

# Intelligent automation computational modelling for contextual consulting services using Industry 4.0

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## ABSTRACT

The methodology towards operational management and service delivery associated with consulting firms, irrespective of any business domain, are less revisited in perspective from the automation-based process management. Adoption of Industry 4.0 has been attempted by various researchers from the business process management; however, there are less evidence of any computational model towards it. Apart from this, existing models are accompanied by various loopholes which makes its further challenging to analyze it on practical environment. Hence, the proposed study introduces a novel computational and analytical framework which is capable of performing the predictive modelling in order to meet the contextual service development and delivery demands in distributed environment. The novelty of this model is its inclusion of contextual data aggregation, contextual constraint analysis, predictive maintenance, and self-adjusting machine which are core attributes of Industry 4.0 automation standards. The study outcome shows that proposed system offers 20% cost reduction and 89% of minimized service delivery time in contrast to existing related work. Same has been also observed in benchmarked outcomes with state-of-art models.

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## 1. INTRODUCTION

The term contextual consulting states a mechanism of a consulting approach that considers typical circumstances of an organization or clients, environment, and particular context [1]. It essentially focuses towards understanding the significance of dynamics, opportunities, and unique challenges associated with a particular situation of a business prior to offering the solution and advice [2]. In this process, various in-depth information associated with internal processes, market condition, industry, and the organization of the clients are worked more closely by the business consultants. The mechanism doesn't only offer an importance to the quantitative data but also it offers an importance to the employee dynamics, leadership style, and organization culture. Some of the key elements associated with the contextual consulting are in-depth analysis, customization, collaboration, flexibility, holistic approach, cultural sensitivity [3]. However, from the contextual of data analysis and decision making, there are various challenges. The primary challenges are associated with the complexity of the context where right from oversimplification to all the associated factors towards understanding and analyzing is highly computationally and logically challenging [4]. The second challenge is associated with the dynamic environment as context are not static and they eventually evolve over time [5]. The third challenge is associated with the subjectivity and bias where the solution could possibly be biased over certain perspective put forward by the consultants and may not appropriately

represent the complete context [6]. The fourth challenge is associated with the effective communication between the client and service provider along with the development team leading to lack of understanding [7]. It is also noted that consultants would be likely to more rely on prior implementation strategies that could be also less accounted for the alteration in the current context or the demand for innovative solution; hence over emphasis on past success is fifth challenge in contextual consulting practice [8]. Finally, the sixth challenge is associated with balancing the qualitative attributes with the quantitative attributes towards decision making. The existing methods of contextual consulting varies from one to another organization where some of the standard models in practice are appreciative inquiry, soft system methodology, cultural intelligence framework, cynefin framework, agile consulting, scenario planning, and design thinking [9]. It is also noted that automation is increasing playing a significant role in transforming conventional consulting with an agenda to improve upon the efficiency [10]. The methods by which automation are being included in consulting practices are via data analysis and reporting, market research, process automation, client relationship management, workflow automation, proposal generation, artificial intelligence (AI)-based insights, virtual assistance, cybersecurity consulting, and training and development [11], [12]. In this context, Industry 4.0 is making its way towards contributing the incorporation of automation standards in consulting practices [13]. The Fourth Industrial Revolution, Industry 4.0, represents the integration of automation, data, and technologies in industrial and manufacturing processes. The prime beneficial perspective of Industry 4.0 is increased efficiency, enhanced productivity, cost reduction, improved quality, flexibility in production, supply chain optimization, innovation and customization, enhanced sustainability, improved workplace safety, empowered decision making, and novel business models [14]. However, developing a proper automation-based approaches for contextual consulting practices is not simple as existing Industry 4.0 is mainly focused on industrial practices and manufacturing units. Its principle is not made for non-manufacturing units, although, there is a fair possibility of utilizing this strategy to harness in any business demands.

