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RESEARCH ARTICLE

# Improving Software Robot Maintenance in Large-Scale Environments–is Center of Excellence a Solution?

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**ABSTRACT** Robotic Process Automation (RPA) performs high-volume tasks such as checking invoices. However, the governance and maintenance of large-scale software robot environments can be challenging when robot servers perform automatized tasks simultaneously for customer organizations with complex programming rules, dedicated parameters, and dependencies on timetables. A multivocal literature review (MLR) was conducted to explore whether there are 1) mechanisms to improve software robot maintenance in large-scale robot environments, 2) or software robot maintenance practices for scalable RPA in organizations providing shared services, 3) or governance models for optimizing the performance of software robot maintenance, and 4) is the Center of Excellence (CoE) one of the success factors concerning large-scale robot environments. By doing this, 5) we found eleven functional requirements for the monitoring tool to support maintenance in a large-scale environment. In addition, we adapted them to the RPA monitoring tool abilities for the Finnish Government Shared Services Centre for Finance and HR (Palkeet). As a result, the eleven functional requirements and the monitoring tool abilities are adaptable for other large-scale environments to improve software robot maintenance. However, commercial monitoring tools for RPA maintenance do not fulfil functional requirements, and organizations in large-scale environments must develop their monitoring tools. Based on MLR, either in-house or outsourced CoE seems to be one of the success factors in RPA maintenance in large-scale environments.

**INDEX TERMS** Center of excellence, CoE, governance, maintenance, robotic process automation, RPA.

## I. INTRODUCTION

Organizations are increasingly interested in improving processes by utilizing robotic process automation (RPA) to maintain competitiveness in a rapidly changing technology environment. RPA refers to the programming of activities and transactions that automatically repeats the performance of a similar task on data sets or/and systems according to specific rules, replacing human work. RPA is defined as a ''preconfigured software instance that uses business rules and predefined activity choreography to complete the autonomous execution'', where the execution is ''a combination of processes, activities, transactions, and tasks in one or more unrelated software systems to deliver a result or service with a human exception management'' [1]. The automated process can reduce errors and costs from manual work and perform repetitive routine tasks in agile, influencing the efficiency and quality of the operations. The RPA benefits are apparent; for example, software robots can work 24/7, increase productivity and daily throughput, improve accuracy, increase client satisfaction, and decrease operating risks [2, pp. 11 and 12].

Software robots of the RPA solutions ''mimic'' human interactions with systems to perform specific tasks in processes [1], [3], [4], [5], [6], [7], [8], [9], [10]. Usually, software robots perform routine tasks that are rule-based, repetitive, well-structured, and high-volume [2, pp. 32], [5], [7], [10]. Furthermore, RPA is non-invasive: it does not change the involved software systems because the robot utilizes the software systems like a user, but automation is sitting ''on top of them'' [7], [8], [10].

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The RPA effects can be positive or negative for humans or companies; for example, when deploying RPA, employees may have performed non-value-adding tasks that the robot can execute, and the employees will focus on cognitively demanding tasks. Still, the employees may be afraid of losing their job, especially low-level tasks, or fearful of learning the use of modern technology [10]. Positive effects on the companies are speed: rapid automated tasks, availability: robots are working 24/7, compliance: executed tasks are transparent and documented, and quality: accuracy and data quality increase [10]. Nevertheless, negative effects on the companies remain the rule-based RPA cannot make decisions, and project costs can exceed the budget. RPA also has limitations: the non-invasiveness RPA solution as a workaround or temporary solution requires the stability, availability, and performance of the system [10].

Typically, the business areas for utilizing RPA are Business Process Outsourcing, Shared Services, Telecommunication, and Banking; for example: updating employee payment details and creating new employment relationships, copying data from Excel to the HRM systems, carrying out the SIM swaps, and applying the pre-calculated credit to the account, and copy details of the personal loan or current account from the mainframe application to Excel [10].

RPA technology is relatively new in shared services. A shared service provider is ''a performer of work within one unit within an organization that can be used by many more units within the organization'' [11]. Shared services are centralized administrative functions, for example, human resources, accounting, and information services [11]. Shared service organizations process high-volume data with defined and standardized processes and software systems and have found the advantage of RPA utilization to achieve cost-effectiveness and high quality to meet the expectations of the customers. The processes include repetitive tasks with clear rules, and the data are well-structured to process by RPA. Shared services can meet the RPA requirements, for example, well-defined processes and a high volume of repetitive, regular, and routine tasks [3]. The most implemented RPA areas in the shared services, according to Figueiredo *et al.* [3], are accounting (75%), human resources (62,5%), information technology (62,5%), and customer service (50%). Shared service organizations have identified candidates for RPA; for example, Finance: Accounts Payable, Order-to-Cash, Procure-to-Pay, HR: Payroll, Hire-to-Retire, and IT function: Ticket Management, Database Management [9]. In the Deloitte survey [12], Global Business Services had three key transformation enablers: RPA, global standard processes, and single-instance ERP. According to the study [12], 72 % of the organizations had implemented RPA, with 20% realizing between 20% and 40% savings (up from 9% in 2019).

The earliest RPA adopter in the shared services was Telefonica O2, which started with RPA in 2010 [13]. After five years, it deployed over 150 robots with noticeable results: increased return on investment, reduced turnaround times, and enabled scalability [13]. Shared services have had five main transformation levers from back-offices: centralize physical facilities and budgets, standardize and optimize processes, relocate from high-cost to low-cost destinations, and technology-enabled by self-service portals, and the sixth lever is automation [13]. As a result, the customer expectations of the shared services are to deliver cost-effective, scalable, flexible services with business enablement, innovation, and high compliance. Therefore, RPA seems to have three distinctive characteristics compared to other automation tools: 1) easy to configure and does not require programming skills, 2) non-invasive: RPA software uses the presentation layer, and 3) enterprise-safe: fulfils needs of security, scalability, auditability, and change management [13].

