Design Patterns for Board-Based Collaborative Work Management Tools

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Abstract. Board-based software tools for managing collaborative work (e.g. Trello or Microsoft Planner) are highly configurable information systems. Their structure is based on boards that contain cards organized in lists. This structure allows users to organize a wide variety of formal or informal information and work processes in a very flexible way. However, this flexibility means that in every situation the user is required to make decisions to design a new board from scratch, which is not a straightforward task, specially if performed by non-technical users. In this paper, we carried out a study following an inductive approach consisting of analyzing 91 Trello board designs from both research works and board templates proposed by Trello users, which cover a wide variety of domains and use cases. The result is twofold. First, we propose a metamodel for designing boards that takes into account not only the structure of the board but also other decisions like the type of information cards manage and behavioural aspects of how cards flow. Second, we use this metamodel to identify and characterize 8 patterns that are commonly used in board designs. These results, applicable to all board-based tools, provide insights that can be useful for users to design solutions more effectively and efficiently and help us to better understand the roles that these information systems may play in the current enterprise information systems ecosystem.

Keywords: Collaborative work · Design patterns · Digital transformation · Kanban-based software

1 Introduction

Board-based collaborative work management tools, like Trello, Asana or Planner[1], are largely spreading as a way to organize a wide variety of formal

[1] https://trello.com, https://asana.com, https://tasks.office.com/.

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or informal information and work processes. These tools allow creating boards where users can add information or actions in form of cards and distribute them into compartments or columns usually called lists or buckets. Depending on the tool, the user can also add labels, descriptions or due dates to cards, assign cards to certain users or define checklists inside cards.

The main purpose with which these tools have been conceived is to manage collaborative tasks. Nevertheless, as shown in the existing literature, their use expands to other scenarios like sharing knowledge, managing shared informal processes or representing shared schedules [2,6,7,10–12,14,15,17]. These different uses are possible because of the different meanings that lists and cards can be given in each board as well as the different ways they can be used (e.g. how cards can be moved between lists). The use of these tools can be divided into two phases. The first one is the board design phase, which involves, first, making decisions about how the board should be used and the meaning of lists and cards, and second, defining an initial set of lists and maybe cards. Once the board is designed, then the board execution phase begins. This phase involves using the board for the predetermined purpose usually by adding, removing or moving cards between lists.

Designing boards is not a straightforward task, specially if it is performed by non-technical users, as commonly occurs in these tools. In an attempt to give support in this endeavour, many of these tools provide the possibility of reusing board designs for specific tasks like human resources onboarding, or SCRUM-based project management by defining board templates or reusing previous boards[2]. All of the research performed around these tools has also been focused on this direction and details reusable board designs that solve specific problems [2,6,11,14,15,17].

In this paper, instead, we want to analyze these tools from a broader perspective. Our goal is to analyze the different purposes for which these tools are used and to characterize the main principles and decisions that lay behind the board designs used for each purpose.

To do so, we carried out a study following an inductive approach analyzing both, the existing literature and the 91 board templates proposed by Trello users that were available when this analysis was made[3] and that cover a wide variety of domains and use cases. As a result, we present a twofold contribution. First, we propose a metamodel for defining board designs that goes beyond the well-known structure of boards, lists and cards, and makes most of the main decisions made during board design explicit. Second, using the proposed metamodel, we identify and characterize a catalogue of 8 patterns of board design. All the board designs of the templates analyzed fit at least in one of these 8 patterns.

These results provide valuable insights for both research and practice. Concerning the former, the metamodel makes it explicit design decisions about the use of these tools that are currently implicit. This opens up new possibilities to reason about them and to provide a more automated support to the design and

[2] For instance, https://trello.com/templates or https://asana.com/uses.
[3] Their number at https://trello.com/templates is constantly growing.

execution phases. As for the latter, by relying on the well-grounded notion of patterns as a way to promote reuse, we provide a tool that can help users to design boards more effectively and efficiently since much of the knowledge that used to be spread over a catalogue of 91 domain-specific templates is now synthesized into 8 domain-independent patterns. Furthermore, they give hints on the different roles these information systems can play or the different ways they can be used to address challenges on current enterprise information systems [18].

