Improving the Understanding of Business Processes

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Abstract: Business processes are important knowledge resources of a company. The knowledge contained in business processes impart procedures used to create products and services. However, modelling and application of business processes are affected by problems connected to knowledge transfer. This paper presents and implements a layered model to improve the knowledge transfer. Thus modelling and understanding of business process models is supported. An evaluation of the approach is presented and results and other areas of application are discussed.

Keywords: business process modelling, Event-driven Process Chains (EPC), knowledge transfer.

1 Introduction

Knowledge is an important resource and a critical factor for organisations to sustain and extend competitive advantages ([Te03]; [Da11]; [CDK11]). The important knowledge of a company, describing the procedures for the production of products and services, is incorporated in business processes. A business process is a sequence of activities performed in order to create a specified product or service [SS13] taking a holistic view on the value creation [SN00]. Thus, the business processes of an organisation need to be captured and represented as a business process model in order to guarantee an efficient production and repeatable quality. A model is an abstract representation focused on the attributes relevant to the modelling goal [St73].

1.1 Challenges in Business Process Modelling

The knowledge about the processes is often decentralised and tacit. Furthermore, the documentation of the business processes is hampered by communication problems [Ve04]. Reijers and Mendling [RM11] investigated in the understanding of business process models and the influence of modelling and personal factors. Their research revealed that personal factors such as education, and knowledge of theory and practice might have a larger impact on the understanding of business process models than modelling factors might have. However, modelling factors such as size of the model and number and type of connectors also influence the understanding [MRC07].

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Personal factors are of particular importance as modelling of business processes normally requires bidirectional communication. Modelling is usually done by experts who are unaware of the processes in the organisation and the employees who know the processes are not familiar with the modelling language. Therefore an approach should take into account the knowledge of both involved parties and support their communication. This is where our prototype tool comes into play.

1.2 Related Work

An approach that represents the knowledge required to perform an activity and enables the evaluation of the transfer is presented by Bahrs et al. [BBG11]. It implements the Knowledge Modeling and Description Language (KMDL), which is focused on knowledge intensive business processes and comprises three modelling views, namely process view, activity view and communication-based-view. The process view contains the sequence of activities and the associated roles. The activity view concentrates on the knowledge conversions required to perform an activity and include the four knowledge conversions of the SECI Model [NT95]. The communication-based-view describes the sequence of communication and involved roles. The model was evaluated by an experiment with 89 students. Thereby the experiment investigated in different factors and their influence on knowledge transfer. The authors [BBG11] identified a need for: 1) "*A more precise method for description of knowledge transfer with a model reflecting influential attributes of the sender and receiver based influences and success factors of knowledge transfers*." 2) "*An empirical foundation for the evaluation and design of knowledge transfer success*".

The layered model for knowledge transfer developed by Schiele et al. [SLC13] shortly recapped in Section **Fehler! Verweisquelle konnte nicht gefunden werden.** describes the process of knowledge transfer and points out problems that occur during the knowledge transfer based on differences in the knowledge of sender and receiver. The application of this model to the area of business process modelling aims to solve the knowledge transfer problem. The application of the layered model for knowledge transfer in business process modelling is described in detail in [SLC14]. However, an implementation in software or an empirical evaluation has not yet been conducted.

1.3 Contribution

To demonstrate that the model of Schiele et al. [SLC14] really helps to support the knowledge transfer in the area of business process modelling a prototype was implemented and an empirical study was conducted. The prototype implements a modelling environment with the basic EPC symbols and a knowledge repository to facilitate the reuse of elements. The prototype aims to support the modelling and the understanding of business process models.

1.4 Outline

This paper is structured as follows: Chapter 2 will present a brief description of business process modelling, the modelling language applied in the prototype and the application of the layered model for knowledge transfer in business process modelling. Chapter 3 will present the prototype and its relevant features. The evaluation of the prototype will be presented in chapter 4. In Chapter 5 we discuss the results and future directions.

2 Business Process Modelling

The layered model for knowledge transfer [SLC14] is implemented in a modelling tool that uses the Event-driven Process Chain (EPC) diagram for the representation of business processes. The first section will provide a brief description of the modelling language EPC and their benefits and disadvantages. The second section briefly recapitulates a knowledge transfer model of Schiele et al. [SLC13] and its application in business process modelling.

