of identity regarding a sortal S makes explicit the properties that no two instances of S can have in common, because such properties uniquely identify S instances" ([76], p. 140). A kind

[3] We refer to the article Eriksson & Ågerfalk [6] for a more elaborate discussion.

is necessarily rigid because it must apply to its instances in all possible situations [72,77]. “In particular, it also informs which changes an individual can undergo without changing its identity, i.e., while remaining the same.” ([76] p. 140)

Based on the principle of identity, UFO ontology distinguishes between substance sortals and moment sortals. Substance sortals can provide a principle of identity, while moments cannot.

Substance sortals are rigid types that provide a uniform principle of identity for their instances (e.g., Person) [75]. For example, “contrast the rigid type Person with the anti-rigid types Student or Husband. While the same individual John never ceases to be an instance of Person, he can move in and out of the extension of Student or Husband, depending on whether he enrolls in/finishes college or marries/divorces, respectively” (ibid. p. 4).

Accordingly, moments are existentially dependent on substance sortals. Moments can be modes, qualities, and relators. A mode inheres in a single substantial (e.g., Mary’s headache), while relators are moments that connect substantials. For example, “an enrollment relator connects an individual playing the Student role with an Educational Institution. Every instance of a relator type is existentially dependent on at least two distinct entities. Moreover, relators are typically composed of modes; for example, in the way that the marriage between John and Mary is composed of their mutual commitments and claims” ([75], p. 3). Accordingly, moment sortals cannot provide a uniform principle for their instances because their existence depends on substance sortals.

5.2.2. OntoUML

Elaborating on how typical institutional entities such as legal entities, customers, and organizations should be modeled using OntoUML [75], we arrive at the model below.

The upper part represents types and the lower part represents instances of Substance Sortals (Kinds) that exist in reality. We have modeled organizations as instances of Substance sortals to conform with OntoUML.

We have also marked the names of Customer and Organization with {Id} to clarify that these are rigid designators. A “rigid designator” is an identifier that could be used for “picking out the same individual in all possible worlds” ([78], p. 27), which means that it “refers to the same individual in all possible situations factual or counterfactual”. For instance, the name “John Schmidt”, i.e., the referent of “John Schmidt” at a time t should be the same as the referent of “John Schmidt” at any time t’.

We have modeled Legal Entity ([75], p. 4) as a Non Sortal, which is a type that aggregates properties that are common to different sortals. Non Sortals cannot be directly instantiated because they do not provide a uniform principle of identity for their instances. Customer must be modeled as a RoleMixin, which represents roles played by entities of different Substance Sortals; they “represent externally-dependent anti-rigid non-sortals whose instances may follow different identity principles and are not constrained to a specific ontological nature” (ibid. p. 10). Conversely, roles are “externally dependent anti-rigid sortals whose instances have a common ontological nature and follow a unique identity principle” (ibid p. 9).

Relator Sortals are “abstractions over properties of substantials, and, thus, identificationally dependent on the latter”. ([75], p. 21) Accordingly, we have modeled the relator EnrolledPrivateCustomer (“John Schmidt-qua-PrivateCustomer-of-Postbank”) ([79], p. 172). We have also modeled the relator EnrolledOrganizationCustomer (“Autoankaf-quaOrganizationCustomer-of-Postbank”). Roles are considered to be qua individuals who are externally dependent modes of a sortal individual. The class diagram in Fig. 9 shows that typical institutional classes, such as Customer and Legal entity, cannot be directly instantiated.

