AI AUGMENTED INTELLIGENT SYSTEM INTEGRATION AND BUSINESS AUTOMATION

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Dedication

In loving memory of my late father, Mr. S. Subramanian, a mathematics teacher, whose unwavering belief in me continues to inspire and motivate me. This dissertation is a testament to his enduring influence, guiding me with strength and encouragement throughout my professional journey. His legacy lives on in every accomplishment, forever cherished and deeply missed. I dedicate this research dissertation to his memory, with profound gratitude and love.

The below is written in Tamil, so that my mother can read.

ஆணித்தரமான நம்பிக்கையால் என்னை ஊக்குவித்த, மறைந்த எனது தந்தையார், கணித ஆசிரியர் திரு. ச. சுப்ரமணியன் அவர்களின் அன்பான நினைவாக, நான் இந்த ஆய்வுக் கட்டுரையை, ஆழ்ந்த நன்றியுடனும், அன்புடனும், அர்ப்பணிக்கிறேன்.

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ABSTRACT

AI AUGMENTED INTELLIGENT SYSTEM INTEGRATION AND BUSINESS AUTOMATION

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The increasing number and complexity of systems required for business process automation have resulted in system integration issues, leading to IT project failures or delays, necessitating a need for a better approach to streamline system integration and business automation with efficient use of resources. Existing research have identified the need for using AI techniques in business process automation, however there is a scarcity of research of applying AI techniques in the context of system integration and business automation. This research provides a comprehensive review of system integration and business automation and discusses the AI techniques in this context. This research focuses on the use of established AI techniques and emerging AI Augmented Software Engineering (AIASE) for intelligent system integration and business automation. The study employs deductive reasoning, descriptive analysis, and inductive reasoning to examine existing literature, collect primary and secondary data from the industry using

quantitative methods, and propose a framework and approach for AIASE implementation. The study emphasizes the contemporary challenges of system integration, skillset, infrastructure, and environment for applying AIASE and highlights the benefits and challenges resulting from AIASE. The proposed framework and approach have the potential to significantly improve the system integration market and shape the future of system integration software. The research findings are valuable to system integration consultancy businesses and integration software providers in developing better consultancy practice, products, and tools for applying AI augmented system integration and business automation.

KEYWORDS

Systems – Software applications, solutions, products, and tools needed in a business.

System Integration – An engineering process to connect and unify systems and processes.

Business Process – A set of activities to reach a desired result in a business.

Business Automation – The technique of running processes and functions in a business automatically using technologies.

Intelligent or Hyper Automation – Orchestrated use of multiple technologies to identify, vet and automate business processes.

AI Augmented Software Engineering (AIASE) – A technique to significantly improve productivity in software engineering using AI.

Augmented Intelligent Process Automation (AIPA) – Applying Intelligent or Hyper Automation techniques to automate a business.

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LIST OF ABBREVIATIONS, SYMBOLS, NOTATIONS

AI	Artificial Intelligence
AIASE	AI Augmented Software Engineering
AIPA	Augmented Intelligent Process Automation
AMER	America
APAC	Asia Pacific
API	Application Programming Interface
AR	Augmented Reality
BPA	Business Process Automation
BPM	Business Process Management
BPMS	Business Process Management System
CAGR	Compound Annual Growth Rate
CEO	Chief Executive Officer
CGI	Common Gateway Interface
CLI	Command-line interface
CMS	Content Management System
CPA	Cognitive Process Automation
CRM	Customer Relationship Management
CSV	Comma Separated Values
CX	Customer Experience
DB	Database
DIP	Data Integration Platform

DPA	Digital Process Automation
DTO	Digital Twins of Organization
EMEA	Europe, Middle East, and Africa
ERP	Enterprise Resource Planning
FTP	File Transfer Protocol
GAN	Generative Adversarial Network
GenAI	Generative Artificial Intelligence
GPT	Generative Pre-trained Transformer
GSD	Global Software Development
GUI	Graphical User Interface
HR	Human Resources
HTTP	Hypertext Transfer Protocol
IaaS	Infrastructure as a Service
IEEE	Institute of Electrical and Electronics Engineers
IPA	Intelligent Process Automation
iPaaS	integration Platform as a Service
iSaaS	integration Software as a Service
IT	Information Technology
LCAP	Local Control and Accountability Plan
LMS	Learning Management System
ML	Machine Learning
NCAP	No Code Application Platform

NLP	Natural Language Processing
OCR	Optical Character Recognition
OTS	Off The Shelf
PaaS	Platform as a Service
RAG	Retrieval Augmented Generation
RLHF	Reinforcement Learning from Human Feedback
RPA	Robotic Process Automation
SaaS	Software as a Service
SASO	Self-Adaptation and Self Organization
SDK	Software Development Kit
SI	System Integration
SISSY	Self-Improving System Integration
SP	Solution Provider
SQL	Structured Query Language
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UML	Unified Modeling Language
USD	United States Dollar
VM	Virtual Machine
VR	Virtual Reality
WfMS	Workflow Management System

CHAPTER I

INTRODUCTION

1.1 Introduction

Business process automation has become an essential aspect of modern organizations, but as the number of systems increases, the complexity and time required for integration and automation become increasingly difficult to manage. IT projects often fail or are delayed due to integration issues, and significant expertise and effort are required for successful implementation. The need for an intelligent integration and automation solution has become evident.

This research focuses on AI Augmented Intelligent System Integration and Business Automation, with the aim of reducing the complexity of integration, improving the management of integration, reducing the expertise, effort, and money required, and improving the ability to adapt to changes by applying AI techniques. The research will address the questions: what the challenges of system integration are, the need for intelligent automation and industry perceptions, what skills and environment are required to implement AI-based techniques, what benefits and challenges does AI bring to integration and automation, and how to approach the implementation of AI for intelligent system integration and business automation.

The research will utilize deductive reasoning and descriptive analysis to study existing theories and practices, and inductive reasoning to observe the market and propose a model for implementation. The research will target three populations: software systems data, solutions data, and senior businesspeople, and collect both primary and secondary data. The results of this study will be useful to system integration consulting

businesses and integration software providers in developing better practices, products, and tools with AI augmented system integration and business automation.

1.2 Research Problem

Businesses need Business Process Management (BPM) to integrate and coordinate business processes with people and software systems. The need for new and upgrade of software applications, products, and tools, collectively referred as systems in this research, are growing in a rapid pace. Integration of applications and data to make systems to work together is one of the key challenges that businesses face to operationalize BPM. Integration of software systems are needed but challenging when the number of software to be integrated and their interoperability and the architecture complexities are increasing over time (Shibl et al., 2022).

The continuous growth of systems in technology, scale and complexity across industries and domains increased the challenges. The cloud with IaaS, PaaS and SaaS have emerged as a new way of running and using software systems for business. There it brings the new cloud, system, and data integration challenges as the systems on cloud and on-premises also need to be integrated and work together (Hai and Sakoda, 2009).

Software integrations are always challenging and lack of it is even more challenging. Exploratory study of software integration challenges (Ilyas and Khan, 2017, p. 12) identified 16 total barriers including 10 critical barriers for integrating bespoke or off-the-shelf (OTS) products. The software system integration challenges affect the businesses to effectively perform business process management required for business success.

The problem is summarized as below.

1. Business process automation require many systems to be integrated and it is increasingly complex and time consuming as the number of the systems increase.
2. Significant number of IT projects fail or delayed due to system integration issues.
3. In depth knowledge and expertise in domain, system, technology, and integration development are required to implement business process automation.
4. Effort and money spent for system integration and automation needs to be reduced.
5. There is a significant impact if one or few new systems need to be introduced or improved in the later stages or on-the-fly after commissioning in production.

The complexity needs to be reduced, integration need to be better managed, expertise, effort and money required for system integration and business automation shall be lowered. Finally, the lack of ability to adapt for changes needs to be resolved when new systems to be added or existing systems are improved.

1.3 Purpose of Research

The purpose of the research is to provide valuable insights and guidance for the system integration and automation industry to enable comprehensive understanding of the contemporary challenges in the system integration, analyze the latest technologies to combat these challenges, identify the requisite skills and environment required for successfully applying these technologies, and elucidate the associated benefits.

Ultimately, the research endeavors to offer practical recommendations and strategic directions for the industry, facilitating informed decision-making and fostering advancements in system integration and automation practices.

The need for Intelligent Process Automation or Hyper-automation for System Integration and Business Automation is evident from the literature reviews. The existing research are identifying that the AI techniques are the way forward. AI Augmented Software Engineering (AIASE) is a new and novel technique to apply AI for Software Engineering. However, there is a very little to no research paper focusing on analyzing and applying AIASE especially in the context of Hyper-automation for System Integration and Business Automation. Such research can change the paradigm of System Integration market and future development of System Integration Software and that is the motivation for this research.

1.4 Significance of the Study

According to Verified Market Research, System integration software (Verified Market Research, 2020a) and consultancy industries (Verified Market Research, 2020b) are rapidly growing markets. This research is focusing on analyzing and applying AI techniques especially in the context of Hyper-automation for System Integration and Business Automation. The result of this research will be immensely useful to system integration consultancy businesses and integration software providers in developing better consultancy practice, products, tools, and an approach for using AI augmented software engineering for system integration and business automation.

1.5 Research Questions

This research will answer the following questions:

1. What are the challenges of system integration in business process automation, the need for intelligent automation and the industry perceptions?
2. What skillset and environment are required to implement AI techniques like AIASE to achieve Augmented Intelligent Process Automation (AIPA)?
3. What benefits and challenges AIASE brings to system integration and business automation and who will be benefited?
4. How to approach an implementation of AIASE for intelligent system integration and business automation?

1.6 Research Hypotheses and Model

The following are the hypotheses for this research.

- H1: Complexity of system integration and business automation is based on the systems involved and requires efficient and intelligent system integration.
- H2: Existing and new AI techniques can be applied for intelligent system integration and business automation.
- H3: New AI techniques like AIASE bring benefits and challenges to business automation. Despite the challenges, business, integration developers, system integration software and consultancy industry are beneficiaries.

These hypotheses need to be validated in this research study.

Also, an approach will be proposed to implement intelligent system integration and business automation with theory, mechanisms, frameworks, and model for using the new and novel AI techniques like AIASE.

1.8 Research Objectives

The objective of this research is to explore the concepts, processes, techniques, model, infrastructure, tools. skillsets required to use AIASE and establish an architecture mechanism and model to achieve AIPA for business process automation with intelligent software system integration.

This research has the following goals.

- To provide a comprehensive review of business automation and system integration and spotlight the needs for intelligent automation with AI techniques.
- To identify the skillset and environment required to implement AIASE to achieve AIPA.
- To assess the benefits and challenges AIASE brings to business automation and system integration and to analyze the beneficiaries in the integration software and consultancy market.
- To develop an approach and framework for implementation of AIASE for intelligent system integration and business automation.

1.9 Research Benefits

Achieving the goals of this research will bring enhanced knowledge and understanding along with an approach mechanism and model for using AI techniques like AIASE in system integration and business automation. This will be valuable to system integration and automation consultancy industry to establish better practice of consultancy and integration software providers to build better environment, infrastructure, and tools for Augmented Intelligent Process Automation (AIPA) in any business.

CHAPTER II

REVIEW OF LITERATURE

2.1 Overview

Businesses need Business Process Management (BPM) to integrate and coordinate business processes with people and software systems. The need for new and upgrade of software applications, products, and tools, collectively referred as systems in this research, are growing in a rapid pace. Efficient integration of systems with Business Process Management System (BPMS) is key to realize the business processes. Various techniques of automation and intelligence have improved the system integration in business process management.

Research in this area is leaning towards Artificial Intelligence (AI) techniques to gain advantages of AI in system integration and business automation. Artificial Intelligence Augmented Software Engineering (AIASE) is a novel and latest technique in AI which can achieve Artificial Intelligence Augmented Intelligent Automation (AIPA) to boost intelligence in system integration and business automation.

This research aims to identify concepts, processes, techniques, model, infrastructure, tools required to use AIASE and establish an architecture mechanism and model to achieve AIPA for business process automation with intelligent software system integration.

2.2 Literature Review Objectives

The key perspective and objectives of the literature review in this research is to:

- Review of literature on Business Process, BPM and BPMS and understand the role of these in business success.

- Review of literature on integration of products, applications, tools, systems traditionally and in the cloud and understand system integration.
- Analysis of the automation techniques like RPA, CPA and IPA and their usage in business automation and system integration.
- Identification the latest techniques in system integration and business automation, and research work required in these areas.
- Review of literature on the AI Augmented Software Engineering (AIASE), research gaps, future research direction.
- Review of literature related to Augmented Intelligent Process Automation (AIPA) and its role in System Integration and Business Automation

2.3 Literature Review Procedure

The following is the high-level procedure done for literature review in this research.

- Identify the journals related to systems integration, artificial intelligence, and business automation.
- Search for the related areas and keywords: Business Process, Business Process Management, System Integration, Workflow, Robotic, Cognitive, Intelligent, AI Augmented Automation, AI Augmented Software Engineering in Google Scholar, Web of Science, Research Gate, Mendeley Discovery and Science Direct
- Identify relevant research, research approach, conclusions, future work, research gaps of using AI techniques in system integration and business automation.

- Synthesis the findings of agreements, disagreements, conclusions, and future direction of Augmented Intelligent Process Automation (AIPA).

Key journals in the field of System Integration, Artificial Intelligence and Business Automation are scanned for articles, research papers, studies related to this research.

- Human Intelligent Systems Integration, Springer (https://www.springer.com/journal/42454/)
- Progress in Artificial Intelligence, Springer (https://www.springer.com/journal/13748)
- SICE Journal of Control, Measurement, and System Integration, Taylor & Francis Online (https://www.tandfonline.com/journals/tmsi20)
- Journal of Artificial Intelligence Research, (http://www.jair.org/), AI Access Foundation,
- International Journal of Business Strategy and Automation (IJBSA), IGI Global
- Artificial Intelligence, ScienceDirect by Elsevier (https://www.sciencedirect.com/journal/artificial-intelligence)
- Applied Artificial Intelligence by Taylor & Francis (https://www.tandfonline.com/journals/uaai20)
- IEEE Intelligent Systems (https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=9670)

2.4 Business, Business Process and Software

Researchers have contributed immensely to comprehend the basis of business, the importance of processes in business, and how processes are managed to achieve business goals, along with the significance of software and artificial intelligence in every business.

2.2.1 Business and the role of business process

Every organization has a theory of business. The assumptions about environment (markets, customers, and competitors), mission, and core competencies (technology, strengths, and weaknesses) form the theory of business. The assumptions must fit reality, fit one another, understood, and tested constantly (Drucker, 1994)

Business Process is a set of activities to reach a desired result. Business Process Model provides a common understanding and analysis of a business process. (Aguilar-Savén, 2004, p. 129).

The theory of business of an organization has a significant influence on its business processes. Activities of a business process to achieve the desired result are aligned with the assumptions about the business. Documenting business processes into Business Process Model helps to communicate consistently throughout the organization.

2.4.2 Business process management

Customers care only about results and that are by the outcome of business processes. A business process needs good design and execution to meet the performance requirements. Business process needs continuous monitoring and improvement to meet and improve performance metrics. Business process management is to establish an integrated system for managing end-to-end business processes and process performance (Hammer, 2015, p. 6).

Businesses perform better when their end-to-end business processes across people, information and technologies are well managed. Only the businesses with integrated and coordinated business processes can establish products or services fit for the consumer needs (Reijers, 2021).

Business Process Management System (BPMS) is expected to define and model the business processes as well as establish the semantics of the organization and its several facets in multidimensional model. BPMS is a tool for managing business processes and not necessarily the execution of processes (Hammer, 2015, p. 14).

Thus, Business Process Management (BPM) and Business Process Management System (BPMS) are critical to the success of any business as these are the means of realizing business processes to achieve results for customers.

2.4.3 Businesses run on software.

Major businesses and industries are run by software and entrepreneurial technology companies are disrupting established industries (Andreessen, 2011). Software ate the world and industries like entertainment, photography, marketing, telecom, recruitment, automobiles, retail, oil & gas, agriculture, financial service, health care, education, and even national defense.

Software did conquer the world and it is now the turn of Artificial Intelligence (AI) to take over software. Year 2009 to 2019 is the acceleration wave of software starting to rule the world and year 2019 to 2030 is the hyper-acceleration wave of AI starting to control the world (Van Aekum et al., 2019). CEOs and executives need to be proactive with AI adaption through organic and inorganic means.

Businesses need software and AI irrespective of the industry or function to excel in the present and survive in the future. There is a clear agreement on the direction that

AI wave of hyper-acceleration and potential of its current impact or future impact on every business.

2.5 Integration and Automation

The topic of system integration has been extensively researched, and the prediction for the system integration consultancy and integration software industry is promising. Research in Workflow management and the lately popular Robotic Process Automation to automate processes illustrate the way automation is moving in the system integration industry.

2.5.1 System integration

Integration originates from the fundamental principles of engineering, human psychology, and human existence. System Integration is a system engineering process to connect and unify many solutions, products, processes into a whole system that makes hardware, software, and human interaction to achieve the system purpose or the customer's need (Grady, 1994). Concepts of decomposition, integration spaces, and forming teams for development and integration of products and processes aid to analyze the system integration landscape.

The expansion of systems in terms of technology, magnitude, and intricacy in various industries and domains has led to an increase in challenges. In response, the cloud has emerged as a new method for running and utilizing software systems for businesses, offering Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) options. However, the adoption of cloud computing presents new challenges for integrating cloud, system, and data, as systems located on the cloud and

on-premises need to work together. This integration presents a complex task that must be addressed to fully utilize the benefits of cloud computing (Hai and Sakoda, 2009).

A comprehensive research study (Ilyas and Khan, 2017), analyses the challenges faced by Global Software Development (GSD) vendors in integrating software from multiple teams located in different geographical locations. They identified challenges such as communication gaps, cultural differences, and technical disparities that hindered the effective integration of software components. The study also discussed the importance of ensuring compatibility between software components, as well as the use of standard protocols and interfaces. The paper concluded that successful software integration in GSD requires a structured approach that addresses the various challenges and promotes effective communication and collaboration among team members.

The system integration challenges affect the businesses to effectively perform business process management required for business success. It is imperative to address system integration challenges on an ongoing basis adapting to growing number of systems. The literature in the field of systems integration is wide and there is a consensus system integration is critically challenging.

2.5.2 Integration market

In the industry, there are two markets that are linked with integration and closely related with each other: System Integration Market and Integration Software Market. According to Verified Market Research (2020), the system integration software market size (2020) was USD 301.4 billion, and it is expected to grow at a CAGR of 11.84% from 2021 to 2028 to reach USD 735.85 billion (Verified Market Research, 2020a). And the system integration market size was United States Dollar (USD) 320.1 billion in 2020 and it is expected to grow at a Compounded Annual Growth Rate (CAGR) of 10.4% from 2021 to 2028 to reach USD 617.5 billion (Verified Market Research, 2020b). As the

research study progressed, further forecasts observed from Allied Market Research (2022) stating the system integration market generated USD 351.8 billion in 2021 and is projected to reach USD 1,838.6 billion by 2031, growing at a CAGR of 18.1% (Allied Market Research, 2022). Furthermore, according to IndustryARC (2022), system integration software market surpassed USD 335.5 billion in 2022 and estimated to rise to USD 841.48 billion by 2030, growing at an estimated CAGR of 11.5% (IndustryARC, 2022). These upward trends confirm the growth potential of markets around system integration.

Global System Integration Market encompasses the process that brings various software and services together to improve the productivity and quality of operations within the organization. This market is bifurcated further into infrastructure integration, application integration and consulting. The key players in this market include Capgemini, Fujitsu Limited, Oracle Corp, Infosys, HCL, Aichi, Altec, Time Benelux, Dxc Technology, and IBM Corp.

Integration Software Market encompasses the software that integrates several systems and brings large heterogenous data into meaningful value and action for the business by merging, summarizing, visualization and analysis. The key players in this market include IBM Corp., Microsoft Corporation, SAP SE, Oracle Corporation, SAS Institute Inc., Cisco Systems, Inc., Dell Boomi, Talend Inc., Hitachi Vantara Corporation, Informatica LLC.

Breakthrough research in integration and automation using modern techniques and technologies will greatly impact the system integration market and integration software market in a positive way.

2.5.3 Workflow management and automation

Workflow is a collection of software and human tasks organized with an order of execution, conditions for execution, synchronization, and information flow. Workflow management encompasses modelling processes as workflow model with specification, process reengineering and workflow implementation and automation (Georgakopoulos et al., 1995, p. 119).

Workflow Management System (WfMS) are information systems, that define work items of the activities in the workflow, coordinate activities, control the transitions between activities, maintain the workflow instance for each process according to rules, and works as a middleware to integrate systems. WfMS face technical, managerial, economic, market and social issues that needs to be addressed (Stohr and Zhao, 2001).

Automation through WfMS is the starting point of realizing business process automation with further exciting techniques of automation.

2.5.4 Robotic process automation

Robotic Process Automation (RPA) is one of the automation solutions for business processes management. RPA centers on the usage of software robots to automate processes by choreographing technologies and controls within the applications of Information Technology (IT) ecosystem (Hofmann et al., 2020, p. 100).

RPA employs an "outside-in" strategy, which leaves the current information systems undisturbed. Humans are replaced with agents instead of revamping the system. RPA strives to be resilient to changes in the underlying information systems. RPA should adjust exactly like people do when there are any minor changes in the information systems (van der Aalst et al., 2018).

While RPA has been a vehicle for operational efficiency, it comes with a long list of challenges that are important to be addressed (Syed et al., 2020, p. 10). One of the key

limitations is that RPA is only appropriate for processes that are rule-based. RPA is carried out by a robot without cognitive abilities and dependent on rules to complete tasks properly. As humans and robots must be coordinated to complete the jobs consecutively and error-free, processes that include many exceptions must be delegated to humans, which increases process complexity (Santos et al., 2020, p. 411).

RPA enables system integration simply from application user interface to do repetitive tasks across systems. RPA is just one of the several automation techniques available in the industry. With the current challenges and limitations in RPA, and the emergence of Artificial Intelligence (AI), the automations are leaning towards intelligence.

2.6 Intelligent Automation

The field of Intelligent Automation is the next level of automation, whereas research efforts are focused on topics ranging from Cognitive Process Automation to Intelligent Process Automation, and then on to AI Augmented Intelligent Automation and Autonomous Agents.

2.6.1 Cognitive process automation

RPA utilizes classical AI that are rule based to automate tasks flawlessly in absolute certainty. But knowledge work requires experience-based judgement to handle ambiguity and uncertainty and it requires learning-based constructed AI to automate. Cognitive Process Automation (CPA) brings-in the capability of performing tasks that were sole domain of knowledge workers which require judgement, decision making and dealing with uncertainty resulting in unpredicted outcomes (Richardson, 2020, p. 186).

2.6.2 Intelligent process automation

Intelligent Process Automation (IPA) enables more complicated automation than RPA by minimizing human-dependent training and automating increasingly complex decision-making activities. The scope of IPA is greater than RPA in that it coordinates between people and various bots and spans the whole process automation lifecycle. However, IPA still evolves to address the challenges and brings in a plenty of research opportunities (Chakraborti et al., 2020, p. 7).

2.6.3 AI Augmented intelligent automation.

Intelligent Automation or Hyper-automation is a new age digital transformation that takes advantage of RPA, Process Mining, Digital Twins of Organization (DTO), Optical Character Recognition (OCR), Natural Language Process (NLP), Machine Learning (ML). The future of hyper-automation will be heavily relying on the many facets of AI for process mining and developing unified business automation initiates to reduce costs and improve productivity (Haleem et al., 2021, p. 3).

2.6.4 Autonomous agents

An autonomous agent is a system in an environment to observe that environment, take action to achieve its own goals on a continuous basis, and to impact on what it discovers in the future (Franklin and Graesser, 2015, p. 25).

Autonomous agents face challenges in three major categories with several potential research opportunities: Affective and cognitive implications, design issues and unintended consequences. Autonomous agents shall be researched for ethical use, trustworthiness and management of decision making, accountability, auditability, and responsibility (Seeber et al., 2020, p. 10)

A systematic literature review on intelligent automation reveals research directions for future on holistic automation strategy that demands automation to be self-

adaptable, user-centric, cognitive-based, data-driven, real-time/ near-time decisive, interactive, and collaborative with human, and understand human emotions (Ng et al., 2021)

Intelligent automation ranges from enabling cognitive abilities on RPA to building autonomous agents. Intelligent Automation has a strong focus on the application of AI to enhance intelligence, where machine and human intelligence may coexist in harmony and complement each other.

There is a difference among researchers on the scope of various techniques. Some refer RPA a non-intelligent automation technique while other include intelligent automation part of RPA. However, there is an explicit direction established in the literature that artificial intelligence is the path forward in all types of automation.

2.6 AI Augmented Software Engineering

Continuous and widespread research on Artificial Intelligence introduces new techniques such as AI Augmented Software Engineering, which is predicted to have great potential in software engineering, particularly when combined with widely researched low-code platforms but requires more research to solidify its applicability.

2.6.1 What is AI augmented software engineering?

Ever since the term “Artificial Intelligence” was coined and proposed (McCarthy et al., 1955), there have been several research in the history of artificial intelligence, continuously evolving this (Haenlein and Kaplan, 2019).

Artificial Intelligence Augmented Software Engineering (AIASE) is a technique to boost software engineering with artificial intelligence and related techniques and technologies. AIASE is one of the quickly developing technologies in the field of

artificial intelligence, will reach a productivity plateau in the next 5 to 10 years, predicts Gartner (2021). This indicates that, despite research efforts in artificial intelligence, software engineering with AI enhancements is still in its infancy and will take 5 to 10 years to achieve widespread use.

AI Augmented Software Engineering/ Software Development is a new and novel approach to apply artificial intelligence to Software Engineering. A systematic literature review paper of Perkusich et al., (2020) regarding Intelligent Software Engineering for Agile Software Development identifies that many areas in this topic are still in its infancy and there is a plenty of opportunity for research.

2.6.2 Why AIASE is revolutionary?

Gartner's impact radar for 2022 identified AIASE as productivity resolution quadrant due to its potential to productivity in software engineering life cycle. By automating repetitive software engineering operations, AIASE produces solutions that have a demonstrable value to customers and are quicker, cheaper, and of higher quality.

The freshly rebranded Low-Code Platform, which has been around for a while, combines many reusable classical development components to increase productivity by reducing everyday software development work (Bock and Frank, 2021).

Applying AIASE technique with Low-Code Platforms is expected to bring in productivity revolution in software industry due to the productivity elements in both. That enables low-cost, high-quality, quick solution to customer unlocking new potentials of software development and software engineering. With this, AIASE can democratize software development and technology to everyone, especially non-tech savvy entrepreneur and businesses.

With Gartner (2023) continue to highlight AIASE in the emerging technologies hype cycle and positioning Generative AI and AIASE on 'Peak of Inflated Expectation'

(“Gartner Places Generative AI on the Peak of Inflated Expectations on the 2023 Hype Cycle for Emerging Technologies,” n.d.) and emphasizing AIASE on specific hype cycle of Generative AI, there is a huge interest on researching in AIASE. However, there is very limited literature available currently in AIASE and there is none in specifically applying AIASE to achieve AIPA in System Integration and Business Automation.

2.7 AI Augmented System Integration and Automation

The field of system integration has produced literature on self-adaptation and self-organization (SASO) and self-improving system integration (SISSY) because of research work on automation of system integration. On the other hand, there is a great deal of Generative AI (GenAI) research going on. However, there is no specific research on using AI Augmented Software Engineering for System Integration and Automation that can combine SASO, SISSY and GenAI.

2.7.1 Self-adaptation and self-organization

As a result of the rising complexity and interconnection of component systems, self-adaptation, and self-organization (SASO) have been integrated into technological systems. The fundamental notion is to respond to environmental dynamics and shocks by reconfiguring productive behavior and/or relationships with other systems.(Goller and Tomforde, 2020).

2.7.2 Self-improving system integration

"Self-integration" is a continuous, autonomous process that connects a variety of heterogeneous computing systems, hardware, and software applications to achieve system goals. Self-integrating systems are self-improving by continuous learning, adjusting the integration towards optimization to attain objectives in a stable state. Self-

improving system integration (SISSY) aims to conquer the dynamic system requirements, developing architectures, and highly dynamic open ecosystems with autonomous subsystems that make integration decisions on the fly at the run-time (Bellman et al., 2021).

2.7.3 Generative AI

Generative AI (GenAI) models and applications have been growing multi-fold since the publish of Generative Adversarial Network (GAN) by Google Brain's Goodfellow et al, 2014. Recent work of using GenAI for Code, Co-Pilot from GitHub, is a model trained from massive codebase from GitHub to enable autocompleting and auto-generating code (Sun et al., 2022).

SASO and SISSY are modern techniques on system integration to survive dynamic environment and growing need of systems. The literature around this leads to researchers trying to make the systems self-adapting, self-organizing in establishing relationship with other systems as well as self-improving to attain autonomous system integration. Tremendous growth in research on GenAI with a new start to autocomplete and auto-generate source code further increases research on GenAI. Combining SASO, SISSY and GenAI as AIASE indicates interesting and useful research for system integration market which is currently a gap in the existing research.

2.8 Findings from this Literature Review

The key findings of this literature review are:

- BPM and BPMS are foundations for running business processes by integrating systems and people.
- Systems are rapidly growing, and systems integration is a major challenge.

- RPA and IPA are the key techniques to combat integration challenges.
- There is consensus that AI and ML is the future of system integration and business automation but there are research gaps on how AI and ML will address system integration challenges.
- Intelligent Automation and AI Augmented Intelligent Automation is the future of integration.
- The need for Intelligent Process Automation or Hyper-automation for System Integration and Business Automation is evident from these literature reviews.
- AI Augmented Software Engineering (AIASE) is emerging and research on how it can revolutionize integration and business automation.
- AIASE is a novel and there is a need for intensive and widespread research to enable it for integration and business automation.
- AIASE on a low-code platform with SISSY and GenAI are candidates to drastic positive shift in the software development, system integration and business automation.

2.9 Contribution to the Literature

This research specifically contributes to the literature in the following ways:

- Systematically identify and synthesize the needs, concepts, and processes in the field of system integration and business automation
- Identify and discuss the techniques and models like AIASE, SISSY, GenAI for Augmented Intelligent Process Automation
- Describe the environment, infrastructure, and tools to use AIASE to achieve intelligence in system integration and business automation.

- Analyze the benefits and challenges of AIASE in system integration and business automation.
- Express the beneficiaries of AIASE in the industry of system integration and automation.
- Propose a model and implementation candidate to build an intelligent platform for system integration and business automation by applying AIASE.
- Highlight the future research areas and indicate directions for AI augmented intelligence in system integration and business automation.

With the above contribution, this research will potentially become a reference point for modern researchers researching the application of Artificial Intelligence techniques in the context of system integration and business automation.

2.10 Summary

This literature review concludes that Artificial Intelligence (AI) techniques are the clear direction for combating the growing system integration challenges and business automation needs. AI Augmented Software Engineering (AIASE) is promising, novel technique to achieve Augmented Intelligent Process Automation (AIPA) and it needs intensive and widespread research. However, there is a very little to no research paper focusing on analyzing and applying AIASE especially in the context of Intelligent Automation or Hyper-automation for System Integration and Business Automation. This research will greatly influence and can change paradigm of System Integration market and future development of System Integration Software, thereby benefiting System Integrators, and Business Owners.

CHAPTER III

METHODOLOGY

3.1 Overview of the Research Problem

The research problem under investigation revolves around the challenges faced by businesses in the integration and automation of software systems, particularly in the context of business process management. As organizations increasingly rely on diverse software applications and tools to streamline their operations, the need for seamless integration and coordination of these systems has become critical.

The integration of multiple systems presents complexities and time-consuming processes that hinder efficient business process automation. These challenges often result in delays and failures in IT projects, impacting overall business performance. Additionally, successful implementation of business process automation requires deep domain knowledge, expertise in systems, technologies, and integration development.

Another key aspect of the research problem is the optimization of efforts and resources invested in system integration and automation. Businesses seek to reduce costs and enhance operational efficiency by streamlining the integration of various software systems. Furthermore, the adaptability and scalability of business processes are vital, as organizations must be capable of incorporating new systems or improving existing ones during or after production.

By addressing these challenges, businesses can achieve more efficient system integration and automation, leading to streamlined operations, reduced costs, and improved overall performance. The research aims to investigate these issues, propose effective solutions, and provide insights that can guide organizations in enhancing their system integration and business automation initiatives.

3.2 Research Purpose and Questions

This research aims to provide valuable insights and guidance for the system integration and automation industry by comprehensively understanding the contemporary challenges, analyzing the latest technologies, identifying necessary skills and environments, and elucidating associated benefits. The research seeks to offer practical recommendations and strategic directions, fostering advancements in system integration and automation practices. Motivated by the evident need for Intelligent Process Automation or Hyper-automation, this research focuses on the transformative potential of AI Augmented Software Engineering (AIASE) within the system integration and automation market. By bridging the gap in existing research, this study aims to shape the future development of system integration and automation software and contribute to improved practices and outcomes in the field.

The research questions this research aims to answer are:

1. What are the challenges of system integration in business process automation, the need for intelligent automation and the industry perceptions?
2. What skillset and environment are required to implement AI techniques like AIASE to achieve Augmented Intelligent Process Automation (AIPA)?
3. What benefits and challenges AIASE brings to system integration and business automation and who will be benefited?
4. How to approach an implementation of AIASE for intelligent system integration and business automation?

3.2 Operationalization of Theoretical Constructs

This research employs a structured approach to identify the theoretical constructs related the research questions, hypothesis and goals that delve with challenges and needs

of system integration in business, skills, and environments to apply AIASE for integration, assess the benefits and challenges thereof and propose an implementation approach. This research then presents the measurements of these constructs along with the methodology and methods to arrive at the measurements. The constructs and measurements are summarized below.

- 'System Integration Challenges' can be measured with 'Complexity Index of the System', 'Complexity Index of the Process' and finally 'Complexity Index of the Business'.
- 'Need for Intelligent Automation' can be measured with 'Perceived Need Scale'.
- 'Skillset' is a collation of all skills required and can be measured with 'Skill Level'.
- 'Environment' can be measured with 'Environment Readiness'.
- 'Impact of AIASE on Integration' can be measured with 'Benefits', 'Beneficiary Stakeholders' and 'Perceived Challenges'
- 'Proposed Implementation Model' can be measured with the proposed 'Functionality, Extensibility, Performance, Scalability'.

This systematic operationalization explores AI augmented intelligent system integration and business automation with the interconnection of concepts, theoretical constructs, and corresponding measurements to fulfill the goals of the research.

3.4 Research Design

This research study is designed to apply a mixed-methods approach, incorporating both deductive and inductive reasoning, to explore the application of AI Augmented

Software Engineering and related AI techniques for intelligent system integration and business automation.

The deductive approach involves the study of existing research and theories around the theme of system integration & business automation, and the development & validation of hypotheses through descriptive analysis. Secondary data on the software systems and integration solutions used to run businesses are collected and analyzed, along with data collected from sample businesses. Primary data are collected from senior businesspeople and business practitioners on system integration challenges, automation needs and current trends. The aim is to answer research questions and verify hypotheses.

The inductive approach will involve observation of the market, integration software, and the needs for integration and automation in modern businesses. The aim is to propose an approach and model for implementing AI Augmented Software Engineering and related AI techniques for system integration and business automation. This will be accomplished through exploratory analysis, with the analysis of models on popular code repositories used as a basis for modelling the proposed approach.

3.5 Population

This research is revolving around the software systems, systems integration, intelligence in integration and business automation. The players are software systems, the solutions that integrate and automate these systems, the solution providers who provides these solutions, and the businesses that uses these systems and solutions.

There are three population targeted for this research.

1. Software systems data – Secondary data – Quantitative Research
2. Solution providers – Secondary data – Quantitative Research
3. Senior Businesspeople – Primary data – Quantitative Research

The first population is the software systems: products, applications, platforms, tools, etc., that are used in the business and the integration software market. This study collects secondary data from authentic Internet sources, analyses and reveals insights in the context of system integration and business automation. This is conducted as quantitative research to collect quantifiable data of close-ended attributes from the sources. Along with this, a system complexity study is conducted to assess the complexity of the business in terms of the involved systems.

The second major population is the solution providers. They are the integration products/ solutions and the organizations who develop products and solutions for integration and automation. This includes players in data integration, application integration, system integration, iSaaS, iPaaS, aPaaS, LCAP, NCAP, RPA, BPA, DPA areas. Quantitative research is conducted to collect quantifiable data of close-ended attributes from Internet sources. These are further analyzed and synthesized to form a deep understanding of the solution providers.

The third major population is the businesses that need system integration and business automation. The theoretical population for this research is all businesses that run using software and needs integration and automation to achieve business goals. Businesses across all industry and worldwide with these criteria are in the population. Within these businesses, a sample set is identified, and primary data is collected directly from the business owners, entrepreneurs, business analysts, department heads, domain specialists and architects. This is conducted as quantitative research to collect quantitative data with close-ended questions.

3.6 Sample and Participant Selection

Systems are categorized into accounting, customer relationship management, productivity, communication, collaboration, office management etc. Some categories are critical to the business and others are supplementary in nature. This research is planned to identify around 10 critical categories and around 20 supplementary categories. For each category, 50 to 75 systems are planned to be identified. This expects a range of 1,500 to 2,250 systems identified. For each system, around 20 data points is collected. This results in a sample of 30,000 to 45,000 data points are identified, data collected, analyzed, and presented with insights.

Solution provider organizations are identified based on the products, solutions, or services they are catering in to following areas: data integration, application integration, system integration, iSaaS/iPasS, aPaaS/LCAP/NCAP and RPA/BPA/DPA. The market size and their competitive positioning according to Gartner are the key for identification of an organization. Each category is expected to identify around 50 to 75 organizations resulting in a range of 300 to 450 overlapping organizations. For each organization, around 10 data points are identified. This results in a sample size of 3000 to 4500 data points regarding organizations in the integration and automation industry.

A sample of around 250 people holding senior positions are targeted from various businesses across the world, across industries, to provide data for businesses in the context of system integration and business process automation. The sample selection of businesses is done across industries, mainly, Information Technology, Consultancy, Education, Financial Services, Telecommunication, Healthcare, Manufacturing, Energy, Automobile, Food, E-commerce. The participant sample is predominantly drawn from businesses in the local region, emphasizing a strong representation from India and the APAC (Asia Pacific) region. Additionally, to ensure a comprehensive global perspective,

participants from diverse regions, including EMEA (Europe, Middle East, and Africa) and AMER (North, Central and South America), have been included, imparting a distinctly global touch to the study.

3.7 Instrumentation

Depending on the nature of the data and source, the following instruments are employed.

1. Observation of software systems data: The rapid phase of introduction of new software systems or new versions on existing systems are observed in covert non-participant mode from the market and quantitative data are recorded and analyzed.
2. Existing database of records: A huge set of existing databases from Internet sources about the software systems from various organizations and various categories are collected as quantitative secondary data.
3. Observation of solutions and providers: There is a wide range of contemporary integration and automation solutions, spreading into several sub-categories in the market. The characteristics of these solutions are collected from several Internet source as quantitative data, recorded for analysis.
4. Survey of senior businesspeople: Quantitative primary data is collected with pre-defined questionnaires by conducting survey of senior businesspeople who needs system integration and business automation.

3.8 Data Collection Procedures

3.8.1 Sources of data

A comprehensive list of software systems, applications, off-the-shelf products, organizations, solutions, solution providers etc. for on-premises and the cloud are taken from the following sources.

- Gartner Peer Insight Market Reviews ("Select a market to read reviews," n.d.)
- Capterra (Capterra, 2023)
- G2 (G2, 2023)
- GetApp (GetApp, 2023)
- Product Hunt (Product Hunt, 2023)
- The businesses that need integration and automation and senior businesspeople are identified from social media, predominantly LinkedIn, professional WhatsApp Groups, and personal networking.

3.8.2 Collection of data

To collect information about systems, solutions, and organizations, there are manual and automated techniques employed. Manual techniques include collecting data manually from authentic websites, and data sources mentioned above. Automated techniques include running scripts and programs to collect data from authentic sources using methods like web scrapping and further cleansed and curated before usage.

A quantitative survey questionnaire is prepared for collecting inputs from senior businesspeople of businesses that need systems integration and automation. This questionnaire is prepared on Google Forms and the Google Form link is sent as to targeted people via Email, WhatsApp, and LinkedIn.

3.8.3 Data management

The automated data collection scripts are developed on cloud environment and run continuously to collect several available system information data from the identified sources. The collected data is structured into a two-dimensional table format and stored on Google Sheets (spreadsheet on the cloud). The data is manually reviewed and curated to improve the quality. The data collected in the Google Sheets is periodically uploaded into a MySQL cloud database for backup and further analysis.