The rest of the paper is organized as follows. Section 2 introduces some background and discusses related work. The metamodel is presented in Sect. 3 and the catalog of board design patterns is described in Sect. 4. Section 5 discusses the application of the identified patterns in the analyzed templates. Finally, Sect. 6 concludes the paper, provides the implications for research and practice and describes the main limitations identified as well as proposes some future research directions to address some of them.

2 Background and Related Work

The initial idea of board-based collaborative work management tools like Trello, Assana or Planner bases on the principles of Kanban, a method of visualizing workflows to provide an overview of a project from start to finish. To do so, they provide three main elements: boards, lists, and cards. According to this common use of these tools, for each project, like the production of an article, a corresponding board is created. Each board includes a set of lists that may, for example, indicate the progress of a project. Finally, lists contain cards that hold information on a specific task. Figure 1 shows a screenshot of Trello of such a board. Many of these tools also provide other elements such as people, labels, due dates, or checklists that can be assigned to cards.

Besides the static structure, a relevant aspect of a board is how to use it. Commonly, cards are moved from list to list while the board is used. The meaning of moving a card from one list to another depends on the board. For instance, in a board like the one in the example, a card is moved when completed. But other behaviors are also possible.

The use of a board can be divided into two phases, namely: board design and board execution. During board design decisions about the static structure, the dynamic use, and the meaning of the different elements (lists and cards) are made based on the purpose the board is intended to have. In our example, this

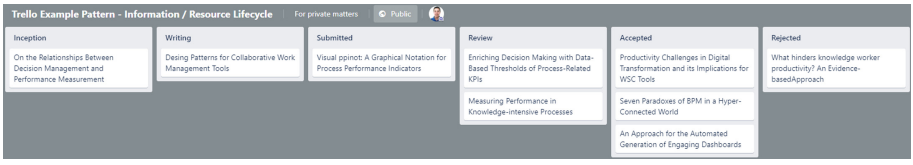

Fig. 1. Screenshot of a Trello board of an article production.

involves deciding that cards represent papers, lists represent states of the paper, and moving a paper from one list to another represents transitioning the paper from one state to another. It also involves deciding and creating the lists that represent each of the states of the paper.

During board execution, the board is used based on the decisions made during design. This involves adding, removing, editing, or moving cards. Also, depending on the features of the tool, the use includes assigning people to cards, adding or completing checklists, or defining due dates amongst others. In our example, this involves creating cards as new papers come into our pipeline, and moving them throughout the different lists until reaching the "Accepted" list, hopefully, or "Rejected" in the worst case.

In recent years, a large number of research that report on the use of Trello in different domains, from education or libraries to software development has been published [10–12,14,15,17]. In this research body, it is quite common that authors propose a board design to model a solution to a specific problem:

We can find Kanban-based solutions in the context of education and libraries like in [14,15,17], board designs for SCRUM agile methodology [12,15], or other solutions specific to certain domains like an editorial calendar [6] or a farm [2].

This need to provide a board design to specific problems avoiding to start from scratch every time has also been identified at a practical level. Trello provides a set of public templates categorized according to different domains (like personal, business, or education) and scenarios (like wedding planning, new year resolutions or book club inside of the personal domain)[4]. Many of them are actually proposals by users of Trello. However, a template is just a board that includes a set of predefined lists and may include some predefined cards either to illustrate the use of the board or to provide some information that is reused between boards. It also includes a description in natural language that explains how the boards copied from it should be used (e.g. how cards should move between lists). To the best of our knowledge, none of the existing tools of this type allows the definition of the way to use a specific type of board in a structured and systematic manner.