RPA seems to be ''a strategic priority for the shared services and global business services leader all over the world'', and ''also an enabler for other technology lead initiatives'' [14]. When implementing and deploying RPA, the shared services (i.e., organizations that provide the shared services) have found the need for an internal core team called the ''center of excellence'' (CoE), which includes the business process knowledge and technological skills [3]. CoE is responsible for the entire life cycle of the RPA program: governance and strategy, the architecture of the RPA ecosystem, and RPA operations, for example, maintenance, and delivery [2, pp.124 and 125]. CoE is established with RPA but is a rare concept in scientific research.

In general, the types of industrial maintenance are predictive, preventive, and reactive. Preventive maintenance is the most effective maintenance strategy for large-scale software robots due to their requirements concerning user interfaces (UI) and workflows. Preventive maintenance is defined as a ''process of inspection, replacement and/or repairs of components that is performed at regular intervals on assets to avert damage or failure'' [11], where the UIs of the software systems and their using workflows are typical assets to considered in RPA solutions. In addition, the planned service outages are considered in the RPA solutions. These planned outages are examples of predictive maintenance concerning ''activities involving continuous or periodic monitoring and diagnosis in order to forecast component degradation so that as-needed, planned maintenance can be performed prior to equipment failure'' [11]. Reactive maintenance is driven by hardware or software problems. The RPA solutions are sensitive to either the hardware or software problems being deviations that concern ''performance, functionality, or security standards in hardware or software'' [11].

Maintenance in large-scale software robot environments can be challenging even if CoE is responsible for implementing and deploying. For example, in the Finnish Government Shared Services Centre for Finance and HR (Palkeet), the robot servers may perform automatized tasks simultaneously for sixty customer organizations with complex programming rules. When scaling the robot job, different parameters might exist dedicated to the customer organization during the robot run. The job timing may depend on the performance of other

**TABLE 1. Research search details. Last accessed Feb. 19, 2022.**

| Search Engine | 1) Search process | Hits | 2) Source selection | 3) Quality assessment | 4) Data analysis | |
|---|---|---|---|---|---|---|
| Google Scholar | "robotic process automation" & monitor since 2018 | 3980 | 169 articles | Include and exclude criteria 124 articles | ATLAS.ti text analysis | Validation for RQ1-4 |
| | maintenance & "robotic process automation" & since 2018 | 2440 | | | RQ1: 13 codings | → 8 papers |
| | dashboard & "robotic process automation" | 360 | | | RQ2: 14 codings | → 6 papers |
| | "center of excellence" & RPA since 2019 | 209 | | | RQ3: 22 codings | → 8 papers |
| University of Eastern Finland (Primo) | "center of excellence" & RPA since 2019 | 432 | | | RQ4: 10 codings | → 6 papers |
| | "shared service" & RPA | 224 | | | | |
| CORE | Search for public articles which were not available by other search engines | 3 | | | | |

robots. Therefore, optimizing the performance of the virtual workforce may need RPA governance and maintenance practices to lead a successful automation pipeline. In this study, we present the challenges of software robot governance concerning maintenance in large-scale environments and perform a case study to improve the maintenance of RPA in the Palkeet CoE. The study answers the following research questions

- RQ1: Are there mechanisms to improve software robot maintenance in large-scale environments?
- RQ2: Are there software robot maintenance practices for scalable RPA in organizations providing the shared services?
- RQ3: Are there governance models for optimizing the performance of the software robot maintenance?
- RQ4: Is the Center of Excellence a success factor in large-scale robot environments?
- RQ5: Are there any functional requirements for the RPA monitoring tool to improve maintenance?

First, we conduct phases of a literature review and report the results of research questions based on multivocal literature (Chapter II). Then, the multivocal literature review (MLR) results from the case study concerning improving the RPA CoE in the Shared Service Centre (Chapter III). Finally, we summarize the results of the research questions and experiments of the case study (Chapter IV).

## II. MULTIVOCAL LITERATURE REVIEW

This chapter includes how we applied a multivocal literature review (MLR) for the articles found and presents the review results.

### A. PHASES OF LITERATURE REVIEW CONDUCTING

To find relevant literature to our study to answer research questions, we adapted a MLR [15] to summarize state-of-art. Phases of our MLR were 1) search process, 2) source selection and 3) quality assessment of sources, and 4) data analysis. In addition, after every MLR phase, peer-reviewing was performed by two authors. Our research process and MLR phases within the outputs are presented in Fig. 1. At the beginning of the search process, we chose Google Scholar

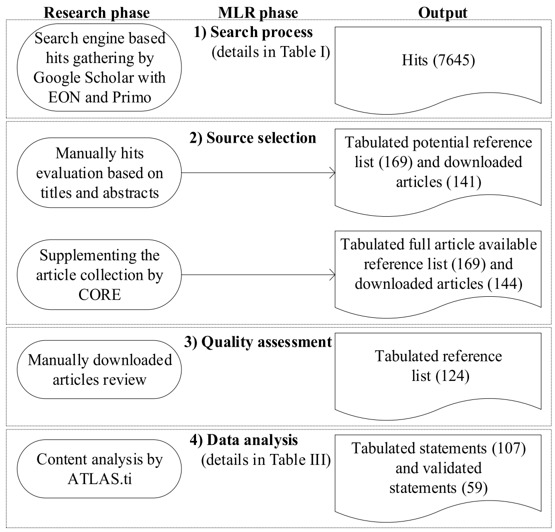


**FIGURE 1. Literature review phases and outputs.**

and specialized search services: University of Eastern Finland Primo and CORE,[1] and we utilized the

EndNote plugin (EON) provide access to the databases of the institution libraries for researchers.[2] In addition, we found papers during the search process by contacting a consulting firm (Deloitte Ltd) to get the report of global shared services [12]. The research search engines, search queries, hits, source selection, quality assessment, and data analysis results are presented in Table 1.

