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IMPLEMENTATION OF OVERALL EQUIPMENT EFFECTIVENESS MEASURE FOR ROBOTIC PROCESS AUTOMATION VIRTUAL MACHINES

Abstract:

Nowadays one of the leading business process automation technologies is Robotic Process Automation (RPA). This type of software develops the action list by recording the activities of a user who performs them directly in the application's graphical user interface (GUI). The automation is performed by entering the GUI and following the preprepared list of actions. Such approach requires that RPA software runs on a computer configured the same way as it is for a human user. Very often for that purpose are used Virtual Machines set in cloud. In a usual licencing model one RPA software licence in connected with one machine. As an access to business applications via GUI is time-consuming in comparison to access via e.g. application programming interface (API) a certain amount of time has to be booked to perform all planned activities. This paper describes the implementation of Overall Equipment Effectiveness (OEE) measure, known from manufacturing industry, for a pool of virtual machines used for RPA. The common issue is to balance the business requirements: performing processes in certain time and doing it with a low cost. To goal is to ensure the best licenses utilization. OEE identifies the running time that is truly productive. Its components: availability, performance and quality, together with losses identification, are described from a perspective of Virtual Machines used for RPA.

Keywords:

RPA, OEE, TPM, Overall Equipment Effectiveness, Robotic Process Automation

1 Implementation of Overall Equipment Effectiveness Measure for Robotic Process Automation Virtual Machines

1.1 Introduction

Robotic Process Automation (RPA) is a technology which aims to reduce human intervention in computer applications, especially in processes with high-volume of repeatable tasks. RPA works primarily by interacting with “high level” applications, on graphical interfaces, as oppose to programming code. It aims to use a computer to manipulate existing application software (CRMs, ERPs, helpdesk and claim applications) in the same way that a person works with those systems. This means that employees have more time to focus on other business activities like decision-making or improving customer relations. It is a relatively fast technology to implement and can therefore bring immediate benefits to a company through time and cost savings, especially if it can be applied in the bottlenecks of certain processes [Doguc 2020, Kukreja & Nervaiya 2016]

Gartner defines RPA as the software to automate tasks within business and IT processes via software scripts that emulate human interaction with the application user interface.

KION Group, a German multinational manufacturer of materials handling equipment, is also automating its business processes with RPA software. The technology is provided by UiPath, one of the market leaders. To run bots with UiPath a bought of licenses is required. One license allows to run one bot that executes the automated business processes at certain moment. The optimalization of licenses' utilization is a key to lowering the costs and making the use of RPA more profitable.

One of proven methodologies to optimize the usage of manufacturing equipment is Total Productive Maintenance (TPM) developed by Toyota [Liker 2004] and now being regarded as integral to Lean [Bicheno & Holweg 2016]. This method can be adapted to RPA factory model. In this paper author will analyze the usage of RPA infrastructure by applying one of key TPM measures, Overall Equipment Effectiveness (OEE).

1.2 Methodology and data

OEE is a measure of the current utilization of the manufacturing to its full potential. It shows the manufacturing time that is truly productive.

According to some authors [McCarthy & Rich 2004 and Willmott 1994] OEE concept can be extended:

- Equipment OEE, that focuses on The Six Big Losses and is applied to certain manufacturing machines.
- Door-To-Door OEE extends the concept of identifying loses to sets of machines, lines or whole plants.
- Supply chain OEE is another extension that aims to identify loses in w whole supply chain.

Analysis in this paper can be classified to Door-To-Door OEE case but because Virtual Machines (VM) that are used to run the RPA bots are identical to each other and fully replaceable simpler Equipment OEE version of the calculation was applied.

The OEE calculation:

Availability [%] = Actual run time / Planned run time * 100%

Performance [%] = Quantity produced / Theoretical quantity produced * 100%

Quality [%] = Quantity produced right first time / Quantity produced * 100%

OEE [%] = Availability * Performance * Quality

The three measures (Availability, Performance and Quality) can be split into The Six Big Loses. It leads to better understating of the issues with manufacturing and target improvement actions.

1. Breakdowns – unplanned stoppages of 10 minutes or more.
2. Set-up and adjustment – preparation of machines to manufacture certain product.
3. Idling and Minor Stops – unplanned stoppages less than 10 minutes.
4. Reduced speed – machines running at lower than designed speed.
5. Quality losses – products that don’t match standard requirements.
6. Start-up – due to their designee machines need to run for some time to be able to produce correct products.

Data set for the analysis are RPA bots logs gathered during first half of the 2022 year. The data are stored in SQL database and each record represents one processed item. The data are grouped in queues and each one of them is strictly connected with a certain artefact. One or more artefacts make up an RPA bot that executes a business process.