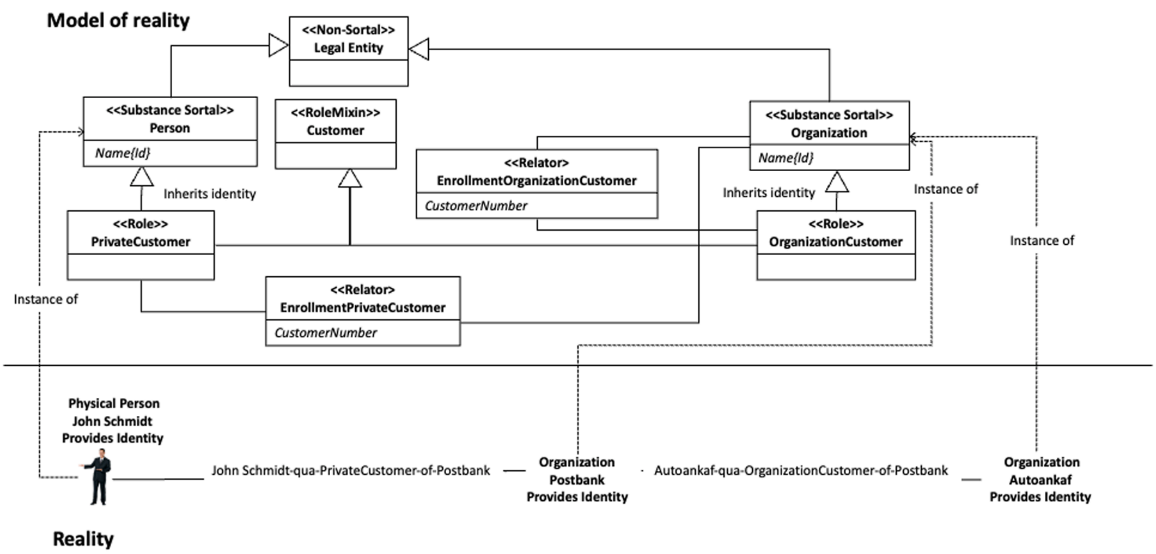

Fig. 9. A model based on OntoUML.

5.3. Comparing the model based on OntoUML with a model based on the institutional turn

We concur with UFO that every entity must possess an identity. However, there is a need for a different principle of identity, which does not assume that identity is provided by a substance sortal.

In contrast to UFO, we acknowledge the importance of understanding institutional identity. Institutional identity is socially constructed, assigned during the instantiation of institutional entities. Institutional identity plays a pivotal role in the constitution of institutional reality, because there is no institutional entity without an assigned identity. This has important implications for conceptual modeling, as depicted in Fig. 10.

If we define qualitative identity for the institutional concept of a Bank Customer, it could be something like this: "Customers are bank depositors, who entrust their money, banking facilities, for storage and fruiting, for which they receive interest, and applicants or those who need temporarily, some additional money for paying interest or commission" ([80], p. 128). This is what makes Bank Customers the same, whether they are organization customers or private customers. We have defined the concept of Bank Customer based on its institutional function. We also need to differentiate between different individual customers when they are instantiated. We use a unique identifier, a Customer Number, which represents the individual identity of a customer.

This is different compared to UFO, which does not have the notion of institutional functions. In UFO, a Bank Customer is stereotyped as a RoleMixin (Anti-Rigid Non Sortal), see Fig. 9. In Fig. 10, a Bank Customer is stereotyped as a Legal Entity that is an institutional entity legally liable for its institutional actions (Teubner, 2018). This is different compared to UFO, where a legal entity is exemplified by "people, organizations, contracts". We do not concur that contracts are examples of legal entities.

In UFO, only substance sortals have instances, which are "existentially independent objects such as John Lennon, the Moon, a dog, and a car" ([75], p. 3); as a consequence, a class such as a Bank Customer cannot have instances of its own (see Fig. 9). This is different when compared to Fig. 10, where the class Bank Customer can have instances of its own, and these instances are institutional entities not physical objects. An institutional entity could be physically grounded in a human agent, such as in the instance of identity 1383883; still, the physical human is not the same as the institutional entity. Fig. 10 illustrates this, where a number of physical human beings have not been identified as Bank Customer in this institutional context. Fig. 10 also shows that the institutional entity 6789098, which is an organization, has no physical counterpart.

In UFO, only a "rigid designator" could be used to identify an entity. However, "John Schmidt" cannot be used as a rigid designator in institutional contexts because it is not guaranteed to be unique; there is no regulative rule which guarantees that names of private persons are unique in every institutional context. Every identity assigner must guarantee that the institutional identifier assigned is unique and that it is assigned in a secure manner. For instance, the assignment should guarantee that the same customer number is not given to two different human beings. The registration also means that the institutional entity is assigned the rights prescribed in the definition above.

