

Optimization of License Management for Business Process Automation with Robotic Process Automation

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Abstract

Purpose: Nowadays automation of business processes is increasing in popularity among organizations. The undeniable benefits, like freeing up the potential and time of well-educated employees so they can focus on more valued activities, are well known. With the growing number of automated processes, optimization of bot usage has become a significant factor in reducing costs. This paper presents an analysis supporting the proper management of business process automation in the context of bots' license usage.

Design: The goal of this research is to build a tool that allows for the analysis of license demand and supports automated management of process runs.

Findings: For the described case, the research estimated the minimum number of bot licenses to ensure that the automated processes would run in a stable manner, and identified the time periods of different license utilization levels.

Practical implication: The described analysis is a tool for cost optimization of current bot infrastructure. It supports the continuous improvement processes for automated processes run management with balanced levels of license utilization.

Value: The analysis can be easily adopted for different setups of bot infrastructure to bring about benefits of cost optimization.

Keywords RPA, heat-map, licenses, utilization, CI, improvement, UiPath

INTRODUCTION

Robotic Process Automation (RPA) is a developing technology of software automation (Taulii, 2020). Its main aim is to mimic human interactions with business software (Javed, 2021). The technology allows us to interact with the user interfaces of various applications. This allows us to develop automation without additional support from application maintenance and development teams (van der Aalst, 2018).

According to the IEEE Standards Association (2017), RPA is defined as “a preconfigured software instance that uses business rules and predefined activity choreography to complete the autonomous execution of a combination of processes, activities, transactions, and tasks in one or more unrelated software systems to deliver a result or service with human exception management”.

A significant cost of using the RPA technology is related to the purchase of licenses (Dilmegani, 2024) that are utilized while the software is performing the automated processes. This analysis seeks to establish the number of required licenses for a bot infrastructure setup by developing a method of analyzing license utilization. This method should also facilitate continuous monitoring of the infrastructure to optimize license utilization by identifying timespans with low usage, during which new process runs can be scheduled without the need for additional license purchases.

The increase in the number of automated processes over time has necessitated the expansion of the infrastructure, leading to a higher demand for additional licenses. If this growth is not managed effectively, it can result in significant cost increases, making automation projects less cost-effective and potentially hindering automation efforts within organizations.

This article focuses on a certain software, UiPath, for which the analysis and optimization of license usage was done. This analysis may also be applicable for other RPA software. The requirements are availability of the software to support multiple sessions run on a single machine and dynamic license allocations between users. In the UiPath software, this functionality is called High-Density Robots (*Robot User Guide*, 2023).

This literature review concentrated on the management of software licenses within the context of Robotic Process Automation (RPA). Notably, only a limited number of the publications analyzed here addressed the issue of license management, and when

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they did, the discussion predominantly focused on its technical aspects. The issue of reliable license utilization analysis is crucial for cost optimization in RPA solutions. The lower overall costs of the technology result in more positive business cases, allowing for the automation of more rule-based activities.

License management in RPA is a seldom-explored topic within the examined publications. An analysis of existing monographs revealed that authors have primarily emphasized foundational concepts of RPA and implementation tools (Tripathi, 2018; Merianda, 2018; Lim, 2018; Mahey, 2020), practical implementation and development of RPA bots (Mullakara & Asokan, 2018; Lim, 2018; Mahey, 2020), strategic implementation of RPA and its organizational impact (Willcocks & Lacity, 2016; Burnett, 2018; Lacity & Willcocks, 2017), integration of RPA with advanced technologies (Lacity & Willcocks, 2018; Bornet, Barkin, & Wirtz, 2020), and the future of work concerning automation's influence on the labor market (Willcocks & Lacity, 2016; Bornet, Barkin, & Wirtz, 2020).

Recent literature reviews focusing on RPA find scholarly articles primarily concentrating on the application of artificial intelligence (AI), digital transformation, and the automation of business processes, as well as methodologies for RPA implementation (Ukłańska, 2023). Furthermore, these works discuss successful RPA implementation strategies, benefits; challenges related to RPA adoption; and which processes are suitable for automation (Costa, 2022). Some publications also highlight the advantages of integrating AI with RPA, as well as the challenges faced by organizations transitioning from RPA to Intelligent Process Automation (IPA) (Siderska, 2023).

However, most publications lack detailed discussions or dedicated sections addressing licensing issues. When the topic is mentioned, it is typically relegated to a minor role, devoid of comprehensive analysis.

A supplementary search for articles pertaining to the optimization of license usage yielded limited results. For instance, the article "Don't Pay Your Digital Workers to Sleep on the Job: Bot Utilization", from *Hyper-Botz*, outlines a general framework for bot utilization management, but does not delve into specifics. Similarly, "A Guide to Optimizing Licensing Costs When Adopting RPA" from *Infopulse*, offers general recommendations, emphasizing the importance of monitoring bot run times and designing schedules to minimize interruptions in automated processes. Additionally, the publication "RPA ROI: 10 Metrics and KPIs to Drive Automation Success", from *Blueprintsys*, identifies utilization as a critical metric, reflecting the frequency and timing of automated process executions.

In summary, this literature review indicates a significant knowledge gap in the realm of RPA license management, particularly regarding methods for analyzing license utilization within the complex environment of RPA solutions that perform multiple automated tasks.

The paper describes a tool prepared in Microsoft Excel that supports the process of license management. This process focuses on maximum license utilization by the proper setup of the automated processes' runs schedule.