Adoption of automation standard has been witnessed in couple of existing related work. Alghamdi and Agag [15] have used AI-based big data scheme towards analyzing the market changes. Elizondo and Reyes [16] have used Industry 4.0 principle in developing a competency maturity model for an employee using delphi method. Adoption of Industry 4.0 using lean principle is witnessed in work of Foley *et al.* [17] to enhance the workflow operation and reduce waste. Gajdzik and Wolniak [18] have studied the impact of standard automation towards business operations. Similar form of study was also carried out by Godina *et al.* [19] towards evaluating models of sustainable business process. Habraken and Bondarouk [20] have analyzed decision-making challenges associated with an adoption of Industry 4.0 standard. Considering a unique case study of fashion industry, Madsen and Slåtten [21] have developed a study framework towards assessing significance of 4.0 and 5.0 industry standard. Rosin *et al.* [22] have presented a decision-making computational model towards improving the performance of cyber-physical system. An intelligent system is designed by Serey *et al.* [23] where a model is designed using Industry 4.0 standard towards facilitating strategic planning in the business models. Further, Sun *et al.* [24] have developed an evaluation platform for consulting projects using fuzzy logic. Apart from this, there are various other studies where various forms of decision-making models have been evolved towards assisting the consulting firm indirectly for an effective decision making viz. learning-based analysis of content [25], modelling dispatching reliability [26], personnel management using analytics [27], analyzing sustainability capability in dynamic environment [28], knowledge-based human resource management [29], sustainable system using machine learning [30]–[34], decision making using data-driven methods [35], predictive methods in production [36], productivity analysis [37], dispatching management [38], and learning-based digitization management [39].

However, there are different forms of research-based challenges associated with the related work methodologies linking to its adopting in consulting practices. The identified research problems in this regard are as follows; i) scalability issues: the consulting firm is required to ensure that their automation consulting solutions are highly scalable and can accommodate the maximized complexities and workloads. This is quite a challenging task owing to highly interconnected attributes right from development of contextual solution and dispatching them to the clients, ii) consistent maintenance and monitoring: developing a computational solution towards contextual consulting demands ongoing monitoring of all the modules involved in solution in order to ensure an optimal performance. Although predictive approach can do this task quite fruitfully, but likelihood of inclusion of new set of dynamics are more to be ignored in this process, iii) change management: the business processes incorporating Industry 4.0 demands to include organizational change for effective predictive solution. However, this is quite challenging for outsourcing consulting firms with distributed task management included in them, iv) interoperability issues: accomplishing interoperability among varied number of heterogeneous system and technology is quite challenging to be accomplished. Multiple vendors can adopt multiple standards while offering a seamless interactivity platform towards

development and communication between various teams is quite challenging to be accomplished, and v) issues in integrating with the legacy system: existing consulting business may already possess existing legacy system in place while integrating Industry 4.0 could incorporate further complexities towards its management and could require additional resources just to make it operational. Hence, it is quite challenging to develop a computational model which harnesses the potential of Industry 4.0 automation standard for evolving into contextual consulting practices.

Therefore, the prime contribution of the proposed study is to develop a distinct and cost-effective practical modelling of contextual consulting firm with an incorporation of automation standards of Industry 4.0. The value added to this model is that unlike existing consulting practice models observed in literature, proposed scheme offers a fully automated decision-making system considering constraint-based modelling to offer more viability in its implementation. The next section illustrates its methodology.

**2. METHOD**

The proposed system introduces a novel intelligent modelling which hybridizes the analytical core and statistical inference system in order to incorporate Industry 4.0 for automating the service delivery of contextual consulting firms. In order to introduce practicality aspect of deployment, the scheme considers three essential constraint attributes viz.  $\theta_1$ ,  $\theta_2$ , and  $\theta_3$  related to consulting team, client’s requirement, and libraries respectively. The term libraries represent blueprint of the contextual solution offered by development team towards meeting client’s requirement. The architecture of proposed study is shown in Figure 1.