The collected quantitative survey responses via Google Forms are stored automatically on Google Sheets in a two-dimensional table format. Necessary validations like mandatory check, length checks, options check etc. are enforced on the Google Forms so that the collected data is consistent and high level of quality from the source itself. This spreadsheet can be monitored online for the progress. A Google Forms' add-on called Form Director is used for notifying the form response as it arrives and storing the response in a MySQL cloud database as a backup.

The collected data on the Google Sheets can be shared online for scrutiny or collaboration purposes. The data can be downloaded in Microsoft Excel or Comma Separated Values (CSV) formats either from Google Sheets or from MySQL cloud database whenever required in the future.

The collected data is cleaned using spreadsheet tools on Google Sheets and made ready for further analysis. Data is then visualized through graphs/ charts and pivot tables using in-built Google Sheets visualization as well as using Looker Studio (online visualization tool).

3.9 Data Analysis

The independent variables collected with the system information, organization information and the quantitative data collected from businesses are analyzed with the following data analysis methods.

- Descriptive statistics to describe the collected system information and businesspeople survey data with common statistical tests like mean, median, mode etc.
- Inferential statistics to arrive at inferences or predictions on the full populations using the relationship between variables.
    - Cross Tabulations techniques are used for showing relationship between variables.
    - Cluster analysis to group based on category, organization, and criticality to business to bring additional context to the collected dataset.
    - Factor analysis to narrow down large set of multiple inputs into small set of factors.
    - Regression analysis (multiple regression) to arrive at dependent variables: system complexity score and system integration complexity score.

3.10 Research Design Limitations

This research does in-depth review of relevant research literature on system integration and business automation to identify needs of intelligence and AI techniques, consensuses, gaps, and future direction. With market research, data collected from the industry of system integration consultancy businesses and software vendors along with

the data collected for systems build a strong foundation for system integration challenges and complexity and the need for AI augmentation. While a large data is collected in this regard, analyses and synthesized, it may not be a complete set of data and getting a complete set of data from ever growing software systems industry is beyond the scope of this research.

This research collects quantitative data from identified businesses to get their inputs on intelligence in system integration and business automation. This is a direct input from people who are directly impacted and need innovative ways to resolve their issues. This may have an element of positive bias due to the current hype of using AI in business, however, it may not directly impact the results as it is focused on system integration and business automation.

3.11 Conclusion

The research methodology employed in this study is designed to address four primary research questions, validate three hypotheses, and establish a novel conceptual framework for AI augmented integration and business automation. It encompasses a comprehensive approach, starting with an extensive literature review and secondary data collection. Subsequently, a quantitative survey targeting senior business professionals and industry leaders are conducted. These methods collectively provide a holistic understanding of AI augmentation in integration and automation for businesses.

This research methodology serves as a systematic and rigorous framework to contribute significantly to the integration and automation knowledge. The findings will not only answer research questions and validate hypotheses but also offer practical insights for integration and automation industry stakeholders.

CHAPTER IV

RESULTS

This research aims to provide valuable insights and guidance to the system integration and automation industry by comprehensively examining the contemporary challenges in system integration, analyzing cutting-edge technologies to address these issues, identifying the essential skills and environments required for successful implementation, and highlighting the associated benefits. The goal is to offer practical recommendations and strategic directions, facilitating informed decision-making and fostering advancements in system integration and automation practices within the industry. Moreover, the evident need for Intelligent Process Automation or Hyper-automation in System Integration and Business Automation is underscored by existing literature, with AI techniques emerging as promising solutions. Particularly, the study focuses on AI Augmented Software Engineering (AIASE), a novel technique with limited prior research in the context of System Integration and Hyper-automation. The potential transformative impact of AIASE on the System Integration market and the future development of System Integration Software serves as the primary motivation driving this research.

The research aims to find answers for the following questions.

1. RQ1 - What are the challenges of system integration in business process automation, the need for intelligent automation and the industry perceptions?
2. RQ2 - What skillset and environment are required to implement AI techniques like AIASE to achieve Augmented Intelligent Process Automation (AIPA)?
3. RQ3 - What benefits and challenges AIASE brings to system integration and business automation and who will be benefited?

4. RQ4 - How to approach an implementation of AIASE for intelligent system integration and business automation?

The collection and analysis of software systems and solution providers from the market is foundational to this research study. Various independent attributes of the software systems and solution providers are collected, analyzed, and synthesized for relations, similarities, and differences.

4.1 Foundational market research – Software Systems

The secondary data about software systems are collected predominantly from Gartner Peer Insights market review ("Explore Enterprise Software Categories | Gartner Peer Insights," n.d.) and G2 ("All Software Categories | G2," n.d.). There are 14,545 software systems identified and 28 independent attributes collected for each of the software system. That results in 407,260 attributes collected for analysis and synthesis.

4.1.1 Categorization of software systems

These software systems are classified into 601 distinct categories. These categories are further grouped into 25 category families. The below table shows number of categories and corresponding software systems within each category family.

Table 4.1
Category families of software systems

Category Families	Categories	Systems
Analytics	11	305
AR/VR Software	2	80
Artificial Intelligence	9	242
B2B Marketplaces	4	120
Collaboration & Productivity	25	646
Commerce	5	199
Content Management	33	818

Customer Service	20	551
Data Privacy	11	277
Design	14	375
Development	37	825
Digital Advertising	10	212
ERP	28	668
Governance, Risk & Compliance	16	307
Hosting Providers	6	170
HR	38	862
IoT Management Platforms	9	180
IT Infrastructure	42	1076
IT Management	48	1115
Marketing	62	1480
Office	42	1051
Sales	27	632
Security	14	437
Supply Chain & Logistics	15	309
Vertical Industry	73	1608
Grand Total	601	14545

The data on system categories and families offers several notable insights into the landscape of software systems. Firstly, it demonstrates the diversity and breadth of software solutions available, spanning across various domains and functionalities. For instance, categories such as Development, Marketing, and Office exhibit high numbers of systems, indicating the prevalence and importance of these functionalities in modern business operations. Conversely, categories like AR/VR Software and IoT Management Platforms, while having fewer systems, highlight the emergence of specialized technologies catering to niche domains such as virtual reality and Internet of Things. Additionally, the significant number of systems within categories like HR, IT Management, and Vertical Industry emphasizes the critical role of technology in addressing organizational needs across sectors, from human resources management to

industry-specific solutions. Overall, there is a rich and expansive landscape of software systems, reflecting the evolving needs and priorities of businesses.

The collected software systems data identified the organizations who developed, published, and maintaining theses software systems. The key organizations that develop software systems in more than 5 category families and more than 10 categories are listed below.

Table 4.2
Key organizations playing across categories.

Organization	**Family**	**Category**	**Systems**
Microsoft Corporation	22	200	263
Google LLC	19	154	227
Oracle Corporation	21	134	193
Adobe Inc.	19	93	170
IBM Corporation	21	137	165
SAP SE	19	97	127
Zoho Corporation	19	107	121
Salesforce.com, Inc.	17	80	101
Cisco Systems, Inc.	17	61	69
Amazon Web Services, Inc.	13	54	61
Apache Software Foundation	10	29	60
Atlassian Pty Ltd	12	44	58
Citrix Systems, Inc.	9	42	48
Intuit Inc.	8	19	46
Symantec Corporation	8	26	42
VMware, Inc.	8	29	41
Autodesk, Inc.	6	15	39
Apple Inc.	11	30	39
Freshworks Inc.	8	28	35
ServiceNow, Inc.	11	25	34
Facebook, Inc.	11	28	33

HubSpot, Inc.	7	32	32
Slack Technologies, Inc.	11	27	30
SAS Institute Inc.	10	26	29
Red Hat, Inc.	7	21	27
McAfee, LLC	5	16	27
Talend Inc.	6	20	26
Workday, Inc.	7	22	25
TIBCO Software Inc.	8	21	25
DataRobot, Inc.	5	10	23
Grand Total			2216

The data on key organizations operating across different software categories provides valuable insights into competitive landscape of the market, and dominance and strategic positioning of prominent players. Microsoft Corporation emerges as a leader, with a significant presence across various categories, particularly in Family and Category counts, indicating its wide-ranging influence and diverse product offerings. Google LLC and Oracle Corporation also command substantial presence, underscoring their competitiveness and breadth of solutions in the market. Adobe Inc. and IBM Corporation follow closely, demonstrating their significance in driving innovation and delivering solutions across multiple categories. Interestingly, while some organizations like Microsoft and Google exhibit dominance across numerous categories, others like Symantec Corporation, Red Hat Inc and Workday Inc demonstrate specialization in specific categories with relatively fewer systems.

In the realm of contemporary business automation, understanding the financial implications of software systems employed in the business processes is paramount. The license cost, representing a substantial portion of the operational budget, plays a pivotal role in decision-making.

Table 4.3
Average software cost per month

Category Family	Mean	Median	Standard Deviation
Analytics	$2,075	$999	4955.00
AR/VR Software	$407	$39	738.18
Artificial Intelligence	$1,509	$499	2249.15
B2B Marketplaces	$374	$149	1414.80
Collaboration & Productivity	$260	$15	1052.13
Commerce	$808	$69	3733.09
Content Management	$574	$39	1871.50
Customer Service	$381	$125	722.54
Data Privacy	$1,339	$350	2785.89
Design	$499	$19	3619.42
Development	$942	$200	1974.71
Digital Advertising	$4,136	$650	9829.71
ERP	$1,665	$393	3506.03
Governance, Risk & Compliance	$2,180	$1,500	3190.54
Hosting Providers	$665	$14	2417.52
HR	$637	$150	1159.61
IoT Management Platforms	$1,969	$500	3261.92
IT Infrastructure	$1,707	$350	3253.28
IT Management	$1,165	$299	2450.44
Marketing	$1,338	$149	8357.91
Office	$87	$15	281.59
Sales	$1,304	$350	3903.91
Security	$882	$39	2034.74
Supply Chain & Logistics	$2,979	$1,000	5077.84
Vertical Industry	$1,111	$150	4618.99

The analysis focuses on key statistical measures mean, median, and standard deviation to provide a nuanced understanding of the distribution of license costs per month. These metrics offer insights into the central tendency of the cost, with a wide

standard deviation showing the dispersion, revealing the costs are more spread out and difference between mean and median indicate that the cost of systems is not normally distributed but skewing towards lower average per month.

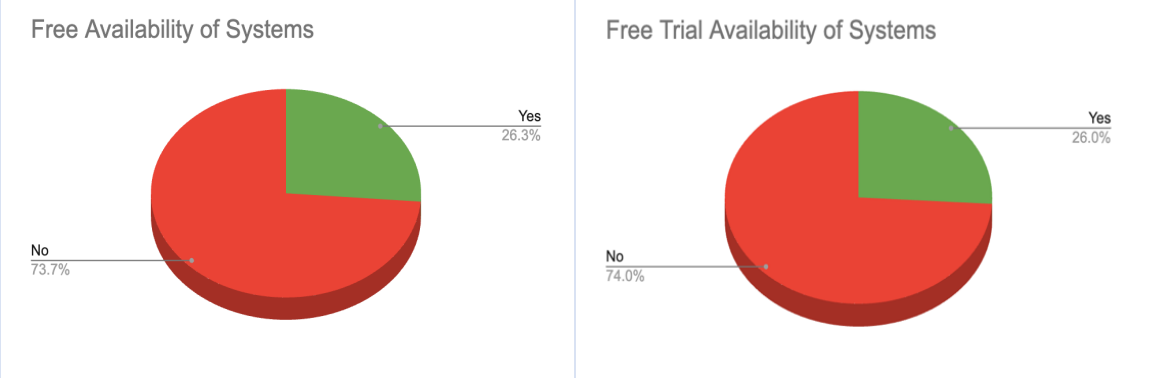

Figure 4.1
Free and free trial availability of the software systems

26.3 percentage of the software systems are providing free plans with limited features and usage restrictions and 26 percentage of software systems are providing free trial access to their featured plans. This means, 1 out of every 4 systems makes it easy to try and check the fitness of the software without any financial commitment.

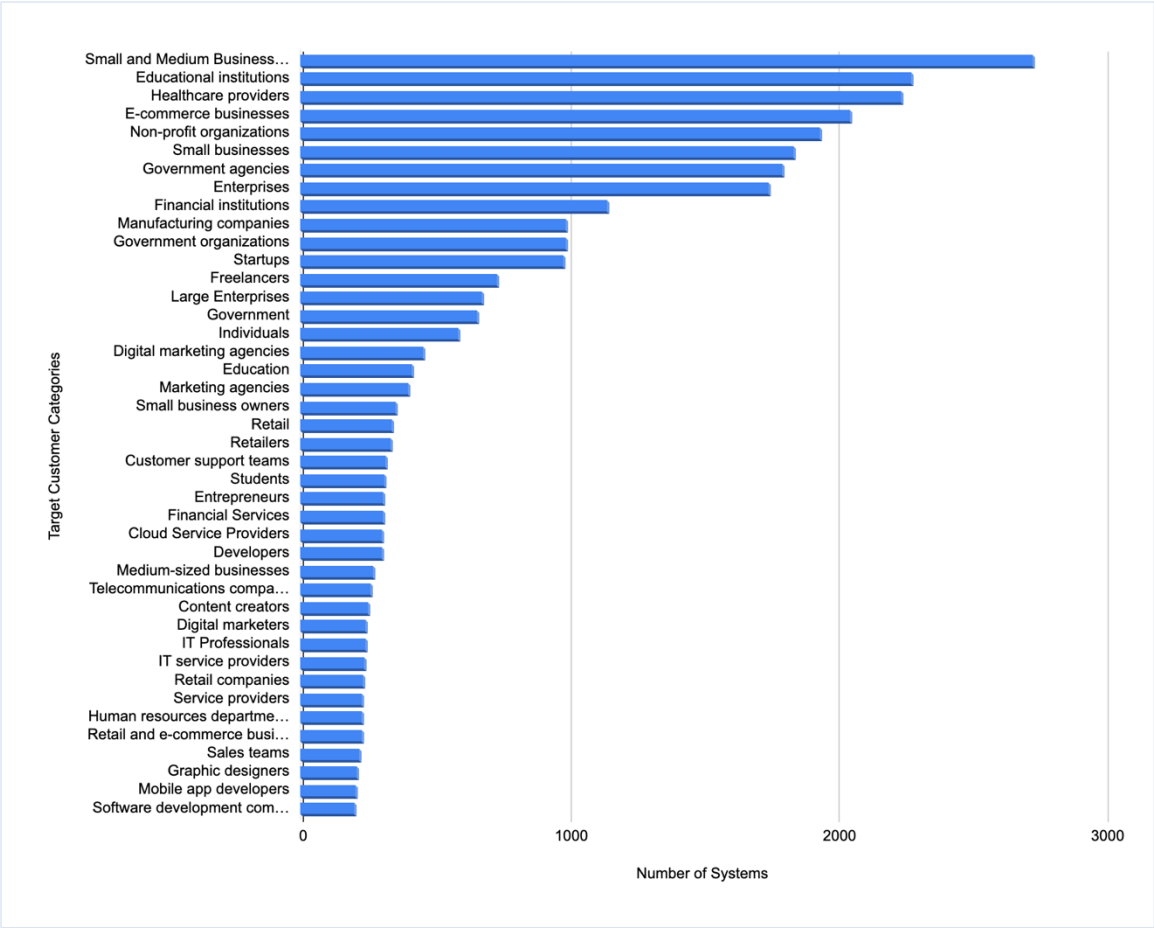

Figure 4.2
Popular target customer categories of the software systems

The top 5 customer categories targeted by each system is identified and analyzed. There are 102 customer categories targeted by more than 100 systems each. There are 43 customer categories targeted by more than 200 systems each and the figure above illustrates these top customer categories. Top 10 customer categories are targeted by more than 1000 systems each. This annotation brings out a crowded array of software systems and big pool of options for customers from every segment to evaluate and choose what to use in their business.

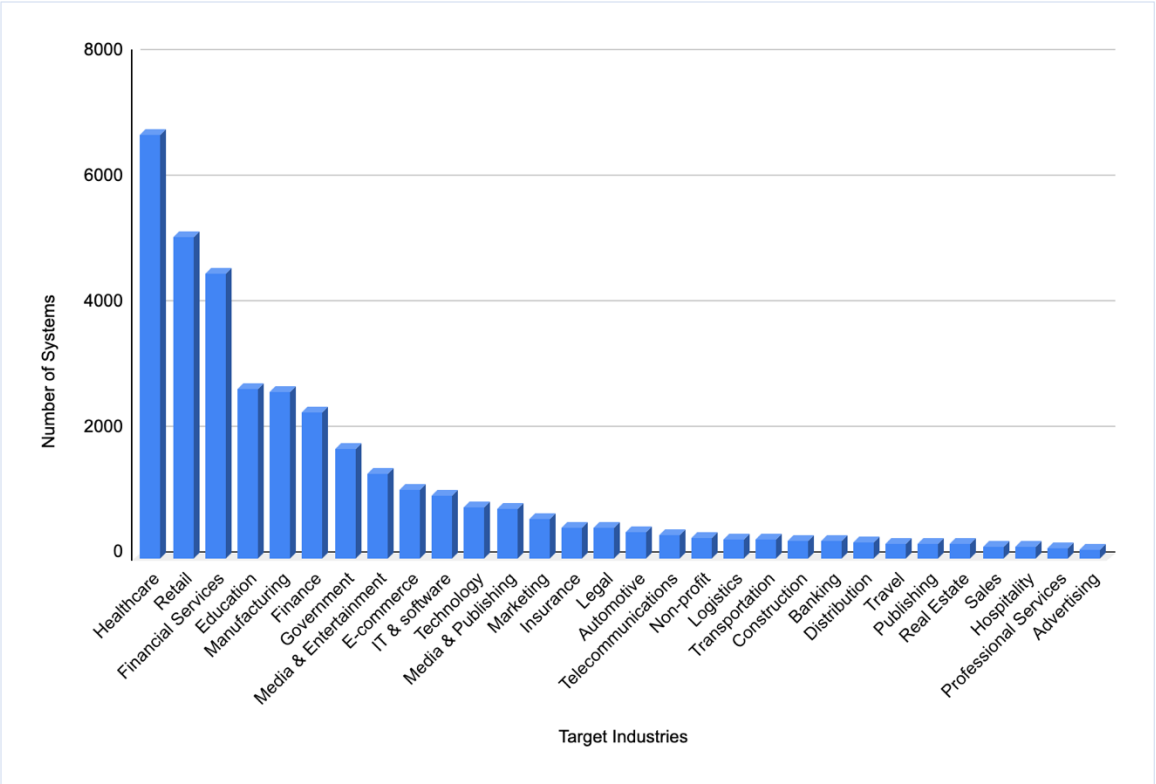

Figure 4.3
Popular target industries of the software systems

The top 5 industries targeted by each system is identified and analyzed. The figure above depicts the number of systems for the top 30 industries. The number of systems is ranging from 125 to a staggering 6742 per industries in the top list. Each industry is targeted by as an average of 1204 systems bringing in a huge availability of popular software in the industry.

4.1.2 Foundation for integration and automation

This section presents the results from cross-cut analysis of software systems with integrations aspects like inherent domain entities, provided built-in integrations, available interface types, supported integration languages,

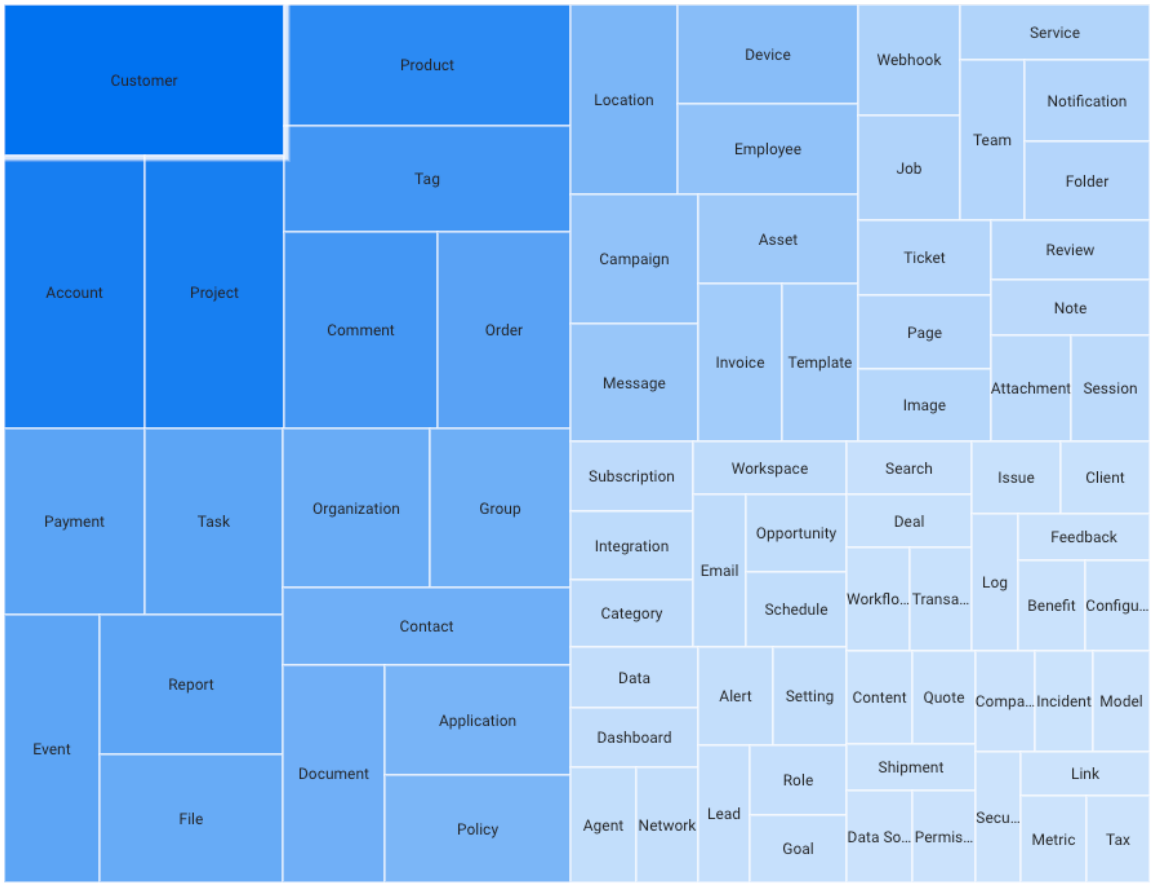

Figure 4.4
Word cloud of popular domain entities in the software systems

This picture depicts a word cloud of popular domain entities across the software systems. The most popular domain entities are Customer, Product, Account, Project. There exists a large common or shared data spread among the systems that need to be synchronized to offer a consistent perspective.

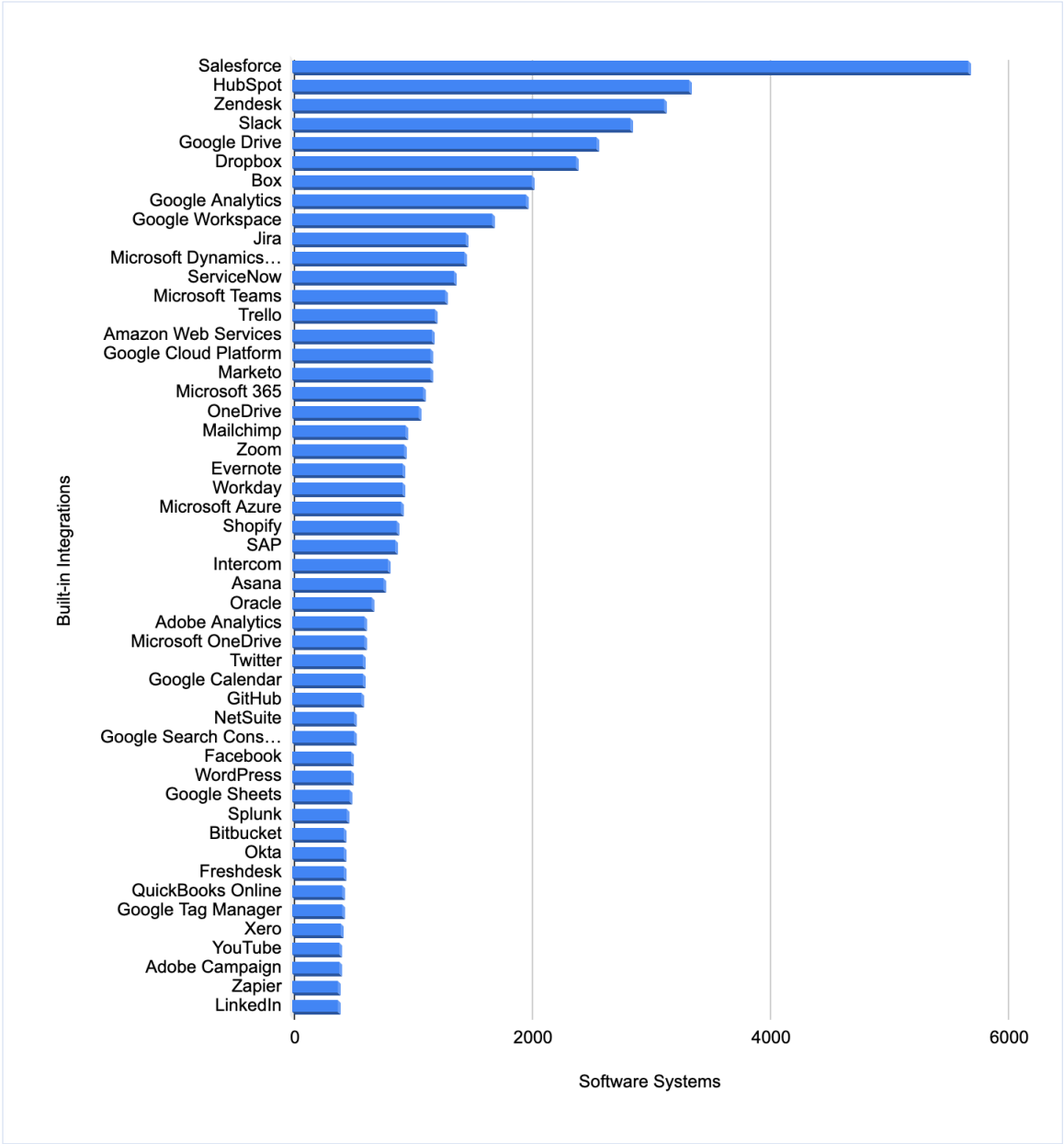

Figure 4.5
Popular built-in integrations provided in the software systems.

Examining the inherent integrations, the findings indicate a notable trend among software systems, as they actively invest in developing built-in integrations with widely used software platforms. The chart presented above illustrates the top 50 built-in integrations, encompassing categories such as CRM, customer success, productivity,

storage, ecommerce, cloud platforms, marketing, and social media platforms, which are extensively incorporated into these software systems. Specifically, over 2000 systems have established built-in integrations with prominent CRM and customer success tools like Salesforce, HubSpot, Zendesk, as well as communication and collaboration, and storage solutions such as Slack, Google Drive, and Dropbox. The presence of built-in integrations with key software systems emerges as a pivotal factor influencing the overall integration capability of a software system.

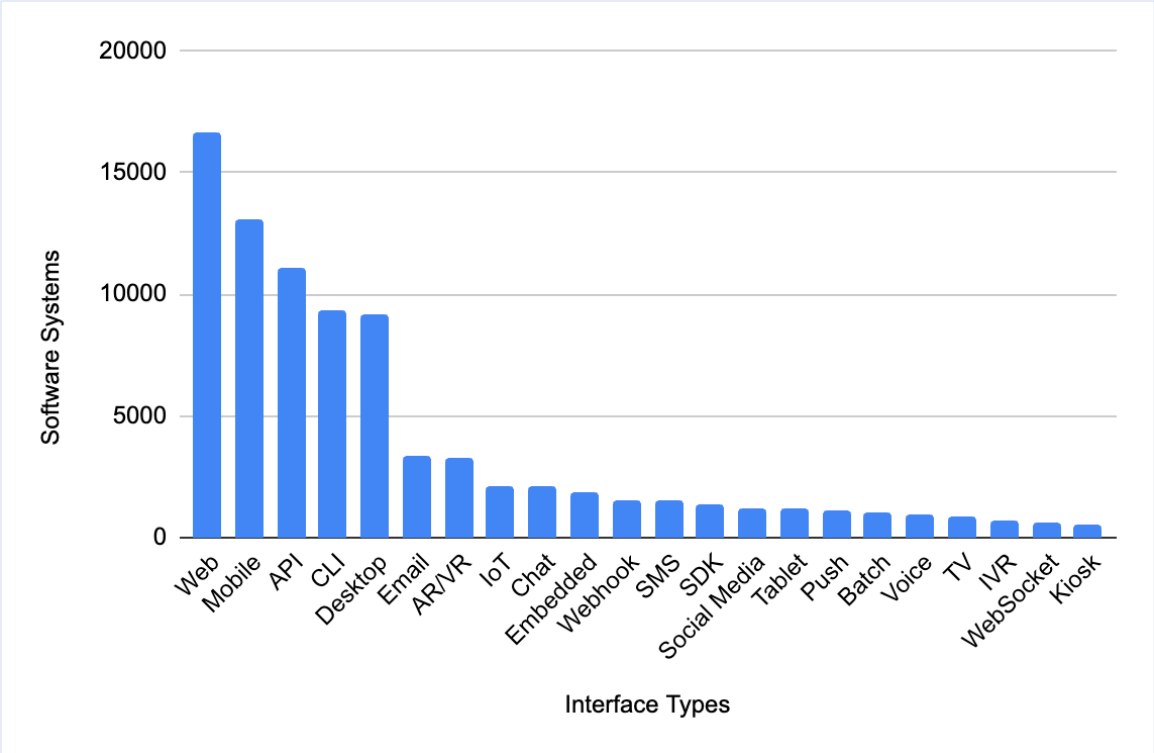

Figure 4.6
Popular interface types exposed from the software systems.

Software systems offer accessibility through various interface types, and the chart above illustrates the relative popularity of these interfaces. Topping the list is the Web interface, showcasing its widespread usage among software systems, followed closely by Mobile. Notably, API emerges as the third most popular interface type, underscoring its

pivotal role in facilitating integrations provided by software systems. Additionally, CLI and Desktop interfaces follow in popularity, contributing to the diverse ways users engage with these systems.

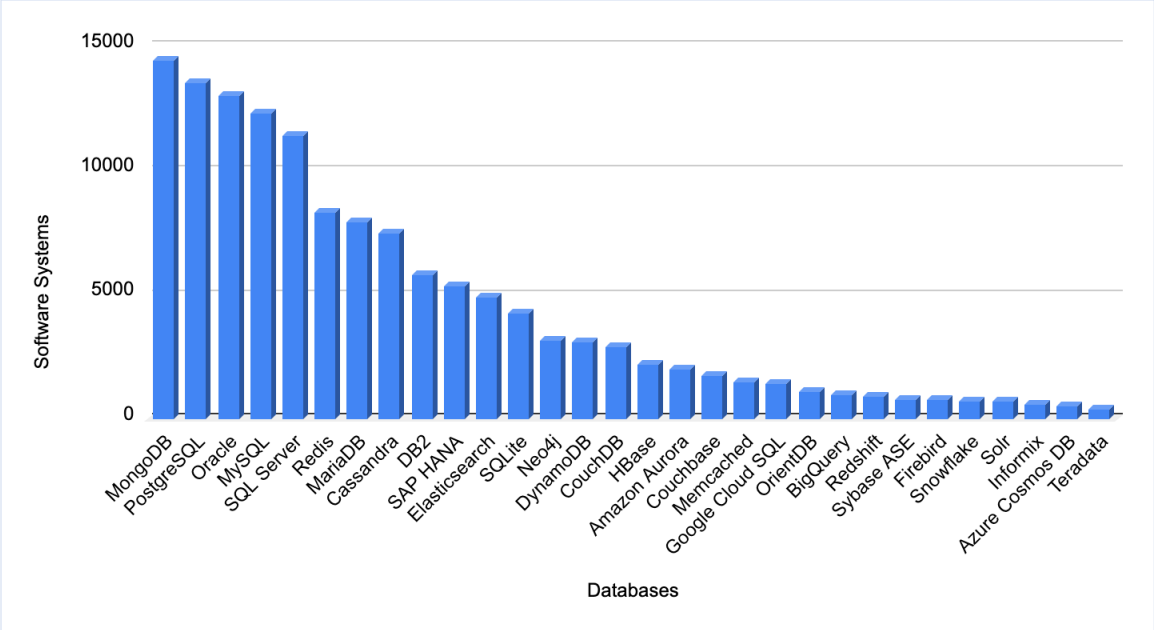

Figure 4.7
Popular databases used in the software systems.

The chart above portrays the popularity distribution of databases within software systems. It's crucial to note that a single software system might employ multiple databases, and the data doesn't distinguish these databases based on criticality or usage volume. Against this backdrop, MongoDB emerges as the most popular, succeeded by PostgreSQL, Oracle, MySQL, and SQL Server. Notably, there's significant adoption of modern NoSQL databases such as MongoDB, Redis, Cassandra, CouchDB, and cloud-based databases like DynamoDB, Amazon Aurora, alongside a diverse range of less prevalent databases. Given that system integration often involves tasks like data transfer, synchronization, and direct integration at the database level for enhanced performance,

resource efficiency, and scalability, the use of a myriad of heterogeneous databases across software systems introduces challenges and complexity in integration processes.

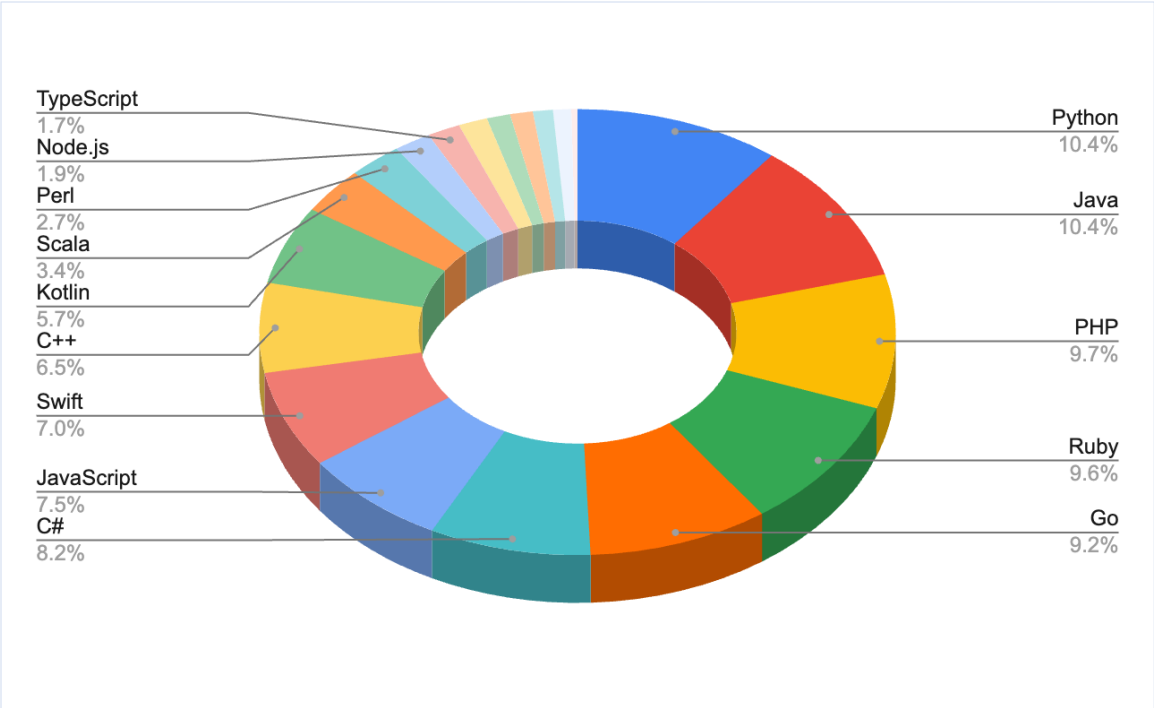

Figure 4.8
Popular integration languages used in the software systems.

Software systems often support computer programming languages for realizing customizations and integrations requirements. The chart above portrays the role and position of those language for the purpose. Python and Java taking the top shares of 10.4% followed by PHP, Ruby, Go and C#. Notably, JavaScript is just holding a 7.5% share on its own. However, when considering JavaScript variants like TypeScript and server-side variant NodeJS, the combined total share of 11.1% surpasses Python and Java, marking it as the leading language in this context.

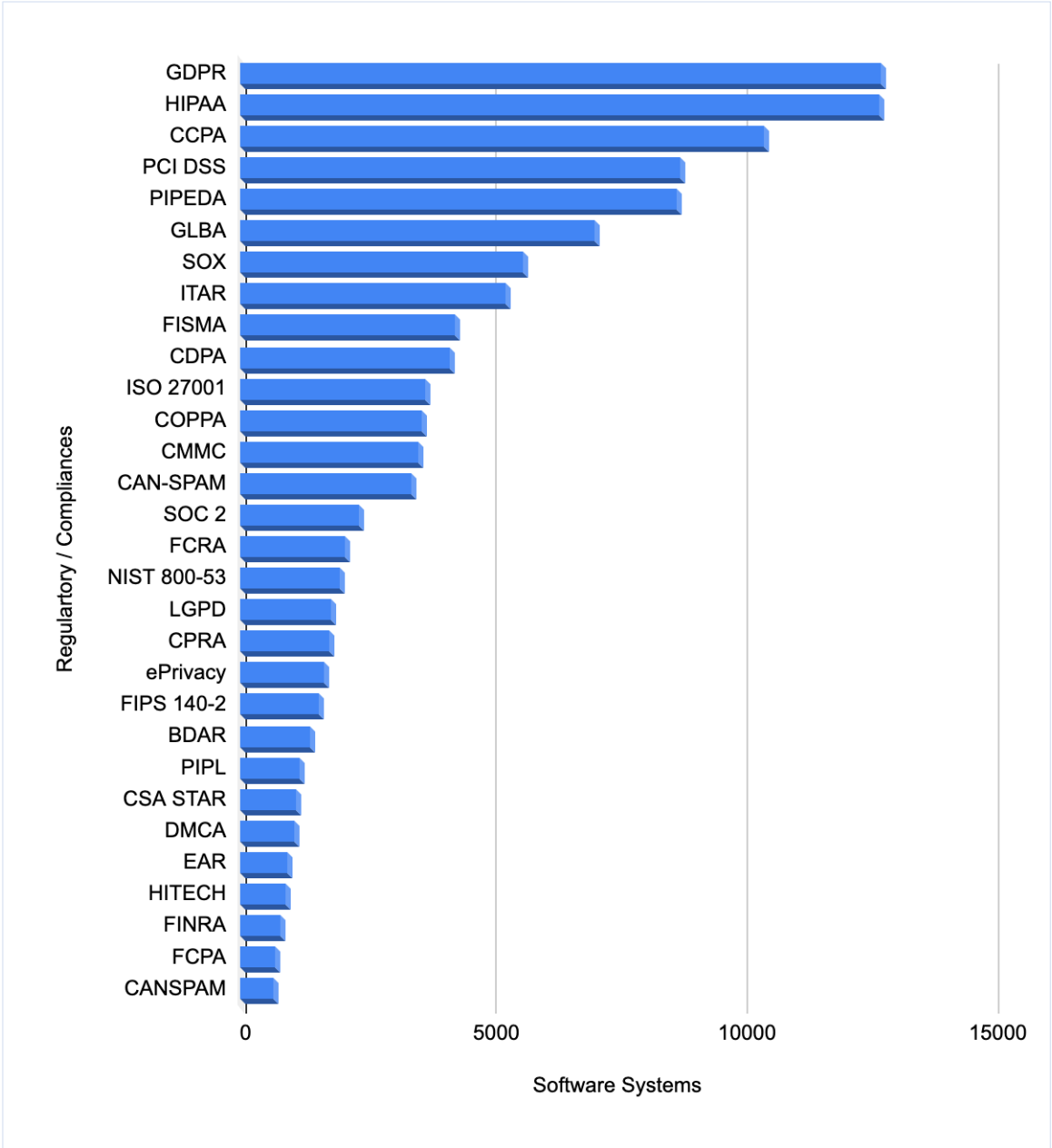

Figure 4.9
Regulatory and compliances required in the software systems.

It is imperative to comprehend and strictly adhere to industry-specific, legal, and geographical regulatory and compliance frameworks within software systems. The process of system integration must align with a comprehensive set of regulatory and compliance requirements associated with the involved software systems. Additionally,

business automation processes are obligated to conform to and satisfy all relevant compliance standards. The above chart depicts the popular regulatory and compliance needs of software systems and hence the needs of the platforms/ solutions that help integrating software systems to operationalize business processes.

4.1.3 Complexity analysis

The findings derived from the amassed data on various systems suggest that conducting a comprehensive analysis of the complexity inherent in the underlying software systems, business processes, integrations, and business automation establishes a foundational framework for comprehending and evaluating the overall complexity of the business.