Unlike existing research, the goal of this paper is not to propose a specific board design, but to identify and characterize which are the patterns that commonly appear in these designs. According to [5], "Patterns, in general, are vehicles for encapsulating knowledge. They are considered one of the most effective means for naming, organizing, and reasoning about design knowledge" in the broader sense of Design knowledge. The concept of patterns has been widely applied and has proven to be useful in a multitude of different domains. In the software development domain, the roots can be found in the well-known analysis [8] and design patterns [9], but they have spread to many other related domains like patterns for different perspectives of business processes: control-flow [1], data [21], resources [20], performance [19], or compliance [23], ontology patterns [5], or organizational patterns for B2B environments [13], to name a few.

[4] https://trello.com/templates shows the current existing templates.

We aim to apply the same concept of pattern for the creation of board designs, based on an analysis performed on the common use of Trello. Actually, it would also be applicable to other similar tools. To the best of our knowledge, there exists no previous work in this direction.

3 A Metamodel for Board Design

Before describing the patterns for designing boards, we first need to characterize which are the main elements of a board design. We do that by means of the metamodel for board design, shown in Fig. 2. We have obtained this metamodel based on our analysis of both the research papers mentioned in the related work [2,6,10–12,14,15,17] and the board design of the templates provided by Trello. To do so, we first developed a web scrapper that extracted the main information (template name, description, link) about the 91 board templates proposed by Trello users available at that moment (early 2020) and collected it into an Excel stylesheet. Three researchers from the author team analyzed the collected data and aimed to recognize different aspects that could help to identify categories among the templates. The aspects considered by these researchers, especially the use of Trello features like lists, cards, or labels, were different from one to another. They then decided to perform the categorization according to the use of the basic features that are common to all board-based tools, i.e. boards, lists, and cards, ignoring other features that may be specific to Trello. This resulted in a first version of the metamodel as well as a first categorization of the board templates. Unfortunately, not all templates fit into the defined categories. Therefore, another round was necessary. In this final round, not only the template static structure used in the previous round, but also its behaviour, i.e. the dynamic use and the meaning of the different elements of the board, were taken into account. This yielded the metamodel we present here as well as the catalog of 8 patterns described in Sect. 4. In this case, the categorization covered all the templates analyzed, the 91 Trello templates as well as the templates proposed in the analyzed related literature. Note that both the metamodel and the patterns are general and applicable to all board-based tools. In the following, we describe the metamodel in detail.

The static structure of a board design is modelled by means of three elements: `Board`, `List` and `Default card`. A `Board` represents the panel in which lists and cards are contained. `Boards` are composed by an ordered set of `Lists`, which are the divisions of the boards in the different containers where we will stock the content. `Lists` are also known as "buckets" or "columns," depending on the nomenclature. The order of the lists represents the visual order in which they appear in the board from left to right. Finally, `Default Cards` represent the content that appears on the lists, also visually ordered. We use the term `Default card` instead of just `Card` to emphasize the fact that we are modelling a board design with a predefined set of cards, and they do not refer to the cards that will be added to the board during its execution phase.

