Examining Collaborative Business Process Modeling Techniques

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Abstract – In recent years, there has been a significant increase in the recognition and use of Business Process Management (BPM) in both academic research and practical applications. The use of innovative ICT plays a crucial role in efficacy enhancement and efficiency of corporate collaboration and the management of inter-organizational business processes. Within this particular context, it is essential for organizations that engage in cooperation to possess a collective comprehension of their internal processes, as well as those of their collaborating partners. Additionally, they must also possess an awareness of the evolving inter-organizational process structures that may arise. To foster a collective comprehension, the use of collaborative modeling might prove to be a valuable strategy. The scope of business processes extends to include activities that go outside the confines of a company, hence necessitating the adoption of process of modelling collaborative business. The practice of BPM involves several intricate iterations and extensive collaboration between business analysts and domain experts. Processes of collaborative business serve as enablers for businesses to cultivate adaptable and dynamic partnerships, allowing them to effectively respond to changing circumstances and maintain competitiveness within the global market. The primary objective of this study is to conduct a comprehensive examination of contemporary cBPM methodologies.

Keywords – Business Process Modeling, Collaborative Business Process Modeling, Integrated Definition for Function Modeling, Unified Modeling Language

I. INTRODUCTION

According to Tinnilä [1], a business process may be characterized as a series of interconnected operations within a corporate framework, undertaken with the objective of achieving certain outcomes. The primary objective of this initiative is to augment the overall worth of the firm for both customers and organizations. The analysis of a company may be conducted by examining its established business processes. The use of the Business Process Management (BPM) strategy is employed to effectively manage, enhance, and optimize the operational processes inside a business. Business Process Modeling (BPM) is a crucial element within the framework of Business Process Management. Current business process management (BPM) methodologies rely on several techniques and descriptive languages, mostly using graphical representations or textual programming languages. BPM techniques have evolved as a significant and integral component of conceptual modeling. The aforementioned elements serve as the foundation for many stages within the BPM lifecycle, including execution, implementation, monitoring, regulating, and improvement of business processes. In recent years, organizations have seen significant transformations in response to the emerging difficulties of globalization, mass customisation, and volatile demand. In order to maintain competitiveness in the worldwide market, organizations must possess the capacity to standardize, articulate, and adjust their responses to various business possibilities.

In order to accomplish these objectives, a three-step procedure (refer to **Fig 1**) has been devised: The user's message is academic in nature. The first objective is to begin the process of overcoming obstacles to innovation by fostering and augmenting creativity. The objective of this stage is to facilitate the exploration of group dynamics, including the establishment of trust among participants and equipping them with the necessary readiness to collaboratively engage in the generation of new ideas. Furthermore, the present study introduces the overall methodology and provides a clear explanation of the anticipated outcomes. From a pragmatic standpoint, several methodologies for fostering creativity are used to generate a plethora of concepts, particularly in the context of devising numerous potential business models tailored to the burgeoning industry. The objective of the second phase is to compel individuals to make choices. The primary objective of this endeavor is to establish a shared comprehension among the participants about the industry and its projected evolution. This step is used afterwards to the phase of idea production in order to mitigate the potential inhibitory effects of consolidating ideas on the creative process. At a pragmatic level, this widely accepted consensus serves as the foundation for the process of prioritization. This procedure compels participants to deliberate on their expectations about various business models, with the aim of curating a focus group including the most captivating company ideas. The objective of the third phase is to facilitate the readiness for executing business models.

This study examines and assesses the most prominent business models, providing a comprehensive analysis and validation of their effectiveness. This provides a comprehensive foundation for the established business models, facilitating the transfer of these concepts to particular enterprises for their further refinement and implementation. At the group level, this stage also encompasses the identification of collaborative follow-up initiatives that facilitate the further advancement of systemic innovations that are beyond the scope of a single company's implementation capabilities. **Fig 2** serves to emphasize many methodologies used in each sequential phase.

