

ATOE-Based Qualitative Investigation of Cloud Resource Allocation Challenges in Small and Medium Enterprises

Dr. Surekha Manohar Jadhav

*Assistant Professor, Loknete Dr. Balasaheb Vikhe Patil (Padmbhushan Awardee),
Pravara Rural Education Society's Women's College of Home Science and BCA, Loni*

Abstract: Cloud computing provides several advantages such as flexibility, scalability, and cost-efficiency. However, many small and medium enterprises (SMEs) still fail to fully utilize available cloud resources including memory, computing power, storage, and network bandwidth which in turn lowers their productivity and increases operational costs. This paper aims to investigate the key challenges affecting cloud resource allocation in SMEs. A qualitative research approach was employed, consisting of in-depth interviews with cloud computing owners, managers, and domain experts. Empirical analysis of the collected data revealed 11 major barriers to effective resource allocation, which were categorized using the Technology–Organization–Environment (TOE) framework. Theoretically, this study contributes to the growing body of knowledge on cloud computing adoption and provides a deeper understanding of how SMEs manage and allocate cloud resources. From a practical standpoint, the findings offer valuable insights that can assist SMEs in designing successful and sustainable strategies for cloud resource allocation.

Keywords: Cloud computing; resource allocation; sustainability; technology–organization–environment (TOE); small and medium enterprises.

I. INTRODUCTION

The advent of cloud computing has marked a transformative phase in the computing domain by enabling flexible, scalable, and cost-efficient services. Resource Allocation in Cloud Computing (RACC) [1] refers to the distribution of computing resources including memory, processing power, storage, and network bandwidth — among different users and applications. However, ensuring optimal allocation of these resources, particularly for small and medium enterprises (SMEs), remains a major challenge, as many such organizations encounter difficulties in

efficiently managing cloud-based assets [2]. Addressing these challenges is essential not only to improve the sustainability of cloud computing but also to reduce operational costs and the associated environmental impacts of large-scale cloud infrastructures. SMEs that fail to adopt effective resource allocation mechanisms often suffer from increased expenses and reduced productivity [3]. Therefore, their competitiveness and long-term sustainability depend heavily on the efficient deployment and utilization of cloud resources. This efficiency, however, is undermined by several constraints, including financial limitations, shortage of skilled personnel, and difficulties in integrating emerging technologies [4]. Consequently, policymakers, SME owners, technology managers, and domain experts need to explore viable strategies [5] that support optimized RACC and facilitate desired organizational outcomes. In response to this need, the present study empirically investigates the barriers faced by SMEs in implementing effective cloud resource allocation practices. Several prior studies have attempted to address specific aspects of RACC. For instance, ref. [6] introduced an economic resource allocation model that predicts resource demand using heuristics, yet it focused solely on cost-related issues. Ref.[7] proposed an energy-efficient resource relocation approach based on power conversion efficiency to reduce consumption while ensuring acceptable performance. Although such a strategy enhances sustainability, operational expenses remain largely unaddressed. Ref. [8] presented a method for selecting optimal resources in real-time using an extended flexible algorithm, but energy implications were ignored. In a similar direction, ref.[9] designed a virtual machine upgrade method that demonstrated reduced execution time and energy

usage, yet incurred significant cost. A scheduling-based heuristic approach was proposed in ref. [10] to lower costs while satisfying QoS constraints; however, the study overlooked resource utilization and execution time. Beyond technical solutions, other studies examined the broader challenges associated with cloud adoption. These include cost, security, technical expertise, management support, and complexity, as outlined in ref. [11]. Ref. [12] highlighted the influence of senior leadership support, competitive pressure, and company size in cloud-related decisions. The importance of training programs for enhancing cloud competence was emphasized in ref. [13], while ref. [14] identified TOE-based determinants such as compatibility, trialability, and uncertainty specific to SMEs. Additionally, ref. [3] underscored concerns such as usability, convenience, privacy, and cost reduction, where as ref.[15] noted limited technological awareness as a major barrier. In the context. of cloud security, ref. [16] examined both societal (trust, behavior, privacy) and technical factors (encryption, transparency, scalability). Moreover, ref. [17] discussed financial gains derived from optimized cloud resource usage. Despite these contributions, earlier works either addressed isolated issues or lacked a clear categorization of the full spectrum of RACC challenges in SMEs. Understanding these challenges is crucial for SMEs to formulate tailored strategies that improve competitiveness, reduce costs, and enhance operational efficiency in rapidly evolving digital ecosystems. This study contributes by identifying efficient RACC practices and determining the factors that influence these practices, thereby providing insights for scholars, practitioners, and decision-makers. The study further employs the Technology–Organization–Environment (TOE) framework [18] to categorize the identified challenges. As defined by Tornatzky and Fleischer [19], the TOE framework captures technological, organizational, and environmental dimensions influencing technological innovation. The technological dimension addresses issues such as scalability and security, the organizational dimension reflects internal limitations such as lack of expertise, and the environmental dimension encompasses external constraints such as regulations and market pressures.

