Towards a Continuous Temporal Improvement Approach for Real-Time Business Processes

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***Abstract*—Time is relative, which makes the interaction so sensitive. Indeed, contemplating the concept of real-time enterprises resembled envisioning an idealized notion that seemed unattainable and impracticable in reality. Consequently, we give a new definition of the real-time concept according to our needs and targets for a successful business process. According to this definition, we can go towards a real-time business process validation algorithm, which has the goal of ensuring quality in terms of time, i.e., time latency $\simeq 0$. Put simply, it serves as a method to assess the consistency of a process. This approach aids in comprehending the temporal patterns inherent in a process as it evolves, empowering decision-makers to glean insights and swiftly form initial judgments for effective problem-solving and the identification of appropriate solutions. Thus, our main purpose is to deliver the right information and knowledge to the right person at the right time. To achieve this, we introduce a novel real-time component within the Business Process Management Notation (BPMN), encompassing various attributes that facilitate process monitoring. This extension transforms the BPMN into a unified real-time business process meta-model. To be more specific, our contribution proposes a continuous temporal improvement assessment and knowledge management as temporal knowledge helps to evaluate the real-time situation of the business process.**

***Keywords*—Real-time business process; real-time enterprises; temporal latency; process validation; continuous improvement approach**

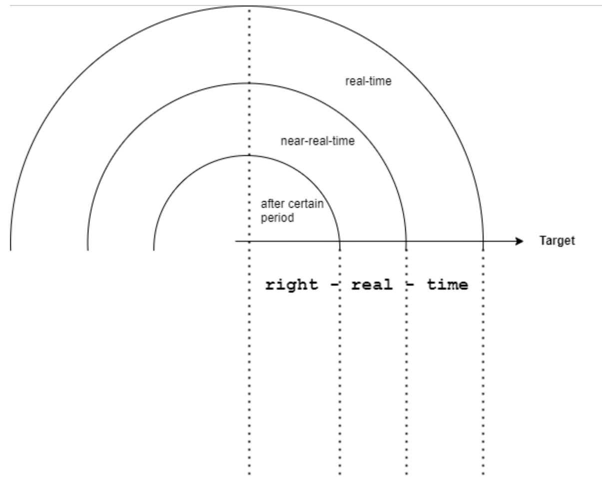

Fig. 1. Concept position: real-time enterprise/process, near-real-time entreprise/process, right-real-time enterprise/process.

I. Introduction

Business process management is one of the top development priorities in organizations; therefore, improving it becomes a priority, especially through the continuous improvement capability process [1], [2], [3]. Enhancing business process management is crucial for organizations to optimize their operations and achieve higher efficiency[1]. Our interest is time sensitivity in processes, or real-time processes, which we call right-real-time (as we will see in the research approach). Real-time enterprises entail immediate responsiveness to business demands, but in practice, achieving such instantaneous reactivity is not feasible; we are rather 'near real-time'; consequently, we depend here on customer needs that we're trying to meet through services. If an event that happens an hour from now is judged acceptable, that occurrence is now practically the standard for what constitutes real-time, in other words, right-real-time, which generates automatically time latency. One of the significant bases of our study is time latency to eliminate waste of time and have control over the whole process (see Fig. 1). Our approach aims to introduce a novel measure of capability specifically related to time. However, it is important to distinguish between two types of capabilities: those that enhance an organization's ability to run processes and those that pertain to conducting business process management (BPM) [1]. Our contribution falls within the latter category. Successful Business Process Management initiatives rely on various capability factors that significantly impact their outcomes. Our objective is to define a new capability factor, namely the temporal capability factor, which plays a crucial role in the continuous improvement process. By focusing on prevention rather than cure, particularly when dealing with sensitive parameters, we can implement appropriate solutions to proactively control the situation. The continuous improvement process enables the ongoing refinement of processes and the optimization of working conditions, ultimately leading to waste elimination. (Please see the general process of continuous improvement steps below in Fig. 2, as it is inspired from [4]). After conducting extensive studies, we have discovered that time wastage has emerged as a significant concern in today's highly competitive landscape, but there is no direct tool or method that can show the real-time situation of a business process with a continuous temporal improvement method. This explains the originality of our approach, which is useful for every business process because it includes the time aspect, which allows them to identify and rectify any potential deviations, bottlenecks, or errors as they occur, preventing negative impacts on overall operations in terms of time. Effectively managing and controlling time has become a formidable challenge in the current business environment. By continually improving their Business Process Management temporal practices, businesses can streamline workflows, reduce bottlenecks,

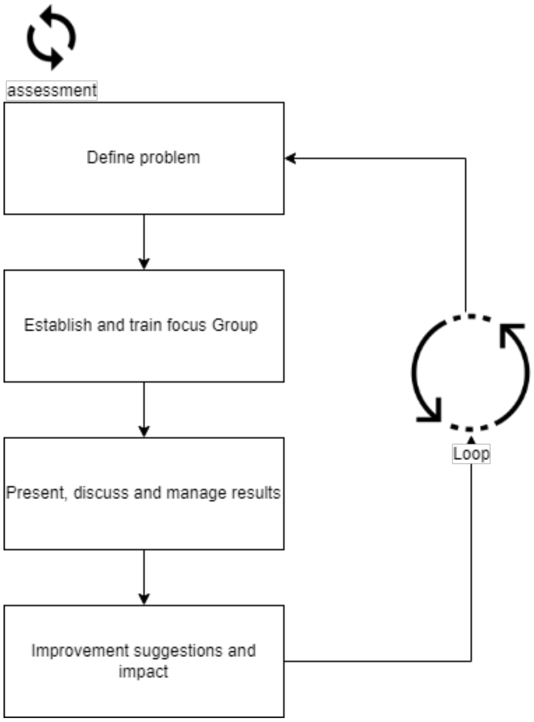

Fig. 2. CI Process.

and enhance productivity. This involves analyzing existing processes, identifying areas for improvement, and implementing strategies to enhance process efficiency and effectiveness. By focusing on Business Process Management improvement, organizations can achieve better resource allocation, reduced costs, improved customer satisfaction, and increased overall competitiveness in the market. Ultimately, continuous business process management temporal improvement leads to enhanced agility and adaptability, enabling organizations to navigate the ever-evolving business landscape with confidence [1], [5], [2], [3]. In this paper, we present a new "real-time process continuous improvement methodology" plus a "real-time process validation algorithm", which is an original search in terms of definition, modeling, and application. "Real-time Process Continuous Improvement" is an important topic for improving organizations' systems. This allows them to identify and rectify any potential deviations, bottlenecks, or errors as they occur, preventing negative impacts on overall operations in terms of time. Accordingly, we divide our contributions into four sections: Section I focuses on an overview of related works, which provides an in-depth exploration of relevant works in the field; Section II presents our proposed approach, elucidating its key components and methodologies; and Section III offers architectural thinking, which presents our approach within the enterprise architecture. Lastly, Section IV unfolds an in-depth examination, presenting the analysis, results, and discussions within the context of a case study format.

Foreword: Considering the need to establish clarity and avoid any potential confusion with existing definitions of real-time, particularly within the context of enterprise management case studies, we introduce a novel term in alignment with our specific understanding: right-real-time.

II. Related Works

The existing literature in this field can be classified into three main categories: the advancement of business process management, the exploration of real-time enterprises, and the multifaceted understanding of time and real-time figures. These categories encompass a wide range of research and practical applications, each shedding light on different aspects of achieving efficiency and agility in organizational operations. By categorizing the related works, we can gain a comprehensive understanding of the diverse perspectives and approaches taken in the study of this subject matter.

A. *Business Process Management (BPM)*

The development of Business Process Management (BPM) brings forth numerous benefits for organizations. Firstly, it enables companies to enhance their operational efficiency by streamlining and optimizing their processes, effectively eliminating bottlenecks and unnecessary steps. This results in improved productivity and cost reduction. Secondly, BPM provides organizations with better visibility and control over their processes, allowing them to monitor performance in real-time and make data-driven decisions[3]. This promotes timely interventions and continuous improvement. Thirdly, BPM fosters collaboration and coordination among various departments and stakeholders, facilitating effective communication and alignment of objectives. This leads to enhanced teamwork, quicker decision-making, and heightened customer satisfaction. Moreover, BPM empowers organizations to adapt and respond swiftly to evolving market conditions and customer needs, ensuring flexibility and a competitive edge. Overall, the development of BPM empowers organizations to achieve excellence in their processes, drive operational effectiveness, and foster sustainable growth [3], [5].

