International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Review Article)

Check for updates

Integrating IoT and Agile Methodologies for Smarter Engineering Solutions

Abhishek Goyal *

Independent Researcher.

International Journal of Science and Research Archive, 2023, 08(02), 754–766

Publication history: Received on 25 February 2023; revised on 17 April 2023; accepted on 20 April 2023

Article DOI: https://doi.org/10.30574/ijsra.2023.8.2.0284

Abstract

The integration of IoT with Agile methodologies has ushered in transformative potential for engineering solutions, fostering enhanced adaptability, efficiency, and responsiveness in product development and system optimisation. IoT provides interconnected networks of devices that can communicate and interact autonomously, while Agile methodologies prioritise iterative progress and flexibility to adapt to changing requirements. Together, they enable engineering teams to leverage real-time data and continuous feedback, enhancing rapid prototyping, predictive maintenance, and resource management across various sectors. This paper explores the architectural framework of IoT and examines how Agile practices support IoT-based engineering, especially in product development and predictive maintenance. By examining key integration areas, this study demonstrates the compounded value IoT and Agile bring to engineering, where Agile principles such as iterative development, situational awareness, and stakeholder collaboration are pivotal. Ultimately, this paper highlights how this synergy drives smarter, more responsive engineering solutions and sets the foundation for innovations that align with the evolving demands of modern industries.

Keywords: Agile IoT Framework; Agile Engineering; Agile and IoT; IoT-enabled Engineering; Integrating IoT

1. Introduction

An easy-to-understand example from our everyday lives may illustrate the IoT. A television is one kind of IoT display. By just sitting at a distance and using the remote control, we may change the channel stream without ever touching the TV [1]. IoT principles remain unchanged; almost all of our electrical appliances may be controlled from a distance [2][1]. The IoT enables seamless connectivity and control over various devices in personal and industrial settings. A simple example can be remote control of appliances like smartphones and portable ACs, TVs and heaters [3][4][5].

IoT systems include devices connected via web interfaces along with processors, sensors and communication interfaces for data to be collected, transmitted and processed through cloud systems. These make a way to work together, allowing real-time analysis of data and adaptive and smart automation to impact users and industries. Aligning with IoT's constantly evolving ecosystem[6], Agile processes, in particular for software engineering, conduct tight iterations and cross-functional collaboration[6][7]. Techniques such as Scrum and eXtreme Programming (XP) are well-structured but flexible help teams to respond proactively to customers' changing needs [8][9]. Placing specific emphasis on people side of operation, agile methodologies rely on individuals' abilities to accomplish successful projects [10][11]. This adaptability matches IoT projects perfectly since such systems require relative freedom for embedding various components and addressing different users' requirements [12][13].

Agile methodologies applied to IoT development life cycles enable the application of vigorous prototyping, rigorous testing, and continuous enhancement – all critical to the successful implementation of sophisticated IoT solutions. With agile, developers are capable of managing several issues that IoT systems present, such as the merger of software and

* Corresponding author: Abhishek Goyal

hardware, as well as data security issues [14][15]. Since segregating the overall project into more manageable parts is possible with Agile, IoT projects can respond more may be towards new findings and customer feedback. Moreover, Agile iterative approach helps to update and build IoT system enhancement which is significant for reflecting the user requirement changes and new emerging technologies[16].

The Agile-IoT model discussed in this paper has shown promising outcomes, but these are not without their issues. As mentioned, IoT systems create huge amounts of data, and therefore, good data management solutions are required [17][18]. Agile processes overcome this through rationalisation of data handling into phases for availability, reliability and data integrity across the system [19][20]. Furthermore, security threats to IoT devices are not the same; that is, they are of different levels. High-vulnerability devices are extremely vulnerable in terms of security and access and involve tight procedures in the context of Agile. To reduce risks, Agile methodologies ensure these devices go through several cycles of validation and testing for ultimate protection and system robustness[21].

1.1. Structure of the Paper

The paper is organised as follows: Section II provides an overview of IoT and its architecture, detailing core components like sensors and communication technologies. Section III discusses Agile methodologies in IoT, emphasising principles like user involvement and iterative development. Section IV examines Agile-IoT integration, covering benefits, challenges, and frameworks such as Scrum and Kanban. Section V reviews the impact of Agile on IoT, and the paper concludes with future directions for advancing Agile practices in IoT development.

2. Overview of internet of things (IOT) and its architecture

Figure 1 demonstrates how the IoT envisions the future of the Internet, where real objects may be connected to and recognised online. Different technologies used to implement the IoT lead to different definitions of the term. Nonetheless, fundamentally, the IoT means that virtual representations of items in the IoT may be uniquely identifiable[22]. Everything in an IoT network may communicate with one another and, if necessary, process data in accordance with established protocols [23]. The IoT is envisioned as a pervasive physical inner-connected network that enables constant connectivity and remote control of objects [24][25]. Smart systems embedded in tags or sensors may autonomously perceive their surroundings and share data with other devices in the sensing layer [26][27]. For a variety of uses and applications, objects may be uniquely recognised, and the surroundings can be observed. Each IoT device has a digital identification that makes it simple to trace it online[3][28]. A UUID is a method of giving a thing a distinct identification. Names and addresses may be included in the IDs. A 128-bit integer called a UUID is used to identify an item or entity on the Internet in a unique way[29][30].

