Overcoming Obstacles in Model-Driven Engineering: Lessons from the Software Industry

Sayeda Rahnuma Akthar[1][a], Muhammad Rezaul Islam[2][b], Marzan Binte Hasan[2][c], Mahpara Sayema Siddiqua[2][d], Shadat Irtisamul Haque[2][e], Jamil Ahmad Saad[2][f], Farzana Sadia[3][g] and Mahady Hasan[2][h]

[1]*Department of Computer Science, Independent University Bangladesh, Dhaka, Bangladesh*

[2]*Department of Computer Science and Engineering, Independent University Bangladesh, Dhaka, Bangladesh*

[3]*Department of Electronic Engineering & Technology, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia*

Keywords: Software Modelling, System Modelling, Model-Driven Engineering (MDE), Developers, Practitioners.

Abstract: Software modeling, as used in Model-Driven Engineering (MDE), is the process of abstracting software systems using formal or informal notations to help with communication, analysis, and design. This study looks into the difficulties Bangladesh's software industry faces while using model-based engineering, or system modeling. A survey of several companies in Bangladesh was carried out to get opinions from professionals such as software developers, project managers, test engineers, and architects. The data gathering instrument utilized was Google Forms, and the questionnaire's design was informed by extant literature. Results show that about 75.1% of respondents use system modeling in their projects, and 56.3% of them say it helps to streamline project development. Strong internal consistency among survey items pertaining to system modeling methodologies is indicated by a high Cronbach's alpha value (0.93007), which suggests growing adoption among software enterprises in Bangladesh. Response analysis revealed trends and patterns that were represented through data quantification. Based on these results, the paper offers suggestions for resolving these problems and advancing more comprehensive system modeling methodologies. The steps that have been proposed to address the challenges in Model-Driven Engineering (MDE) include conducting in-depth research to determine the underlying causes of the problems, putting scalability techniques into practice, maintaining documentation standards, and setting up training sessions, seminars, and workshops. Such measures have the potential to increase the efficacy of resolving the problems.

1 INTRODUCTION

Software modeling in model-based software design converts abstract models into tangible ones, which facilitates pre-implementation system comprehension (Troya et al., 2021)(Pourali and Atlee, 2018). These models, which act as copies of the software that needs to be developed, make system testing easier and provide insightful information for early defect discovery (Troya et al., 2021). Since its beginnings with UML in the 1990s, model-driven engineering (MDE) has advanced dramatically (Pourali and Atlee, 2018). While practitioners anticipate that model-driven engineering (MDE) or system modeling will provide an effective development route, they run into roadblocks that prevent operations from running smoothly (Feichtinger and Rabiser, 2020). Difficulties go beyond the system model itself and include a lack of data regarding how it is used (Badreddin et al., 2018). Although there has been some research on these issues, there is still a dearth of perspectives from Bangladeshi software companies in the literature. The main challenges (discussed in detail later) that we found through previously done researches and different literatures are as follows:

- No previous use cases or data to help build the

[a] https://orcid.org/0009-0009-6049-8182
[b] https://orcid.org/0009-0004-5721-0276
[c] https://orcid.org/0009-0007-5421-9664
[d] https://orcid.org/0009-0005-4115-0106
[e] https://orcid.org/0009-0005-4570-695X
[f] https://orcid.org/0009-0008-8041-6183
[g] https://orcid.org/0009-0005-1895-1044
[h] https://orcid.org/0000-0002-9037-0181

Akthar, S., Islam, M., Hasan, M., Siddiqua, M., Haque, S., Saad, J., Sadia, F. and Hasan, M.
Overcoming Obstacles in Model-Driven Engineering: Lessons from the Software Industry.
DOI: 10.5220/0012805800003753

In *Proceedings of the 19th International Conference on Software Technologies (ICSOFT 2024)*, pages 153-160
ISBN: 978-989-758-706-1; ISSN: 2184-2833

model (Badreddin et al., 2018).

