Reliability Displays in Building Information Modeling
A Pattern Approach

Alexander G. Mirnig
and Manfred Tscheligi

Center for Human-Computer Interaction
University of Salzburg
Salzburg, Austria
firstname.lastname@sbg.ac.at

Peter Fröhlich, Johann Schrammel
and Michael Gafert

Center for Technology Experience
AIT Austrian Institute of Technology GmbH
Vienna, Austria
firstname.lastname@ait.ac.at

Damiano Falcioni

BOC Asset Management GmbH
Vienna, Austria
damiano.falcioni@boc-eu.com

***Abstract*—Process management systems allow the user to, among other things, predict possible outcomes of larger processes and make decisions based on a pool of data available to the system. What can greatly influence the success of such processes is the *reliability* of the data that feeds the system's output. This, however, is usually not part of such systems and is left to the experience and expertise of the individual user. Design patterns are a method that can capture and communicate such implicit expert knowledge. In this paper, we present initial solutions for integrating reliability indicators in process management. Based on expert stakeholder requirements from the use case Building Information Modeling (BIM), we created three initial solutions for the realization of reliability displays in this context, which we abstracted into three draft patterns. These solutions pertain to expertise-based rights management, visualisation of entry timeliness, and communicating reliability via penalty indicators.**

Keywords–Patterns; reliability displays; process management, building information modeling.

I. Introduction

When working with large quantities of data, then any decision that is made based on that data must operate under the basic assumption that the data is accurate to a sufficient degree. In practice, this *reliability* of data is subject to fluctuation, depending on the type of data, where it came from or by whom it was fed into the system, and a number of similar factors. It would be very helpful, then, to have an indicator for the reliability of the data the system bases its output on in addition to whichever output the system generates via its primary functionality (sum calculations, predictions, a.s.o.). Such values, that could allow to determine the reliability of any individual piece of data, are usually not integrated and it is left to the user, to determine how reliably the data he/she is working with is in the end.

Reliability displays are displays or User Interface (UI) elements intended to address this gap and introduce indicators to convey reliability information. Such displays add an additional dimension to data displays: in addition to showing the data itself to the user, they also convey how reliable the output can or should be expected to be by the user. This information can be very valuable for predictions (e.g., weather forecasts) or contexts with high degrees of variability (e.g., automated driving [1]), although such displays or indicators are not yet widely integrated or researched and, as a result, not yet used within process management or BIM.

In this paper, we present an attempt to design reliability indicators for process management in the BIM context. Following a pattern approach [2], we decided to generate intitial design patterns based on stakeholder requirements. From initial expert interviews, we extracted reliability requirements for the BIM context. For three of these, we then generated high- to mid-level solutions, which we present as pattern drafts. These are intended to serve as the basis for continued efforts to design UI reliability indicators.

II. Related Work

In the following, we provide an overview of relevant literature and state-of-the art for BIM and process management, reliability displays, and design patterns.

A. Process Management and BIM

There is a growing belief that digital transformation in the architecture and construction industry can only happen if four key parameters are properly addressed: digital data, digital access, automation and connectivity [3]. The common denominator of all these factors is the utilization of BIM as both the backbone for the launch of new processes and new service features to the architecture, engineering and construction industry, as well as the link between the various stakeholders involved in the renovation and construction value chain [4].

Using BIM methodologies and tools has been proposed to yield large benefits for the construction/renovation sector, most importantly by: (i) reducing critical mistakes and omissions and (ii) improving collaboration between stakeholders, subsequently enabling lower costs through less rework, greater speed by removal of additional documentation efforts, and higher quality due to closer control. Other direct benefits of BIM for renovation projects, include reduction of uncertainties regarding the post-renovation performance, early visualization of renovation impact to get consensus from building owners, improved collaboration between stakeholders leading to fewer conflicts, mistakes and re-works on site.

As for building owners and financiers, BIM are conceived as a way to make the estimation process more accurate and facilitate more visibility and interaction in the overall design/build process for the owners of a building, enabling them to take a more active role in determining the final outcome of capital-intensive projects. This appears even more relevant in building renovation processes, an area with the largest untapped potential for energy saving and reduction in greenhouse gas emissions [5], where BIM tools can help in the identification of the renovation options that can deliver the best value for money. This requires the availability of specific BIMR (BIM-based renovation) tools that can accurately estimate the impact of renovation options and lead the involved stakeholders through an efficient implementation path (see [6] for a detailed description of state-of-the-art renovation workflow models for BIM-based renovation process management).