2.1 Event-driven Process Chains

The EPC diagram invented by Scheer [Sc00] consists of events and functions interconnected by a control flow. Functions are rectangular symbols that represent an activity. Events are hexangular symbols that represent a situation that triggers a function. The control flow can be split and merged by the use of a logical connector such as AND, OR, and XOR [KNS92]. Another basic symbol used in EPC diagrams is the role. The role is connected to a function and shows who is involved in the execution of the function. If further symbols, standard or company-specific, are added to the EPC it becomes an enhanced Event-driven Process Chain (eEPC). Commonly used symbols are resources such as system, data base, and document which can be connected to functions by an information flow indicating the input or output of a function. EPC is a semi-formal modelling language especially for the functional representation of business processes. EPCs are widespread, at least in Germany and supported by various tools [SS13]. Due to the simple graphical representation EPC is easy to understand and therefore suitable for discussions with department specialists. However, the limited amount of symbols restricts the accuracy of the representation. Details of functions and events are expressed by comments or, if supported by the tool, by additional attributes with an undefined semantic.

The modelling of business processes entails conceptual problems as good standards are missing [AHW03]. Guidelines for modelling [MRA10] and standardised process models such as Business Process Model and Notation (BPMN) have contributed to an improvement. However, BPMN is more complex therefore harder to learn than the EPC notation. Reijers and Mendling [RM11] investigated the factors that influence the understanding of business processes. The following cognitive dimensions are considered relevant for the understanding and reading of business process models. 1) The *abstraction gradient* that describes the potential of the modelling language to group actions to reduce complexity. 2) The *hard mental operation* that describes the disproportionate increase of reading difficulty with an increase in elements. 3) The *hidden dependences* that describe dependences which are not obvious in the first place. 4) The *secondary notation* which includes regulations that are not part of the primary notation such as rules for denomination of elements and process layout.

2.2 Application of the Layered Model for Knowledge Transfer

The layered model for knowledge transfer [SLC13] contributes to a better understanding in order to support knowledge transfer. The transfer of knowledge from the sender to the receiver requires a transformation as knowledge cannot be transferred directly. The sender needs to encode the knowledge to transfer it as a message and the receiver needs to decode the data received from the message to obtain knowledge. The knowledge transfer from sender to receiver is influenced on four layers. At the lowest level is the *code layer* that consists of symbols or signs. They represent the smallest units, which form the basis of the higher layers. In the case of written language, which is the focus here, the smallest elements are the characters, σ, taken from an alphabet Σ. The *syntactic layer* is constituted by the syntax that contains rules for the combination of signs or symbols. In written language, L, the characters σ are combined to form words ω by the use of production rules P. The *semantic layer* contains the semantics that establish the relation between words ω and meaning m. This relation, called semantics $s(\omega, m)$, connects the word to its meaning, which can be a real world entity or an abstract thing. The top layer is the *pragmatic layer*. Pragmatics $p(s, c)$ connects the semantic term s with a concept c. The concept contains the course of action and the aims and moral concepts that are represented in the human brain. They influence the thinking and acting of sender and receiver. The interpretation of the message depends on the elements that are used and whether they are part of the knowledge base of the receiver and equivalent to the elements of the sender's knowledge base.

When we consider the modelling language EPC with respect to the layered model for knowledge transfer we can derive the following statements. The code layer contains the symbols used in the EPC diagram as well as the language in which the process is modelled. The syntactic layer contains the rules for the EPC diagram and the rules of the natural language. The semantic layer contains the connection between the words or symbols and its meaning. Because of the simple EPC representation the precise meaning depends mainly on the wording. More precise descriptions are almost impossible as the annotation of the used words is not possible. The pragmatics of a process is nearly impossible to model by the EPC, with the exception of start and end event of a business process, which represents the goals that are to be achieved when the process is performed. However, the pragmatic is affected by the natural language used to describe the process and the knowledge base of the person modelling the process and the person who reads it. The simple notation of EPC leads to a lack of precision in the semantic and pragmatic layer of the knowledge transfer. To achieve the goal of a better and ideally lossless communication in the area of business processes the descriptions concerning the semantic and pragmatic layer need to be enhanced. To achieve a better representation on the semantic and pragmatic layers the authors have decided to use frames. Every function and event in the business process will be represented as a frame.