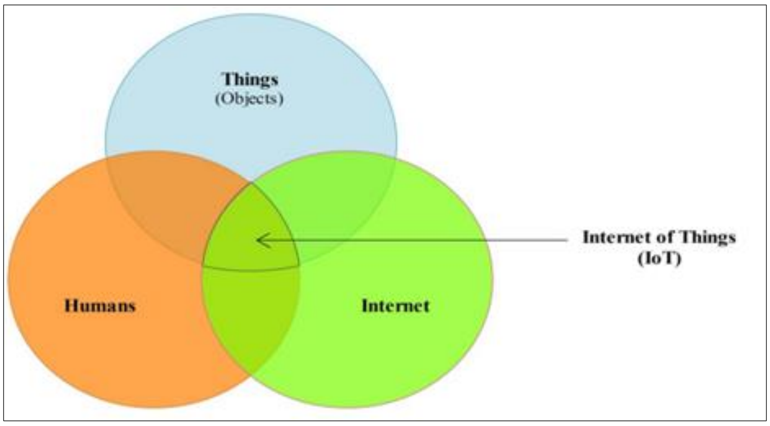

Figure 1 Internet of Things

There is a great deal of promise for the social, environmental, and economic effects of IoT adoption. IoT-based ideas include mobility, smart grid, smart homes and buildings, medical and healthcare, industrial processing, agriculture and breeding, public safety and environment monitoring, and independent living[31]. These apps are all connected to us in some manner. Vibrant advantages and the use of these apps are crucial, and their presence is now heavily relied upon. Their presence and usefulness have reached a revolutionary level in recent years and are now of utmost significance. It may not be inaccurate to say that the IoT's idea and vision are the only things that will propel us practically into the future[32][33].

The phrase "IoT" refers to the internet's dramatic transformation into a network of linked items that form a smart environment. "The IoT allows people and things to be connected Anytime, Anyplace, with Anything and Anyone, ideally using Any path/network and Any service," is the definition of IoT that will be used in this research. IIoT is a newly coined word that describes the IoT use in manufacturing and other industrial settings. It denotes the utilisation of control systems, machine-to-machine communication, data analytics, security measures, and sensors and actuators [34]. There are a plethora of new, noteworthy uses for industrial IoT. Modern companies may be fortified by the IIoT on three fronts: process optimisation, resource consumption optimisation, and the development of sophisticated autonomous systems [35][36]. Multiple academic disciplines contribute to the IoT. Embedded electronics, semantics, and the IoT all came together, according to the authors.

2.1. Architecture of IoT

IoT systems rely on sensors to detect and gather data, which is then processed, analysed, and utilised to make decisions by means of gateways that send the data to control centres or the cloud [37]. Following the decision-making process, the system's actuator receives a command based on the sensed data [38][39]. Architecture of IoT is shown in Figure 2.

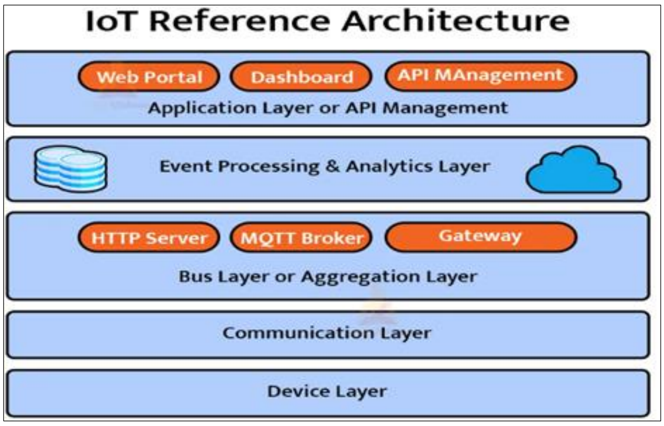

Figure 2 Reference Architecture of IoT

- Sensor Devices: The IoT is propelled by sensors. Their job is to gather data in real time and send it on. Sensors are essential to the development of the IoT because they improve efficiency and functionality. There are many varieties of sensors, each tailored to a certain set of needs[40].
- Actuators: A certain kind of energy may be converted into motion by use of an actuator. The automation systems provide them with electrical signals, and these actuators then move the many machines and gadgets that make up the IoT. Motions like linear, oscillatory, or spinning may be generated via actuators[41].
- Communication Technologies: The IoT is primarily enabled via wireless communication networks. The sensor devices are linked to IoT gateways by wireless systems, which also provide end-to-end data transfers among various IoT components[42]. Various wireless standards form the basis of wireless system development; the use of any one standard is application-specific and may vary with respect to factors like communication range, bandwidth, and power consumption.
- IoT Data and Computing: Computing and analysing the data produced by the IoT enables a more thorough understanding, accurate system response, and aids in making appropriate choices about the systems' energy use. But processing data from the IoT is no easy task. Since a vast quantity of organised and unstructured data is produced by different components of IoT systems, including sensors, software programs, smart or intelligent devices, and communication networks, IoT data is also referred to as big data[43].

3. Agile methodologies in the context of IOT

In the context of the IoT, Agile methodologies have become instrumental in addressing the dynamic and interconnected challenges inherent in IoT projects. Building upon the foundational "Manifesto for Agile Software Development" devised in 2001 by 17 leading software practitioners, Agile principles emphasise flexibility, iterative development, and customer collaboration over rigid, upfront planning[44]. These methodologies are particularly suited for IoT development, where requirements can rapidly evolve due to technological advancements and changing user needs. Agile approaches in IoT encourage embracing changes in requirements at any stage of the project and promote constant feedback from end users and customers, leading to smarter and more responsive engineering solutions[45].

A crucial seventh level, Situational Awareness, has been added to the agile life cycle model framework. The Awareness stage interacts with all of the previous phases while attending to active situational awareness, both internal and external. One aspect of effective agile systems engineering that has recently come to light is the proactive awareness of situational opportunities and risks to both the process and the product. This proactive awareness is maintained throughout the systems engineering process and the life cycle of the target system[46][47]. An agile system of interest must be created at the Development stage in order for the agile life cycle model framework to enable evolution, which allows for continual development beyond the first delivery[48]. All subsequent stages build on the Situational Awareness stage, which is when the first realisation that a new system is required occurs. As seen in Figure 3, there is a strong relationship between situational awareness and Attention Management as well as Optimal Estimation and Control.