B. *Real-Time Enterprise*

A Real-Time Enterprise refers to an organizational paradigm where operations are optimized to enable instant responsiveness and agility. This strategic approach involves harnessing advanced technologies and innovative methodologies to enhance business processes and decision-making capabilities[6]. By embracing the concept of a Real-Time Enterprise, companies can leverage real-time data access, proactive decision-making, and seamless collaboration to gain a competitive advantage in the market. This transformation requires integrating cutting-edge data analytics, real-time monitoring systems, and automated workflows to enable swift responses to market changes, customer demands, and emerging opportunities. Shifting towards a Real-Time Enterprise involves transitioning from traditional, time-consuming processes to agile methodologies, dynamic process modeling, and adaptive strategies driven by real-time insights. By embracing the Real-Time Enterprise vision, organizations position themselves for sustained growth, improved operational performance, and the ability to swiftly adapt to evolving market dynamics [7], [8].

C. *Time and Real-time Figures*

The concept of real-time encompasses a wide range of meanings and finds extensive applications across various fields.

Its interpretation and utilization vary significantly, reflecting the diverse contexts and requirements in which it is applied. Real-time can refer to the ability to process and respond to data or events instantly, enabling rapid decision-making and actions. This is particularly crucial in time-sensitive industries such as finance, healthcare, and transportation. Additionally, real-time can also denote the synchronization of processes and activities with the passage of time, ensuring smooth coordination and minimizing delays [9], [10].

Real-time systems play a vital role in industries like manufacturing and logistics, where their reliance on such systems is substantial for enhancing operational efficiency and productivity [8]. These industries leverage real-time capabilities to optimize their processes, ensuring smooth and timely execution of tasks[5], [2]. For instance, the processing of large volumes of data in real-time enables the detection of anomalies and deviations, providing valuable insights for proactive decision-making and risk mitigation. This allows businesses to identify and address potential issues promptly, leading to improved operational performance and overall effectiveness. Therefore, the integration of real-time systems, coupled with advanced data processing techniques, proves instrumental in driving operational excellence across various sectors, including manufacturing and logistics [11].

Hence, the concept of real-time spans a vast spectrum of meanings and holds significant relevance in numerous sectors, highlighting its broad applicability and importance in today's dynamic and interconnected world.

Within the context of enterprise architecture development, the As-Is phase depicts the current state of the organization, while the To-Be phase represents the envisioned future state. This differentiation allows for a clear understanding of the present and future status of the company. In Business Process Model and Notation (BPMN), time constraints are effectively handled and modeled through the utilization of event time entities, which prove to be generally adequate for managing temporal aspects. However, as the demands of companies continue to expand across various dimensions, the time axis, known for its sensitivity and significance, becomes increasingly critical[9], [10].

III. Proposed Approach

A. Right-Real-time Ontology

The initial phase involved establishing a formal definition of the real-time concept. While in an ideal scenario, real-time enterprises would respond instantaneously to business requirements, it is acknowledged that achieving true real-time capabilities is challenging. Hence, the concept of "near real-time" is introduced. The primary focus is on minimizing the time latency between data storage and availability, aiming to provide decision-makers with relevant and timely information. Considering the inherent challenges of achieving real-time capabilities in their entirety, it is important to prioritize timely reactions. Therefore, the key lies in delivering the appropriate information to the designated individual at the opportune moment. This ensures that decision-makers receive the necessary insights precisely when they are most advantageous [12].

When dealing with time in a real-time process, it becomes necessary to consider both an acceptance interval and a theoretical-time. The acceptance interval refers to a predefined range that ensures customer satisfaction, while the theoretical-time represents the ideal duration that can be predicted using various prediction tools. These two elements play a crucial role in effectively managing time within a real-time process.[12]. Based on the findings from the aforementioned results, we can provide a formal definition of real-time as follows:

$$\textbf{Right-Real-time ontology} = \textbf{Time ontology} + \begin{cases} \textbf{Latency} \\ \textbf{Acceptance interval} \\ \textbf{Theoretical time} \end{cases}$$

The adapted version of the time ontology, as depicted in Fig. 3, incorporates the concept of real-time [13]. This ontology defines time based on three components: time element, linear/nonlinear, and absolute/relative. However, our aim was to introduce a novel time component that would provide us with a fresh understanding of time.

In this adapted version, a new component called real-time is added to the time ontology. Within this component, three additional sub-components are included: latency time, acceptance interval, and theoretical time. This definition presents a new perspective on time, moving beyond the conventional notions of periods and calendars, and instead focusing on its significance in addressing the needs of real-time enterprises.

Please note that the figure mentioned can be found in Fig. 3, and the adapted ontology incorporates the real-time concept proposed by Kirikova et al. [13].

The first attribute in our definition is latency, which is closely linked to the concept of real-time as we previously mentioned. Since attaining real-time in its entirety is not feasible, latency becomes a reliable indicator in defining real-time. It can be conceptualized as an interval. In order to align with client needs, we found it essential to introduce a new attribute that establishes a safe range of latency. Thus, we defined the second attribute as the acceptance time interval. Similar to latency, the acceptance interval is also defined as an interval, representing a safety range within which latency does not disrupt the process flow.

Theoretical time, on the other hand, serves as our projection into the future based on our results. The purpose of defining the theoretical time is to enable result comparison and determine the degree to which we deviate from the ideal outcome. Generally, theoretical time is regarded as the ideal result, while the upper bound of the acceptance interval represents the worst outcome. Consequently, the lower bound of the acceptance interval corresponds to the theoretical time.

B. Right-real-time Process

The conventional interpretation of a process refers to a sequence of actions undertaken to attain specific outcomes. However, the definition of a process varies across different domains, tailored to suit their respective requirements. For instance, within the industrial context, a process represents a series of steps involved in manufacturing products. Within numerous enterprises and organizations, the concept of a process surpasses the simplicity of its elementary definition.

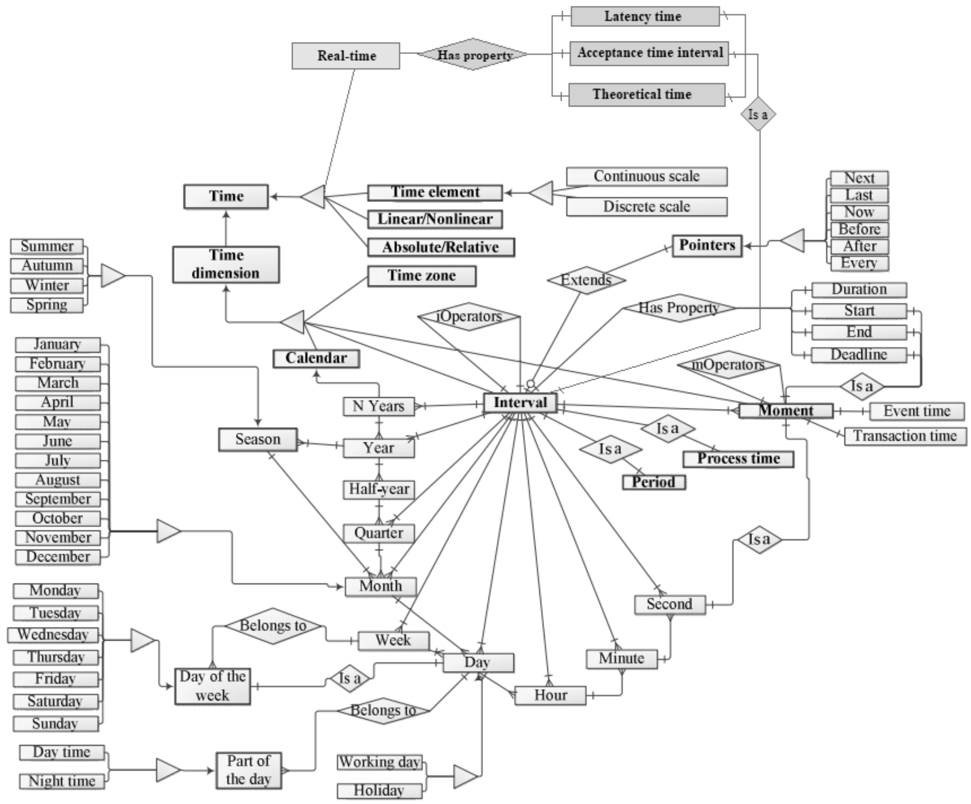

Fig. 3. Time ontology (adapted with real-time ontology).

It encompasses a greater level of complexity, often involving a collection of interconnected sub-processes, amplifying its intricacy. Companies have a wide array of languages at their disposal to effectively model processes, enabling them to visualize, interpret, and execute these processes while considering various constraints. One such language commonly utilized is BPMN (Business Process Model and Notation), which offers extensive capabilities in this regard.