According to Sowa [So00], the frames specified by Minsky [Mi74] are a more precise and implementable representation of the schemata. The schemata were first mentioned by Aristotle to categorise the elements of his logical arguments. Minsky defined a frame as a data structure to represent a consistent situation [So00]. The frame can be complemented with attributes to describe the application of the frame, the following action, or alternative actions. Minsky [Mi74] characterises the frame "*as a network of nodes and relations*". Minsky pointed out, that a frame has several layers and the top levels represent the true characteristics of the frame. Lower levels contain terminals that store specific data about the instance. Those instances often constitute sub- frames. With the frames Minsky intends to create an approach that imitates the human thinking in the aspect of creating pattern and applying them to new situations. He points out that a new frame often is an imperfect representation, which is gradually refined. This is facilitated by a loose coupling that enables replacement of assignments to slots. The application of frames intends to enhance a function with a precise description. Frames allow describing a situation and changes to this situation. When used for functions the frame enables a precise description of the performance and thereby a representation of the pragmatic layer. Frames provide the opportunity to create nested structures, which allows an efficient representation of complex situations. The inputs and outputs of functions and events, represented as frames, are described in a formal way. This aims to verify interfaces and make suggestions for modelling based on the interface verification. In addition, the semantic description should help to clarify the properties of the input and output objects. The objects describing the application of a function and the objects that represent the inputs and outputs of the function can be represented as frames too. According to Minsky they are called terminals and constitute *slots* where the data are saved. Based on the usage of the word *terminal* in computer science for an entity that cannot be further broken down, the authors will refer to the terminals of the frame as slots. Each slot can contain an object describing the characteristics of the function or an object representing an input or output of a function. Each of these objects needs to be further broken down until the costs for the break down is higher than the gained benefit.

3 The Prototype

The layered model for knowledge transfer is applied to the area of business process modelling in a modelling environment based on the EPC language. The prototype includes the basic EPC symbols and a repository to facilitate the reuse of elements. Furthermore, it contains a repository for *description objects*, which can be used to represent an input or output of an activity. Based on the *description objects* the prototype checks connections and creates recommendations for modelling. The categorisation of the description objects, additional annotations and the reuse of symbols support not only the person modelling a business process but also the one who reads the process.

3.1 Structure and Features

The application of the layered model for knowledge transfer aims to support both, modelling and the usage of the business process model. The modelling should benefit through the automatic syntax checks, verifying the model against the modelling rules. However, such syntax checks are already implemented in various modelling environments. Furthermore the modelling environment should generate recommendations for the subsequent process step if an appropriate element exists in the database. An important point for this suggestion is constituted by the descriptions of the outputs of the current process step. To model a business process EPC symbols can be selected from the toolbox and dragged to the modelling surface where they are dropped. Figure 2 shows the sEPK prototype. The modelling surface is located on the right side and contains the graphical representation of the business process. The toolbox is located in the top left-hand corner and contains the basic EPC symbols, plus a symbol for database. The frame is located below the toolbox and is only visible when a symbol is selected. The frame contains important details of the selected symbols. When a function or event is selected it displays an overview of the inputs and outputs and allows their administration.