The analysis relies on heatmaps that are in the form of two-dimensional charts displaying the magnitude of certain values up to the present time. In their article, Wilkinson and Friendly (2009) describe clustering heatmaps that go even further by reorganizing the rows and columns so that the data create clusters. Nevertheless, the information about simple heat maps stays the same: The heat map is a rectangular tiling of a data matrix. Within a relatively compact display area, it facilitates inspection of rows and columns. In this way, moderately large data matrices (of several thousand rows/columns) can be displayed effectively on a high-resolution color monitor, and even larger matrices can be handled in print or in megapixel displays.

Data

The data for the analysis are taken from the data set of automated processes runs. The data are stored in a SQL database (Tanimura, 2021) managed by UiPath Orchestrator's (*Orchestrator User Guide*, 2023). The set of data represents logs of jobs from October to December 2022. The UiPath Orchestrator manages automated business processes by triggering them according to the schedule. Figure 1 shows a sample of records from a SQL database.

StartTime	EndTime	State	Username	Process	CreationTime	MachineName	StartTime_Hours	EndTime_Hours
01/10/2022 02:32	01/10/2022 02:35	Successful	masldom\fcde9027	S0016_Dispatcher_B	01/10/2022 02:30	E2R2S02IWCL0006	02:32:00	02:35:00
01/10/2022 03:15	01/10/2022 03:18	Successful	MASTD0M\FC000008	K0100	01/10/2022 03:15	E2R2S02IWCL0004	03:15:00	03:18:00
01/10/2022 03:30	01/10/2022 03:35	Successful	MASTD0M\FCDE498E	L0024	01/10/2022 03:30	E2R2S02IWCL0004	03:30:00	03:35:00
01/10/2022 03:45	01/10/2022 03:58	Successful	MASTD0M\FCDE6C64	S0057	01/10/2022 03:45	E2R2S02IWCL0004	03:45:00	03:58:00
01/10/2022 04:00	01/10/2022 04:40	Successful	MASTD0M\FCES401D	COOR05	01/10/2022 04:00	E2R2S02IWCL0004	04:00:00	04:40:00
01/10/2022 04:45	01/10/2022 04:51	Successful	MASTD0M\FCDE2060	D0083	01/10/2022 04:45	E2R2S02IWCL0004	04:45:00	04:51:00
01/10/2022 07:00	01/10/2022 07:02	Successful	MASTD0M\FCDE4987	L0002_Performer	01/10/2022 07:00	E2R2S02IWCL0001	07:00:00	07:02:00
01/10/2022 08:10	01/10/2022 08:11	Successful	masldom\fcde9027	S0016_Dispatcher_A	01/10/2022 08:10	E2R2S02IWCL0006	08:10:00	08:11:00
01/10/2022 09:00	01/10/2022 09:02	Successful	masldom\fcde9027	S0016_Dispatcher_B	01/10/2022 09:00	E2R2S02IWCL0006	09:00:00	09:02:00
01/10/2022 14:30	01/10/2022 15:05	Successful	masldom\fcde9027	S0016_Performer	01/10/2022 14:30	E2R2S02IWCL0006	14:30:00	15:05:00
01/10/2022 19:00	01/10/2022 21:06	Successful	MASTD0M\FCDE6C38	S0031	01/10/2022 19:00	E2R2S02IWCL0005	19:00:00	21:06:00
02/10/2022 03:15	02/10/2022 03:18	Successful	MASTD0M\FC000008	K0100	02/10/2022 03:15	E2R2S02IWCL0004	03:15:00	03:18:00
02/10/2022 03:30	02/10/2022 03:33	Successful	MASTD0M\FCDE498E	L0024	02/10/2022 03:30	E2R2S02IWCL0004	03:30:00	03:33:00
02/10/2022 03:45	02/10/2022 03:55	Successful	MASTD0M\FCDE6C64	S0057	02/10/2022 03:45	E2R2S02IWCL0004	03:45:00	03:55:00
02/10/2022 04:45	02/10/2022 04:51	Successful	MASTD0M\FCDE2060	D0083	02/10/2022 04:45	E2R2S02IWCL0004	04:45:00	04:51:00
02/10/2022 07:00	02/10/2022 07:02	Successful	MASTD0M\FCDE4987	L0002_Performer	02/10/2022 07:00	E2R2S02IWCL0001	07:00:00	07:02:00
02/10/2022 08:10	02/10/2022 08:11	Successful	masldom\fcde9027	S0016_Dispatcher_A	02/10/2022 08:10	E2R2S02IWCL0006	08:10:00	08:11:00
02/10/2022 09:00	02/10/2022 09:02	Successful	masldom\fcde9027	S0016_Dispatcher_B	02/10/2022 09:00	E2R2S02IWCL0006	09:00:00	09:02:00
02/10/2022 14:00	02/10/2022 14:01	Successful	MASTD0M\FCHU4004	L0009_Dispatcher	02/10/2022 14:00	E2R2S02IWCL0004	14:00:00	14:01:00
02/10/2022 14:30	02/10/2022 14:31	Successful	masldom\fcde9027	S0016_Performer	02/10/2022 14:30	E2R2S02IWCL0006	14:30:00	14:31:00
02/10/2022 16:00	02/10/2022 16:02	Successful	MASTD0M\FCDE4987	L0002_Performer	02/10/2022 16:00	E2R2S02IWCL0001	16:00:00	16:02:00
02/10/2022 19:00	02/10/2022 19:02	Successful	MASTD0M\FCDE4987	L0002_Performer	02/10/2022 19:00	E2R2S02IWCL0001	19:00:00	19:02:00
02/10/2022 22:00	02/10/2022 22:00	Successful	MASTD0M\FCNL6002	S0055_Dispatcher	02/10/2022 22:00	E2R2S02IWCL0002	22:00:00	22:00:00
02/10/2022 22:01	02/10/2022 22:01	Successful	MASTD0M\FCGB4630	L0005_ReleaseOffInvoices_Dispatcher	02/10/2022 22:01	E2R2S02IWCL0007	22:01:00	22:01:00
02/10/2022 22:05	02/10/2022 22:06	Successful	MASTD0M\FCDE6C1E	S0030_Dispatcher	02/10/2022 22:05	E2R2S02IWCL0003	22:05:00	22:06:00
02/10/2022 22:05	02/10/2022 22:06	Successful	MASTD0M\FCGB4630	L0005_ReleaseOffInvoices_Performer	02/10/2022 22:05	E2R2S02IWCL0007	22:05:00	22:06:00
02/10/2022 22:10	02/10/2022 22:11	Successful	masldom\fcde9027	S0016_Performer	02/10/2022 22:10	E2R2S02IWCL0006	22:10:00	22:11:00
02/10/2022 22:15	02/10/2022 22:18	Successful	MASTD0M\FCNL6002	S0055_Performer	02/10/2022 22:15	E2R2S02IWCL0002	22:15:00	22:18:00
02/10/2022 22:15	02/10/2022 22:32	Successful	MASTD0M\FCDE6C1E	S0030_Performer	02/10/2022 22:15	E2R2S02IWCL0003	22:15:00	22:32:00
02/10/2022 23:00	02/10/2022 23:57	Successful	MASTD0M\FCDE6C39	S0033	02/10/2022 23:00	E2R2S02IWCL0011	23:00:00	23:57:00
02/10/2022 23:30	03/10/2022 04:24	Successful	MASTD0M\FCDE6C47	S0047	02/10/2022 23:30	E2R2S02IWCL0003	23:30:00	04:24:00
03/10/2022 00:05	03/10/2022 00:06	Successful	MASTD0M\FCGB6008	S0015_Dispatcher	03/10/2022 00:05	E2R2S02IWCL0004	00:05:00	00:06:00
03/10/2022 00:10	03/10/2022 00:12	Successful	MASTD0M\FCGB6008	S0015_Performer	03/10/2022 00:10	E2R2S02IWCL0004	00:10:00	00:12:00
03/10/2022 01:00	03/10/2022 01:00	Failed	MASTD0M\FC000017	L0097_Dispatcher	03/10/2022 01:00	E2R2S02IWCL0016	01:00:00	01:00:00
03/10/2022 01:30	03/10/2022 01:30	Failed	MASTD0M\FC000017	L0097_Performer	03/10/2022 01:30	E2R2S02IWCL0016	01:30:00	01:30:00
03/10/2022 01:30	03/10/2022 02:04	Successful	MASTD0M\FCDE6C1C	S0026_A	03/10/2022 01:30	E2R2S02IWCL0010	01:30:00	02:04:00