- Couldn't scale the model for the full system (Badreddin et al., 2018).
- Different modules of the model couldn't be merged due to inconsistency in design (Badreddin et al., 2018).
- Unconventional to the company's usual system (Feichtinger & Rabiser, 2020)
- Bad model quality (Badreddin et al., 2018).

The study aims to assess and pinpoint areas for development regarding the difficulties faced by practitioners when applying software modeling methodologies. Understanding the factors impacting software modeling is one of the survey's goals; doing so could improve the approaches used. Events such as the Grand Challenges in MDE workshop and MoDELS have shed light on the current state of MDE and its evolution (Badreddin et al., 2018)(Troya et al., 2021). This research seeks to rectify the deficiency of Bangladeshi software developers' viewpoint in the existing literature. Model alignment and system integration are two unresolved difficulties that MDE still faces, despite its importance for interoperability (Akdur et al., 2018) . If these issues are resolved well, MDE adoption may increase and project failure rates may decrease. For the purpose of the study, a survey was conducted that included software developers, software project managers, software architects, software test engineers working in different software firms in Bangladesh. The online survey was based on a questionnaire focusing on the following areas of concern along with other relevant research questions.

RQ1. What levels of difficulties do practitioners encounter with the various types of software modeling challenges?

RQ 2. What unique challenges might practitioners go through when modeling software systems?

The purpose of this study is to examine present practices and identify the difficulties that practitioners face while applying model-based engineering in Bangladesh's software sector. By highlighting these issues,contribution of this study:

- Identification of present practices and challenges faced by practitioners applying model-based engineering in Bangladesh's software sector.
- Utilization of our analysis to examine challenges confronted by software modeling practitioners.
- Proposal of a framework to guide future endeavors in addressing challenges and advancing system modeling practices in Bangladesh's software sector.

2 LITERATURE REVIEW

Badreddin Badreddin et al. observed a ten-year trend indicating increased adoption of formal and domain-specific modeling languages, suggesting a growing prevalence of modeling practices (Badreddin et al., 2018). Troya et al. reviewed defining uncertainty in software models, presenting a classification framework to compare proposals and identify trends (Troya et al., 2021). Pourali and Atlee investigated challenges in modifying and debugging UML models, focusing on Class and State-Machine diagrams, identifying contextual memorization and debugging model flaws as primary obstacles(Pourali and Atlee, 2018). Feichtinger & Rabiser outlined a transformation strategy for variability models, focusing on meta models and generic transformation operations(Feichtinger and Rabiser, 2020). Akdur et al. surveyed engineers to investigate modeling practices in the embedded software industry, finding the Sketch/No Formal modeling language commonly used (Akdur et al., 2018). Rukhsara et al. introduced a cloud-based e-commerce model designed for Bangladesh, aiming to facilitate application development and foster e-business growth(Rukhsara et al., 2016). Baresi et al. discussed challenges in mobile software engineering, emphasizing the importance of mobile computing research(Baresi et al., 2020). Khan and Khan proposed a Software Security Assurance Model (SSAM) to aid Global Software Development (GSD) vendors in secure software development(Khan and Khan, 2018). Tantithamthavorn and Hassan discussed challenges in software modeling and defect analytics, stressing data quality and well-documented modeling scripts(Tantithamthavorn and Hassan, 2018). Bucchiarone et al. reviewed the evolution of Model-Driven Engineering (MDE) research, presenting grand challenges (Bucchiarone et al., 2020). Rahim et al. surveyed software engineering practices in Bangladesh, focusing on process models, SDLC standards, and communication methods(Rahim et al., 2017). Amershi et al. mapped challenges for machine learning applications in software engineering, highlighting issues like the oracle problem(Amershi et al., 2019).

3 RESEARCH METHODOLOGY

Sample Profile: The survey data was collected from 15-25 participants in Bangladesh-based software companies, including project managers, developers, architects, solution architects, and testing engineers with 1-5 years of experience. Table 1 details the

demographics, industry types, and employment disciplines of the participants.