4.1.3.1 Complexity of software systems

The following independent variables identified from the collected secondary systems data as the key complexity influencers that lead to the complexity of the system.

- Number of Entities in the system (NEs)
- Number of Key Functions of the system (NFs)
- Number of Interfaces in the system (NIs)

The following independent variables are based on how the system is used in an organization.

- Number of Users of the system (NUs)
- Rate of Data generated in the system (RGs)
- Rate of Usage of the system (RUs)
- Criticality of the system (CRs)

The complexity of the system is the dependent variable of the research interest.

- Complexity Index of the system (CXs)

Analysis and synthesis of system data reveals that the complexity of the system is an aggregation of data complexity and functionality complexity influenced by the criticality of the system and can be expressed as a function that directly proportional to independent variables.

Data Complexity DXs = NEs * RGs * CRs

Function Complexity FXs = (NUs + NIs) * NFs * RUs * CRs

Complexity Index of the System CXs = DXs + FXs

4.1.3.2 Complexity of business processes realization

The characteristics of business processes in an organization reveals the following independent variables.

- Number of Business processes (Np)
- Number of Systems involved in the process (NSp)
- Rate of Integration required in the process (RIp)
- Criticality of Business process (CRp)

The dependent variable of this research interest is the complexity to achieve any business process realization.

- Complexity Index of a Business Process Realization (CXp)

Complexity of a business process realization as the accumulation of complexity of all the systems in the business process influenced by the rate of integration required and the criticality of the business process. This can be expressed as an aggregation function of the independent variables and previously calculated complexity of the system.

$$CXp = \sum_{1}^{NSp} CXs * RIp$$

The final cumulative complexity of business of this research's interest is another dependent variable.

- Cumulative Complexity Index of Business (CXb)

The aggregate complexity of a business encompasses the amalgamation of all complexities inherent in its ever-evolving processes. This can be quantified as an integration function of process complexity, further influenced by the criticality of each process within the broader business framework.

$$CXb = \int_{1}^{Np} CXp * CRp$$

4.2 Foundational market research – Solution Providers

The integration and automation solutions help organizations achieve data and processes integrations of software systems used in the organizations. The companies that build, sell and service these integration and automation solutions are referred as solutions providers in this research. The solution providers are categorized mainly into two segments:

- Software Vendors
- System Integrators.

Software vendors, specifically, integration and automation software vendors are companies who build software products and platforms for integrating software systems and implementing automation. The secondary data about software integration and automation software vendors are collected from Gartner Peer Insights ("Gartner Peer Insights | Find & Compare Enterprise Software and Services Reviews," n.d.).

These integration and automation solutions and platforms are categorized into the following:

- DIP - Data Integration Platforms
- AIP - Application Integration Platforms
- iSaaS/ iPaaS Platforms – Integration Software as a Service/ Integration Platform as a Service
- aPaaS/ LCAP/ NCAP Platforms – Application Platform as a Service, Low Code Application Platforms, No Code Application Platforms
- RPA/ BPA/ DPA/ IPA Platforms – Robotic Process Automation, Business Process Automation, Digital Process Automation, Intelligent Process Automation

Collecting the data points of the contemporary integration and automation solutions across these categories, analyzing and synthesizing provided three foundational aspects towards the objective of this research. Firstly, it gives strong understanding about the wide classification of solutions, and the functionalities these classifications are bringing to address the integration and automation challenges. Secondly, the cost analysis and free or free trial availability analysis to see an expected operational license cost, entry barrier for customers and price positioning of these different categories of integration and automation solutions. Thirdly the analysis and synthesis on popular domain entities and functionalities makes a solid ground for modelling approach and framework for implementation of the integration and automation solution.

4.2.1 Data integration platforms

According to Gartner ("Best Data Integration Tools Reviews 2023 | Gartner Peer Insights," n.d.), data integration is the discipline comprising the architectural patterns, methodologies and tools that allow organizations to achieve consistent access and delivery of data across a wide spectrum of data sources and data types to meet the data consumption requirements of business applications and end users. Data integration tools

enable organizations to access, integrate, transform, process, and move data spanning various endpoints and across any infrastructure to support their data integration use cases.

This research encompassed a comprehensive analysis of the Data Integration Platform (DIP) landscape. Fifty popular software solutions offered by various solution providers were identified and meticulously evaluated. Each software product was examined based on 29 distinct attributes, resulting in a rich dataset encompassing 1,450 data points. This data was subsequently subjected to rigorous analysis and synthesis, yielding valuable insights and trends within the DIP market.

Table 4.4
Data Integration Platforms (DIPs) of different sizes and headquarters countries

Headquarters	**Very Large**	**Large**	**Medium**	**Small**	**Total**
United States of America	10	7	7	7	**31**
Sweden			2	1	**3**
Germany	2	1			**3**
Canada		2	1		**3**
Spain				2	**2**
Ireland			1	1	**2**
United Kingdom			1		**1**
Slovenia		1			**1**
New Zealand			1		**1**
Luxembourg				1	**1**
Finland			1		**1**
Australia				1	**1**
Total	**12**	**11**	**14**	**13**	**50**

This table shows the distribution of 50 companies across different headquarters locations, categorized by company size: Very Large (>10B USD revenue per year), Large (1B to 10B USD), Medium (50M to 1B USD), and Small (<50M USD). The United States of America dominates with 31 companies, more than half of the total, across all

size categories, with a balanced distribution across categories, with 10 Very Large, 7 Large, 7 Medium, and 7 Small companies. Europe has a noticeable presence with 15 companies, primarily in Sweden (3), Germany (3), Spain (2), and Ireland (2).

Table 4.5
The Gartner Magic Quadrant of Data Integration Platform solution providers source: Gartner

Headquarters	**Leaders**	**Challengers**	**Visionaries**	**Niche Players**	**Total**
United States of America	10	4	2	4	**20**
Canada	2			1	**3**
Sweden	1	1			**2**
Germany	1			1	**2**
United Kingdom				1	**1**
Spain	1				**1**
Ireland				1	**1**
Total	**15**	**5**	**2**	**8**	**30**

The United States of America dominates with 20 vendors, holding the most significant share across all categories (Leaders, Challengers, Visionaries, Niche Players).

Table 4.6
The distribution of average cost per month of DIPs

Metric	**Amount (USD)**
Mean	$1979
Median	$844
Standard Deviation	2674

The above table shows the mean, median, and standard deviation of the average monthly operational cost (among the plans) for the data integration solutions. The high standard deviation tells a skewed distribution of cost, seen in the lower side, making

easier for businesses to start using Data Integration Platforms and enterprise grade solutions are significantly costlier as the mean is more than double of median cost.

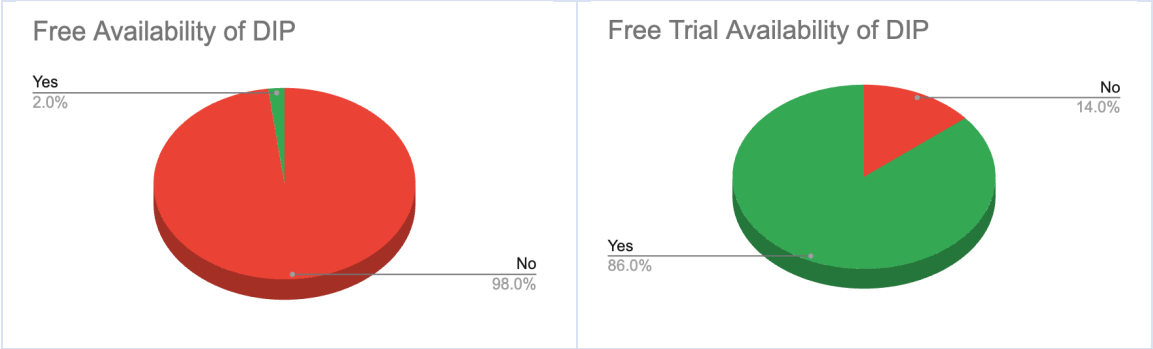

Figure 4.10
Free and free trial availability of DIPs

The negligible 2% of Data Integration Platforms (DIP) are offered on freemium model underscores that these platforms are not widely offered as free but focused on serious businesses who are ready to pay. However, the businesses are encouraged to try free trials with 84% of DIPs are offering free trials which insists some sort of financial commitment from the businesses.

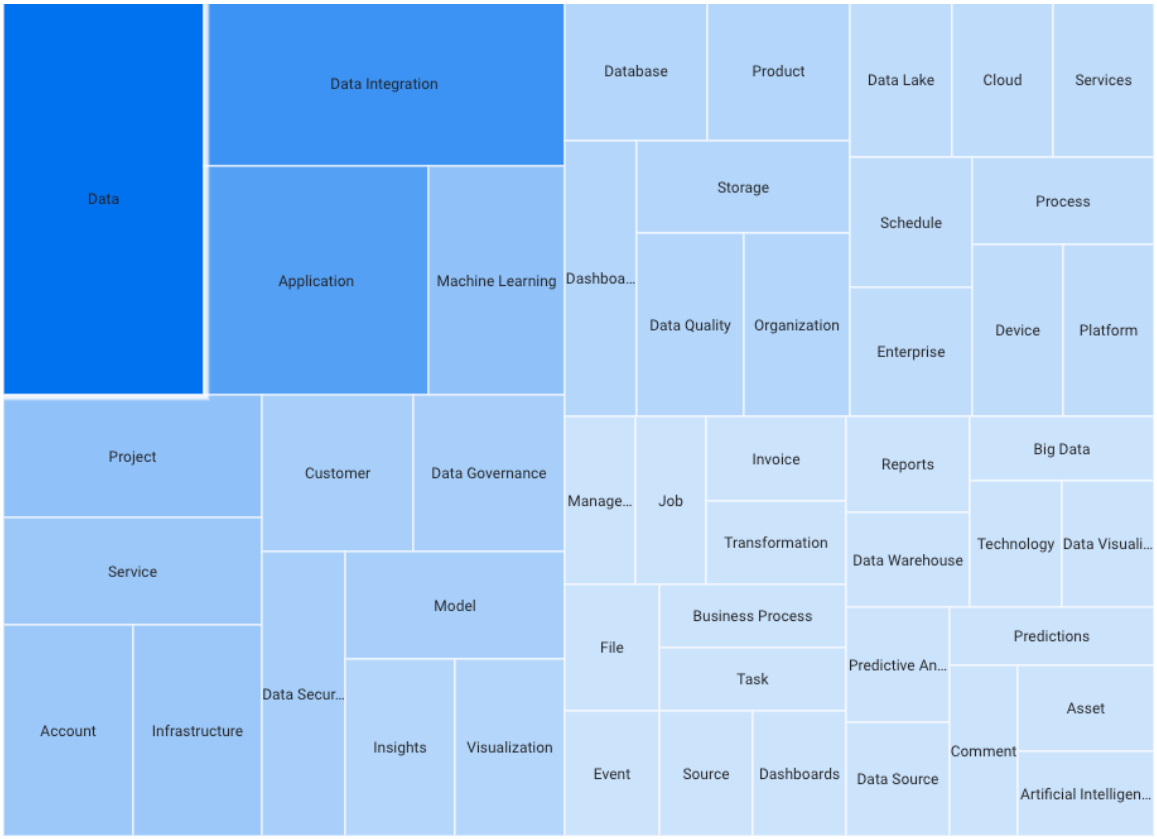

Figure 4.11
Popular domain entities in DIPs

The establishment of domain entities lays a fundamental groundwork for shaping design models, notably the class diagrams integral to the envisioned implementation approach, one of the key goals of this research. Illustrated in the above graph are the key domain entities pertinent to Data Integration Platforms (DIP). Encompassing both standard concepts such as Data, Data Integration, Storage, and Database, as well as more specialized terms like Data Lake, Big Data, Data Warehouse, and Data Source, the graph provides a nuanced view. Moreover, it accentuates certain characteristics of DIPs like Data Quality, Data Governance, and Data Security, while infusing elements of AI with terms like Predictions, Predictive Analytics, and Machine Learning.

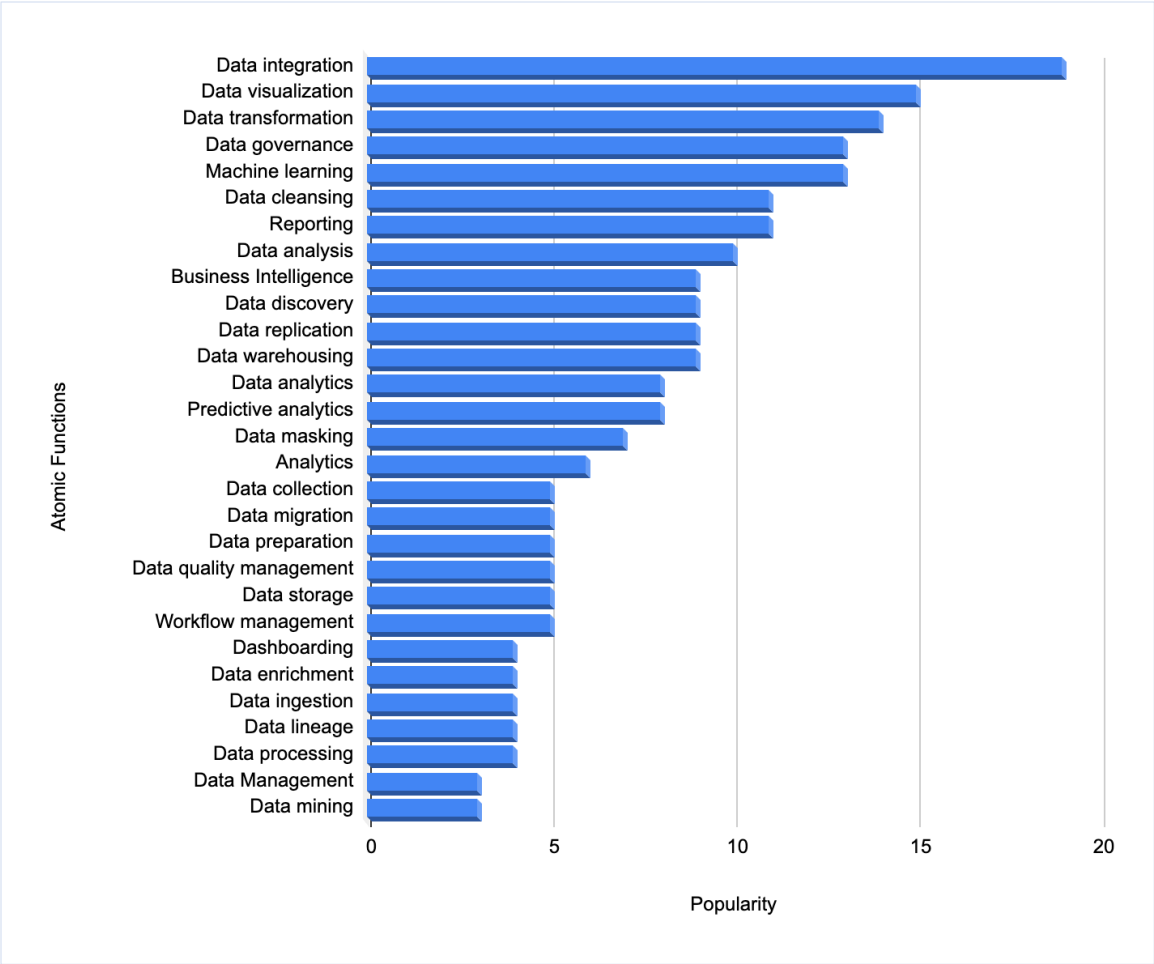

Figure 4.12
Popular functions of DIPs

Scrutinizing the functionalities inherent in Data Integration Platforms (DIP), a diverse spectrum of operations on data unfolds. Spanning standard procedures in a sequential hierarchy ranging from collection, migration, cleansing, masking, and transformation to preparation, ingestion, integration, processing, enrichment to analytical maneuvers including discovery, mining, lineage, analytics, visualization, reporting, dashboarding, and business intelligence, and extending to managerial functions such as quality management, governance, workflow, as well as AI operations like Machine Learning. This delineation of key functionalities serves as a pivotal foundation, enabling

this research to articulate robust functional constructs for the proposed implementation methodology.

4.2.2 Application integration platforms

Application integration platforms enable independently designed applications and services to work together. Gartner reviews Application Integration Platforms ("Best Application Integration Platforms Reviews 2023 | Gartner Peer Insights," n.d.) that provides key capabilities such as communication that reliably moves messages/ data across, support for web and web services standards, dynamic binding of consumer and provider, message validation, mapping, transformation, enrichment, and orchestration.

This research employed a data-driven approach to explore the Application Integration Platform (AIP) landscape. Fifty popular software solutions from various providers were meticulously examined based on 29 distinct attributes, generating a comprehensive dataset of 1,450 data points. This data underwent a comprehensive analysis and synthesis, yielding valuable insights and trends within the AIP market.

Table 4.7
Application Integration Platforms (AIPs) of different sizes and headquarters countries

Headquarters	Very Large	Large	Medium	Small	Total
United States of America	9	3	6	11	**29**
India				3	**3**
Germany	2	1			**3**
Canada				3	**3**
Switzerland				2	**2**
Japan	2				**2**
Israel			1	1	**2**
Australia				2	**2**
United Kingdom				1	**1**
Romania		1			**1**

Finland			1		**1**
Czech Republic				1	**1**
Total	**13**	**5**	**8**	**24**	**50**

This table provides insights into the distribution of top 50 Application Integration Platforms (AIPs) based on their sizes and headquarters countries. Most AIPs are headquartered in the United States of America, with a significant presence across all size categories. India also emerges as a notable hub for AIPs, particularly in the small and medium size categories. Other countries such as Germany, Canada, and Switzerland are represented in smaller numbers but still contribute to the global landscape of AIP providers. Interestingly, some countries like Japan, Israel, and Australia also have a presence in this space, though with fewer AIPs.

Table 4.8
The Gartner Magic Quadrant of Application Integration Platform solution providers

Headquarters	**Leaders**	**Challengers**	**Visionaries**	**Niche Players**	**Total**
United States of America	9	1	3	1	**14**
Germany	2		1		**3**
Total	**11**	**1**	**4**	**1**	**17**

The majority of the leading AIP solution providers are headquartered in the United States of America, with nine identified as Leaders, three as Visionaries, and one as a Niche Player. Germany also emerges as a notable player in the AIP landscape, with two companies recognized as Leaders and one as a Visionary.

Table 4.9
The distribution of average cost per month of AIPs

Metric	**Amount (USD)**
Mean	$1709
Median	$310

Standard Deviation	4371

The above data is the distribution of costs per month associated with Application Integration Platforms (AIPs). The median cost per month is substantially lower than the mean, suggesting that while the mean may be influenced by outliers or high-cost solutions, the median represents a more typical or central value. The relatively large standard deviation further highlights the variability in costs across different AIP solutions, indicating that there is considerable diversity in players and pricing models within the market.

Figure 4.13
Free and free trial available of AIPs

Contrary to Digital Integration Platforms (DIPs), 20% of Application Integration Platforms (AIPs) offer free access, albeit with limitations on usage or features, thus lowering the barrier to entry. Similarly, like DIPs, most AIPs (80%) provide free trial options, allowing businesses to evaluate their suitability before committing to a purchase.

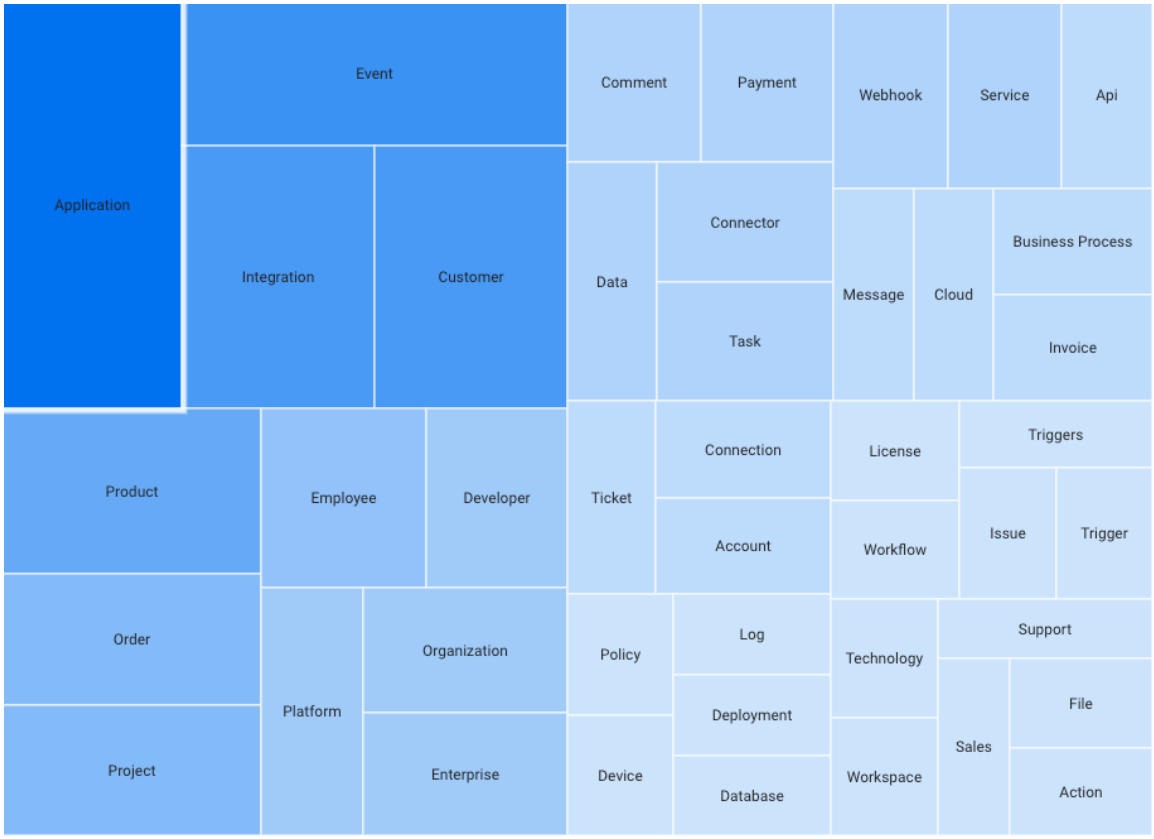

Figure 4.14
Popular domain entities of AIPs

The data on popular domain entities of Application Integration Platforms (AIPs) reveals several key insights. The most prevalent domain entities include applications, events, and integrations, indicating a focus on facilitating seamless interactions between different software applications and systems. Additionally, customer-related entities such as customers, products, orders, and employees are also highly prominent, suggesting a strong emphasis on streamlining customer-centric processes and operations. Other notable entities include projects, platforms, organizations, and enterprises, underscoring the platforms' versatility and ability to cater to various organizational needs. Furthermore, the inclusion of developer-related entities like APIs and connectors highlights the platforms' support for custom integrations and extensibility.

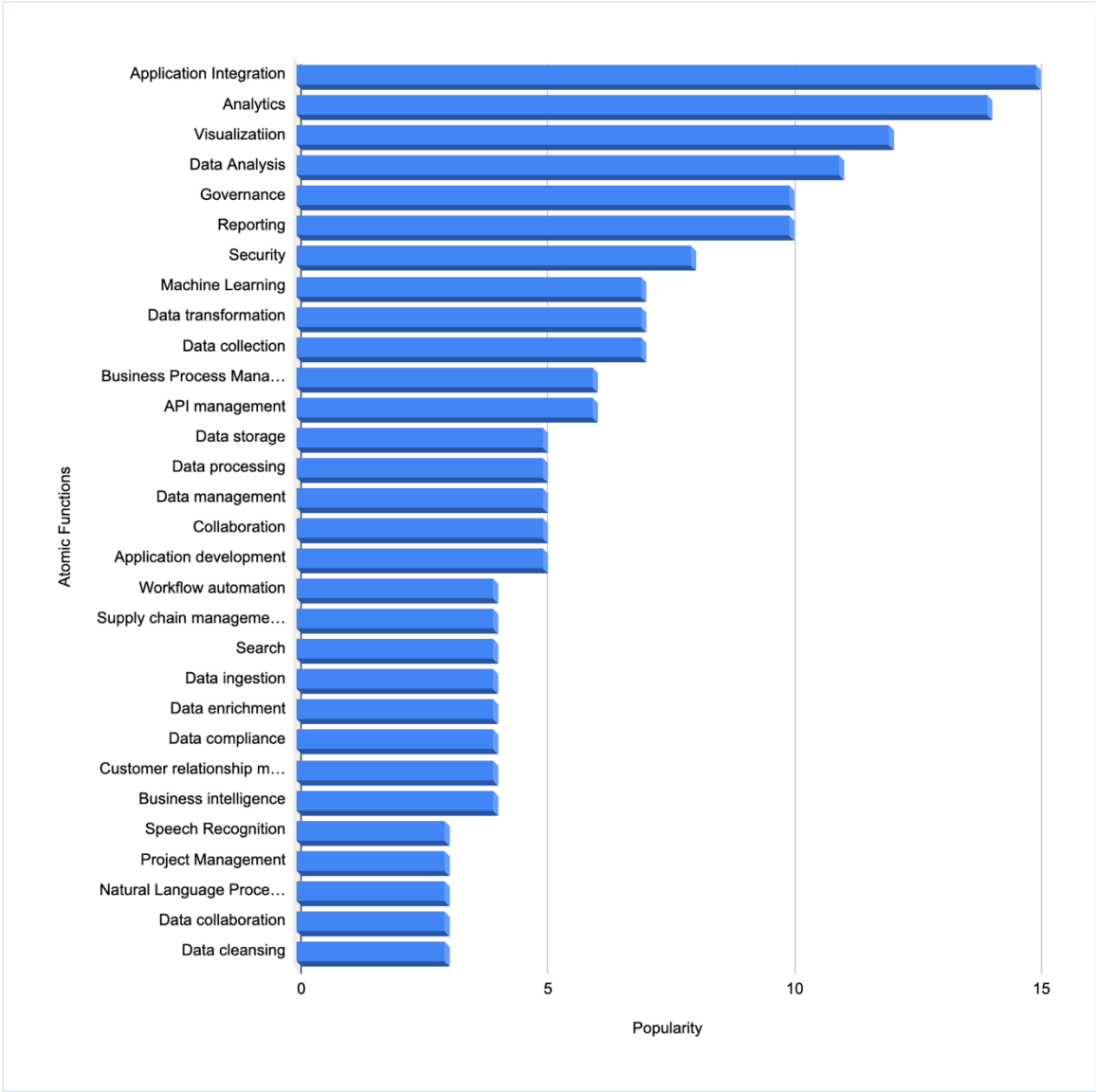

Figure 4.15
Popular functionalities of AIPs

Application integration emerges as the most prevalent atomic function, highlighting the platforms' primary purpose of facilitating seamless integration between various software applications and systems. Additionally, analytics and visualization functionalities are highly prominent, indicating a focus on data analysis and visualization capabilities to derive meaningful insights from integrated data sources. Other notable functions include data analysis, governance, reporting, and machine learning,

emphasizing the platforms' comprehensive support for data management, governance, and advanced analytics. Furthermore, functionalities such as data transformation, data collection, and API management underscore the platforms' role in facilitating data processing and API-based integrations.

4.2.3 iSaaS/ iPaaS platforms

Gartner defines Integration Platform as a Service (iPaaS) as a suite of cloud services enabling development, execution and governance of integration flows connecting any combination of on premises and cloud-based processes, services, applications, and data within individual or across multiple organizations ("Definition of Integration Platform as a Service (iPaaS) - IT Glossary | Gartner," n.d.). Integration Software as a Service (iSaaS) is essentially a specialized iPaaS platform that enables citizen developer and citizen integrators to build and operate integration with low-code/no-code user experience. Both iPaaS and iSaaS platforms focus on providing the integration as a cloud service.

Leveraging a data-centric approach, this research delved into the iSaaS/ iPaaS platform landscape by meticulously evaluating 116 popular software solutions from various providers. Each solution was analyzed across 29 distinct attributes, resulting in a rich dataset of 3,364 data points. This data was then subjected to rigorous analysis and synthesis, uncovering valuable insights and trends within the iSaaS/ iPaaS market.

Table 4.10
iSaaS/ iPaaS platforms of different sizes and headquarters countries

Headquarters	Very Large	Large	Medium	Small	Total
United States of America	16	6	15	25	**62**
Germany	1		3	5	**9**
India	1			7	**8**
Sweden			4	2	**6**

Ireland				5	**5**
Israel				3	**3**
France			3		**3**
Finland				3	**3**
Switzerland			1	1	**2**
Singapore				2	**2**
Canada			1	1	**2**
United Kingdom			1		**1**
Spain				1	**1**
Slovenia				1	**1**
Romania			1		**1**
Poland				1	**1**
Norway			1		**1**
Latvia				1	**1**
Hong Kong				1	**1**
Czech Republic				1	**1**
China	1				**1**
Brazil				1	**1**
Total	**19**	**6**	**30**	**61**	**116**

Like DIPs and AIPs, the United States has the strong presence and dominance of the United States in the iSaaS/iPaaS market. Additionally, Germany and India stand out as prominent headquarters countries, particularly in the medium and small size categories, indicating the growing prominence of iSaaS/iPaaS platforms in these regions. Sweden, Ireland, and Israel also exhibit notable representation, particularly in the medium size category, reflecting the diverse geographical distribution of iSaaS/iPaaS platforms globally.

Table 4.11
The Gartner Magic Quadrant of iSaaS/ iPaaS platform solution providers

Headquarters	Leaders	Visionaries	Challengers	Niche Players	Total
United States of America	6	4	1	2	13
Germany	1	1			2
China				1	1
France				1	1
Total	**7**	**5**	**1**	**4**	**17**

The United States dominates with a significant number of platforms categorized as Leaders, Visionaries, and Niche Players highlighting the innovation and market leadership of US-based iSaaS/iPaaS platforms. Germany also demonstrates a notable presence, with platforms positioned as both Leaders and Visionaries, indicating a strong foothold in the market. Additionally, China and France exhibit emerging potential, each housing platforms classified as Challengers and Niche Players, suggesting the spread of players in these regions.

Table 4.12
The distribution of average cost per month of iSaaS/ iPaaS

Metric	Amount (USD)
Mean	$1635
Median	$510
Standard Deviation	3866

The cost distribution reveals significant variability in the average monthly costs of iSaaS/iPaaS platforms, with a wide range of pricing models and features offered by providers.

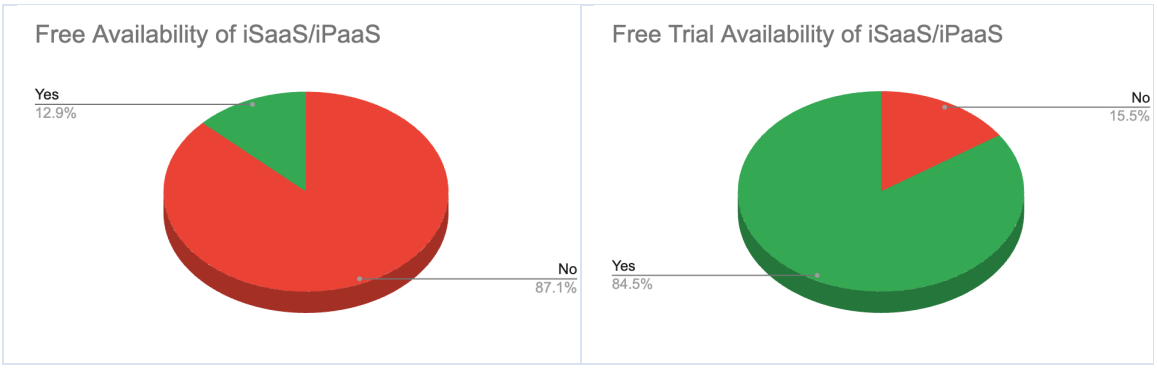

Figure 4.16
Free and free trial availability of iSaaS/ iPaaS

Only 13% of the iSaaS/iPaaS platforms are free with limited usage or features, while 85% of the platforms encourage a free trial for a limited period before making financial commitment.

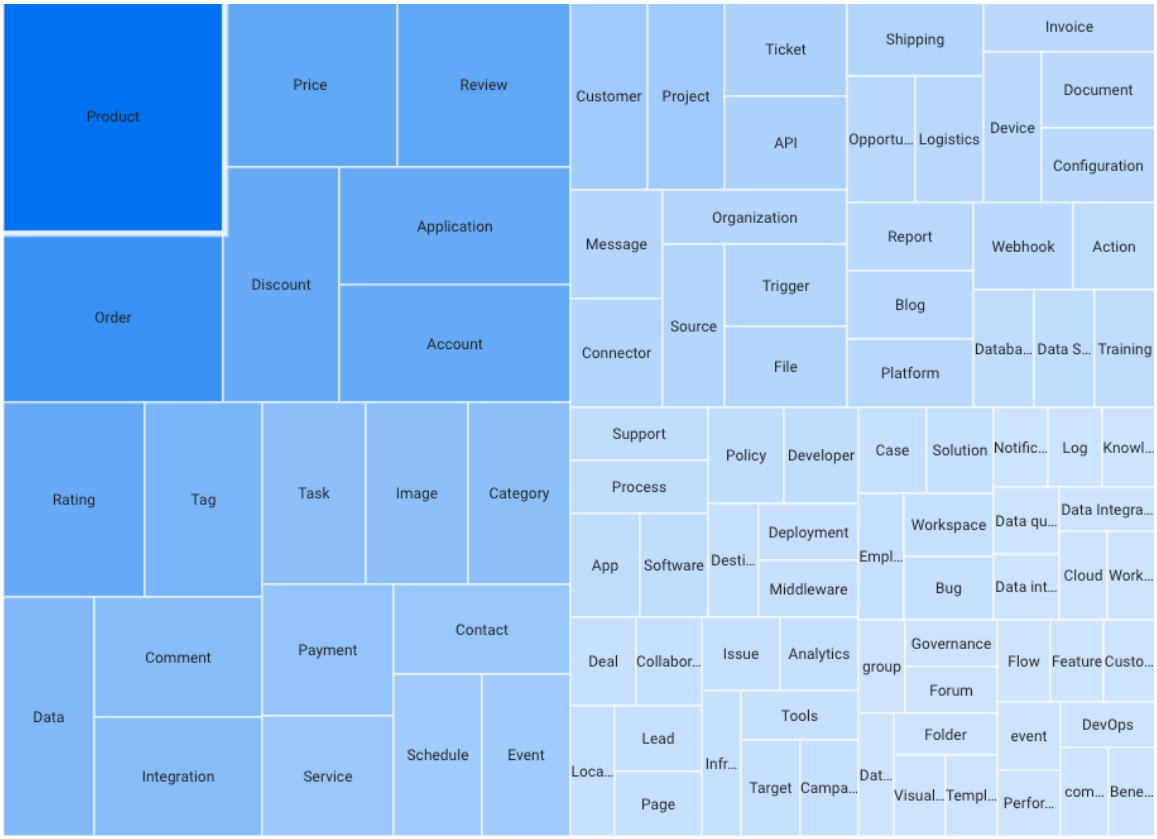

Figure 4.17
Popular domain entities in iSaaS/ iPaaS

This analysis of popular domain entities within iSaaS/iPaaS platforms reveals a strong focus on core product and integration management. Entities like Application, Product, Account, Order, Review, Account, Task, Category etc. rank highly, suggesting a primary emphasis on product management. Naturally, Integration, Data, Task, and Connector highlight the importance of data management and automation within these platforms, which aligns with the integration and automation capabilities typically offered by iSaaS/iPaaS solutions.

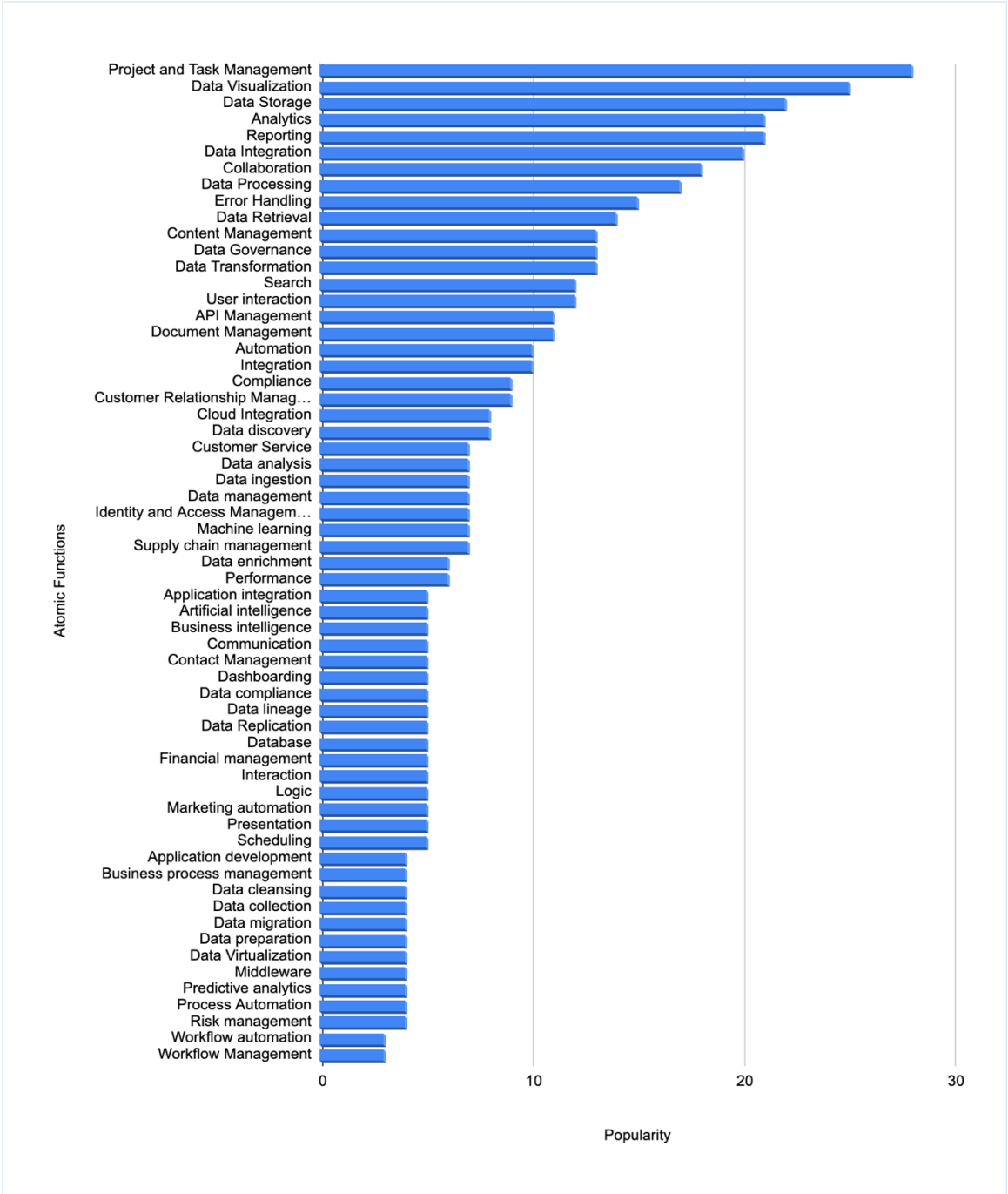

Figure 4.18
Popular functionalities of iSaaS/ iPaaS

The data on the popularity of functionalities within iSaaS/iPaaS platforms provides valuable insights variety of functionalities exposed from iSaaS/ iPaaS platforms.

Project and task management emerge as the most sought-after functionalities, indicating a strong emphasis on workflow organization and task tracking. Data integration, visualization, storage, analytics, and reporting also rank high, underscoring the importance of data-driven insights and reporting capabilities in decision-making processes. Application connectivity, integration, automation, along with collaboration tools are also in demand, highlighting the importance of teamwork and data interoperability in modern business environments. Additionally, functionalities related to error handling, data retrieval, and content management demonstrate a focus on data and application integration quality.

4.2.4 aPaaS/ LCAP/ NCAP platforms

Application Platform as a Service (aPaaS) is a cloud service that offers development and deployment environments for application services ("Definition of Application Platform as a Service (aPaaS) - IT Glossary | Gartner," n.d.). aPaaS is closely associated with the concept of low-code/ no-code that enables citizen developer and non-developers to build and operate applications without writing code or very minimal code. There emerges the category of solutions; Low Code Application Platforms (LCAP) and No Code Application Platforms (NCAP).

To understand the current state of aPaaS/ LCAP/ NCAP solutions, this research meticulously examined 52 popular offerings from various providers. Analyzing 29 distinct attributes for each software, a comprehensive dataset of 1,508 data points was established. Through rigorous analysis and synthesis of this data, key insights and trends shaping the aPaaS/ LCAP/ NCAP market were revealed.