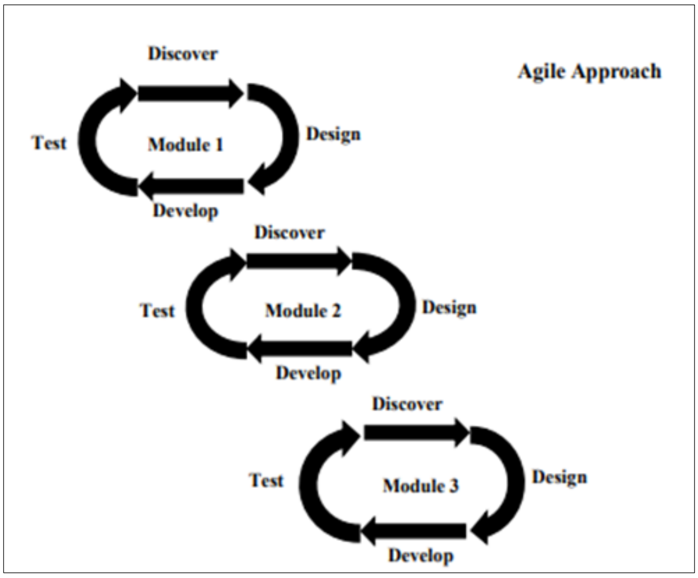

Figure 3 Agile Methodology process

3.1. Principles of Agile Methodology

This section outlines the key principles and aspects of Agile methodology as they are applied and described.

- Active User Involvement: Agile essentially requires active user participation. To examine how the agile concept stacks up against alternative approaches to project management. When developing an agile product, it's not always feasible to incorporate end users directly. This is especially true when the product will be aimed at consumers or customers outside of the company[49].
- Empowered Team: To implement a top-down management strategy, the project team needs discretionary authority to carry out their work and take full ownership of the final result.
- Flowing Requirements: Requirements change over time, but deadlines stay the same in agile development. Realising that clients desire a certain budget and scope but also need maximum flexibility and the ability to quickly change the capacity of their solution is mutually exclusive.
- Quick, Small, Incremental Releases and Iteration: This principle logically persists as needs change. Analyse, Develop, Test is the (simplified) lifecycle of a product-based project. This phase involves collecting all known requirements for the final product or output, producing all software components, and finally testing the complete product to ensure it is release-ready[50].

Complete First, then Move to the Next: By the time the Sprint comes to a close, all improvements made throughout iteration should be fully functional. The needs are being moved to the backlog2 and will be created or finished according to their priority [51].

Test Early and Often: According to its definition, the agile methodology tests the output continually as it develops, with testing being incorporated throughout the lifecycle. As a distinct step, testing is not part of agile development.

Collaboration between All Stakeholders: Collaborating with customers and maintaining control is always important in an agile culture. So is recognising the necessity and possibilities of change. Competence is about motivation, individuality, and continuing to pay attention to technical excellence [52].

3.2. Challenges in traditional Engineering processes

This section delves into the challenges commonly faced in conventional engineering processes, highlighting issues such as inflexibility, lengthy development cycles, and difficulty adapting to changing requirements[14]. It provides an overview of these limitations and how they impact project outcomes and responsiveness.

- The conventional software development process adheres to a rigid phase concept, conducting each phase in a sequential and organised fashion, and is therefore limited to the initial requirements and design created at the software project's inception, in contrast to the Agile software development process. In the requirement analysis phase, clients submit their needs; the team then uses those specifications to inform the design process, which in turn kicks off development [37]. The software project manager is responsible for monitoring the progress of the project at all times until the client receives the finished product.
- The traditional software development process has two major flaws: first, it takes too long to provide a functional software product to clients, and second, it isn't flexible enough to accommodate changes to requirements.
- Since the agile methodology is incremental and iterative, the software development process is divided into tiny iterative cycles called sprints to carry out each of the stated phases. However, in the conventional method, which is also called the lightweight development process, each step is carried out in turn without specifying any kind of repetition [53][54]. The client may deploy the deliverable product that is created during the incremental cycles. In addition, agile encompasses additional phases that are absent from conventional methods, such as ideation, release, production, and retirement.
- When compared to conventional development methods, agile development is more sustainable and expedited since it facilitates continuous client engagement and can easily adjust to changing requirements. Further, customer satisfaction is prioritised by engaging with them more often or at almost every stage of a sprint compared to previous methods [14].
- There are a plethora of models used in conventional approaches, including the waterfall, spiral, iterative improvement, evolutionary, and prototype models. A plethora of models, including Kanban, scrum, extreme programming, feature-driven development, and many more, make up agile methodology. The needs assessment of the program to be built and the resources that are available might help choose the best model. When it comes to creating software systems, Scrum is among the most widely utilised methodologies for agile software development. Since Scrum places more emphasis on meeting the evolving needs of customers, its alternate moniker is "flexible."[55].

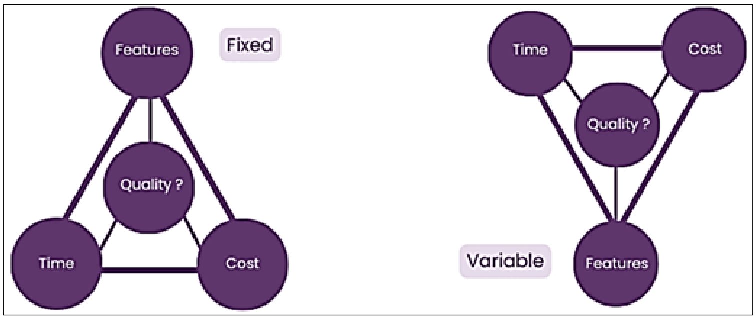

Figure 4 Traditional v/s Agile approach

The following Figure 4 shows the Traditional v/s Agile approach. Illustrate the key difference between traditional and Agile approaches to software development. In the traditional model, Features are considered fixed, and the focus is on delivering them within a specific Time and Cost constraint[50]. This often leads to compromises in Quality as the project progresses. In contrast, the Agile model prioritises Quality and Time over Features. It emphasises iterative development, continuous feedback, and adaptability to changing requirements. This approach is more versatile and frees up the possibility to create really high-quality software in the given time, even if some features will have to be cut down slightly.