Despite its clear benefits for all stakeholders involved, BIM is still facing reluctance to uptake in the mainstream market [7], mainly due to a number of key factors such as the requirement for the entire construction value chain to use consistent BIM tools in order for any party to reap benefits, the investment in time required as a learning curve on behalf of architecture and construction professionals, the size and the processing load induced by BIM models.

B. Trust Calibration and Reliability Displays

Trust can be understood as a relation between at least two agents, in which one or more agents (trustors) depend on the achievement of another agent's (trustee) goals in a situation that is characterized by uncertainty and vulnerability (compare Ekman et al. [8], Mirnig et al. [9], and de Visser et al. [10]. Undertrust in a system occurs when the perceived capabilities are lower than the actual capabilities, and inversely, overtrust implies that the perceived capability is higher than the actual capability. Users can underestimate the consequences if a system fails, and/or users can underestimate the likelihood that a system will make serious mistakes at all. The trust in a system is calibrated when neither over- nor undertrust occur.

Trust calibration can play an important role in intelligent and predictive systems, to establish and guarantee their long-term acceptance. Schrammel et al. [11] have shown that in different fields of research and practice different techniques for trust calibration have been proposed, most importantly reliability displays, uncertainty indicators, awareness and intent displays and the communication of available alternatives. Reliability displays, which are the focus of our paper, directly communicate the reliability as estimated by the system to the user [12]. This normally includes only one value, which is frequently expressed as a percentage, i.e.: "I am 60% sure that the data is correct". The display of this information needs to be adapted to the application domain, and different interface elements are used depending on the domain.

C. Patterns

Design patterns are structured solution documentations to reoccurring problems [13]. Design patterns were originally conceptualised by Christopher Alexander [14][15] to capture individual solutions to reoccurring problems in the architecture domain. His idea later influenced other domains as well, most prominently software engineering [16], where patterns are still widely used to document solutions to both common and obscure problems encountered by software engineers.

Patterns feature a number of characteristics that separate them from "classical" means of documentation, such as guidelines: Since they are problem-based, they can cover both high- and low-level solutions, depending on how the individual problem is framed [17]. A side effect of this is that pattern collections are never complete in a standard sense – whenever a new problem within a specific context occurs, so does the need for an appropriate pattern. Since patterns also focus on providing ready-to-use along with a description of the problem context, they can be useful to make expert knowledge accessible to novices [18] and serve as a powerful knowledge transfer tool in this regard.

These features render patterns particularly suitable for capturing and communicating solution knowledge in new or rapidly evolving domains [2]. BIM is one such domain, which is currently evolving based on advances in digitalisation, data management, and measurement technologies. Isikdag and Underwood presented two design patterns for synchronous collaboration in BIM [19], showing that the pattern approach can be successfully used in this domain.

Since both BIM and reliability displays are relatively novel without the solid literature basis that other more traditionally rooted fields have, patterns seem particularly suitable to capture solution knowledge in these domains. In this paper, we therefore apply a pattern approach to create initial draft patterns for conveying reliability information in BIM applications, based on expert stakeholder requirements. After an overview of the related work in Section 2, we present the requirements gathering approach in Section 3, the resulting patterns in Section 4, and conclude in Section 5.

III. Gathering Requirements for Trustworthy Process Management

Following an iterative pattern approach [2], we first gathered expert stakeholder requirements, which we then prioritized and used as a basis for the design solutions and resulting patterns. To this end, we formulated the following two guiding research questions:

RQ1 Which factors are most indicative of the data reliability in BIM process management?

RQ2 How can these factors be integrated into UI designs to communicate data reliability to the user?

We address RQ1 in Sections III-B and III-C, RQ2 in Section IV.

A. Method

The method consisted of a stepwise process from the state of the art analysis and interviews to requirement derivation and pattern writing.

State of the art analysis: Based on analysis of previous work on trust calibration, we came up with common design approaches for the communication of reliability, uncertainty, awareness and intent, as well as of choice alternatives [11]. Examples from research and practice were collected, whereby the most detailed guidance was available in the area of automated driving, as here reliability displays have already been investigated in experimental research.

