

Table 1. Classification of BPMN extensions: “Domain-specific BPM”

Attributes/Basic characteristics					Compliance with the standard				Approach			
Authors Year	Name of the extension	Domain	New extension concepts	Objective	Type of extension definition	Abstract Syntax	Concrete Syntax	Semantic conflicts	Requirements analysis	Semantic verification	Reuse of artifacts	Methodological approach
Braun et al. (2014)	BPMN4CP 1.0 (Clinical Pathways)	E-Health	Medical Document, CPG Reference, Diagnosis Task, ...	Descriptive	Valid extension	BPMN extension meta-model (Ext MM)	An example	No	Explicit	Yes	Yes (requirements for CP modeling)	Yes: extension of Stroppi et al.
Braun et al. (2015b)	Untitled (Integrated Hospital Management) BPMN4CP 2.0	Clinical process modeling (Clinical Pathways)	Resource Perspective, Equipment Resource, CP Resource, Therapy Task, Case Chart, Objective, Quality Indicators, ...	Descriptive	Valid extension	Ext MM	Explicit BPMN Diagram Graphics	No	Explicit	Yes	Yes (CP domain ontology; BPMN4CP 1.0)	Yes: extension of Stroppi et al. / Braun and Schlieter
Rekik et al. (2015)	OutyBPMN	BP Outsourcing (to Cloud Providers)	Outsourcing Concerns, Feature Requirement, Cost, BusinessCriticality,...	Descriptive	Valid extension	Ext MM	Explicit	No	Explicit	No	Yes	Yes (a specific approach of their own)
Yousfi et al. (2016)	uBPMN (for Modeling Ubiquitous Business Processes)	Modeling ubiquitous processes	Smart object, SensorTask, ReaderTask, AudioEventDefinition,	Descriptive	Own Extension	MOF class diagram	Explicit	No	Explicit	No	Yes (ubiquitous computing technologies (ubicomp))	Yes (a specific approach
Domingos et al. (2016)	relyBPMN (Recording reliability information to reduce failure rate of IoT-aware BPMN healthcare processes)	Healthcare	Reliability Information, Probability	Execution	Valid extension	Ext MM/XML Schema	No	No	Implicit (descriptive)	No	No	Yes: extension of Stroppi et al.
Graja et al. (2017)	BPMN4CPS (for modeling Cyber-Physical Systems)	Cyber-physical system	Real Word Environment, Physical Task, Cyber Task, ...	Descriptive	Own Extension	UML	An example	No	Explicit	Yes	Yes (CPS aspects and requirements)	No
Mandal et al. (2017)	Untitled (Propose an event management model based on explicit subscriptions and event buffering)	IoT (Internet of Things) event management	SubscriptionTask, BufferPolicy, consumptionPolicy, ...	Descriptive	Valid extension	Ext MM	No	No	Explicit	No	Yes	Yes: extension of Stroppi et al.

Table 1. Classification of BPMN extensions: “Domain-specific BPM” (*continued*)

Attributes/Basic characteristics					Compliance with the standard				Approach			
Authors Year	Name of the extension	Domain	New extension concepts	Objective	Type of extension definition	Abstract Syntax	Concrete Syntax	Semantic conflicts	Requirements analysis	Semantic verification	Reuse of artifacts	Methodological approach
Vogel et al. (2018)	BPMN4SGA (for Smart Glasses Applications)	IoT Technology	Manual Decision, Object Identification, Camera, Context via sensor, Distractive Visualisation, Communication	Descriptive	Own Extension	UML	An example	No	Explicit	Yes	Yes	Partially: extension of Stropi et al.
Onggo et al. (2018)	BPMN4SIM (BPM which require an explicit representation of queues, attributes and data-driven decision points)	Medical domain	SharedTask, FrontQueueSharedTask, BackQueueSharedTask, FrontBackQueueSharedTask, DataTable, Pull Flow DataDrivenGateway	Descriptive/ Execution	Valid extension	Ext MM	Explicit	Yes	Explicit	Yes	Yes	Yes (Model Driven Architecture approach)
Abouzid and Saidi (2019)	Untitled (Manufacturing process modeling)	The manufacturing	Time Schedule, Inventory Task	Descriptive	Own Extension	UML	Explicit	No	Implicit (Description)	No	Yes	Yes (a specific approach of their own)
Neumann et al. (2019)	BPMNSIX (Intraoperative workflow modeling and execution)	Medical Field/Surgical Workflow Management	Intervention, Location, Surgical Activity, Role, Resource Exception, ...	Execution	Valid extension	Ext MM/XML Schema	An example	No	Implicit (Domain ontology for intraoperative workflows)	Yes	Yes (BPMN4CP 1.0 and 2.0 of Braun et al.)	Yes: extension of Stropi et al. /Braun and Schlieter
Zarour et al. (2019)	BPOMN Ensuring the security and compliance of BP deployed on cloud environments	The Cloud computing	BPO Criteria, Security, Compliance, Cost, Performance	Descriptive	Valid extension	Ext MM, XML Schema	Explicit	No	No	No	Yes (BPO aspects)	Yes (a specific approach)
Chergui and Benslimane (2020)	Untitled (BPMN Security Extension for the Visualization of Cyber Security Requirements	Cybersecurity	Security Requirement, Availability, Confidentiality, Integrity, ...	Descriptive	Valid extension	Ext MM, XML Schema	Explicit	No	Explicit (security requirements)	No	Yes (cybersecurity ontologies)	Yes: extension of Stropi et al.
Szelągowski et al. (2022)	Untitled (Proposal of BPMN Extension with a View to Effective Modeling of Clinical Pathways)	Healthcare (specifically clinical pathways)	elements for clinical decision- making, patient conditions, treatment alternatives, and checkpoints	Analytical	Own Extension	No	Explicit	No	Explicit	No	domain-specific elements (such as clinical guidelines and best practices)	Yes (a specific approach)