Figure 1. A sample of bots' runs logs from UiPath Orchestrator

Source: Own description

Analysis

Two research questions have been formulated in the context of analyzing license utilization in RPA systems:

RQ1: What is the minimum number of licenses required for efficient management of automated process runs?

RQ2: What time periods can be identified as having low, medium, and high total license utilization?

Estimating the minimum number of licenses ensures that the stable automated processes' runs support the cost optimization. The above-mentioned model was set with 16 licenses and the same number of virtual machines with one-to-one connections. For each virtual machine, there was a schedule in place, with time spans for certain processes. The time spans were set according to the maximum potential volume of transactions that needed to be performed in a single run. Very often the maximum potential volume was significantly higher than the average. That led to a great waste of unused time for each license.

An established setup, with scheduled process run times based on maximum potential volume, was determined, based on business requirements, to be able to fully perform the current workload.

Such setups may lead to further issues. As the schedule for processes was set based on the maximum potential volume, which was established based on historical data, a future workload may exceed this level. If the preceding process is not finalized due to a bigger workload than expected, this leads to additional maintenance actions that have to be taken by the team responsible for the maintenance of the bots' infrastructure. Such unscheduled additional activities have an impact on teams' performance. Table 1 shows the utilization of virtual machines/licenses based on actual process running times. In the past, a new machine was set up when the schedules of the rest were filled. The total utilization of licenses in the analyzed time period was between 12% and 16%. The rest of the unutilized time can be treated as a waste (Bicheno & Holweg, 2016).

Table 1. Utilization of Virtual Machines (licenses) in a one-to-one model.

Virtual Machine ID	Virtual Machine Utilization		
	October	November	December
VM1	19%	15%	12%
VM2	17%	21%	20%
VM3	2%	0%	28%
VM4	9%	5%	3%
VM5	7%	11%	10%
VM6	5%	4%	3%
VM7	9%	8%	6%
VM8	9%	8%	6%
VM9	5%	5%	1%
VM10	41%	40%	46%
VM11	37%	39%	40%
VM12	0%	1%	26%
VM13	7%	12%	32%
VM14	27%	0%	1%
VM15	1%	0%	1%
VM16	16%	20%	15%

Source: Own description

A change to a high-density robot model requires information about the future number of licenses needed, as will only be one multisession virtual machine. The number of fully utilized licenses can be estimated based on data from Table 1. If in the analyzed period, there are 16 licenses used, and the maximum utilization was 16%, the minimum number of used licenses, rounded to whole numbers, is 3 ($16 \times 16\% = 2.56$). This calculation does not take into account the business requirements related to certain time periods when processes need to be performed. To account for this information, more extended analysis is required. The software used for the analysis is Microsoft Excel. The procedure of building the heat map is as follows (Walkenbach 2013). Original data, structured like on Figure 1, are stored in the table titled "JobsTable".

