A Canvas Metamodel to Bridging Agile Project Planning and Requirements Engineering

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Abstract. This paper addresses the lack of methodological support for canvas model construction, focusing on the link between project planning and the Requirements Engineering process. To tackle this problem, we present *MM4Canvas*, a metamodel that provides a solid foundation for creating canvas models, facilitating structuring, standardization, and promoting the reuse of models in different projects. We conducted a proof of concept by applying the *MM4Canvas* metamodel to instantiate a general-purpose canvas model for projects, which, in turn, was extended to address the domain of IoT-critical systems with safety and security requirements. The goal is to demonstrate the reuse and extensibility properties promoted by the *MM4Canvas* metamodel and its instances.

Keywords: Canvas · Metamodel · Agile · Planning · Requirements elicitation · Reuse · Safety-critical · IoT

1 Introduction

Planning is a critical step for the success of a project [34], being the object of interest of several studies and with different perspectives, ranging from the proposition of models and tools [2] up to the level of stakeholder involvement [7]. However, many organizations face difficulties in incorporating project planning practices, making it a challenge, especially for those dealing with complex projects and needing to involve diverse stakeholders [26].

Aiming to minimize these difficulties, improve communication and collaboration, and make project planning more practical and understandable compared to traditional approaches, Tezel et al. [29] highlight the growth of visual tools for different contexts and domains of application. This movement originates in the *Lean* approach, which aims to add value to the customer, improve processes, and promote efficiency and continuous improvement [11].

Although project planning is not inherently part of the Requirements Engineering (RE) process, they are closely intertwined [20]. Both project planning and RE necessitates determining and analyzing its scope. Therefore, we begin with the premise that it is beneficial to undertake these activities jointly at the beginning of a project. The connection between planning and RE becomes

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particularly apparent in agile software development contexts, where continuous project planning often aligns with core RE practices [3].

Agile approaches discard long periods of preliminary analysis but recognize the importance of defining project directions and understanding your requirements [4]. In this context, a challenge often faced in practice is finding the balance between agility and efficiency, focusing on artifacts that add value to the project [9, 19]. Project planning and requirements engineering share this concern.

Considering the intersection between project planning and the early activities of the RE process, the outcomes should not directed towards a minutely detailed plan or a requirements specification document. At this stage of the process, such documents could quickly become obsolete. Instead, the focus should be on creating artifacts that steer the project in the right direction and serve as input for the other stages of the process. In this context, the canvas approach has shown promise for the scope definition and capturing essential project information, mainly where collaboration among stakeholders is crucial, contributing to the ease of understanding, analyzing, and communicating ideas visually and effectively.

Currently, the use of canvas is widespread, serving diverse needs and applications in various fields. However, after conducting an ad-hoc study on the different types of canvas, encompassing a series of primary studies, e.g. [4, 27, 28] and a systematic review [30], we highlight the lack of methodological support regarding the construction of these artifacts, which implies problems, such as (i) lack of standardization; (ii) inconsistencies between models within a same domain; (iii) poor understanding of the canvas elements; (iv) difficulties in the reuse or extension of reference models; (v) misuse of general-purpose models for specific application domains; and (vi) poor effectiveness of the models due to one or more preceding cases.

Considering the mentioned issues, this work proposes a metamodel to canvas structuring and methodological support called *MM4Canvas*. The objective of the proposed metamodel is to provide a solid basis for modeling, analysis, development, and maintenance of canvas, promoting standardization, reuse, and the possibility of specialization in a consistent way in different application domains. This metamodel allows the instantiation of canvas models for several purposes, including projects (the focus of this study), business, etc. As a proof of concept, this study employed the *MM4Canvas* to instantiate a reference project model canvas that serves the mutual purpose of project planning and initial RE activities. Furthermore, we reuse and extend this model in a new canvas for support planning and the RE process of IoT-critical systems projects with dependencies on safety and security requirements (SSR).

The structure of this paper is organized as follows: Section 2 presents background on the use of canvas and reference models; Section 3 discusses related work; Section 4 proposes and details the *MM4Canvas* metamodel; Section 5 presents the proof of concept, with by instantiating of two canvas models from *MM4Canvas*; and Section 6 brings our concluding remarks and future work.

Table 1. Fundamental questions and components: BMC and PMC.