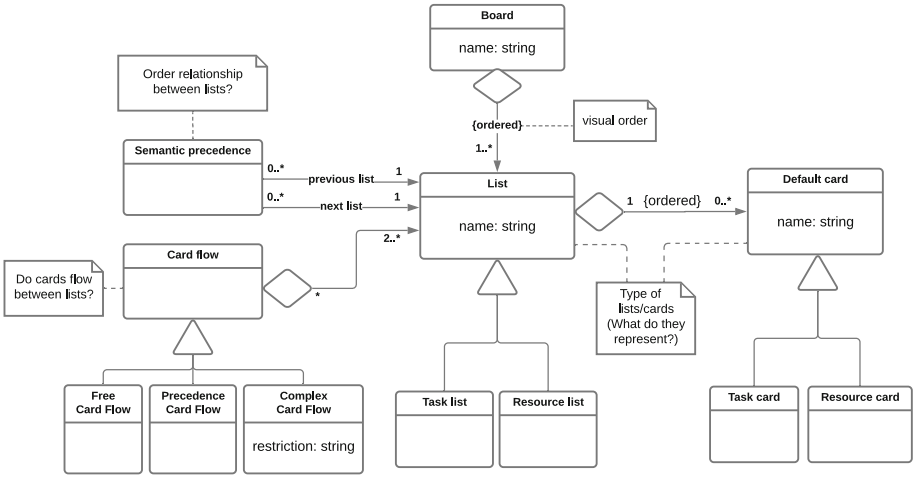

Fig. 2. A metamodel for board designs

However, as we have mentioned before, a board design is not only the static structure. All board designs that appear in templates include additional information collected in natural language about their semantics and how they should be used. Particularly, it is interesting to note how the meaning of cards and their possible behaviour varies from one design to another. While in some of them cards are conceived as tasks or work items, in others, they represent pieces of information or resources. In some cases, cards flow among lists, while in others cards always stay in the same list. Finally, in some cases there is an implicit order relationship between lists (e.g. if lists represent states of a lifecycle), whereas in others this relationship does not exist (e.g. if lists represent people or groups of people). These three elements together characterize how a board design must be used and are included in the metamodel as follows.

Based on the analysis performed, the meaning of cards can be divided into two broad categories. On the one hand, cards may represent tasks or work items. We use the term work item with the same meaning as in [20]. They represent an action or activity and its name (if it is well defined) is usually a verb. On the other hand, cards may also represent resources or, in general, pieces of information. In this case, their name is usually a noun. An example of this type of card can be found in the example of Fig. 1, where a card represents a publication. These two types of cards are represented in the metamodel by means of classes `Task card` and `Resource card` respectively.

Furthermore, the analysis also shows that all lists collect cards of the same type either tasks or resources. For this reason, we also apply the same categorization to lists. A `Task List` is a list that only contains task cards. Similarly, a `Resources List` is a list that only contains resources cards.

The second aspect that characterizes board designs is whether there exists an order relationship between lists. Inspired by the approach followed by BPMN

with the sequence flow definition in its metamodel, this is modeled by means of a class called `Semantic Precedence`. When we say that there is semantic precedence between two lists in a board we are specifying that there is some high-level connection between them, besides their visual representation. For example, we can have an order relationship between the phases of a project (requirements before execution), the states of a task lifecycle (doing before done), or just numeric order (day 1 before day 2).

As we discuss in the following section, having an order relationship between two lists does not mean that cards can be moved between them. Therefore, it is necessary an additional concept to specify the lists among which cards can flow, namely class `Card flow`. This class specifies the set of lists between which cards can flow. The meaning of a card flowing between lists depends on the specific board. For instance, a board in which lists represent people and cards are tasks, moving a card from one list to another means assigning a task to a person. Instead, a board in which lists represent states and cards are resources, moving a card from one list to another means changing the state of the resource. Another example with precedence but without flow is cascade software project, where lists represent states (requirement, analysis, etc.) and cards tasks to be done in every step; cards don't flow between phases, but there is an order between them. A board may also have several card flows, for instance, because it contains different types of lists: some containing information and others containing tasks.

Besides specifying that cards flow between a set of lists, we can also specify if there is any restriction about this card flow. In this paper, we define three different types of restrictions:

- `Free Card Flow`: Cards can move between lists without any type of restriction. For example, cards can move back to previous lists, or they can skip some intermediate list.
- `Precedence Card Flow`: Cards can only flow through the buckets following the precedence detailed in the semantic precedence item previously described. For example, if the semantic precedence represents numeric order, cards will be only allowed to move following that order (cards cannot move from list 2 to list 1, for example).
- `Complex Card Flow`: The movement of cards between lists is restricted by some criteria that must be specified (see restriction item in the metamodel). For example, a complex card flow could allow the movement of cards following a rule different to (and more complex than) the semantic precedence. Another example is to specify that a card cannot be moved into a list if there are more than n cards in that list already. Inspired by the approach followed by BPMN to define complex gateways, the metamodel does not provide any specific detail about how this complex card flow can be defined. However, we envision that a language (or several languages) to model this kind of relationship could be defined.