1. Add following columns to JobsTable, as shown in Figure 2.:
 - StartTime2, with the time part of the data in column StartTime, excluding date
 - EndTime2, with the time part of the data in column EndTime, excluding date
 - Date, with the date part of data in column StartTime, excluding time

StartTime	EndTime	State	Username	Process	CreationTime	MachineName	StartTime_Hours	EndTime_Hours	StartTime2	EndTime2	Date
01/10/2022 02:32	01/10/2022 02:35	Successful	masldomfcd9027	S0016_Dispatcher_B	01/10/2022 02:30	E2R2S02WCL0006	02:32:00	02:35:00	0.105565556	0.107038889	01/10/2022
01/10/2022 03:15	01/10/2022 03:18	Successful	MASTD0MF-CDE00008	K0100	01/10/2022 03:15	E2R2S02WCL0004	03:15:00	03:18:00	0.135416667	0.1375	01/10/2022
01/10/2022 03:30	01/10/2022 03:35	Successful	MASTD0MF-CDE498E	L0024	01/10/2022 03:30	E2R2S02WCL0004	03:30:00	03:35:00	0.145833333	0.149305556	01/10/2022
01/10/2022 03:45	01/10/2022 03:58	Successful	MASTD0MF-CDE6C64	S0057	01/10/2022 03:45	E2R2S02WCL0004	03:45:00	03:58:00	0.15625	0.165277778	01/10/2022
01/10/2022 04:00	01/10/2022 04:40	Successful	MASTD0MF-CES401D	COOR05	01/10/2022 04:00	E2R2S02WCL0004	04:00:00	04:40:00	0.166666667	0.194444444	01/10/2022
01/10/2022 04:45	01/10/2022 04:51	Successful	MASTD0MF-CDE2060	D0083	01/10/2022 04:45	E2R2S02WCL0004	04:45:00	04:51:00	0.197916667	0.202083333	01/10/2022
01/10/2022 07:00	01/10/2022 07:02	Successful	MASTD0MF-CDE4987	L0002_Performer	01/10/2022 07:00	E2R2S02WCL0001	07:00:00	07:02:00	0.291666667	0.293055556	01/10/2022
01/10/2022 08:10	01/10/2022 08:11	Successful	masldomfcd9027	S0016_Dispatcher_A	01/10/2022 08:10	E2R2S02WCL0006	08:10:00	08:11:00	0.340277778	0.340972222	01/10/2022
01/10/2022 09:00	01/10/2022 09:02	Successful	masldomfcd9027	S0016_Dispatcher_B	01/10/2022 09:00	E2R2S02WCL0006	09:00:00	09:02:00	0.375	0.376388889	01/10/2022
01/10/2022 14:30	01/10/2022 15:05	Successful	masldomfcd9027	S0016_Performer	01/10/2022 14:30	E2R2S02WCL0006	14:30:00	15:05:00	0.604166667	0.628472222	01/10/2022
01/10/2022 19:00	01/10/2022 21:06	Successful	MASTD0MF-CDE6C38	S0031	01/10/2022 19:00	E2R2S02WCL0005	19:00:00	21:06:00	0.791666667	0.879166667	01/10/2022
02/10/2022 03:15	02/10/2022 03:18	Successful	MASTD0MF-C000008	K0100	02/10/2022 03:15	E2R2S02WCL0004	03:15:00	03:18:00	0.135416667	0.1375	02/10/2022
02/10/2022 03:30	02/10/2022 03:33	Successful	MASTD0MF-CDE498E	L0024	02/10/2022 03:30	E2R2S02WCL0004	03:30:00	03:33:00	0.145833333	0.147916667	02/10/2022
02/10/2022 03:45	02/10/2022 03:55	Successful	MASTD0MF-CDE6C64	S0057	02/10/2022 03:45	E2R2S02WCL0004	03:45:00	03:55:00	0.15625	0.163194444	02/10/2022
02/10/2022 04:45	02/10/2022 04:51	Successful	MASTD0MF-CDE2060	D0083	02/10/2022 04:45	E2R2S02WCL0004	04:45:00	04:51:00	0.197916667	0.202083333	02/10/2022
02/10/2022 07:00	02/10/2022 07:02	Successful	MASTD0MF-CDE4987	L0002_Performer	02/10/2022 07:00	E2R2S02WCL0001	07:00:00	07:02:00	0.291666667	0.293055556	02/10/2022
02/10/2022 08:10	02/10/2022 08:11	Successful	masldomfcd9027	S0016_Dispatcher_A	02/10/2022 08:10	E2R2S02WCL0006	08:10:00	08:11:00	0.340277778	0.340972222	02/10/2022
02/10/2022 09:00	02/10/2022 09:02	Successful	masldomfcd9027	S0016_Dispatcher_B	02/10/2022 09:00	E2R2S02WCL0006	09:00:00	09:02:00	0.375	0.376388889	02/10/2022
02/10/2022 14:00	02/10/2022 14:01	Successful	MASTD0MF-CHU4004	L0009_Dispatcher	02/10/2022 14:00	E2R2S02WCL0004	14:00:00	14:01:00	0.583333333	0.584027778	02/10/2022
02/10/2022 14:30	02/10/2022 14:31	Successful	masldomfcd9027	S0016_Performer	02/10/2022 14:30	E2R2S02WCL0006	14:30:00	14:31:00	0.604166667	0.604861111	02/10/2022
02/10/2022 16:00	02/10/2022 16:02	Successful	MASTD0MF-CDE4987	L0002_Performer	02/10/2022 16:00	E2R2S02WCL0001	16:00:00	16:02:00	0.666666667	0.668055556	02/10/2022
02/10/2022 19:00	02/10/2022 19:02	Successful	MASTD0MF-CDE4987	L0002_Performer	02/10/2022 19:00	E2R2S02WCL0001	19:00:00	19:02:00	0.791666667	0.793055556	02/10/2022
02/10/2022 22:00	02/10/2022 22:00	Successful	MASTD0MF-CNL6002	S0055_Dispatcher	02/10/2022 22:00	E2R2S02WCL0002	22:00:00	22:00:00	0.916666667	0.916666667	02/10/2022
02/10/2022 22:01	02/10/2022 22:01	Successful	MASTD0MF-CGB4630	L0005_ReleaseOfInvoices_Dispatcher	02/10/2022 22:01	E2R2S02WCL0007	22:01:00	22:01:00	0.917361111	0.917361111	02/10/2022
02/10/2022 22:05	02/10/2022 22:06	Successful	MASTD0MF-CDE6C1E	S0030_Dispatcher	02/10/2022 22:05	E2R2S02WCL0003	22:05:00	22:06:00	0.920138889	0.920833333	02/10/2022
02/10/2022 22:06	02/10/2022 22:08	Successful	MASTD0MF-CGB4630	L0005_ReleaseOfInvoices_Performer	02/10/2022 22:06	E2R2S02WCL0007	22:06:00	22:08:00	0.920138889	0.920833333	02/10/2022
02/10/2022 22:10	02/10/2022 22:11	Successful	masldomfcd9027	S0016_Performer	02/10/2022 22:10	E2R2S02WCL0006	22:10:00	22:11:00	0.923611111	0.924305556	02/10/2022
02/10/2022 22:15	02/10/2022 22:18	Successful	MASTD0MF-CNL6002	S0055_Performer	02/10/2022 22:15	E2R2S02WCL0002	22:15:00	22:18:00	0.927083333	0.929166667	02/10/2022
02/10/2022 22:15	02/10/2022 22:32	Successful	MASTD0MF-CDE6C1E	S0030_Performer	02/10/2022 22:15	E2R2S02WCL0003	22:15:00	22:32:00	0.927083333	0.938888889	02/10/2022
02/10/2022 23:00	02/10/2022 23:57	Successful	MASTD0MF-CDE6C39	S0033	02/10/2022 23:00	E2R2S02WCL0011	23:00:00	23:57:00	0.958333333	0.997916667	02/10/2022
02/10/2022 23:30	03/10/2022 04:24	Successful	MASTD0MF-CDE6C47	S0047	02/10/2022 23:30	E2R2S02WCL0003	23:30:00	04:24:00	0.979166667	0.183333333	02/10/2022
03/10/2022 00:05	03/10/2022 00:06	Successful	MASTD0MF-CGB6008	S0015_Dispatcher	03/10/2022 00:05	E2R2S02WCL0004	00:05:00	00:06:00	0.003472222	0.004166667	03/10/2022
03/10/2022 00:10	03/10/2022 00:12	Successful	MASTD0MF-CGB6008	S0015_Performer	03/10/2022 00:10	E2R2S02WCL0004	00:10:00	00:12:00	0.006944444	0.008333333	03/10/2022
03/10/2022 01:00	03/10/2022 01:00	Failed	MASTD0MF-C000017	L0097_Dispatcher	03/10/2022 01:00	E2R2S02WCL0016	01:00:00	01:00:00	0.041666667	0.041666667	03/10/2022
03/10/2022 01:30	03/10/2022 01:30	Failed	MASTD0MF-C000017	L0097_Performer	03/10/2022 01:30	E2R2S02WCL0016	01:30:00	01:30:00	0.06025	0.06025	03/10/2022
03/10/2022 01:30	03/10/2022 02:04	Successful	MASTD0MF-CDE6C1C	S0026_A	03/10/2022 01:30	E2R2S02WCL0010	01:30:00	02:04:00	0.06025	0.086111111	03/10/2022
03/10/2022 02:15	03/10/2022 02:15	Successful	MASTD0MF-CDE6C1C	S0026_B	03/10/2022 02:15	E2R2S02WCL0010	02:15:00	02:15:00	0.09375	0.09375	03/10/2022
03/10/2022 02:30	03/10/2022 02:32	Successful	masldomfcd9027	S0016_Dispatcher_B	03/10/2022 02:30	E2R2S02WCL0006	02:30:00	02:32:00	0.104166667	0.105565556	03/10/2022