II. LITERATURE REVIEW

Cloud computing has emerged as a dominant paradigm for delivering IT services on demand, offering elasticity, scalability, and economic benefits to organizations of all sizes. However, the process of Resource Allocation in Cloud Computing (RACC) remains a persistent challenge, particularly for small and medium enterprises (SMEs), where financial, organizational, technical, and environmental constraints significantly affect adoption and performance. Early studies focused mainly on technical aspects of cloud resource distribution, aiming to optimize utilization, cost, and service quality. For example, [6] proposed an economic resource allocation model using heuristic techniques to forecast resource distribution requests, primarily addressing cost optimization. Likewise, [7] developed a resource relocation approach based on power conversion efficiency to reduce energy consumption without compromising performance, emphasizing sustainability through lower carbon footprints. While such approaches improved either cost or energy consumption, they often overlooked operational complexities and multidimensional challenges encountered by SMEs. Subsequent studies attempted to improve real-time allocation. Ref. [8] expanded a flexible algorithm to assign resources to active workloads more efficiently, though the study excluded energy-related considerations. In contrast, [9] focused on upgrading virtual machine resources to reduce execution time and energy usage; however, operational costs remained high. A heuristic scheduling-based method was introduced in [10] to minimize expenses while meeting Quality of Service (QoS) demands, yet it ignored execution time and utilization factors, again solving partial but not holistic allocation issues.

Parallel to technical improvement studies, other strands of literature explored contextual and organizational constraints affecting RACC in SMEs. Ref. [11] identified cost, data security, complexity, and lack of technical expertise as influential challenges limiting effective resource allocation. Similarly, [12] emphasized the role of top management support, firm size, competitive forces, and external pressure in shaping cloud resource decisions. Training and workforce capability constraints were highlighted in [13], indicating that lack of employee competence discourages productive use of cloud resources. In addition, [14] reported

determinants such as compatibility, uncertainty, trialability, and top-level commitment as key factors affecting allocation in SME environments.

From a decision-making perspective, usability, convenience, privacy assurance, and cost reduction were listed as major determinants in [3], suggesting that SMEs weigh both technical and experiential factors before allocating cloud resources. Ref. [15] further argued that knowledge limitations among decision-makers act as a structural barrier to cloud deployment and allocation. In the domain of secure cloud computing, [16] examined technological and social dimensions — including trust, transparency, encryption, and user behavior — revealing that challenges are not confined to infrastructure alone. Additionally, [17] underlined the financial advantages of optimized cloud allocation, including reduced upfront capital investment and improved efficiency.

Although these studies provide valuable insights, most existing works either address isolated technical challenges or examine singular organizational factors without integrating them into a comprehensive classification. Few studies categorize RACC challenges systematically in the context of SMEs or investigate them using empirical field evidence. Moreover, prior research does not sufficiently apply structured Frame works such as the Technology–Organization–Environment (TOE) model to classify barriers in a multi-dimensional manner, leaving a significant conceptual and empirical gap.

III. MATERIALS AND METHODS

This section describes the methodological procedures adopted to achieve the research objective. It is organized into five sub-sections covering the research approach, participant selection, data collection methods, data analysis procedure, and ethical considerations.

A qualitative research approach was employed using semi-structured interviews. This approach provides flexibility and allows the researcher to probe deeper into participants' perspectives and experiences [20]. It also enables the identification of recurring patterns and themes within the collected data, facilitating deeper insight into the challenges of cloud resource allocation in SMEs.

Purposive sampling was used to select participants with relevant expertise in cloud computing resource

management. This method ensures the inclusion of individuals whose experience aligns with the study's objectives, thereby increasing the validity and relevance of the findings. A total of 12 participants with professional experience in SMEs were recruited from the United States, the United Kingdom, India, and Pakistan. Their roles included system manager, web server administrator; DevOps engineer, head of cloud computing, and team manager, representing a diverse range of industries and organizational contexts.