In Fig. 10, institutional reality takes priority. We have modeled the classes at the type and instance levels, which are both parts of institutional reality. The model shows that institutional entities such as bank customers are symbolically constructed, and that identity is assigned when these entities are instantiated and registered.

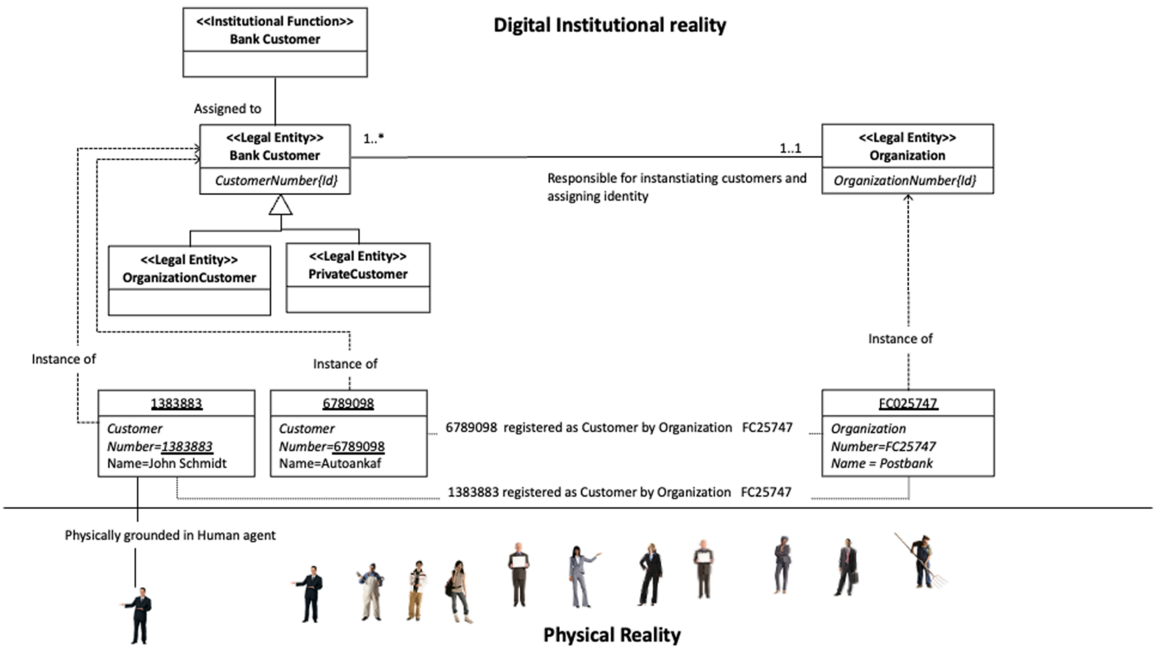

Fig. 10. A model based on an institutional ontology.

Today, these registries of institutional entities are digitized. The real original institutional entity, Bank Customer, is a digital institutional entity. For instance, Bank Customer 1383883 is a digital institutional entity with an institutional function in a bank context as it represents legal rights and liabilities and is an actual viable entity that can be directly instantiated.

The main difference between Fig. 9 and Fig. 10 is that OntoUML (Fig. 9) makes no distinction between physical reality and institutional reality. Consequently, the basic ontological constructs of reality are Substance Sortals and because of that institutional constructs such as Legal Entity and Bank Customer are just stereotyped as Non Sortals. If the primary unit of analysis is institutional reality, the Bank Customer class should not be stereotyped as a RoleMixin. According to UFO the RoleMixin type is an externally-dependent Anti-Rigid Non Sortal whose instances may follow different identity principles and are not constrained to a specific ontological nature. In contrast, if we assume that we are modelling Institutional Functions and Institutional Entities there is no problem with the principle of identity and the ontological nature of Bank Customers and these entities can be directly instantiated and identified. Non Sortals cannot be directly instantiated and identified, because Non Sortals do not include existentially independent entities on their own, which assumes that there are not real viable entities. Stereotypes such as Non Sortal and RoleMixin tell us that they are not constituent entities in reality. UFO only tells us that basic institutional entities are not Substance Sortals, not what they actually are. OntoUML lacks basic ontological constructs (stereotypes) such as Institutional Function and Institutional Entity for making institutional reality the primary unit of analysis. In contrast, we assume an institutional reality constituted by institutional functions and institutional entities, which requires the notion of institutional identity, and that we need them for the purpose of organizing social interaction in society.