Figure 2. Adjusted log used in analysis.

Source: Own description

- In another sheet, start building the heat-map like in Figure 3. Set the rows' headings for dates and days of the week. Column headings for time start from 0:00, with each following column heading increasing by one minute. Group the first 60 columns, change their width to 1px, and on the top, set a heading to 0:00. Follow the same steps for hours 01:00, 02:00, ... till 23:00. The result is shown in Figure 3.

DATE/TIME		00:00	00:01	00:02	00:03	00:04	00:05	00:06	00:07	00:08	...
01/10	Sa										
02/10	Mo										
03/10	Tu										
04/10	We										
05/10	Th										
06/10	Fr										
07/10	Sa										
...	...										

Figure 3. A table setup for a heat-map.

Source: Own description

- For the first top-left cell, on intersection of the first day and first minute headings, set a COUNTIFS formula, where criteria_range1 is in column Date, criteria1 is the cells in the DATE column on the heatmap, criteria_range2 is the column StartTime2, criteria2 is $\geq$ the cell in row TIME on heat map (minute), criteria_range3 is the column EndTime2, criteria3 is $<$ the cell in row +1 in the row TIME on the heatmap.
- Set Conditional Formatting with a Color Scale based on the number of jobs performed in a given minute.

The result is the heat-map shown in Figure 4.