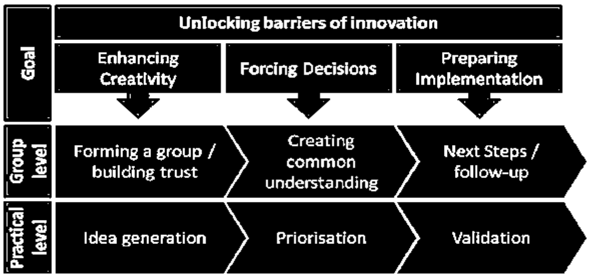

Fig 1. Three phases of the collaborative business modelling process

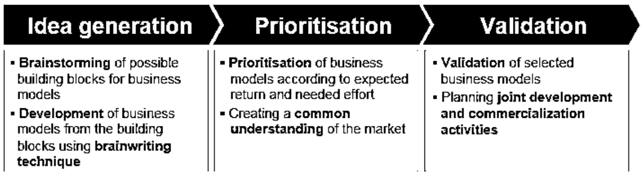

Fig 2. The Collaborative Business Modelling process

In order to facilitate this worldwide cooperation, organizations must include both external and internal systems, partners, and resources. In order to attain these goals, it is essential to establish business procedures that facilitate collaborative endeavors across numerous firms. A process of collaborative business may be characterized as a pertinent process of business that spans across many participating companies, which are interconnected to facilitate the effective operation of firms within the global market. Therefore, within the realm of BPM, the investigation of collaboration support elements in modeling process and associated tools has emerged as a significant area of scholarly inquiry. Considerable attention has been devoted to the investigation of process modeling in academic research. The primary emphasis lies in the examination of the modeling task's characteristics and the provision of collaborative tools to assist individuals in their modeling endeavors. There has been little research conducted on Collaborative Business Process Modeling, with the existing works mostly focusing on prototype tool implementations and experimental investigations.

The objective of this research is to provide a comprehensive analysis of the current advancements in cBPM. The primary objective of our research is to investigate the current methodologies that facilitate collaborative business process modeling. The subsequent sections of the article have been structured in the following manner: Section II presents a background analysis of the research. Section III reviews previous works related to the aspect of business process management. Section IV provides a critical survey of collaborative business process modeling approaches. Lastly, Section V presents a conclusion to the paper.

II. BACKGROUND ANALYSIS

Business Process Management (BPM) has been a prevalent practice in both academic prototypes and commercial goods since the late 1990s. The first and essential phase in the BPM life cycle is the implementation of BPM. The primary objective is to establish a clear distinction between process logic and application logic, so enabling the automation of the underlying business process. Models are very beneficial in facilitating the conceptualization, communication, comprehension, analysis, design, and development of business processes and information systems. company Process Management (BPM) is a widely used approach in the field of company management with the purpose of identifying and providing descriptions of various business processes. According to Al-Mashari [2], Business Process Management (BPM) may be seen as a collection of photographs capturing real business processes at various moments in time. Business Process Management (BPM) plays a crucial role in the examination, assessment, and enhancement of organizational workflows. The purpose of this tool is to organize and arrange processes in a manner that allows for systematic and complete analysis of both current and alternative sequences of tasks. Furthermore, it is worth noting that Business Process Management (BPM) serves as a valuable instrument for capturing the organizational structure and formalizing the understanding of business processed. In order to include a wide range of elements inside business processes, many methodologies related to Business Process Management (BPM) were established.

According to Massingham and Al Holaibi [3], business process models serve primarily as tools for acquiring knowledge about processes, facilitating decision-making processes, and aiding in the development of software applications that effectively support the operational aspects of these processes of business. Different BPM approaches are used for different applications based on certain constructs. The prevalent diagrammatic methodologies used in Business Process Management (BPM) are flowcharts, Integrated Definition for Function Modeling (IDEF), and Petri nets (PN). Furthermore, other modeling techniques such as State Charts, Activity Cyclic Diagram (ACD), Role Activity Diagrams (RADs), Discrete Event

Specification (DEVS), Integrated Enterprise modeling (IEM), and GRAI Methods are also used. Nonetheless, it is important to note that there exist several established standards for Business Process Modeling the Object Management Group's Business Process Modeling Notation (BPMN), the XML Process Definition Language (XPDL), the Unified Modeling Language (UML), the Business Process Execution Language for Web Services (BPEL4WS), the Event-Driven Process Chains (EPC), and BPEL4WS are all examples of such notations. The bulk of businesses today rely on very simplistic diagrammatic modeling techniques.

The concept of collaborative Business Process Management (cBPM) entails the collective endeavor of a group of individuals in the development of a model of business process. The team of modelers demonstrates a collective motivation in developing a business process model, with each member contributing to the final output via collaborative teamwork. The architecture of cBPM may be characterized as an adaptation of BPM, specifically designed to serve as a tool for investigating the collaborative business domain. The process entails a collaborative endeavor to construct models, the incorporation of diverse viewpoints on a given process, and the establishment of a collective comprehension of those models. The objective is to provide an advantageous setting for collaborative enterprises, promoting strategic dialogues about the growth of markets and the emergence of models of business. In the realm of BPM, there is a need for innovative modeling techniques that facilitate the depiction of "collaborative processes". Business operations are fundamentally defined by a heightened level of cooperation. The issue of collaboration within the modeling work has not been extensively explored. There are many methodologies used in the modeling of business processes, including Integrated Definition for Function Modeling (IDEF3), Petri nets (PN), Architecture of Integrated Information Systems (ARIS), and Unified Modeling Language (UML), among others. However, these methodologies are insufficient for effectively characterizing collaborative processes. This phenomenon occurs due to their inability to effectively portray several players engaged in each collaborative work while maintaining coherence in the overall processes.