After searching Google Scholar and Primo, we evaluated manually hits findings (7645) based on titles and abstracts as well as whether the entire article might be available. Hits exclusion criteria included articles not available in English, abstract access only, case studies written by vendors (e.g., BluePrism, Microsoft, and UiPath), and articles without references to other papers. After the hits evaluation, we gathered a tabulated list of 169 references for full-text retrieval.

The next step in the search process was retrieval by CORE to search for public articles which were not available by other

[1] https://core.ac.uk/

[2] https://click.endnote.com/for-libraries

**TABLE 2. Database services of the selected articles.**

| Database service | Count of articles | Included articles | Code-based co-occurrence articles | Validated articles |
|---|---|---|---|---|
| link.springer.com | 25 | [28], [39], [48], [49], [52], [53], [56], [58], [60], [62], [66], [72], [80], [85], [107], [120], [121], [122], [127] | [2], [7], [9], [17], [21], [23], [52], [60], [72], [107], [127] | [2], [7], [9], [17], [21], [23] |
| ieeexplore.ieee.org | 18 | [26], [35], [42], [43], [47], [50], [76], [86], [95], [103], [110], [106], [117], [118], [124], [125], [126], [128] | | |
| sciencedirect.com | 8 | [33], [64], [69], [77], [92], [102], [116] | [4], [77], [92] | [4] |
| researchgate.net | 7 | [55], [82], [89], [105], [109] | [3], [16] | [3], [16] |
| ssrn.com | 7 | [41], [44], [54], [108], [129], [130] | [22], [44] | [22] |
| mdpi.com | 5 | [40], [65], [112], [115] | [6] | [6] |
| sagepub.com | 5 | [31], [37], [38], [93] | [18] | [18] |
| sciendo.com | 3 | [29], [111], [113] | | |
| aisel.aisnet.org | 2 | [123], [81] | | |
| arxiv.org | 2 | [27], [78] | | |
| dl.acm.org | 2 | [59], [101] | | |
| ijitee.org | 2 | [96] | [14] | [14] |
| iopscience.iop.org | 2 | [36], [98] | [98] | |
| proquest.com | 2 | [74], [83] | | |
| tandfonline.com | 2 | [79], [10] | | |
| aaltodoc.aalto.fi | 1 | [32] | | |
| acrn-journals.eu | 1 | [57] | | |
| aircconline.com | 1 | [88] | | |
| amazonaws.com | 1 | | [13] | [13] |
| ase.ro | 1 | [94] | | |
| aston.ac.uk | 1 | [97] | [97] | |
| cejsh.icm.edu.pl | 1 | [70] | | |
| cyberleninka.org | 1 | [30] | | |
| dbc.wroc.pl | 1 | | [20] | [20] |
| dl.gi.de | 1 | [63] | | |
| econstor.eu | 1 | | [19] | [19] |
| gito.de | 1 | [61 | | |
| hawaii.edu | 1 | | [8] | [8] |
| hdl.handle.net | 1 | [84] | | |
| hrcak.srce.hr | 1 | [34] | [34] | |
| iacis.org | 1 | [75] | | |
| ijctjournal.org | 1 | [46] | | |
| ijeat.org | 1 | [71] | | |
| ijert.org | 1 | [100] | | |
| ijresm.com | 1 | [45] | | |
| ijsrcseit.com | 1 | [104] | | |
| jssidoi.org | 1 | | [24] | [24] |
| logforum.net | 1 | [99] | | |
| meridian.allenpress.com | 1 | [90] | | |
| onlinelibrary.wiley.com | 1 | [73] | | |
| pbn.nauka.gov.pl | 1 | [114] | | |
| proc.conisar.org | 1 | [91] | [91] | |
| scielo.br | 1 | [87] | [87] | |
| semanticscholar.org | 1 | [68] | | |
| uminho.pt | 1 | [119] | | |
| umsl.edu | 1 | | [5] | [5] |
| unimas.my | 1 | [51] | | |

search engines. Still, we got only three full-text downloads from CORE. Finally, the tabulated reference list rejected 26 papers without full access. 19 papers did not meet the purpose of the study, and one was a case study written by the vendor. After manual quality assessment, the final tabulated reference list contained 124 papers targeted at their databases services before and after the content analysis research phase (Table 2 ). We found the digital object identifier (DOI) for the included articles. If we did not find DOI, then we figured out another link to assess the article. The validated articles have DOI, except [5], [8], [13] and [14].

We performed the content analysis with ATLAS.ti[3] (version 22.0.10.0), and coded sentences of 124 papers with words: RPA OR Robotic Process Automation OR software robot, CoE OR center of excellence, shared service, governance OR governance model, maintenance OR maintenance practice, operating environment OR robot environment OR RPA environment OR bot environment OR software robot environment, large scale, success, optimal OR optimize OR optimizing, performance and scalable OR scale OR scaling.