The restrictions specified in the card flow can also be hard or soft. Restrictions are hard if the tool actually prevents moving the card if they are not followed. Instead, restrictions are soft if restrictions are understood as recommendations.

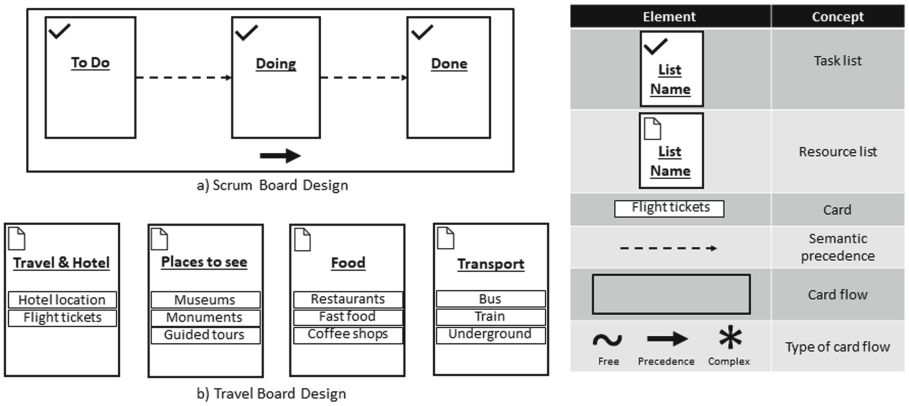

Fig. 3. Examples of board designs modelled using the metamodel

In this case, the tool allows the user to move the cards to any list regardless of the restrictions and it is the user the one who should enforce them. Trello, for instance, does not allow the definition of hard card flows. It is also important to note that a tool might provide some mechanisms to notify the user in case a soft restriction has not been met.

We are going to illustrate how this metamodel can be used to model board designs by means of two examples. Figure 3.a shows a Scrum board design that models three possible states of a project task ("To Do", "Doing" and "Done") by means of three `Lists` (depicted as rectangles). They are `Task lists` because they store cards that represent tasks. We represent it with a tick in the upper-left corner of each list. In this board, there is clearly a `Semantic precedence` defined between "To Do" and "Doing", and between "Doing" and "Done." This is depicted by means of a dashed arrow that links the two corresponding lists. Finally, when using the board, cards will move between the lists to signal that we have started performing a task (move from "To Do" to "Doing") and that we have finished a task (move from "Doing" to "Done"). Therefore, there is a `Card flow` between the three lists, which is represented by means of a rectangle that groups them. An icon at the bottom of the rectangle indicates the type of `Card Flow`, which can be either free, precedence, or complex (represented by a tilde, an arrow , or an asterisk, respectively). In this case, the movement will be according to the semantic precedence defined by the context of the problem.

The second example (Fig. 3.b) depicts a board design to organize information related to a trip. There are four lists ("Travel & Hotel", "Places to see", "Food", and "Transport") that contain information or resources, as indicated by the document icon in the upper left corner of each list. In this case, lists are independent of each other, so there is no semantic precedence between them. Furthermore, cards do not flow between lists. Instead, this board design includes some default cards as examples of the information that can be added in two of the four lists ("Places to see" and "Transport"). They are represented by means of rectangles inside the list.

It is important to note that, except for the name of the lists and the default cards contained in them, all the information about the board designs described above is currently specified in natural language in the description of the template or some predefined cards with information about how to use the board. Therefore, one advantage of the metamodel is that it makes this information explicit in a structured way, and hence, it can be used as a foundation to automate parts of its management like the card flow.