Several business process languages, like BPM and WS-BPEL, have been introduced to facilitate the representation of collaborative business processes. These languages have gained widespread acceptance and are now considered as industry standards. The collaborative modeling architecture presented by Aslam, Chen, Butt, and Malavolta is grounded on the design science methodology, as outlined in [4]. The architectural design incorporates both the requirements of the company and relevant expertise. Applicable knowledge is described as the result of deriving insights from theoretical frameworks and empirical evidence obtained via modeling studies conducted utilizing traditional methodologies. In order to ascertain the requirements of the firm, interviews were held with IT experts hailing from four distinct organizations. The researchers included just those issues that were seen twice in the participants' artifacts in their investigation.

Subsequently, they used relevant information to expound about those issues. Following the study of the data, an architectural framework was designed to facilitate collaborative modeling. The architectural framework has three distinct tiers, namely linguistic, pragmatic, and social. The first coding process exposes the syntactic and semantic layers of the language level. The domains may be further categorized into natural language and modeling language domains. The categorization of business processes is predicated upon the linguistic characteristics used to articulate them. At the pragmatic level, actions may be categorized into two distinct groups: comprehending and arranging the modeling process. The categorization of "understanding" tasks was then divided into two distinct components: "understanding text" and "understanding language". The latter may be categorized into two distinct components: "negotiation" and "agenda setting". The social level encompasses a set of norms and guidelines that govern the process of acceptance and rejection via negotiation.

Within the context of the design circle, two distinct artifacts were developed: the architecture, known as COMA, and a corresponding tool that effectively executes this architecture. The technique used in their study was guided by theoretical frameworks and an analysis of behavior of group modeling. Within the context of the circle of relevance, they discovered and evaluated the alignment between the indicated business requirements and the extent to which the artifact addressed these needs. Subsequently, they subjected the artifact to a practical examination. The researchers inside the rigor circle have verified the understanding of the available methods for addressing common challenges in collaborative modeling. A noteworthy beneficial effect was seen in five out of 10 difficulties. The need for more study has been acknowledged in both domains where the utility of the intervention has been shown, as well as in those where its efficacy in problem-solving has not been seen. According to their perspective, collaboration may be defined as a closely integrated kind of cooperative work that aims to address the needs and interests of all parties involved. The negotiation of the meaning of words and intended outcome is necessary. The significance of project management was also acknowledged as a critical matter for more investigation.

III. RELATED WORK

This section gives an overview of previous research done in the field of collaborative process modeling.

Notion of Model

The concept used since reference [5] encompasses a broad range of ideas and pre-notions that have been utilized and recognized in the field of general model theory. The user's message is lacking. Please provide the message that requires to be rewritten. A model is a reliable and effective tool that accurately portrays sources and is functional in many use settings. The criteria of well-formedness, adequacy, and reliability must be widely acknowledged by the community of practice (CoP) in a specific context and align with the roles that a model serves in utilization situations. The user's message does not contain any data to rewrite in academic manner. This concept also permits the examination of the ontological nature of any instrument. Any concept or object has the potential to serve as a model, provided that it is used in such a manner. The model entity serves as a tool used in many contexts.

Models have a purpose inside certain application situations, since they possess a designated role in those particular contexts. In scientific and engineering settings, common purposes include reflection, illustration, visualization, serving as a proxy for theory, directing thoughts and actions, assisting in theory building, mediating, and replacing theories. Models are used as tools or instruments in many contexts. The existence of the instrument-being is thus a necessary condition for the existence of the model-being. In order to ensure optimal performance, models must be optimized based on their purpose inside the specific application situation. Instead of prioritizing comprehensive models, model suites that have a sophisticated and clear association schema among the models within the suite are more suitable for the purpose of reasoning about and using models in various contexts. A scenario comprises a task space and a conceptualized delivery space. Instruments may serve several tasks. Hence, a model may fulfill several roles. Moreover, it is worth noting that a scenario might potentially include a compilation of many situations.

Research on the Process of Process Modeling

The PPM focuses on the interaction between participants, such as domain experts and model engineers, throughout the modeling process. The significance of the modeling process itself, in addition to the ultimate product, is emphasized in the work of [HPvdW05]. Previous studies have previously investigated the PPM, as shown in the works of PZW+12 and PSZ+12. However, the aforementioned works mostly concentrate on the modeling of scenarios where a solitary model engineer is responsible for developing the process model. In contrast, our tool allows for the examination of the effects of collaborative process modeling on the process of creating process models. In a unique case, [Rit07] also examines collaborative modeling settings with a specific focus on the negotiating phase of this process. Furthermore, the team procedures, such as the combining of the top performing teams, are examined in [Rit12a] and assessed with regards to the quality of the model. Once again, our technology enables the examination of process modeling and the exploration of team processes alongside individual processes.