[3] https://atlasti.com/

**TABLE 3. Co-occurrence table of the codes.**

| Code | CoE OR center of excellence | governance OR governance model | maintenance OR maintenance practice | performance | shared service |
|---|---|---|---|---|---|
| governance OR governance model | 21 | 0 | 21 (RQ3) | 8 (RQ3) | 1 (RQ2) |
| large scale | 2 (RQ4) | 2 | 0 (RQ1) | 1 | 0 |
| maintenance OR maintenance practice | 11 (RQ1) | 21 (RQ3) | 0 | 8 (RQ3) | 0 (RQ2) |
| operating environment OR robot environment OR RPA environment OR bot environment OR software robot environment | 1 (RQ4) | 5 | 2 (RQ1) | 1 | 0 |
| optimal OR optimaze OR optimizing | 3 (RQ4) | 0 (RQ3) | 1 (RQ3) | 5 (RQ3) | 0 |
| RPA OR Robotic process automation OR software robot | 121 | 186 | 108 | 156 | 39 (RQ2) |
| scalable OR scale OR scaling | 4 | 7 | 3 (RQ2) | 6 | 1 (RQ2) |
| shared service | 1 (RQ2) | 1 (RQ2) | 0 (RQ2) | 0 | 0 |
| success | 5 (RQ4) | 14 | 4 | 7 | 1 |

We found the co-occurrences presented by ATLAS.ti (Table 3 ), which indicates the number of findings referring to research questions RQ1-RQ4. After the co-occurrence analysis, we validated the findings by trying to get answers to research questions. In the beginning, the co-occurrence table had 107 codes; after the validation, we had 59 codes, which referred to nineteen papers to answer the questions. Papers removed from the study after data analysis are in [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92], [93], [94], [95], [96], [97], [98], [99], [100], [101], [102], [103], [104], [105], [106], [107], [108], [109], [110], [111], [112], [113], [114], [115], [116], [117], [118], [119], [120], [121], [122], [123], [124], [125], [126], [127], [128], [129], and [130]. In addition, answers to research question 5 are based on the results of the research questions 1–4.

### B. RESULTS OF THE LITERATURE VIEW

#### 1) RQ1

Are there mechanisms to improve software robot maintenance in large-scale environments?

Selected literature did not contain pieces of evidence to use to define the software robot maintenance mechanisms (a mechanism is accounted for in this study as ‘‘a natural or established process by which something takes place or is brought about’’ [11]) concerning the large-scale robot environments. The selected literature deals with the development or deployment of individual software robots, not the maintenance of multiple or scalable software robots. However, there were few recommendations or requirements for organizing the maintenance when analyzing the literature [2], [4], [6], [16], [17], [18], [19], [20].

There are studies [2, pp.123–133], [4], [6], [16], [17], [18], and [19] that recommend organizations to build a center of excellence (CoE) to be responsible for robot maintenance. However, internal IT or external providers can take this responsibility in organizations [20]. Furthermore, according to studies [2, pp. 123–133], [6], [19], CoE should separate the robotic process automation (RPA) development and maintenance into distinct functions. For example, the preventive maintenance to update robots includes advanced information on changes in the UI, business process, and robot input [18].

CoE should ensure a maintainable automated process utilizing the core workflow principles and design practices from the beginning to the end of the automation pipeline [16]. In addition, CoE should proactively ensure service delivery maintenance by engaging the business and IT change management teams to manage operational and system changes [16]. The maintenance team should provide the second level of support for the workflow incidents and third level of RPA vendor support and confirm that the virtual workforce in the robot environment achieves the optimal level [16].

#### 2) RQ2

Are there software robot maintenance practices for scalable RPA in organizations providing the shared services?

When exploring the software robot maintenance practices in shared services, the literature presented the benefits of the RPA deployment. The selected literature deals with the development or deployment of scalable software robots, not the maintenance practices of scalable software robots. However, we found the suggestions for a governance structure for maintenance and the proposals that can affect maintenance when scaling up RPA [2], [7], [8], [13], [14], [16].

Although adopted service automation within IT or business operations/shared services, there are requirements for the RPA capability embeddings into the business units and shared service functions [13]. Global Shared Service Centers can organize the governance structure or CoE for development and maintenance 1) decentralized, 2) centralized model, or 3) federated [7], [16]. For example, two co-operated business units can organize the government shared service center RPA [8].

For example, the long-term maintenance challenges of the shared service are quality control and SLA adherence [14]. Furthermore, the RPA tool may have features that affect scalability, maintainability, changeability, or low-coding [2] (p.170). Maintenance challenges may increase when the organization is scaling up RPA, whereas further standardization requires less maintenance and causes fewer exceptions [7].

#### 3) RQ3

Are there governance models for optimizing the performance of the software robot maintenance?

The selected literature contained one piece of evidence for the governance model [21]. However, the software robot maintenance includes in governance [2], [4], [18], [19], [22]. The selected literature deals with conceptual RPA governance containing RPA maintenance without maintenance performance optimization. However, governance practices, including process and data management, can improve and optimize the performance of software robots [23].

The RPA governance and maintenance are the key issues when implementing and deploying the software robots. The benefits of RPA are eliminated by software development or maintenance deficiencies, RPA governance, or IT infrastructure [18]. In these areas, potential problems are exception handling, difficulty integrating modern technologies, reusability of components, dealing with downtimes, lack of standardization, improving already robotized processes, and IT system complexity [18]. On the other hand, the development team can optimize robot performance by reviewing the software robot workflows and analyzing root-cause of the faulted tasks [23]. Moreover, the data management governance, including the design principles for the data structure and data quality improvement of the automatized tasks, will affect the robot performance [23].