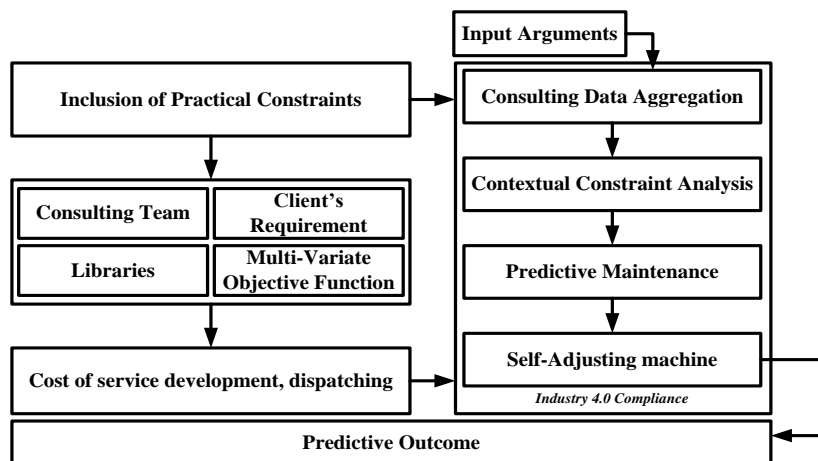


Figure 1. Proposed intelligent contextual consulting service delivery system

As noted in Figure 1, the proposed scheme consists of inclusion of multiple constraints viz. i) the 1<sup>st</sup> constraint  $\theta_1$  represents cumulative limit of libraries generated by consulting team, ii) the 2<sup>nd</sup> constraint  $\theta_2$  represents the logical condition for meeting the client’s requirement, iii) the 3<sup>rd</sup> constraint  $\theta_3$  represents overall storage, delivery, and maintenance of libraries, and iv) the 4<sup>th</sup> constraint is about meeting the newly constructed objective function to ensure that client’s requirement is fulfilled with just-in-time delivery even in presence of uncertainty. The novelty of this methodology is the mechanism used for extracting the intelligent information which is basically the predictive outcome associated with service delivery of consulting firm without using any training algorithms or deploying any iterative operation as noted in conventional practices of AI-based predictive schemes. The system is basically a decentralized structure where all the consulting firms are globally connected and so are their clients. The system acquires and updates information about the constraints of various service delivery team in sync with consulting development team assuming that client’s requirement is permissible for alteration with certain threshold of randomness. Another significant novelty of this method is associated with inclusion of varied ranges of operation in order to introduce the inherent operational characteristic of standard automation protocol i.e., Industry 4.0, which was never attempted before in consulting firms. The next section elaborates about the complete methodology of proposed scheme.

## 2.1. Implementation strategy

The prime agenda of the proposed framework is to perform a preemptive analysis of the client's requirement considering the fact that the entire system consists of core units i.e., consulting team, client requirement, and libraries. A novel mechanism of AI-based automation scheme has been implemented in the study which is unconventionally different than any existing approaches ever reported, the implementation strategy is initiated by considering some of the practical constraints: i) the pattern of the fluctuation of client's requirement is exponentially stochastic in nature. Such pattern fluctuation depends upon various intrinsic and extrinsic attributes when associated with specific business of consulting firm. It will mean stochastic variable of client's requirement is a dependent attribute towards consulting team and libraries. ii) for a large scale and distributed consulting firm, it is essential to localize the selected consulting team and precise library that are required to be highly flexible in case of dynamic user's requirement. The system is required to be properly synced with the requirements and delivery agenda of the business enterprise in adherence of Industry 4.0 standards. According to the highlights of the constraints, it is now clear that client's requirement is one of the most challenging aspects of the proposed system modelling. Apart from this, it can be also noted that there is a strong linkage among all the three attributes. The proposed scheme deploys a linear optimization method in order to induce the automation process towards the contextual consulting practices. Another essential consideration of design principle is towards considering the selection of distributed consulting team of same consulting firm as well as its libraries along with diverse selection of front-end unit where the client's requirement could be catered up. The complete modelling is carried out considering the possible situation of distributed operation linked with the consulting team in associated with the libraries. Apart from this, the model also considers multiple state of constraints connected with number of consulting team that are demanded to fulfil the client's requirement on varied location.

## 2.2. Algorithm modelling

This section presents discussion of the proposed intelligent algorithm towards automating the contextual consulting practices. The core agenda of this algorithm is to develop a novel AI-based scheme which bears a completely different characteristics mainly associated with reduced dependencies on trained data, higher predictive accuracy, and non-iterative operation. The algorithm mainly assists towards just-in-time delivery of the libraries to meet the client's requirement. The essential steps of algorithmic operation are shown as follows.