Interviews: In order to capture the requirements for BIMR and related trust calibration aspects in depth, we conducted semi-structured individual interviews, which followed a consistent agenda but could then expand on specific further topics brought up by the respondents. After filling in a consent form and providing background information about their job profile and specific expertise, participants were asked some introductory questions on BIMR, its relevant processes, involved software environments and major issues in the field. Then, participants were briefly introduced into the above described investigation topics of trust calibration and process management in BIMR, through showing and commenting a few illustrative slides on the concepts and related example applications and use cases.

Respondents were then asked to comment on the use case as to whether or not it corresponded to their own work situation and to which extent they saw differences. They were then also asked about the types of data they use in their BIMR projects and to draw the timeline of a typical renovation process. The participants were then debriefed and asked about their preparedness to provide feedback to the next stages of pattern generation. Three experts were asked to participate in the interviews: an architect proficient in BIMR for building (I1), a project manager for highway construction projects (I2), and an IT solution provider specialized in BIMR (I3).

Derivation of requirements: The responses were analysed as to their potential for the derivation of requirements for pattern writing. The gathered requirements were then consolidated across the three different interviews and allocated to 9 requirements (or requirement groups).

B. Interview Results

In general, the BIMR use case itself was seen by all three participants as a promising alternative to currently prevailing, less data-intensive renovation approaches. All three respondents confirmed that the integration of BIM is not yet common in standard construction industry processes, as data for most actors in the construction industry appears to be restricted to PDFs with 2D or 2.5D plans (I2). However, in the participants' view the number of customers demanding for more informed modeling, documentation and monitoring is growing. Based on the respondents' experience with BIM renovation so far, a number of benefits were identified, such as the improved communication opportunities between different involved stakeholders through the joint exploration of the same model from different viewpoints (I1-3), the interconnection between the construction and the accounting data with different preferences for their level of integration, (I1-3), clear guidance in construction processes, due to high-precision data (I2), long-term reliable data availability for asset management purposes (I2), and a better overview and verifiability in complex buildings (I2).

While each of the respondents described a 'typical BIMR process' with a different focus, several commonalities could be identified. The first BIMR process step consists in the detailed creation of a model of the initial conditions of the site. This is then used for the planning, cost estimation and offer creation for the different renovation phases of the renovation project. During each actual renovation phase, BIMs are then used to track the process on site, and often the data on used materials is also used for billing. In some cases (I2), the BIM is then provided also for the further asset management.

C. List of requirements

R1: The presentation of reliability displays should follow the degree of abstraction. Therefore, it is necessary to highlight upfront the level of detail of the model.

R2: The system should always highlight the properties and restrictions of the underlying model. To this end, potential uncertainties of the model in representing the reality should be highlighted. Furthermore, the nature of the analysed object with regard to the related expected uncertainty/accuracy should be shown. For instance, a more geometrically complex object could provide more precise insights than a simpler object, in comparison with standard planning tools.

R3: It should be possible to filter system output (both with regard to data protection and to usability).

R4: It should be possible to define who provided an input and the related chosen approach.

R5: There should be a clear indication on who provided an input, estimation or prognosis. In addition, the system should show how this input was provided, with regard to the applied method, the used system, the user role and expertise. For example, for an infrastructure construction manager, providing information on whether data has been collected by a drone each week, as opposed to less systematic data capture by ground personnel. Also, for architects or project managers it is worthwhile to check on whether the person entering the data comes from the same company, or from a company with processes that they are familiar with.

R6: The system should provide cues and detailed information on whether the considered building model or respective estimations have undergone previous reliability checks. For example, if the system shows whether or not certain specific software-based tests (e.g., with Solibri [20]) have been applied on some or all of the available aspects of the model (e.g., jointings of different building parts) and if it is clarified whether manual corrections have been applied to further plausibilize them, this will help the user get an initial understanding which parts of the model can be trusted to what degree. To make this indicator meaningful, it is necessary to also show whether the software output has been surveyed by an expert to disambiguate them and to filter for relevancy in the given context.

R7: In the case that Artificial Intelligence (AI) is involved in the processing of the data, it would be necessary to provide an indication on which underlying data and models a respective estimation or prognosis has been made. In this respect, best practice from the currently evolving field 'Explainable AI' should be considered [21].