Table 4.13
aPaaS/LCAP/NCAP platforms of different sizes and headquarters countries

Headquarters	Very Large	Large	Medium	Small	Total
United States of America	4	1	6	7	18
United Kingdom			1	2	3
Switzerland				1	1
Sweden				1	1
Spain			1		1
Singapore				1	1
Portugal			1		1
Poland				1	1
Netherlands			1		1
Japan				1	1
Israel				2	2
Ireland		1		2	3
Indonesia				1	1
India	1	1		3	5
Germany				1	1
China	3		1	1	5
Canada			2	3	5
Argentina		1			1
Total	**8**	**4**	**13**	**27**	**52**

The data above illustrates a diverse geographical distribution of aPaaS/LCAP/NCAP platforms, with the United States, the United Kingdom, and Switzerland emerging as notable headquarters locations. The prevalence of platforms across various sizes suggests a dynamic market landscape, accommodating both established players and emerging start-ups. Interestingly, countries like China and India exhibit a significant presence of emerging platforms, underscoring their growing prominence in the global technology sector. Furthermore, the data highlights the widespread adoption of aPaaS/LCAP/NCAP platforms across different regions, reflecting

their importance in facilitating easy ways of application development and deployment on a global scale.

Table 4.14
The distribution of average cost per month of aPaaS/LCAP/NCAP

Metric	Amount (USD)
Mean	$572
Median	$165
Standard Deviation	1862

The average monthly costs of integration solutions within the aPaaS/LCAP/NCAP category demonstrate a notable downward trend comparing the previous categories, primarily attributed to the proliferation of solution providers in this segment. The substantial variance between the mean and median costs within the aPaaS/LCAP/NCAP category highlights the diverse spectrum of solution providers, ranging from entities of varying sizes and scales, resulting in a wide spectrum of costs.

Figure 4.19
Free and free trial availability of aPaaS/LCAP/NCAP

The accessibility of aPaaS/LCAP/NCAP Platforms at no cost rises notably to 17%, underscoring the generous offerings within this sector. The availability of free trials

stands at 77%, marginally lower compared to other categories, likely influenced by the prevalence of extended free access options.

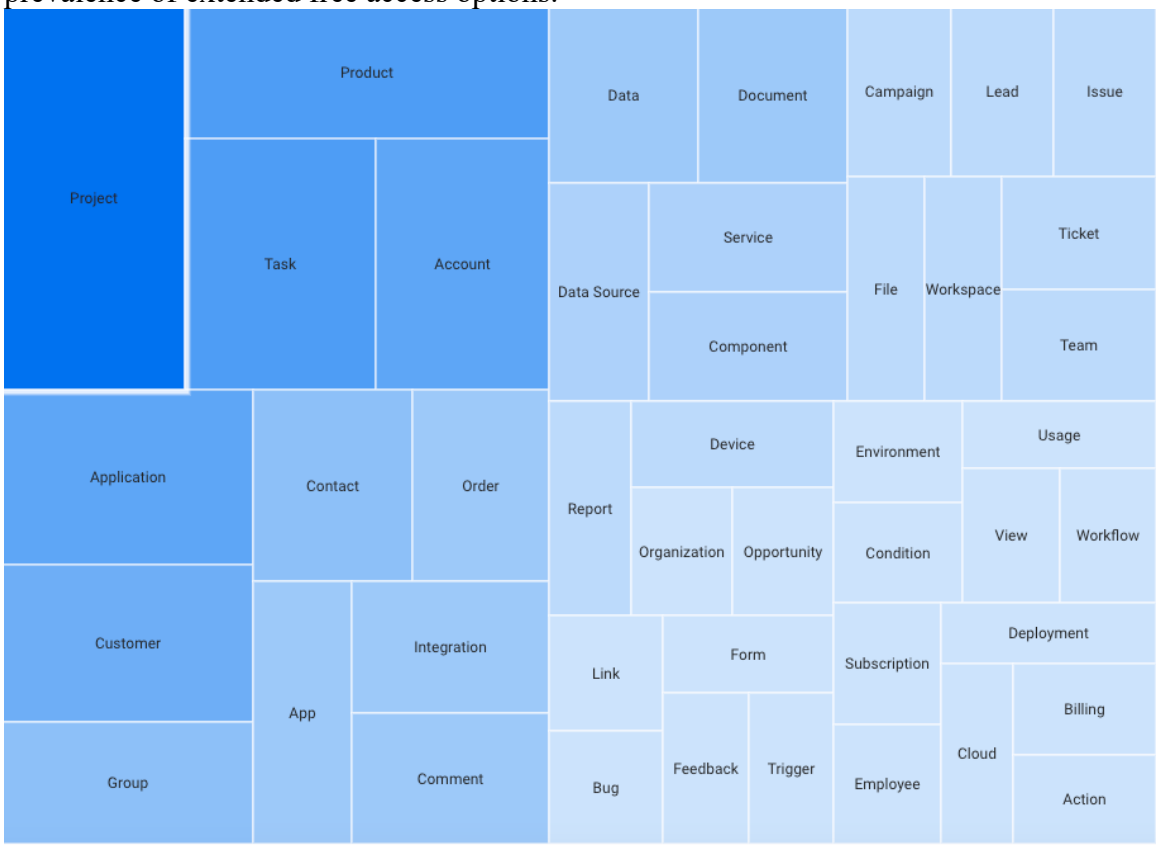

Figure 4.20
Popular domain entities in aPaaS/LCAP/NCAP

Analysis of the data reveals several noteworthy trends regarding popular domain entities within the aPaaS/LCAP/NCAP category. Among these entities, Project and Task emerge as the most prevalent along with Service, Team, Workspace, suggesting a significant emphasis on project management functionalities within these platforms. Similarly, Product, Application, Account, Order follow closely behind along with Contact, Customer, Subscription, Billing, indicating a focus on application and subscription management functionalities. The entities like Data, Data Source, Document, File, indicate data and file management functionalities.

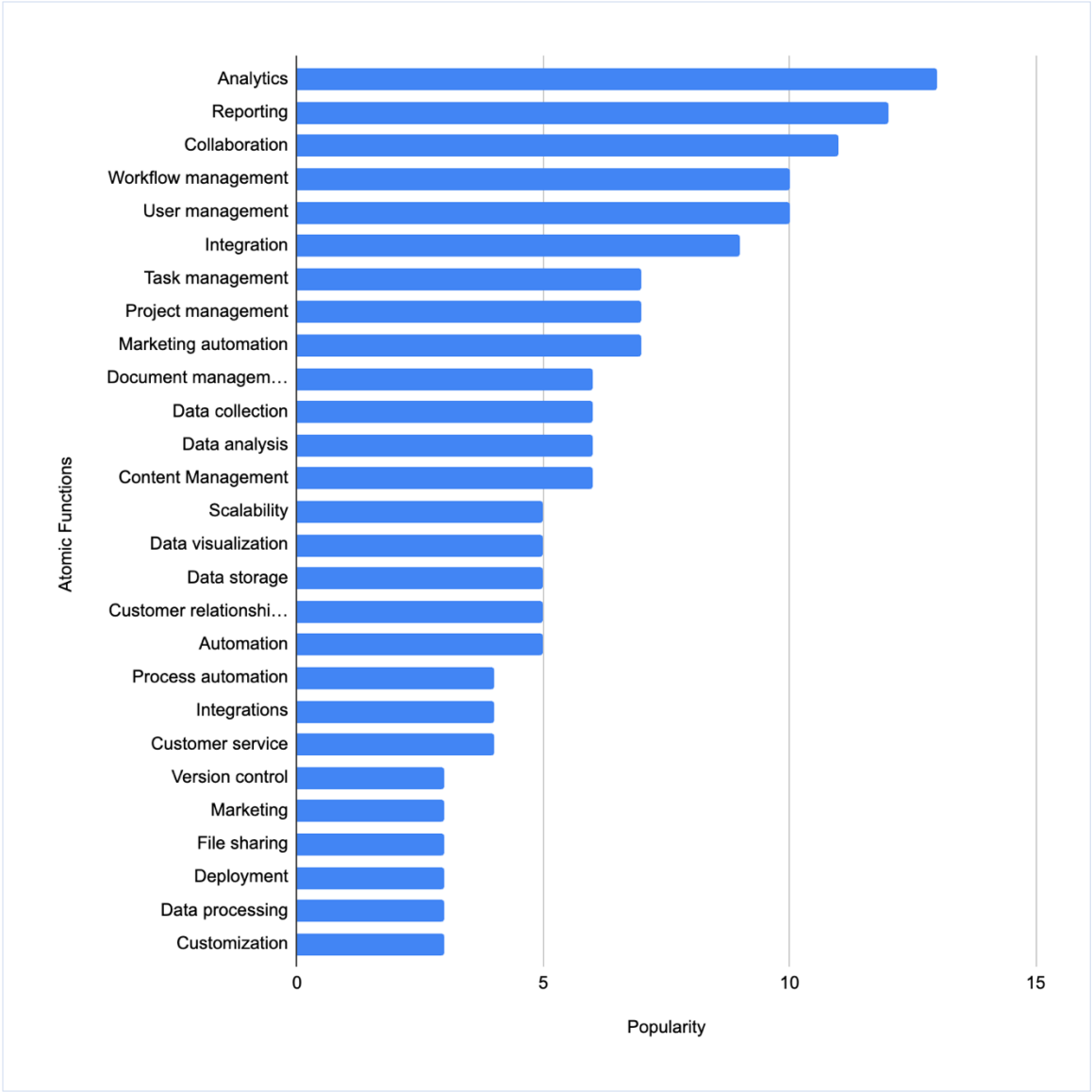

Figure 4.21
Popular functionalities of aPaaS/LCAP/NCAP

The analysis of popular functions within the aPaaS/LCAP/NCAP category yields valuable insights into the key functionalities. Notably, Analytics and Reporting emerge as the most popular functions, underscoring the significance of data analysis and reporting capabilities in these platforms. Collaboration and Workflow Management closely follow, suggesting a strong emphasis on facilitating collaboration and streamlining workflow processes. Furthermore, functionalities such as User Management, Integration, and Task

Management are prominently featured, reflecting the importance of user administration, seamless integration with other systems, and efficient task allocation and tracking.

4.2.5 RPA/ BPA/ DPA/ IPA platforms

The literature study encouraged to explore process automation platforms in the categories of Robotic Process Automation (RPA), Business Process Automation (BPA), Digital Process Automation (DPA), and Intelligent Process Automation (IPA). While definition of these terms differs from each other in the literature and market study ("RPA vs. BPA vs. DPA: Compare process automation technologies | TechTarget," n.d.), the industry uses it more liberally to refer to process automation to realize business processes, and this research collates solutions of all these categories together into a category of focus.

This research leveraged a comprehensive data collection and analysis approach to explore the landscape of software solutions within the categories of RPA, BPA, DPA, and IPA. Specifically, it identified and meticulously evaluated 93 popular software products offered by various solution providers in these categories. For each solution, we examined 29 distinct attributes, resulting in a rich dataset encompassing a total of 2,697 data points. These data points were subjected to rigorous analysis and synthesis, uncovering key insights and trends within the market.

Table 4.15
RPA/BPA/DPA/IPA platforms of different sizes and headquarters countries

Headquarters	Very Large	Large	Medium	Small	Total
United States of America	4	1	11	18	**34**
India	1		6	7	**14**
Israel		1	1	4	**6**
Sweden				5	**5**
Ireland		1	2	2	**5**

China	1			4	**5**
United Kingdom				3	**3**
France				3	**3**
Spain			1	1	**2**
Germany	1			1	**2**
Canada				2	**2**
Australia				2	**2**
Vietnam				1	**1**
Ukraine			1		**1**
Switzerland				1	**1**
South Korea	1				**1**
Slovenia				1	**1**
Romania		1			**1**
Netherlands				1	**1**
Japan	1				**1**
Finland				1	**1**
Czech Republic				1	**1**
Total	**9**	**4**	**22**	**58**	**93**

Most RPA/BPA/DPA/IPA platforms are headquartered in countries with established technological landscapes, notably the United States, India, and Israel. The distribution across different sizes of platforms reflects a diverse global presence in the America, Europe, Asia, and Middle East with a significant concentration of medium and small-sized platforms. This suggests a robust and competitive market environment, fostering innovation and development across various regions.

Table 4.16
The distribution of average cost per month of RPA/BPA/DPA/IPA

Metric	**Amount (USD)**
Mean	$350
Median	$100

Standard Deviation	739

The cost breakdown of RPA/BPA/DPA/IPA solutions indicates that this category is among the most affordable in comparison to other integration solution categories, with an average monthly cost as low as $100, indicating a relatively low-cost barrier to entry. However, the wide disparity between the mean and median suggests the existence of enterprise-grade solutions commanding higher costs.

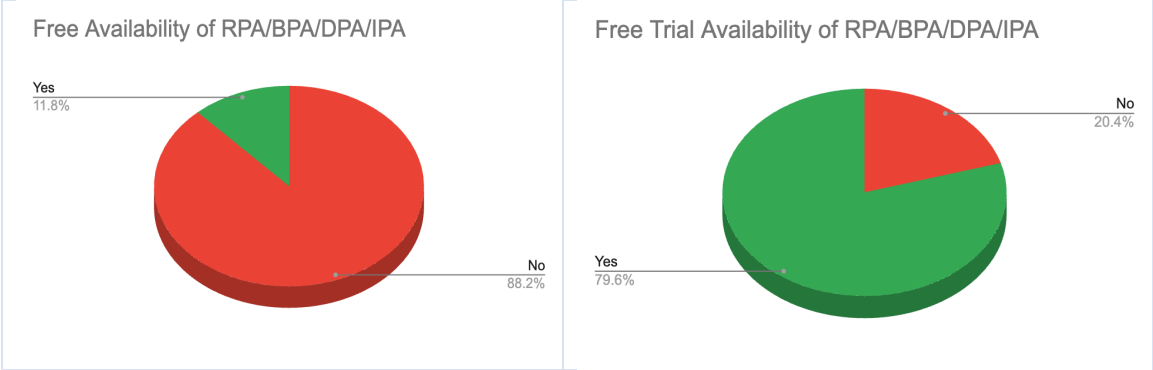

Figure 4.22
Free and free trial availability of RPA/BPA/DPA/IPA

Despite the affordability, the free and free trial availability stands in the same level as other categories with 12% allowing free limited access and 80% opening door for free trial before wide deployment.

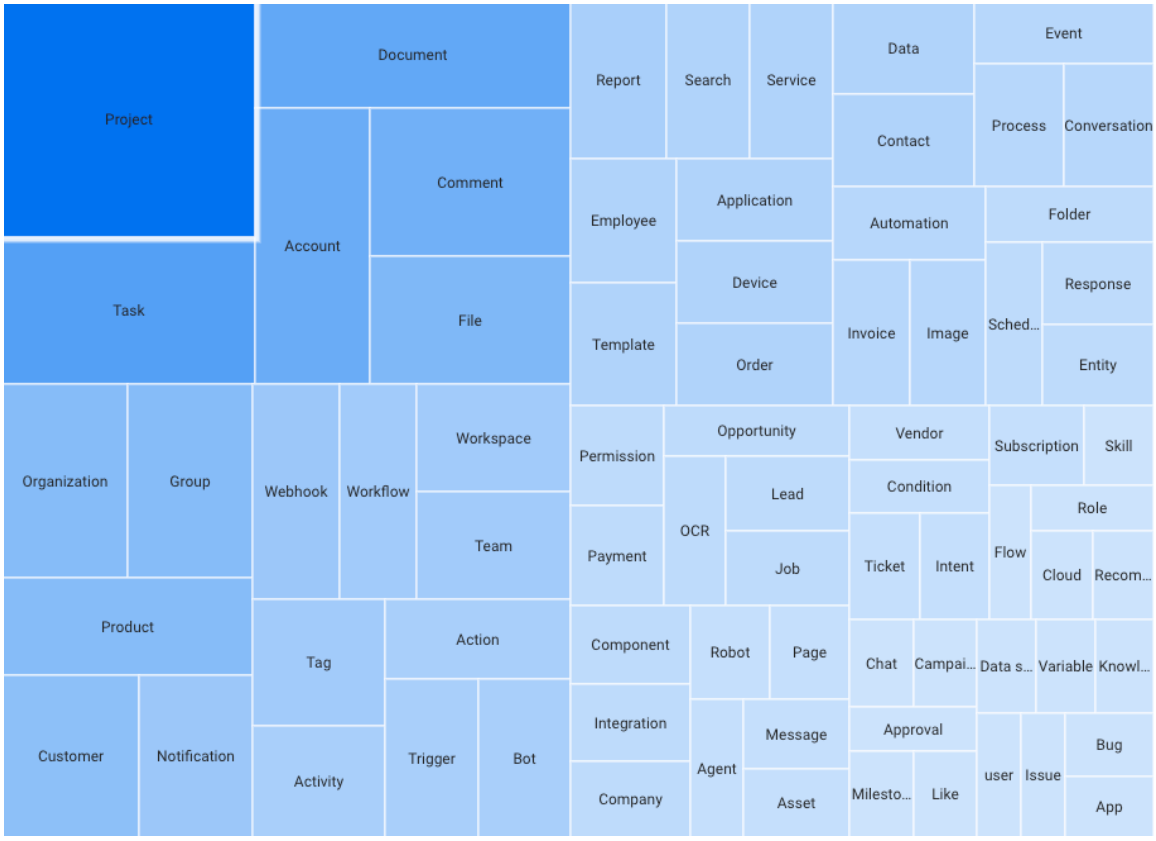

Figure 4.23
Popular domain entities of RPA/BPA/DPA/IPA

Examination of the prevalent domain entities within the domain of RPA/BPA/DPA/IPA solutions unveils a diverse spectrum of entities commonly addressed in automated workflows. Leading the list are Project and Tasks indicating its pivotal role in project management in integration and automation endeavors. Following closely are Documents, Files, Folders emphasizing their significance in automated processes. Noteworthy entities also include Accounts, Comments, and Products, showcasing the broad range of processes and data types subject to automation. Additionally, entities like Webhooks, Notifications, and Workspaces highlight the integration of automation solutions with external systems and communication channels.

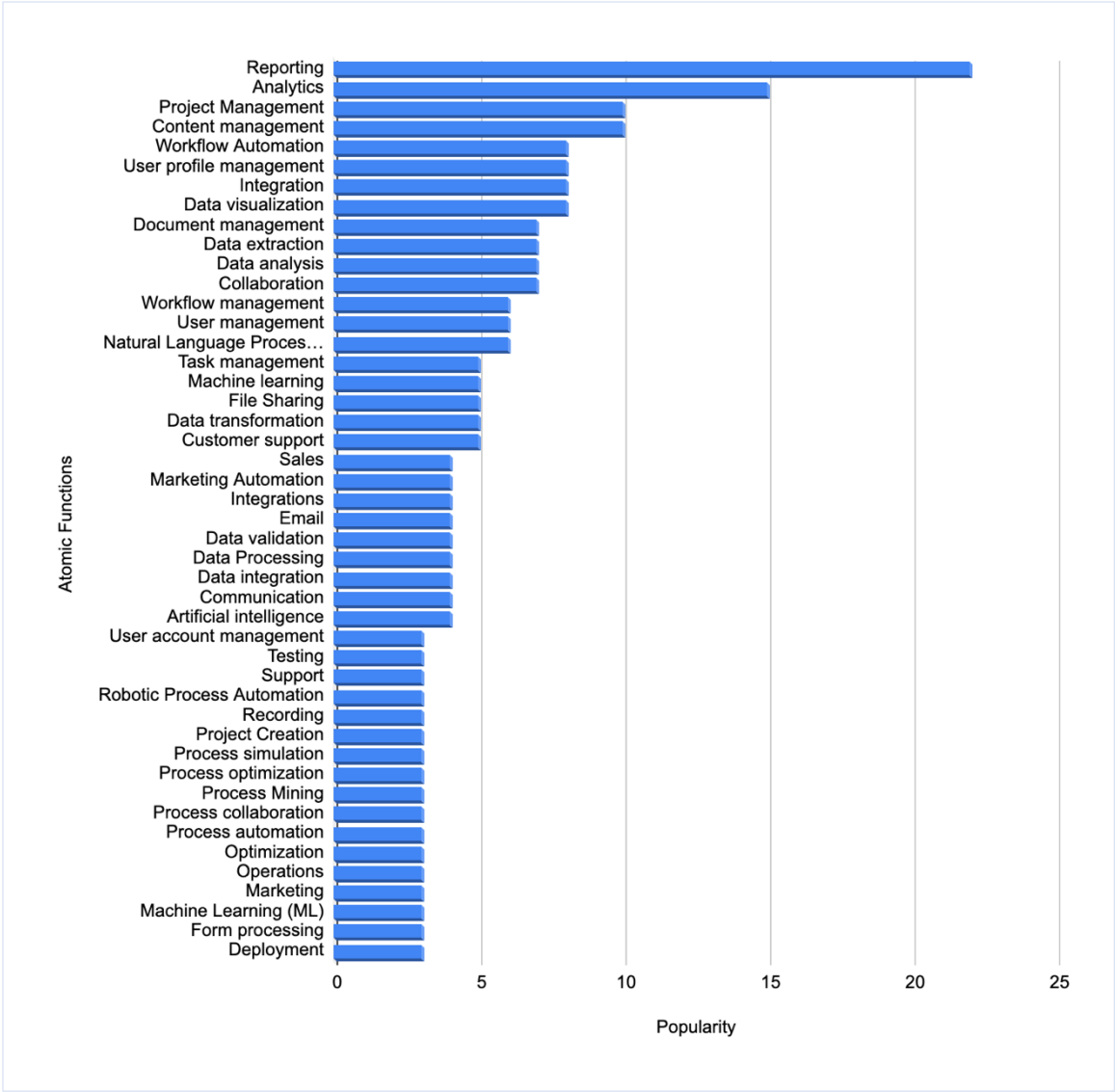

Figure 4.24
Popular functionalities of RPA/BPA/DPA/IPA

Examination of prevalent functions within the scope of RPA/BPA/DPA/IPA solutions unveils noteworthy insights into key functionalities utilized within automated processes. Notably, Analytics and Reporting emerge as the predominant functions, underlining the paramount importance of data analysis, insights, intelligence, and control highlighting the significance of data-driven decision-making in integration and automation initiatives. Project Management, Content Management, Workflow

Automation, and Integration features are prominently emphasizing the organizational management, content-related aspects of automated processes, the need for streamlined workflow orchestration and seamless integration across diverse systems and applications. Functions such as Data Visualization, Document Management, and Data Extraction further underscore the emphasis on efficient data management and visualization. Moreover, the inclusion of collaboration, user management, and natural language processing functions underscores the comprehensive nature of automation solutions, addressing various facets of collaboration, user interaction, and language processing.

4.2.6 Common interfaces and AI techniques in solutions

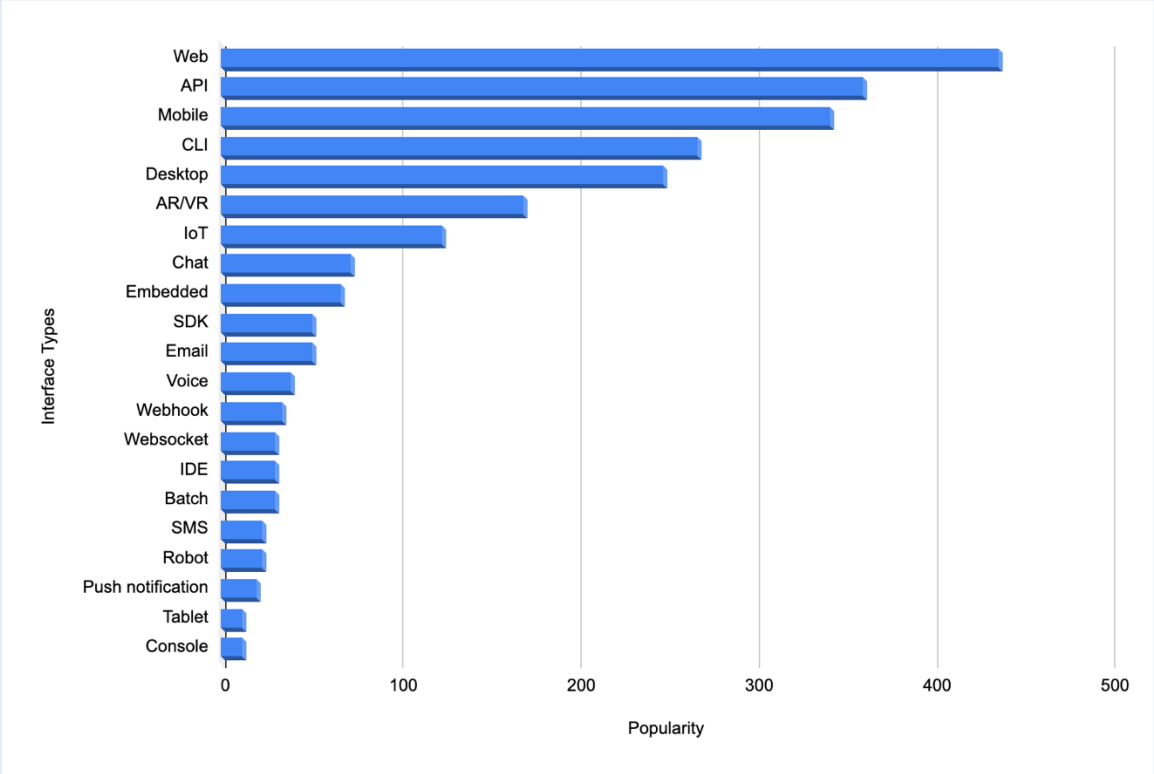

Figure 4.25
Popular interface types of integration and automation solutions

Analysis of the popularity of interface types among integration and automation solutions reveals that web interfaces are the most prevalent, with 437 instances reported.

This is followed closely by API interfaces, which are present in 361 solutions, highlighting the significance of web-based and API-driven approaches in modern integration practices. Mobile interfaces also demonstrate considerable popularity, with 342 instances, emphasizing the importance of mobile accessibility in today's interconnected systems. CLI and desktop interfaces rank next, indicating the continued relevance of command-line and desktop-based interaction methods in certain contexts. Other interface types such as AR/VR, IoT, and chat interfaces show moderate to lower levels of popularity, suggesting their specific applicability in niche scenarios within the integration and automation landscape.

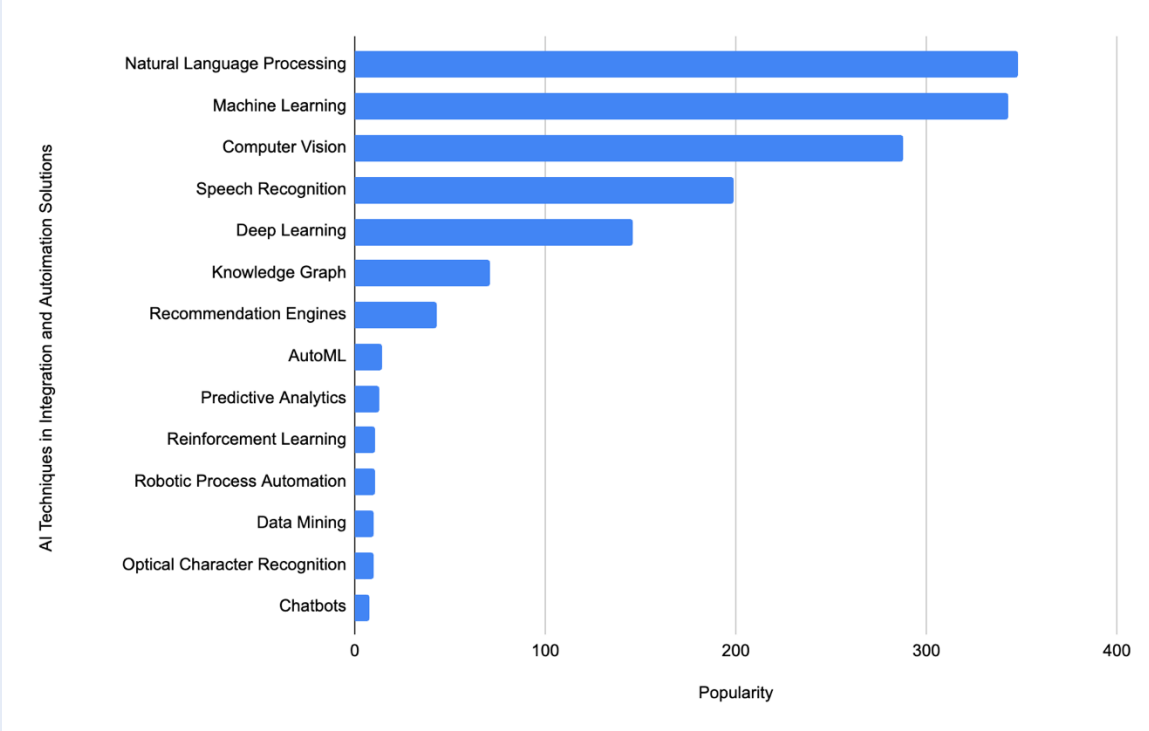

Figure 4.26
AI techniques popularly used in integration and automation solutions.

Analysis of AI techniques utilized in integration and automation solutions indicates that Natural Language Processing (NLP) emerges as the most popular technique, with 348 instances reported. This underscores the importance of NLP in

enabling systems to understand and process human language, facilitating seamless interaction between users and automated systems. Machine Learning follows closely behind, with 343 instances, demonstrating its widespread adoption for predictive modelling and data analysis tasks within integration and automation workflows. Computer Vision emerges as another prominent technique, with 288 instances, highlighting its role in enabling systems to interpret and understand visual data, which is increasingly valuable in various automation scenarios. Other techniques such as Speech Recognition, Deep Learning, and Knowledge Graphs also exhibit substantial usage, reflecting the diverse applications of AI in enhancing integration and automation capabilities.

4.2.7 System integrators

System Integrators are companies who bring together hardware and software subsystems to provide a comprehensive solution. Gartner ("Definition of SI (System Integrator) - IT Glossary | Gartner," n.d.) defines System Integrator as an enterprise that specializes in implementing, planning, coordinating, scheduling, testing, improving and sometimes maintaining a computing operation.

Table 4.17
Top System Integrators and headquarters countries

Headquarters	Companies	Count
United States of America	Cisco Cognizant Dell Fiserv	4
India	HCL Technologies Infosys Tata Consultancy Services Wipro	4

France	Capgemini Atos	2
Ireland	Accenture	1
England	Deloitte	1
Canada	CGI	1
Total		**13**

System Integrators play a crucial role in consulting and implementing the system integration and fulfil the business processes. The proposed implementation approach shall be designed to accommodate system integrators' role, which includes building partner and developer ecosystem, strengthening programmable interface types, and establishing collaboration across customer, software vendors, integrators, developers.

4.3 Businesspeople Survey

A meticulously crafted survey sought with senior businesspeople in the industry to understand the landscape of systems, integrations, automations need of the business, challenges, and perceptions surrounding system integration and the adoption of advanced AI techniques for system integration and business automation. There are 259 responses (planned 250 responses) received from this survey and this section unveils the nuanced understanding of these results.

The survey results have three major parts. First part covers the demographics and firmographics of the respondent to gain a deep understanding of the survey audience. The second part covers the system integration and automation challenges that the audience are currently facing in their business. The third part elucidate the benefits and risks of using AI techniques in system integration and business automation.

4.3.1 Demographics of the audience

This section delves into the demographics of the survey respondents, shedding light on the diverse landscape from which insights have been sourced. Understanding the contextual backdrop, encompassing gender composition, geographic distribution, age group, educational background, adds depth to the interpretation of findings that ensures a nuanced comprehension of the varied perspectives that contribute to the richness of this research on AI augmented intelligent system integration and business automation.

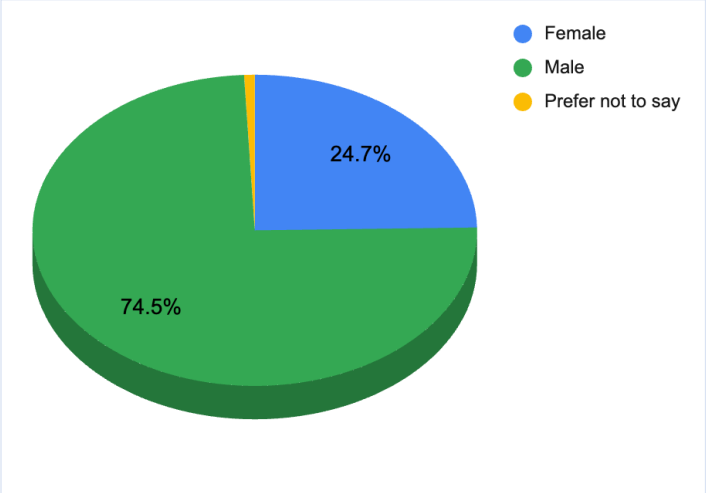

Figure 4.27
Gender of the audience

3 out of every 4 survey respondents are males and 1 out of every 4 is female. A negligible number of respondents did not want to reveal their gender. A possible gender-bias due to this proposition can be ignored as the survey focuses on system integration and automation of the business and does not have any directly influencing elements merely by the gender.

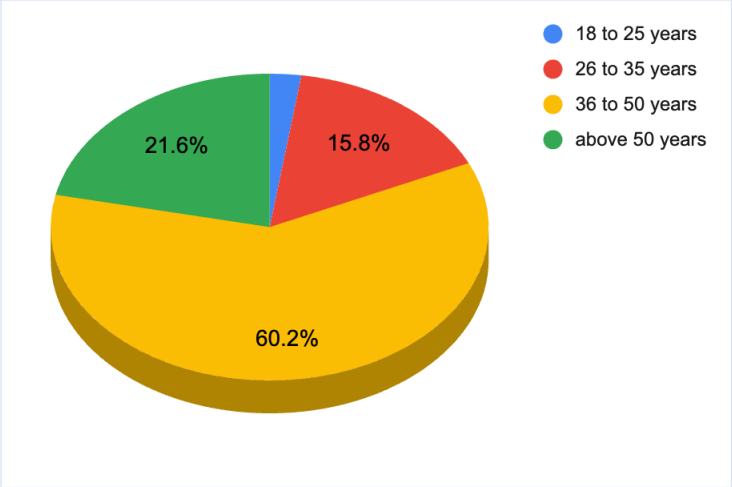

Figure 4.28
Age group of the audience

82 percentage of the population are above the age of 35, making it a strong group of audience, 15 percentage are in the range of 26 to 35 years old, and a negligible number of respondents are below 25 years old.

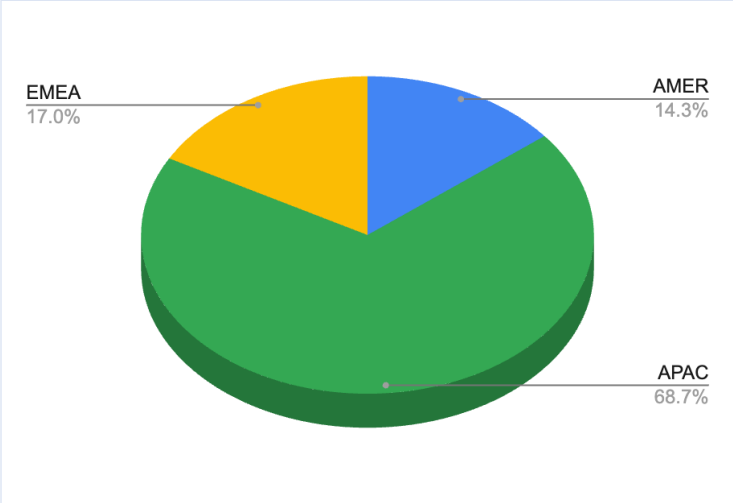

Figure 4.29
Geographical region of the audience

The survey participants exhibit a robust global presence while maintaining significant local engagement. A substantial 69% of respondents originate from the APAC (Asia Pacific) region, 17% from the EMEA (Europe, Middle East, and Africa) region,

and 14% from the AMER (North, Central, and South America) region. This distribution underscores the survey's ability to capture insights on a worldwide scale while emphasizing the impactful contributions from distinct regional perspectives.

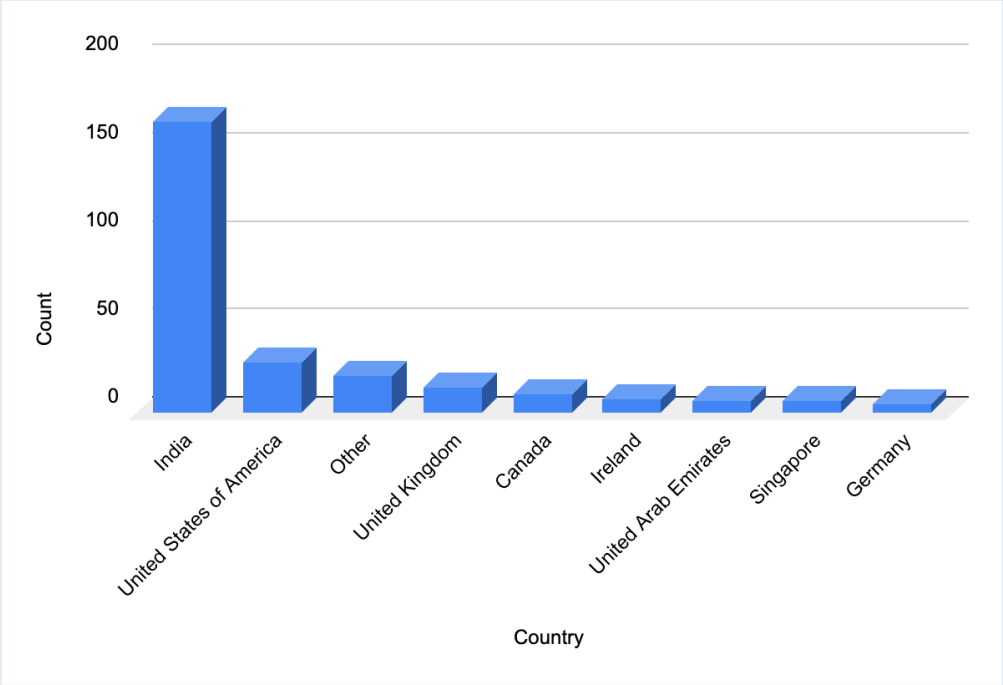

Figure 4.30
Country of the audience

The graph above depicts the country-wise geographical distribution of the received 259 responses. Predominantly, responses emanated from India, with notable contributions from the United States of America, the United Kingdom, and various other countries. This nuanced distribution not only underscores a robust local engagement but also imparts a distinctly global character to the responses, reflecting diverse perspectives from across the international landscape.

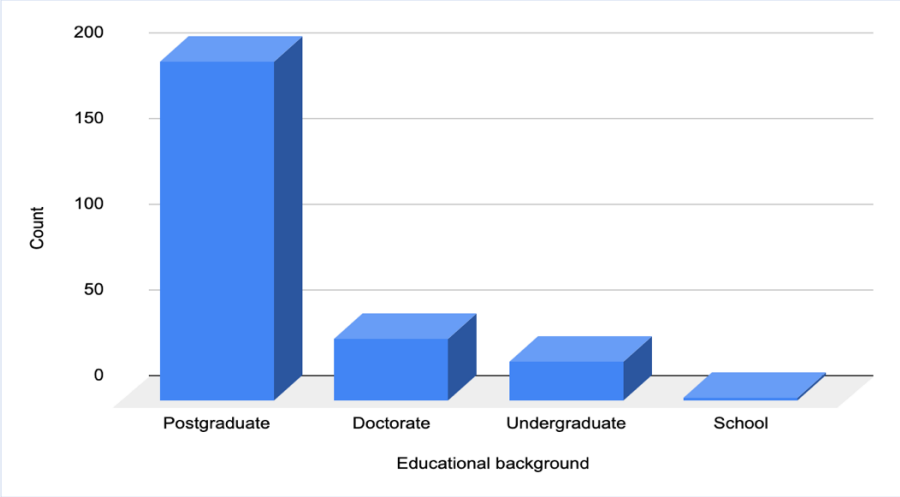

Figure 4.31
Educational background of the audience

234 out of 259 responses are from audience with educational background of postgraduate or doctorate, which underscores the academic caliber of the survey respondents.

4.3.2 Firmographics of the audience

In this section, an exploration into the firmographics characterizing survey participants unfolds, revealing a detailed portrait of the organizational landscape. This analysis encompasses industry experience, organizational size, industry sectors, and technological profiles, offering a comprehensive understanding of how different organizational attributes intersect with perceptions and practices related to AI augmented intelligent system integration and business automation, contextualizing the findings and discerning patterns that may influence the adoption and implementation of AI techniques in diverse business settings, specifically for system integration.