Table 1: Participants Demographic.

Field of Practice	Industry Type	Type of Product Developed
Software Test Engineer	E-commerce	Web Applications
Project Manager	Finance and Banking	Mobile Applications
Software Test Engineer	E-commerce	IoT (Internet of Things) Applications
Software Developer	Healthcare	Enterprise Applications
Project Manager	Finance and Banking	Others
Solution Architect	Healthcare	Web Applications
Project Manager	Finance and Banking	Web Applications
Software Architect	E-commerce	Web Applications
Software Developer	E-commerce	Web Applications
Software Developer	Others	Enterprise Applications
Software Developer	Finance and Banking	Web Applications
Software Architect	Finance and Banking	Web Applications
Software Test Engineer	Finance and Banking	Web Applications
Software Test Engineer	E-commerce	Mobile Applications
Software Developer	Healthcare	Desktop Applications
Software Test Engineer	E-commerce	Mobile Applications

Data Collection and Analysis Method: Information was gathered using Google Forms, with a questionnaire based on current literature. The survey was distributed via email and messaging services. Responses were analyzed for patterns and trends, with results visualized through data quantification.

Limitation of Research Design: The study focuses on challenges in the Bangladeshi software sector regarding model quality, scalability, and industrial acceptance in Model-Driven Engineering (MDE). It aims to provide solutions and facilitate MDE adoption, helping practitioners and researchers improve its effectiveness. The concepts which are needed to conduct this study includes :-

- An understanding of how the software modeling process works

- A good insight of the difficulties that practitioners undergo when practicing software modeling

- A thorough survey was carried out among different software businesses in Bangladesh to obtain insights into the obstacles associated with software modeling. In order to overcome the constraints of earlier research and guarantee wide representation within the development community, the questionnaire was modified. For instance

- Do you implement system modeling in your projects?
- In which phase(s) of the software development life cycle do you use modeling?
- What are the main challenges you faced when using system modeling for any project?
- Does System Modeling help facilitate the development of software?
- Do you face any difficulties using modeling language(s)?

With a focus on evaluating current practices and gathering insights on the efficacy of software modeling, practitioner satisfaction, and challenges faced in model-based software systems, a thorough analysis of survey data aims to uncover practitioners' challenges and perceptions regarding software modeling. Future plans involve incorporating practitioner feedback, broadening the survey scope, and implementing solutions to further understand and address identified difficulties.

4 FINDINGS/RESULTS

The demographic data in illustrates the various roles that are involved in software development. It highlights the importance of quality assurance for Software Test Engineers, the critical role project managers play in project management, and the software designs that are implemented by Software Developers. The strategic vision and technical know-how of solution and software architects help to create scale-able, reliable software solutions that support organizational objectives.

Since most of the respondents are in their early stages of their careers and have fewer than five years of experience, their knowledge with the sector and technological aptitude may be affected. The population questioned is from a variety of industries, with e-commerce, banking, finance, and healthcare having a significant presence. A comprehensive range of software projects, such as web and mobile applications, Internet of Things applications, and business solutions, demonstrate the sample's competency.

Usage of System modeling and modeling language and challenges face: System modeling

Table 2: Practice Items and their Adaptation Rate.

Annotation	Practice Item	Total points	Mean	Adaptation rate (%)	Variance
P1	System Modeling helps facilitate the development of a software.	14	3.5	70	0.33
P2	How MDE affects personal experience (Productivity)?	13	3.25	65	0.25
P3	How MDE affects personal experience (Problem Solving)?	13	3.25	65	0.25
P4	How MDE affects personal experience (Creativity)?	14	3.5	70	0.33
P5	How MDE affects personal experience (Enjoyment)?	12	3	60	0.67
P6	The level of challenges you are facing for Managing language complexity.	12	3	60	0.67
P7	The level of challenges you are facing for Extending Modeling languages.	12	3	60	0.67
P8	The level of challenges you are facing for Domain-specific modeling environments?	11	2.75	55	0.92
P9	The level of challenges you are facing for Developing formal modeling languages?	12	3	60	0.67
P10	The level of challenges you are facing for Analyzing models?	13	3.25	65	0.927
P11	The level of challenges you are facing for Supporting separation of design concerns?	14	3.5	70	0.33
P12	The level of challenges you are facing for Transforming models?	11	2.75	55	0.25
P13	The level of challenges you are facing for Managing models?	13	3.25	65	0.92
P14	System Modeling helps facilitate the development of a software.	14	3.5	70	0.33