Basically, the traditional model is bureaucratic in nature and aims at providing a specific number of features, while the Agile model is fluid and aims at developing quality software within the given time frame.

4. Key areas for integration of IOT and agile in engineering solutions

The following key areas for the integration of IoT and agile in engineering solutions are discussed below:

4.1. Product Development and Prototyping

IoT is getting widely implemented in the product development process with the combination of Agile due to its efficiency and constant feed. The combination improves flexibility in engineering as it enables quick modification of the product design from real-time information [56].

4.1.1. Rapid Prototyping with IoT-Driven Feedback Loops

Specifically, a number of studies have noted that when IoT feedback loops are included in the context of product prototyping, the time to market is diminished due to the enhanced iteration process [57]. Thus, using the information from the sensors placed in the prototypes, the engineers can track the usage and observe the drawbacks in order to make corrections in time. This feedback loop is crucial for the capturing of design errors before the start of a new development cycle thus minimising costs that may be incurred by changes made in the later design cycles.

4.1.2. Agile Sprints for Iterative Product Development

Sprints in Agile development enable a planned sequence of product development that allows the teams to focus on unique concerns regarding design in a single sprint. Recent studies show that Agile sprints used in combination with IoT data would provide a more effective approach to prototyping since each sprint can be based on real-life performance of the product, thereby increasing the quality of every sprint.

4.2. Predictive Maintenance and Optimization

As a result of modern engineering, predictive maintenance is used intensively to notice equipment wear and possible failure using IoT sensors [58]. This is supported by other methodologies that depend on agile production processes to facilitate fast and effective changes to maintenance strategies.

4.2.1. IoT Data Collection for Predictive Analytics

Engineering IoT sensors in engineering environments collect data which can be used to forecast failure of specific instruments before they 'give out'.) Through the analysis of data coming from the sensor including temperature, vibration and pressure, companies are able to predict when a maintenance should be conducted thereby minimising time spent on maintenance and costs for such maintenance [59].

4.2.2. Agile Adaptations for Maintenance Workflows

Adapting Agile concepts effectively optimises maintenance flows while responding flexibly to IoT findings, aligning maintenance practices with findings derived from big data risk evaluations. Proposed studies demonstrate that Agile changes to maintenance practices result in improved performance, especially regarding operational costs.

4.3. Quality Assurance and Testing

Due to increased use of IoT devices, quality checking mechanisms are also improved with Agile methodologies as methods of testing in each iteration [60].

4.3.1. Using IoT for Real-Time Quality Monitoring

Wireless IoT sensors attached to a physical product or a production system also facilitate real-time quality assurance. Based on research, real-time monitoring of products through IoT can mean that the moment an issue arises, it will quickly be identified and addressed, further enhancing quality. For example, variations of data from sensors used in manufacturing lines can generate signals that would otherwise allow for the production of substandard products to be sold in the market.

4.3.2. Agile Approaches in Testing and Quality Control

This makes it easy to conduct testing in cycles that are easy to manage because agile methodologies allow quality assurance teams to integrate IoT data into testing cycles. Studies prove that Agile testing enhances the communication capacity of an organisation through frequent and timely adaptations at every level in the interest of delivering the perfect product.

4.4. Smart Project Management

This work successfully integrates IoT and Agile to propose efficiency improvements to project managers in terms of visibility and flexibility.

4.4.1. IoT Dashboards for Project Monitoring

Dashboards that have been developed leverage IoT technologies and the result is that managers can monitor metrics of projects in near real-time and determine sources of delays. Research shows that IoT dashboards enhance decision-making capabilities by offering real-time information on the status of the project together with the stock.

4.4.2. Agile Metrics and Performance Tracking

Velocity and lead time along with IoT data when implemented provides the project managers with the visionary view of the project. This integration enables real-time data on project performance prognosis and, subsequently, timely modifications to meet project goals and objectives.

5. Literature review

The following is a paper review section focusing on Agile methodologies for smarter engineering solutions. It discusses how Agile practices sponsor flexibility, communication, and productivity enhancement in engineering.

This paper, Gal, Filip and Dragan (2018) propose an Agile approach of managing the projects that is capable of responding to the existence of the IoT network and its incorporation in the procedure of project management that implies Things and characteristics of Things. In order to improve various project metrics, such as team collaboration, efficiency, technique level, technological level, and automation level, the Agile project management solution slightly alters the software project management steps and implements them across the IoT network[61].

In, Gabr and Azer (2018) There are significant obstacles to securely processing large data due to the interactivity of internet-connected devices with their environments. High susceptibility and low vulnerability IoT devices are the two categories into which this study divides them. Attack ease determines the categorisation. Using an agile strategy, high-vulnerability devices are secured first, followed by low-vulnerability devices using encryption techniques to guarantee the security of IoT devices[62].

In, Gouthaman and Sankaranarayanan (2018) suggested a system that helps achieve this aim by including architecture and a risk assessment approach. Additionally, this suggested system incorporates machine learning methods, which prove to be more suitable for an uninterrupted system. Furthermore, the present software risk management metrics may not be yielding the desired results when used in the Internet of Things; thus, IoT-based software metrics must be included for efficient performance. A software risk assessment methodology and the architecture of agile software risk management for IoT-Fog-based systems are the main topics of this article[63].

In, Jusoh et al. (2019) carried out a case study with the four chosen SMEs that have made the IoT their main business. According to the study's findings, the development methodologies that all of the organisations are utilising include Lean, FDD, DSDM, and extreme programming (XP). Nonetheless, Scrum approaches are the most widely utilised framework for agile methodologies. Businesses used Agile SDM, according to the report. This is because Agile SDM enables software development teams to efficiently plan their work and deliver often to customers and stakeholders[64].