Algorithm for intelligently automating contextual consulting services

Input:  $\eta, \alpha, \beta_1, \beta_2, \beta_3, \gamma, \delta$

Output:  $P_{out}$

Start

1. For  $i=1: \theta_1$
  2. For  $j=1: \theta_2$
  3.  $\text{prox}(\theta_1, \theta_2) \rightarrow E_{dis}(i, j)$
  4. End
  5. End
  6. For  $i=1: \theta_3$
  7. For  $j=1: \theta_2$
  8.  $\text{prox}(\theta_3, \theta_2) \rightarrow E_{dis}[(\theta_1, \theta_2)^{i,j}]$
  9. End
  10. End
  11. For  $i=1:\pi$
  12.  $\text{Lib}_{max} \rightarrow \text{sum}(p) < \beta_1$
  13.  $\text{C}_{req} \rightarrow (\text{sum}(p) \sim (\delta \cdot w))$
  14.  $\text{Cap}_{max} \rightarrow \text{sum}(G < \theta_2)$
  15.  $\text{Coll}_{del} \rightarrow \text{sum}(q) == \text{one}(\theta_3)$
  16. End
  17. For  $i=1:\pi$
  18.  $P_1 \rightarrow \text{sum}(p) \cdot \alpha$
  19.  $P_2 \rightarrow \alpha \cdot \rho$
  20.  $P_3 \rightarrow \text{sum}[\delta \cdot \alpha \cdot \text{sum}(p) \cdot w]$
  21.  $P_s \rightarrow \text{sum}(P_1, P_2, P_3, P_4)$
  22.  $P_{out} \rightarrow \varphi(P_s)$
  23. End
- End

The algorithm is executed considering number of libraries  $\eta$ , cost of developing consulting service  $\alpha$ , limit of libraries  $\beta_1$ , limit of maintenance for libraries  $\beta_2$ , deliveries of libraries  $\beta_3$ , service dispatching cost  $\gamma$ , and client's requirement  $\delta$  as an input argument which upon execution yields an outcome of predictive output  $P_{out}$ . The complete operation of the proposed algorithm is carried out in four essential automation modules as per norms of Industry 4.0 standards as discussed:

- Consulting data aggregation: this is the primary step of actions which not only deals with processing the input arguments but also deals with making them more suitable towards performing simplified analytical operations. This step is meant to offer an adherence of proposed model with Industry 4.0 standards of automation by involving various analytical actions, information processing, decision making, client's requirement settings, and predictive insights. The deployment of specific input arguments of proposed system is carried out in this basis with respect to arbitrariness of the distributed service location of a consulting firm. All the information acquired in this step is subjected to analysis in next consecutive operational steps.
- Contextual constraint analysis: this is the second operation of proposed algorithm which is mainly dedicated towards processing and analysing various practical constraints associated with the system model. The algorithm takes the input of dual constraints viz.  $\theta_1$  and  $\theta_2$  (Line-1, Line-2) for assessing the proximity  $prox$  between them using Euclidean distance  $E_{dis}$  (Line-3). Equivalent actions (Line-6, Line-7) are also performed for distributed position related to  $\theta_2$  and  $\theta_3$  constraints (Line-8). The prime motive of this operational step is to perform contextual analysis of relaying the consulting services located in distributed position with respect to cater up the client's requirement.
- Predictive maintenance: this is the third set of operation which is mainly related to perform predictive maintenance with respect to constraint and client's requirement. For this purpose, the algorithm considers all the total number of constraints  $\pi$  involved in the process (Line-11) followed by evaluating maximum number of libraries  $Lib_{max}$  that can be possibly generated by consulting team (Line-12). This is done by assessing the summation of variable  $p$  which is always required to be less than limit of libraries i.e.,  $\beta_1$  (Line-12). Further, the operation also involves investigating the client's requirement to be met for all the distributed position of both client and service delivery team. This is done by computing the new client's requirement  $C_{req}$  to be equivalent to summed value of variable  $p$  when the summed value is found to be equivalent to product of actual client requirement  $\delta$  and variable  $w$  (Line-13). The variable  $p$  and  $w$  represent tentative randomness factors associated with libraries and client's requirement respectively. The consecutive operation performed is towards evaluating maximum capability  $Cap_{max}$  of a consulting team by summing up values of  $G$  for all values lesser than constraint limit of maintenance for libraries. The empirical formulation of  $G$  is carried out by summing all values of  $(1/\beta_3)$  multiplied with client requirement  $\delta$  and variable  $q$  (Line-14). The final step of this operation is carried out by computing collaborative delivery variable  $Coll_{del}$  which is equivalent to summed up value of variable  $q$  when found equivalent to matrix-based ones value of constraint  $\theta_3$  (Line-15). All the evaluated variables in these operational modules are basically the computed intelligence i.e.,  $Lib_{max}$ ,  $C_{req}$ ,  $Cap_{max}$ , and  $Coll_{del}$  are used for predictive maintenance of the entire automation process involved in proposed contextual consulting service relaying. The core idea is also to ensure that irrespective of any form of randomness or uncertainty in constraint, the client's requirement should be fulfilled by relaying proper services just-in-time. However, this process is also boosted by self-adjusting machine in proposed scheme as discussed next.
- Self-adjusting machine: this is the final operational step of proposed algorithm which is basically meant towards satisfying the multi-variate objective functions unlike any predictive processed deployed in conventional AI-based scheme. The scheme associates the cost involved in delivering the contextual services to client with the objective functional metric ( $P_1$ ,  $P_2$ , and  $P_3$ ) considering all the constraints  $\pi$  (Line-17). The first metric  $P_1$  is computed in compliance with the cost of development  $\alpha$  (Line-18), the second metric  $P_2$  is related to dispatching of the contextual services considering overall cost of development and delivery (Line-19), the third metric  $P_3$  is associated with cost involved only in service delivery (Line-20). Finally, all the metric are summed up in order to obtain final matrix  $P_s$  (Line-21). A method  $\phi$  is used on the accomplished metric  $P_s$  in order to normalize the outcome in order to finally obtain predictive outcome  $P_{out}$  (Line-22). It can be said that the predictive outcome of  $P_{out}$  is a metric which shows the practically optimal solution for contextual consulting service delivery by considering all the practical constraints in order to maintain just-in-time service delivery.