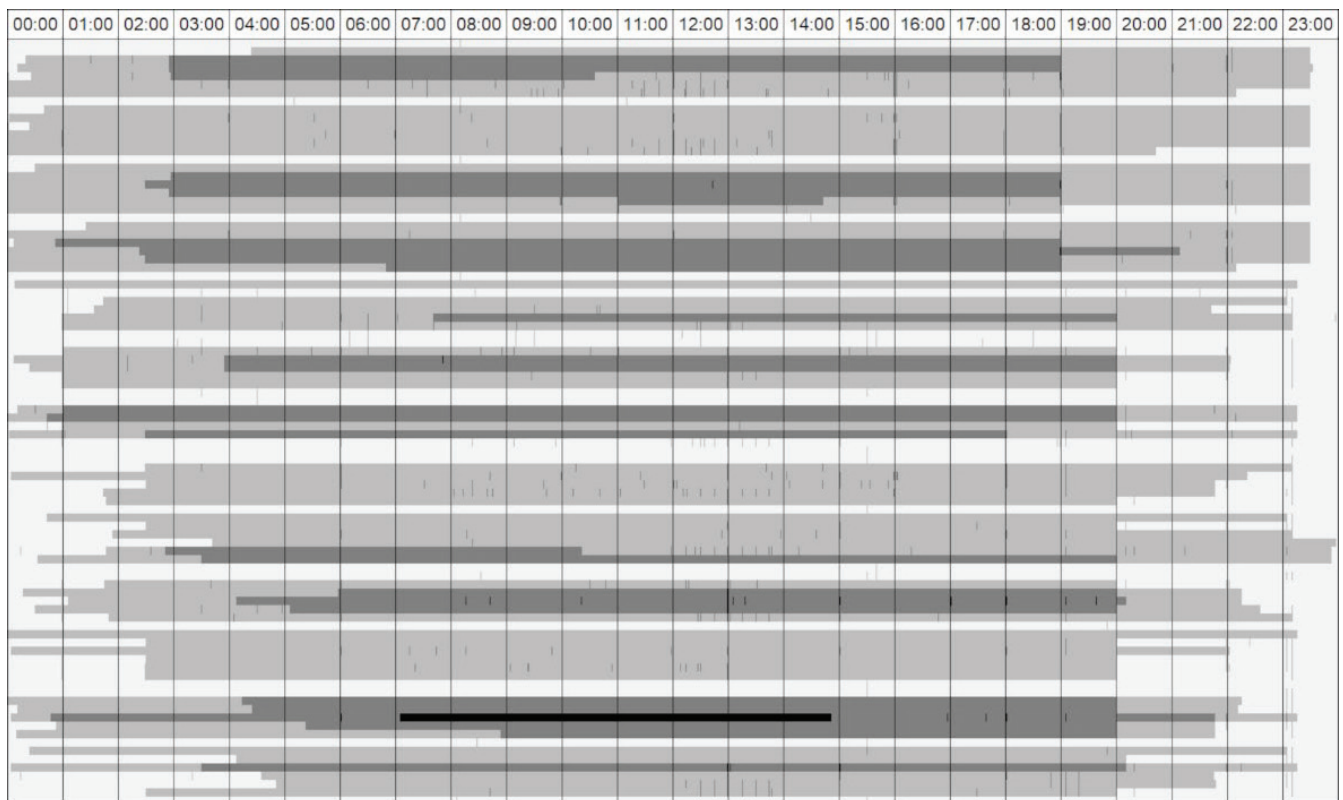


Figure 4. Heat-map for automated process runs numbers in period from October 2022 to December 2022.

Source: Own description

This heat-map shows the volume of automated process runs in the last quarter of 2022. The first dimension is the date and the second dimension is the time. The number of performed processes is shown with a color scale described in Figure 5. The number of performed process is equal the number of licenses used in a given minute. The magnitude, with low, medium, and high levels, simplifies the analysis. It would be especially useful when the number of used licenses is greater. The three-level scale provides more clarity. The example is shown in a later part of the paper.

No.	Color	Magnitude
0		n/a
1		low
2		low
3		low
4		medium
5		medium
6		medium
7		high
8		high

Figure 5. Heat-map color scale

Source: Own description

RESULTS

To establish the number of licenses required in this specific business environment, detailed analysis is needed. For this purpose, a visualization in the form of a heat-map (Figure 4) was prepared based on the system logs gathering the running times for supported processes.

The visualization on Figure 4 shows the magnitude of the automated processes performed in a given minute. It was calculated based on the running times of the processes performed on the virtual machines. As the resolution of the heat-map is minute-based it may cause issues for processes for which the running time is under one minute. The issue was solved by counting all process runs within the analyzed period of time (one minute). This solution may result in an increased number of used licenses, e.g. two processes running for 20 seconds within analyzed minute, one after another, which may be counted as a usage of two licenses. Despite this measurement inaccuracy, the final result is not affected. Such one-minute scenarios can be analyzed individually, and if they are real, the process can be queued and will be performed when the first license is freed.

The heat-maps shown in Figure 4 provide high-level information about the numbers of performed processes (at low, medium, high levels), and visible periodic occurrences. The goal of the analysis was to find the minimum number of licenses that can ensure proper management of automated process runs and satisfactory performance of automated processes. For this purpose, more detailed analysis is needed. Tables 2, 3 and 4 show the running times (in minutes) for a certain number of simultaneously-run processes in a given minute.