This paper, Selvakumar and Jayashree (2020) examines in the first section how supply chain management is affected by the use of the Internet of Things. In order to fulfil the contemporary world's commercial needs, software engineering processes are changing quickly, and businesses are shifting towards more agile approaches. Many issues in the contemporary software development process are resolved by the microservices design. The second section of the study examines the effects of using a microservices architecture. Lastly, the emergence of microservices-architected supply chain solutions enabled by the IoT connects all the dots. Although supply chain management, IoT, and microservices are all developing in different ways, this article aims to combine the three to create more flexible supply chains that can meet the expanding demands of business[65].

This adoption, Tashtoush et al. (2022) arises from the fact that agile approaches facilitate the delivery of services and products in smaller batches and are highly iterative, allowing security experts to easily combine agile approaches with software development security operations. In light of IoT, ITS, and related cybersecurity and risk issues, this article provides a thorough and in-depth analysis of agile software development. Additionally, they provide a methodical comparison of the examined literature according to a predetermined set of standards. Finally, they provide a more comprehensive perspective and a roadmap for creating agile software development solutions with security enhancements for IoT and ITS systems in the future[66].

Here is a literature review Table I summarising the papers discussed, focusing on the integration of IoT and Agile methodologies for smarter engineering solutions.

Table 1 Summary of the literature review of iot and agile integration

Reference	Research Focus	Framework Used	Key Findings	Relevance to IoT and Agile Integration	Challenges Identified	Implications for Engineering Solutions
[61]	Proposes an Agile project management solution that adapts to IoT networks by embedding devices with features into the project management process.	Agile project management tailored for IoT	Focus on improving team collaboration, efficiency, project techniques, and automation levels.	IoT integration into Agile project management increases efficiency and technological level.	Ensuring alignment between IoT and Agile processes in project management.	Facilitates the implementation of Agile in IoT-focused engineering projects by enhancing team dynamics and automation.
[62]	Examines the classification of IoT devices into high and low vulnerability categories, proposing an agile approach to security using encryption algorithms.	Agile approach for IoT security	Focus on the security challenges posed by IoT devices and how an Agile methodology can secure high-vulnerability devices first.	Security integration into IoT networks through Agile approaches, securing devices through encryption.	Balancing security protocols with Agile flexibility.	Supports secure development and management of IoT devices in engineering solutions, ensuring better protection.
[63]	Proposes an agile software risk management framework for IoT and Fog-based systems, integrating machine learning for continuous system adaptation.	Agile software risk management framework	Introduction of IoT-specific software risk metrics and machine learning techniques to assess and mitigate risks.	Focus on developing a tailored agile framework for managing risks in IoT systems with Fog computing.	Adapting traditional software risk management techniques for IoT environments.	Enhances the management of risks in IoT-based engineering systems through Agile practices and continuous learning.
[64]	Case study on SMEs using Agile methodologies for IoT application development, highlighting the use	Scrum, XP, DSDM, FDD, Lean	Most companies use Scrum for IoT development due to its flexibility and iterative	Provides insight into how SMEs use Agile frameworks to improve IoT application	Challenges of choosing the right Agile methodology for IoT development.	Supports Agile adoption in IoT-based engineering projects by promoting task organisation and

	of Scrum, XP, DSDM, and FDD.		approach, promoting frequent deliveries to stakeholders.	development efficiency.		frequent iteration.
[65]	Investigates the impact of IoT in supply chain management and the role of microservices architecture in enhancing Agile methodologies.	Microservices architecture	Microservices improve flexibility and scalability in IoT-based supply chain solutions, making them more agile.	Explores the integration of IoT, microservices, and Agile methodologies to optimise supply chain management.	Complexity of integrating microservices and IoT in an Agile environment.	Enhances supply chain engineering solutions by combining IoT with Agile and microservices for improved responsiveness.
[66]	Review of the integration of Agile methodologies in IoT and ITS systems, focusing on cybersecurity and risk management challenges.	Comprehensive review and comparison of Agile and IoT cybersecurity practices	Agile methodologies facilitate seamless integration of security activities, allowing continuous development with integrated security.	Highlights how Agile software development can improve IoT and ITS systems security.	Cybersecurity concerns in Agile IoT development.	Encourages the development of secure IoT systems with Agile methods, improving security management in engineering solutions.

6. Conclusion and Future Work

Integrating IoT with Agile methodologies presents a powerful approach to addressing the dynamic demands of modern engineering solutions. This symbiosis enables the coordinated sharing of data in real-time and the accelerated delivery of changes so that lasting, effective solutions can be created with equal emphasis on conventions and user experience. IoT lets engineers gather significant information, allowing for predictive maintenance, and Agile principles offer the basis for a timely response to changes. Agile development is a collaborative, iterative approach which validates IoT-enabled systems and improves them in real time to meet quality, scalability, and end-user needs constantly. Lastly, the integration of IoT and Agile methodologies reveals a new qualitative level of engineering development not only improving such processes' productivity and adaptability but also creating new avenues for constant evolution of various industries toward building stronger and smarter solutions demanded with the constant advancements of IoT technology.

Agile methodologies should, therefore, be developed to better suit IoT large-scale systems in future research and development plans. One of the issues is processing huge amounts of data created by smart connected devices: This can be solved by looking deeper into the hybridisation of Agile with some other processes, such as DevOps, for example. Moreover, future research can expand strategies for improving the security measures within such Agile IoT projects with an emphasis on specific high-risk equipment. The use case of AI and machine learning for Agile process might enact possibilities of automating testing, data management and security which is beneficial prospect in the IoT development

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] J. Thomas, K. V. Vedi, and S. Gupta, "The Effect and Challenges of the Internet of Things (IoT) on the Management of Supply Chains," *Int. J. Res. Anal. Rev.*, vol. 8, no. 3, pp. 874–879, 2021.

[2] P. Badakhshan, K. Conboy, T. Grisold, and J. vom Brocke, "Agile business process management: A systematic literature review and an integrated framework," *Bus. Process Manag. J.*, vol. 26, no. 6, pp. 1505–1523, 2020, doi: 10.1108/BPMJ-12-2018-0347.