Questions	Canvas Type	
	BMC (business-oriented)	PMC (project-oriented)
Why	–	Justifications, Objectives, Benefits
What	Value Propositions	Product, Requirements
Who	Customer Relationships, Customer Segments, Channels	Stakeholders, Team
How	Key Partners, Key Activities, Key Resources	Assumptions, Delivery Groups, Constraints
When	–	Timeline
How much	Cost Structure, Revenue Streams	Risks, Costs

2 Background

A canvas is an artifact for prototyping a mental and visual model applicable to analyzing projects, businesses, or other purposes. As a strategic planning tool, its primary goal is to address fundamental questions related to the object of analysis. Each fundamental question encompasses components – elements that encapsulate and detail essential information according to the type of canvas – forming an interconnected structure to describe the intended subject. Canvas uses logic to build a visual map, helping to organize and define ideas, and must be accessible, viewable, and collaboratively adjustable as required.

As mentioned earlier, the adoption of the canvas approach is becoming more prevalent across various purposes and application domains. Analyzing this scenario, Osterwalder and Pigneur [22] are pioneers in adopting a canvas to describe, through a simplified model, the logic of creation, delivery, and value capture for a given business. The *Business Model Canvas* (BMC) comprises nine key components (Table 1) and has wide acceptance in the business model area. It established the basis for various canvas types developed with the same principles and has been widely adopted as a reference model.

Exploring a more comprehensible and efficient project planning model, Finocchio [5] introduced the *Project Model Canvas* (PMC). While BMC focuses on conceiving new businesses, the PMC offers a novel approach to agile and efficient project planning, incorporating 13 key components tailored for this purpose (Table 1), grounded in project management concepts, with a logical sequence for fill and validation. Furthermore, BMC and PMC group components into fundamental questions presenting different perspectives on the analysis object. These questions derive from the idea of an action plan (5W2H), a set of questions used to compose strategic plans quickly and efficiently [12]. Table 1 compares BMC and PMC, showcasing the fundamental questions used by each canvas type and the components integrated into each question.

Starting from the analysis of the structure of the BMC and the PMC, consolidated canvas models for different purposes (businesses and projects, respectively), we can observe their constructions based on common elements. Both models have components that aim to support the extraction of specific information about the purpose of the analysis performed and are organized into blocks structured clearly and concisely. These components, in turn, in both models are grouped into fundamental issues. Similar behavior was observed in several other canvas models, whether inspired by these two reference models or not.

After examining multiple canvas models, we identified essential and common elements and an opportunity to introduce a generic canvas abstraction. This abstraction, implemented as a metamodel (see Section 4), aims to provide methodological support for instantiating, reusing, and extending various types of models to meet the specific needs of organizations and project teams.

3 Related Work

A well-known benefit of canvas usage is the reduction of complexity without compromising the result's efficiency. However, the static nature of canvas construction often leaves the relationships between its components in the background.

According to [1] a canvas should be seen as a system composed of components, links between components, and dynamics. In this sense, [17] proposes a detail of the BMC elements to create an ontology-based metamodel representing a formal basis for business modeling. The objective is to map the BMC into an open standard modeling language for specifying architectural descriptions and their motivation, ranging from business objectives to technological infrastructure.

The work of [8] proposes an approach that integrates canvas-based analysis with traditional analysis techniques for machine learning (ML). A metamodel defines the relationships between the elements of the different models used in the development of the proposal. This metamodel merges components with the same concept (e.g., "value proposition") into a single component and addresses the safety requirement. Also working metamodeling in the BMC context, Gottschalk et al. [6] propose an approach that uses the functions of a domain expert, a method engineer, and a business developer, together with a repository of method fragments to develop models and another with artifacts to support development.

In brief, the literature presents a series of works that use metamodeling to explore, in different ways, the business-oriented approaches BMC-based. When we analyzed the project-oriented vision, for example, using PMC, despite identifying a series of works that adopt this canvas model, no metamodel proposal or other type of abstraction supports its use for the terminal model's instantiation.

Furthermore, the abstraction models found to refer to domain models (business, ML, etc.), and even though they have an appropriate level of abstraction for these purposes, they are specialized and do not allow the instantiation of canvas models for other purposes and application domains, such as projects in general. In the meantime, we observed the opportunity to propose a generic metamodel for a canvas that offers the necessary methodological support and allows the instantiation, reuse, and extension of models for any purpose, e.g., IoT-critical systems projects, as presented in the proof of concept of this work.