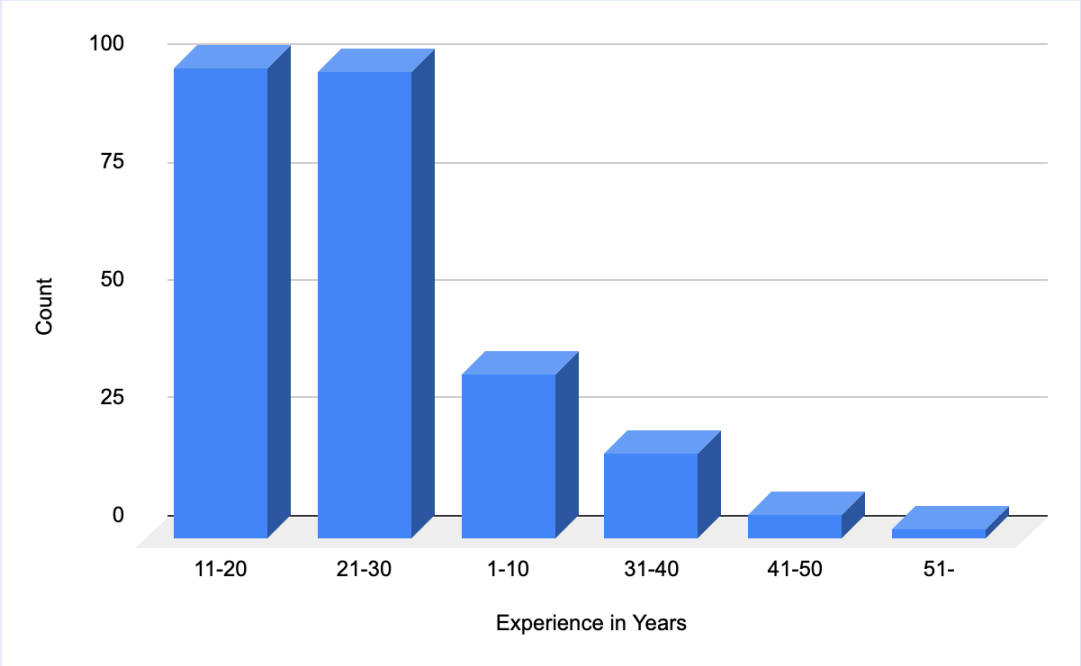

Figure 4.32
Experience range of the audience

The survey participants exhibit substantial industry experience, with 86% boasting over a decade of professional involvement and an impressive 48% surpassing the two-decade mark. This wealth of experience within the respondent pool is particularly valuable, as it comprises individuals who have navigated the dynamic landscape of software systems for an extended period. Their prolonged exposure positions them as insightful contributors, uniquely equipped to offer perspectives on the evolution of systems over the years and the consequential impact on business operations.

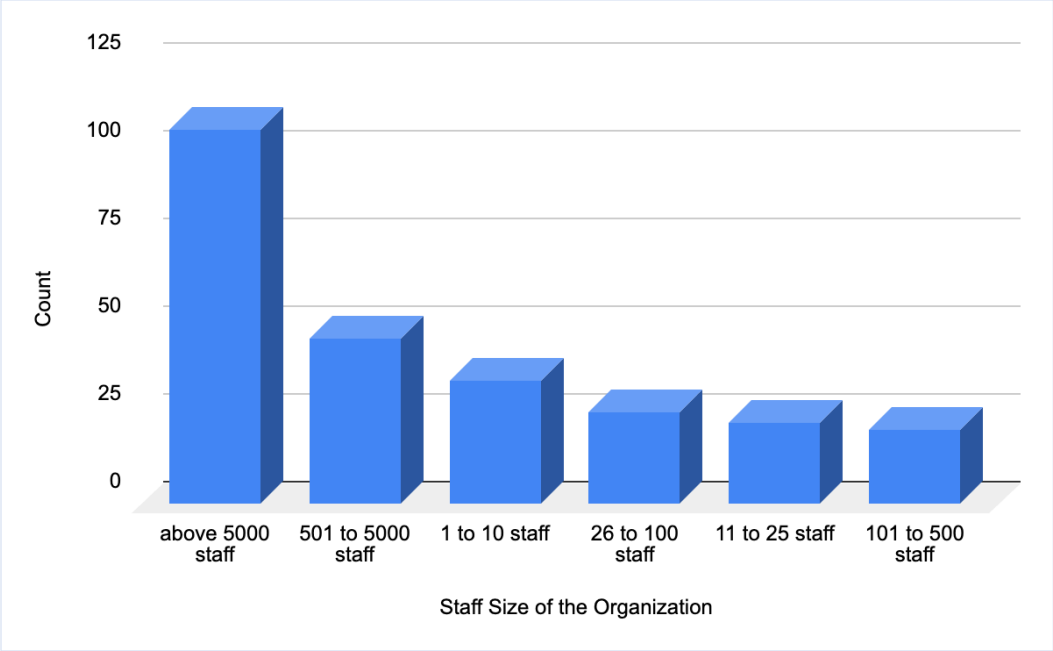

Figure 4.33
Distribution of organization size

The survey participants represent a diverse spectrum of organizational sizes, with 41% hailing from very large enterprises (above 5000 staff), 18% from large entities (501 to 5000 staff), 8% from medium-sized organizations (101 to 500 staff), 10% from small companies (26 to 100 staff), 9% from micro-businesses (11 to 25 staff), and 13% from nano-scale entities (1 to 10 staff). This varied composition ensures a comprehensive and inclusive perspective on software systems, system integrations, challenges therein, and their perceptions regarding the application of AI techniques to system integration and business automation.

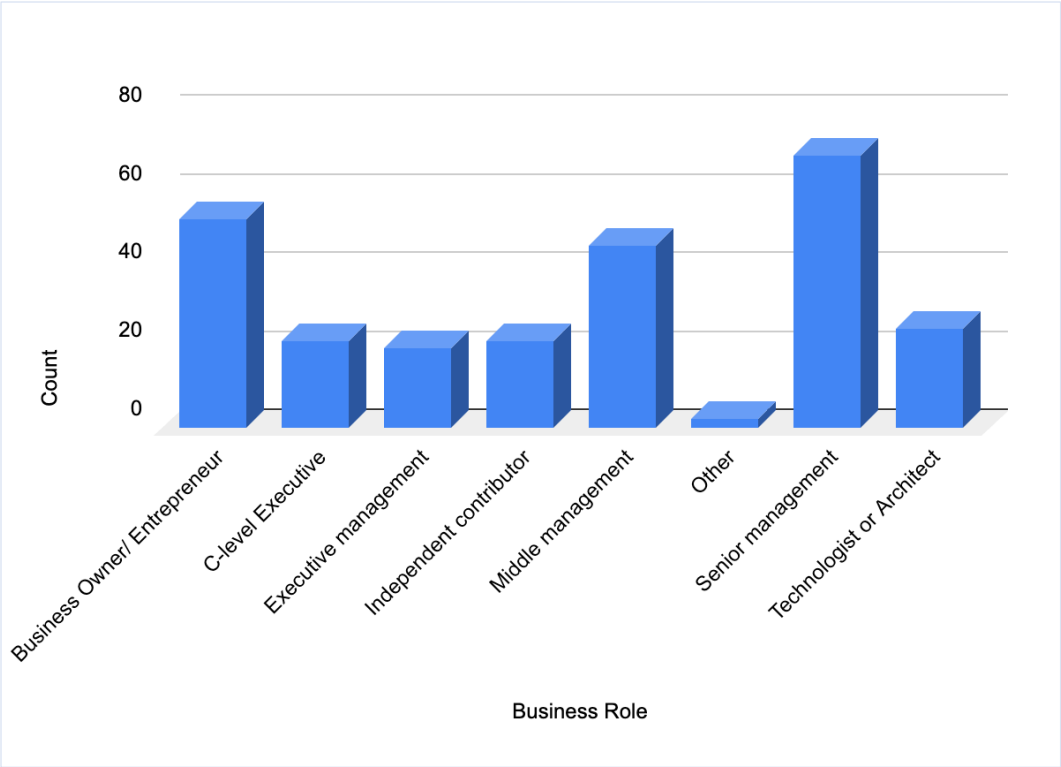

Figure 4.34
Business role of the audience

The distribution of respondents' current roles reveals a diverse array of positions within organizations. Senior Management constitutes the largest segment, comprising 30.5%, followed by Business Owners/Entrepreneurs (23.6%), C-level Executives (7.8%), Executive Management (7.2%), highlighting the prominence of high-level decision-makers in this survey. Subsequently Middle Management (20.1%), and Technologists or Architects (8.9%) are suggesting a noteworthy presence of people directly involved in tactical, technological, and operational leadership with a pinch of and Independent Contributors (7.8%) and contribute to the diversity of roles emphasizing the predominant distribution across key organizational positions. This diverse participation ensures a comprehensive understanding of perspectives across various hierarchical levels on importance of system integration and automation to realize business processes and perceptions of leveraging AI techniques.

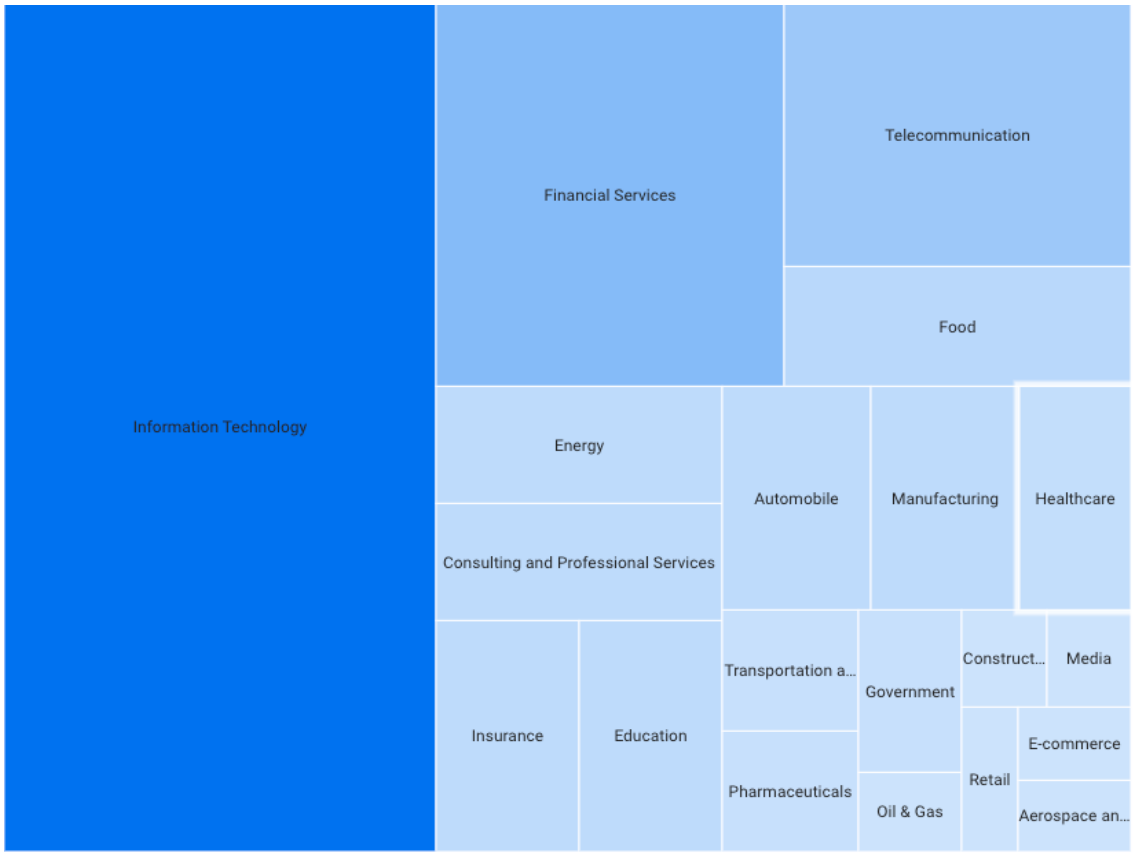

Figure 4.35
Industry spread of the audience.

The diverse composition of industries represented in the depicted graph underscores the survey's comprehensive reach across heterogeneous sectors. The resulting responses encapsulate a collective perspective on software systems, integration challenges, and the nuanced expectations and concerns associated with the application of AI techniques in addressing system integration and business automation across the industries though there is some level of dominance from information technology, financial and telecommunication sector.

4.4 Research Question One

The first research question is 'What are the challenges of system integration in business process automation, the need for intelligent automation and the industry perceptions?'. This research question has 2 sub questions.

- RQ1.1 - What are challenges of system integration in business process automation?
- RQ1.2 - What are the need for intelligent automation and the industry perceptions?

The literature review elucidates the lineage among business, business processes, systems, and system integration and identifies consensus that system integration is critically challenging. The key barriers of system integration are identified as lack of communication, lack of proper documentation, lack of compatibility, architecture mismatch, lack of planning, heterogeneous environments/platforms, improper/no unit testing, wrong product or implementation, lack of resources and skills, lack of interfaces, unclear responsibilities, configuration/ versioning complexity, unclear requirements, time constraints, and integration processes (Ilyas and Khan, 2017). These challenges are deeply rooted from individual systems and need for them to work together in a business automation context. The foundational analysis of systems, system complexity and system integration complexity done in this research demonstrate a directly proportional relationship among them.

4.4.1 Challenges of system integration

To understand the challenges of system integration in business processes of the survey participants, the fundamental details of systems involved in their business processes, need for systems to work together, current state of integration, challenges, and

skills they have or lack are formed as questions and the results are analyzed and synthesized. The following survey questions are asked to the senior businesspeople.

- How many software systems are used in your organization?
- What type of software systems are used in your organization?
- Do you need these software systems to work together?
- How are these software systems integrated in your organization?
- How satisfied are you with the current system integration processes in your organization?
- What challenges do you face when integrating software systems and automating your business processes?

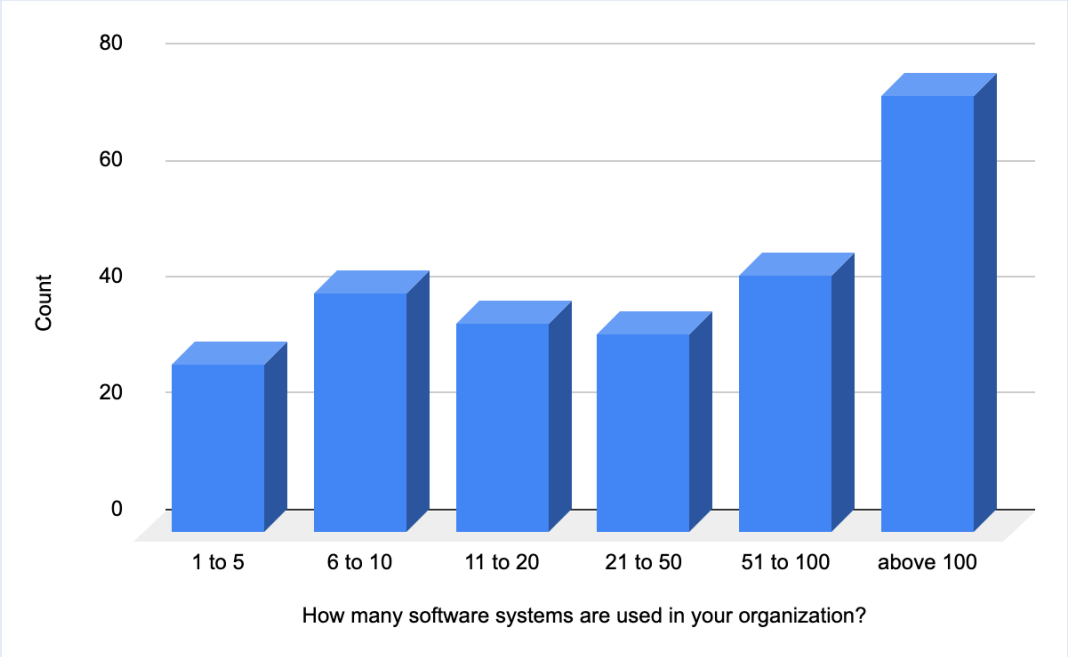

Figure 4.36
Number of software systems used in an organization.

Survey participants elucidate the varied landscape of software system usage within their organizations. Notably, 29% indicated their organizations employ over 100

software systems, while 46% reported a range between 51 to 100 systems. This distribution underscores the prevalence of a substantial number of software systems in contemporary business operations. Furthermore, majority of the respondents, 73%, affirmed the utilization of more than 10 software systems, with an even more significant proportion, 89%, acknowledging the use of at least 5 software systems. These results highlight the significant role that software systems play in the modern business environment.

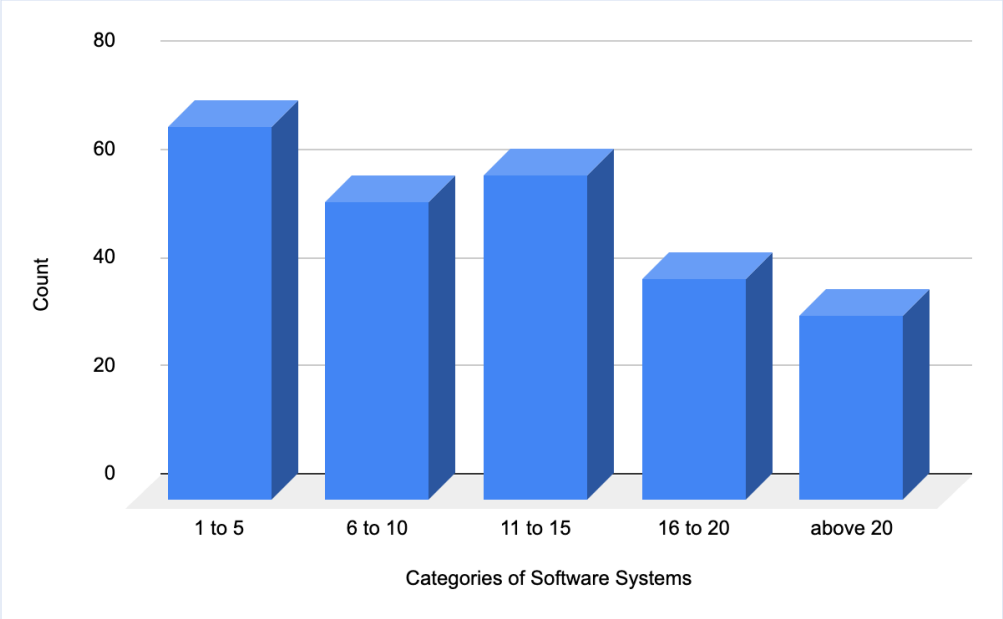

Figure 4.37
Number of categories of software systems used in an organization.

The cluster analysis of software systems, categorized as outlined in the 'Foundational market research - Software' section, provides a deeper understanding of the diverse array of software categories employed within organizations. Notably, 29% of respondents utilize software systems of more than 15 software categories, and half of the organizations surveyed employ over 10 software categories. A significant 75% of organizations leverage more than 5 software categories, and a substantial 94% use a minimum of 2 different categories of software systems. These findings underscore the

necessity for a diverse range of software categories in organizations to effectively manage their business processes.

Table 4.18
Relation between company size and number of software systems

Company Size ↓	**Software Systems →**	**1 to 5**	**6 to 10**	**11 to 20**	**21 to 50**	**51 to 100**	**> 100**
Very Large	above 5000 staff		6	12	13	9	67
Large	501 to 5000 staff		9	11	12	9	6
Medium	101 to 500 staff		3	4	5	9	
Small	26 to 100 staff		12	5	7	1	1
Micro	11 to 25 staff	4	6	1	10	2	
Nano	1 to 10 staff	25	5	3	1		1

The table above depicts the relationship between Company Size and the number of Software Systems. As the number of staff in the company increases, the number of systems increase and a clear pattern emerge, highlighted with green background in the table, except a few outliers.

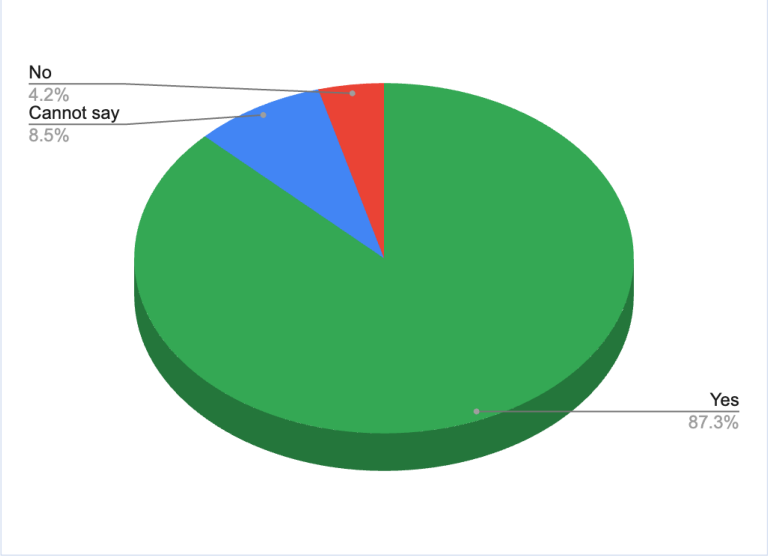

Figure 4.38
Need for software systems to work together.

A significant 87% of the survey respondents confirm the need for their software systems to be working together to achieve their business processes. Around 9% are unclear whether it is crucial for their software systems to work together and a minimal 4% of the respondents are negative about the need for their software systems to work together.

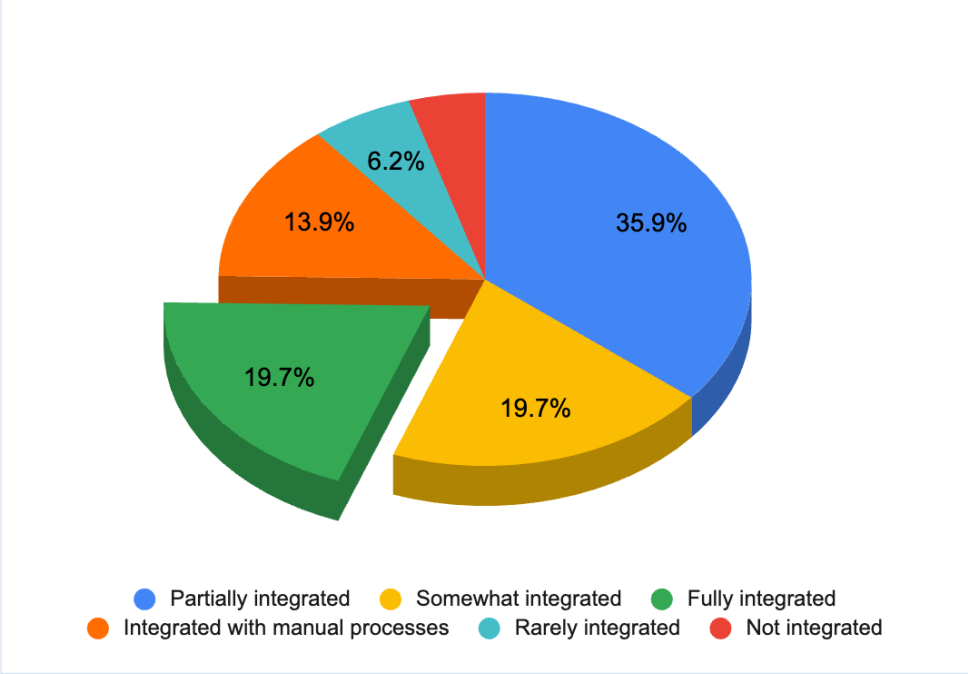

Figure 4.39
Integration status of software systems

The above chart shows the current state of integration of software systems as per the survey participants. Only a 20% say, the systems are fully integrated, the remaining 80% are confirming their systems are either not integrated at all, or partially/ somewhat / rarely integrated or integrated with manual processes. This means 4 out every 5 survey participants responded that their systems need further work to be fully integrated, demonstrating the wide gap between the current state, and expected integrated state.

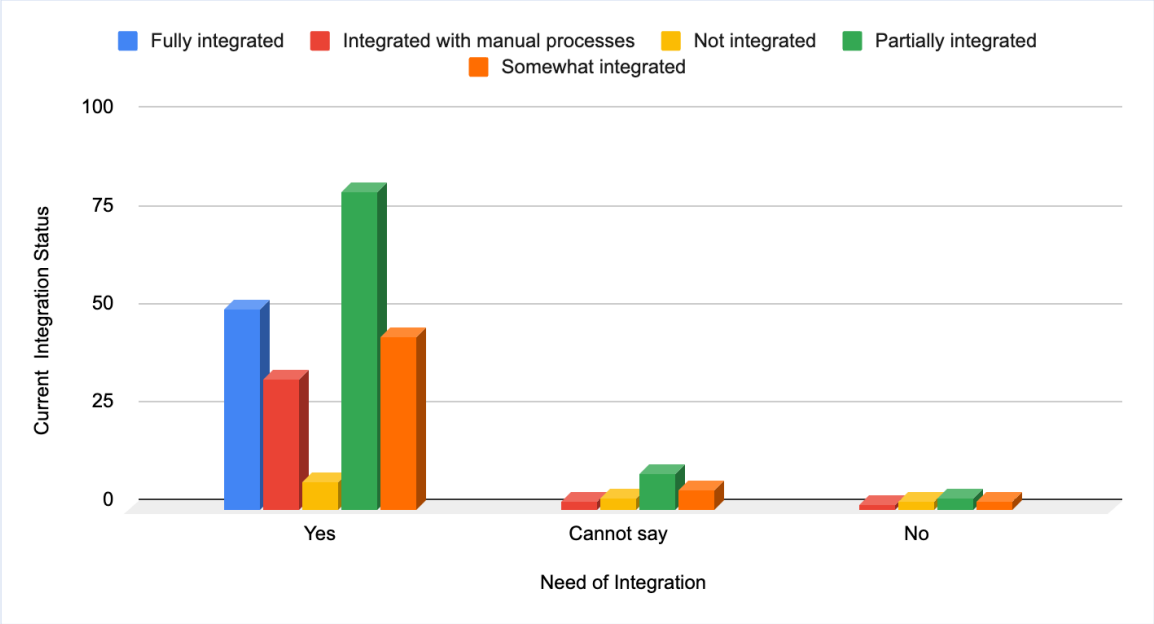

Figure 4.40
Inspection of integration need vs current state.

The illustration above highlights the comparative analysis between participants' perceptions regarding the necessity for system integration and the current integration status within their respective organizations. Remarkably, 77% of participants acknowledging the imperative of integration also reported that their organizations have yet to achieve full system integration. This disparity between recognition of the need for integration and its actual implementation underscores a notable gap between intent and execution within organizational practices.

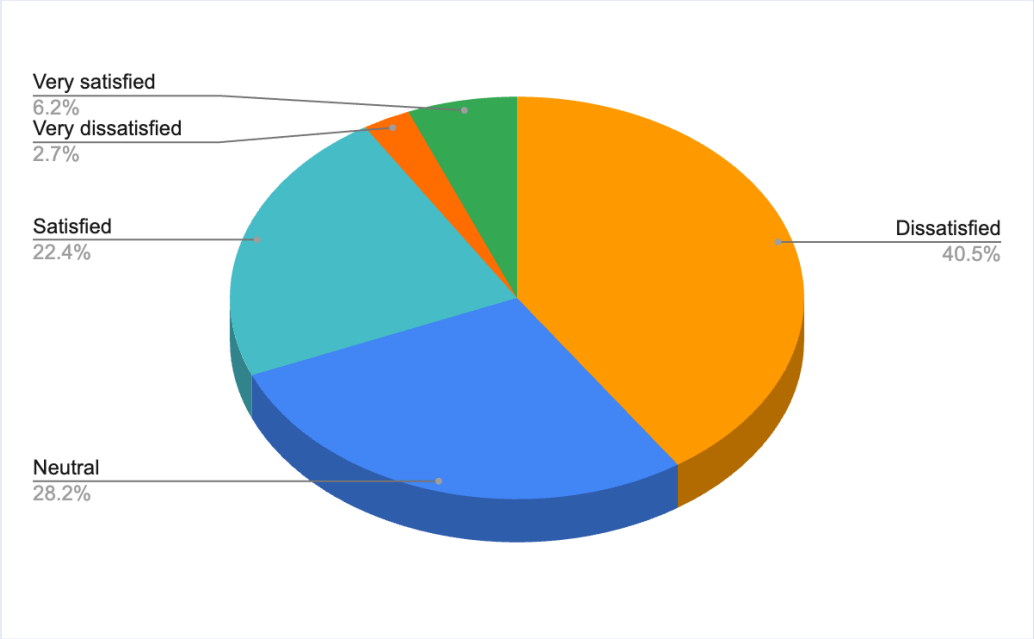

Figure 4.41
Audience's sentiment about current integration of software systems

The sentiment analysis of audience members regarding current software system integration reveals that a significant majority (71.4%) are either neutral (28.2%) or dissatisfied (40.5%) or very dissatisfied (2.7%) with the current situation. Conversely, only 28.6% of the audience reported being satisfied (22.4%) or very satisfied (6.2%). These findings suggest that there is significant improvement required in how software systems are integrated, and that more work needs to be done to address the concerns of users.

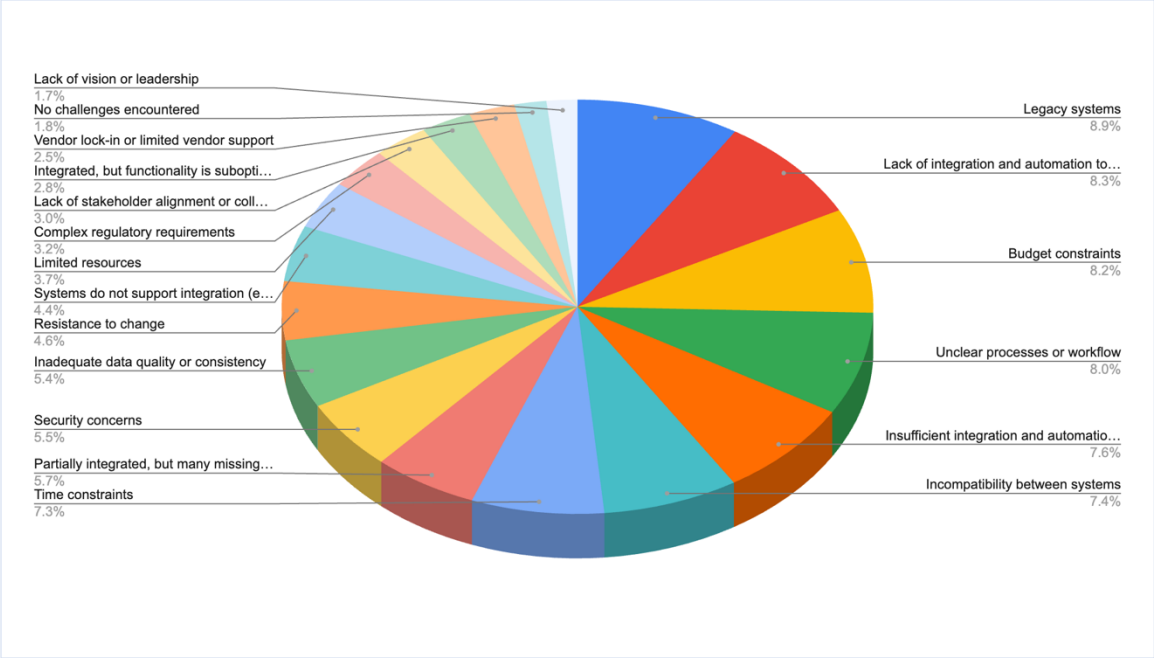

Figure 4.42
Challenges of integrating software systems and business automation.

The chart depicts the top challenges faced by the participants in their businesses when integrating software systems and automating business processes. More than 90% of the respondents are facing some or the other challenges in integrating software systems and automating business processes. ‘Legacy systems’ emerged as the most prominent challenge, followed by notably ‘Lack of integration and automation tools’, ‘Budget constraints’, ‘Unclear processes or workflow’, ‘Insufficient integration and automation skills’, ‘Incompatibility between systems’, ‘Time constraints’, ‘Partially integrated, but many missing use cases’ and ‘Security concerns’ voiced as the key challenges. These findings suggest that businesses face a multitude of obstacles when attempting to implement software systems and automation, and that addressing these challenges is crucial for successful integration and business process realization.

4.4.2 Need for intelligent automation and perception of industry

Intelligent automation or Hyper-automation is needed to unify organization strategy, optimize end-to-end processes to enable innovativeness, efficiency, productivity, and standards by reducing human involvement (Haleem et al., 2021, p. 3). To assess the perception of the need for intelligent automation with AI techniques from the senior businesspeople, the following questions are asked in the survey.

- To what extent do you believe that the adoption of Artificial Intelligence (AI) techniques like AI augmented Software Engineering has the potential to improve systems integration and automation in your organization?
- To what extent has your organization adopted Artificial Intelligence (AI) techniques for systems integration and business automation?
- How inclined are you to implement AI Augmented Software Engineering and related AI techniques for intelligent system integration and business automation in your organization?

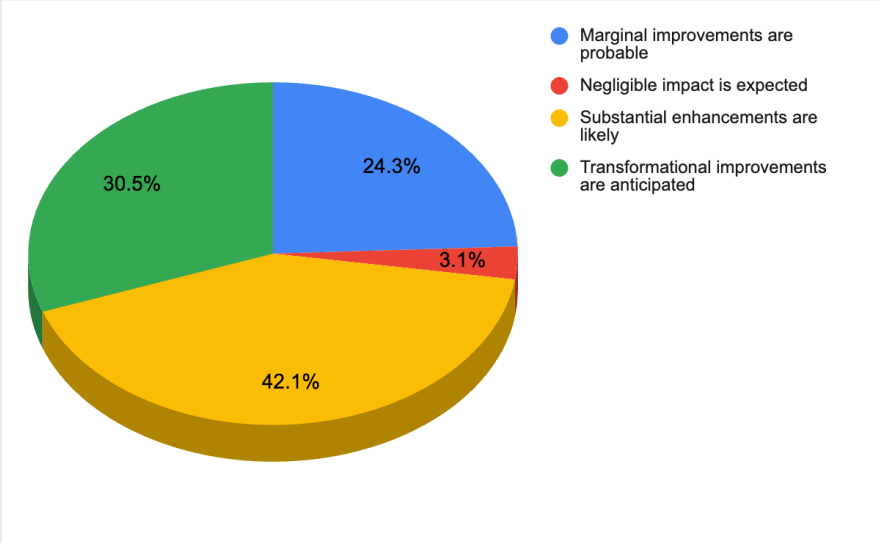

Figure 4.43
Audience belief and expectation on adoption of AI techniques

A large majority (73%) of respondents to the survey indicated that they believe the adoption of AI techniques like AI augmented software engineering will have a transformative or substantial impact on improving systems integration and automation within their organizations. This finding suggests a widespread optimism and belief in the potential of AI to address challenges in this area. Notably, only 3% of respondents anticipated a negligible impact, indicating a low prevalence of skepticism regarding the potential benefits of AI in this context. However, it is important to acknowledge that a minority (24%) still expect only marginal improvements, suggesting that some reservations or uncertainties persist.

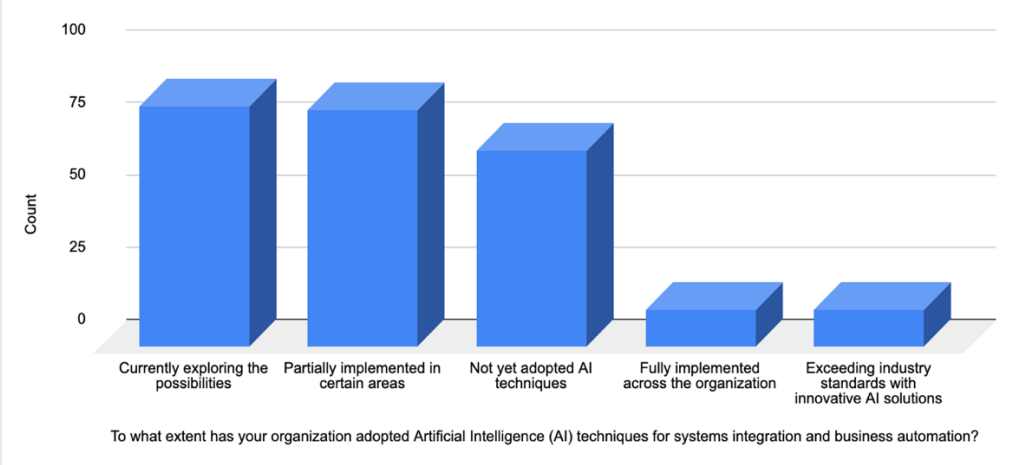

Figure 4.44
Current level of adopting AI techniques in integration and automation.

The survey findings reveal a noteworthy trend in organizational adoption of artificial intelligence (AI) techniques for systems integration and business automation, with a substantial 74% of organizations embracing such technologies, and an impressive 10% surpassing industry benchmarks or have successfully implemented across their

operations. However, a larger segment (36%) has only achieved partial implementation, and 24% have yet to incorporate AI at all. The findings highlight a growing awareness of AI's capacity to enhance systems integration and automation, while also emphasizing the persistence of implementation challenges, necessitating ongoing support and research to develop tailored system integration and automation solutions for organizations.

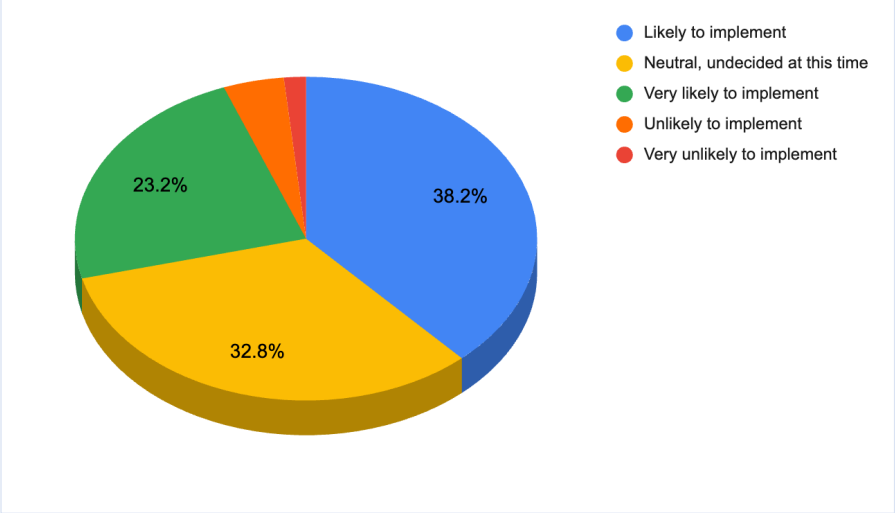

Figure 4.45
How inclined the audience to implement AIASE and other AI techniques.

An analysis of organizational inclination towards AI-augmented software engineering (AIASE) and related AI techniques reveals a significant interest, but also highlights the presence of uncertainty and reservations. While a combined 61% of respondents expressed strong enthusiasm responding, “Very likely to implement” (23.2%) or “Likely to implement” (38.2%), a sizeable group (33%) remained undecided or neutral. This suggests that while many organizations recognize the potential benefits of AI for system integration and business automation, a sizeable portion requires further information or resources to overcome potential doubts or barriers to implementation. Notably, only 5% of respondents indicated an unlikely or very unlikely adoption,

pointing towards a generally positive yet cautious sentiment towards embracing these AI-driven system integration and automation.

Table 4.19
The 'Perceived Need' for intelligent automation with influencer and scale

Influencer	**Method**	**Inclination**	**Need Scale**
Consensus and Evidence	Literature Review	Very High	Very High
Business Complexity Analysis	Market Research	High	High
Established AI Techniques	Market Research	Moderate	Moderate
Integration Need	Quantitative Survey	87%	Very High
Integration Challenges	Quantitative Survey	90%	Very High
Sentiment of Current State	Quantitative Survey	Negative	High
Belief on AI Techniques	Quantitative Survey	73%	High
Future use of AI Techniques	Quantitative Survey	61%	High

Note: Scale is classified as Very High (>80%), High (60% to 80%), Moderate (40% to 60%), Low (20% to 40%), Very Low (<20%).

Consensus and Evidence from the literature review indicate a very high perceived need for intelligent automation, supported by a wealth of evidence and research findings. Business Complexity Analysis from market research suggests a high inclination towards intelligent automation, correlating with the complexity of modern business environments. Established AI Techniques in the existing integration and automation solutions, also identified through market research, show a moderate inclination towards intelligent automation already existing, indicating a recognized but not yet fully embraced potential. The results from the quantitative survey further validate the perceived need, with a significant majority (87%) identifying a very high integration need and an even higher percentage (90%) citing very high integration challenges. Additionally, sentiment analysis of the current state reveals a negative sentiment, indicating a high need for

improvement. Despite this, there is a high belief (73%) in the efficacy of AI techniques and a high inclination (61%) towards their future use in addressing integration challenges, underscoring their perceived need scale of intelligence in enhancing system integration and automation.

4.5 Research Question Two

The second research question is ‘What skillset and environment are required to implement AI techniques like AIASE to achieve Augmented Intelligent Process Automation (AIPA)?’.