Real-time processes encompass attributes that align with immediate responsiveness. However, the concept of real-time derives its definition from the specific requirements of customers, as opposed to a literal "right now" interpretation. So, if an event that happens an hour from now is judged acceptable, that occurrence is now practically the standard for what constitutes real-time. Establishing a precise definition for real-time is a complex task as it encompasses various interpretations. Given that achieving real-time in its absolute sense is often impractical, timely reactions become crucial. Therefore, delivering accurate information to the appropriate individual at the opportune moment becomes essential. Consequently, a real-time process refers to a process capable of providing a service and meeting client satisfaction. citeouarhim2019.

C. Right-Real-time Enterprises/organisations

A real-time process constitutes a fundamental attribute of Real-Time Enterprises (RTE). These companies stand out because they can quickly react to different situations, usually using automated systems guided by built-in business rules or advanced technology solutions.

Within a real-time enterprise, there exist four primary categories of real-time processing, namely: (1) straight-through processing; (2) on-demand real-time data; (3) real-time performance management; and (4) real-time predictive analysis [14]. These processes encompass significant alterations over an extended duration, involving long-term changes, according to B. Kuglin and H. Thielmann [6]. These factors play a significant role in various areas: (1) within the internal and cross-company work processes; (2) in the division of labor both within an organization and across multiple companies; (3) through the implementation of technologies during the transition towards a Real-Time Enterprise; and (4) in the management of processes as well as the overall governance of the enterprise itself.

According to A. Ouarhim et al. [12] analysis, we can concisely outline the attributes of a real-time organization and establish a formal definition as follows: A real-time company is characterized by its agility, swift responses, prompt dissemination of information, rapid data analysis, efficient management of real-time processes, and incorporation of cutting-edge technologies, all of which converge to achieve near-zero latency.

D. Managing Time in Business Process Toward Right Real-time Business Process in a Continuous improvement approach

1) Time in a business process: Within a business process, time manifests in various ways, yet a precise definition of the real-time concept remains elusive. In the context of a business process, time can be characterized as follows:

- Duration: interval with two ends (processes or tasks).

- Point: moments of execution of processes or execution time of tasks.
- Now: means that the process is auto-reactive (real-time).
- Time condition: reactive according to a time condition.

2) Temporal latency index or temporal capability: real-time process validation algorithm: The business process capability index serves as a metric that evaluates the correlation between a process's current performance and the predefined industry standards. It holds a keen interest in novel research about quality assurance and capability analysis. Capability indexes effectively measure both the potential and actual performance of processes, playing a vital role in quality improvement initiatives and serving as a cornerstone for successful implementation of quality programs [15] as shown in Fig. 4.

$$C_p = \frac{\text{USL} - \text{LSL}}{6\sigma}$$
$$C_a = 1 - \frac{|\mu - m|}{d}$$
$$C_{pk} = \min\left\{\frac{\text{USL} - \mu}{3\sigma}, \frac{\mu - \text{LSL}}{3\sigma}\right\}$$

Fig. 4. Capability indexes [15].

where:
• USL and LSL are the upper and the lower specification limits, respec-tively,
• Mu is the process mean,
• Sigma is the process standard deviation,
• m=(USL+LSL)/2 is the mid-point of the specification interval,
• d=(USL-LSL)/2 is half the length of the specification interval.

The process capability index, denoted as C_p, quantifies the overall variation of a process concerning the specified tolerance, providing insight into the process's inherent potential or precision. On the other hand, the process capability index C_a gauges the level of process centering, serving as an indicator when the process mean deviates from the target value, thereby reflecting process accuracy. Introducing the process capability index C_{pk}, it not only considers the magnitude of process variation but also accounts for the degree of process centering, thereby assessing process performance based on yield, which represents the proportion of conformity.

Undoubtedly, these measures serve as powerful tools for assessing process performance and efficiency. However, there exists another factor that significantly influences process effectiveness: time. Time has been a subject of ongoing research and, in this context, is increasingly recognized as a critical quality factor. By monitoring the behavior of time, valuable insights can be gained regarding the temporal dynamics of processes across different periods.

In light of this, we propose a comprehensive system for temporal process monitoring; see Algorithm 2. Each process is characterized by its response time, waiting time, and execution time. Through this system, we aim to derive the following outcome [16]:

$$L_t = (T_{tmax} - T_{tmin})/(VAR * T_{tmax})$$

- Introducing the index L_t, also referred to as the "temporal latency index" or "temporal capability", provides valuable insights into the temporal dynamics of a process. This index enables us to gain a comprehensive understanding of a process's temporal behavior, empowering us to take timely action and implement necessary improvements accordingly.
- The parameter T_tmax represents the maximal temporal tolerance, which signifies the acceptable limit within each specific case study.
- T_tmin denotes the minimal temporal tolerance, representing the ideal scenario within the context of each case study.
- VaR: value at risk.

The concept revolves around determining the ratio between the tolerance margin and the maximum permissible risk of delay.

The percentage of response latency varies across different periods. This implies that if the error rate is calculated over a week, it tends to be higher compared to calculating it over a month. This variation can be attributed to the level of process discontinuity experienced within each period. Furthermore, the significance of response latency becomes less important when addressing past-present problems, whereas it holds greater importance when dealing with present-future problems. Moreover, as organizations strive for real-time capabilities, acknowledging and mitigating time latency becomes imperative for achieving optimal results in dynamic environments. However, time latency plays a pivotal role in influencing the outcomes of various events and processes. The duration between the occurrence of an event and the corresponding system response can significantly impact the overall efficiency and effectiveness [17], [18].

Hence, it is crucial to determine the appropriate scale based on our specific requirements. If the problems or questions pertain to the present, our focus will be on the "day-month" scale. Conversely, if they relate to the future, our attention will be directed towards the "month-year" scale.

The utilization of VaR (Value-at-Risk) (see Algorithm 1) is driven by our interest in understanding the variations associated with time latency, which are never constant. By identifying the most unfavorable of these discrepancies, we can enhance control over our business processes. Hence, the index L_t serves as a means to compare the theoretical and real outcomes. Value-at-Risk refers to the maximum potential loss that is only expected to occur with a given probability over a specific time period. In simpler terms, it represents the most severe loss anticipated within a defined time horizon, considering a certain level of trust [19].

Our approach entails identifying the most severe temporal risk that our business process can handle, utilizing a learning system. Therefore, it is crucial to determine the time period under examination, as previously discussed: "day," "week," or "month." When interpreting the VaR (value-at-risk) figure, one must consider the probability (x) and the holding period (t)[19]. First, we'll start by looking at each month of the year. After that, we'll analyze each month individually, and eventually, we'll broaden our examination to cover multiple years.

The utilization of the L_t formula offers the advantage of simplifying the time period, making it applicable across all periods. Therefore, the choice of time period becomes significant in terms of result accuracy and precision.

Algorithm 1 VaR calculation

```
Result: VaR value
i=1
while i ≤ lenght(filename) do
    tri=sort(Rnd(:,i))  for k ← 1 to b(i) − 1 do
        I(k) = k/(b(i) − 1)
    end
    J = find(I ≥ 0.01)  PvaR = J(1)  VaRT(i) = −tri(PvaR)a
end
```

Algorithm 2 Real-time process validation algorithm

```
Result: Process state functioning
// we start with algorithm inputs
Input: T_tmax, T_tmin, VAR
L_t = (T_tmax − T_tmin)/(VAR ∗ T_tmax)
if 0 < L_t ≪ 1 then
else
    // A requirement for making
       improvements in the process
end
if L_t ≃ 1 then
else
    // A state of balance and indicates
       that the process is functioning
       well: low latency
end
if 1 ≪ L_t < 2 then
else
    // The business process is operating
       at a near-perfect level:
       right-real-time process
end
```

Functioning of the index :

The functioning of the index can be described based on the findings obtained from our analysis of three different case studies:

- If the value of L_t deviates significantly from 1 to 0 (but never equals 0), it indicates the need for process improvements. Specifically, when $0 < L_t \ll 1$, action should be taken to enhance the business process.
- When the value of L_t is approximately 1, it indicates a state of balance and indicates that the process is functioning well(on time demand: right-real-time): $L_t \simeq 1$.
- When the value of L_t is significantly greater than 1 but less than 2 (and never equal to 2), it indicates that our business process is operating at a near-perfect level: $1 \ll L_t < 2$.

We have chosen to employ the historical method for calculating our VaR due to its simplicity, speed, and efficiency. By multiplying VaR with Ttmax, we obtain the maximum risk of daily delay. In other words, if tomorrow's delay is 'd', the worst-case scenario will be 'd + VaR*Ttmax'. Therefore, the concept of the L_t formula represents a comparison between the maximum acceptable delay and the practical implementation using VaR (value at risk).