4 Patterns for Board Design

After analyzing the board designs of the templates using the elements defined in the metamodel, we have identified 8 different patterns that repeat across them (summarized in Table 1). These patterns represent different ways of designing the lists of a board (or a subset of them) based on the elements of the metamodel. Like all patterns, several of them can be used together on the same board. The patterns are characterized by the three elements of the metamodel related to the semantics of the cards and how they should be used, namely: what cards represent in `Lists` (column *List/Card type* of Table 1) i.e. tasks (`Task list`) or information or resources (`Resource list`); whether there is semantic precedence relationship between lists (column *Semant. prec.*), and whether cards flow between lists (column *Card flow*). A full pattern description template for each pattern can be found at [16] and at http://www.collaborativetoolspatterns.org. Each pattern includes a description of the problem, a detailed motivation, a graphical representation of the pattern, real examples (Trello templates) where the pattern is used, and a discussion of related patterns. In the following we briefly describe each of these eight patterns.

- ***Information/Resource Lifecycle.*** **Problem:** Managing the lifecycle of several resources and to know in which step every resource is. **Solution:** Lists represent sequenced and ordered steps or states to follow, and the cards, which represent the resources, flow between them. Each card can also contain additional information about the resource. This information can change as the card passes through the different lists. **Example:** The publication lifecycle described in Fig. 1, where cards represent publications and the lists are the states publications go through. Another example is a human resource boarding process.
- ***Ordered/Structured Information.*** **Problem:** Organizing information in lists that follow some kind of sorting criteria. **Solution:** Cards represent pieces of information and lists represent the topics used to organize these pieces of information. These topics have some order relationship between them according to some criteria. Cards do not change their topic over time (i.e., cards do not flow). For this reason, this pattern is commonly used to publish information to others. **Example:** A board that publishes information to the students about the syllabus of a course. Each list represents a topic covered by the course organized by the temporal sequence in which they are taught and each card represents a piece of information regarding that topic.

Table 1. 8 patterns description table

Pattern	Problem	List/Card type	Semant. prec.	Card flow	Trello template examples	# Tot.	# Pure	# Comb.
Information/ Resources Lifecycle	Management of the lifecycle of several resources at the same time	Resource	Yes	Yes	“Bike Repair Pipeline” “Customer Success Board”	23	23	0
Ordered Information	Organize information in lists that follow some kind of sorting criteria	Resource	Yes	No	“Annual Email Marketing Calendar” “Freelance Branding Project”	12	11	1
Kanban	Manage tasks, handling how they evolve, and monitor them	Task	Yes	Yes	“Planning Your Day” “Kanban Template”	31	19	12
Process Tasks	Provide a sequenced task guide, divided according to the different stages that make up the project	Task	Yes	No	“Design Sprint” “Project Based Learning”	8	5	3
Assigned Information / Resources	Organize information or resources whose classification could change over time	Resource	No	Yes	“Book Clubs” “Setlist Organizer”	2	2	0
Categorized Information	Categorize information by any criteria, but unlike in the previous pattern, information does not change its category over time	Resource	No	No	“Align Your Team With V2MOM” “Customer Support Knowledge Base”	31	21	10
Assigned Tasks	Manage multiple tasks by changing the container to which it belongs, usually to represent that the task is assigned to one person or another	Task	No	Yes	“Team Tasks (5 Things Workflow)”	1	1	0
Categorized Tasks	Manage multiple to-do lists	Task	No	No	“8 Creative Habits” “Personal and Work Goals”	4	4	0