Table 2. Classification of BPMN extensions: “Improving the scope of BPM/BPMN”

Attributes/Basic characteristics					Compliance with the standard				Approach			
Authors Year	Name of the extension	Domain	New extension concepts	Objective	Type of extension definition	Abstract Syntax	Concrete Syntax	Semantic conflicts	Requirements analysis	Semantic verification	Reuse of artifacts	Methodological approach
Stroppi et al. (2011)	Untitled (Ressources)	Resources	Resource Privilege, Resource Base, Subsumption, ...	Execution	Valid extension (modèle d’extension BPMN)	Ext MM	An example	No	No	No	No	Yes BPMN ext. (applied extension mechanism)
Braun and Esswein (2015]	Untitled (Multi- Perspective Modeling with BPMN)	BP complexity	Resource Perspective, Resource Diagram, Human Resource, Medicine, ...	Descriptive	Valid extension	Ext MM	An example	No	Explicit	Yes	Yes (Conceptual Domain Model for the Extension of resource extension)	Yes: ext. of Stroppi et al./Braun and Schlieter
Martinho et al. (2015)	CF4BPMN (Controlled Felexibility)	Modeling flexible BPs	ConFlexElement, COfChange, CFLEExpression, ...	Descriptive	Own Extension	UML	An example	No	Implicit (descriptive)	No	Yes (ontology for a CF in BP)	Yes BPMN ext.
Ben Said et al. (2016 ; 2017)	BPMN4V-CC (BPMN for Versions of Collaborations and Choreographies	Flexibility Modeling and manipulation of flexible (inter- organizational) BPs	Version Extension Definition, Version_of_ Collaboration, Version_of_Event, Version_of_Message	Descriptive	Valid extension	Ext MM	Explicit	No	Implicit (static and dynamic aspects of collaboration and choreography versions)	No	Yes (versioning patterns/collaboration version adaptation patterns)	Yes BPMN ext.
Bukhsh et al. (2017)	Untitled (Modeling Requirements of Unstructured Business Processes)	Managing unstructured/flexible dynamic BP	Collaborative Sub- process, Decision Activity, Goal, Business Rule, ...	Descriptive	Own extension notation (graphical definition)	No	Explicit	No	Explicit	No	Yes (Aspects of CaseManagement, requirements for Unstructured BP modeling)	No

Table 2. Classification of BPMN extensions: “Improving the scope of BPM/BPMN” (*continued*)

Attributes/Basic characteristics					Compliance with the standard				Approach			
Authors Year	Name of the extension	Domain	New extension concepts	Objective	Type of extension definition	Abstract Syntax	Concrete Syntax	Semantic conflicts	Requirements analysis	Semantic verification	Reuse of artifacts	Methodological approach
Carvalho et al. (2018)	AO-BPM 2.0 (Aspect-oriented BPM notation for improved readability and simplicity of BPMN models)	Complexity of BP	Join Point, Pointcut, Advice	Descriptive	Notation Ext Propre	No	An example	No	Implicit (description)	No	Yes	Yes (a specific approach of their own)
Santra and Choudhury (2018)	C-BPMN (Context Aware BPMN)	Modeling of complex and dynamic BPs	Contextual Event	Descriptive / Execution	Own extension notation	No	Explicit	No	Explicit	No	Yes (Graph- based BP context model)	Yes (a specific approach of their own)
Heguy et al. (2019)	Performance Measurement (in the exchange of data objects)	Performance measurement	Cost, Quality, Time, Reliability, ...	Descriptive	Valid extension	Ext MM	Explicit	No	Implicit (description)	No	Yes	Yes (a specific approach of their own)
Ramos-Merino et al. (2019)	BPMN-E ² (BPMN— enhanced expressiveness)	Monitoring / HACCP Hazard Analysis Critical Control Points	Monitoring Group, Activity Effect, Time Expected, Decision Question, ...	Execution	Own extension	UML	Explicit	No	Explicit	No	Yes (HACCP model)	Yes (a specific approach of their own)
Polančič (2020)	BPMN-L (A BPMN extension for modeling of process landscapes)	Organization process architecture	Process Landscape, Process Composition, Support Process, Conditional trigger relationship	Descriptive	Own extension	UML (BPMN-L conceptual domain model)	Explicit	No	Explicit	Yes	Yes (UML use cases); extended value chains	Yes: ext. de Stroppi et al.
Intrigila et al. (2021)	A Lightweight BPMN Extension for Business Process- Oriented Requirements Engineering	Requirements Engineering in Business Process Management	constrained action, pre- and post- conditions	Descriptive	Own extension notation	No	Explicit	No	Explicit	No	No	Yes (a specific approach of their own)
Strutzenberger et al. (2024)	Evaluating BPMN Extensions for Continuous Processes	Continuous processes	Closed-Loop Sub- System Gateway, Intermediate catching events (Branch, Measure, Control)	Analytical	Own extension notation	No	Explicit	No	Explicit	No	No	Yes (a specific approach of their own)