4 The *MM4Canvas* Metamodel

4.1 Methodological path

We adopt Design Science Research (DSR) [23] as the methodological approach due to its problem-solving nature and the systematic creation of artifacts (e.g., models and methods). In this research, we apply the DSR-Model [24], which has three pillars: i) the problem in context, reasoned on the state of the art; behavioral conjectures, based on a theoretical framework; and iii) the proposed artifact, based on the state of the practice, whose conception-driven by conjectures and addresses the problem. From the DSR-Model application, we identified the opportunity to propose a metamodel for canvas methodological support.

Analyzing different types of canvas on the state of practice [22, 5, 4], we identified the essential elements present in all canvas models (e.g., fundamental questions, components, and posts) and the relationships between them (e.g., inheritance, composition, association). By modeling these elements and specifying their relationships, we propose in this article a metamodel that allows their instantiation in general-purpose or application domain models to address different needs.

Another important characteristic for defining the metamodel was the canvas models categorization into (i) general-purpose canvas and (ii) application domain canvas. General-purpose models encompass components generic enough to avoid restricting the canvas to a single application domain. Still, designers create these models with a well-defined orientation to meet your purposes, such as projects (PMC) or business (BMC). Application domain models, such as MVP Canvas [4], IoT Canvas [27], and ML Project Canvas [28], are either based on general-purpose models or extensions of them, developed to cater to a particular application domain with specific characteristics.

The proposed metamodel, named *MM4Canvas*, adopts the MetaObjectFacility (MOF) metamodeling architecture [21], where the elements of the lower layers are instances of those in the immediately higher layers, as shown in Figure 1.

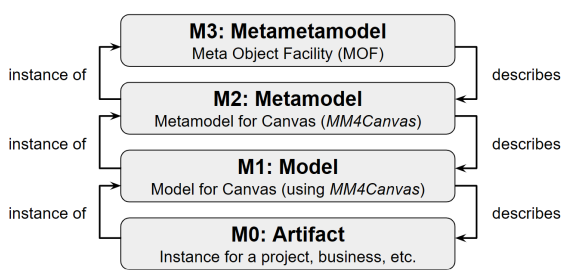

Fig. 1. Integration between MOF and *MM4Canvas*.

The proposed metamodel (M2 layer) is an instance of the MOF (M3) and describes the possible terminal models, which are the different types of model canvas (M1) that can be instantiated. These canvas models are templates for canvas instances (M0) for projects, businesses, or other purposes, instantiated from the model canvas (M1).

4.2 *MM4Canvas*: elements and definitions

A general canvas abstraction was established from a set of essential elements, which we consider as pillars for the definition of *MM4Canvas* metamodel.

- **Canvas** (metaclass *Canvas*): represents the principal artifact that will be composed of the other elements. Its attributes describe essential about the instantiated model.
- **Fundamental questions** (metaclass *FundamentalQuestion*): these are high-level questions inspired by the idea of an action plan (5W2H) that articulate essential aspects of the project. They offer a perspective on the project by addressing key questions such as "what" needs to be done, "who" will do it, etc.
- **Components** (metaclass *Component*): elements that indicate a essential information or a specific need for a project, business, etc. Can be specialized in:
  - **General-purpose components** (metaclass *GeneralPurposeComponent*): in the case of a project-oriented canvas, for example, whose reference model we adopted is the PMC, the general-purpose components are based on classic project management concepts (according to Table 1). These components are grouped into fundamental questions according to the type of information they describe about the project.
  - **Domain-specific components** (metaclass *DomainSpecificComponent*): these are components added as extensions to reference models (PMC or BMC) or that modify general-purpose components to expand the description capacity of a canvas model for projects with specific needs or requirements. Must be associated with a given domain (metaclass *Domain).*
- **Posts** (metaclass *Post*): short sentences that detail each component, describing essential information to a project, business, etc.
- **Relationships** (metaclass *Relationship*): components can be linked by relationships, defining relevant associations according to the needs of a canvas model. Every relationship between components (metaclass *CompRelationship*) starts "from" one component and goes "to" at least one other.