The literature review reveals that a strong understanding about the business, business process, systems involved, and the required integration among systems, are the process skills that are needed in a business. The literature review further demonstrates a lineage of the technologies that can help system integration and automation like WfMS, RPA, CPA, IPA combined with AI techniques like DTO, OCR, NLP, ML, AIASE, SASO, SISSY, GenAI, and the tools around these technologies are the technical skills that are needed in a business to achieve AIPA.

The foundational market research on systems and solutions with respect to this research question exposes the skills required on strong understanding of various system categories, organizations behind these systems, cost factors, customer categories, industries, domain model, functionalities, built-in integrations, popular interface types, underlying databases, integration programming languages, regulatory and compliances needed for systems, system integration and business automation. Furthermore, the knowledge on various categories integration and automation solutions and platforms like DIP, AIP, iSaaS, iPaaS, aPaaS, LCAP, NCAP, RPA, BPA, DPA, IPA, and the internals of these platforms including their positioning, cost factors, domain model, functionalities,

level of AI usage, integration languages, interface types etc. and how these are ingredients for system integrators to provide comprehensive solution.

To further elucidate the skillset, and environment required for leveraging AI techniques like AIASE to achieve AIPA from the senior businesspeople, the survey formed questions that focuses on current skills for integration, external consultancy/ implementation support, tools usage, their perception of approach, technical and professional skills, and the needed environment.

- Does your organization have skills for integrating the software systems?
- Is your organization getting integration/ automation consultancy and implementation from experts?
- Does your organization utilize any integration or automation software to connect your software systems together?
- What do you consider as a best approach for software systems integration and automation?
- What technical and professional skills do you think are required to implement Artificial Intelligence (AI) techniques for systems integration and business automation?
- What environment do you think you need for using Artificial Intelligence (AI) techniques for systems integration and business automation?

The expected skills for achieving AIPA can be categorized into business knowledge, systems knowledge, integration knowledge, integration solution knowledge, and skills of established and emerging technologies based on the literature review and market research study.

Table 4.20
The 'Expected Skill Level' from literature review and market research.

Skill Category	Method	Expected Skill Level
Business Knowledge	Literature Review	High
Systems Knowledge	Market Research	Very High
Integration Knowledge	Literature Review	Very High
Integration Solution Knowledge	Market Research	High
Established Technologies	Literature Review	High
Emerging Technologies	Literature Review	Moderate

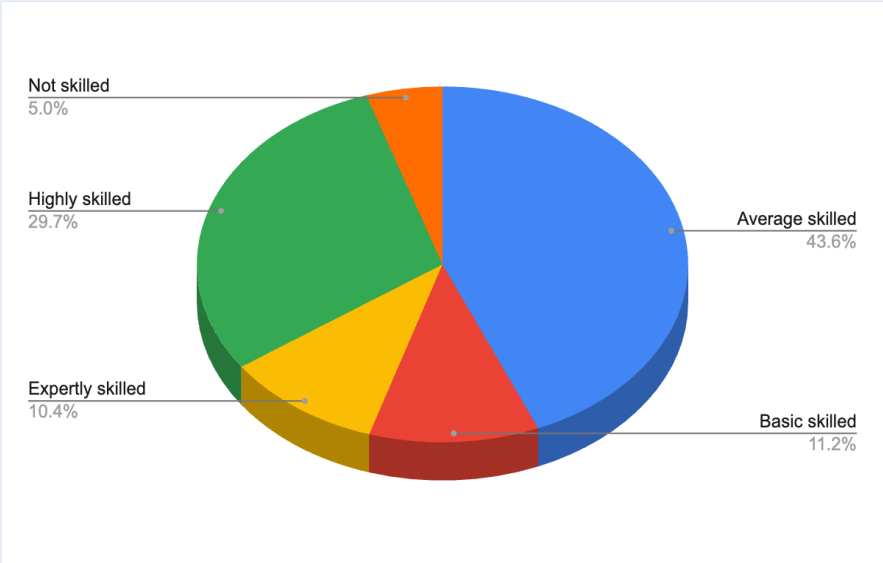

Figure 4.46
Current skill level of organization in software systems integration.

An analysis of the current staff's integration skills reveals that a significant 60% of respondents replied that their organization lack the necessary expertise for seamless system integration within business process automation, either possess average integration skills (43.6%), or concerning not skilled (5.0%) or possess only basic skills (11.2%). This skills gap suggests that a substantial portion of the workforce struggles with the challenges from system integration.

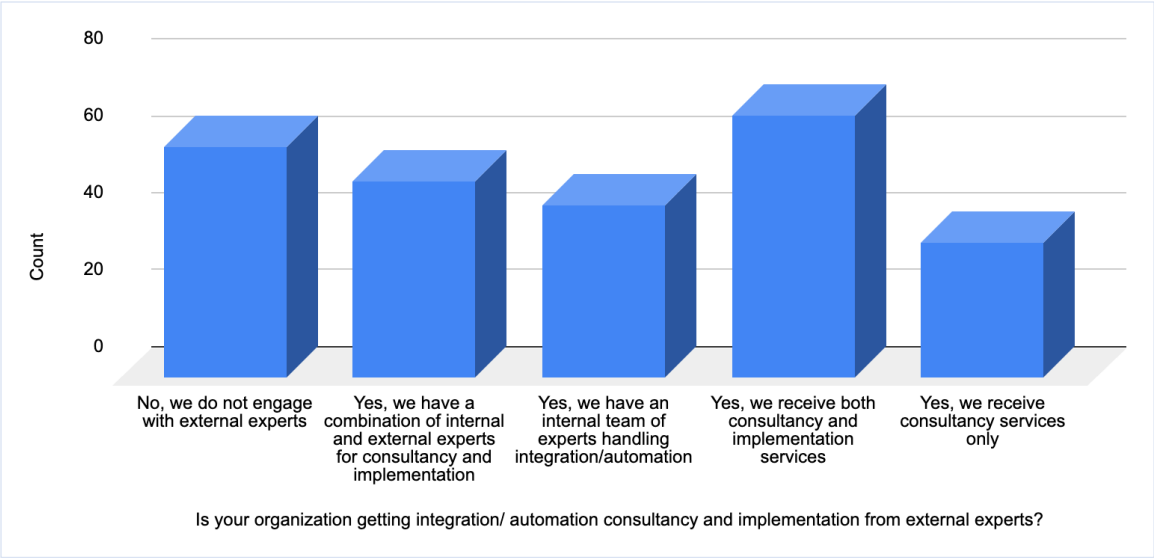

Figure 4.47
External experts' consultancy and implementation in system integration and automation

3 out of every 5 respondents confirmed that they use some form of external expertise in either consultancy or implementation or both for software systems integration and automation. Only 1 out of 5 respondents said they have an internal experts' team to handle software systems integration and automation. The remaining 1 out of 5 is currently neither having internal experts nor engaging with external experts. The prevalence of support taken from external experts, for consultancy or implementation evidence at the potential complexity of system integration and automation, prompting specialized external expertise.

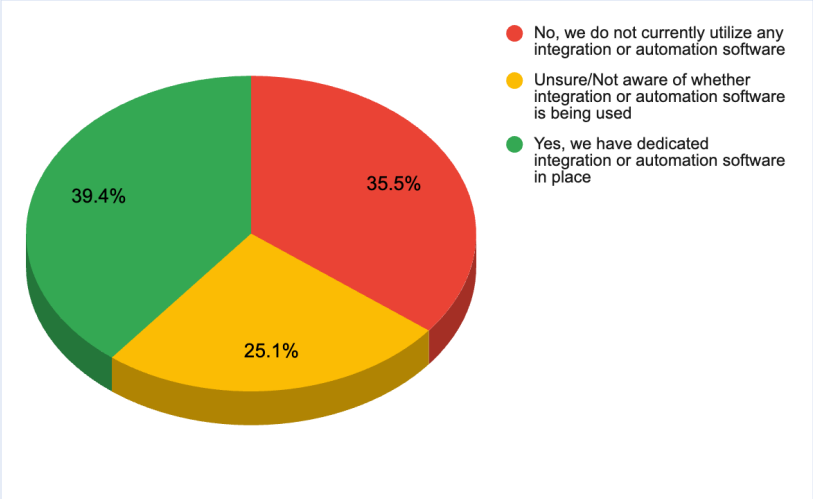

Figure 4.48
Integration and automation software usage

The data indicates that 39% of organizations have dedicated integration or automation software in place, while 36% do not currently utilize any such software. Interestingly, 25% of respondents are unsure or not aware of whether integration or automation software is being used within their organization. This highlights a potential gap in awareness or understanding of the integration and automation tools being employed as a total of 61% are either not using or unaware, reinforcing the need for and awareness and skill building efforts within organizations.

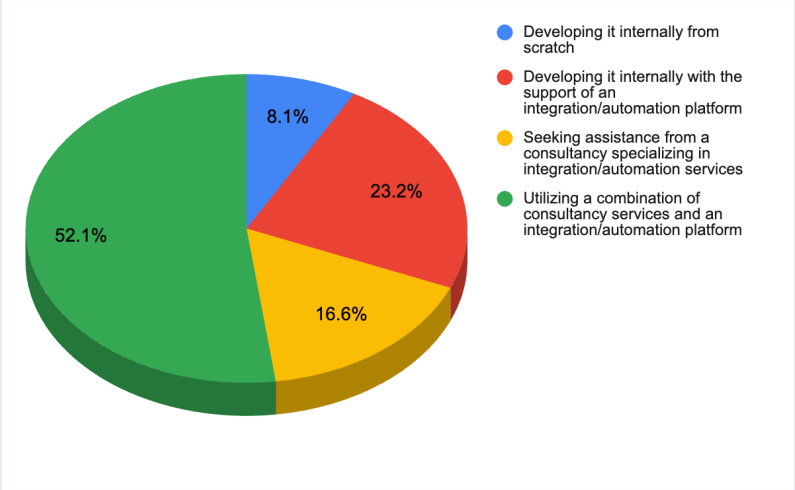

Figure 4.49
Approach for software systems integration and automation

When asked for the preferred approach for system integration and automation, majority of the respondents (52%) favored utilizing a combination of consultancy services and an integration/automation platform. Additionally, 23% indicated that developing integration and automation internally with the support of a specialized platform was the preferred approach. Seeking assistance from a consultancy specializing in integration/automation services garnered 16% of responses, while developing solutions fully internally from scratch was the least favored option, with only 8% of respondents expressing preference for this approach. These results suggest a preference for leveraging external expertise and support in conjunction with advanced automation platforms, indicating a recognition of the complexity and specialized skill set required for effective implementation of AI driven system integration and automation solutions.

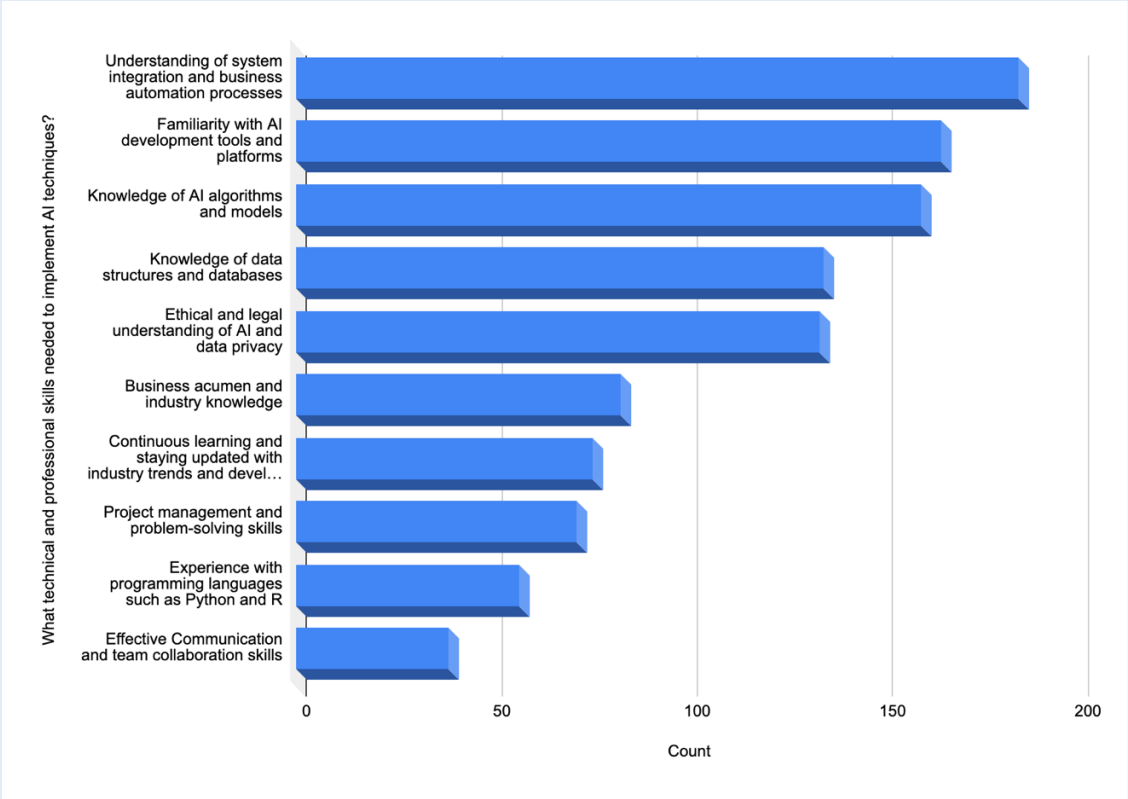

Figure 4.50
Technical and professional skills for AI techniques in integration and automation

Analyzing the required skillset for AI powered integration and automation, the survey reveals a multi-faceted profile demanding both technical and professional expertise. At its core lies a strong foundation in system integration and business automation processes (71%), further bolstered by proficiency in AI development tools and platforms (64%) and knowledge of AI algorithms and models (62%). Data competency plays a key role, highlighted by the need for data structures and databases knowledge (52%), alongside ethical and legal considerations reflected in the importance of understanding AI and data privacy (52%). Business acumen and industry knowledge (32%) emerge as critical elements, emphasizing the focus on delivering impactful business solutions beyond just technical prowess. Adaptability is underscored by the need for continuous learning (29%) and effective communication and collaboration (15%). While programming skills (22%) are valuable, they are outweighed by the emphasis on broader problem-solving abilities. This paints a picture of a team requiring a diverse skillset that go beyond purely technical expertise, embracing business understanding, ethical awareness, and a commitment to continuous learning and collaboration.

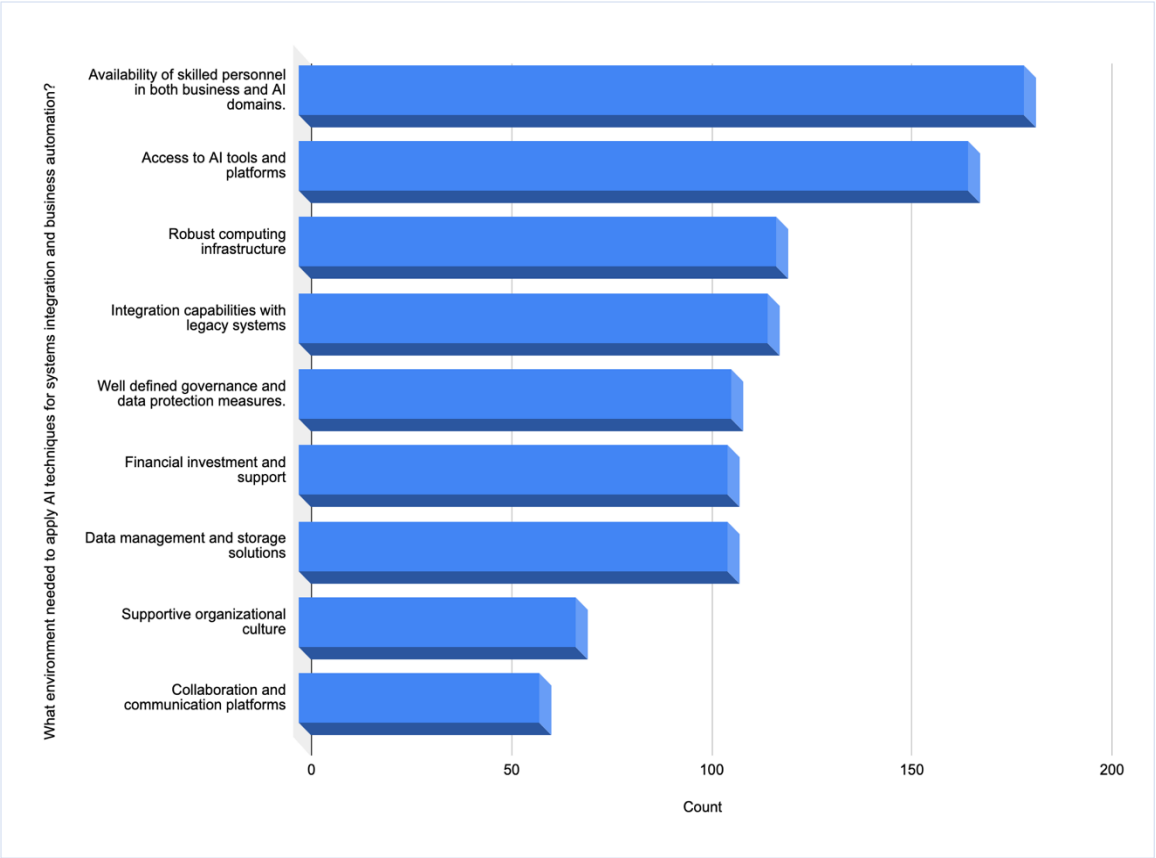

Figure 4.51
Environment needed for AI techniques in integration and automation.

Implementing AI techniques like AIASE for AIPA necessitates a carefully cultivated environment, as revealed by the survey findings. The cornerstone lies in access to skilled personnel (70%) across both business and AI domains, ensuring a bridge between technological capabilities and real-world needs. This is closely followed by the need for AI tools and platforms (64%), empowering the workforce with the necessary resources to translate ideas into reality. A robust computing infrastructure (45%) forms the backbone, enabling efficient data processing and model training. Integration capabilities with legacy systems (45%) are crucial for ensuring seamless adoption within existing IT landscapes. The foundation is solidified by well-defined governance and data protection measures (42%), fostering trust and mitigating risks associated with AI

deployment. Financial investment and support (41%) provide the energy for sustained development and implementation efforts, while robust data management and storage solutions (41%) ensure the AI engine has access to the necessary fuel. Interestingly, supportive organizational culture (27%) and collaboration and communication platforms (23%) emerge as significant factors, highlighting the importance of fostering a culture of innovation and open communication to bridge potential silos and ensure successful AIPA adoption. for Cultivating an environment rich in human capital, technological resources, sound governance, and a collaborative spirit appears to be paramount for harnessing the power of AIASE and achieving AIPA's transformative potential.

The skill level and environment readiness outlined above serve as essential benchmarks, forming a comprehensive checklist for organizations embarking on the integration of AI techniques like AIASE to enhance system integration and business automation. Prior to implementing such advanced technologies, it is imperative for organizations to meticulously assess both the skill level of their workforce and the readiness of their operational environment. This assessment ensures that the organization possesses the necessary expertise and infrastructure to effectively leverage AIASE and similar techniques, thus maximizing the potential benefits of intelligent automation while minimizing potential challenges. By prioritizing skill development and ensuring environmental preparedness, organizations can pave the way for successful integration of AI driven solutions, ultimately driving innovation and competitiveness in the rapidly evolving landscape of system integration and business automation.

4.6 Research Question Three

The third research question is ‘What benefits and challenges AIASE brings to system integration and business automation and who will be benefited?’.

The literature study revealed that AIASE is relatively new and a novel technique to boost software engineering productivity. This research question tries to connect AIASE specifically with system integration and business automation and elicits the expected benefits and challenges. The following questions are presented to the senior businesspeople in the survey.

- To what extent do you believe that the adoption of Artificial Intelligence (AI) techniques like AI augmented Software Engineering has the potential to improve systems integration and automation in your organization?
- What are the biggest benefits you anticipate from implementing AI Augmented Software Engineering and related AI techniques for intelligent system integration and business automation in your organization?
- To what extent has your organization adopted Artificial Intelligence (AI) techniques for systems integration and business automation?
- What are the potential challenges associated with the integration and automation of business systems using Artificial Intelligence (AI) techniques?
- How inclined are you to implement AI Augmented Software Engineering and related AI techniques for intelligent system integration and business automation in your organization?
- Which stakeholders in your organization will benefit the most from AI-driven system integration and business automation?

In the previous section, the audience belief on using AI techniques to improve system integration and business automation was analyzed. A significant share of 97% of the respondents mentioned that AI techniques bring some form of improvements to

system integration and automation. This indicates the audience are seeing AI techniques in system integration and automation and believe it is beneficial.

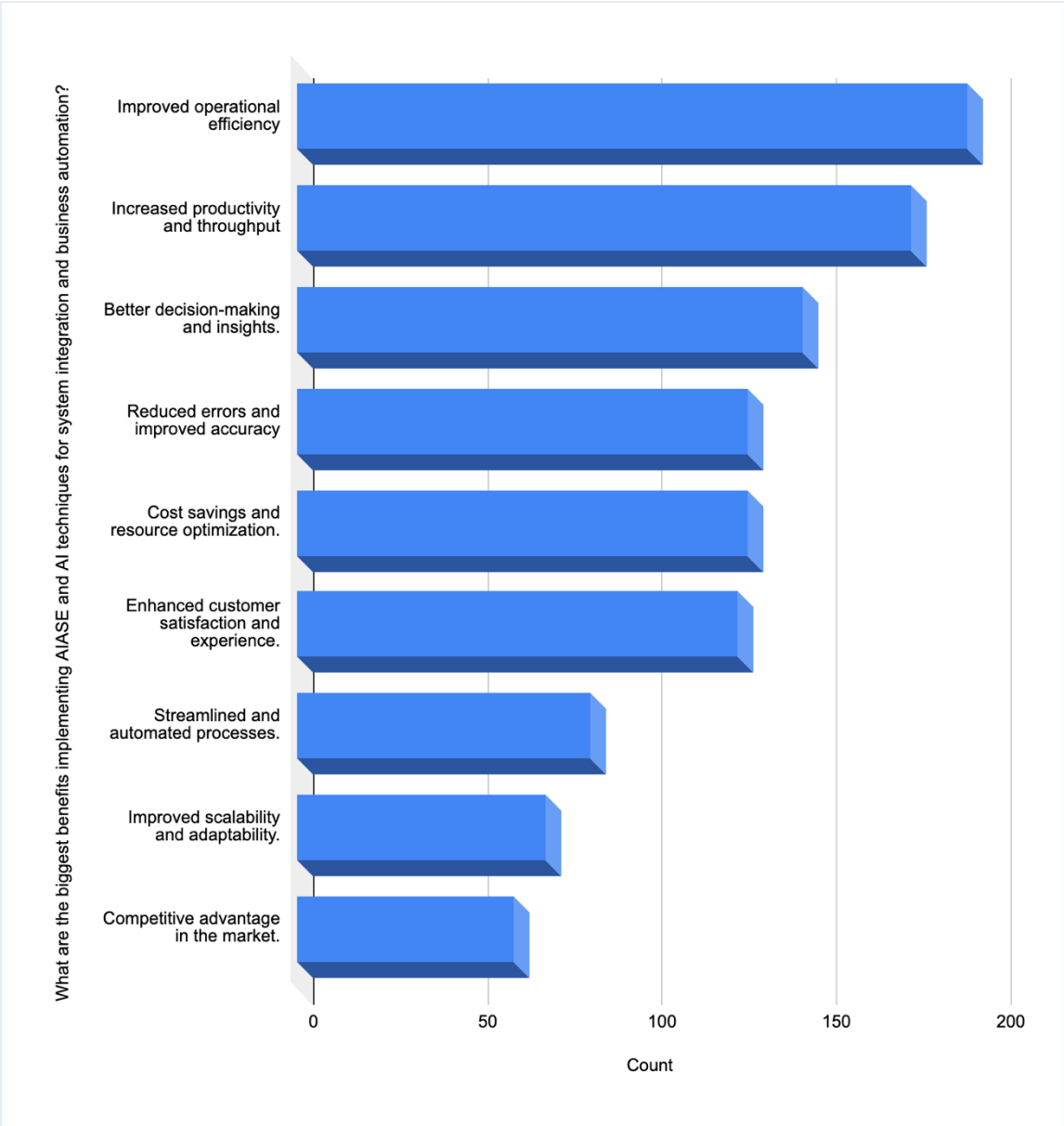

Figure 4.52
Benefits of AIASE and AI techniques in software systems integration and automation.

Deep diving to investigate the perceived benefits of AI Augmented Software Engineering (AIASE), the survey reveals a clear focus on enhanced operational

efficiency (74%) and increased productivity and throughput (68%). Organizations anticipate AIASE to unlock valuable business insights and improve decision-making (56%), alongside reducing errors and improving accuracy (50%) for streamlined operations. Cost savings and resource optimization (50%) emerge as key drivers, potentially through automation and process improvement. Notably, enhanced customer satisfaction and experience (49%) gain significant traction, highlighting the potential for AIASE to elevate customer interactions. Streamlined and automated processes (32%) are perceived as additional benefits, paving the way for improved scalability and adaptability (27%). Interestingly, a competitive advantage in the market (24%) appears as a long-term vision for some organizations, suggesting potential for AIASE to contribute to strategic differentiation. Overall, the findings paint a compelling picture of AIASE as a multifaceted tool capable of transforming system integration and business automation, driving efficiency, accuracy, customer satisfaction, and ultimately, a competitive edge.

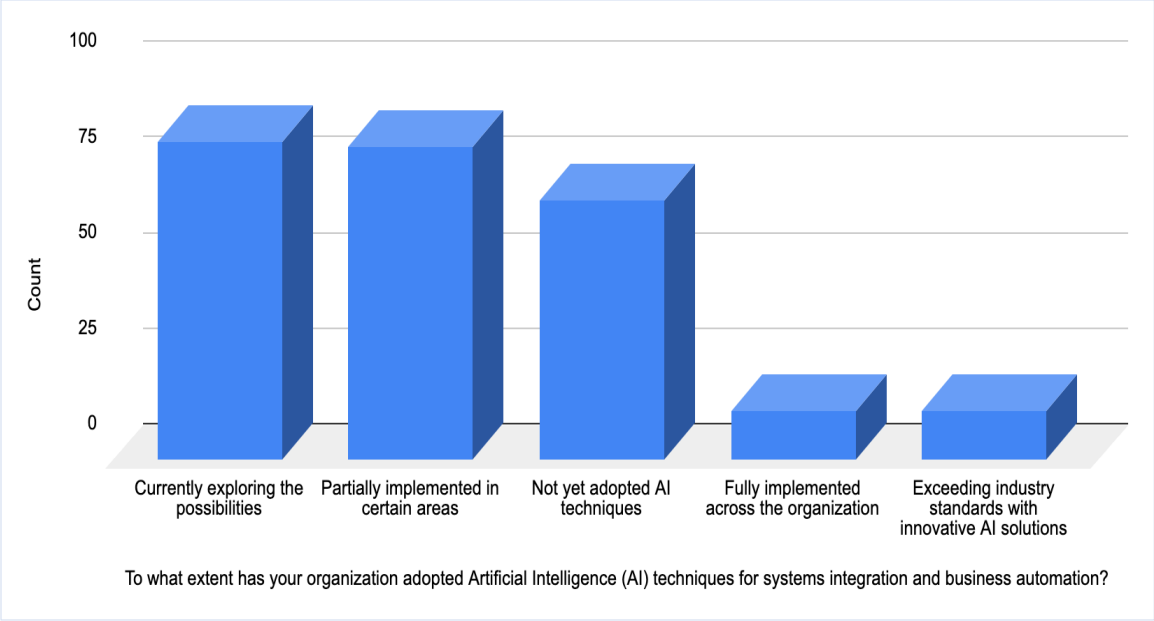

Figure 4.53
Organization's adoption of AI techniques for system integration and automation.

Examining AI techniques like AIASE adoption within organizations, the survey unveils a diverse landscape: 32% are actively exploring its potential, highlighting an undeniable interest in this technology. However, 26% haven't yet adopted AI techniques, suggesting either hesitancy or lack of awareness. While 32% report partial implementation, and a select few boast full integration or even industry-leading solutions (5% each), widespread adoption appears to be in its early stages. This summarizes to only 10% have fully implemented AI techniques for system integration and automation but 90% has not yet started or still exploring or only partially implemented AI techniques though a significant 97% believe on the improvements as highlighted in the earlier question. This dichotomy underscores the challenges associated with AIASE implementation. By acknowledging the challenges and fostering an environment conducive to innovation, organizations can unlock the transformative power of AIASE and contribute to the ever-evolving landscape of intelligent automation.

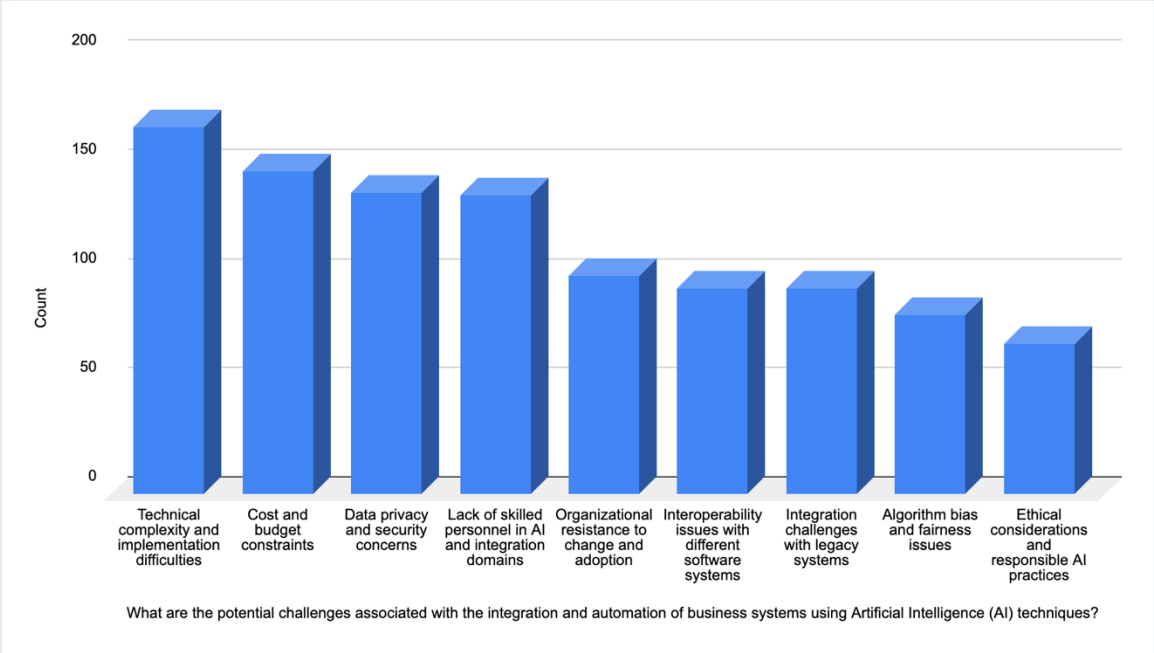

Figure 4.54
Challenges in using AI techniques for system integration and automation.

While AI techniques like AIASE hold immense promise for transforming system integration and business automation, the survey unveils a landscape filled with potential challenges. Technical complexity and implementation difficulties (65%) emerge as the top concern, highlighting the intricate nature of integrating AI effectively. Close behind are cost and budget constraints (57%), underlining the need for careful financial planning and resource allocation. Data privacy and security concerns (53%) loom large, necessitating robust data governance and ethical practices. The lack of skilled personnel (53%) in AI and integration domains poses a significant hurdle, further amplified by organizational resistance to change and adoption (39%). Interoperability issues between diverse software systems (36%) and integration challenges with legacy systems (36%) pose additional technical roadblocks. The element of algorithm bias and fairness issues (32%) underscores the need for responsible AI development and deployment. Finally, ethical considerations and responsible AI practices (27%) emerge as crucial factors, emphasizing the importance of building trust and aligning AI initiatives with organizational values. Addressing these challenges head-on through strategic planning, skills development, ethical frameworks, and robust data governance will be essential for organizations to unlock the full potential of AIASE and navigate the path toward intelligent automation.

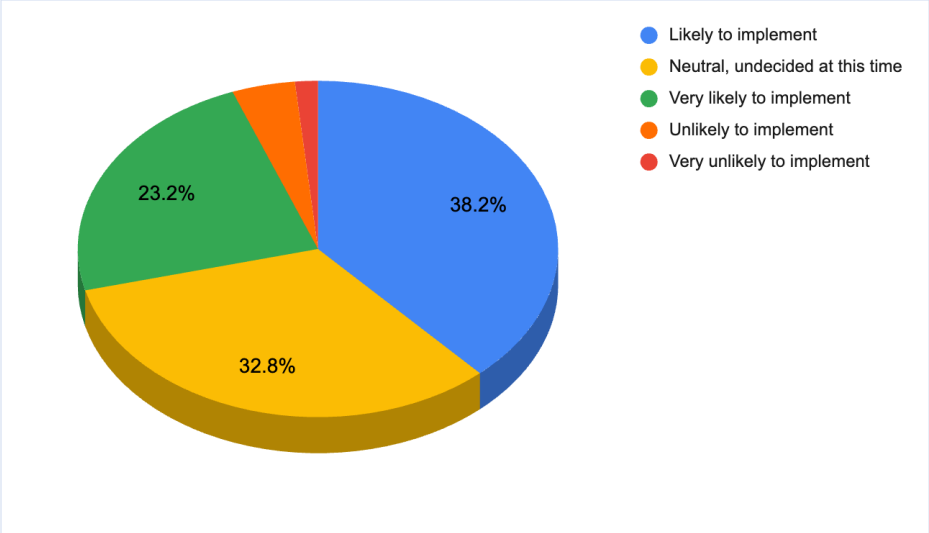

Figure 4.55
Incline to implement AI augmented system integration and automation.

While the above result is presented in the previous section, it is brought here in context to highlight that despite the potential challenges envisioned in the previous question, only a 5% are not looking for implementing AI techniques for system integration and business automation underlining the potential benefits overweigh the potential challenges.

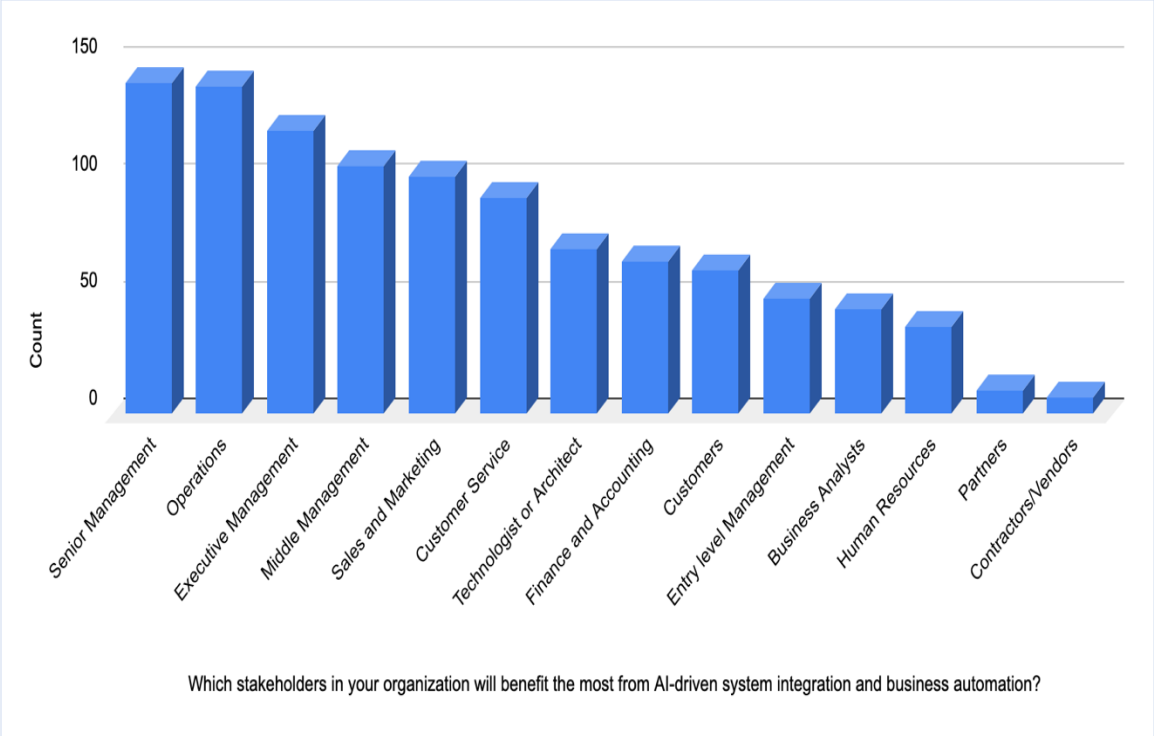

Figure 4.56
Stakeholders benefited from AI driven system integration and automation.

Investigating the potential beneficiaries of AI powered system integration and business automation with techniques like AIASE, the survey reveals a widespread impact across organizational functions. Senior Management, Operations, and Executive Management (54%, 54%, and 47% respectively) emerge as frontrunners, poised to capitalize on improved decision-making, efficiency gains, and strategic insights. Middle Management (40%) stands to benefit from streamlined processes and data-driven insights, while Sales and Marketing (39%) and Customer Service (36%) are empowered by enhanced responsiveness and personalized experiences. Notably, Customers (24%) are recognized as direct beneficiaries, highlighting the potential for AIASE in system integration to elevate interactions and satisfaction cutting across systems. Technologists and Architects (27%) gain valuable tools for development and integration, while Finance and Accounting (25%) streamline tasks and improve financial insights. Business Analysts

(17%) and Human Resources (14%) are equipped with better data and automation for more informed decision-making. Interestingly, even Partners (4%) and Contractors/Vendors (3%) recognize potential benefits, suggesting a ripple effect throughout the ecosystem. This comprehensive picture reinforces the transformative potential of AI techniques like AIASE, impacting stakeholders at all levels and driving organizational success through its multifaceted benefits in system integration and business automation.

The application of AI techniques such as AIASE in system integration and automation presents a multifaceted landscape characterized by its benefits, challenges, and beneficiary stakeholders. Despite the inherent challenges associated with implementing AI driven system integration and business automation, the overwhelming inclination towards adopting these techniques underscores the substantial benefits they offer. Organizations stand to gain significant advantages in terms of efficiency, productivity, and competitiveness by leveraging AI in their integration and automation processes. Moreover, a diverse range of stakeholders are poised to benefit from the successful implementation. While challenges certainly exist, the collective determination to harness the potential of AI in integration and automation remains robust, signaling a promising future for intelligent automation technologies like AIASE in revolutionizing the way organizations operate and innovate.

4.7 Research Question Four

The fourth and final research question is ‘How to approach an implementation of AIASE for intelligent system integration and business automation?’.

AI augmented software development or software engineering with the recent advancements in Generative AI like Large Language Models (LLM) can lead to a future

of “self-validating software development” or “self-adaptive software development” or “reflective, intelligent software development” or “design prompt-driven iterative development.” (Ozkaya, 2023). A research paper on of System Integration for Large-Scale Software Projects summarizes the Models, Approaches, and Challenges and highlights future work on system integration shall be aimed to mitigate interoperability and architecture challenges (Shibl et al., 2022)

In this research, the future of AI augmented software engineering is explored to provide an approach to mitigate interoperability and architecture challenges of system integration and enabling efficiency in business process automation. The approach aims at building a software platform that enables AIASE in integration and automation. The knowledgebase, models, and architecture required for system integration along with the building blocks, algorithm to reach an implementation approach of AIASE for intelligent system integration and business automation are illustrated in this section.

4.7.1 Key functionalities

The foundational market research conducted on integration and automation solutions serves as the cornerstone for the proposed implementation, providing a comprehensive understanding of domain entities and functionalities essential for effective system integration and business automation. This in-depth study lays the groundwork for compiling a diverse and comprehensive list of must-have functionalities critical to the success of the proposed implementation.

Table 4.21
Key functionalities and related domain entities

Functionality	Domain Entities
Project Management	Organization, Workspace, Project, Task, Services

Content Management	Folder, File, Document
Data Management	Storage, Data, Data Source, Schema, Cleansed Data
Integration Management	Application, Connection, Protocol, Integration
Workflow Management	Workflow, Process, Scheduler
Analytics, Reporting, Business Intelligence	Report, Chart, Dashboard
Subscription Management	Contact, Customer, Account, Subscription, Billing, Invoice, Receipt,
Security Management	User, Authentication, Role, Privilege, Group

The proposed approach incorporates these functionalities in the platform as these are identified as foundational for any integration and automation platform in the study.

4.7.1 Knowledgebase

Knowledgebase is a backend data for AI engines to provide knowledge, experience, and creativity for AI systems namely Analytical AI, Cognitive AI, and Generative AI (Beheshti, 2023). This research collected a comprehensive dataset on systems and integration solutions which forms the foundational knowledge for building AIASE solution for system integration and business automation.