- ***Kanban.*** **Problem:** Managing tasks, handling how they evolve, and monitoring them. **Solution:** Cards represent tasks and lists represent different states in which tasks can be. Therefore, it allows one to control and easily know the status of each task at any given moment. **Example:** A board with three lists "To Do", "Doing," and "Done" as the one used in Fig. 3.a. However, more advanced lifecycles for tasks can be used that includes states like allocated, started, suspended, or failed as discussed in [20].
- ***Process Tasks.*** **Problem:** Providing a sequenced task guide, divided according to the different stages that make up the project. **Solution:** Lists represent ordered stages of a project and cards represent tasks to complete at each stage of the project. Therefore, cards do not flow. When all tasks of all stages are completed, the project will be finished. **Example:** A waterfall engineering process where we have lists for requirements, analysis, etc. and cards for the tasks to be done in each stage.
- ***Assigned Information/Resources.*** **Problem**: To organize information or resources whose classification could change over time. **Solution:** Cards represent pieces of information or resources and lists represent categories that group them. These categories do not have any order relationship between them and cards can flow between lists. **Example:** If lists represent work departments and cards represent employees, we can use this pattern to represent and manage the structure of an organization. In it, cards moving to a different list could happen if employees change their departments
- ***Categorized Information.*** **Problem:** Categorizing information by any criteria, but unlike in the previous case, information does not change its category over time. **Solution:** Cards represent pieces of information and lists represent categories used to group them. These categories are independent of each other, i.e. there is no ordering relationship between them, and cards do not flow between lists. **Example:** A board that works like a school notebook, where lists are subjects and in each of them, we will stock cards that represent the different notes (text) of that subject. In a work context, lists could represent, for instance, projects. This is also the pattern used in the example of a travel board design of Fig. 3.b.
- ***Assigned Tasks.*** **Problem:** Managing multiple tasks by changing the list to which it belongs, usually to represent that the task is assigned to one person or another. **Solution:** Cards represent tasks and lists represent a resource to which tasks are assigned. Cards flow to change task assignment. **Example:** Each list represents an employee and contains her assigned tasks. When she finishes her part of the task, it will flow to another employee that will continue working on the same task.
- ***Categorized Tasks.*** **Problem:** Managing multiple to-do lists. **Solution:** Cards represent tasks that are assigned to a specific list according to the criteria defined by the problem context. For example, task duration, project to which it belongs, or deadline date. Lists are independent of each other and cards do not flow between them. **Example:** A typical set of to-do lists, where each list groups tasks by the context in which they have to be done (e.g., at the phone, at work, at home, at the computer) as proposed by a personal productivity methodology like Getting Things Done [3].

A conclusion of this description is that, in several cases, two different patterns can serve to represent the same information, but emphasizing different aspects depending on the use case the user wants to highlight. For instance, both Kanban and Assigned Tasks are useful to collaboratively manage a set of tasks. However, Kanban is better if you want to have an overview of the global state of all tasks (for instance, if the tasks are complex and need to go through lots of different states), and Assigned Tasks is better if you want to focus on who has each task assigned and if the workload of all members of the team is balanced (the longer the list, the higher the workload). A detailed discussion on the relationships between patterns can be found in the pattern description templates that are available in [16].

5 Application of Patterns in the Templates

All 8 patterns identified have been found applied in practice in different domains in at least one Trello template proposed in the 91 templates analyzed. The details about this classification can be found at [16]. Table 1 summarizes this information. Column *Trello Template Examples* includes a couple of Trello templates in which each pattern is used. Columns *# Tot.*, *# Pure*, and *# Comb.* refer to the total number of times each pattern is found in the board design of the templates, the number of times each pattern is the only one found, and the number of times each pattern is found combined with another pattern, respectively.

A first conclusion of the analysis is that each pattern appears in the templates applied to different domains, which shows how they are generalized solutions that can be applied to a variety of specific domains. For example, as shown in the previous section, the Process Tasks pattern can be used in the software engineering domain for modelling a waterfall process, but it is also used in the template "Design Sprint" to represent a graphical design process.

Another conclusion is that there are three patterns that appear with a much higher frequency than the others. Two of them, Kanban and Information Lifecycle, represent the typical main use case for which board-based tools were initially created. The only difference between them is the meaning of the cards (tasks and information or resources, respectively). For this reason, it is not surprising that together they appear in almost half of the board designs. The case of the Categorized Information pattern, which is the other one, is more interesting. Our hypothesis is that once you have a Kanban-based board, you may find it useful to have a place to share relevant information using the same tool that is already used for managing the tasks. This is implemented using lists for classifying information, which is the purpose of the Categorized Information pattern.

Regarding the other patterns, they are less frequent probably because their purpose differs more from the best-known purpose of board-based tools. In any case, we can find at least one board design in the set of templates analyzed that matches with one of our proposed patterns. We expect that after making explicit this catalog of patterns, some patterns like Assigned Information, Assigned Tasks, or Categorized Tasks (the least used) could increase their use.