is widely used by respondents across the Software Development Life Cycle (SDLC), with popular languages like Matlab/Simulink and SysML being advantageous and complying with business rules. Nonetheless, difficulties like complexity and a dearth of information or assistance are frequently mentioned. Programming languages like Python and diagrams like process and deployment diagrams are frequently used in conjunction with specialized software like Matlab and general tools like SQL Database Modeler. Some res-ponders have mentioned problems with model-driven approaches' scalability and integration.

Practice items and their adaptation rate and variance: The adaptation rate and variance provided in table 2 offer valuable insights into the extent to which the surveyed individuals have applied or adapted various system modeling practices in their respective fields of practice.

Adaptation Rate (%): The adaptation rate represents the percentage of professionals who have employed methods in their work and offers information about the level of acceptance in each field. Higher adaptation rates indicate that system modeling techniques are more widely accepted, which may emphasize how valuable and effective they are thought to be in improving software development processes.

Variance (%): Variance is a measure of how consistently or diversely system modeling methodologies are used by practitioners; lower variance denotes more uniform adoption. Reduced adaptation rates could indicate that there are technological obstacles or knowledge gaps preventing these strategies from being successfully integrated. Low variance is seen in Practice Items P2, P3, P4, P11, and P14, suggesting that there is a general consensus regarding the advantages of Model-Driven Engineering (MDE) in terms of creativity, productivity, and facilitation of system modeling and problem-solving.

Table 3: Field of practice and their Adaptation Rate.

Field of Practice	Total (Out of 70)	Mean	Adaptation (%)	Variance
Project Manager	43	3.07	61.42	0.53
Software Architect	45	3.21	64.28	0.18
Software Test Engineer	36	2.57	51.42	0.26
Software Developer	54	3.85	77.14	0.13

Field of practice and their Adaptation Rate and variance: Table 3 offers insights into the adaptation rates and variations in system modeling practices across different professional roles within the surveyed

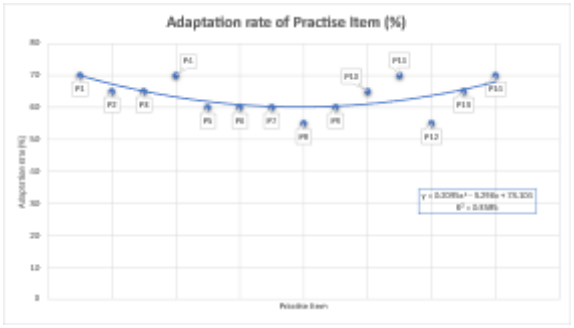

Figure 1: Polynomial Regression of Adaptation rate of practice Items.

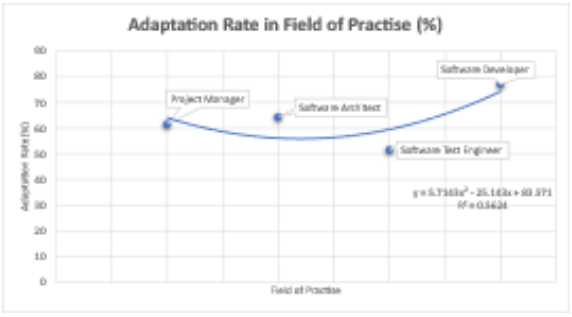

Figure 2: Polynomial Regression of adaptation rate in field of practice.

population.