3) Continuous temporal improvement approach: Prevention is better than cure, having the appropriate tool to prevent specific issues will be better than reforming all present damage. Continuous improvement processes give many cycles that help to improve processes continuously, according to specific ethics for each cycle as we show in the following Table I, time in continuous improvement's tools and methods adapted version of [20]:

These continuous improvement processes have the goal of optimizing the performance of working conditions in terms of planning, organization, waste elimination, work methods, and knowledge management. In the present era, time wastage has emerged as a critical concern, particularly with the advent of the new digital transformation approach [5]. As significant changes continue to unfold, it becomes crucial to examine whether we can still maintain the same level of control over diverse business processes. Our pioneering contribution aims to tackle this challenge by not only preventing time wastage in business processes but also ensuring effective control to gain a comprehensive understanding of the real-time situation. Through our innovative approach, we strive to optimize time utilization and maintain a firm grip on business processes, thereby enabling informed decision-making and improved efficiency. First of all, our based contribution process is as follows: Fig. 5:

Our based process begins with analysis. We analyze data from our source of knowledge using simple and proactive parameters so we can detect the problem. After that, it is time to learn and discover different causes and try to find solutions to deliver the right information and knowledge to the right person at the right time. Before proposing solutions for the correction phase, we are faced with judging current practices.

We propose a rational approach dedicated to continuously improving time in business processes. As we all know, wasting time is a special case in all areas, and its damage becomes significant, especially when we face a serious situation. So, having a specific approach to time issues will give us the right answers to what we need. For that, we propose a right-real-time approach that is more responsive and compliant with time changes, namely our proposition about the L_t index. Fig. 6, which is inspired by [21] and the Deming wheel introduced by William Edwards Deming (1950s).

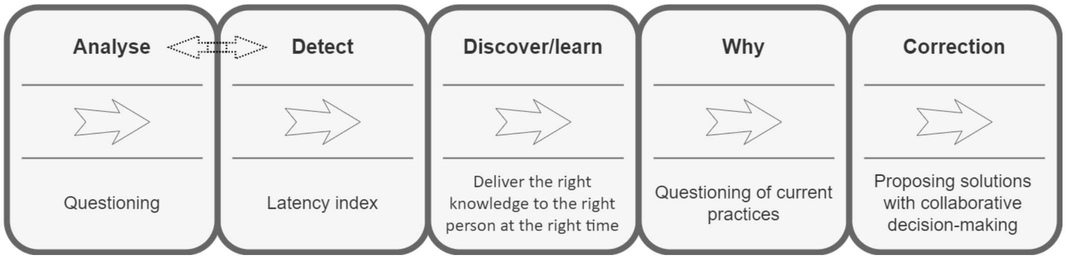

Fig. 5. The based wheel process suitable to temporal issue, case right-real-time processes.

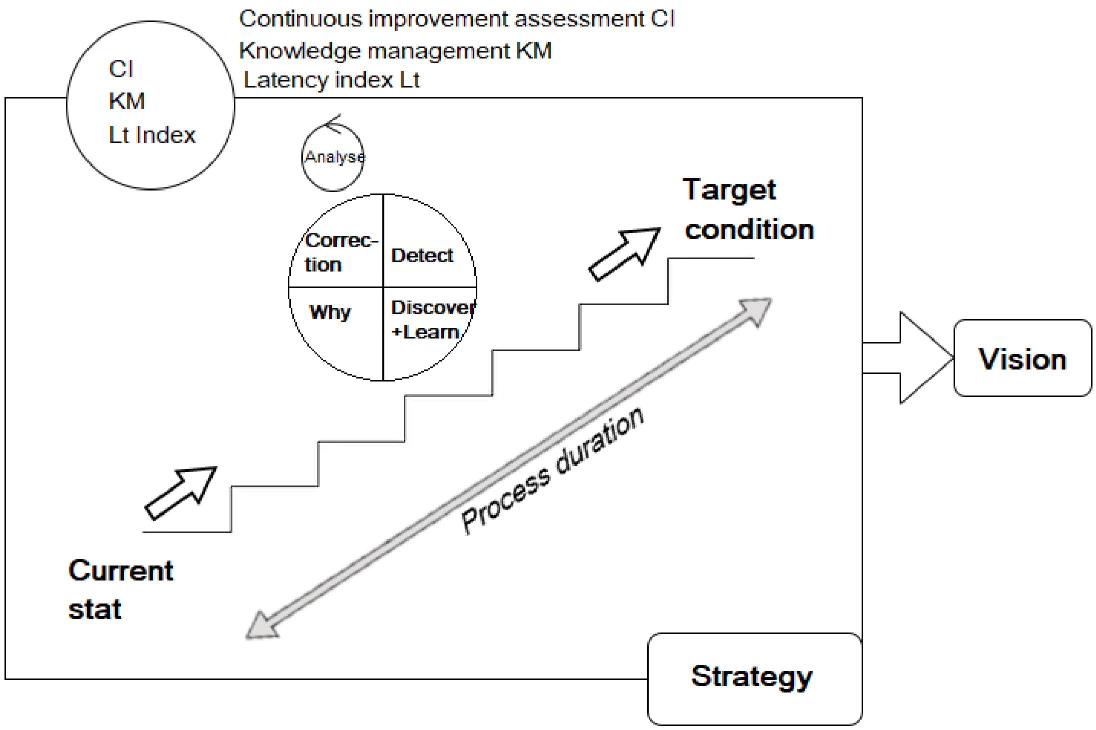

Fig. 6. Continuous temporal improvement approach and elements with Latency index Lt.

The originality of our approach can be seen in Fig. 6 as follows: The L_t index provides real-time insight into the business process's temporal status. Based wheel process fits for right-real-time processes, serving continuous analysis or on-demand use for processes temporal improvements. In fact, during the implementation of continuous improvement, we must take into account the elimination of waste in all processes, highlighting the importance of our contribution to continuous improvement, which aims to control the waste of time to have the right-real-time CI process according to a previously established strategy. Our contribution L_t index will support continuous improvement assessment and knowledge management as temporal knowledge that helps to evaluate the real-time situation of the process each time. Consequently, the company's vision will be clearer over time. The L_t index will learn from all previous history of time processes to give a great prediction of present and future responding time process situations.

E. Proposition of a New Component in BPMN: Right Real-time Component

Our focus lies on components that are time-related, and after an extensive analysis of the BPMN specification, we have identified Events as the key elements of interest. Events are directly related to FlowNodes and indirectly related to activities through BoundaryEvents and, specifically, CatchEvents. Both Events and Activities inherit from FlowNodes, which, in turn, inherit from FlowElements. The Process component inherits from FlowElementContainer, which is a composition of various FlowElements. This observation highlights that activities, along with the entire process, are more closely associated with time and real-time considerations, as indicated by the definition of time within a process [22].

Our proposal involves the creation of a novel component called Real-timeAttribute [16] as follows, Fig. 7, (OMG specification diagram [22]: adapted version): Fig. 7 illustrates a meta-model diagram depicting components that are relevant

TABLE I. OBSERVING TIME IN CONTINUOUS IMPROVEMENT'S TOOLS/METHODS [ADAPTED TO [20]]

Tool/method	Method Description	presence of waste-time analysis (t)
Kaizen Event	Kaizen events are structured initiatives that drive incremental improvements in processes, with a primary focus on enhancing process value and minimizing waste.	However, the connection is not straightforward.
Value Stream Map	A Value Stream Map is a visual depiction that illustrates the sequence and interrelationships of all the steps involved in a particular process.	No
Lead Time Analysis	The overall duration between the initiation and completion of a task, process, or service can be divided into two components: value-added time and non-value-added time.	Yes
Gemba	Japanese term used to describe the practice of physically going to the location where work is being performed.	No
5 Why's	problem-solving method that involves repeatedly asking "why" to uncover the underlying root cause of a particular issue.	No
Spaghetti Diagram	A visual representation that illustrates the flow of transportation or movement of a product or service.	No
SIPOC	A comprehensive analysis of Supplier - Input - Process - Output - Customer that offers a customer-centric perspective of a process and its deliverable.	No
6 S	An implementation method employed to establish and uphold a well-arranged work environment: Sort, Set in Order, Shine, Standardize, Sustain, and Safety.	However, the connection is not straightforward or direct.
Project Evaluation Matrix	A technique for assessing the business impact and the ease of resolving a problem to determine the priority of actions needed.	No

to our study. The depicted figure highlights the focus on the rightRealTimeAttributes within the activity. Notably, this attribute has a direct impact on both Processes, Subprocesses, and Pools, as illustrated in the figure. As a result, these processes are automatically influenced by this particular property.