R8: The time period of data input as well as its relation to the respective billing period should be displayed. This should encompass ranges of default threshold values beyond which the provided data is deemed unreliable. The underlying assumption is that a closer match of data input with the actual billing period indicates its level of detail and correctness, as with longer delays of data input human error is more likely. Naturally, data to be considered in the context of this requirement is attached to a concrete time specification, such as the date of the made payment and the timestamp of the corresponding project deliverable.

R9: The system should provide cues on which of the renovation project deliverables is subject to a contractual penalty related to quality or time delays. In case of existence of such a penalty, a higher reliability is ascribed to it by project managers.

IV. From Requirements to UI Solutions

All requirements were discussed in an internal workshop with three UI experts. In the workshop, the requirements were prioritized regarding estimated effectiveness and feasibility of integrating with existing UIs. For the three highest priority requirements (R5, R8, and R9), solutions were then generated and brought into a minimal pattern draft format, including name, short description, problem, solution, and examples. These patterns are described in the following:

A. Draft Pattern 1: Expertise-Based User Roles

This pattern describes a solution to assign levels of expertise to user roles and communicate reliability of input data based on the combination of role and expertise level that entered it.

1) Problem: In the building construction context, there is often a large number of stakeholders who all contribute to one single project. This means that the data that feeds the process management system comes from a variety of sources and not all of them can be assumed to be equally reliable. In particular, the reliability of the data will depend on whether

1) the individual who entered or supplied the data held the appropriate role to do so, and
2) their level of expertise was sufficient to reduce the possibility of oversights/errors to a standard minimum.

In addition, the reliability is also influenced by whether the data was imported directly from another system or whether it was entered by a human individual. All of this information is typically not provided by the system when working with or viewing individual data or data sets. Thus, the judgement regarding data reliability depends entirely on the user's own experience and familiarity with the context, including any individuals that might have provided data with in the system. This is suboptimal in general and becomes more severe the larger the project in question is.

2) Solution: The rights management needs to provide an account system that allows to assign different user roles and levels of expertise within each role. The accounts are then coded (e.g., via colors and/or acronyms) to allow quick information regarding:

1) Type (human or other system)
2) Role
3) Level of expertise

Item 1 can be handled indirectly by assigning no user account, role, or expertise information to anything that was automatically generated or imported from a different system. This means that in the eventual output, the user can quickly see where the data came from via the presence or absence of any user account indicators.

Item 2 is addressed by simply defining the appropriate number of roles within the context. These need to be set specific to the individual context and type of the project. Examples for such roles within the construction context are project manager, site manager, foreman, (shift) supervisor, etc.

Item 3 is addressed by further defining levels of expertise for each role. This pattern proposes a simple 3-level-system based on two metrics. This allows a comparably easy definition of levels by defining one threshold for each metric, then assigning the level of expertise based on whether both, one, or none of the thresholds are exceeded.

Figure 1. Example for seller reputation information from *Amazon*.

For example, within a project, there can and probably will be a role "project manager". For this role, the metrics could be defined as years of experience in the field (*M1*) and average size of previously managed projects ((*M2*). For both metrics, an expertise threshold is defined (e.g., 6 years for *M1*, EUR 300.000 for *M2*. If the threshold is exceeded, high expertise is assumed. Assuming a three-level-system with *L1* being the lowest and *L3* being the highest level of expertise, the user will be assigned *L1* if no threshold is exceeded, *L2* if the threshold in *M1* or *M2* is exceeded (but not the other, and *L3* if both thresholds are exceeded

Figure 3 provides an illustrative overview of such an account hierarchy and a suggestion for highlighting roles and levels via color coding in the eventual output. Note that Roles can also be entirely denoted via acronyms (e.g., 'PM' for 'project manager', 'SV' for 'supervisor', etc.) with one single color in different levels of brightness/saturation to donate the levels. This can be used to avoid color overload when working with a large volume of users and user roles.

3) Examples: This solution is strongly related to the following UI solutions, which address a similar problem space:

Seller-trustworthiness indicators on e-commerce sites. E-commerce sites that support re-selling on their platform (e.g., *Amazon*, cf. Figure 1) have the need to show indicators for the level of trustworthiness of the different individual sellers. Typical solutions here are to provide ratings by past customers, rank the sellers based on these ratings, and to provide historic and meta information (sales history, number of complaints, etc.)