Figure 2 presents the proposed canvas metamodel *MM4Canvas*. As it is based on essential elements of canvas construction, and not on elements or relationships from a specific domain, the *MM4Canvas* metamodel, M2 level, is a reference for the construction of canvas models catering to different purposes (projects, business, etc.) and application domains, instantiated at the M1 level. A model, at the M1 level, comprises a set of fundamental questions defined and instantiated based on each type of model canvas intended. Each fundamental question consists

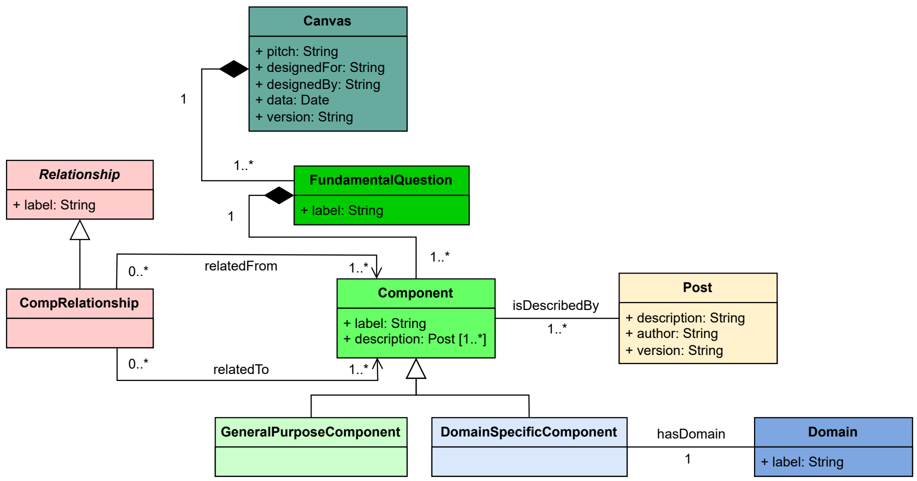

Fig. 2. *MM4Canvas*: metamodel (M2) for creating canvas models.

of a components set, which can be general-purpose or domain-specific and have relationships. Each instantiated component will detailed in one or more posts, providing your descriptions at the M0 level.

5 Proof of Concept

As a way to demonstrate the validity of the proposed metamodel, we developed two *MM4Canvas*-based models (M1): i) an instance for the PMC (discussed in Section 2), a widely used general-purpose canvas for projects; and ii) a reuse-based PMC-extension for IoT-critical system projects with SSR, named *SafeSecIoT Canvas*.

The project domain was chosen for this proof of concept due to its initial motivation for using a canvas model to support project planning and early RE activities. Through the studies aimed at proposing a canvas model, gaps were identified in the methodological support for canvas construction, which was addressed with the introduction of the *MM4Canvas* metamodel.

The specific application domain of IoT-critical systems projects is motivated by the development of studies aimed at aligning safety and security requirements [16, 25, 31, 32]. These systems depend on specific requirements analysis techniques that can benefit from the initial gathering of information from the project through a canvas model properly built for this domain.

To accomplish this, we work initially with the fundamental questions, components, and relationships derived from the PMC methodology proposed by [5]. Then, we reuse and extend the established PMC model by incorporating specific components to meet the SSR domain needs [32].