In Fig. 7, we can observe significant components that are relevant to our research. Additionally, we introduce our new component called Real-timeAttributes, which encompasses three essential attributes: latency, acceptanceInterval, and theoreticalTime (represented by RT). The inclusion of this component enhances our understanding and control over real-time processes, providing a clearer perspective and definition of what constitutes a real-time process.

The Fig. 7, represents a prototype of the extending component. We propose the development of a prototype that extends the Activity component, creating a specialized component known as "real-time Activity." This prototype aims to enhance the capabilities of the Activity component by incorporating real-time functionality and features.

IV. ARCHITECTURAL THINKING

A. Research Approach Diagram

Fig. 8, shows a diagram that elucidates the interconnection among all sub-sections and their corresponding outcomes, using the proposed based wheel process.

B. Capability Metamodel with our New Real-time Contribution

In the TOGAF content model, the objective of the organization is essential to fulfilling the capability. The TOGAF model can be further extended by providing additional meta-entities that describe the definition of capabilities as a measurable entity as shown in [23]. A business process enables the capability to execute the expected activities and outcomes. These entities that enable the capabilities, namely process, business service, and the lower level system components namely application architecture components, are measurable. A measurable entity is an entity whose attributes are measurable.

Our approach is to provide a new measure of capability concerning time. As the following figure shows inspired from [23], Fig. 9, our entity "Right-Real-time" is a measurable entity, that influences capability somehow according to each case study, for example, the influence can be generally latency as we discuss in the previous section. We define the measure of "Right-Real-time" as another entity "Right-Real-time-Index" that provides many attributes as shown in the previous section. "Right-Real-time-Index" has a goal that indicates the temporal situation of the process, as well we can make a decision, that we have named the index values'; that's considered as one of its attributes; previously as temporal latency index or temporal capability.

C. The Overview of the Unified Business Process Meta-model with our New Component: Real-time Business Process

So, we propose a unified business process meta-model containing our new component by integrating it into the unified meta-model proposed by Heidari, Farideh, et al. [24]. Their approach was to create a unified meta-model as a unified business process meta-model that provides a language-independent business process ontology. The mainstream business process modeling languages on which they were based are Business Process Modeling Notation (BPMN), Role Activity Diagram (RAD), Unified Modeling Language Activity Diagram (UML-AD), Integrated Definition for Function Modeling (IDEF0 and IDEF3), Structured Analysis and Design Technique (SADT), and Event-driven Process Chain (EPC). Each concept of these business process modeling languages is mapped onto only one concept in the unified business process meta-meta-model. They categorized the concepts of the unified business process meta-model into four aspects of a business process, namely: behavioral, functional, organizational, and informational aspects. This approach will give a full definition of the business process meta-model in terms of a unified meta-model and a real-time definition. Our CI approach plus real-time attributes, will give a specific time recognition about each process, which helps to first of all have a clear idea about the as-is timing situation and to make the right decisions about present and future processes. Fig. 10 presents our extended version of the unified modeling language; our components take part in behavioral aspects.

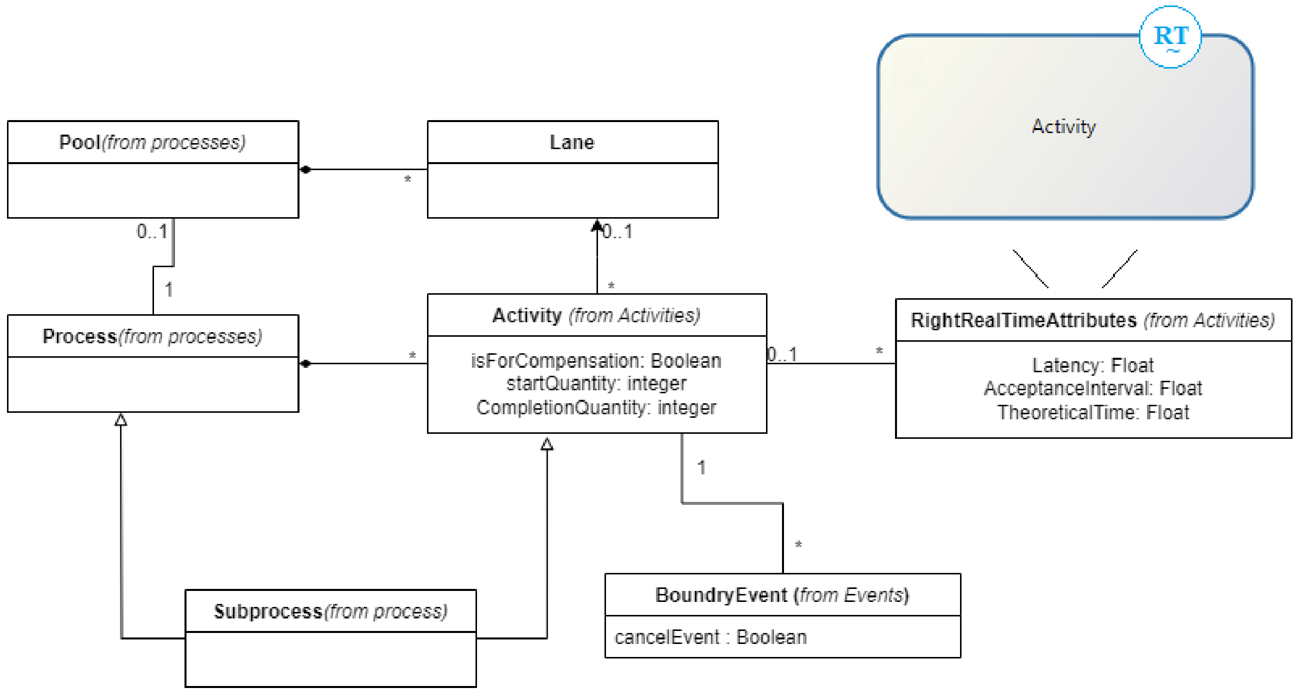

Fig. 7. New real-time component with additive attributes and a prototype of the extending component (RT).

V. Case Study: Analysis, Results and Discussion

A. General Train Process

The train transport process is a crucial component of the modern transportation industry. It encompasses a series of coordinated activities that facilitate the movement of goods and passengers efficiently and safely. Starting from the scheduling and planning of train routes to ticketing, boarding, and on-board services, this process requires precision and attention to detail. Safety measures, maintenance routines, and adherence to schedules are fundamental aspects of this process. The efficiency of this process is vital for ensuring the seamless operation of train services, contributing to the overall connectivity and accessibility of regions and nations. Fig. 11 shows our proposed general train transport business process inspired by [25].

B. Context of Work: Train Delays Problem

Train delay problems are due to so many reasons, especially train driver scheduling problems, which are considered more complex than other public transport problems. Indeed, this is due to driver work rules, constraints on the network, and the rolling stock. However, late trains can be resumed by: engineering work areas where the speed of trains is limited; the lack of double lines; conditioned speed (not the same all the way); overcrowded tracks owing to more and more trains each year; poor infrastructure bringing frequent maintenance, especially old tracks, which causes speed restrictions and delays; train driver behavior; and freight traffic contesting passenger routes.

According to Toor and Ogunlana [26], a delay is a result of many problems that can be resumed in factors related to local and environment, factors related to employees (designers, contractors, and consultants) and clients, and factors related to logistics sides such as lack of resources and other tasks problems such as planning and scheduling deficiencies. This problem is common in developed and developing countries and is considered one of the most recurring problems in construction projects. Problems of delay concern all types of construction projects, including trains. Major problems which this construction faces are usually due to three factors: system, resources, and communication.

However, the lateness of trains is due to so many reasons, like engineering work areas where the speed of trains is limited, lack of double lines, conditioned speed (not same all the way), Overcrowded tracks owing to more and more trains each year; poor infrastructure brings frequent maintenance, especially old tracks, which causes speed restrictions and delays; train driver behavior; and freight traffic contesting passenger routes. Trains driver scheduling problems are considered more complex than other public transport, and this is due to driver work rules, constraints on the network, and rolling stock.

This complexity arises from strict rules that the driver must follow for the safety of passengers and freight trains. Ronald et al. [27] did a study about the behavior and the psychological thinking of the train driver and set all situations that can make him not aware of his environment as a problem of control, and they present many methods that trait this kind of problems as COCOMO that help to understand train driver behavior.