[3] Mani Gopalsamy, "An Optimal Artificial Intelligence (AI) technique for cybersecurity threat detection in IoT Networks," *Int. J. Sci. Res. Arch.*, vol. 7, no. 2, pp. 661–671, Dec. 2022, doi: 10.30574/ijsra.2022.7.2.0235.

[4] Mani Gopalsamy, "Enhanced Cybersecurity for Network Intrusion Detection System Based Artificial Intelligence (AI) Techniques," *Int. J. Adv. Res. Sci. Commun. Technol.*, vol. 12, no. 01, pp. 671–681, Dec. 2021, doi: 10.48175/IJARSCT-2269M.

[5] M. Gopalsamy, "Artificial Intelligence (AI) Based Internet-ofThings (IoT)-Botnet Attacks Identification Techniques to Enhance Cyber security," *Int. J. Res. Anal. Rev.*, vol. 7, no. 4, pp. 414–420, 2020.

[6] R. Goyal, "THE ROLE OF REQUIREMENT GATHERING IN AGILE SOFTWARE DEVELOPMENT: STRATEGIES FOR SUCCESS AND CHALLENGES," *Int. J. Core Eng. Manag.*, vol. 6, no. 12, pp. 142–152, 2021.

[7] K. Patel, "An Analysis of Quality Assurance Practices Based on Software Development Life Cycle (SDLC) Methodologies," *J. Emerg. Technol. Innov. Res.*, vol. 9, no. 12, pp. g587–g592, 2022.

[8] S. A. and A. Tewari, "AI-Driven Resilience: Enhancing Critical Infrastructure with Edge Computing," *Int. J. Curr. Eng. Technol.*, vol. 12, no. 02, pp. 151–157, 2022, doi: https://doi.org/10.14741/ijcet/v.12.2.9.

[9] S. A. and A. Tewari, "Security Vulnerabilities in Edge Computing: A Comprehensive Review," *Int. J. Res. Anal. Rev.*, vol. 9, no. 4, pp. 936–941, 2022.

[10] M. R. Kishore Mullangi, Vamsi Krishna Yarlagadda, Niravkumar Dhameliya, "Integrating AI and Reciprocal Symmetry in Financial Management: A Pathway to Enhanced Decision-Making," *Int. J. Reciprocal Symmetry Theor. Phys.*, vol. 5, no. 1, pp. 42–52, 2018.

[11] M. T. Arora, Rajeev and Kumar, Shantanu and Jain, Nitin and Nafis, "Revolutionizing Healthcare with Cloud Computing: Superior Patient Care and Enhanced Service Efficiency," *SSRN*, 2022, doi: http://dx.doi.org/10.2139/ssrn.4957197.

[12] D. Pandit, S. Chowdary, P. S. R. Patnaik, B. Shaharkar, and A. K. Surde, "Agile Methodology for IoT Application Development and Business Improvisation," in *Lecture Notes in Networks and Systems*, 2022. doi: 10.1007/978-981-16-4016-2_57.

[13] R. Bishukarma, "Adaptive AI-Based Anomaly Detection Framework for SaaS Platform Security," *Int. J. Curr. Eng. Technol.*, vol. 12, no. 07, pp. 541–548, 2022, doi: https://doi.org/10.14741/ijcet/v.12.6.8.

[14] K. Patel, "Quality Assurance In The Age Of Data Analytics: Innovations And Challenges," *Int. J. Creat. Res. Thoughts*, vol. 9, no. 12, pp. f573–f578, 2021.

[15] A. P. A. Singh, "STRATEGIC APPROACHES TO MATERIALS DATA COLLECTION AND INVENTORY MANAGEMENT," *Int. J. Bus. Quant. Econ. Appl. Manag. Res.*, vol. 7, no. 5, 2022.

[16] A. Buja, M. Apostolova, A. Luma, and Y. Januzaj, "Cyber Security Standards for the Industrial Internet of Things (IIoT)- A Systematic Review," in *HORA 2022 - 4th International Congress on Human-Computer Interaction, Optimization and Robotic Applications, Proceedings*, 2022. doi: 10.1109/HORA55278.2022.9799870.

[17] R. Goyal, "Software Development Life Cycle Models: A Review Of Their Impact On Project Management," *Int. J. Core Eng. Manag.*, vol. 7, no. 2, pp. 78–87, 2022.

[18] R. Bishukarma, "The Role of AI in Automated Testing and Monitoring in SaaS Environments," *IJRAR*, vol. 8, no. 2, 2021, [Online]. Available: https://www.ijrar.org/papers/IJRAR21B2597.pdf

[19] M. Vecchio, P. Azzoni, A. Menychtas, I. Maglogiannis, and A. Felfernig, "A fully open-source approach to intelligent edge computing: Agile's lesson," *Sensors (Switzerland)*, 2021, doi: 10.3390/s21041309.

[20] V. K. Yarlagadda, "Harnessing Biomedical Signals: A Modern Fusion of Hadoop Infrastructure, AI, and Fuzzy Logic in Healthcare," *Malaysian J. Med. Biol. Res.*, vol. 2, no. 2, pp. 85–92, 2021.

[21] T. M. Gahroee, T. J. Gandomani, and M. S. Aghaei, “The main pillars of Agile consolidation in newly Agile teams in Agile software development,” *Indones. J. Electr. Eng. Comput. Sci.*, 2022, doi: 10.11591/ijeecs.v26.i2.pp1216-1226.

[22] R. Arora, S. Gera, and M. Saxena, “Mitigating Security Risks on Privacy of Sensitive Data used in Cloud-based ERP Applications,” in *2021 8th International Conference on Computing for Sustainable Global Development (INDIACom)*, 2021, pp. 458–463.

[23] V. V. Kumar, M. K. Pandey, M. K. Tiwari, and D. Ben-Arieh, “Simultaneous optimization of parts and operations sequences in SSMS: A chaos embedded Taguchi particle swarm optimization approach,” *J. Intell. Manuf.*, 2010, doi: 10.1007/s10845-008-0175-4.