Data Collection

A semi-structured interview guide was developed following the five-step protocol suggested in, including identifying interview requirements, reviewing prior literature, drafting the guide, pilot testing, and finalizing the instrument. The guide contained 20 primary open-ended questions and eight supplementary sub-questions across six thematic domains. Sub-questions were used when initial responses lacked sufficient depth.

Interviews were conducted online between 1 January 2024 and 15 March 2024, in English. The interview guide was shared with participants in advance to allow adequate preparation and improve the quality of responses. All interviews were recorded and transcribed using Avrio, an AI-based transcription tool. Standard transcription procedures were followed to document fillers, inaudible segments, and overlapping speech. Sensitive personal information, if any, was anonymized or omitted in accordance with ethical norms.

Data Analysis

Thematic analysis was applied to identify dominant patterns and themes in the interview data. An iterative coding procedure guided by a predefined codebook was followed. The analysis comprised the following steps:

Familiarization: Repeated reading of transcripts and reviewing relevant literature to gain understanding and note preliminary impressions.

Generating Initial Codes: Systematic coding of meaningful segments related to RACC challenges based on research objectives [14].

Theme Development: Grouping related codes to form coherent themes by identifying patterns and relationships [20].

Review and Refinement: Critically evaluating themes

for accuracy and representativeness; reorganizing or merging as necessary.

Thematic Relationship Mapping: Constructing a thematic map to visually present interconnections among themes.

Reporting: Presenting themes with supporting quotations in a structured narrative and interpreting findings in relation to existing literature [14].

IV. RESULTS

The thematic analysis revealed 15 distinct challenges affecting Resource Allocation in Cloud Computing (RACC) among SMEs. Guided by the TOE framework, these challenges were categorized into technological, organizational, and environmental contexts (see Table 2). For ethical and confidentiality reasons, participants are anonymized as P1–P12. The

following subsections elaborate each theme.

This category comprises five major challenges:

- (1) lack of knowledge, (2) lack of expertise, (3) network performance issues, (4) optimization complexity, and (5) security and privacy concerns.

Lack of Knowledge

A recurring challenge noted by 30% of participants was insufficient knowledge of cloud computing technologies and their relevance to RACC. Participants indicated limited understanding of cloud benefits, risks, and application domains. For example, P2 stressed the need for programming and API knowledge:

“Having knowledge of programming languages and APIs is crucial... it helps automate resource allocation and maximize cloud benefits.”

Table 1: Challenges in RACC among SMEs (n=12)

| S.No | Challenge | TOE Category |
|------|-----------------------------------|----------------|
| 1 | Lack of Knowledge | Technological |
| 2 | Lack of Expertise | Technological |
| 3 | Network Performance | Technological |
| 4 | Optimization Complexity | Technological |
| 5 | Security & Privacy | Technological |
| 6 | Cost Efficiency | Organizational |
| 7 | Inadequate Training & Development | Organizational |
| 8 | Monitoring Usage & Performance | Organizational |
| 9 | Economic Factors | Environmental |
| 10 | Market Competition | Environmental |
| 11 | Scalability & Performance | Environmental |

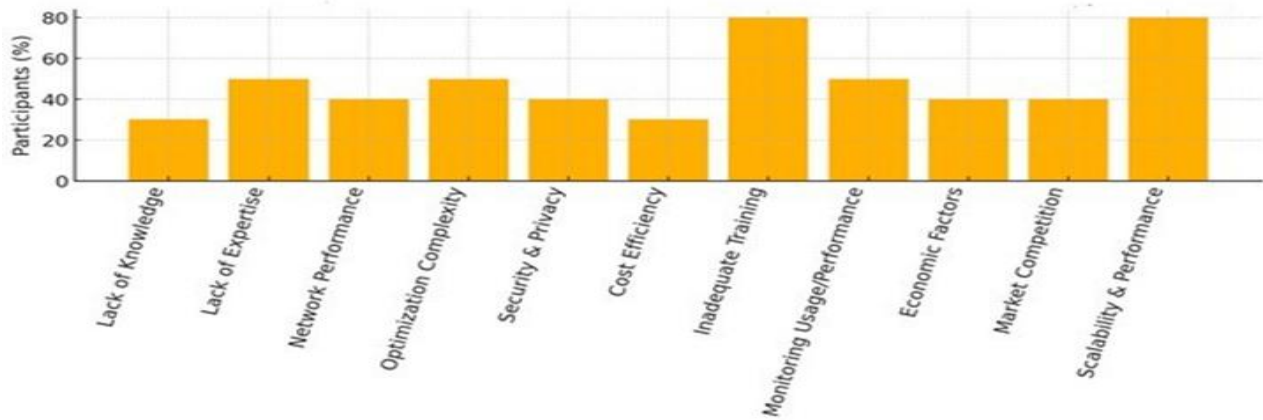


Figure 1: Challenges in RACC

The above Table presents the frequency distribution of the 11 identified challenges affecting Resource

Allocation in Cloud Computing (RACC) among SMEs, categorized according to the TOE framework.