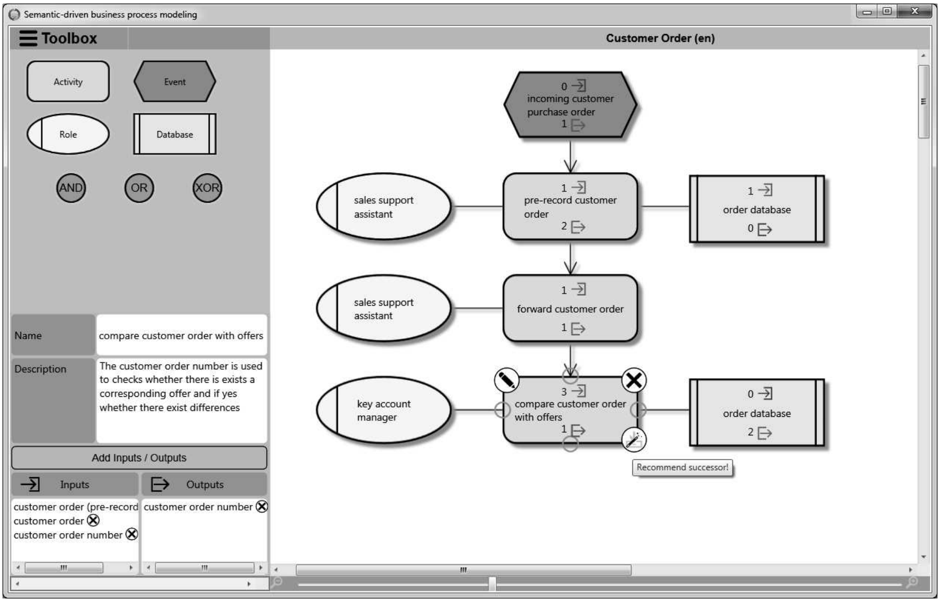

Fig. 1: sEPK

3.2 Modelling Support

The representation of inputs and outputs facilitates new prospects of analysing the process and creating recommendations for modelling or optimisation. The prototype analyses the process model and signals mismatches of *description objects*. This is possible through the representation in the semantic layer. Every function, event and database has a notification (e.g. see →] in Figure 2) for the number of inputs and outputs. The colour of this notification changes according to the result of the analysis. The standard colour of the notification is grey. This indicates that the input or output is empty or for some reason not checked. A red notification indicates a mismatch, namely too little, too much or at least one wrong *description object*. Figure 2 illustrates a business process where the last function has a mismatch in the outputs due to the fact that the function has one output which is not stored in the connected database, nor is it used as input to a successor element in the process. Thus, the recommendation wizard is shown to offer support by recommending elements from the repository which can be used as a successor to the selected function. The recommendation wizard thereby supports the modeller and facilitates reuse of established functions and events. Figure 3 shows the recommendation view with its three areas. The left side displays the selected symbol for which a successor is recommended. All recommendations are listed in the middle with type, name and a graphical representation of the match between the outputs of the selected symbol and the inputs of the recommended symbol in percent. The right side shows details of a symbol chosen from the recommendation list. For each input of the selected recommendation the matching with the conformity with the outputs of the symbol selected in the process is indicated in percent. The recommendation supports the reuse of established symbols by providing a list with established functions and events stored in the repository with all necessary details. This is another example of the application of the semantic layer of the knowledge transfer model. The precise specification of the *description objects* on the semantic layer supports the decision of the modeller who knows the purpose (pragmatic layer) of the required function.

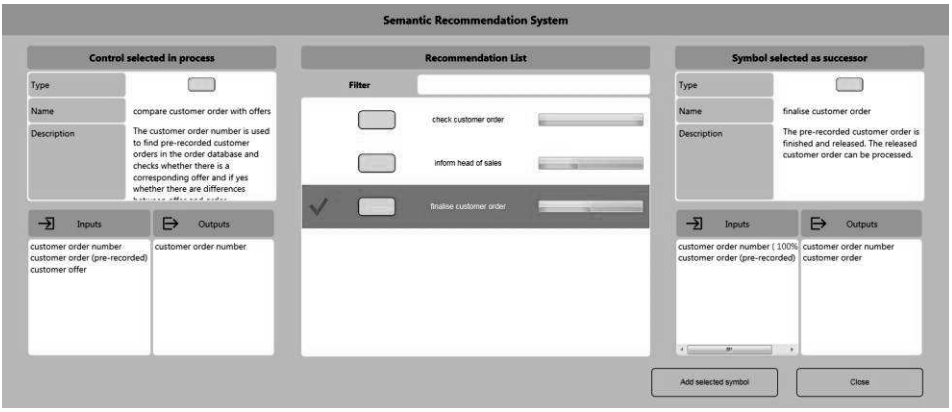

Fig. 2: Recommendation

The chosen symbol can be adopted as it is or it can be used as template that can be adjusted as required. The selected symbol of the recommendation list can be added as successor by clicking on *add selected symbol*. Consequently the symbol is automatically placed in the process and connected with its predecessor. In addition sEKP offers a recommendation wizard for missing inputs. The algorithm searches all databases existing in the process for the input missing. In case a database contains the required input, the recommendation system lists this database and facilitates an automated integration in the process. Furthermore, the modelling of the inputs and outputs with the description objects leads to a more detailed process. The more detailed representation requires a deeper understanding of the process and an accurate modelling. However, with respect to the recommendation system and the reuse of established functions, events and description objects the additional expense is limited. It has to be considered that process models pursue different targets. For process models used as work instruction the semantic annotation and enhanced descriptions can constitute a benefit. For the optimisation the description of inputs, outputs and application are of great importance. Based on this various optimisation approaches could be undertaken.