Table 2. Running times for various numbers of simultaneously-used licenses, October 2022

Date	WD	Running time [min] for license number use								
		8	7	6	5	4	3	2	1	0
1-10	Sa	0	0	0	0	0	0	0	1	1439
2-10	Mo	0	0	0	0	0	1	4	1141	294
3-10	Tu	0	0	0	0	8	963	297	122	50
4-10	We	0	0	1	5	69	897	212	218	38
5-10	Th	0	0	1	6	168	299	582	330	54
6-10	Fr	0	0	0	0	6	21	963	420	30
7-10	Sa	0	0	0	0	2	25	968	335	110
8-10	Su	0	0	0	0	0	0	0	3	1437
9-10	Mo	0	0	0	0	0	1	4	1365	70
10-10	Tu	0	0	0	0	4	10	1002	392	32
11-10	We	0	0	0	0	0	5	18	1365	52
12-10	Th	0	0	0	0	3	11	1120	276	30
13-10	Fr	0	0	0	0	4	18	1098	290	30
14-10	Sa	0	0	0	0	1	19	1035	188	197
15-10	Su	0	0	0	0	0	0	0	1	1439
16-10	Mo	0	0	0	0	0	0	5	1375	60
17-10	Tu	0	1	0	3	15	945	145	300	31
18-10	We	0	1	4	16	945	30	308	106	30
19-10	Th	0	1	0	4	14	947	154	289	31
20-10	Fr	0	0	0	1	12	221	896	280	30
21-10	Sa	0	0	0	0	0	2	30	1110	298
22-10	Su	0	0	0	0	0	0	0	2	1438
23-10	Mo	0	0	0	0	0	0	6	1319	115
24-10	Tu	0	0	0	0	4	9	1265	131	31
25-10	We	0	0	2	18	703	367	113	202	35
26-10	Th	0	0	3	17	751	358	158	123	30
27-10	Fr	0	0	0	4	23	970	319	94	30
28-10	Sa	0	0	0	4	18	708	264	336	110
29-10	Su	0	0	0	0	0	0	0	1	1439
30-10	Mo	0	0	0	0	0	2	602	784	52
31-10	Tu	0	0	0	0	0	0	1	12	1427

Source: Own description

Table 3. Running times for various numbers of simultaneously-used licenses, November 2022

Date	WD	Running time [min] for license number use								
		8	7	6	5	4	3	2	1	0
1-11	We	0	0	0	0	0	2	11	1270	157
2-11	Th	0	0	0	0	1	6	19	1188	226
3-11	Fr	0	0	1	3	22	720	251	336	107
4-11	Sa	0	0	0	0	3	14	977	339	107
5-11	Su	0	0	0	0	0	0	0	10	1430
6-11	Mo	0	0	0	0	0	0	2	14	1424
7-11	Tu	0	0	0	1	1	21	944	180	293
8-11	We	0	0	1	5	19	943	176	175	121
9-11	Th	0	0	1	3	32	932	178	155	139
10-11	Fr	0	0	0	0	2	4	33	1109	292
11-11	Sa	0	0	0	0	0	3	20	1121	296
12-11	Su	0	0	0	0	0	0	0	5	1435
13-11	Mo	0	0	0	0	0	0	0	5	1435
14-11	Tu	0	0	0	2	16	1128	158	81	55
15-11	We	0	0	1	7	469	685	161	72	45
16-11	Th	0	0	0	0	1	2	16	1130	291
17-11	Fr	0	0	1	3	31	908	340	111	46
18-11	Sa	0	0	0	0	0	0	1	26	1413
19-11	Su	0	0	0	0	0	0	0	2	1438
20-11	Mo	0	0	0	0	0	0	1	5	1434
21-11	Tu	0	0	0	0	1	16	993	233	197
22-11	We	0	0	0	0	3	18	1037	282	100
23-11	Th	0	0	0	1	2	18	914	226	279
24-11	Fr	0	0	0	0	0	22	1050	134	234
25-11	Sa	0	0	0	0	0	3	18	1076	343
26-11	Su	0	0	0	0	0	0	0	3	1437
27-11	Mo	0	0	0	0	0	1	5	1337	97
28-11	Tu	0	0	0	0	2	6	15	1036	381
29-11	We	0	0	0	0	1	10	1007	259	163
30-11	Th	0	0	0	0	0	1	101	1115	223

Source: Own description

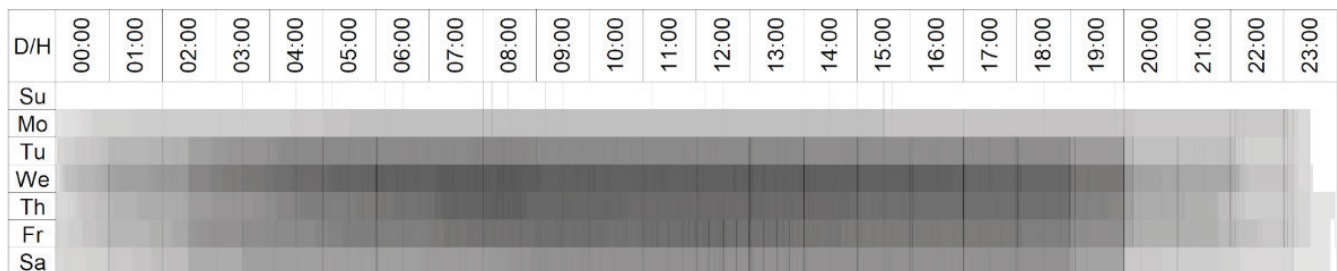
Table 4. Running times for various numbers of simultaneously-used licenses, December 2022