As shown, organizational and environmental challenges such as inadequate training and development and scalability and performance were reported by the highest proportion of participants (80% each). Among the technological factors, lack of expertise and optimization complexity were the most frequently acknowledged issues (50% each), followed by network performance and security and privacy concerns (40% each).

The bar chart visually reinforces these findings by depicting the relative weight of each challenge based on participant responses. The graph clearly shows that organizational capacity specifically lack of employee training — and environmental constraints related to scalability impose greater barriers to effective cloud resource allocation than some of the technical aspects alone. This suggests that RACC failures in SMEs are not driven solely by technology limitations but are also strongly influenced by human-resource readiness and demand volatility in market environments.

Lack of Expertise

Half of the participants (50%) reported the absence of adequate technical expertise as a major barrier. Required skills include architecture design, virtualization, storage, database integration, compliance, automation, and DevOps. P3 remarked: Other participants (P4, P5, P7, P9) reinforced this by citing the need for knowledge in resource pooling, elasticity, containerization, and cost optimization strategies.

Network Performance

Network-related constraints were mentioned by 40% of respondents. Challenges included latency, traffic handling, and complex hybrid connectivity between on-premises and cloud environments. As P11 reported: “Establishing network connections between on-premises and cloud resources was challenging and required significant time to resolve.”

Optimization Complexity

Half of the participants cited difficulties in performance, cost, and load optimization. P5 noted: “Optimization is very important — customers want their objectives achieved with less cost.”

Security and Privacy

Security and privacy concerns were raised by 40% of respondents. Participants stressed compliance, architectural compatibility, and trust as central to RACC decision-making. P3 summarized: “Ensuring data security, choosing the right service provider, and integrating with existing systems are major challenges.”

Organizational Challenges

Three key organizational barriers emerged: (1) cost efficiency, (2) inadequate training and development, and (3) monitoring of resource usage and performance.

Cost Efficiency

While savings are achievable over time, P8 noted that achieving cost efficiency is a gradual process.

Inadequate Training and Development

A dominant 80% of participants identified lack of structured employee training as a barrier. Training in server maintenance, resource selection, load balancing, and DevOps was emphasized. P3 reported: “Training improved adoption and utilization leading to greater efficiency and effectiveness.”

Monitoring Resource Usage and Performance

Half of the participants stressed inadequate monitoring practices. P3 pointed out: “Monitoring performance is a side-by-side goal to ensure regular optimization.” Participants confirmed the use of tools for tracking consumption and enabling capacity planning.

Environmental Challenges

Environmental-level barriers include: (1) economic factors, (2) market competition, and (3) scalability and performance pressures.

Economic Factors

Participants recognized economic incentives of cloud computing such as reduced CAPEX and better utilization. P6 illustrated with an analogy:

Market Competition

Forty percent reported that competition and regulatory pressures influence RACC decisions. P9 shared: “Market competition can drive organizations to adopt cloud solutions to gain advantage.” Competition, compliance (e.g., HIPAA, GDPR), and technology trends drive strategic allocation decisions.

Scalability and Performance

Scalability and performance concerns were raised by 80% of respondents. Cloud growth demands auto-scaling, load balancing, and right-sizing practices. P4 remarked: “Scalability is one of the hallmarks of the cloud and a primary driver of its popularity.” Participants highlighted using modern techniques to maintain performance under fluctuating workloads.

V. DISCUSSION AND FUTURE DIRECTIONS

The primary purpose of this study was to explore the challenges associated with Resource Allocation in Cloud Computing (RACC) within SMEs. A total of 11 barriers were identified from interviews with 12 participants and classified according to the TOE (Technology–Organization–Environment) framework. Technological barriers included:

(1) lacks of expertise, (2) lack of knowledge, (3) network performance issues, (4) optimization complexity, and (5) security and privacy concerns. Organizational barriers comprised: (6) cost efficiency constraints, (7) inadequate training and development, and (8) Challenges in monitoring resource usage and performance. Environmental barriers consisted of: (9) economic factors, (10) market competition and (11) scalability and performance requirements. The findings reveal that participant sempha sized technology-related challenges more prominently than organizational and environmental ones. This is likely influenced by the participants’ professional profiles — as noted in, eight of the twelve respondents hold technical roles — and by the continuously evolving nature of cloud technologies and resource configurations. Similar emphasis on technological barriers has been reported in earlier studies, indicating that the literature predominantly addresses technical constraints while under-emphasizing organizational and environmental influences.