A closer look into the proposed scheme will show that proposed scheme is developed by incorporating above-mentioned operational steps in order to ensure the just-in-time delivery of contextual consulting services to different number of clients located in distributed scale globally. The system evaluates the intelligent information which are quite flexible to shape it up on any domain on business enterprise. The next section discusses about the result accomplishes from implementation of proposed study.

### 3. RESULTS

The implementation of the proposed study model is carried out considering Kaggle dataset associated with the survey of consulting firm [40]. The dataset consists of a smaller number of fields (field=19) that is synthetically increased to 10 thousand fields. Apart from this, the dataset is further augmented by including a new column associated with locations of consulting team as well as user's locations too. The study modelling considers its fine-tuning parameter (range:15-25), where the initialization of the constraints is carried out using probability values for better applicability of proposed model in global business domain. The initialized values are  $\theta_1=0.05$ ,  $\theta_2=0.05$ , and  $\theta_3=1$  which are carried out on the basis of p-significance value in inferential statistics. The assessment model also considers the presence of 30 number of libraries to be developed by the consulting firm that are also utilized for assessing the cost involved in the service delivery process. The assessment is carried out with respect to multiple standard performance parameters as discussed below.

#### 3.1. Comparative assessment of model

The comparative assessment of proposed study model is carried out considering the work done in [17], [24] with respect to cost reduction and service delivery time. The existing models are subjected to similar test-bed where only the core algorithmic segment of existing model has been implemented. The mean of values for performance metric for existings scheme. Exist is chosen to be compared with proposed scheme ProP. The analytical outcome shown in Figure 2. The Figure 2(a) highlights that proposed scheme offers approximately 20% of more cost reduction compared to the existing system. The prime reason behind this is proposed scheme offers a highly integrated scheme where a better collaborative approach is applied on every consulting team with proper maintenance of their libraries in compliance for meeting the client's requirement in presence of uncertainty/randomness associated with it. This phenomenon reduces the increasing effort and resources towards processing the client's requirement leading to decreased cost. Whereas the existing scheme involves increasing number of efforts towards service delivery leading to increasing operational and service delivery cost. The outcome exhibited in Figure 2(b) showcase that proposed scheme offers approximately 89% of reduced service delivery time in contrast to existing models.