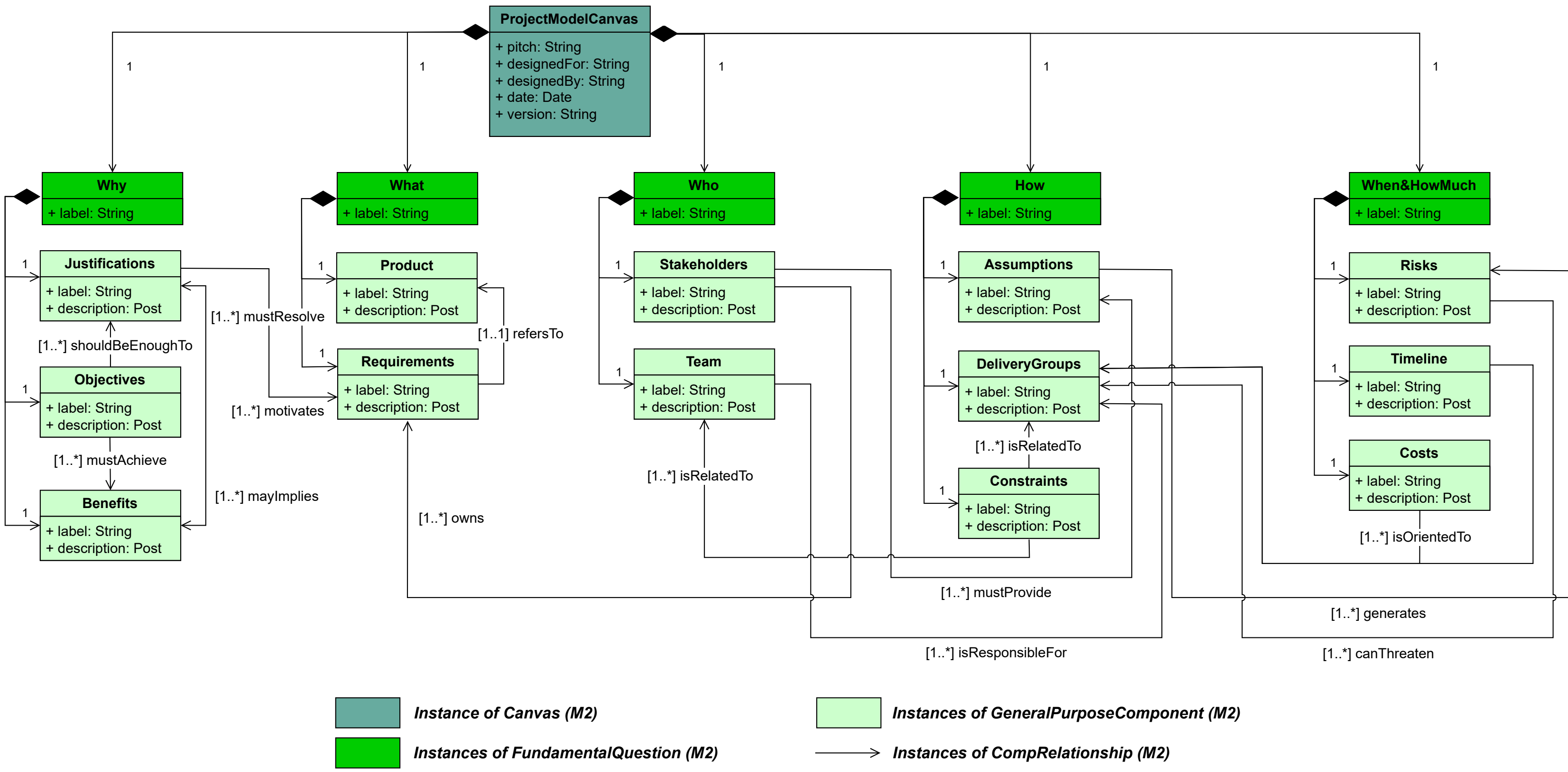

Fig. 3. Model PMC (M1) instantiated from the *MM4Canvas* metamodel (M2).

5.1 Instantiating Project Model Canvas (PMC)

In the *MM4Canvas*-based PMC model (M1), presented in Figure 3, the fundamental questions and its components (general-purpose components, in this case) are instantiated by the proposed metamodel and in the PMC methodology [5] (see Section 3). We also map the existing relationships between these components, defining your connections. This model will guide the process of answering the project's fundamental questions and validating the information raised (M0).

The first part of the model comprises the "why" of the project, where the justifications (problems to be attacked and resolved), objectives, and benefits are intrinsically related. Justifications should directly correlate with benefits, resolving identified issues. Objectives must act as a bridge between the before/after scenario of the project, effectively addressing described issues and guiding the project towards the envisioned benefits.

Having defined the "why" of the project, we move on to the "what" must be described about him and a set of essential requirements. These requirements are motivated by the problems presented in the justification and must refer directly to the product. Furthermore, other canvas components can provide context and motivation for defining these requirements, which can defined throughout the entire canvas completion process.

The components corresponding to the fundamental questions "who", "how", and "when&how much" (addressed collectively in the PMC) are intricately interconnected, as illustrated in Figure 3. Ensuring that the information collected by each component aligns with the defined relationships is vital for validating the accuracy of an instance of this canvas. Project stakeholders must act as the "owners" of the requirements and provide assumptions for the project. The team is accountable for the delivery groups and is associated with restrictions linked to these. Project risks originate from assumptions and can threaten deliveries, requiring organization on a timeline and guiding project costs.

Utilizing the *MM4Canvas* metamodel to map fundamental issues, components, and relationships inherent to the PMC methodology enhances the effectiveness of the resulting model canvas. Firstly, it can be employed as a visual tool for project planning and gathering initial requirements by project teams and stakeholders. Moreover, it supports the validation of the artifact generated. Finally, as an instance of the *MM4Canvas*, this PMC model can be reused and expanded for diverse project finalities within specific application domains, as elaborated next.