4 Empirical Evaluation

An empirical evaluation of the implementation of the layered model for knowledge transfer in the prototype was conducted as an experiment with a pre-test / post-test design. The experiment aimed to investigate whether a modelling tool that implements a layered model for knowledge transfer would lead to better results than other solutions. The experiment was conducted with students of the Business Informatics study programme at Reutlingen University. All participants were enrolled in the fourth, fifth or sixth semester, so it was ensured that all participants have already gained some experience in business process modelling as part of their studies. 43 participants completed the pre-test and the post-test of the experiment.

4.1 Experimental Architecture and Design

The experiment included the task of modelling a business process based on a textual description. The participants had to internalise the textual description of the business process and subsequently create a business process model by externalising this process. To measure the accuracy of the transfer two main key figures were used. First, *representation* reflects the semantics of the business process model, namely the completeness of the transformation from the textual description. To determine the key figure *representation* all symbols of the process were rated on an ordinal scale (*good*, *acceptable* and *bad*), in accordance with the modelled characteristics. Second, *design* reflects the syntactic elements of the business process model, namely the compliance with the business process modelling rules. To assess the key figure *design* the rules for EPC were rated on an ordinal scale (*very good*, *good*, *acceptable*, *bad* and *very bad*).

To measure the differences between the implementation of the layered model and standard approaches the individual modelling capabilities of each participant were measured in the pre-test. In the pre-test all participants used only pen and paper to create the model based on the description of task 1, describing the process *customer offer*. The post-test aimed to investigate the difference between the applied approaches, thus three different approaches were used. The ***experimental group 1*** used the sEPK prototype that implements the layered model for knowledge transfer to determine whether this would support modelling. The ***experimental group 2*** used ARIS Express to analyse the support for modelling given by a standard modelling tool. The ***control group*** used again pen and paper to determine whether the results of the pre-test and the post-test could be compared. To perform a randomised assignment that creates three groups with equal cognitive performance all participants were ordered based on their results of task 1 and assigned to the groups alternately. Pre-test and post-test were performed to measure differences in the process model based on the applied approach. Therefore tasks 1 (pre-test) and task 2 (post-test) were designed to have the same complexity and structure.

4.2 Results

An initial analysis of the results was performed by a graphic analysis of the differences in the results of pre-test and post-test for the three groups. Figure 4 shows the deviation of the results of the post-test compared to the pre-test. Based on the used scale a negative number represents an improvement in the post-test compared to the pre-test. Participants whose result in representation has improved are shown in the lower area of the chart. Those who improved in terms of design are shown on the left side of the chart.

Figure 4 shows that the participants who used sEPC could achieve the biggest improvement in terms of representation. In terms of design both experimental groups show slightly better results than the control group. For the analysis of the results non-parametric tests were used because a Shapiro-Wilk test indicated that the key figures representation ($D(43) = 0.91$, $p = 0.002$) and design ($D(43) = 0.88$, $p < 0.001$) were not normally distributed. A Kruskal-Wallis test was used to investigate the differences between the three groups based on the key figures calculated for representation and design for the pre-test and the post-test. The Kruskal-Wallis test indicated a significant difference in terms of representation ($K = 17.074$, $p < 0.001$) and design ($K = 12.183$, $p = 0.002$) between the two experimental groups and the control group. Mann-Whitney U tests were used for further investigations and a direct comparison of two groups at a time. Experimental group 1 performed significantly better in terms of representation in comparison with experimental group 2 ($Z = 3.057$, $p = 0.002$) and the control group ($Z = 3.859$, $p < 0.001$). Only in terms of design there was no significant difference between the both experimental groups ($Z = 1.879$, $p = 0.068$) but experimental group 1 performed significantly better in relation to design than the control group ($Z = 3.290$, $p = 0.001$). A Mann-Whitney U tests indicated that there was no significant differences between experimental group 2 and the control group in terms of representation ($Z = -1.206$, $p = 0.240$) or in terms of design ($Z = -1.930$, $p = 0.058$).