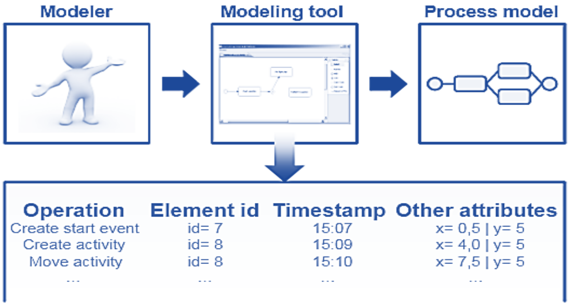

Fig 3. The Properties of The Recorded Data and the Method of Process Modeling

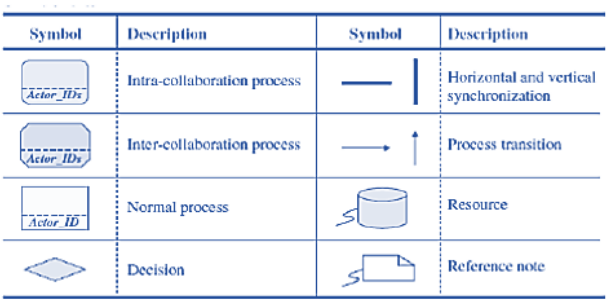

Fig 4. CPM Elements

The PPM, or Process Model Construction, is a human activity where a modeler creates a process model by visually representing model components like edges, activities, gateways, and events on a canvas (refer to **Fig 3**). To effectively use the PPMChart visualization for representing a PPM instance, it is necessary to gather data from the PPM instance at a designated level. Hence, it is advantageous to use a modeling tool equipped with logging capabilities for the development of the model of the process. The implementation of the PPMChart assumes that it is feasible to capture data for each modeling operation performed on the canvas. This includes actions such as creating a start event, creating an activity, and moving an activity. In addition to the operation name, the visualization requires two other attributes: the model element identification on which the operation was conducted, and the timestamp indicating the execution time of the operation. The visualization disregards other recorded data, such as the location of a model piece on the canvas.

Alternative Process Modeling Tools

There are now existing ecosystems that facilitate cooperation among diverse parties. An instance of such an environment is the Collaborative Modeling Architecture, as referenced by Chin, Ramanathan, and Saluja [6]. The COMA Tool facilitates process model collaboration via the process of negotiation among participants over suggested models. In contrast to the aforementioned collaboration technique, which involves participants working asynchronously, there is an alternative approach known as synchronous collaboration or concurrent modeling. In this method, participants engage in simultaneous collaboration, working simultaneously on the same model. One benefit of this technique lies in the participants' ability to promptly monitor changes in the model. Two examples of collaborative tools that allow simultaneous work on a single model using a web browser are the Signavio Process Editor and the Software AG's ARIS3. CoMoMod (DHFL11) serves as an additional example of a collaborative modeling tool. In addition to its failure to provide adequate support for the BPMN process modeling notation, it primarily focuses on the resulting model rather than the actual process of modeling. The aforementioned statement applies to both the Signavio Process Editor and the Software AG's ARIS collaboration tool. In this context, our objective is not to provide an alternate solution, but rather to provide a controlled environment for the analysis of cooperation. Given the potential for monitoring the modeling process, it may be argued that a Complex Event Processing (CEP) platform is well-suited for this objective.

Research on Collaborative Process Modeling

Previous studies have been conducted in the field of collaborative process modeling [Rit12b, Rit12a]. The research conducted by [Rit12b] examines the team-building procedures involved in the collaborative creation of a model utilizing a proposal-based tool known as COMA, while also considering the impact of face-to-face communication on the quality of the model. Once again, our technology enables the analysis of the PPM. In addition, our solution offers the capability to collaboratively work on the same model in real-time, even while physically separated, using an integrated communication channel.

Research on Process Model Quality

Extensive study has been conducted in the field of business process model quality (Rit09b). Furthermore, it is worth noting that there are established standards that outline the criteria for assessing the quality of business process models [BRU00]. These guidelines include the Seven Process Modeling standards (7PMG), which define the ideal attributes of a business process model [MRvdA10], as well as other frameworks that identify different dimensions of process model quality [KSJ06]. The impact of model complexity on the understandability of process models was examined by MRC07. [RSG+09] offers prediction models for usability and maintainability of process models. The study conducted by MVvD+08 and Men08 examined the influence of several quality indicators on the frequency of errors. The paper by Page [7] discusses the significance of visual notations in enhancing cognitive performance. The shared characteristic of these publications is in their emphasis on the resultant process model, with very less attention given to the process of modeling itself.

IV. COLLABORATIVE BUSINESS PROCESS MODELING APPROACHES

Numerous endeavors have been undertaken to provide an optimal approach for defining the methodology that best suits the context-aware Business Process Management (cBPM) phenomenon. The majority of these techniques are rooted on conventional modeling methodologies. Several more expansions of those concepts were created, as elaborated upon in subsequent sections.