[24] V. K. Y. Nicholas Richardson, Rajani Pydipalli, Sai Sirisha Maddula, Sunil Kumar Reddy Anumandla, “Role-Based Access Control in SAS Programming: Enhancing Security and Authorization,” *Int. J. Reciprocal Symmetry Theor. Phys.*, vol. 6, no. 1, pp. 31–42, 2019.

[25] V. K. Yarlagadda, S. S. Maddula, D. K. Sachani, K. Mullangi, S. K. R. Anumandla, and B. Patel, “Unlocking Business Insights with XBRL: Leveraging Digital Tools for Financial Transparency and Efficiency,” *Asian Account. Audit. Adv.*, vol. 11, no. 1, pp. 101–116, 2020.

[26] V. V Kumar, M. Tripathi, M. K. Pandey, and M. K. Tiwari, “Physical programming and conjoint analysis-based redundancy allocation in multistate systems: A Taguchi embedded algorithm selection and control (TAS&C) approach,” *Proc. Inst. Mech. Eng. Part O J. Risk Reliab.*, vol. 223, no. 3, pp. 215–232, Sep. 2009, doi: 10.1243/1748006XJRR210.

[27] R. Arora, A. Soni, R. Garine, and A. Kumar, “Impact of Cloud-Based Mobile Application during Pandemic (Covid-19).” 2024. doi: 10.2139/ssrn.4935564.

[28] S. Bauskar, “BUSINESS ANALYTICS IN ENTERPRISE SYSTEM BASED ON APPLICATION OF ARTIFICIAL INTELLIGENCE,” *Int. Res. J. Mod. Eng. Technol. Sci.*, vol. 04, no. 01, pp. 1861–1870, 2022, doi: DOI : https://www.doi.org/10.56726/IRJMETS18127.

[29] M. R. Al Asif, K. F. Hasan, M. Z. Islam, and R. Khondoker, “STRIDE-based Cyber Security Threat Modeling for IoT-enabled Precision Agriculture Systems,” in *2021 3rd International Conference on Sustainable Technologies for Industry 4.0, STI 2021*, 2021. doi: 10.1109/STI53101.2021.9732597.

[30] V. Kumar, V. V. Kumar, N. Mishra, F. T. S. Chan, and B. Gnanasekar, “Warranty failure analysis in service supply Chain a multi-agent framework,” in *SCMIS 2010 - Proceedings of 2010 8th International Conference on Supply Chain Management and Information Systems: Logistics Systems and Engineering*, 2010.

[31] B. Patel, V. K. Yarlagadda, N. Dhameliya, K. Mullangi, and S. C. R. Vennapusa, “Advancements in 5G Technology: Enhancing Connectivity and Performance in Communication Engineering,” *Eng. Int.*, vol. 10, no. 2, pp. 117–130, 2022, doi: 10.18034/ei.v10i2.715.

[32] A. Sharma, A. Jain, P. Gupta, and V. Chowdary, “Machine Learning Applications for Precision Agriculture: A Comprehensive Review,” *IEEE Access*. 2021. doi: 10.1109/ACCESS.2020.3048415.

[33] A. Khanna and S. Kaur, *Internet of Things (IoT), Applications and Challenges: A Comprehensive Review*, vol. 114, no. 2. 2020. doi: 10.1007/s11277-020-07446-4.

[34] K. V. V. and S. G. Jubin Thomas , Piyush Patidar, “An analysis of predictive maintenance strategies in supply chain management,” *Int. J. Sci. Res. Arch.*, vol. 06, no. 01, pp. 308–317, 2022, doi: DOI: https://doi.org/10.30574/ijsra.2022.6.1.0144.

[35] S. Bauskar, “Predictive Analytics For Sales Forecasting In Enterprise Resource,” *Int. Res. J. Mod. Eng. Technol. Sci.*, vol. 04, no. 06, pp. 4607–4618, 2022, doi: https://www.doi.org/10.56726/IRJMETS26271.

[36] R. Goyal, “THE ROLE OF BUSINESS ANALYSTS IN INFORMATION MANAGEMENT PROJECTS,” *Int. J. Core Eng. Manag.*, vol. 6, no. 9, pp. 76–86, 2020.

[37] V. K. Yarlagadda and R. Pydipalli, “Secure Programming with SAS: Mitigating Risks and Protecting Data Integrity,” *Eng. Int.*, vol. 6, no. 2, pp. 211–222, 2018.

[38] D. Mourtzis, E. Vlachou, and N. Milas, “Industrial Big Data as a result of IoT adoption in Manufacturing,” *Procedia CIRP*, vol. 55, pp. 290–295, 2016, doi: 10.1016/j.procir.2016.07.038.

[39] H. S. Chandu, “A Digital Interface for the Part Designers and the FixtureDesigners for a Reconfigurable Assembly System,” *Math. Probl. Eng.*, vol. 9, no. 4, pp. 930–935, 2013.

[40] S. K. R. Anumandla, V. K. Yarlagadda, S. C. R. Vennapusa, and K. R. V. Kothapalli, "Unveiling the Influence of Artificial Intelligence on Resource Management and Sustainable Development: A Comprehensive Investigation," *Technol. \& Manag. Rev.*, vol. 5, no. 1, pp. 45–65, 2020.

[41] A. P. A. Singh, "Streamlining Purchase Requisitions and Orders : A Guide to Effective Goods Receipt Management," *J. Emerg. Technol. Innov. Res.*, vol. 8, no. 5, pp. g179–g184, 2021.

[42] J. Thomas and V. Vedi, "Enhancing Supply Chain Resilience Through Cloud-Based SCM and Advanced Machine Learning: A Case Study of Logistics," *J. Emerg. Technol. Innov. Res.*, vol. 8, no. 9, 2021.

[43] N. H. Motlagh, M. Mohammadrezaei, J. Hunt, and B. Zakeri, "Internet of things (IoT) and the energy sector," *Energies*. 2020. doi: 10.3390/en13020494.