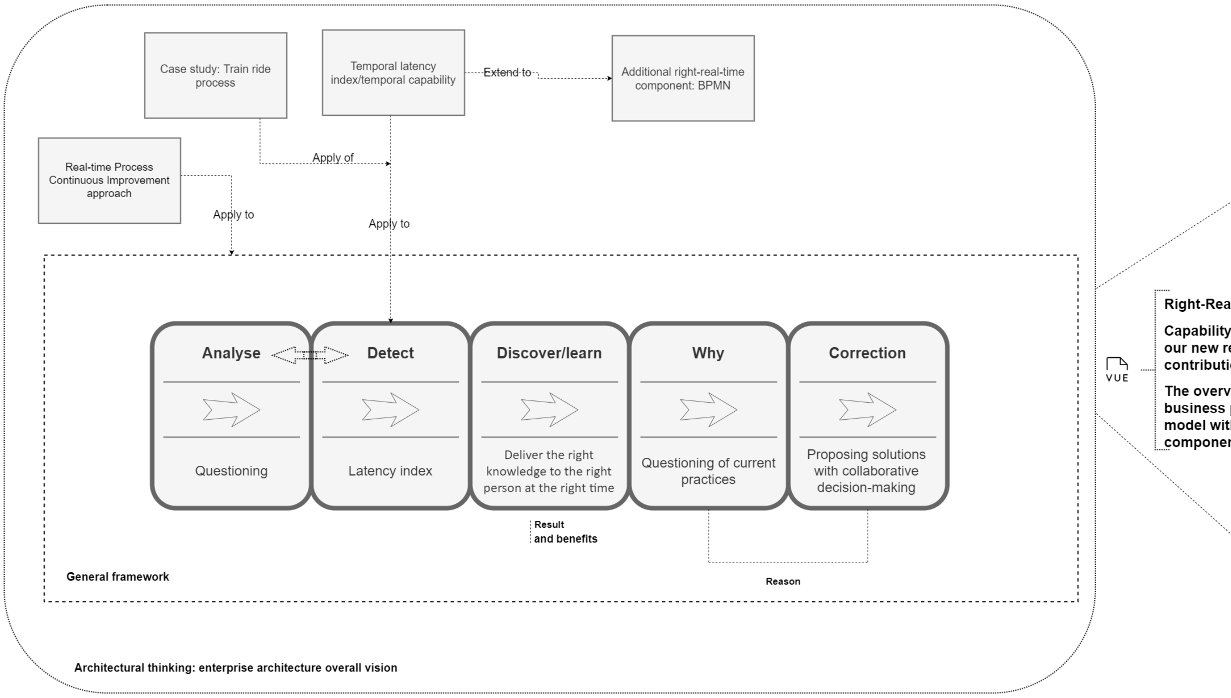

Fig. 8. Research approach diagram.

C. Results

According to our based contribution process (see Fig. 5), we start by analyzing our data, then go to check the latency index value, and so on.

1) Analyse: As we have seen, the lateness of trains is due to so many reasons, like engineering work areas where the speed of trains is limited, the lack of double lines, conditioned speed (not the same all the way), overcrowded tracks owing to more and more trains each year, poor infrastructure that brings frequent maintenance, especially old tracks, which cause speed restrictions and delays, train driver behavior, and freight traffic contesting passenger routes. After analyzing our data based on the study, which focuses on presenting the findings specifically from year X, the results show that delays were not the same across all periods. Fig. 12, 13, and 14 show some examples of diagrams that we had during our analysis:

Fig. 12 shows delays of all trains/lines on each month during a year. Trains' late varies monthly and daily. As we can see, delays are not the same in all periods, but we can conclude that trains have the same attitude in all months. Fig. 13 shows the variation of mean delay in each station for the same train "train A" in a year, we see that delays are not the same and change according to each station.

Similarly, in the case of train B, as depicted in Fig. 14 during the same time-frame, it is observed that the mean delay varies across different stations. It's essential to note that in this context, the term "trains" serves as a representation of lines.

Our approach aims to identify any potential latency issues within our business process. In the event of a positive indication, we will proceed to explore and implement possible solutions. The advantage of using L_t Index is to have a gain in terms of time. Indeed, it resolves the problem of latency twice.

TABLE II. TABLE OF RESULTS

Years	L_t
X	0.142[1]

[1] the value of L_t deviates significantly from 1 to 0 (but never equals 0), it indicates the need for process improvements.

2) Detect: Through extensive research conducted over various periods, this study focuses on presenting the findings specifically from the year 2018, offering a comprehensive overview. When implementing this methodology for the first time, it is advantageous to initially analyze previous years as a foundational element [13], [19], In line with this approach, we have specifically chosen to focus on previous years in our study. This approach provides a holistic perspective on the alignment of our processes with the concept of real-time. To facilitate a thorough examination, we gradually narrow down the time periods, starting with months and subsequently delving into weeks, and so forth [19]. This progressive analysis enables a deeper understanding and evaluation of our processes at different levels of granularity.

The company has already determined the values of T_{tmax} and T_{tmin} as two predefined elements. The analysis results will be condensed and presented in the following Table II.

Fig. 15 shows Train transport cases business process with our right real-time component.

3) Discover/learn: L_t value shows that the train process is far from being a real-time business process.
We observed similar graphs for other trains and found that the

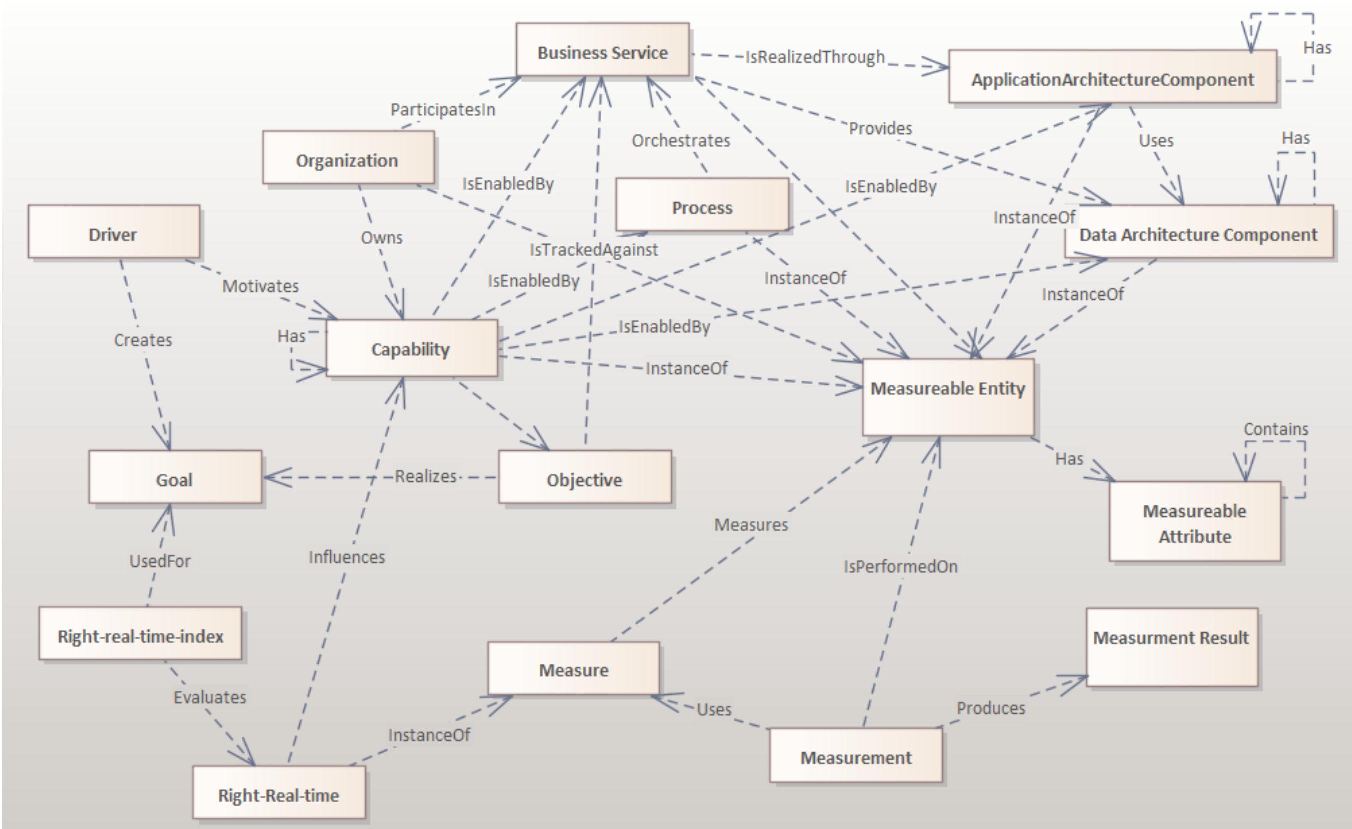

Fig. 9. Capability metamodel with right-real-time components (adapted with “right-real-time” components).