Extension of UML

The majority of efforts aimed at facilitating cooperation in modeling languages include the expansion of the Unified Modeling Language (UML). The development of a novel approach known as Collaborative Process Modeling (CPM) was undertaken by Su, Liang, and Dong [8]. The CPM approach facilitates the advancement and validation of collaborative process models. The CPM methodology is primarily grounded in the context of industrial sectors. The genesis of this concept may be traced back to the need of documenting and comprehending the collaborative processes occurring among the many components of a system, in order to enhance the knowledge and delineation of the supporting services provided by such system. In order to facilitate the modeling of collaborative processes, researchers have classified them into two distinct categories: intra-collaboration and inter-collaboration. Intra- refers to the collaboration among distinct groups inside an organization, whereas inter- pertains to the interaction between separate organizations. The CPM methodology involves the representation and analysis of collaborative processes involving many players who possess diverse connections. CPM exhibits many distinct features. Firstly, it is process-oriented in nature, emphasizing the systematic execution of tasks. Secondly, it adheres to the UML activity diagrams notation, which provides a standardized graphical representation for modeling processes. Lastly, CPM has eight constituent pieces, as visually shown in **Fig 4**. The comprehensibility of the text is facilitated by the use of distinct symbols to represent inter- and intra-collaboration activities. Various processes conducted by multiple actors may be consolidated into a unified Critical Path Method (CPM) Model, whereby each participant can be readily seen within the model.

One possible approach to use analytical methods for Petri nets (PN) is to convert generated models into marked graph models. This transformation allows for the utilization of analytical techniques in the analysis of Petri nets. The Critical Path Method (CPM) lacks explicit components for representing the current state of processes or systems. Nevertheless, it is worth mentioning that the capturing of state changes may be achieved by a comprehensive understanding of the interplay between various processes. In relation to the conversion from CPM to PN, it is not feasible to achieve a one-to-one correspondence between all parts of CPM and PN due to the limited number of components in PN, which is four. To achieve this objective, Wei and Mei [9] first establish the concept of MGBB (Marked Graph Building Blocks) via the combinatorial usage of components of SPN. The researchers reached the conclusion that using the Critical Path Method (CPM) for modeling purposes is characterized by its simplicity and high level of comprehensibility. The participation of many stakeholders in each joint endeavor is evident, and the examination of the model is viable. The shortcoming of the process-oriented approach is in its limited ability to effectively simulate collaborative processes that include diverse opinions. The Critical Path Method (CPM) is a theoretical approach that currently lacks practical implementation.

Smiarowski and Chen [10] suggest an enhanced version of CPM, referred to as exCPM, which offers increased capabilities for modeling and analyzing collaborative processes. The Extended Configuration Process Model (exCPM) has a total of ten parts, including the ICOM capabilities derived from the IDEF0 methodology. The Information Control and

Management (ICOM) system is used to denote the transmission of data and is visually shown by the utilization of dotted arrows. Petri nets (PN) use states and colored tokens to provide real-time monitoring of process states and provide a clear understanding of the many individuals involved in cooperation. One notable characteristic of exCPM is the process of model verification, which is accomplished by the automated conversion of exCPM models into SPN. In this iteration, the transformation rules were also changed. The use of exCPM is utilized to facilitate collaborative endeavors within the industrial and commercial sectors, hence bolstering its contribution. The current state of this work is in the conceptual stage. on their study, Son, Kim, and Kim [11] introduced a methodology grounded on the principles of Model-Driven Architecture (MDA) to facilitate the development, validation, and execution of collaborative processes. The technique described involves the use of UML to model collaborative processes, specifically focusing on UP-CoIBPIP. The language of representation of BPMN of interaction process models.

The language of UP-CoIBPIP is used for the purpose of describing protocols of interaction. The establishment of interface and integration procedures is essential for facilitating collaboration across diverse firms, as it enables the execution of collaborative activities by each individual company. Enterprises have the ability to construct and modify business process models using the Model-Driven Architecture (MDA) technique, which allows for the generation of B2B specification code. The language of UP-CoIBPIP promotes the use of protocols of interaction as a means to express collaborative processes behavior. Additional research relating to the MDA framework provided by Brown may be found in reference [12]. This study involves the mapping of models of ARIS of cross-companies chains onto models of BPDM of interface processes. The researchers used UML2 activity diagrams in their study, while their suggested architectural framework incorporates a centralized broker to effectively execute and regulate collaborative operations. This method promotes the use of decentralized management strategies for collaborative operations.

Extension of Petri-Nets

The Petri net is a graphical programming language used for the purpose of simulating concurrent systems. The primary use of this technique has been in the modeling of artificial systems, namely in the domains of manufacturing systems and communication protocols. Since the first study conducted by Wang, Zhang, and Luo [13], many versions of Petri nets, such as the stochastic Petri net and the colored Petri net, have been used for the purpose of modeling biological processes. In contrast, biological pathways might be regarded as hybrid systems. An instance of this phenomenon may be seen in the continuous behavior of protein concentration dynamics when they are connected with discrete switches. The regulation of protein synthesis is contingent upon the expression levels of other genes, namely the presence or absence of other proteins at adequate concentrations.