Reputation indicators on expert-forums. In a similar manner, expert help forums, such as e.g., on *stack overflow* (cf. Figure 2) have the need to indicate the level of expertise of an individual user in order to provide context for the interpretation of the answer to a question. *Stack overflow* for example uses an elaborated reputation system based on scores, tags, and badges.

Skill endorsements on business networks (e.g., *LinkedIn*) or knowledge management systems. Also related is the possibility to endorse other users in a network for a specific skill, thereby providing valuable background information and social proof.

B. Draft Pattern 2: Reliability through Recency

This pattern describes a solution to communicate reliability through highlighting the temporal discrepancy between when data was first collected versus when it was entered into the system.

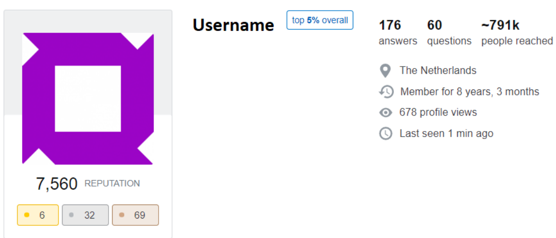

Figure 2. Example for expert reputation information from *stack overflow*.

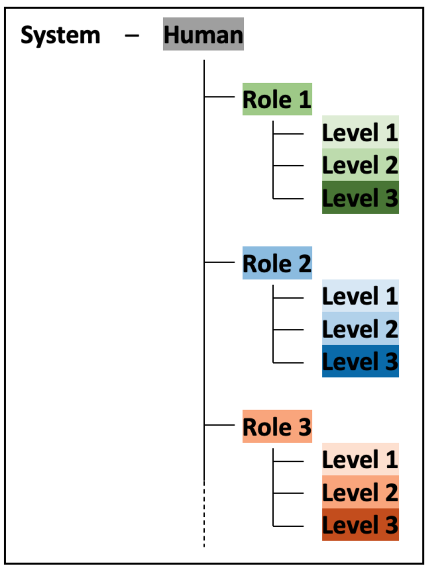

Figure 3. Overview of account hierarchy. User roles are further divided into three levels of expertise. Color coding allows distinction at a glance.

1) Problem: The more distant events are, the more difficult they are to retrace for any individual who was involved with them. As a result, written accounts, receipts, etc. become more important information carriers the more time has passed. Conversely, if the information available via documentation is incomplete, inaccurate, or otherwise insufficient, it becomes more difficult to correct such deficiencies, as additional documentation – if it had been available in the first place – might have been lost, archived, or otherwise hard to access. In addition, individuals who were involved in whichever activity that supplied the relevant data might no longer remember specifics that could have helped to detect or correct inaccuracies or supply missing information. Thus, it becomes necessary to distinguish data that was entered in time from data that was entered delayed, which is usually not supported by default.

2) Solution: The solution consists capturing and visualizing the temporal distance between data collection/availability and entry into the System. Upon entry, each data item is flagged with the date on which it was entered. In addition, each item requires an additional field in which the date of initial data collection or availability is entered. What is to be entered here depends on the documentation and data item but examples here are: billing date for invoices, market date for price estimates (e.g., price per barrel of raw oil at [day]), or the signature date for protocols.

Based on the hypothesis, that the closer these dates match, the more reliable the data is, reliability thresholds can be defined. This solution proposes a simple three-level system, which then corresponds to standard color coding via the traffic light metaphor (red-yellow-green). Level **red** denotes data that was entered late, level **green** denotes data that was entered in time. Level **yellow** can be used to flag entries that were not entered immediately but also without significant delay – e.g, everything that is entered within one week is flagged green, within two weeks yellow, and everything beyond two weeks in red.

This way, delayed entries can be spotted at a glance and the reliability (or lack thereof) of individual items can be spotted at a glance. The delay-level of each entry can be easily visualized by simply showing the date fields and highlighting them in the appropriate color. In order to avoid visual overload, green level entries can be left unhighlighted with only level yellow and red ones being highlighted, as these are the more critical ones. In addition to the color coding, a numerical indicator of elapsed time (e.g., "xx days past") can be added.

As a direct consequence of requiring two dates for each item, this solution is only applicable to data items that can be associated with *documented* dates that are not identical with the entry dates by default.