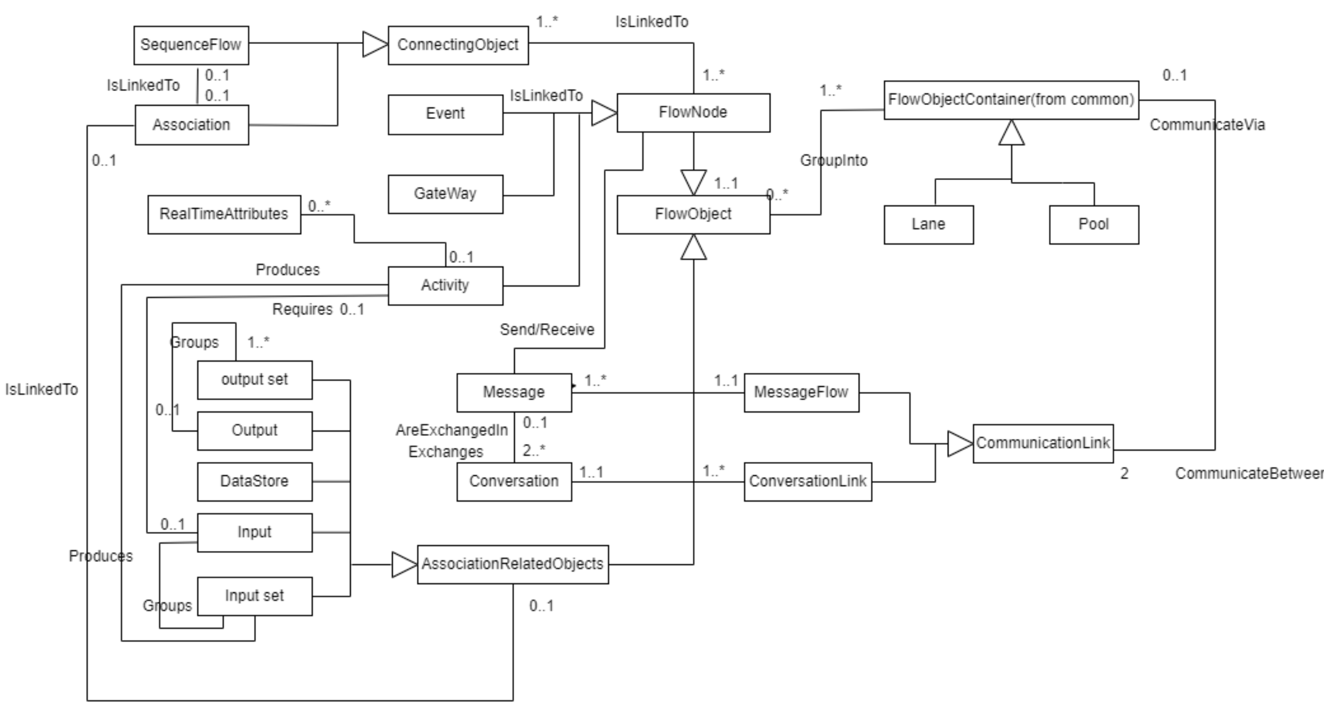

Fig. 10. The overview of the business process meta-meta-model with our new component.

variation in delays is related to periods in a year and station characteristics. The journey of each train is characterized by its lines and stations. A train can change lines daily. So, major delays along a line are related to busy stations compared to

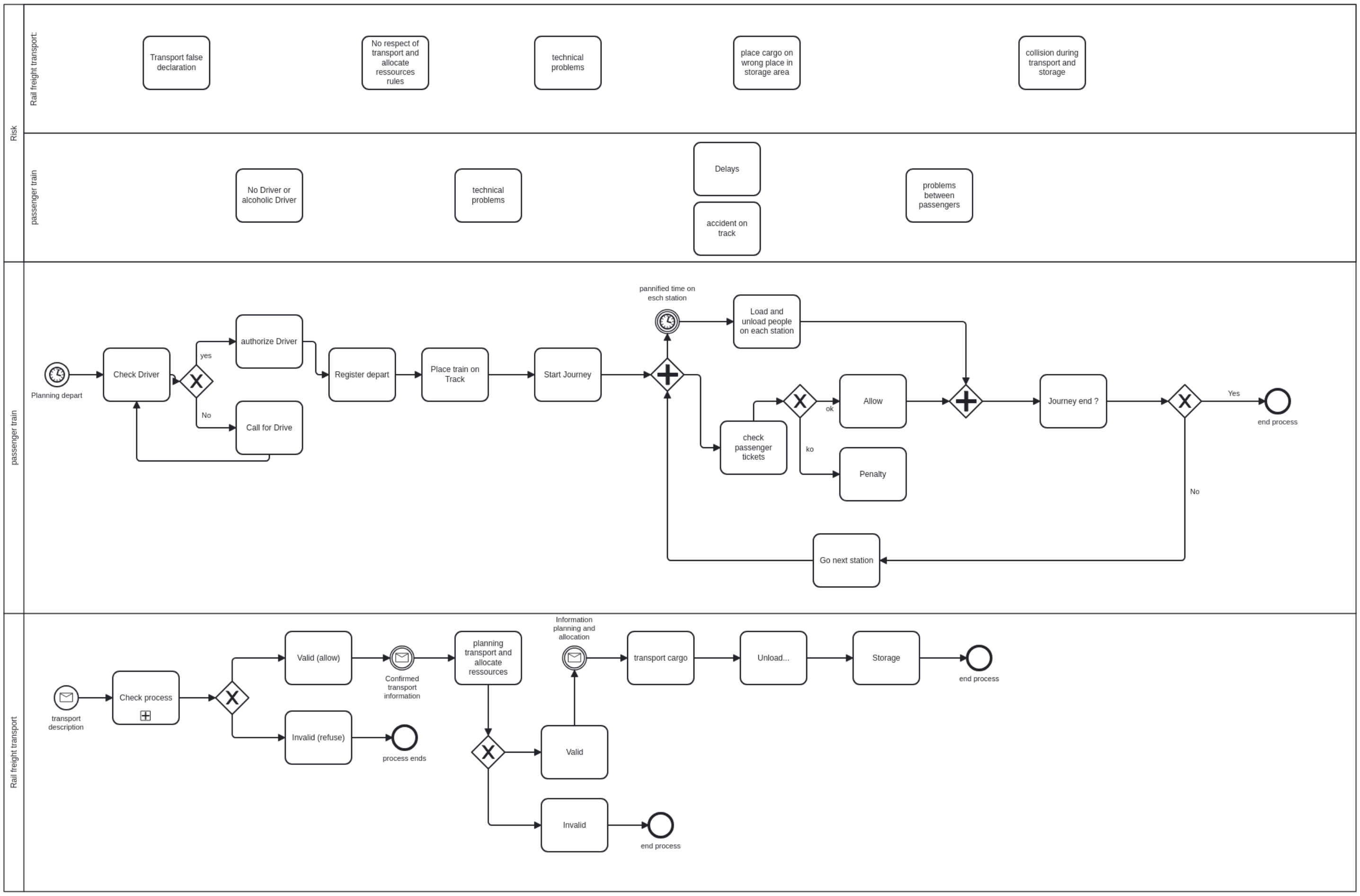

Fig. 11. Train transport business process.

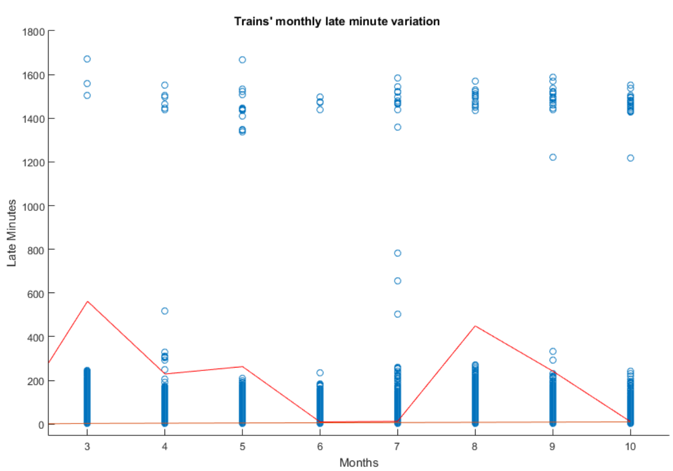

Fig. 12. Trains' monthly late variation in the year X.

other lines with less busy stations.