5.2 *SafeSecIoT Canvas*: reusing and extending PMC for IoT-critical systems projects

Organizations typically address non-functional requirements (NFR) reactively, considering them only after designing and implementing the system [18]. This practice has the potential to generate problems and introduce defects that can significantly impact the project, resulting in higher costs for their correction [33, 10]. Thus, developing a safety and security-dependent software system must address these concerns from the RE phase rather than treating it solely as a late-stage aspect of the development process.

In this context, after verifying the potential of a PMC for project planning and requirements elicitation (general-purpose canvas), we propose an extension of this *MM4Canvas*-based model aiming to reduce the complexity of the process of analyzing SSR for critical IoT systems from the inclusion of components to extract specific characteristics of this domain (application domain canvas). The analysis method presented by Veiga et al. [32] depends on surveying the scope of the system and specific characteristics related to the analyzed IoT-critical system and safety and security concerns. For this, we instantiated an extension of the PMC called *SafeSecIoT Canvas*.

To build the*SafeSecIoT Canvas*, the general-purpose components of the PMC were reused, and IoT and SSR domain-specific components were incorporated, to meet the specific demands of these types of projects, extending and specifying the PMC scope. These domain-specific components support the IoT system description (components, actions, data and connectivity) and the characteristics of SSR (assets, losses, and risks) that will be used later in the RE process (analysis and alignment), as presented in [32].

Reinforced the stated, the purpose of a PMC is to offer guidance for the project planning, streamlining the definition of essential information, the early RE stages, and fostering necessary communication among stakeholders. In this way, the *SafeSecIoT Canvas* model has all the characteristics of a PMC (already discussed previously), allowing the planning of a project with specific characteristics and requirements in the application domain of IoT-critical systems with SSR. Figure 4 introduces the *SafeSecIoT Canvas*, which reuses the general-purpose components of the PMC model and includes the IoT-critical and SSR domain-specific components.

The *SafeSecIoT Canvas* will integrate a work in progress [31, 32] for aligning safety and security, extending the STPA approach [15], in the first step in a RE process, comprising the initial safety and security requirements elicitation. The objective is to support the alignment of these requirements to avoid, from the early RE stages, both system losses caused by known or unintentionally generated hazards and system losses introduced by threats unknown or from intentional sources such as malicious individuals or organizations.

In this way, we show that the model (M1) developed for the PMC, moreover to validate *MM4Canvas* served as a reference model for the development of a new application model canvas (M1), the *SafeSecIoT Canvas*. This model extends the PMC (inheriting its general-purpose components and relationships) and brings domain-specific components required to the IoT systems that address SSR. Likewise, *MM4Canvas* supports the instantiation from everyone else terminal models (M1) previously mentioned in this article (BMC, MVP Canvas, IoT Canvas, ML Project Canvas, and others) and their possible extensions, making it a comprehensive metamodel for canvas.

6 Final Remarks

This work presents a metamodel-based approach – named *MM4Canvas* – to support the development of canvas models for different purposes. We define a strategy for abstracting canvas models at a design level that allows describing the relationships between their elements and that support their construction. Through metamodeling, we offer essential methodological support to streamline the creation of canvas models for diverse needs and application domains. This approach also ensures the instantiation of canvas models in a more effective, standardized, and reusable way.

The *MM4Canvas* metamodel establishes a common language and standardized structure for creating and representing canvas models, promoting consistency and interoperability between models (standardization). It was built with a concise set of concepts and relationships, facilitating straightforward comprehension and utilization for terminal model development, ensuring clarity in understanding metamodel instances (usability). The *MM4Canvas* allows the instantiation of canvas for different purposes and application domains (adaptability) while supporting the extension of general-purpose models to accommodate specific application domains (reusability and extensibility).

We demonstrate the use of the metamodel for instantiating terminal models of canvas for projects, aiming the planning, scope definition, and requirements elicitation to support later stages of the RE process. As proof of concept, we instantiate the PMC (reference model for the project domain) and reuse it as a basis for extending it in *SafeSecIoT Canvas* model, enabling essential IoT-critical systems project information to be agile-defined, discussed collaboratively, and provide support for the definition of SSR.