CoE [2, pp. 123-133], [4], [18], [19] manages the RPA governance. For example, the RPA governance model of Deutsche Bank includes implementation, development, maintenance, compliance, risk management, roles, and responsibilities [21]. Furthermore, CoE is responsible for monitoring, building know-how, upscaling [4], and ensuring the optimal usage of the virtual workforce in the operational environment [16]. The RPA governance is either centralized or decentralized; the first offers assurance and control; the second offers more autonomy while remaining concerned about the non-unified and complex governance environment [22].

One of the success factors for the RPA implementation is ongoing governance, maintenance, and continuous improvement, which requires continuous ensure for long-term functionality and error prevention [19]. Therefore, the recommendations are 1) monitor the performance of the robots, 2) review the standardized implementation procedures, 3) delineate the business continuity plans for the cases of bot unavailability, 4) storage log data storage for transparency, and 5) examine the benefits of the RPA extension with the next-generation technologies continuously [19].

#### 4) RQ4

Is the Center of Excellence a success factor in large-scale robot environments?

According to the selected literature, CoE seems to be one of the success factors in RPA development and maintenance on large-scale [2], [6], [16], [18], [19], [24]. However, the function responsible for the large-scale robot environments is not necessarily designated as CoE in the organizational structure [2, pp.123–133].

When deploying RPA on large-scale, the organizational structure of overall RPA governance needs the following functions [2, pp.123-133]: 1) architecture of the robotic operating environment (for example, infrastructure support), RPA operations (for example, maintenance, monitoring, training, change management) 2) governance and strategy (for example process prioritization, compliance to policies and procedures, security system access), 3) delivery (for example process discovery and assessment, solution design, deployment, development of standards). In addition, the large-scale RPA requires establishing a CoE team with a standardized operating model and assigned team roles [19]. The CoE responsibilities are, for example, to ensure the maintenance and update of the methodology used to build the automation pipeline, optimize the usage of the virtual workforce, and manage technical challenges [16]. Furthermore, engaging with business both the IT change management teams to proactively manage operational and system changes to maintain service delivery [16]

CoE affects successful RPA deployment by standardizing the development and selecting the most optimal processes to automate [6]. In addition to this, uniforming performance levels, reviewing regular management and actions, being responsible for methodology, documentation, and standards, and collaborating across the value chain to optimize results [18]. Furthermore, the CoE success factors can be competence building among the business personnel on RPA and increasing the pro-innovative organizational culture among the workforce [24].

#### 5) RQ5

Are there any functional requirements for the RPA monitoring tool to improve maintenance?

The monitoring tool functional requirements are deliverable from the RQ1-RQ4 answers in Table 4. The keywords in the RQ answer statements are underlined for the derived requirement.

According to the recommendations mentioned in the RQ1 answers, CoE should have preventive maintenance to update robots in the case of changes in the UI, business process, and robot input [18]. Furthermore, CoE must ensure the service delivery maintenance to manage the operational and system changes in cooperation with business and IT [16].

Concerning the suggestions for RQ2, the RPA tool should have features affecting the ability to scale, maintain, change automation, and utilize low coding [2] (p.170). In addition,

**TABLE 4. Derived functional requirements (FRs) for RPA monitoring tool.**

| RQ | RQ answer statement | FR | Requirement | Definition |
|---|---|---|---|---|
| RQ1 | CoE should separate the RPA development and maintenance into distinct functions. For example, preventive maintenance to update robots includes advanced information on changes in the user interface (UI), business process, and robot input [18]. | FR1 | Preventive maintenance. | Support for change management in the UI, business process, and robot input by advanced information. |
| RQ2 | Furthermore, the RPA tool may have features that affect scalability, maintainability, changeability, or low-coding [2] (p.170). | FR2<br>FR3 | Scalability features of the RPA tool.<br>Maintainability and changeability features of the RPA tool. | Support for scaling RPA.<br>Support for maintenance and change management. |
| RQ2 | For example, long-term maintenance challenges of shared service are quality control and SLA adherence [14]. | FR4 | Controlling quality and SLA adherence. | Support for quality control and SLA adherence for robot jobs. |
| RQ3 | In these areas, potential problems are exception handling, difficulty integrating modern technologies, reusability of components, dealing with downtime, lack of standardization, improving already robotized processes, and IT system complexity [18]. | FR5<br>FR6 | Exception handling.<br>Improving reusability of components. | Support for exception handling for the robot jobs.<br>Support for utilizing the reusability of the components. |
| RQ3 | Furthermore, CoE is responsible for monitoring, building know-how, upscaling [4], and ensuring the optimal usage of the virtual workforce in the operational environment [16]. | FR7 | Optimal usage of the virtual workforce. | Support for optimal usage of the robot server capacity. |
| RQ3 | Therefore, recommendations are 1) monitor the performance of the robots, 2) review standardized implementation procedures, 3) delineate business continuity plans for cases of bot unavailability, 4) storage log data storage for transparency, and 5) examine the benefits of extension of RPA with next-generation technologies continuously [19]. | FR8<br>FR9 | Monitoring the performance of robots.<br>Saving log data storage for transparency. | Support ongoing governance and maintenance and continuous improvement by monitoring the performance of the robots.<br>Support for monitoring the log data of the robots from a storage location. |
| RQ1 | In addition, CoE should proactively ensure service delivery maintenance by engaging the business and IT change management teams to manage operational and system changes [16] | FR10 | Managing proactively operational and system changes. | Support the proactive maintenance: CoE can plan timetables considering the robot server capacity (FR7) and system changes (FR1). |
| RQ4 | Furthermore, the CoE success factors can be competence building among the business personnel on RPA and increasing pro-innovative organizational culture among the workforce [24]. | FR11 | CoE competence building. | Support for competence building: developers and the maintenance team can monitor the robot logs. |

the RPA development and maintenance need quality control and SLA adherence [14].