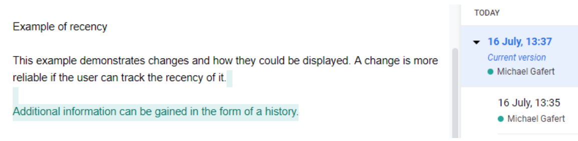

Figure 4. *Google Docs*'s version history. Each user has a unique color and changes are categorised by timestamps.

3) Examples: Many text editing tools offer some kind of version history or version control to provide a sense of recency. *Google Docs*, for example, offers a simple version control depicted in Figure 4. Each continuously written text is tagged with a timestamp and the user who edited it.

A more advanced version control is offered by *GIT* [22]. Only specific users can change files and each change must be described in form of a commit message. Once a change is committed it will be added to the history. *GitHub*, a website implementing *GIT*, offers the ability to view these commits and their corresponding changes. Each change is marked (addition: green, deletion: red) in the corresponding file (see Figure 5).

WebStorm, an IDE (Integrated Development Environment) for developing *JavaScript* applications [23], also has the ability to display *GIT* commit messages. Instead of focusing on commits and their changes, it focuses on the files itself. Figure 6 shows that each line of code has an annotation with linked name and date. These values are extracted from the history and displayed alongside the file. Each user and timestamp have a different associated color and can therefor be differentiated.

C. Pattern Draft 3: Reliability through Penalties

This pattern describes a solution to convey reliability by associating data entries with information regarding whether the entry is tied to a monetary penalty or not.

1) Problem: Especially in larger projects, the level of care taken when reporting and resulting level of detail in reported

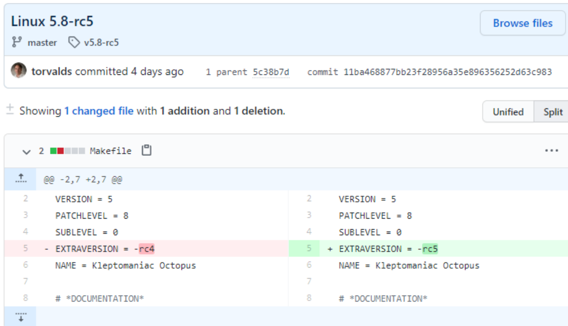

Figure 5. *GitHub's* commit overview with one addition marked green and a corresponding commit message. Excerpt from the Linux Kernel GitHub Page.

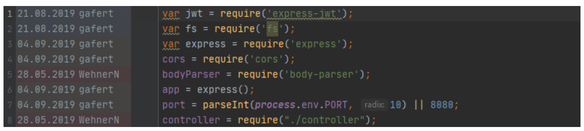

Figure 6. *WebStorm's* annotations display which user changed what line of code and marks it with a timestamp.

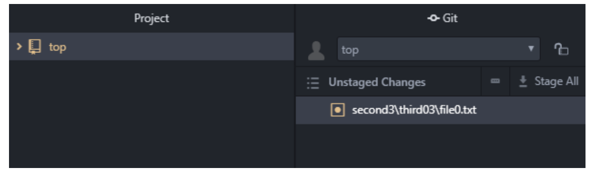

Figure 7. Screenshot of the *Atom* text editor with *GIT* integration. The top item of the tree view (left) is colored orange as items inside the tree have uncommitted changes. All changed items are also visible as a list on the right.

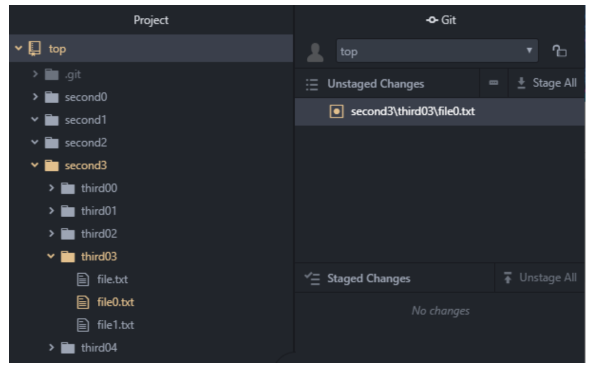

Figure 8. *Atom* text editor with open tree view. The orange marked items can be followed along to the changed item.

data can vary greatly between different stakeholder organizations as well as individuals within these organizations. This can be a result of different levels of interest and involvement between stakeholders in the project but also different degrees of repercussions in case results are not delivered at all or not in a timely (or otherwise satisfactory) manner. Depending on the level of interest/involvement and how close an individual's or organization's goal match the goals of the overall project, the more reliable can their input assumed to be. Such information, however, usually relies on personal knowledge and experience and is usually not captured within process or other management systems.