Adaptation Rate (%): The adaptation rate provides insights into the percentage of practitioners within each field who have integrated system modeling practices into their work, with Software Developers showing the highest adaptation rate at 77.14%.
Variance (%): The variance reflects the range of adaptation rates within each professional field, with Software Developers showing a more uniform level of adoption (variance of 0.131868) compared to Project Managers, who display greater variance in adoption rates (variance of 0.532967).

The differing adaption rates and differences between various professional positions (e.g., software developers and software test engineers) point to unique opportunities and problems for encouraging the use of system modeling that are catered to the requirements and limitations of each role. Taking care of these things can encourage creativity and teamwork, improving software development procedures and results for a variety of jobs inside companies.

With an R2 value of 0.3585, the polynomial regression equation in Figure 1 is $y = 0.2095x^2 - 3.296x + 73.104$, meaning that x components account for approximately 35.85% of the variance in adaption rate. With an $R2$ value of 0.5624, the polynomial regression equation in Figure 2 is $y = 5.7143x^2 - 25.143x + 83.571$, which accounts for roughly 56.24% of the variance in adaption rate.

Cronbach's Alpha: Strong internal consistency among survey items pertaining to system modeling approaches is indicated by the high Cronbach's alpha value (0.93007), which suggests that the survey effectively measures a shared underlying notion.

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k}\sigma_{Y_i}^2}{\sigma_X^2}\right) \quad (1)$$

where:

α : Cronbach's alpha coefficient
k : Number of items (questions)
$\sigma_{Y_i}^2$: Variance of the scores on item i
σ_X^2 : Variance of the total scores

This highlights how system modeling is becoming more and more accepted in Bangladeshi software companies for all jobs assessed. Even if the majority of respondents think system modeling helps with development and actively work to put it into practice, problems still arise.

RQ1. What levels of difficulties do practitioners encounter with the various types of software modeling challenges? The survey responses reflect different levels of difficulties for practitioners. For Modelling language 50% said that it is too complicated to understand while 75% mentioned lack of proper documentation/ tutorial/ support as a difficulty. Managing language complexity increases the level of challenges for practitioners according to 33.3% respondents. Extending Modelling languages adds another level of difficulty for 35.7%. Domain-specific modelling environments and developing formal modelling languages were mentioned as difficulties by 42.9%. Among the respondents 50% said Analysing models, 71.4% said Supporting separation of design concerns, 42.9% mentioned Transforming models and 66.7% said Managing models were difficult. The difficulty levels observed in the survey responses differ from one another but almost all of them are on the higher side. It can be said that the level of difficulty faced by the practitioners while working with system modeling is high.

RQ2. What unique challenges might practitioners go through when modeling software systems? According to our analysis software modeling for organizations presents significant challenges for practitioners globally, not just in Bangladesh. These include design inconsistencies, scalability issues, lack

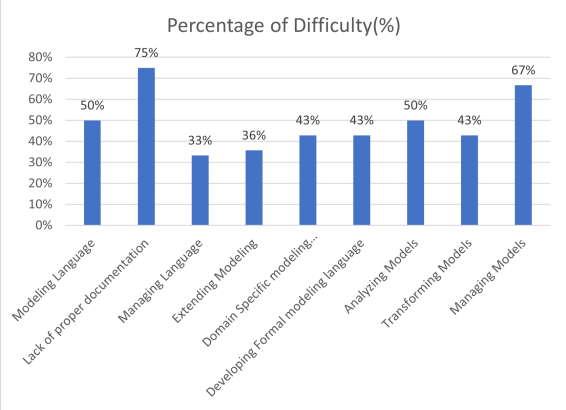

Figure 3: Percentage of difficulty faced by the practitioners.