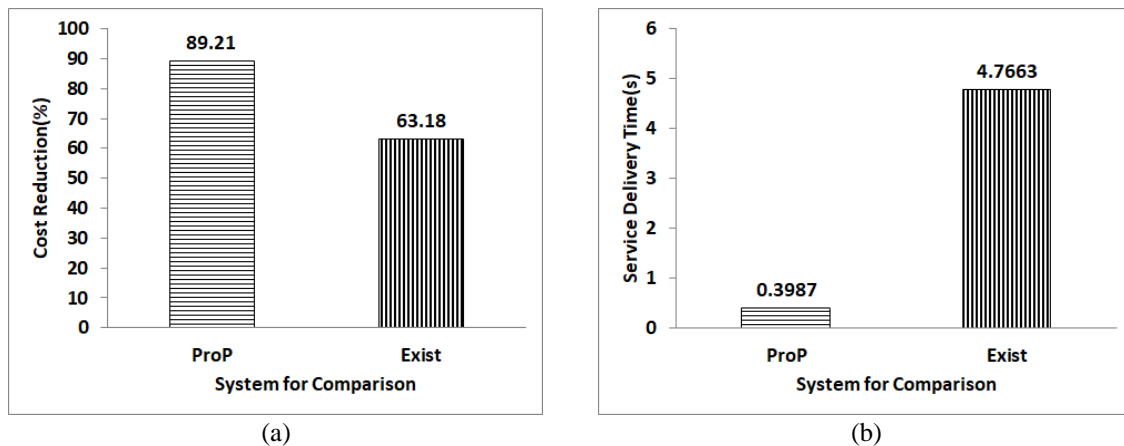


Figure 2. Analytical outcomes of (a) cost reduction and (b) service delivery time

The prime rational behind this outcome is that existing model carry out multiple steps of operation in order to confirm their optimal decision by ignoring the uncertainty attributes associated with it. Therefore, when this model is exposed to current test-environment where it encounters uncertainty and randomness, the existing model was seen to consume maximum operational time just to find the optimal point of delivering the services. However, proposed system excels better mainly due to its inclusion of multi-variate objective function where the intelligent information was already extracted by development team. The development teams are facilitated with faster accessibility to all dynamic information associated with capacity of libraries where the part of the libraries was designed based on direct input of client's requirement while a segment of it is developed also considering the possibility of dynamicity in the client's requirement. Hence, faster service delivery time is offered by proposed scheme.

### 3.2. Benchmarked assessment of model

The comparative evaluation of proposed scheme with state-of-art method has been carried out considering four performance metrics viz. i) cycle time reduction: this metric is computed by measuring the duration involved to complete a consulting process before and after introducing Industry 4.0. ii) resource utilization: the study considers abstractive attributes e.g., human and technology as resources with a defined task to be completed in target time. This term computes the abstractive quantity of resources required to complete the task in defined time. iii) data accuracy: this metric assesses the accuracy of data deployed in decision making. iv) cost reduction: this metric computes the operational cost deployed for decision making right from development to dispatching of contextual solution. Table 1 highlights the outcome which is based on observing the performance of distinct models of both proposed and state-of-art methods in similar test environment discussed in prior section.

Table 1. State-of-art method comparison

Approaches	Cycle time reduction	Resource utilization	Data accuracy	Cost reduction
Elizondo and Reyes [16]	Low	High	Medium	Low
Foley <i>et al.</i> [17]	Low	High	Medium	Low
Gajdzik and Wolniak [18]	Medium	Medium	Medium	Medium
Godina <i>et al.</i> [19]	Low	Low	Medium	Low
Habraken and Bondarouk [20]	Medium	Medium	Low	Low
Madsen and Slåtten [21]	Low	High	Low	Low
Rosin <i>et al.</i> [22]	Low	High	Medium	Low
Serey <i>et al.</i> [23]	Medium	Medium	Low	Low
Proposed	High	Low	High	High

Table 1 highlights the prime distinction in the proposed study model with state-of-art where it can be noted that proposed study model offers significantly better performance in every stated performance metric. The prime reason behind this outcome is that existing state-of-art are mainly found to develop a use-case specific model where the defined solution is less practical when exposed to a dynamic events or uncertainty. However, with a comprehensive multiple constraint-based modelling, proposed scheme offers more flexibility not only in identifying various loopholes but also to determine an optimal way to dispatch the generated solution to distributed clients.

## 4. CONCLUSION

This prime contribution stated in proposed study model are i) faster and efficient processing the contextual solution with effective operational planning for both development team and clients, ii) derivation of linear constraints from practical consulting cases in order to facilitate model reliability, and iii) adoption of multi-objective principle of optimization which can bridge the gap between consulting demands and service dispatching with just-in-time delivery. The future work of proposed study model will be further enhanced to incorporate a greater number of complexities associated with internal processing of demands of clients with exclusive emphasis towards more faster dispatching mechanism in distributed way. The notion is to offer more faster and seamless consulting services with least development team and more client base.




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