In addition, the RQ3 results contain recommendations for improving the governance model regarding maintenance to ensure long-term functionality and error prevention. For example, monitoring the performance of the software robots, reviewing the implementation procedures, and storing the log data [19]. In addition, the monitoring tool can assist the optimal usage of the virtual workforce [4], [16] and monitor the performance of the robots [19]. Finally, derived from the RQ4 answers, transparency of the operating environment supports CoE competence building [24].

## III. AN EXAMPLE OF RPA COE IN SHARED SERVICE CENTRE

This chapter introduces a case study concerning the improvement of the robotic process automation (RPA) center of excellence (CoE) in the Shared Service Centre. First, we validated the results of the multivocal literature review (MLR) to the CoE current state, and second, we derived functional requirements for future development.

Finnish Government Shared Services Centre for Finance and HR (Palkeet) has a centralized RPA CoE having more than five years of experience concerning in-house RPA based on UiPath [24]. The automation process involves the process owners and substance experts identifying, analyzing, and prioritizing tasks that CoE can robotize. For five years, rapidly increased process automation has challenged the CoE to assess the practices and methods to produce high-quality and easily maintainable robots when the finance and HR systems and processes change. For example, the Purchase Invoice Processor robot has checked over 2.1 million invoices over five years, performing the invoice checking job six times a week for sixty-four customers by five robot servers and operating three systems. The software robot environment at Palkeet manages over 140 automatized tasks 24/7 with twenty-eight robot servers. UiPath Orchestrator manages the robot servers to perform the automatized scheduled tasks. The robot servers are in seven customer-specified tenants. Most jobs of the robot servers are scalable to all customers and process their data in the finance and HR systems (Fig. 2).

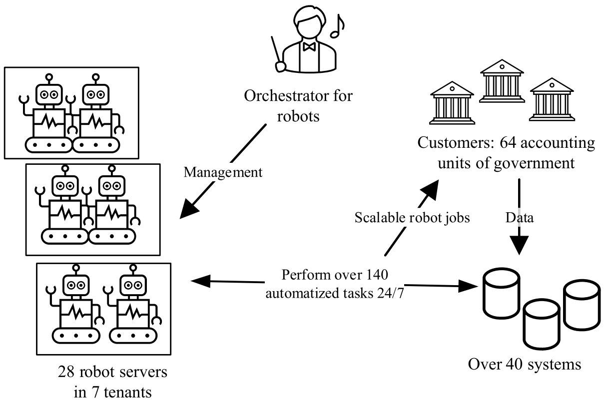


**FIGURE 2.** Software robot environment at Palkeet.

### A. RPA MAINTENANCE CURRENT STATUS

The Palkeet CoE has encountered software robot maintenance challenges due to a large-scale robot environment and miscellaneous practices when scaling up RPA. However, there are investigation tools for incidents or problems concerning RPA maintenance, for example, UiPath Orchestrator, Kibana, Outlook calendar, and Excel-based robot timetables.

This study examines software robot maintenance and scalability: there is still a need for a real-time operating environment maintenance tool besides the UiPath Orchestrator.

The Palkeet CoE has practices recommended by RQ1: the organization has the RPA CoE with separated development teams and maintenance teams [2, pp.123-133], [6], [19]. Furthermore, development from idea to maintenance (automation pipeline) has design practices [16], for example, requirement documentation, agile implementation utilizing Scrum[4] methods, documented testing, piloting use cases before delivery, and instruction of software robot maintenance for each use case. The maintenance team has second-level support from development teams and third-level support from RPA and infrastructure vendors for workflow incidents [16]. However, change management of robotized tasks is challenging because of inadequate system test environments, which generate testing after system changes. The virtual workforce could have been more optimized and scheduled in advance with a more accurate maintenance monitoring tool than the UiPath Orchestrator, presenting only a real-time view of robot runs.

The Palkeet CoE is centralized, working in five locations. The cooperation with business and ICT units has been intensive from the beginning of the RPA journey, which follows the regards of the RQ2 recommendations [7], [16]. As a result, all departments have strengthened RPA capabilities [13]. However, scaling RPA from seven automatized tasks to 140 tasks in five years has increased the software robot maintenance challenges due to the low-level standardization [7], and deficiencies in robot run maintainability and changeability [2, pp. 170].

The Palkeet CoE has an implementation model, which includes development: identification and prioritization of tasks, implementation, testing, piloting; and transferring to go-live and maintenance. However, the CoE does not have a governance model regarding the recommendation of RQ3.

However, there are governance practices: reusability of components and continuous improvement when automating processes [18]. The Palkeet CoE has assessed the risk analysis of RPA and defined roles and responsibilities [21]. The CoE maintenance team monitors the performance of the robots with existing tools like UiPath Orchestrator and manually tries to ensure optimal virtual workforce usage [4] in an MS Excel spreadsheet. Continuous improvement focuses on the practices and methods of the development and continuity plans and exploring the benefits of the enlarging RPA with machine learning [19].