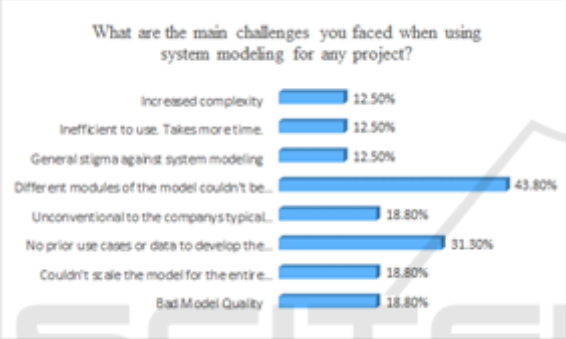

Figure 4: Challenges Faced by the practitioners while implementing system modelling.

of prior use cases or data, inadequate resources, and limited experience. These challenges hinder integration of modules into larger systems and highlight the need for comprehensive solutions to improve adoption and effectiveness of system modeling practices. To overcome challenges in implementing system modeling, it is essential to comprehend the viewpoints of practitioners in Bangladesh.

Not with standing these misgivings, the poll shows that system modeling is becoming more widely accepted, with a sizable portion of respondents believing in its advantages. Coordinated efforts in organizational support, training, and research and development are needed to overcome obstacles. Stakeholder engagement, resource provision, and training are also necessary. Although system modeling is becoming more popular, considerable technological and cultural adjustments are still required, as some practitioners choose not to use it in order to save time.The framework to handle difficulties and promote system modeling methods is suggested by the discussion of global challenges, the increasing acceptance of system modeling. This emphasizes how crucial it is to involve stakeholders, provide resources, and provide

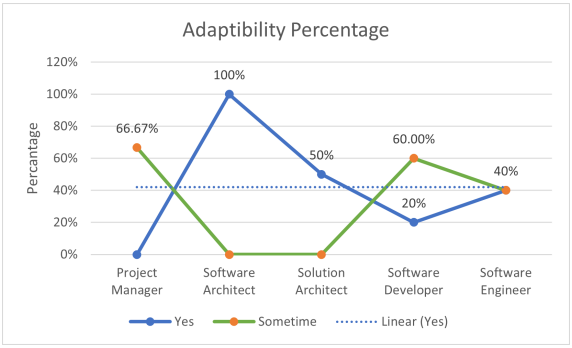

Figure 5: The percentage for adopting system modeling by practitioners.

training in order to overcome barriers and encourage the use of system modeling techniques.

Even though the usage percentage of implementing system modeling is promising, the percentage of the system modeling not being used is not neglectable.

5 PROPOSED GUIDELINES

The challenges in system modeling faced by practitioners in Bangladesh are reflected globally, necessitating comprehensive research to uncover their root causes and improve understanding through detailed documentation and comparative analysis. The ability to handle very large models for system of systems and Ultra-Large-Scale (ULS) systems is one of the main challenges of Model-Driven Engineering (MDE). Solutions like modular engineering principles, incremental processing, and logic inference engines, alongside emphasizing the importance of documenting MDE processes and showcasing real-world use cases at seminars to motivate practitioners and foster broader adoption of system modeling. Currently, the trend is positive, that is, more developers prefer to use system modeling. In the future, an in-depth survey can be conducted based on all these new projects being done.

6 PROPOSED MODEL

In the context of Model-Driven Engineering (MDE), the challenges outlined can be addressed through various strategies and practices within the MDE framework:

Identify Challenges: Addressing the challenges requires a multi-faceted approach involving collaboration between researchers, practitioners, industry stakeholders, and educational institutions.