Petri nets have been used as a modeling tool since the latter part of the 1960s. Since this juncture, there have been several shifts and enhancements. Initially, these objects were mostly regarded as objects of interest rather than having practical use, since the lack of accessible tools hindered the construction and examination of models. Since the inception of these first stages, a plethora of computerized tools have been made accessible, facilitating the execution of simulations pertaining to the structure of a model and the accumulation of performance data. Additionally, there have been advancements in the development of specific Petri net analysis tools, which have gained widespread availability.

To date, in the field of cBPM, many colored stochastic Petri Nets and extensions of high-level have been effectively used. The process-oriented method provided by Jedlička [14] is based on XML-net. The integration of graphical XML schemas with the fundamental Petri-net schema is undertaken in order to facilitate the performance management of collaborative business processes. The graphical representation offers a user-friendly visual display that presents a comprehensive snapshot of the real-time state of cBPM via a web-based interface. The use of XML networks may increase the modeling, analysis, and monitoring of business processes using performance indicator-based approaches. The usefulness of Klink, Li, and Oberweis [15] was proven by its implementation in a software prototype known as INCOME2010. In their work, Gao, Zhu, and Liu [16] introduced a model that utilizes extended stochastic Petri nets (SPN) as its foundation. Stochastic Petri Nets (SPN) encounter the challenge of state-space explosion, which limits their ability to represent dynamic parallel mechanisms.

Consequently, Shahzadi, Fang, and Alilah [17] included object-oriented characteristics and color mechanics into the fundamental Stochastic Petri Net (SPN) framework, resulting in the development of an expanded SPN. An additional five tuples were created for the aforementioned purpose. The implementation of the model used a hierarchical modeling tool and a programming methodology inside the simulation habitat known as ExSpect [18]. The webpage elucidates the workflow of concurrency with prioritization and addresses the limitations of the Shortest Processing Time Next (SPN) approach. An example using ExSpect was also used to elucidate the implementation of a workflow procedure. The notion of modeling collaborative and its implementation in CoMoMod was presented by Aslam, Chen, Butt, and Malavolta [19]. The researchers used EPC and Petri nets for the purpose of modeling. The research conducted by Wang and Feng [20] offers evidence in favor of the concurrent execution of tasks inside a single process model diagram. Hence, the researchers organized modelers who were geographically dispersed, included communication elements, and accommodated the use of diverse modeling languages by various modelers. The tool that has been built also utilizes the Design Science methodology.

Barjis [21] presented a comprehensive discussion on a Collaborative, Participative, and Interactive (CPI) methodology for enterprise modeling. Belyaeva [22] assert that capturing complex corporate processes has considerable importance. The purpose of the CPI strategy is to facilitate the active involvement of stakeholders who possess significant insights into the operations and business processes of the firm. The solution they suggest is based upon the principles of SPN and Design and Engineering Methodology for Organizations (DEMO) transactions. The DEMO theory delineates two distinct types of actions that occur inside an organization: production acts and coordination acts. Transactions may be characterized as a general framework in which two activities take place. Every transaction is conducted via 3 distinct phases: the outcome phase, the execution phase, and the order phase. The one responsible for initiating the transaction within the context of acting is often referred to as the initiator, whereas the individual who performs the production act is known as the executer. The transaction of DEMO is predicated on the concept of PN.

Agent based Methodology

Several researchers drew inspiration from the technology of semantic agents and used it to enhance the transmission of model information. According to Kłodawski and Żak [23], the process of cooperation is categorized into three distinct components in order to optimize its efficacy and efficiency. The three main components of collaboration in this context are Information-based interoperability, Resource-based coordination, and Business rules-based collaboration. Information-based interoperability refers to the standards and protocols used for communication and interaction across different systems. Resource-based coordination involves the control and shared resources scheduling. Lastly, Business rules-based collaboration encompasses the methods used for coordinating processes based on predefined rules and guidelines. The suggested concept used a semantic agent to enhance cooperation in business processes across both application-centric and human-centric environments. Semantic agents play a crucial role in enabling the exchange of collaborative knowledge across various processes. Multiple business process management systems retrieve information from various processes that have been collected by all agents. Process ontology is the framework through which they are expressed. Ontology refers to the representation of a certain domain's conceptualization in a manner that can be understood by both humans and machines. The use of description ontology process was employed to impart formal semantics to conventional modeling process methodologies. Within this theoretical framework, the researchers used a semantic interface, agent rules, and elucidated the system architecture. Further development of this framework is required with respect to ontology mapping, coordination rules, and agent design.