### B. FUTURE DEVELOPMENTS IN RPA MAINTENANCE

In the future, the Palkeet CoE will improve the automation pipeline RPA governance, especially maintenance. Therefore, there is a need for a monitoring tool to create dashboards, such as a real-time timeline of the robot work, robot server view, history data of the performed tasks, view of the chained robot tasks, planned shutdowns, and service breaks. The monitoring tool will enable dealing with the system downtimes, improve risk management through real-time views, and proactively manage operational and system changes. The monitoring tool abilities are based on the functional requirements adapted from the RQ5 answers in Table 5.

The Palkeet CoE has defined a template that standardizes programming and implements robot logging to support development and maintenance. To get data for monitoring the software robot performance, the developers implement robots utilizing the LogField activity, which is a part of the programming template for every robotized task.

The LogField activity logs information: LogF_environment - operating environment where the robot is running

- LogF_organization_ID - the identification code of the organization whose task the robot is performing
- LogF_job_ID - the identification code of the robot job
- LogF_job_definition - the definition of the robot job
- LogF_job_step - the utilized step in the calculation of the outputs

The monitoring tool will utilize the log files from the SQL Server, which have copies from UiPath Orchestrator. In addition, the monitoring tool will fetch data also from the fileserver concerning the use case parameters and UiPath Orchestrator concerning robot servers and their jobs by the API requests[5]; for example, requesting jobs started or finished by a specific robot or retrieving faulted jobs according to errors. (Fig. 3).

The monitoring tool will serve as a dashboard of the benefits of RPA, costs, and quality of the robot jobs calculated

[4]https://www.scrumalliance.org/

[5] https://docs.uipath.com/orchestrator/reference/jobs-requests

**TABLE 5. Adapted functional requirements (FRs) for RPA monitoring.**

| FR | Requirement | Definition | Palkeet monitoring tool ability |
|---|---|---|---|
| FR1 | Preventive maintenance | Support for change management in the user interface (UI), business process, and robot input by advanced information. | The solution has a UI where the users can inform about the planned shutdowns, version updates, and service breaks of the systems. In addition, the monitoring tool has real-time and future views to present the details mentioned above in the timeline. |
| FR2 | Scalability features of the RPA tool | Support for scaling RPA. | The monitoring tool can follow the scalable robot runs across the organizations and processes, for example, by the customer code. |
| FR3 | Maintainability and changeability features of the RPA tool | Support for maintenance and change management. | The monitoring tool has different views of the robot runs and their dependencies: real-time, historical, and future. |
| FR4 | Controlling quality and SLA adherence | Support for quality control and SLA adherence for robot jobs. | The solution has history and real-time views, which present the status (successful, stopped, faulted, running, pending), errors, exceptions, and duration of the robot jobs compared to the contractual SLA saved in the use case information. |
| FR5 | Exception handling | Support for exception handling for the robot jobs. | The monitoring tool filters errors by severity in a real-time view. |
| FR6 | Improving reusability of components | Support for utilizing reusability of the components. | The monitoring tool filters reusable components from the log files to consider in change management. |
| FR7 | Optimal usage of the virtual workforce | Support for optimal usage of the robot server capacity. | The monitoring tool shows the capacity of the robot servers in real-time and historical views to support planning the robot run timetables. For example, a robot server may have a 35 % utilization rate and 65 % free capacity. |
| FR8 | Monitoring the performance of robots | Support ongoing governance and maintenance and continuous improvement by monitoring the performance of the robots. | The monitoring tool presents<br>a) Real-time views of the robot run, and their dependencies of other robot runs, excluded runtimes in the timeline using API requests from UiPath Orchestrator.<br>b) History views of the robot run, dependencies of other robot run, system shutdowns, and service breaks in the timeline utilizing the SQL database (i.e., the log data storage). |
| FR9 | Saving log data storage for transparency | Support for monitoring the log data of the robots from a storage location. | The monitoring tool can use the log data storage for the history views. |
| FR10 | Managing proactively operational and system changes | Support the proactive maintenance: CoE can plan timetables considering the robot server capacity (FR7) and system changes (FR1). | The monitoring tool presents the future views of the scheduled robot runs and their dependencies on other robots running in a timeline and system changes utilizing the SQL database. |
| FR11 | CoE competence building | Support for competence building: developers and the maintenance team can monitor the robot logs. | The monitoring tool presents the log data of processes, including error messages by log data from the SQL-server. Developers and the maintenance team can monitor robot logs and focus on detailed error handling from log data storage. |

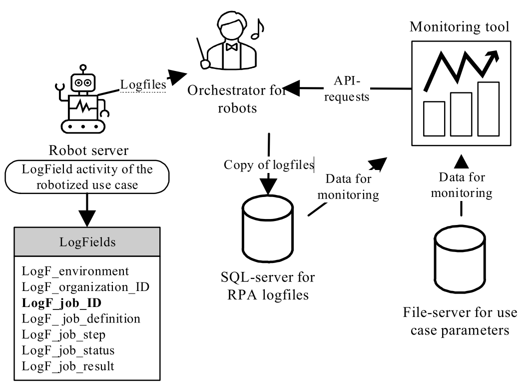


**FIGURE 3. Future development to the operational environment for the monitoring tool.**

from the robot logfiles. The monitoring tool also utilizes the case parameters data from the file server for these dashboards. Furthermore, Palkeet should pay attention to the software robot maintenance, ensure delivery with a standardized operating model [19] and development [6], and to review regular management and actions [18].