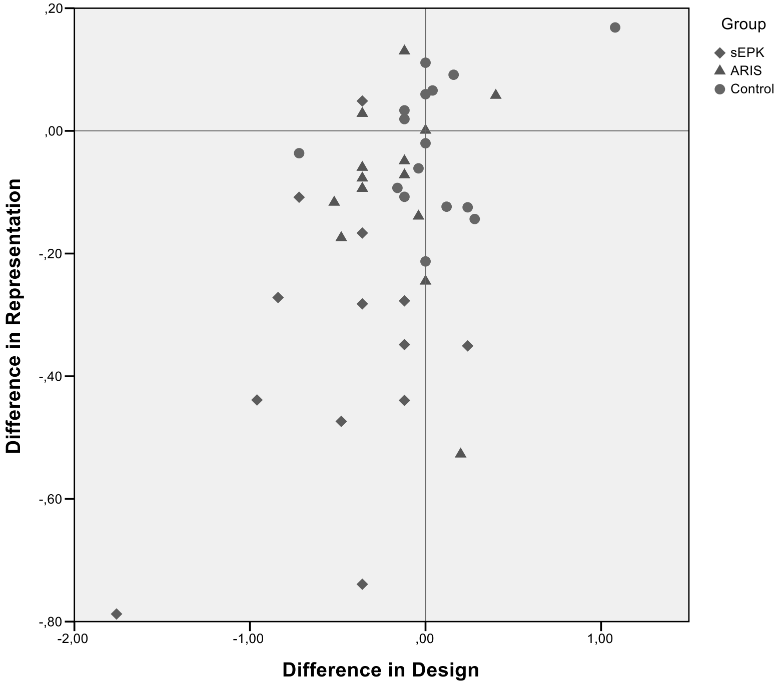

Fig. 3: Scatter Plot for Differences of all Groups

5 Discussion and Future Directions

In this paper we have presented challenges in business process modelling. In particular we focused on problems based on differences in the knowledge base of a person who knows a process and a person who creates the business process model. Such communication problems may also occur when a business process model is read. To meet these challenges the layered model for knowledge transfer was implemented in a prototype for business process modelling.

5.1 Discussion

A comparison of the results of the three groups revealed a significant better result in terms of representation for the group which used the sEPK prototype for modelling. The improvement in terms of representations had been anticipated as sEPK offered a more detailed representation for inputs and outputs than the other approaches. The results of experimental group 2 with ARIS also improved compared to the control group but not significantly. The improvement may be due to the support of the ARIS toolbox that offers all EPC symbols. However, the possibilities of describing the execution of a function, the occurrence of an event or required inputs or outputs are limited to text attributes. In contrast, the sEPK prototype offers predefined categorised description objects, which can be enhanced if necessary. Based on the fact that sEPK and ARIS provided a toolbox with all required symbols for the creation of an EPC process it was expected that both experimental groups could improve in terms of design. While experimental group 1 improved significantly in terms of design experimental group 2 could not improve significantly. Some of the participants using sEPK or ARIS had difficulties with the process alignment and thus their results in terms of design declined. The problems may be explained by the fact that the participants had only little or no experience with modelling tools, so that the alignment of the process was more difficult for them than without a tool. The control group using pen and paper for the modelling did neither improve nor deteriorate. The experiment showed that a modelling tool like sEPC could help to improve the precision of a business process model. The support for the modeller in matters of reusability and recommendation offered this possibility without losing too much time for the more precise representation. However, the approach demands a profound engagement with the business process as the creation of a detailed process model requires detailed knowledge about the business process that needs to be modelled. A limitation of this research may be that the experiment has only involved 43 students, thus the generalisation could be limited.

5.2 Future Directions

The implementation of the layered model in the area of business process showed first results. More effort in the representation of the description objects can be a worthwhile goal. An ontology-based implementation might provide new options in combination with an inference engine. The detailed representation of the functions and events and the detailed description of their inputs and outputs provide a basis for process analysis and optimisation. This was confirmed by experts from industry and research who tested sEPK. Early detection of errors in business processes could be a further field of application. From an economic view an error must be detected as soon as possible because the costs of fixing the error rise disproportionately with the passed time.

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