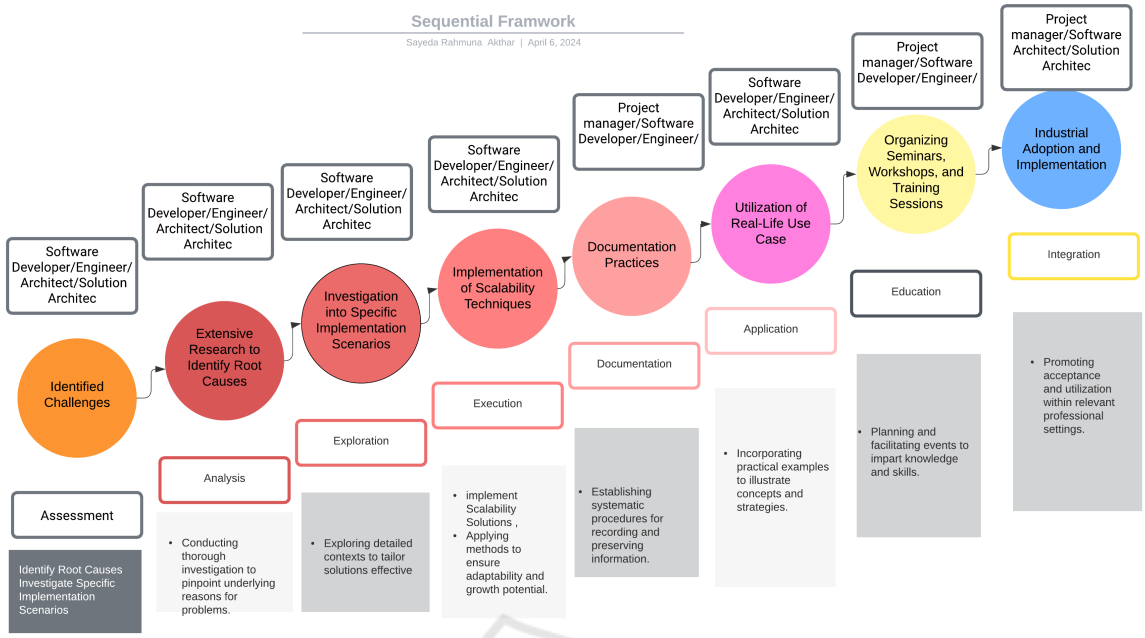

Figure 6: Sequential Approach to Address Challenges in Model-Driven Engineering (MDE).

Table 4: Steps proposed to address the challenges in Model-Driven Engineering (MDE).

Specific Practices	Artifacts
Recognize the challenges faced in MDE, which are not unique to Bangladesh but prevalent globally	identified Challenges
Conduct thorough research to identify the root causes of the challenges in MDE	Extensive Research to Identify Root Causes
Examine specific scenarios encountered during MDE implementation to understand the challenges	Investigation into Specific Implementation Scenarios
Establish comprehensive documentation practices to record all steps taken in MDE	Documentation Practices
Implement real-life use cases as successful examples to encourage MDE adoption	Utilization of Real-Life Use Cases
Arrange educational events to promote understanding and adoption of MDE	Organizing Seminars, Workshops, and Training Sessions
Encourage the adoption of MDE practices in industrial settings to gather more data for research	Industrial Adoption and Implementation

Extensive Research to Identify Root Causes: To comprehend the fundamental reasons behind the difficulties encountered in system modeling, MDE practitioners had to conduct thorough research. To go deeper into the topics, this entails examining previously published material, performing empirical experiments, and working with other academics.

Investigation into Specific Implementation Scenarios: MDE practitioners must investigate scenarios while system modeling is put into practice. Through the analysis of real-world situations, professionals can acquire a deeper understanding of pragmatic issues and create efficient solutions customized for various settings. Implementation of Scalability Techniques: Scalability solutions such as modular engineering principles, incremental processing, caching mechanisms, and indexing strategies should be used by practitioners because MDE requires handling big models. These methods make it possible to handle and manipulate big models efficiently, especially when modeling Ultra-Large-Scale (ULS) and systems of systems.

Documentation Practices: To record the actions made during the modeling process, proper documentation is crucial in MDE. Documentation is an important tool for future reference and learning, as well as for facilitating information sharing among practitioners and preserving best practices.

Utilization of Real-Life Use Cases: MDE practitioners ought to use actual use cases as examples of how to successfully apply system modeling. By showcasing practical uses and measurable benefits, practitioners may foster confidence and encourage the widespread deployment of MDE techniques.

Organizing Seminars, Workshops, and Training Sessions: System modeling organizations and companies should host training sessions, workshops,

and seminars to share knowledge and encourage practitioners' skill development. These gatherings provide chances for knowledge sharing, networking, and practical learning.