Another technique based on agent systems was explored in [24]. The researchers put forward an expanded UML-based multi-agent cooperation model for the purpose of work allocation inside a virtual enterprise (VE). The protocol used is the Contract-Net protocol (CNP). In order to address the collaborative challenges that arise inside an open distributed environment, the use of a multiple agent system (MAS) is required. The enhancement of concurrency mechanisms and semantic features inside the Unified Modeling Language (UML) is crucial for adapting UML to Multi-Agent Systems (MAS). Several synchronous joint symbols have been created for representing agent UML messages. The process of cooperation was regulated by the use of CNP, as shown by Zhu, Li, and Saad [25]. The Collaborative Network Protocol (CNP) is recognized as the predominant tool for cooperation across several domains. Wang [26] provide a more detailed explanation of the contract net framework, which is characterized by a network of nodes. In this framework, each individual node assumes the function of a manager responsible for overseeing a specific contract. In order to facilitate the exchange of messages between agents, it is necessary to have a common ontology. Agents may use the (Knowledge Query and Manipulate Language) KQML as the means of communication language. However, it is important to note that the basic communication protocol can be TCP/IP. The complexity of extended UML poses challenges in effectively modeling multi-agent cooperation, as stated by researchers.

Semantic Web based Methodology

A limited number of academics use web-based methodologies to provide assistance for the collaborative aspect of process modeling. The technique presented in reference [27] tackles the problem of formulating dynamic collaborative business processes and has successfully proved its practicality. The researchers used the Business-OWL ontology. Additionally, they proposed a novel method for the dynamic formulation of Constraint-Based Planning (CBP), which serves as an addition to the existing Hierarchical Task Network (HTN) planning algorithm. The algorithm has the capability to generate CBP definitions in a dynamic manner in real-time. The process of breaking down complex jobs at a higher level into simpler duties at a lower level, known as operational primitive tasks, is accomplished using an innovative approach. The hierarchical task decompositions of cBPM are maintained inside an ontology known as Business-OWL. The approach presented by Bazydło [28] involves the use of a GUI that may be accessed using a web browser.

The research effectively encapsulated the overarching objectives of the organization and the criteria used for strategic planning. The language of OWL is used for the representation of knowledge of HTN, making it conducive for the seamless of web languages of integration. Subsequently, the typical business-to-business (B2B) activities are encapsulated as methods inside the "HTN-ontologised" framework. The algorithm of Genesis is designed to extract the overarching business objectives from the graphical user interface (GUI) and then break them down into a series of interdependent activities that need collaboration. The assertion was made that there has been no prior effort to do this particular kind of dynamic decomposition and sequencing of CBPs, which involves the transformation of strategic objectives into operational-level tasks that are prepared for execution using Web Services. Previous studies [29] that used hierarchical task networks for compositions of web service did not adequately include the high-level business objectives and cooperation requirements that are often encountered in real-life scenarios.

In another study [30], an alternative strategy is introduced, which exhibits a methodology that is somewhat manual, lacks scalability, and does not possess the potential for dynamic business process integration. In their publication, Nandy [31] presented the DREAMs Framework, which aims to enhance business-to-business (B2B) cooperation. Within this conceptual framework, two distinct entities were identified: a supplier, which serves as a representative of the organization. The second role is that of a requestor, which provides a description of the company seeking an external actor to collaboratively carry out the process of the business. At the provider's end, this technique used BPEL to describe business operations. The ontology is delineated using the WSML language, while annotations are performed using the XML-based language SWSAL. The BPMN language is used at the requestor side to articulate the specification of the behavioral component. Annotations of semantic are used to articulate the ontological component of a specification published in the Semantic Web Service Annotation Language (SWSAL). The use of a semantic model checking method is employed for the purpose of verifying processes in accordance with specified requirements. Additionally, a tool was created by the researchers, which is built upon their architecture.

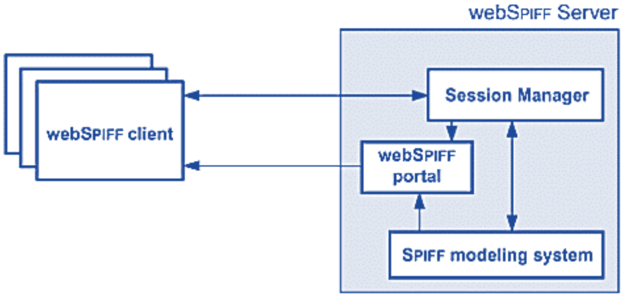

Fig 5. Architecture of webSPIFF

Tann and Shaw [32] present webSPIFF, a novel web-based characteristic of collaborative system of modeling that represents a significant advancement in this field. This system exemplifies the efficacy of effectively using the idea of features in addressing these issues. The webSPIFF system is designed with a client-server architecture, including many components as seen in **Fig 5**. On the server side, there are two primary components that may be distinguished: the SPIFF modeling system, which encompasses all feature modeling capabilities, and the Manager Session, which facilitates the initiation, participation, termination, and administration of modeling sessions, as well as the handling of all communication between the clients and SPIFF. The portal components of webSPIFF serves as the primary entry point for new clients to initiate a webSPIFF session. It incorporates a web server that facilitates the provision of model data for clients to download. The clients prioritize local execution of operations, particularly in relation to visualizing and interacting with the property model.