4) Why: This problem of latency can be related to the variation in the load of people at each station and the need or demand for train transport during the year. There are periods when trains are less in demand in some lines; however, in the same period, trains are more needed in other lines, which unfortunately causes delays.

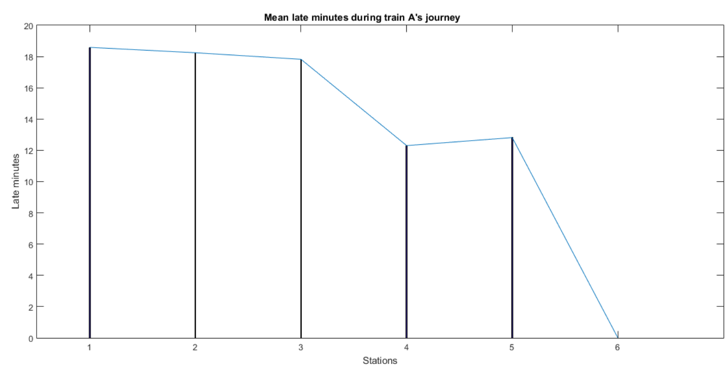

Fig. 13. Mean late minutes during train A's journey in the year X.

5) Correct: In this phase, we identify and rectify errors, inconsistencies, or inefficiencies. This phase aims to refine and enhance the process's quality and performance by addressing any issues that have been identified during the assessment or execution stages. By conducting a thorough analysis, addressing issues, and optimizing, the corrective phase ensures

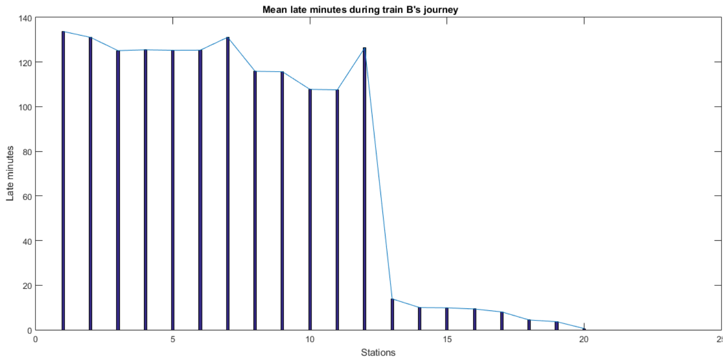

Fig. 14. Mean late minutes during train B's journey in the year X.

the alignment of the process with desired outcomes and adherence to established standards. This, in turn, enhances overall effectiveness and results. After the 'Why' phase, it is clear that a lack of stations and train traffic management is the main cause of latency. So, proposing a preliminary approach to managing train traffic according to the needs of each station will be the first step in improving this case study. The results attained will serve as inputs for the subsequent phase of our ongoing enhancement journey, creating a cycle of progress that perpetuates sequentially (see Fig. 6).

D. Discussion

This approach combines two advantages: the first is the proposed based wheel process suitable for temporal issues, and the second is the latency index that indicates latency issues in a process. The usual waste tools didn't give a whole treatment that combined two approaches toward continuous temporal improvement.

VI. Conclusion

We present a new "real-time process continuous improvement methodology" plus a "real-time process validation algorithm", which is an original search in terms of definition, modeling, and application. This approach is useful for every business process, including the time aspect, which allows them to identify and rectify any potential deviations, bottlenecks, or errors as they occur, preventing negative impacts on overall operations in terms of time. Indeed, time waste has emerged as a significant challenge in today's highly competitive world. Consequently, effectively managing and controlling time has become a critical endeavor. To address this issue, we have introduced a novel definition of the real-time concept that aligns with customer needs and our objectives of achieving a successful business process. Expanding on this definition, we've created an algorithm for real-time validation of business processes. The main goal is to ensure high-quality timing, with the ultimate aim of achieving minimal time latency (i.e., time latency $\simeq 0$). In essence, this algorithm serves as a means to assess process consistency by leveraging temporal capability. It provides decision-makers with insights into the temporal behavior of processes during execution, enabling them to make prompt decisions and find suitable solutions. The proposed algorithm is supported by our "continuous temporal improvement approach.". Furthermore, we have introduced a new BPMN real-time component that includes various features to ease process monitoring within a continuous improvement (CI) approach. Furthermore, we have introduced a real-time unified business process meta-model that offers a comprehensive definition of the business process meta-model, unifying it with real-time considerations. By adopting our approach, organizations can gain specific insights into the temporal aspects of each process, establishing a clear understanding of the current timing situation and facilitating informed decision-making for both present and future processes. The limitation of the proposed approach lies regarding prediction; until now, we could use past data to evaluate the current state of a business process or how it could be if we didn't interact. So, in terms of perspective and future research, incorporating a deep learning tool into our approach would be advantageous for obtaining results.

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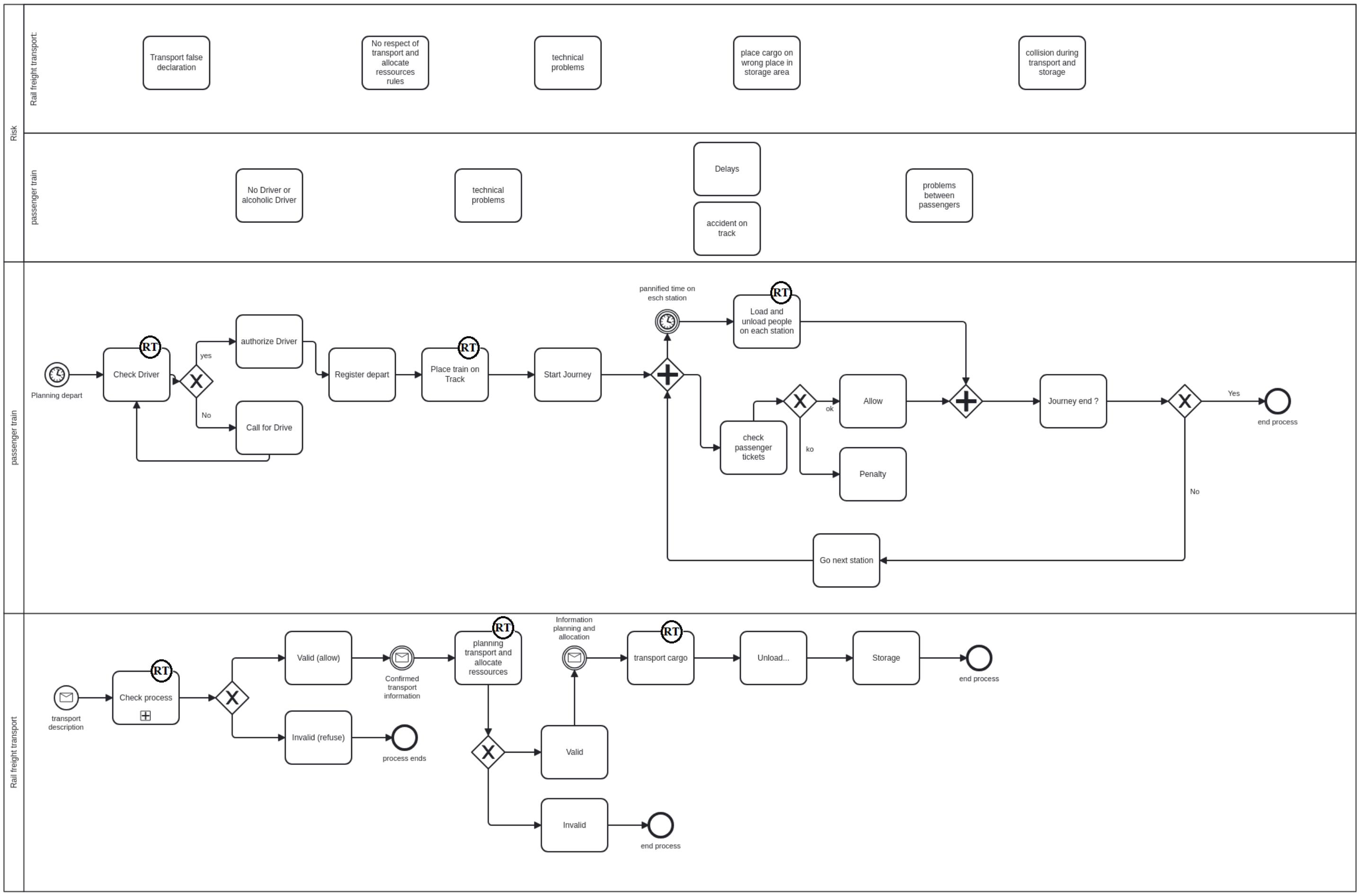

Fig. 15. Train transport business process with our right real-time component.

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