4.7.1.1 Systems Dataset

Secondary data of systems collected in this research forms the key foundational knowledgebase with 407260 attributes from 14545 systems across 601 system categories. Key attributes of each system include:

- Domain Entities
- Features and Functions
- API
- Built-in Integrations

- Interface Types
- Data storage
- Integration Language

This dataset provides a necessary knowledge about the systems that needs to be integrated to realize business process.

4.7.1.2 Integration Solution Dataset

The dataset of integration solutions is sourced as secondary data with the collection, analysis, and synthesis of 15000+ attributes on 500+ software solutions of varied categories – DIP, AIP, iSaaS, iPaaS, aPaaS, NCAP, LCAP, RPA, BPA, DPA and IPA. Key attributes of the integration solution include the following:

- Integration categories
- Customer categories
- Target industries
- Domain Entities
- Features and Functions
- Interface and Client Types
- Data storage
- Integration Language

The knowledgebase distills the characteristics of the integration solution and helps clustering, labeling systems, and mimicking system integration in the implementation.

4.7.2 Requirements knowledgebase

At the heart of the proposed AIASE driven system integration and automation platform lies a robust requirements knowledgebase. This serves as the single source of truth, capturing critical information about the actors involved (users, systems, etc.), the use cases they represent, the context in which they operate, and the necessary instructions

for automation. Additionally, it incorporates relevant documentation, including existing documents, files, and websites, to provide a holistic understanding of the system landscape.

This knowledgebase is a comprehensive map guiding the AIASE driven integration and automation platform with the following details of key concepts.

- Actors and roles define the who and what – the users, systems, and their responsibilities within the integrated environment.
- Use cases represent the specific tasks and goals the platform needs to address, outlining the desired functionality and expected outcomes.
- Context provides vital information about the environment in which these use cases occur, including relevant data sources, dependencies, and external factors.
- Detailed instructions act as the recipe for automation, specifying the steps, tools, and dataflows involved in each task.
- Additional documentation serves as the historical record and reference point, ensuring continuity and facilitating ongoing development and maintenance.

By centralizing this knowledge, the AIASE driven platform gains a deeper understanding of the requirements and intricacies and can make informed decisions about integration and automation strategies. This empowers the platform to adapt to changing requirements, identify potential issues, and continuously improve its performance.

4.7.3 Grooming knowledgebase

The knowledgebase prepared as knowledge graph or simply as raw data and stored in graph and vector databases. The knowledgebase once established, does not stay static. The knowledgebase is incrementally and iteratively improved on a continuous

basis from the new or updated knowledge acquired over time. The process of improving knowledgebase is called grooming. There are three parts of the grooming:

- Acquiring – techniques applied to acquiring new/updated knowledge.
- Ingesting – techniques applied to update the existing knowledgebase.
- Tuning – techniques applied to ensure updated knowledgebase is used.

4.7.3 AI modelling and augmented intelligence

"AI-based modelling is the key to build automated, intelligent, and smart systems according to today's need" (Sarker, 2022). The literature review in this research identifies AI techniques like ML, DL, Data Mining, Knowledge Discovery, Advanced Analytics, Text Mining, NLP, Process Mining, Digital Twin, GenAI are suitable for modeling an approach for using AIASE for system integration and business automation.

Unified AI augmented automation initiatives with Robotic Business Process (RPA), Process Mining, Machine Learning (ML), Natural Language Processing(NLP), Optical Character Recognition(OCR), Digital Twin of an Organization(DTO) empower companies with Hyper-automation to intelligently automate tasks, provide seamless connectivity, adaptability and digital agility across multiple systems, freeing employees for higher-value work, cutting costs and boosting efficiency (Haleem et al., 2021).

In the context of system integration and business automation, how AI techniques are applied is illustrated below.

- Process Mining – A process discovery engine continuously works on arriving at patterns and propose process using the 'Flow' building block.
- OCR – Apply OCR to extract information from raw knowledgebase inputs like images, photos and organize into structured information in the knowledgebase ready to use.

- NLP – Apply NLP to parse requirements or use cases input into identified systems, objects, and functions.
- RPA – The ‘Flow’ building block has the additional capability of RPA to automate tasks using software robots that emulate human actions.
- Digital Twin – Make digital twin of all the systems involved in the organization. The knowledgebase of ‘Systems dataset’ plays a critical role in making this happen.

The proposed implementation approach leverages the above listed established AI and automation techniques in the context of system integration and business automation.

4.7.4 Architectural principles and styles

In crafting an implementation approach for AIASE to realize AIPA, certain architectural principles and styles serve as foundational pillars. These principles guide the design and development of proposed approach.

- Loose coupling and high cohesion: Promoting modularity and independence among system components while ensuring strong internal consistency.
- Asynchronous: Emphasizing non-blocking communication to enhance system responsiveness and scalability.
- Data buffering: Employing buffer mechanisms to manage data flow and optimize processing efficiency.
- Plug and Play: Facilitating seamless integration and interchangeability of system components without disruption.
- Realtime, Event-driven and Batch: Supporting diverse processing modes to accommodate varied system requirements and use cases.

- Service Bus and Message based: Leveraging service-oriented architecture and messaging protocols for flexible and efficient communication.
- Multi-Protocol: Enabling compatibility with multiple communication protocols to enhance interoperability and system integration capabilities.

Through this nuanced exploration of these guiding principles, this proposed approach aims to establish a robust foundation for the effective deployment of AIASE in driving architectural goals like performance, scalability, reliability, flexibility, extensibility, interoperability in system integration and business automation.

4.7.5 Building block – Connectors

Connectors are fundamental building blocks to manage interaction between software system by providing three atomic elements – the interaction channel, data transfer and control (Mehta et al., 2000). Connectors establish the underlying interaction channel with target systems such as application, database, device, etc., manage data transfer and control the communication with architecture principle of plug-and-play. The connections shall enable software platform as protocol-agnostic or multi-protocol supporting HTTP/S, TCP, UDP, FTP, SMTP, WebSocket, Device Drivers, etc.,

The analysis on systems dataset have identified the following fundamental constructs needs to be exposed by the connectors.

- Object - represent Domain Entities, Storage and Data in the system. It could be static structure or dynamic structure.
- Function – represent the atomic action that can be performed by a system.
- Events – represent the events that can be triggered by the system.

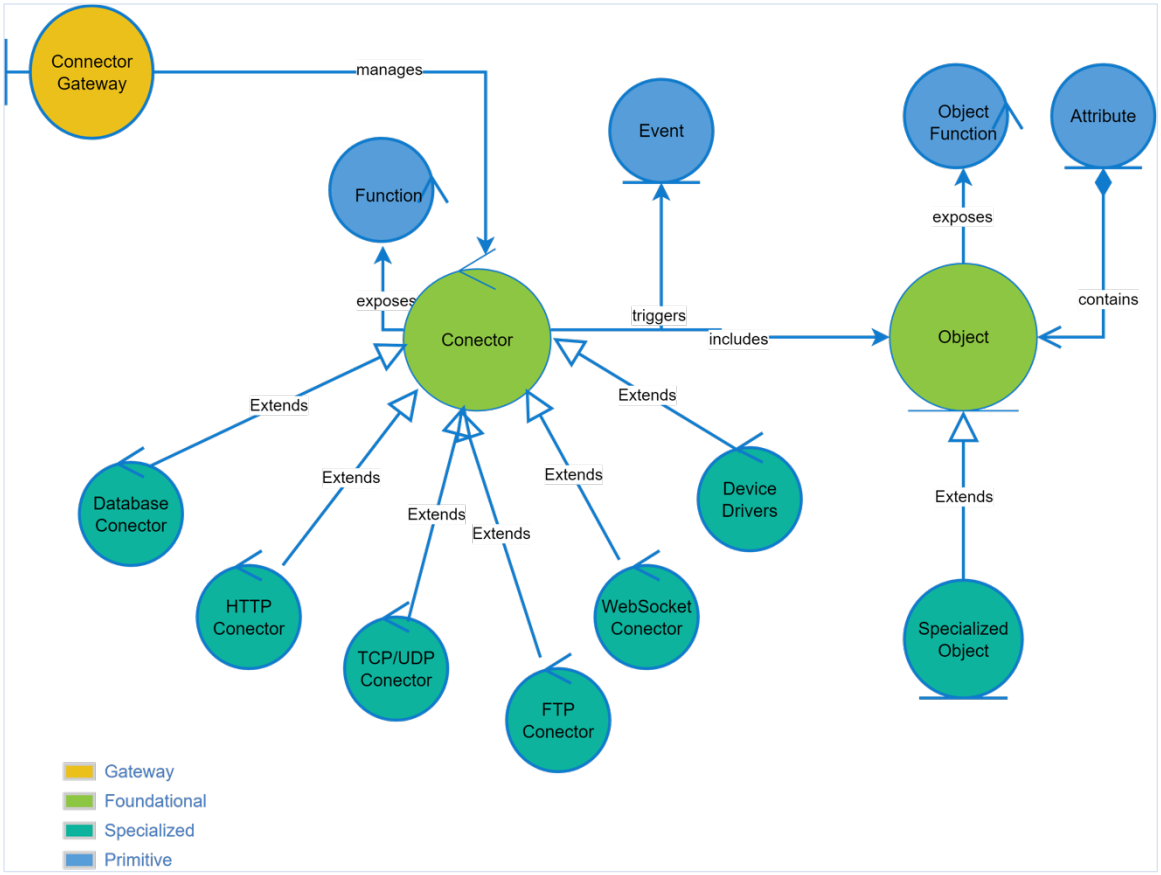

Figure 4.57
Proposed connector model

The connector model expresses the design level classes and relationship among those to build connector building block that can interact with any underlying system. The connector controller and objects are generalized with inheritance to form specialized implementation for specific protocols like HTTP, TCP/UDP, or FTP, ensuring interoperability across heterogeneous systems. Gateways within the model is the entry point for interactions from other building blocks to connector and orchestrates communication with connectors, enabling data exchange and triggering functions based on events. The model provides extensibility through loose coupling and adherence to plug-and-play principles, allowing seamless introduction of new connectors anytime.

4.7.6 Building block – System metadata model

Metadata is a formal representation of data that provides a consistent and standardized definition and description of information with the characteristics of composable small atomic units, datatypes, terminologies, vocabularies, taxonomies that are machine readable and actionable. Metadata and can be stored into metadata repository or data dictionaries (Hannes and Kock-Schoppenhauer, 2022).

In the context of system integration and business automation, the focus of metadata is the data about the systems – the static structure and dynamic behavior of the system to enable integration and automation. A meta model representing systems, objects, attributes, functions, parameters, datatypes, events, processes, tasks, and services as metadata forms this System Metadata Model building block.

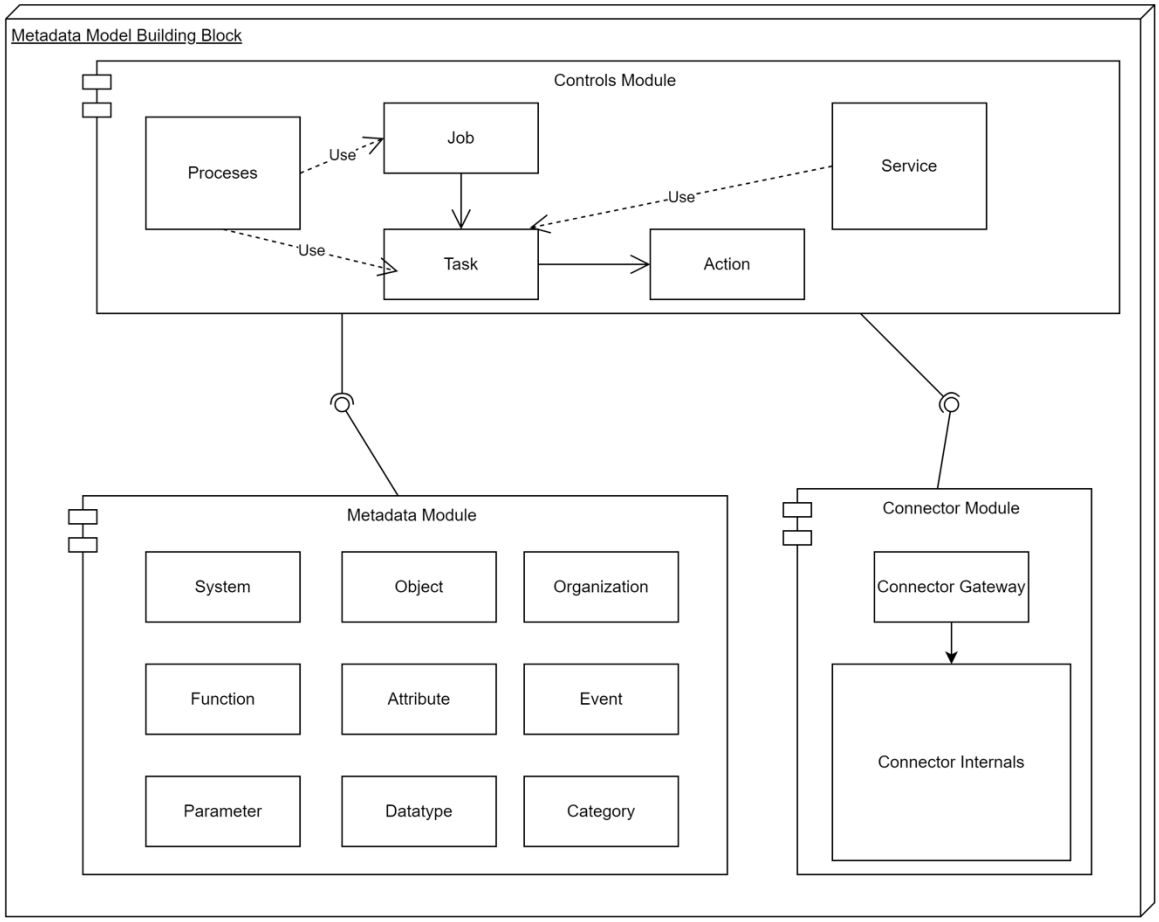

Figure 4.58
Class diagram of proposed metadata model

The proposed AIASE implementation utilizes a layered metadata model to represent and organize essential information for system integration and business automation tasks. At the core lie fundamental entities like systems, objects, functions, and events, each described by comprehensive attributes and parameters. These attributes capture crucial details like data types, protocols, and operational characteristics. This meta module is governed by controls module which communicates with connector in accordance with the metadata. This layered metadata model provides a robust foundation for instrumenting AIASE generated function calls alongside enabling flexibility and extensibility with a dynamic data-driven design in the system integration and business automation context.

4.7.7 Building block – Flow

Flow is a building block to implement a modern Business Process Management System (BPMS) that encompasses capabilities of Workflow Management System (WfMS) with traditional Rule-Based Automation and enabled with Cognitive and Intelligent Automation capabilities. Cognitive Automation leverages ML techniques to mimic and approximate human cognition in machines (Engel et al., 2022) and Intelligent Automation leverages various AI techniques for hyper-automation. (Haleem et al., 2021).

The Flow building block composes, organizes, deploys, executes, and monitors tasks and processes in a business. Flow as a building block shall comprise the following sub-components:

- Trigger – The starting point of the flow. This could range from being automatic based on an event or time to fully manual triggered by a human.
- Action – Atomic action that needs be taken as part of the process.
- Control – Branching and looping control activities.
- Processors – In memory processing like formatting, encoding/decoding, transforming, filtering activities.
- Step – Step is either an action or a control or a processor. Linking multiple steps together makes the Flow.

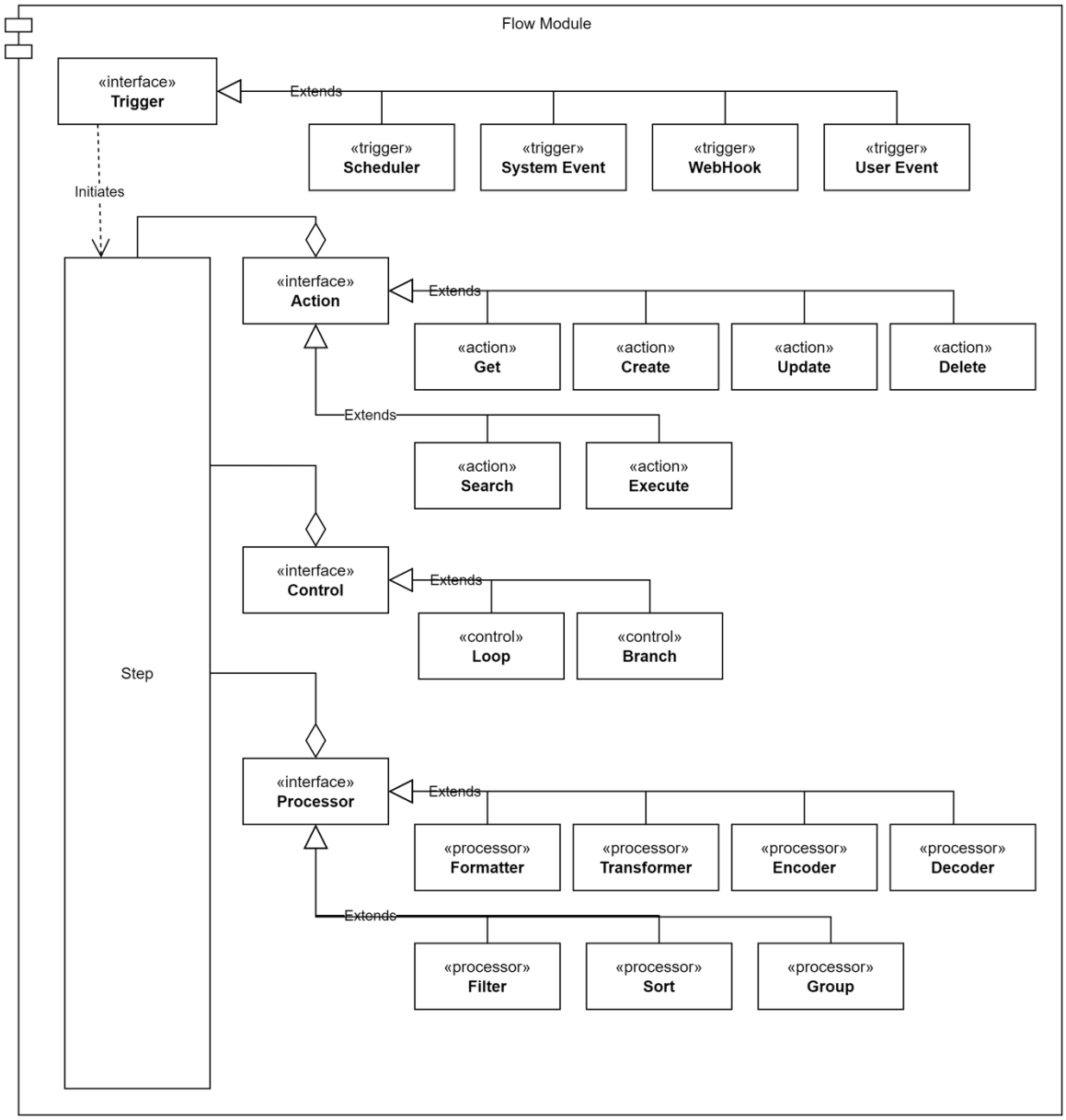

Figure 4.59
Structure of flow

This model offers pre-defined components representing core functionalities: triggers, actions, controls, and processors. Triggers initiate the flow based on events, schedules, or manual interaction. Flow is an assembly of steps, and a step is either an action or a control or a processor. Action executes specific task on a system passing the parameters and context data. Control block manages flow logic, enabling branching,

looping, and decision-making based on conditions. Processor performs in-memory data manipulation tasks like formatting, encoding, transformation, and filtering. The flow building block thereby provides a mechanism to represent, store and execute business processes as workflows.

4.7.9 Building block – No code components

No Code Application Platforms (NCAP) boosts citizen development. Beyond the above building blocks, the following No Code Components shall be part of the proposed integration and automation platform.

- Data Management – Provides the ability to conceptualize and visually design data model and storage that are accessible without any coding.
- GUI Designer – Provides the ability to conceive and design GUI required to build for the application and integration. This includes several reusable GUI Components, Panels and Form elements that naturally work with System Metadata Model building block.
- Security – Provides the platform and system security controls to various users with role-based authentication and authorization.
- Visualization and Reporting – Provide ability to build data visualization, dashboards, and reports.

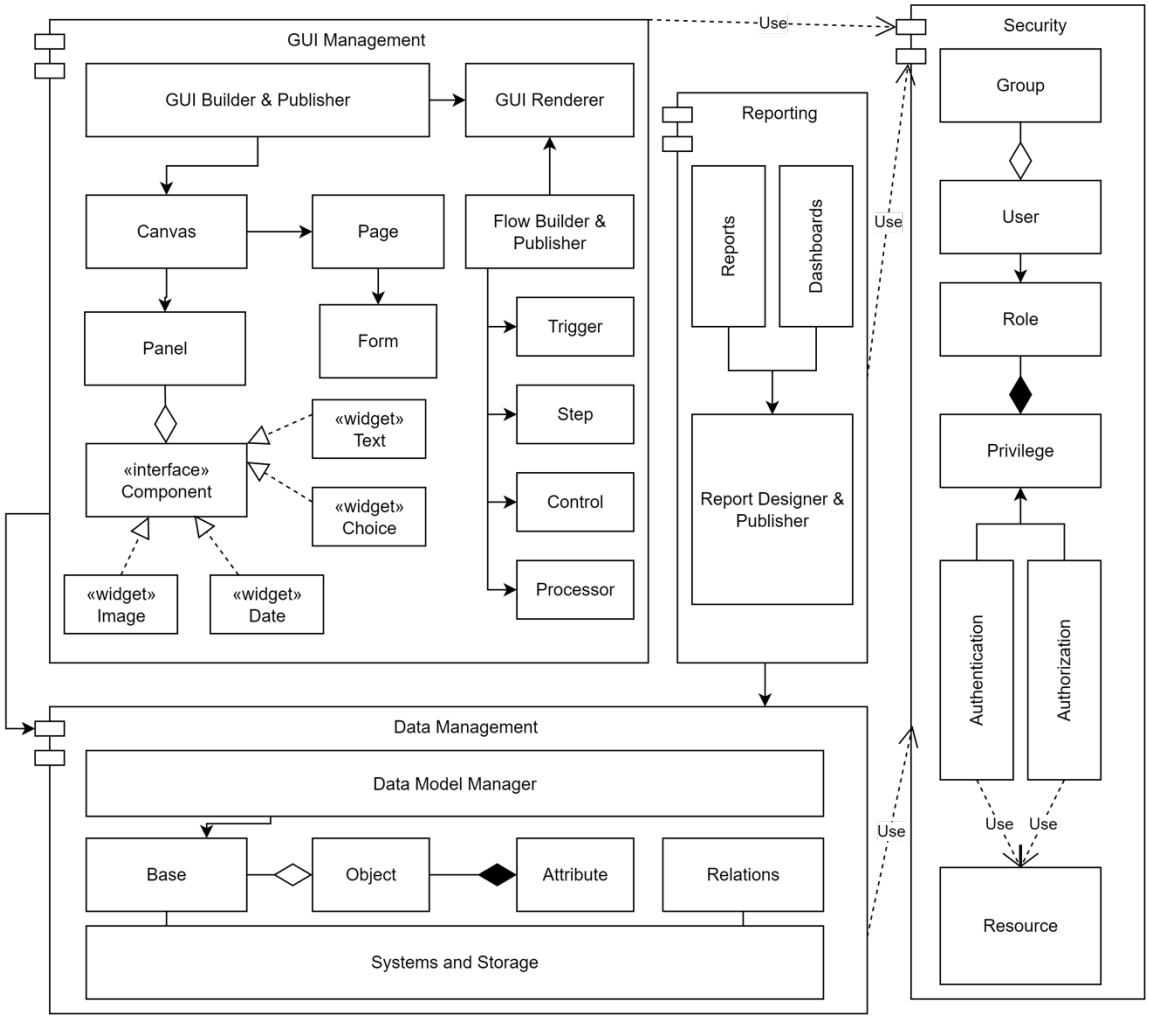

Figure 4.60
Building block - No code components

This research proposes a generative AI powered, no-code platform as part of the proposed solution for streamlined business process automation. The platform adopts a modular architecture with key components: meta-driven GUI management for user-friendly interface and workflow creation, on-the-fly reporting for automated report generation, a data management layer for efficient data handling, and a security layer for robust user access control. With the no-code foundation, generative AI can automatically generate various platform components by generating metadata. This significantly reduces

development effort, empowers non-technical users, and fosters interoperability across diverse systems.

4.7.11 Generative AI

Generative AI learns from existing artifacts to generate new, realistic artifacts at scale and can produce a variety of novel content, such as images, video, music, speech, text, software code and product designs ("Generative AI: What Is It, Tools, Models, Applications and Use Cases," n.d.). Gartner places Generative AI on the peak of inflated expectations and says emergent AI will have a profound impact on business and society. ("Gartner Places Generative AI on the Peak of Inflated Expectations on the 2023 Hype Cycle for Emerging Technologies," n.d.)

Generative AI uses models, tools, applications, and infrastructure to enable generative capabilities. The proposed approach is to apply Generative AI to generate integration solution from the general body of the knowledge from underlying Large Language Model (LLM), influenced by the knowledgebase using Retrieval Augmented Generation (RAG) and fine-tuning techniques, with search capabilities from Vector Databases and all these orchestrated through 'Flow' building block. A curated Prompt Engineering template gallery shall augment the human trying to generate integration and automation solution incrementally improved with feedback loops with Reinforcement Learning from Human Feedback (RLHF) techniques.

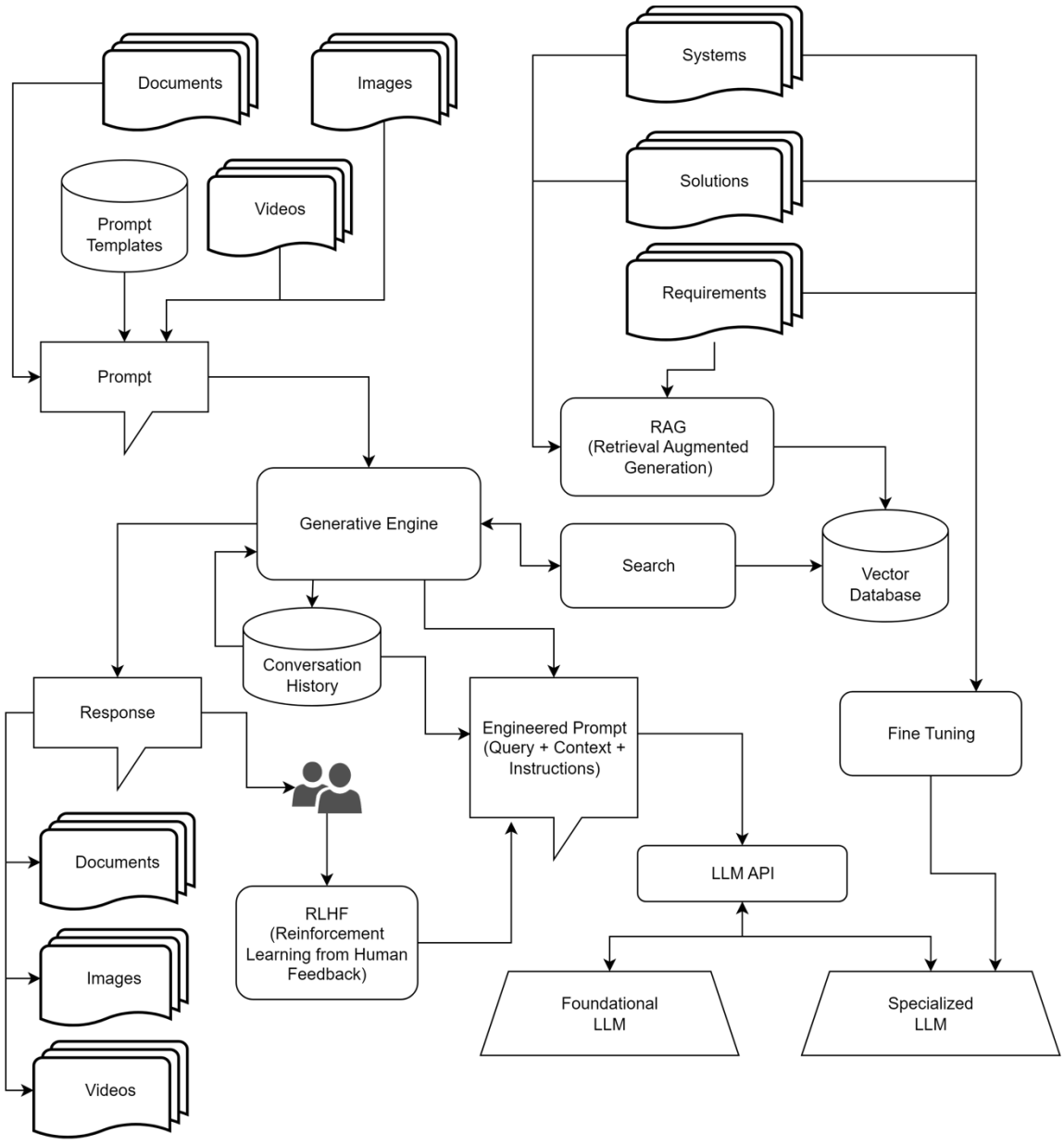

Figure 4.61
Design for generative AI in intelligent system integration and business automation

Three key aspects of Generative AI are employed in this proposed design for leveraging Generative AI for intelligence in system integration and business automation as part of AIASE. Firstly, the Retrieval Augmented Generation (RAG) technique is applied to augment the generation with retrieval from pre-curated knowledge of systems, solutions and requirements injecting the relevant system integration context. Secondly,

pretrained Large Language Models (LLM) are subjected to further training using domain-specific knowledge derived from systems, solutions, and requirements, thereby facilitating the development of tailored models specifically tailored for the system integration and business automation domain. Thirdly, the design incorporates Reinforcement Learning from Human Feedback (RLHF) methodology to enable the model to align its actions more closely with human objectives, preferences, and requirements. Moreover, the system maintains a record of conversation history to ensure the provision of adequate context, facilitating the generation of engineered prompts conducive to fostering intelligence in system integration and automation, thereby meeting the demands of the business environment effectively.

4.7.12 AIASE in practice

AI augmented software development refers to a multimodal "partnership" approach between humans and computers in which the AI tools do a wide range of tasks like an intern or a chatbot or a partner/ companion or a pair programmer (Ozkaya, 2023). Code generation, test case creation from requirements, re-establishing traceability, code explanation, legacy code reworking, software maintenance with enhanced direction, and code improvement are some of the examples of AI Augmented Software Development from Generative AI (Ebert and Louridas, 2023).

AI code generation, code recommendation, code completion software use Artificial Intelligence and Machine Learning (ML) to produce source codes based on natural language inputs and ChatGPT, GitHub Copilot, Google Bard, Repl.it, Pareto, Ask Codi, Tabnine, Amazon CodeWhisperer are some of the best tools in this segment. (“Best AI Code Generation Software in 2024 | G2,” n.d.).

Software Engineering has evolved from “waterfall” of requirements, analysis, design, coding, testing and operations to iterative and incremental agile development with

feedback loops and tools enabling just-in-time mindset to iterative development on requirements. Further enhanced with “test first” and DevOps philosophies and automation tools, the next frontier is to use AI augmented tools to redesign workflows and build new innovative workflows as a self-adaptive, reflective, and intelligent software development to remove barriers (Ozkaya, 2023).

The proposed implementation of AI Augmented Software Engineering (AIASE) aims at addressing key software engineering disciplines in the context of system integration and business automation in the following ways:

- Requirements Engineering – The system integration and automation platform shall auto generate the requirements as human readable use case model as UML (Unified Modeling Language) diagrams and requirements document based on the inputs and prompts to the assistant from users. This is just-in-time generation and synchronized bi-directionally: prompts to requirements and requirements to prompts. An automatic requirements traceability matrix shall be presented.
- Analysis and Design – The platform shall auto generate analysis and design models as UML diagrams along with the document explanation.
- Development – The building blocks of ‘Flow’ and other no-code components shall predominantly cover the implementation of system integration and automation requirements from the user. The models and meta data required for flow and no-code components shall be generated from the proposed platform. Anything that cannot be modeled into these shall use code generation mechanisms like code interpreter of Generative AI to generate code and plug-in automatically into the integration platform.

- Testing – The platform shall generate automated tests with test objectives, test cases and test scripts and execute those whenever there is a change in the requirements triggered by integrator's input/ prompts.
- Deployment and Operations – The platform shall provide seamless scalable deployment capabilities along with monitoring and control mechanism like dashboards, reports, visual progress, event/error logs, etc., to manage operations effortlessly.
- Continuous Improvement – A recommendation engine to discover and recommend improvements continuously and proactively in the platform. The recommendations need to be periodically reviewed and fed into the platform as feedback input/ prompts to auto adjust for better efficiency.

As intermediaries between humans and integration automation platforms, assistants play a pivotal role. The proposed implementation integrates a dedicated Chatbot, derived from the 'Flow' building block, which interacts with citizen integrators to generate processes and necessary sub-structures for integration and automation. Leveraging Generative AI and established AI techniques, the Chatbot translates inputs from users into actionable constructs, which are then implemented through underlying building blocks.

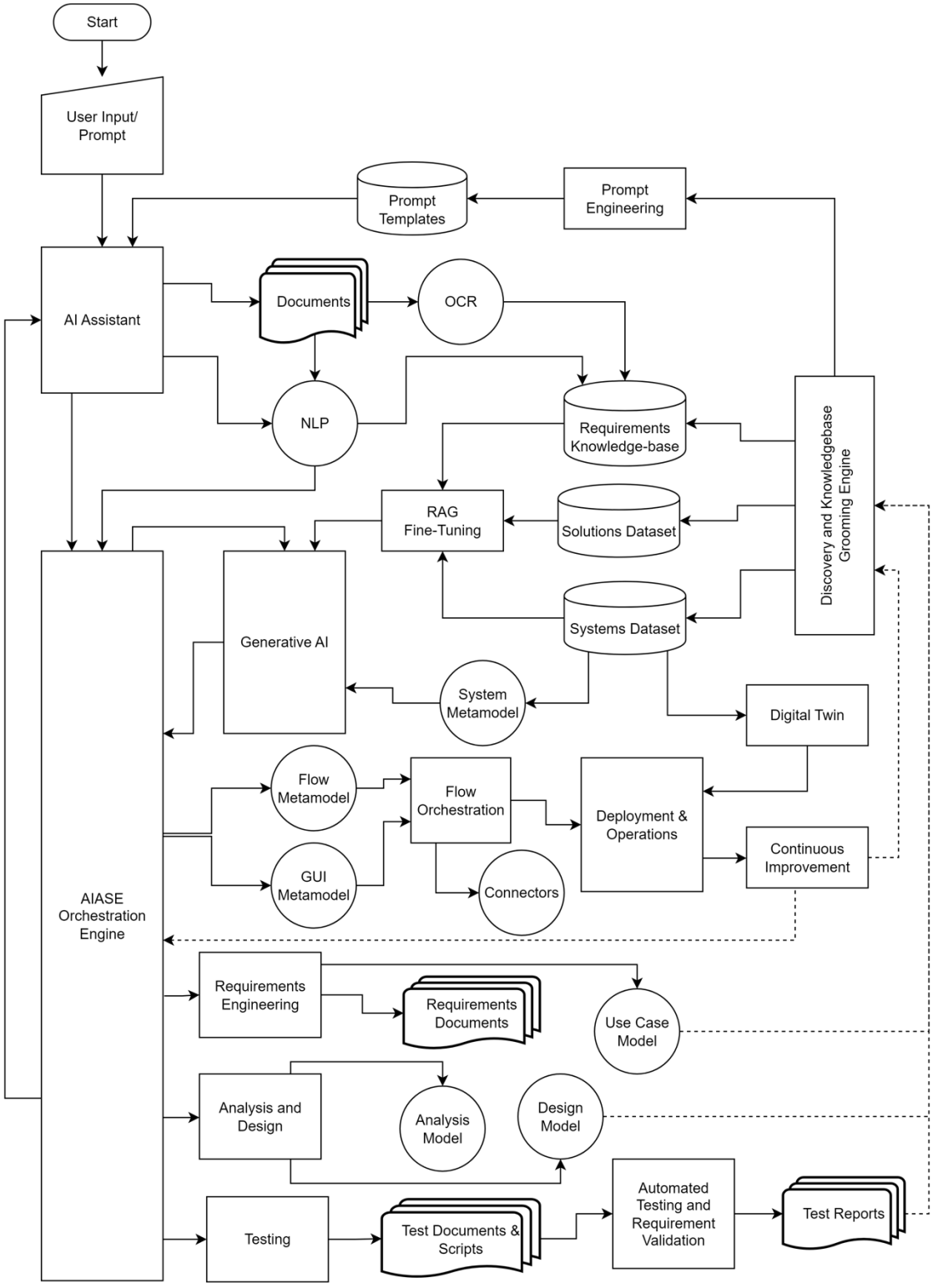

Figure 4.62
Proposed AIASE process for system integration and business automation

The proposed approach entails a dynamic and intelligent platform designed to leverage AI techniques, particularly AIASE, to achieve Augmented Intelligent Process Automation (AIPA). At the forefront of this approach is the AI assistant frontend, equipped with multimodal input capabilities such as text, voice, image, and files, allowing users, including citizen integrators, to interact seamlessly with the platform. This AI assistant serves as the interface between users and the platform, facilitating the acceptance of diverse input forms. Upon receiving inputs, advanced NLP and OCR techniques are employed to extract intents, context, and knowledge from the inputs. Subsequently, the AIASE Orchestration Engine takes center stage, acting as the control hub of the platform. This engine processes the inputs received from the AI assistant, NLP, and Generative AI components, generating flows, requirements engineering outputs, analysis and design artifacts, test scripts, and documents. The Generative AI component plays a pivotal role in enhancing generative capabilities by incorporating local knowledge gleaned from requirements, solutions, and systems datasets, thereby fine-tuning its outputs. The orchestration engine generated or tuned flows, use case models, analysis, design models and the test reports are deployed and reviewed for continuous improvement with feedback loop ensuring ongoing enhancements. With the feedback mechanism, the discovery and knowledgebase grooming engine continuously refines the platform's knowledgebase and uncovers process patterns. In essence, the proposed approach operates as a self-contained and adaptive intelligent platform, poised to intelligently integrate systems and automate business processes to drive organizational efficiencies and realize business objectives.

4.7.12 Infrastructure and deployment

The proposed integration and automation platform shall be deployed mainly in the cloud, typically multi-cloud with the ability to integrate systems across the Internet via

private and public cloud networks. It is also essential to integrate the on-premises systems via mechanisms like edge computing, agents, and flat data interfaces.