Only high-level messages of semantic, such as those specifying operations modeling, along with a minimal amount of data model required for updating client information, are transmitted over the network. The server assumes the responsibility of coordinating the session of collaboration, managing a central model of product, and offering any necessary property that is either impractical or inappropriate to be stated on the client side. Specifically, while doing genuine feature modeling calculations, like operations of modeling, converting between maintaining feature validity and feature views, these tasks are carried out on the webSPIFF server. The server operates on the central model of product, and the outcomes of these computations are ultimately sent back to the clients. One significant benefit of this architectural design is the presence of a single core product model inside the system, thereby mitigating the occurrence of inconsistencies that may arise from the existence of several iterations of the same model.

The system of SPIFF, created at Delft University of Technology, was selected as the foundation for the server due to its provision of several sophisticated modeling capabilities. Firstly, the system provides a variety of perspectives on a model of a product. Each perspective is composed of a property model that includes characteristics tailored to the specific application associated with that perspective. Secondly, the present iteration of webSPIFF offers two distinct perspectives, namely one for the purpose of design and another for the facilitation of production planning pertaining to components. In the design perspective, the model feature encompasses both additive features, such as subtractive, and protrusions features, such as holes and slots. In the perspective of industrial planning, the model feature only comprises features that are subtractive. The maintenance of consistent perspectives on a product model is achieved via the use of feature conversion. Furthermore, it provides capabilities for maintaining feature validity. This ensures that users are able to develop feature models that meet all given constraints, hence guaranteeing their validity.

Thirdly, the system provides advanced ways for visualizing feature models, enabling the display of more detailed feature information compared to existing systems. For instance, it is possible to view features that are not located on the border of the produced image, like the faces closure of a through slot. These facilities exhibit a high level of computational cost and need the use of a sophisticated product model, which includes a model of cellular including comprehensive data on all aspects in all perspectives. The Session Manager is responsible for storing data pertaining to a current session and its participants. The system is responsible for the management of data streams between clients of SPIFF and webSPIFF system of modeling. Concurrency must be managed at the Session Manager in order to handle the simultaneous transmission of queries to the webSPIFF server and modeling operations by many session participants. The responsibility of the Session Manager also includes the synchronization of session participants. This is achieved by transmitting the updated data structures to the participants after the completion of a camera operation. The Session Manager implementation has been carried out using the Java programming language.

Users of web SPIFF access the service with standard browsers. A Java applet is automatically downloaded and installed whenever a new client connection is established with the web SPIFF portal. To make establishing a connection with the Session Manager easier, this applet provides a simple user interface. Clients can initiate or join a modeling session from anywhere in the world, using either a local network or a remote connection over the Internet. When a user connects to a server, they can either join an already running collaborative session or start their own. To do this, you can define the product model you want to use. It's also crucial to be clear about which view of the model is being favored. Client-side UI development begins with retrieving the view's feature model from the server. With this interface, the user can take part in the modeling process. Clients should be able to explain modeling processes by defining features and the entities they represent. A feature that is meant to be added to a model, for instance, should be able to be attached to existing entities within the model, such faces and datums. After all of the operands for a feature modeling operation have been declared, the user is given the choice to confirm the operation. The next step is to send the operation to the server, where it will be validated and eventually executed. It is important to keep in mind that this could trigger a server-side product model update, which would then impact the feature model as seen by all session participants.

V. CONCLUSION

Business Process Management (BPM) is inherently a collaborative endeavor that encompasses several stakeholders. Process modelling activities are often facilitated by specific commercial software solutions; however, they may also be conducted without technological assistance. Nevertheless, despite the extensive study conducted on many areas of process modelling, such as modelling grammars and methodologies, there is a dearth of knowledge about the facilitation of modelling using collaborative technologies. Within the field of cBPM (computer-based process management), there exists a wide range of ways that are used by both academic researchers and industry professionals. These approaches may be categorized into two main groups: formal and informal. The formal methodologies are grounded on the principles of discrete mathematics. Indeed, a significant degree of overlap is seen throughout the various methodologies and programming languages. Cognitive Business Process Management (cBPM) assumes a crucial function within the contemporary domain of business process management. This article gives a view of current status of cBPM (collaborative business process management) techniques. The adoption of these systems and the comprehension of their terminology by non-technical individuals are hindered by a lack of uniformity and simplicity. Approaches such as the UML-based methodology exhibit simplicity, although they lack the capability to effectively manage collaborative aspects and process states. However, other methodologies exist that may effectively provide collaborative functionality, although with increased complexity. In conclusion, cBPM emerges as a thought-provoking subject matter that has significance from both a pragmatic and scholarly standpoint.

Data Availability

No data was used to support this study.

Conflicts of Interests

The author(s) declare(s) that they have no conflicts of interest.

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Ethics Approval and Consent to Participate

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Competing Interests

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