2) Solution: Contractually stipulated monetary penalties can be clearly traced and captured within a system. Whenever a data item or data set is associated with such a penalty, a visual indicator is added to show this (e.g., fulfilment of delivery is associated with a penalty in case of delays; data item date of delivery then shows a penalty indicator). Such an indicator can be a simple icon or text-based indicator and can operate in a binary fashion: if the indicator is present, then a penalty is attached to the data; otherwise, there is not. Since the presence of penalties can be a reliability indicator not only for individual data items or sets but also indicative of reliability within the entire project, including such indicators in hierarchical tree views is recommended. A top-level indicator shows whether there are any penalties in the project at all. Clicking on the top-level indicator expands all trees to the elements that are associated with penalties and highlights them. This provides both a high-level and lower-level reliability indicators as well as quick and efficient access to the latter.

3) Examples: Such hierarchical tree views are common in applications which have some kind of folder management. The text editor *Atom* [24] can forward tagged files in sub-directories up to the root node of the folder structure. The top-level in Figure 7 shows a root node called "top". It is marked orange because of a tag in a sub-directory. In this example the file is tagged because it was changed. The root cause of the tag can however be different as a later example will show. The tagged object can also be viewed as a list (see right side of Figure 7). If the top node is opened the full tree view is shown, which is depicted in Figure 8. The tag of one file is passed along each directory until it reaches the root node which in turn can then be used as a top-level indicator of all objects below.

V. Discussion, Conclusion, and Future Work

We were able to address RQ1 with the requirements identified in Section III-C, and begin to address RQ2 with the draft patterns in Section IV. We found reliability-relevant information in the BIM context to encompass a wide range of aspects, of which we could highlight three with varying degrees of context-specificity. While hierarchical rights management with different user roles has a wide application, the same cannot be said about penalty indicators. While the former can be re-applied in any context, where expertise levels can be defined (and are assumed to be reliability-relevant), the latter can only be used when penalties are part of the project *and* are captured in the system. Recency indicators can be expected to be used in a larger number of contexts, as timely fulfillment is usually a factor in most projects or undertakings. However, that factor can only be applied to data items to which dates can be assigned (invoices, protocols, etc.), which might cover only a fraction of the data a user is interacting with through a management system.

One additional question that is relevant for how to design reliability indicators, is how or if reliability-relevant data should be highlighted or hidden. It would seem obvious that relevant information should be highlighted, this might not necessarily be the default for reliability indicators. Taking the penalty-indicators as an example, these indicators would highlight any item that has a penalty attached to it. However, as we learned from the experts, the presence of a penalty reduces the likelihood of that data being incorrect and increases reliability as a result. If the user is looking for potential errors, then he/she would need to look at the exact opposite, viz. data without attached penalties. Depending on how many penalties are present, switching the behaviour to highlighting all data without penalties by default, might not be a good solution either. If most data items are without penalty, then such a solution would quickly cause visual overload and be ineffective as a result. In the end, it will be difficult to impossible do define a default that works for all contexts and the behaviour will need to be toggleable on the user's end.

In general, a higher level of detail and more solutions are required to solidify the basis for reliability displays in process management and for the BIM context. In future work, we intend to generate full patterns from the drafts laid out in this paper and extend the quantity of patterns to cover additional expert requirements. In particular, the expertise-influencing factors for defining the user roles need to be identified more clearly, data types and how recency can be established needs to be clarified, and we want to further look into penalties and whether a more precise metric (one that includes the penalty amount) is required.

In this paper, we presented an approach towards designing reliability indicators for process management in the BIM context. We generated three draft design patterns, which serve as a basis for continued efforts to introduce reliability indicators into interfaces, where information reliability is paramount. By using a pattern approach, the pool of available knowledge can be continually extended as new working solutions are developed and discovered. Thus, we also want to encourage the community to contribute to the growing field of reliability displays not just within BIM but across application areas and contexts as well.

ACKNOWLEDGMENT

The financial support by the Austrian Research Promotion Agency (FFG) under grant number 878796 (Project: CALIBRaiTE) is gratefully acknowledged. The authors thank Christian Bechinie for his support in preparing this publication.

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