5.4. Summary

Accordingly, the institutional turn assumes a different ontology and principle of identity compared to both the BWW ontology and UFO and comes with a shift in perspective. Institutional entities are language constructs in their own right. These are constituent immaterial entities, and the purpose of institutional entities is to create and distribute powers, privileges, and claims, and thereby organize the social interaction of society at large. Consequently, the institutional turn invites seeing institutional reality and institutional constructs as the primary unit of analysis in conceptual modeling.

Additionally, identity is not just provided by already identified entities. Identity is socially constructed using language when institutional identifiers are assigned. Accordingly, the designer of digital infrastructures and associated identity management systems must deal with how institutional routines are designed in an integrated manner. Digital identity is also the foundation for building security mechanisms, such as authentication and authorization [81]. Identity management is necessary (see Section 4) because it assigns the right to both human and digital agents to perform actions.

Although useful in other contexts, we have not found OntoUML or the BWW ontology sufficient for modeling and reasoning about the interplay between institutions and digital infrastructures in the design of digital institutional reality, where we need to acknowledge the prescriptive role of conceptual modeling. Consequently, what has been referred to as the “institutional turn” offers a new way forward by articulating institutional reality as the primary unit of analysis, thus recasting what is to be explained and understood. The institutional turn recognizes digital infrastructures as a part of institutional reality; we should include the digital infrastructure in conceptual modeling because it is an integral part of institutional reality. Digital infrastructures are not detached from institutional reality; it is a constitutive part of it. The institutional turn in conceptual modeling focuses on the institutional language and the prescriptive role of conceptual models in constructing institutional reality. The institutional turn also brings to light the legitimacy of digital infrastructures. Conceptual modeling can be used to guarantee the legitimacy of digital infrastructures by analyzing how the legitimacy of digital infrastructure is guaranteed based on the institutional context, as illustrated in the case of open banking. For instance, to model conceptual schemas using UML class diagrams, and institutional routines using sequence diagrams, and describe how these models relate to the institution, as exemplified in Section 3. We propose primarily a change of ontological perspective and thinking about the focus of conceptual modeling, and that conceptual schemas should be modeled together with institutional routines. What we need are new ontological assumptions to guide conceptual modeling.

6. Conclusion

In this article, we have examined the contemporary ontological reversal and the institutional turn. Specifically, we have explored the consequences of the institutional turn for conceptual modeling and our understanding of digital infrastructure design. The specific research question we addressed was: What are the fundamental constructs in the design of digital infrastructures that constitute and transform institutional reality?

Through an analysis of the open banking PSD2 case, we have identified digital institutional entities, digital agents regulated by software, and digital institutional actions as critical constructs for conceptual modeling in institutional contexts. These constructs depend on the regulative rules, institutional functions, action specifications, and routines that constitute an institution. These constructs also depend on computational hardware, and thus physical reality, that implements and runs digital agents acting on behalf of legal entities. However, their material essence is secondary to understanding contemporary digital institutions and their design.

We have furthermore shown how conceptual modeling offers tools for enabling concise and precise analysis of digital infrastructures and the institutions they implement. In so doing, we have shown how conceptual modeling can improve our understanding of the digital transformation of institutional reality and the prescriptive role of conceptual modeling.

Finally, we have argued why an institutional turn is needed based on fundamental principles of identity, and generated theoretical insights that identity is assigned and that institutional entities are viable entities. We have also shown the need for legitimacy that advances the study and practice of digital infrastructure design and its consequences.

CRediT authorship contribution statement

Owen Eriksson: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Paul Johannesson:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Maria Bergholtz:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Pär Ågerfalk:** Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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