Consistent with earlier studies [18], security and privacy were among the most pressing concerns reported. SMEs often lack the expertise required to ensure compliance with enforced data protection regulations (e.g., HIPAA, GDPR) or to determine which data should be stored, accessed, or encrypted. Furthermore, the findings corroborate prior work that SMEs risk losing control over resources when relying fully on cloud service providers. Dependence on provider policies may disrupt service uptime, hinder customization, or delay remediation of performance issues.

The results also align with reported concerns regarding vendor lock-in [19]. Limited interoperability and proprietary platforms restrict an SME’s flexibility to migrate or renegotiate service terms, increasing strategic and financial risk. Additionally, organizations in regulated sectors face compliance and legal challenges that, if ignored, may result in fines, litigation, reputational loss, or customer mistrust.

Looking forward, the integration of advanced technologies such as machine learning, AI, and automation holds strong potential for improving resource allocation processes within SMEs. Intelligent algorithms can analyze historical usage, forecast demand, and automate allocation decisions. Future research could explore the practical deployment of AI-based allocation frameworks tailored specifically to SME needs.

Finally, this study focused exclusively on SMEs, yet many challenges identified — such as security, privacy, and cost — are also experienced by large enterprises, though managed differently. Larger organizations employ custom architectures, internal expert teams, and allocate higher budgets for performance and customization, whereas SMEs tend to outsource cloud operations due to budget and capacity constraints. Future research should comparatively analyze RACC challenges across enterprise scales to understand how organizational size influences strategy, capability, and outcomes.

VI. CHALLENGES AND LIMITATIONS

This study is not without limitations, which must be acknowledged when interpreting its findings. First, the sample size was relatively small, which may constrain the broader applicability of the results. However, this is characteristic of qualitative research, which

prioritizes depth of understanding over statistical generalizability. As noted in, qualitative studies do not aim to produce universally generalizable outcomes; therefore, caution should be exercised in extending the findings to all SMEs or other organizational contexts. Second, the study employed a single qualitative method — semi-structured interviews without incorporating complementary data sources or methodological triangulation. The absence of mixed-method integration may limit the internal validity of the findings. A mixed-methods approach combining interviews with survey data or quantitative performance metrics could have strengthened triangulation and enhanced confidence in the derived insights.

Third, the study relied on the subjective perspectives and self-reported experiences of participants. While such narratives are valuable for exploring perceptions and lived experiences, they may be influenced by personal biases, memory limitations, or organizational culture. It is therefore difficult to determine the complete neutrality or objectivity of the responses. To address this limitation, future research should incorporate survey-based instruments with a larger respondent base to examine the views of SME owners, managers, and employees during different phases of cloud implementation, particularly in design and execution stages. Such inclusion would enrich the dataset and improve the robustness and validation of the findings.

VII. CONCLUSIONS

While cloud computing offers substantial benefits, effective management and allocation of cloud resources in SMEs remains a significant challenge. This study conducted an in-depth qualitative investigation into the perceptions of managers and experts to identify and categorize the barriers affecting Resource Allocation in Cloud Computing (RACC) within SMEs. Using the TOE framework, a total of 11 challenges were identified and grouped into three dimensions. The technological barriers included: (1) lack of expertise, (2) Lack of knowledge, (3) network performance issues, (4) optimization complexity, and (5) Security and privacy concerns. The organizational barriers comprised: (6) cost efficiency constraints, (7) inadequate training and

development, and (8) challenges in monitoring resource usage and performance. The environmental barriers consisted of: (9) economic factors, (10) market competition, and (11) scalability and performance requirements.

The results indicate that technological barriers received greater emphasis from participants compared to organizational and environmental factors. This asymmetry highlights a critical research gap: an excessive focus on technical challenges may obscure equally impactful organizational and environmental constraints, ultimately limiting the overall effectiveness of RACC practices in SMEs. Accordingly, future research should place stronger emphasis on exploring and addressing the organizational and environmental dimensions of RACC, as overcoming these barriers is essential for enabling SMEs to harness the full potential of cloud computing and achieve sustainable operational efficiency.

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