Industrial Adoption and Implementation: For producing empirical data and practical insights that can guide future research and development endeavors, the industrial adoption of MDE processes is essential. Through the incorporation of MDE into industrial workflows and projects, professionals can add to the increasing amount of evidence in the area and promote ongoing progress.

By addressing these challenges within the framework of MDE, practitioners can enhance the effectiveness, scalability, and adoption of system modeling techniques, ultimately advancing the state of the art in engineering and software development.

7 CONCLUSIONS

Software modeling is essential to software development, but there are a number of obstacles that businesses must overcome, such as the requirement for accurate, thorough, and stakeholder-aligned models. Practitioners need to acquire the required abilities, comprehend the foundations of software modeling, and keep up with industry changes in order to overcome these obstacles. In order to successfully use system modeling and possibly enhance the results of software development, it is imperative that these issues be resolved. The present study sheds light on the challenges encountered by software modeling experts in Bangladesh, underscoring the necessity for additional investigation and advancement to augment the caliber and efficiency of software modeling.

REFERENCES

Akdur, D., Garousi, V., and Demirörs, O. (2018). A survey on modeling and model-driven engineering practices in the embedded software industry. *Journal of Systems Architecture*, 91:62–82.

Amershi, S., Begel, A., Bird, C., DeLine, R., Gall, H., Kamar, E., Nagappan, N., Nushi, B., and Zimmermann, T. (2019). Software engineering for machine learning: A case study. In *2019 IEEE/ACM 41st International Conference on Software Engineering: Software Engineering in Practice (ICSE-SEIP)*, pages 291–300. IEEE.

Badreddin, O., Khandoker, R., Forward, A., Masmali, O., and Lethbridge, T. C. (2018). A decade of software design and modeling: A survey to uncover trends of the practice. In *Proceedings of the 21th acm/ieee international conference on model driven engineering languages and systems*, pages 245–255.

Baresi, L., Griswold, W. G., Lewis, G. A., Autili, M., Malavolta, I., and Julien, C. (2020). Trends and challenges for software engineering in the mobile domain. *IEEE Software*, 38(1):88–96.

Bucchiarone, A., Cabot, J., Paige, R. F., and Pierantonio, A. (2020). Grand challenges in model-driven engineering: an analysis of the state of the research. *Software and Systems Modeling*, 19:5–13.

Feichtinger, K. and Rabiser, R. (2020). Towards transforming variability models: Usage scenarios, required capabilities and challenges. In *Proceedings of the 24th ACM International Systems and Software Product Line Conference-Volume B*, pages 44–51.

Khan, R. A. and Khan, S. U. (2018). A preliminary structure of software security assurance model. In *Proceedings of the 13th International Conference on Global Software Engineering*, pages 137–140.

Pourali, P. and Atlee, J. M. (2018). An empirical investigation to understand the difficulties and challenges of software modellers when using modelling tools. In *Proceedings of the 21th ACM/IEEE International Conference on Model Driven Engineering Languages and Systems*, pages 224–234.

Rahim, M. S., Hasan, M. H., Chowdhury, A. E., and Das, S. (2017). Software engineering practices and challenges in bangladesh: A preliminary survey. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, 9(3-3):163–169.

Rukhsara, L., Aklam, F., Nawer, T., Chauhan, N. S., and Islam, M. N. (2016). A conceptual cloud-based model for developing e-commerce applications in context of bangladesh. In *2016 5th International Conference on Informatics, Electronics and Vision (ICIEV)*, pages 117–121. IEEE.

Tantithamthavorn, C. and Hassan, A. E. (2018). An experience report on defect modelling in practice: Pitfalls and challenges. In *Proceedings of the 40th International conference on software engineering: Software engineering in practice*, pages 286–295.

Troya, J., Moreno, N., Bertoa, M. F., and Vallecillo, A. (2021). Uncertainty representation in software models: a survey. *Software and Systems Modeling*, 20(4):1183–1213.