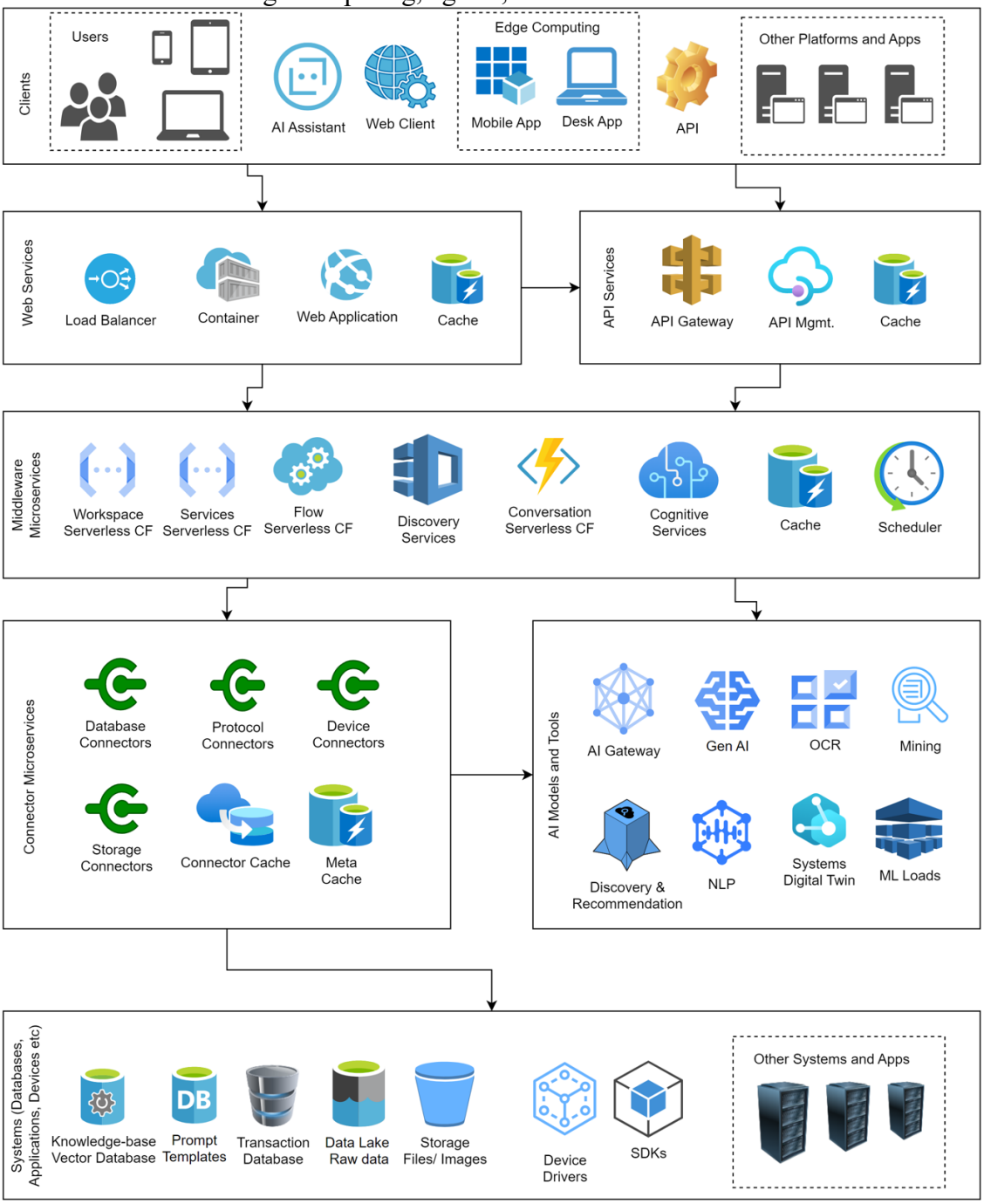

Figure 4.63
Proposed deployment

The proposed AIASE implementation employs hybrid, multi-cloud, and tiered deployment model to achieve AIPA, combining the flexibility of multiple cloud environments like IaaS, PaaS, SaaS with the security and control of on-premises infrastructure. Web Services are deployed with the load balancers and containers that guarantee portability and consistent operation across multiple cloud environments, with orchestrated deployment, scaling, and self-healing. API services deployed with infrastructure like API gateway, management, caching gives API centric architecture performance, scale, and security. Microservices underpin the AIASE architecture, ensuring modularity, scalability, and independent updates. Workspace, services, flow management, discovery, conversation, cognitive and scheduling services are deployed as middleware microservices, and connectivity services are deployed as connector microservices. AI models and tools are proposed to be either custom deployed or consumed via API from pre-deployed infrastructure.

At the bottom tier, interfacing with all systems which includes deployments of databases, applications, and devices either as custom deployment like knowledgebase vector databases, prompt templates, transaction databases or interfacing with pre-existing infrastructure using API, SDKs, or device drivers. This hybrid, multi-cloud, tiered, and microservices deployment model empowers organizations to implement AIASE under various configurations, maximizing the benefits of cloud-based agility, on-premises control, cloud neutrality, portability, scalability, and availability, ultimately enabling the adoption of intelligent system integration and process automation.

4.8 Summary of Findings

The findings from this research study about AI augmented intelligent system integration and business automation focused on addressing the four research questions are summarized as below.

- The foundational market research on software systems, initially planned with secondary data, expanded significantly, revealing a wealth of insights across various dimensions such as categories, organization, cost implications, target industries, customer categories, domain entities, built-in integrations, interface types, integration languages, databases, and regulatory compliances. These insights facilitated complexity analysis and the derivation of complexity indices for systems, business processes, and overall business operations within the context of system integration and business automation.
- The foundational market research on solution providers uncovered diverse categories and subcategories of solutions including DIP, AIP, iSaaS, iPaaS, aPaaS, LCAP, NCAP, RPA, BPA, DPA, IPA, alongside cost analysis, domain entities and functionalities thereby establishing a robust foundation for modelling the proposed approach.
- The survey results from businesspeople with solid demographics and firmographics brought authentic insights of business practitioners about the realities of their businesses, existing systems, integrations along with their expectations on leveraging AI techniques such as AIASE in system integration and business automation.

- The findings eloquently articulated the prevailing challenges, the imperative for intelligence in system integration and business automation and the perceptions of industries within this context.
- A comprehensive set of requisite skills and environments needed for leveraging established and emerging AI techniques like AIASE to achieve AIPA are identified.
- The potential benefits and challenges posed by AIASE in system integration and business automation are elucidated, alongside highlighting the various beneficiary stakeholders.
- Finally, a comprehensive approach for utilizing AIASE to achieve AIPA founded on the knowledge generated from this research study was developed employing a detailed modeling of knowledgebases, connectors, metamodel, flow, no-code components, and overall orchestration of AIASE. The approach established architectural principles, styles, and models for leveraging both established and emerging AI techniques, alongside a scalable deployment strategy to achieve functional and architectural goals, thereby harnessing the potential of AI throughout the integration and automation process.

4.9 Conclusion

The findings presented in this chapter shed light on various facets of AI-augmented intelligent system integration and business automation. Through a multifaceted approach encompassing foundational market research, businesspeople surveys, and literature reviews, valuable insights have been gleaned regarding the challenges, needs, perceptions, and potential surrounding the utilization of AI techniques

in the context of integration and automation. The rich dataset obtained from these research endeavors has enabled a comprehensive understanding of the landscape, spanning from the intricacies of software systems and solution providers to the nuanced perspectives of business practitioners. The synthesized findings underscore the pressing need for intelligence in system integration and business automation, as well as the burgeoning interest and inclination towards leveraging AI techniques like AIASE to address these imperatives. Moreover, the identification of requisite skills, environmental factors, benefits, and challenges associated with AIASE implementation offers actionable insights for stakeholders across various industries and domains. Overall, the culmination of these findings contributes to the existing body of knowledge and paves the way for future research and endeavors aimed at harnessing the transformative potential of AI in driving intelligent system integration and business automation forward.

CHAPTER V

DISCUSSION

5.1 Discussion of Results

This research focused on key aspects of leveraging AI techniques in System Integration and Business Automation to combat the challenges businesses face to integrate rapidly evolving software systems to operationalize BPM. The research was conducted with the quest to find answers to questions on the challenges of system integration, need for intelligent automation, skills and environments required, benefits and challenges of using AI and how to approach an AI implementation. The research also states hypotheses around complexity of system integration and business automation, application, benefits, and challenges of AI techniques, and explores to test the hypotheses to reject null hypothesis and accept an alternate hypothesis or simply accept the null hypothesis.

A comprehensive and systematic literature review conducted on the background of business process, BPM, BPMS, software systems, system integration, with analysis of effect of automation technologies and AI techniques on system integration and business automation. Researchers agreed system integration is critical means to achieve business purpose (Grady, 1994), but system integration is complex (Hai and Sakoda, 2009), bringing in various integration challenges (Ilyas and Khan, 2017) and concur system integration is critically challenging. When a function is critical to business and challenging, there is a market and industry for it; system integration software market(Verified Market Research, 2020a) and consultancy market(Verified Market Research, 2020b) are expected to boom and continue to be up trending in as per market research reports on integration software (IndustryARC, 2022) and consultancy (Allied

Market Research, 2022). There are traditional approaches from WfMS to RPA which have limitations in addressing challenges of system integration and business automation and intelligent automation with AI are emerging to address these challenges. Researchers said 2019 to 2030 being quoted as hyper-acceleration wave of AI (Van Aekum et al., 2019), cognitive capability of AI as a knowledge worker (Richardson, 2020, p. 186), AI unified business initiatives to reduce costs and improve productivity (Haleem et al., 2021, p. 3), and are expressing solidarity leveraging and exploring AI techniques in system integration and business automation. Also, researchers concur a plenty of research opportunity in applying AI for business automation (Chakraborti et al., 2020, p. 7), for intelligent software engineering (Perkusich et al., 2020), and for building autonomous agents (Seeber et al., 2020, p. 10).

Research and Industry are racing each other. It has been 10 years since GAN (Tolstikhin et al., 2014), arguably the origin of Generative AI, there was no significant disruption in the industry until recently. Sudden excitement after OpenAI's ChatGPT, the conversational chatbot launched on Nov 2022, provoked several competitors attempting similar or better Generative AI products, and every other software product vendor and business adopting Generative AI, boosting the industry racing along the systematic research. With Gartner(Gartner, 2021) projecting AIASE (AI Augmented Software Engineering) in the emerging technologies hype cycle, and Gartner classifying AIASE as one of the key technique of Generative AI ("Gartner Places Generative AI on the Peak of Inflated Expectations on the 2023 Hype Cycle for Emerging Technologies," n.d.), and researches in this area are growing, but seeing a gap in specifically applying AIASE to address system integration and business automation, this research tried to fill the gap by answering relevant questions including proposing an implementation of AIASE and verifying related hypotheses.

This research collected a massive set of secondary data on 14,545 software systems across 601 software categories (407,260 actual attribute level data points versus planned 30,000 to 45,000 data points), integration solutions, and their providers (10469 actual data points versus planned 3,000 to 4,500 data points) along with primary data from senior businesspeople (259 actual responses versus 250 planned). The established results are brought adequate dataset to verify the hypothesis, answer the research questions and attain the research goals as explained in the below sections.

5.2 Discussion of Research Question One

RQ1: What are the challenges of system integration in business process automation, the need for intelligent automation and the industry perceptions?

H1: Complexity of system integration and business automation is based on the systems involved and requires efficient and intelligent system integration.

This hypothesis has two parts:

Part 1 - H1.1: Complexity of system integration and business automation is based on the systems involved.

- Null Hypothesis H1.1.0 Complexity of system integration and business automation does not depend on the systems involved at all.
- Alternate Hypothesis H1.1.a Complexity of the system integration and business automation directly proportional to the systems involved.

The literature review reveals a significant number of challenges faced in system integration as listed in the results chapter. The complexity analysis in the results chapter expresses the complexity of process realization by the system integration and automation as an aggregation function involving complexity of each system involved and the rate of integration required in the process. Furthermore, the complexity of the business is

expressed as integration of the complexity of the process influenced by the criticality of the process. This demonstrates a proportionate relation between complexity of the business to the number and complexity of systems involved. As per the survey conducted with businesspeople in this research, there is a clear relationship established between size of the company and the number of the systems. The directly proportional pattern emerged from the results provides a strong support for the alternate hypothesis H1.0.a that the complexity of the system integration and business automation is based on the systems involved and rejects the null hypothesis H1.0.0.

Part 2 - H1.2: Complexity requires efficient and intelligent system integration.

- Null Hypothesis H1.2.0 Complexity does not mandate an efficient and intelligent system integration and automation.
- Alternate Hypothesis H1.2.a Complexity demands an efficient and intelligent system integration and automation.

While there is a difference among researcher on the definition and coverage of various integration and automation techniques, the literature review discloses that there is consensus among researcher that the system integration and automation need efficiency and intelligence especially Artificial Intelligence (AI) to cope with growing demands. The foundational market research performed on the secondary data collected on software systems opened-up an exploded list of popular software categories (601) and popular software systems (14,545) with relevant attributes (407,260), providing evidence for ever-growing software systems, needs intelligent computing than conventional computing. The analysis and synthesis done on the survey results of businesspeople indicate underlying belief (73%), a strong inclination (95%) and progressing at various levels (74%) towards adoption of AI techniques like AIASE for systems integration and business automation. All these three aspects of this research lead to support for alternate

hypothesis that the system integration complexity demands an efficient and intelligent system integration and automation and rejects the null hypothesis.

There is a strong connection between the complexity of the business and the number of systems, complexity of the systems, needs of the system, integration among the systems. This is concurred in the literature and ascertained with the complexity analysis of foundational market research of systems by arriving at derivations for the 'Complexity Indexes' measurements. The challenges experienced and perceived by senior businesspeople based on the survey resonates the similar vibe of system integration challenges revealed from literature study. 73% of the survey results clearly sides with the need for intelligent automation with AI techniques. The percentage goes higher to 84% when the number of systems in the business more than 100, and to 79% size of the organization is larger with 5000+ staff. Looking at the corner quadrant, when both number of systems is more 100 and size of the organization is larger than 5000 staff, the need percentage is pushed higher to 85%. This measurement of 'Perceived Need Scale' demonstrates both research and industry advocate the 'Need for Intelligent Automation'.

The consensus among researchers from previous literature, results of foundational markets in this research, and the senior businesspeople survey ascertain that applying AI techniques like AIASE to achieve Intelligent Automation (IA) and Augmented Intelligent Process Automation (AIPA) are the path forward for business process realization with intelligent system integration.

5.4 Discussion of Research Question Two

This section discusses the findings of results from literature, foundational market research and survey with respect to the research question RQ2: What skillset and

environment are required to implement AI techniques like AIASE to achieve Augmented Intelligent Process Automation (AIPA)?

The literature review stems out a list of business skills and technical skills required to achieve intelligent process automation with integration of systems. The results from foundational market research on systems and solution providers draws relationship of how the business processes are realized with actual systems and their integrations. This cross-cutting means business and technical skills in relation to deep understanding of how the systems work together are required to achieve business processes. Furthermore, the survey results from senior businesspeople adds significant perspective on the skillset and environments needed.

The quantitative survey results from the business practitioners responded with the skillsets required for using AI to realize their business process, listed below in the order of popularity: Understanding of system integration and business automation processes, Familiarity with AI development tools and platforms, Knowledge of AI algorithms and models, Knowledge of data structures and databases, Ethical and legal understanding of AI and data privacy, Business acumen and industry knowledge, Continuous learning and staying updated with industry trends and developments, Project management and problem-solving skills, Experience with programming languages such as Python and R. and Effective communication and team collaboration skills. This result demonstrate there exists a close relation between the findings of literature, foundational market research, and the survey results.

Hypothesis H2: Existing and new AI techniques can be applied for intelligent system integration and business automation.

Null Hypothesis H2.0 – AI techniques cannot be applied for system integration and business automation.

Alternate Hypothesis H2.a – Existing AI techniques can be applied for intelligent system integration and business automation.

Alternate Hypothesis H2.b – New AI techniques can be applied for intelligent system integration and business automation.

Evidence supporting H3.a:

Examining the literature, the role of traditional integration and automation techniques like WfMS and RPA are well researched. The evolution of RPA, CPA, IPA with usage of established AI techniques like NLP, ML, DTO, OCR in integration and automation is evident from the existing literature. The foundational market research conducted with the collected secondary data about integration and automation solutions reveals that NLP, ML, Computer Vision, Speech Recognition, Deep Learning, Knowledge Graph, Recommendations Engines, AutoML, Predictive Analytics Reinforcement Learning, RPA, Data Mining, OCR and Chatbots are the popularly used array of AI techniques. These results provide strong support alternate hypothesis H2.a that existing AI techniques can be applied for intelligent system integration and business automation.

Evidence supporting H2.b:

The literature review reveals that researchers are exploring new or relatively new techniques like AIASE with GenAI, SASO, SISSY, Autonomous Agents with a consensus that these techniques are the future direction for software engineering, development, integration, and automation but there is limited research to conclude these. The collected secondary data about integration and automation solutions do not provide evidence of usage of these new AI techniques due to the newness of these techniques. However, there is strong inclination seen from business practitioners from the survey

results to support alternate hypothesis H2.b, insists further research required to assert conclusive efficiency of new AI techniques in system integration and automation.

The null hypothesis is rejected as there is clear evidence of using existing mature AI techniques in literature and industry and a strong inclination to use new AI techniques among researchers and business practitioners.

5.5 Discussion of Research Question Three

This section examines the findings of the study through the lens of the third research question and formulated hypothesis related to the question.

RQ3: What benefits and challenges AIASE bring to system integration and business automation and who will be benefited?

H3: New AI techniques like AIASE bring benefits and challenges to system integration and business automation. Despite the challenges, business, integration developers, system integration software and consultancy industry are beneficiaries.

Null Hypothesis H3.0 – New AI techniques like AIASE neither brings benefits nor challenges to system integration and business automation and there are no beneficiaries.

Alternate Hypothesis H3.a – New AI techniques like AIASE brings benefits to system integration and business automation.

Alternate Hypothesis H3.b – New AI techniques like AIASE brings challenges to system integration and business automation.

Alternate Hypothesis H3.c – System integration and automation software and consultancy providers are beneficiaries of AI techniques like AIASE.

Evidence supporting H3.a and H3.b:

The literature review identified AIASE as a revolutionary technology with the potential to revolutionize the software industry, including system integration and automation. However, it also acknowledged the infancy of these new techniques and the need for further research. The survey of senior businesspeople unanimously confirmed the benefits of implementing AIASE and other AI techniques in system integration and business automation. Respondents reported multi-dimensional benefits, including improved operational efficiency, productivity, decision-making, accuracy, costs, resource utilization, customer experience, process adherence, scalability, and competitiveness. These findings directly support H3.a, indicating that AIASE does indeed bring benefits to system integration and business automation. Simultaneously, respondents highlighted potential challenges associated with AIASE, such as technical hurdles, budget constraints, privacy concerns, security risks, skill gaps, change resistance, integration issues, ethical considerations, and responsible use of new AI techniques. This supports H3.b, confirming that AIASE also presents challenges in these areas.

Evidence supporting H3.c:

Survey respondents identified various beneficiaries of AIASE, including senior management, operations teams, executive management, middle management, sales/ marketing teams, customer service teams, and even customers themselves. Market research on solution providers revealed that both software vendors and system integrators are already leveraging AI techniques and exploring new ones, demonstrating a strong interest in utilizing AI for competitive advantage. These findings align with H3.c, suggesting that the system integration and automation software and consultancy industry stands to benefit from AIASE adoption.

The study's findings provide strong evidence in support of H3, H3.a, H3.b, and H3.c. The research confirms that AIASE brings both significant benefits and notable

challenges to system integration and business automation. Furthermore, various stakeholders across the industry are poised to reap the rewards of AIASE adoption. These findings contribute to the ongoing conversation about the transformative potential of AI in system integration and business automation, highlighting the need for further research and development to address existing challenges and unlock the full potential of this revolutionary technology.

5.6 Discussion of Research Question Four

Harnessing the potential of myriad AI techniques in system integration and business automation poses a compelling yet complex challenge. This section delves in the proposed approach for implementing AIASE and discusses the research question RQ4: How to approach an implementation of AIASE for intelligent system integration and business automation?

The proposed approach for implementation of AIASE for intelligent system integration and business automation tries to leverage the established and latest AI techniques to address the challenges and future directions highlighted in the research literature, observations of the market solutions, as well as the of responses from survey results.

The formulation of required knowledgebases, application of AI techniques, layered building blocks and governing architectural principles and styles along with design models provide an in-depth approach towards implementation. Adhering to architectural principles of loose coupling and high cohesion, plug and play, multi-protocol makes the approach extensible at every level. For example, the connectors design enables implementation any new connector in the future as a special inheritance of existing interfaces and plug it in without any disturbance to other parts of the system

promoting extensibility at any time. The proposed implementation with operations on asynchronous mode, service bus messaging, and options to choose real-time, event-driven or batch mode based on the scenario makes it designed for performance.

The ‘AIASE in practice’ section illustrates the high-level algorithm bringing all components, techniques, and tools together to explain the flow of proposed implementation for a fully functional AI augmented intelligent system integration and business automation platform. Further, the infrastructure and deployment depict the proposed tiers of modern multi-cloud deployment with micro services for a performing and scalable solution. Thus the ‘Proposed Implementation Model’ construct aims to sufficiently covers the ‘Functionality, Extensibility, Performance, Scalability’ measurement.

This proposed AIASE implementation model stands as a foundational approach for practitioners like integration software vendors and system integrators. Its structured framework provides a roadmap, offering guidance on design decisions, implementation strategies, extensibility considerations, and performance optimization. By incorporating key principles like layering, loose coupling, modularity, and microservices architecture, the model ensures both scalability and adaptability, catering to diverse organizational needs and future growth. This empowers practitioners to confidently navigate the complexities of AI integration, laying the groundwork for seamless and efficient system integration and business automation.

Beyond the practical application, this model serves as a reference for researchers employing further research on applying cutting-edge AI techniques in the context of system integration and business automation. By bridging the gap between theoretical research and practical application, this model paves the way for advancements in AI powered system integration and business automation. Continuous collaboration between

researchers and practitioners will be key to further refine this approach, address emerging challenges, and unlock the full potential of AI in shaping the future of intelligent automation and system integration.

While the proposed model tried a comprehensive approach in the context of system integration and business automation, offers a promising framework, the implementation may require tuning and refactoring the constructs, adjusting to use cases and industry contexts. The proposed model needs vigilance on responsible AI practices on how it navigates ethical considerations like bias, fairness, and explain-ability of AI decision. Implementation will require skillset and expertise on new AI techniques, AI development, data science, system integration in addition to the business process knowledge fostering an upskilling and continuous learning for the organizations with the existing skill gap.

CHAPTER VI

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

The problem at hand centers on the escalating complexity of integrating multiple software systems for business process management and automation. As businesses expand their software toolkit, integration challenges grow, aggravated by factors like system interoperability and architectural intricacies. Cloud computing further complicates matters, requiring seamless integration across cloud-based and on-premises systems. These challenges hinder business process management efforts and warrants research to understand, streamlining integration processes, reducing costs, and enhancing adaptability to evolving system and system integration landscapes.

This research endeavored to provide insights and guidance for the system integration and automation industry by understanding contemporary challenges, analyzing latest technologies, identifying requisite skills, and elucidating associated benefits. With a focus on Intelligent Process Automation and Hyper-automation, the study explored the potential of AI techniques, particularly AIASE, in enhancing system integration and business automation practices. The scarcity of research in this specific context underscores the importance of this study, which has the potential to reshape the system integration market and set directions for the development of future integration software.

The literature review successfully explored multiple objectives, including reviewing literature on Business Process, BPM and BPMS for understanding their role in business success, examining traditional and cloud-based products, applications, tools, and systems to understand system integration processes, analyzing automation techniques like

RPA, CPA, and IPA in business automation and system integration, identifying recent techniques and areas for further research in system integration and business automation, reviewing literature on AIASE for insights into research gaps and future directions, and investigating AIPA's role in system integration and business automation. The literature review uncovered crucial insights, highlighting the foundational role of BPM and BPMS, the escalating complexity of systems, and the challenges of integration, and key techniques like RPA and IPA to address integration challenges, while AI is seen as pivotal for the future of integration. The emergence of AIASE is recognized as a novel development with transformative potential. This research systematically synthesizes the field's needs, concepts, and processes, discussed techniques like AIASE and GenAI, analyzes their benefits and challenges, and proposes a model for intelligent integration platform development. These contributions can serve as a reference for researchers exploring AI's application in system integration and business automation.

Foundational market research with analysis and synthesis on software systems and solution providers jumped several folds in the volume of secondary dataset than the planned, but brought insights into categorization of systems, solutions, customers, and industries, demography, cost factors, domain entities, key functionalities, interfaces, databases, integration languages, regulatory compliances in the system integration and business automation landscape. The complexity analysis exposed the relation between systems, system integration, business process realization, and the business as complexity indexes by exploiting the volume and complexity factors at each of these levels. Altogether, the foundational market research gained a solid ground for this research to fundamentally address questions and build detailed context around the research objectives.

With the sound demographics and firmographics of participants, businesspeople survey yielded invaluable insightful results regarding their perspectives on the challenges, needs, potential, perceptions, skills, and inclinations of AI techniques in their business with respect to system integration and business automation. This quantitative primary played a pivotal role in addressing research questions, shedding light on various aspects such as system integration challenges, the necessity for intelligent solutions, industry perception, along with requisite skillset, environments, challenges, and benefits of implementing AI techniques like AIASE. By complementing the findings from literature review and foundational market research, these survey results enriched the holistic understanding of the landscape surrounding system integration and business automation. Drawing upon all the insights gleaned from the extensive research and analysis, this study has culminated in the proposal of an innovative approach for implementing AIASE to facilitate intelligent system integration and business automation. The proposed approach is underpinned by a contemporary architecture and design framework, meticulously crafted to leverage foundational knowledgebases, architectural principles, and essential building blocks such as connectors, metamodels, flows, and no-code methodologies. Incorporating both established and emerging AI techniques, the approach encompasses a holistic view of AIASE deployment, elucidated through comprehensive model diagrams that portray structure, relation, interaction, dataflow, control flow, and deployment visually.

Overall, in line with the aims and objectives, this research explored concepts, processes, techniques, skillset, environments, infrastructure for business process automation through intelligent software system integration, proposed implementation approach model for utilizing AIASE and establishing architectural mechanisms to achieve AIPA. The findings are particularly valuable for system integration consultancy

businesses and software providers, empowering them to develop better practices, products, and tools for leveraging AI in system integration and business automation.

6.2 Implications

The system integration and automation industry stand as established and burgeoning markets, with key players including software systems vendors, integration and automation software vendors, consultancy businesses, system integrators, and businesses reliant on integration and automation. This research furnishes a comprehensive understanding of the intricate interplay between systems, integration challenges, and business process realization, thereby augmenting the industry's comprehension of the underlying business context. By delineating a spectrum of existing and emerging technologies, including various AI techniques, the study empowers solution providers, consultancy firms, and system integrators to validate their offerings and refine their practices. Specifically, the exploration of AI techniques like AI Augmented Software Engineering (AIASE) unveils insights into skills, environments, benefits, challenges, and implementation approaches crucial for intelligent integration and business automation.

Independent software vendors and solution providers can leverage these findings to develop enhanced software solutions, while consultancy businesses and system integrators stand to expand their expertise and service offerings by integrating AI techniques like AIASE into their practices. The dissemination and application of this knowledge within the industry promise transformative changes, fostering heightened productivity and efficiency.

Furthermore, this research significantly contributes to the literature by consolidating insights into the needs, concepts, processes, challenges, benefits, and

implementation approaches surrounding the utilization of AI techniques, particularly AIASE, in system integration and business automation. Such contributions serve as a cornerstone for future research endeavors in integration and automation industry aimed at advancing the application of AI techniques in these domains.

6.3 Recommendations for Future Research

In the light of the findings presented in this research, several avenues emerge for future investigations to advance the performance in system integration and business automation. Firstly, there is a need to expand the scope of system to include hardware devices, recognizing the evolving landscape where software and hardware intricately interact and expand the scope of system integration to include the interactions among software and hardware systems. This comprehensive approach will enhance the applicability of integration frameworks across diverse technological domains.

Secondly, the role of human elements in assessing the complexity of system integration and business automation warrants nuanced exploration. Variables such as the number of humans involved in the business process and their roles and responsibilities present opportunities for in-depth investigations. Understanding the impact of human factors on the effectiveness of automation strategies is crucial for informed decision-making in the organizational settings. This research notices some reservation and uncertainties from people about using AI in systems integration and automation, though not the majority. Further research could explore the specific factors contributing to these varying perceptions and identify areas where targeted efforts might be needed to build confidence and ensure successful AI implementation for improved systems integration and automation.

The future research agenda should also delve into the integration of other latest AI techniques for system integration and business automation platform implementation. Exploring the potential of synthetic data and autonomous agents promises to enhance the adaptability and intelligence of automation systems. Investigating the synergies between human-machine collaboration, leveraging AI, will contribute to the development of intelligent and adaptive integration platforms.

In consequence, these recommendations seek to extend the boundaries of current research, providing green field for scholars and practitioners to deepen their understanding of system integration and business automation in the context of evolving technological landscapes and human-machine synergies and propose further efficient implementation approaches.

6.4 Conclusion

This research delves into the multifaceted realm of system integration and business automation, addressing the pressing challenges and exploring avenues for leveraging Artificial Intelligence (AI) techniques like AI Augmented Software Engineering (AIASE) to achieve Augmented Intelligent Process Automation (AIPA). Through a comprehensive analysis of the literature, foundational market of systems and integration solutions, and survey data, this study elucidates the intricate interplay between business processes, software systems, system integration and automation. By proposing an implementation approach centered around AIASE, the research endeavors to bridge the gap between theory and practice, offering practical insights and strategic directions for industry stakeholders. The implications of this study extend beyond the confines of academia, with potential transformative implications for software vendors, consultancy firms, system integrators, and businesses alike. By harnessing the power of AI to

augment system integration and business automation, organizations can unlock new levels of efficiency, agility, and innovation. Way ahead, it is imperative that the system integration and automation industry continues to embrace and refine AI driven approaches, laying the groundwork for a future where intelligent integration and automation is not just a possibility, but a fundamental pillar of organizational success.

APPENDIX A

SURVEY COVER LETTER TO BUSINESSPEOPLE

Dear Participant,

I invite you to participate in a research survey that aims to gather insights on using Artificial Intelligence (AI) techniques in system integration and business automation from the perspective of senior businesspeople like yourself.

Your participation in this survey is crucial as it will contribute to the understanding of the challenges, skill requirements, and potential benefits associated with AI augmented intelligent system integration and business automation.

Survey Details:

- Purpose: The purpose of this survey is to examine the use of AI techniques for system integration and business automation.
- Participant Criteria: Specifically seeking senior businesspeople who are interested in utilizing AI in their business operations.
- Survey Length: The survey will take approximately 15 minutes to complete.
- Confidentiality: Your responses will be kept strictly confidential and will only be used for research purposes. Your anonymity will be maintained throughout the study.

Your participation in this survey involves answering a series of questions about your organization's current situation, challenges in system integration and business automation, and your perceptions regarding the use of AI techniques in these areas. Please provide your honest opinions and insights based on your experiences.

By participating in this survey, you will contribute to the advancement of knowledge in the field of AI augmented intelligent system integration and business automation. The findings from this study will help identify best practices, highlight

potential areas of improvement, and provide valuable insights for businesses seeking to leverage AI in their operations. To access the survey, please click on the following link: https://research.jivrus.com/aiaisiba/businesspeople-survey.

We highly value your time and expertise, and your input will be instrumental in the success of this research. If you have any questions or concerns regarding the survey, please feel free to contact the researcher, Michaeswaran Subramanian, at michaes@jivrus.com.

Thank you in advance for your participation. Your contribution is greatly appreciated.

Sincerely,

Michaeswaran Subramanian

APPENDIX B

INFORMED CONSENT

Study Title: AI Augmented Intelligent System Integration and Business Automation

Researcher: Michaeswaran Subramanian

Affiliation: Swiss School of Business and Management

Purpose: You are invited to participate in a research study investigating the use of Artificial Intelligence (AI) techniques in system integration and business automation. Your participation will contribute to understanding the challenges, skill requirements, and potential benefits of AI in these areas.

Procedures: You will be asked to complete a questionnaire about your organization's current situation, system integration challenges, and perceptions of AI usage. The questionnaire will take approximately 15 minutes to complete. Your responses will be treated confidentially and analyzed as part of the research.

Confidentiality and Data Protection: Your participation is strictly confidential. All data collected will be stored securely and anonymized. Only aggregated and anonymized data will be used for reporting and publication.

Voluntary Participation and Withdrawal: Participation is voluntary, and you may withdraw at any time without consequences. Any data collected up to the point of withdrawal will be excluded from the analysis.

Benefits and Risks: While there are no direct benefits, your input will contribute to knowledge advancement. Minimal risks are associated with participation, and measures are in place to ensure data confidentiality.

Contact Information: For questions or concerns about the study, contact Michaeswaran Subramanian at michaes@jivrus.com.

Consent: By proceeding with this survey, you indicate that you have read and understood the information provided above. You voluntarily agree to participate in this research study. You are aware that you can withdraw from the study at any time without any negative consequences. Your participation is greatly appreciated.

APPENDIX C

SURVEY QUESTIONNAIRE

Part A: Basic Information

1. Please provide your full name.
2. Please select the gender
    a. Male
    b. Female
    c. Prefer not to say.
    d. Other
3. Please select your age group
    a. 18 to 25 years
    b. 26 to 35 years
    c. 36 to 50 years
    d. above 50 years
4. Which country are you staying?
5. What is your educational background?
    a. School
    b. Undergraduate
    c. Postgraduate
    d. Doctorate
6. What is your total year of experience?
7. What is your current role?

a. Independent contributor

b. Technologist or Architect

c. Entry level management

d. Middle management

e. Senior management

f. Executive management

g. C-level Executive

h. Business Owner/ Entrepreneur

i. Other

8. What is the organization name?

9. What is the size of your organization?

    a. 1 to 10 staff

    b. 11 to 25 staff

    c. 26 to 100 staff

    d. 101 to 500 staff

    e. 501 to 5000 staff

    f. above 5000 staff

10. Which industry your organization belongs to?

    a. Agriculture

    b. Construction

    c. Education

    d. Telecommunication

e. Automobile

f. Oil & Gas

g. Food

h. Information Technology

i. Insurance

j. E-commerce

k. Real Estate

l. Financial Services

m. Government

n. Media

o. Healthcare

p. Retail

q. Manufacturing

r. Energy

s. Hospitality

t. Transportation and Logistics

u. Aerospace and Defense

v. Pharmaceuticals

w. Consulting and Professional Services

x. Non-profit and Charitable Organizations

y. Other

Part B: System Integration and Automation Challenges

11. How many software systems are used in your organization?

    a. none

    b. 1 to 5

    c. 6 to 10

    d. 11 to 20

    e. 21 to 50

    f. above 50

12. What type of software systems are used in your organization?

    (Choose all applicable answers)

    a. Office management

    b. Customer Relationship Management (CRM)

    c. Productivity

    d. Communication

    e. Collaboration

    f. Databases

    g. Marketing

    h. Accounting

    i. E-Commerce

    j. Analytics

    k. Customer Service

    l. Enterprise Resource Planning (ERP)

m. Human Resources (HR/ Payroll)

n. Content Management System (CMS)

o. Project Management System

p. Supply Chain Management

q. Inventory Management

r. Document Management

s. Learning Management System (LMS)

t. IT Services Management (ITSM)

u. Business Intelligence

v. Other

13. Do you need these software systems to work together?

a. Yes

b. No

c. Cannot say.

14. How are these software systems integrated in your organization?

a. Not integrated

b. Rarely integrated

c. Somewhat integrated

d. Partially integrated

e. Integrated with manual processes.

f. Fully integrated

15. How satisfied are you with the current system integration processes in your organization?
    a. Very satisfied
    b. Satisfied
    c. Neutral
    d. Dissatisfied
    e. Very dissatisfied
16. Does your organization have skills for integrating the software systems?
    a. Not skilled
    b. Basic skilled
    c. Moderately skilled
    d. Highly skilled
    e. Expertly skilled
17. What challenges do you face when integrating software systems and automating your business processes?
    (Select all that apply)
    a. Unclear processes or workflow
    b. Inadequate data quality or consistency
    c. Lack of integration and automation tools
    d. Insufficient integration and automation skills
    e. Systems do not support integration (e.g. no API)
    f. Incompatibility between systems

g. Legacy systems

h. Time constraints

i. Budget constraints

j. Security concerns

k. Complex regulatory requirements

l. Vendor lock-in or limited vendor support

m. Limited resources

n. Lack of vision or leadership

o. Lack of stakeholder alignment or collaboration

p. Resistance to change.

q. Partially integrated, but many missing use cases

r. Integrated, but functionality is suboptimal.

s. No challenges encountered.

t. Other

18. Is your organization getting integration/ automation consultancy and implementation from experts?

a. No, we do not engage with external experts.

b. Yes, we receive consultancy services only.

c. Yes, we receive both consultancy and implementation services.

d. Yes, we have an internal team of experts handling integration/automation.

e. Yes, we have a combination of internal and external experts for consultancy and implementation.

19. Does your organization utilize any integration or automation software to connect your software systems together?
    a. Yes, we have dedicated integration or automation software in place.
    b. No, we do not currently utilize any integration or automation software.
    c. Unsure/Not aware of whether integration or automation software is being used.
20. What do you consider as a best approach for software systems integration and automation?
    a. Developing it internally from scratch
    b. Developing it internally with the support of an integration/automation platform
    c. Seeking assistance from a consultancy specializing in integration/automation services
    d. Utilizing a combination of consultancy services and an integration/automation platform

Part C: Benefits and Risks of using AI techniques in System Integration and Business Automation

21. To what extent do you believe that the adoption of Artificial Intelligence (AI) techniques like AI augmented Software Engineering has the potential to improve systems integration and automation in your organization?
    a. Negligible impact is expected.

b. Marginal improvements are probable.

c. Substantial enhancements are likely.

d. Transformational improvements are anticipated.

22. To what extent has your organization adopted Artificial Intelligence (AI) techniques for systems integration and business automation?

a. Not yet adopted AI techniques

b. Currently exploring the possibilities

c. Partially implemented in certain areas

d. Fully implemented across the organization

e. Exceeding industry standards with innovative AI solutions

23. What technical and professional skills do you think are required to implement Artificial Intelligence (AI) techniques for systems integration and business automation?

(Choose all that apply)

a. Understanding of system integration and business automation processes

b. Knowledge of data structures and databases

c. Knowledge of AI algorithms and models

d. Familiarity with AI development tools and platforms

e. Ethical and legal understanding of AI and data privacy

f. Experience with programming languages such as Python and R

g. Project management and problem-solving skills

h. Business acumen and industry knowledge

i. Effective Communication and team collaboration skills

j. Continuous learning and staying updated with industry trends and developments.

24. What environment do you think you need for using Artificial Intelligence (AI) techniques for systems integration and business automation?

(Choose all that apply)

a. Robust computing infrastructure

b. Access to AI tools and platforms

c. Availability of skilled personnel in both business and AI domains.

d. Data management and storage solutions

e. Integration capabilities with legacy systems

f. Financial investment and support

g. Collaboration and communication platforms

h. Well defined governance and data protection measures.

i. Supportive organizational culture

25. What are the biggest benefits you anticipate from implementing AI Augmented Software Engineering and related AI techniques for intelligent system integration and business automation in your organization?

(Choose all that apply)

a. Improved operational efficiency.

b. Reduced errors and improved accuracy

c. Increased productivity and throughput

d. Enhanced customer satisfaction and experience.

e. Better decision-making and insights.

f. Cost savings and resource optimization.

g. Streamlined and automated processes.

h. Improved scalability and adaptability.

i. Competitive advantage in the market.

j. Other

26. What are the potential challenges associated with the integration and automation of business systems using Artificial Intelligence (AI) techniques?

(Choose all that apply)

a. Technical complexity and implementation difficulties

b. Cost and budget constraints

c. Data privacy and security concerns

d. Organizational resistance to change and adoption.

e. Algorithm bias and fairness issues

f. Integration challenges with legacy systems

g. Lack of skilled personnel in AI and integration domains

h. Interoperability issues with different software systems

i. Ethical considerations and responsible AI practices

j. Other

27. How inclined are you to implement AI Augmented Software Engineering and related AI techniques for intelligent system integration and business automation in your organization?
    a. Very likely to implement.
    b. Likely to implement.
    c. Neutral, undecided currently
    d. Unlikely to implement.
    e. Very unlikely to implement.
28. Which stakeholders in your organization will benefit the most from AI-driven system integration and business automation?

    (Choose all that apply)
    a. Executive Management
    b. Senior Management
    c. Middle Management
    d. Entry level Management
    e. Technologist or Architect
    f. Operations
    g. Customer Service
    h. Sales and Marketing
    i. Finance and Accounting
    j. Human Resources
    k. Business Analysts

l. Customers

m. Partners

n. Contractors/Vendors

O. Other

APPENDIX D

SECONDARY DATA COLLECTION ABOUT SYSTEMS

As part of this research, a systematic analysis of various systems, products, applications, solutions, and tools in the field will be conducted. The information collected from secondary sources will be used to identify key attributes associated with each system. The findings from this analysis will provide valuable insights into the current state of rapidly growing systems in each category and its impact to system integration and business automation and contribute to the advancement of the field. This section of the research proposal aims to describe the methodology and approach used to collect and analyze the data on systems and their attributes.

A list of attributes collected as independent variables for each system as below:

- Name of the system
- Category
- Category Family
- Organization
- Website
- Purpose
- Key Features
- Pricing Options
- Average Cost Per Month
- Free Access Availability
- Free Trial Availability
- Customer Categories
- Target Industries
- Rating

- Reviews
- Domain Entities
- Atomic Functions
- Interface Types
- API Access
- Databases
- Integration Languages
- Regulatory / Compliance Requirements

APPENDIX E

SECONDARY DATA COLLECTION ABOUT SOLUTION PROVIDERS

As part of this research, a systematic analysis of various systems, products, applications, solutions, and tools in the field will be conducted. The information collected from secondary sources will be used to identify key attributes associated with each system. The findings from this analysis will provide valuable insights into the current state of rapidly growing systems in each category and its impact to system integration and business automation and contribute to the advancement of the field. This section of the research proposal aims to describe the methodology and approach used to collect and analyze the data on systems and their attributes.

A list of attributes collected as independent variables for each system as below:

- Name of the system
- Category
- Category Family
- Organization
- Website
- Purpose
- Key Features
- Pricing Options
- Average Cost Per Month
- Free Access Availability
- Free Trial Availability
- Customer Categories
- Target Industries
- Rating

- Reviews
- Domain Entities
- Atomic Functions
- Interface Types
- API Access
- Databases
- Integration Languages
- Regulatory / Compliance Requirements

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