## IV. CONCLUSION

This study presented the challenges of software robot governance concerning software robot maintenance in large-scale environments. The study sought answers regarding improved mechanisms, maintenance practices in shared services, governance models for optimizing the performance the of robots, a center of excellence (CoE) importance of successful large-scale robot environments, and functional requirements for the robotic process automation (RPA) monitoring tool to improve maintenance. The multivocal literature review (MLR) results indicate a research gap in the RPA governance model for optimizing the software robot maintenance performance in large-scale environments. In addition, there was research about the RPA cases and benefits of utilizing RPA. However, there seems to be a research cap concerning the software robot maintenance in the shared services.

Based on the multivocal literature, no mechanisms exist to improve software robot maintenance concerning large-scale robot environments. The literature presented the development of individual software robots, not the maintenance of multiple or scalable software robots. However, there were recommendations or requirements for organizing the maintenance. For example, the recommendation to build CoE to be responsible for the robot maintenance [2], [4], [6], [16], [17], [18], [19]. CoE should separate the RPA development and maintenance into distinct functions. Moreover, CoE should define the core workflow principles and design practices for the automation pipeline. In addition, CoE should consider preventive maintenance to update the software robot in case of the system user interface (UI) changes and proactively ensure the service delivery maintenance cooperation with the business and IT change management teams to manage operational and system changes.

No software robot maintenance practices exist for scalable RPA in organizations providing shared services. The selected literature deals with the development or deployment of scalable software robots, not the maintenance practices of scalable software robots. However, there were several recommendations for organizing the software robot maintenance, and requirements for the RPA tool to support maintenance [2], [7], [8], [13], [14], [16]. For example, usually, the CoE structure is 1) decentralized, 2) centralized model, or 3) federated, and the RPA tool should have the ability to scale and support maintenance and change management. In addition, the RPA maintenance environment should support quality and SLA control and ensure long-term maintenance [14].

Based on the multivocal literature, there were some suggestions for the governance structure of the software robot maintenance [2], [4], [18], [19], [22], [23] and one suggestion for the governance model [21]. Still, performance optimization did not appear in the literature. The selected literature deals with the conceptual RPA governance containing RPA maintenance without maintenance performance optimization. However, governance practices, including processes and data management, can improve and optimize the performance of the software robots. RPA governance and maintenance can support, for example, exception handling, reusability of components, and dealing with downtimes. The governance model included implementation, development, maintenance, compliance, risk management, roles, and responsibilities. There were recommendations to build CoE to manage the RPA governance to be responsible for monitoring, building know-how, upscaling, and ensuring the optimal usage of the virtual workforce in the operational environment. Moreover, a critical factor for the RPA implementation is ongoing governance, maintenance, and continuous improvement, recommending monitoring, reviewing implementation procedures, ensuring business continuity planning, storing log data, and examining extensions of RPA with modern technologies.

CoE seems to be one of the success factors in RPA development and maintenance in a large-scale environment based on the multivocal literature [2], [6], [16], [18], [19], [24]. Furthermore, there were suggestions for functions and practices despite the organizational structure. For example, CoE or other organization functions can ensure the software robot maintenance and update the methodology used to build the automation pipeline, optimize the usage of the virtual workforce, and manage technical challenges. Furthermore, ensuring service delivery success requires engaging the IT change management teams for proactive maintenance and building competence among the business personnel on RPA. Moreover, successful RPA deployment requires selecting the most optimal processes to automate, standardizing of development and documentation, responsibilities of methodology, and collaboration across the value chain.

Based on the multivocal literature, the monitoring tool functional requirements were derived from the RQ1-RQ4 answers. As a result, we found eleven functional requirements: 1) preventive maintenance, 2) scalability, 3) maintainability and changeability, 4) quality and SLA control, 5) exception handling, 6) reusability of components, 7) optimal usage of a virtual workforce, 8) monitor the performance of robots, 9) saving log data storage for transparency, 10) manage proactively operational and system changes and 11) CoE competence building. These functional requirements are adaptable to large-scale environments to improve software robot maintenance.

The multivocal literature review results have been applied to improve the RPA maintenance in the Palkeet CoE. First, the CoE current state is comparable to the RQ1-RQ4 answers. Second, eleven functional monitoring tool requirements have been adapted to define monitoring tool abilities for the Palkeet CoE. Practically, the existing programming template with the log storage and available API requests makes it possible to implement functional requirements for the monitoring tool. However, current commercial monitoring tools (e.g., UiPath Orchestrator) do not meet the functional requirements. For example, in case FR 2 (scalability features of the RPA tool), UiPath Orchestrator presents technical success or fault of scalable robot runs but cannot follow runs by the customer code across organizations or present the process phase in which the robot is running. For example, in the case of FR4 (controlling quality and SLA adherence), UiPath Orchestrator presents the technical success of the software robot job despite results: logfiles can be empty or jobs do not comply with SLA. If the commercial monitoring tools do not fulfil the functional requirements, they must be developed by in-house resources or other vendors. On the other hand, adapted functional requirements (FR1-FR11) for the Palkeet monitoring tool ability can be adapted to any other large-scale environment to support software robot maintenance.

In the future, the Palkeet CoE will focus on defining detailed functional, non-functional, and security requirements for the monitoring tool and then implementing the first version to improve maintenance. In addition, the Palkeet CoE creates a dashboard to make aware the quality and benefits of RPA utilizing software robotic log files. Finally, the Palkeet CoE can strengthen the RPA scaling for customer organizations by increasing standardization to improve the development and maintenance of software robots by using common data tables for robot run parameters that include use case processes, services, and system information. Still, there is a need to define a governance model that focuses on refining practices and methods that support the ongoing RPA development and maintenance, such as reusability of the RPA components and reviews of procedures to ensure successful implementations, deliveries, and maintenance.

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