Integrating *SafeSecIoT Canvas* into critical IoT systems' safety and security RE process is underway [30, 31]. For this reason, we plan to evaluate the artifacts proposed here in two phases: (i) in academia for possible adjustments and improvements in the methodology, materials, and artifacts that compose it and (ii) with professionals in real projects.

As future work, we highlight i) the quality assessment of the *MM4Canvas* metamodel, e.g., through the *Metamodel Quality Requirements and Evaluation* (MQuaRE) framework [14, 13]; ii) the instantiation of other canvas models (M1) in addition to PMC and *SafeSecIoT Canvas*, both for general purpose and specific application domains; and iii) the use and evaluation of *MM4Canvas* and instantiated models in real projects.

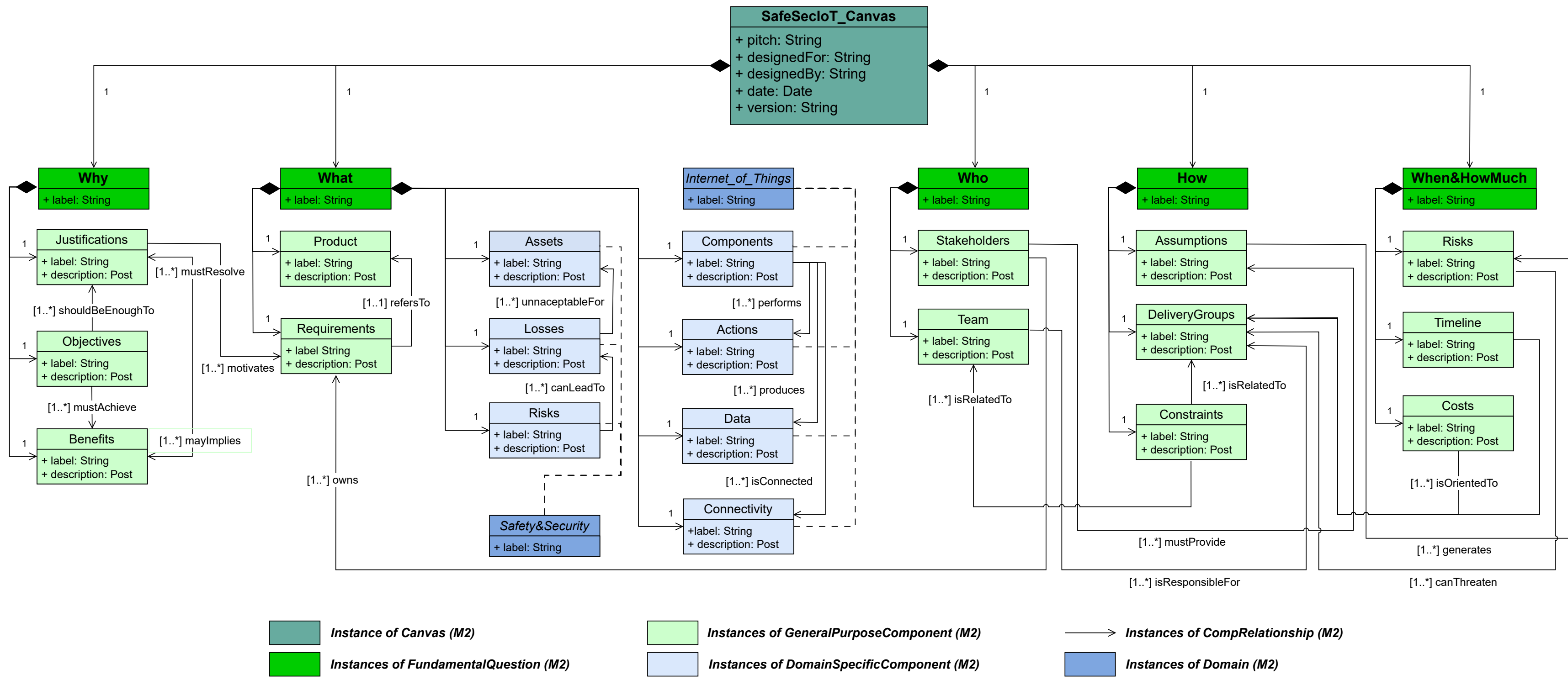

Fig. 4. Model *SafeSecIoT Canvas* (M1): general-purpose components (reused from PMC) and IoT and SSR domain-specific components (extending the PMC).

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