[44] M. S. Rajeev Arora, Sheetal Gera, "Impact of Cloud Computing Services and Application in Healthcare Sector and to provide improved quality patient care," *IEEE Int. Conf. Cloud Comput. Emerg. Mark. (CCEM), NJ, USA, 2021*, pp. 45–47, 2021.

[45] P. Marbach, L. Rosser, G. Osvalds, and D. Lempia, "Principles for Agile Development," *INCOSE Int. Symp.*, vol. 25, no. 1, pp. 524–537, 2015, doi: 10.1002/j.2334-5837.2015.00079.x.

[46] M. S. Rajeev Arora, "Applications of Cloud Based ERP Application and how to address Security and Data Privacy Issues in Cloud application," *Himal. Univ.*, 2022.

[47] H. S. Chandu, "A Survey of Memory Controller Architectures: Design Trends and Performance Trade-offs," *Int. J. Res. Anal. Rev.*, vol. 9, no. 4, pp. 930–936, 2022.

[48] R. Dove and B. Schindel, "Agile Systems Engineering Life Cycle Model for Mixed Discipline Engineering," no. July, 2019.

[49] V. V Kumar, M. Tripathi, S. K. Tyagi, S. K. Shukla, and M. K. Tiwari, "An integrated real time optimization approach (IRTO) for physical programming based redundancy allocation problem," *Proc. 3rd Int. Conf. Reliab. Saf. …*, no. August, 2007.

[50] M. Z. Hasan, R. Fink, M. R. Suyambu, M. K. Baskaran, D. James, and J. Gamboa, "Performance evaluation of energy efficient intelligent elevator controllers," in *IEEE International Conference on Electro Information Technology*, 2015. doi: 10.1109/EIT.2015.7293320.

[51] M. R. S. and P. K. Vishwakarma, "An Efficient Machine Learning Based Solutions for Renewable Energy System," *Int. J. Res. Anal. Rev.*, vol. 9, no. 4, pp. 951–958, 2022.

[52] J. Juricek, "Agile Project Management Principles," *IEEE*, vol. 2, no. 2, pp. 172–175, 2014, doi: 10.7763/LNSE.2014.V2.117.

[53] M. Z. Hasan, R. Fink, M. R. Suyambu, and M. K. Baskaran, "Assessment and improvement of intelligent controllers for elevator energy efficiency," in *IEEE International Conference on Electro Information Technology*, 2012. doi: 10.1109/EIT.2012.6220727.

[54] M. Z. Hasan, R. Fink, M. R. Suyambu, and M. K. Baskaran, "Assessment and improvement of elevator controllers for energy efficiency," in *Digest of Technical Papers - IEEE International Conference on Consumer Electronics*, 2012. doi: 10.1109/ISCE.2012.6241747.

[55] A. Alhazmi and S. Huang, "Survey on Differences of Requirements Engineering for Traditional and Agile Development Processes," in *Conference Proceedings - IEEE SOUTHEASTCON*, 2020. doi: 10.1109/SoutheastCon44009.2020.9397492.

[56] E. Cabrera, P. Cardenas, P. Cedillo, and P. Pesantez-Cabrera, "Towards a Methodology for creating Internet of Things (IoT) Applications based on Microservices," in *Proceedings - 2020 IEEE 13th International Conference on Services Computing, SCC 2020*, 2020. doi: 10.1109/SCC49832.2020.00072.

[57] K. S. H. Ong, W. Wang, N. Q. Hieu, D. Niyato, and T. Friedrichs, "Predictive Maintenance Model for IIoT-Based Manufacturing: A Transferable Deep Reinforcement Learning Approach," *IEEE Internet Things J.*, 2022, doi: 10.1109/JIOT.2022.3151862.

[58] C. Patel and M. Ramachandran, "Agile Maturity Model (AMM): A software process improvement framework for agile software development practices," *Int. J. Softw. Eng. IJSE*, 2009.

[59] V. V. Kumar, F. W. Liou, S. N. Balakrishnan, and V. Kumar, "Economical impact of RFID implementation in remanufacturing: a Chaos-based Interactive Artificial Bee Colony approach," *J. Intell. Manuf.*, 2015, doi: 10.1007/s10845-013-0836-9.

[60] N. D. Fogelström, T. G. M. Svahnberg, and P. Olsson, "The impact of agile principles on market-driven software product development," *J. Softw. Maint. Evol.*, 2010, doi: 10.1002/smr.453.

[61] A. Gal, I. Filip, and F. Dragan, "A New Vision Over Agile Project Management in the Internet of Things Era," *Procedia - Soc. Behav. Sci.*, 2018, doi: 10.1016/j.sbspro.2018.04.003.

[62] B. Gabr and M. A. Azer, "IoT Agile Framework Enhancement," in *1st International Conference on Computer Applications and Information Security, ICCAIS 2018*, 2018. doi: 10.1109/CAIS.2018.8441993.

[63] P. Gouthaman and S. Sankaranarayanan, "Agile software risk management architecture for IoT-fog based systems," in *Proceedings of the International Conference on Smart Systems and Inventive Technology, ICSSIT 2018*, 2018. doi: 10.1109/ICSSIT.2018.8748457.

[64] Y. Y. Jusoh *et al.*, "Adoption of agile software methodology among the SMEs developing an IOT applications," in *International Conference on Research and Innovation in Information Systems, ICRIIS*, 2019. doi: 10.1109/ICRIIS48246.2019.9073678.

[65] G. Selvakumar and L. S. Jayashree, "Agile Supply Chain Management Enabled by the Internet of Things and Microservices," in *Proceedings of International Conference on Artificial Intelligence, Smart Grid and Smart City Applications*, Cham: Springer International Publishing, 2020, pp. 449–456. doi: 10.1007/978-3-030-24051-6_43.

[66] Y. M. Tashtoush *et al.*, "Agile Approaches for Cybersecurity Systems, IoT and Intelligent Transportation," *IEEE Access*, 2022, doi: 10.1109/ACCESS.2021.3136861