Date	WD	Running time [min] for license number use								
		8	7	6	5	4	3	2	1	0
1-12	Fr	0	0	0	0	7	468	783	69	113
2-12	Sa	0	0	1	1	18	973	251	156	40
3-12	Su	0	0	0	0	0	0	0	5	1435
4-12	Mo	0	0	0	0	0	0	1	9	1430
5-12	Tu	0	0	0	0	1	12	688	402	337
6-12	We	0	0	3	0	10	830	128	349	120
7-12	Th	1	1	12	738	25	187	212	97	167
8-12	Fr	0	0	1	13	284	602	300	128	112
9-12	Sa	0	0	0	1	0	19	972	291	157
10-12	Su	0	0	0	0	0	0	0	1	1439
11-12	Mo	0	0	0	0	0	1	3	1392	44
12-12	Tu	0	0	0	1	0	3	78	977	381
13-12	We	0	0	0	1	3	13	1041	264	118
14-12	Th	0	0	0	0	1	1	16	1041	381
15-12	Fr	0	0	0	0	1	12	334	714	379
16-12	Sa	0	0	0	0	0	3	17	1036	384
17-12	Su	0	0	0	0	0	0	0	2	1438
18-12	Mo	0	0	0	0	0	0	1	6	1433
19-12	Tu	0	0	0	1	11	936	264	126	102
20-12	We	0	0	1	1	14	921	208	179	116
21-12	Th	0	13	463	387	104	297	107	21	48
22-12	Fr	0	1	0	4	22	851	93	288	181
23-12	Sa	0	0	1	5	15	647	33	597	142
24-12	Su	0	0	0	0	0	0	0	3	1437
25-12	Mo	0	0	0	0	0	3	909	450	78
26-12	Tu	0	0	0	0	0	1	9	958	472
27-12	We	0	2	8	580	300	116	239	147	48
28-12	Th	0	0	1	0	0	11	723	301	404
29-12	Fr	0	0	0	0	1	14	762	244	419
30-12	Sa	0	0	0	0	1	13	702	340	384
31-12	Su	0	0	0	0	0	0	0	3	1437

Source: Own description

According to the data shown in Tables 2-4, the maximum number of performed process in a specific amount of time was 6 on 21st of December. In the rest of cases, when the number of process runs was above 6, the total duration of that event was usually 1-2 minutes a day, with one exception lasting 13 min.

The conclusion is that reduction from 16 to 6 licenses is possible while still ensuring stable running of the automated tasks and processes. The exceptional potential waiting times are acceptable and should not disturb the process of running the bots. The second objective of the analysis was to identify the most-utilized timeslots, as well as those with low to medium utilization where new automated processes can be scheduled. The average license utilization is depicted in the heat map shown in Figure 6, which is a variation on the heat map from Figure 4. This updated heat map aggregates data from an entire quarter to illustrate the average weekly utilization.

**Figure 6.** Average weekly license utilization

Source: Own description

According to the aggregated heat-map, Figure 6, that shows average weekly utilization, the most-occupied day is Wednesday, followed by Thursday and Friday. Saturday generally has medium utilization, Monday's is low, and on Sunday, almost no

processes are run. Another observation is that the timeslots with low utilization are usually between 20:00 and 2:30.

To clarify the picture, a simplified low, medium and high scale for utilization was made based on extrapolation of the scale from Figure 5. The heat map presented in Figure 7 will be utilized for scheduling purposes related to new bots while aiming to avoid time periods of high utilization.

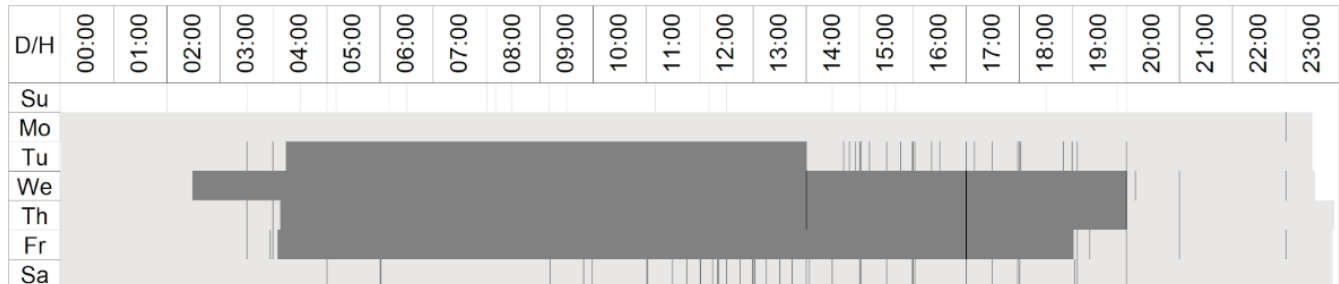


Figure 7. Average weekly license utilization, simplified

Source: Own description

The heat map in Figure 7 provides clear information regarding the timeslots with high, medium, and low usage of licenses.

Conclusion

This study contributes a new method for analyzing bot license utilization, enabling improved resource management. By optimizing costs associated with RPA solutions, this approach can lead to more economical maintenance, resulting in stronger business cases for future projects and greater cost-effectiveness. Reducing the number of licenses from 16 to 6 results in an expected cost reduction of 62.5%. As the license cost comprises the a majority of bot maintenance costs, this will improve business cases for current and future automation projects. With the identification of timeslots with a low license utilization, future automations can be scheduled to these timeslots to reduce runs in high-utilization timeslots. This will result in a more equal distribution of runs so that acquisition of new licenses, with additional costs that it brings, can be postponed.

The implications of this research highlight how inadequate monitoring of infrastructure can lead to increased costs in RPA implementation and maintenance. The findings indicate significant waste in the form of underutilized licenses within RPA setups.

The research faced limitations due to a lack of precise data to analyze other potential inefficiencies affecting license utilization. It also focused solely on the running time of automated tasks, without assessing their quality. Moreover, the analyses focused on aggregated values for all automated processes, not on detailed analysis of single automation runs.

Further analysis should focus on individual process runs that occurred during peak license usage periods. This could potentially enhance the scheduling of these processes or improve the processes themselves. Future research should aim to deepen the examination of process run data and develop a comprehensive framework that addresses not only license utilization and the identification of peak usage periods, but also the optimal scheduling of task executions. This scheduling should result from an analysis of the requirements of automated processes in collaboration with process owners. With such insights, bot scheduling can become more flexible, leading to an even-greater optimization of license utilization.

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