Finally, patterns are not mutually exclusive and several of them can be found together in the same board. The analysis performed shows some evidence of this. The most common combination is the Kanban pattern used together with the Categorized Information pattern that occurs 8 times. The reason for combining these two patterns is to have together in the same board the state of the tasks of the project as well as other relevant information to the project.

6 Conclusions and Future Work

In this paper, we analyzed 91 Trello board designs from both research works and board templates proposed by Trello users. Based on this analysis, we presented, first, a metamodel for defining board designs that goes beyond the well-known structure of boards, lists and cards. It makes explicit most of the main decisions made during board design, including the dynamic use and the meaning of the different elements (lists and cards). In addition, using this metamodel and based on the analysis conducted, we identified and characterized a catalog of 8 patterns of board design.

These two results have implications for both research and practice. Regarding the former, our metamodel opens up a range of possibilities. First, it is possible to create an editor of board designs based on the metamodel and the notation illustrated in Fig. 3. Having board designs modelled with the metamodel brings two advantages: (1) it is possible to have a repository of reusable board designs that are independent of the specific board-based tool (Trello, Planner, Asana). Since all of these tools offer APIs to automatically create boards, it is easy to develop a tool that can instantiate these board designs in the tool of your choice, and (2) the metamodel provides a structured way to make explicit information about the design decisions involved in the use of these tools that were up to now implicit or informally explained using natural language (e.g. whether cards should move from one list to another). This means that it can be used as the input of a compliance monitoring tool that automatically notifies (or even enforces) the user if the board is not being used according to the definition of the metamodel (e.g. if the user is moving the card to a list she is not allowed to).

From a practical point of view, the catalog of 8 patterns constitutes an advantageous tool for users to design boards more effectively and efficiently. As it has been proven in many domains, patterns promote reuse, enhance design effectiveness, reduce the errors derived from incomplete or incorrect solutions, and speed up the development process, avoiding the need to reinvent the wheel [4,22]. In our context, we now provide in 8 patterns information that was spread over 91 templates. Furthermore, there is a relevant difference between patterns and templates. Like two organizations need to adapt their processes and information systems to the way they work, the same applies to board designs derived from some pre-existing template. The knowledge of board-based patterns can help organizations customize these boards to their needs even if the starting point of the board is a Trello template. For instance, organizations that use a scrum template that follows the Kanban pattern could be aware that this pattern can

be used together with Categorized Information if they want to include in the same board relevant information about the project. Nevertheless, an empirical study on board-based tools users should be conducted to validate the benefits of using patterns. Finally, the catalog of patterns gives us some hints on the different roles these information systems can play or the different ways in which they can be used in the current enterprise information systems ecosystem.

There are still some limitations to the work presented here. In our approach for defining the metamodel, for the sake of generality, we considered the more basic features offered by all board-based tools (mainly boards, lists, cards, and their order and flow). However, we did not take into account other more advanced features like labels, due dates, or human resource assignments. Considering these features may lead to identify additional patterns. Also, lower-level patterns that provide more specific solutions might be identified. For example, one such pattern could be defined as "in a board where cards are tasks, there could be a predefined list *done* where cards would move once the corresponding tasks are finished." This is a concept similar to what happens in software development, where we have the architectural patterns, and then, at a lower level, the design patterns. This is a clear direction for future work.

Finally, the metamodel and catalog of patterns were obtained from the analysis we conducted. This means that on the one hand, there might be uses of Trello not included in the board templates analyzed and, thus, they are not supported or included in our approach. On the other hand, although our results are valid for all board-based tools, we just analyzed Trello templates, so it could be interesting to see if similar results are found when analyzing templates from other board-based tools. In any case, the two assets provided in this paper could be easily extended when new scenarios were identified.

Verifiability

For the sake of verifiability, all the information required for the replication of our analysis and the detailed pattern catalgoue is available online and can be found at [16].

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