Multiple RPA bots can be run on one license. The only limitation is that in current moment only one bot can work on one license. The most desirable setup is such distribution of the bots’ activities that a use of single licenses is maximized (schedule covers whole available time) and at the same time the number of simultaneously operating bots is minimized.

1.3 Analysis

After data extraction and preparation, it was possible to calculate OEE. The source data were taken from the logs of 10 machines. Two machines were excluded from the analysis as one, from technical reasons, is dedicated only to one process and second one is treated as a backup machine on which no process should be scheduled on it.

Table 1 Overall Equipment Effectiveness Calculation

		January	February	March	April	May	June
Planning	Total Operational Time	7 440h	6 720h	7 440h	7 200h	7 440h	7 200h
Availability	Available Time	7 440h	6 720h	7 440h	7 200h	7 440h	7 200h
Availability	Production Time	6 765h	6 045h	6 765h	6 525h	6 765h	6 525h
Availability	Unscheduled Time	675h	675h	675h	675h	675h	675h
Availability		**91%**	**90%**	**91%**	**91%**	**91%**	**91%**
Performance	Planned Production	6 765h	6 045h	6 765h	6 525h	6 765h	6 525h
Performance	Actual Production	2 929h	1 775h	2 941h	2 590h	2 942h	2 799h
Performance	Unused Scheduled Time	3 836h	4 270h	3 824h	3 934h	3 823h	3 726h
Performance		**43%**	**29%**	**43%**	**40%**	**43%**	**43%**
Quality	Processed Items	2 929h	1 775h	2 941h	2 590h	2 942h	2 799h
Quality	Successfully Processed Items	1 875h	1 193h	2 153h	1 672h	1 532h	1 370h
Quality		**64%**	**67%**	**73%**	**65%**	**52%**	**49%**
OEE		**25%**	**18%**	**29%**	**23%**	**21%**	**19%**

Source: Own data

Planning

Total Operational Time is calculated for each month by multiplying the number of available licenses by number of days in the month and 24 hours.

Availability

Available Time is equal to Total Operational Time as there are no planned stops and in analyzed period no unplanned stops took place. All service jobs on Virtual Machines, like regular software updates, took place in background and do not affect the Available Time.

Production Time is a total of time reserved for certain process which run according to schedule.

Unscheduled Time is time when according to schedule bots are not run. It is treated as a waste.

For analyzed period the Availability is between 90% and 91%.

Performance

Planned Production is equal to Production Time. It represents the highest possible process efficiency.

Actual Production is a total time when items were processed by bots.

Unused Scheduled Time is a difference between Planned Production and Actual Production. As scheduled time is calculated to ensure that all items available for current run will be processes. Unused Scheduled Time is treated as a waste.

Quality

Processed Items value is a sum of all working time of the VMs.

Successfully Processed Items are the queue items that were processed correctly. That means expected result of the process was achieved.

Losses Analysis

As the six big loses described earlier derives from manufacturing they can be treated only as guidance. For virtual machines and RPA license usage other types of losses has to be defined.

Below table presents the percentage of available time of 10 licenses used in certain month. If schedules would be full, without empty timeslots and planned running times equal real running time the number of needed licenses can be decreased by half.

Table 2 RPA License Utilization

Month	License Utilization
January	39%
February	26%
March	40%
April	36%
May	41%
June	39%

Source: Own data

Unscheduled runs

Periods of times with no planned bot runs results in a loss of 4052 h in first half of 2022. The reason may be that requestor has not pointed certain timeslots as preferable time to perform the process. The reason may be business related, e.g., data needed to perform the process is not yet available or a lack of right communication and scheduling bot in first suggested time slot without deeper analysis of other possible options.

Empty runs

A difference between scheduled time and real running time of bots is responsible for 23 413 h lose in analyzed time period. Because of wrong calculations or a will to ensure that all items are always processes a scheduled time can be significantly higher than a real running time. In the first case, to avoid such issue, details analysis of items to process should be conducted. It would allow to estimate the scheduled time for the first runs. Moreover, continuous analysis of next runs should be made. A volume of items to be process can both decrease and increase with time. Such changes should be reflected in the schedule.

Applications Issues

A failed run may be a result of two types of errors: an Application Exception and a Business Exception.

As mentioned in UiPath software documentation an Application Exception describes an error rooted in a technical issue, such as an application that is not responding. These kinds of issues have a chance of being solved simply by retrying the transaction, as the application can unfreeze. The other reason may be an internal error an of application, like trying to process data that were not copied correctly. Below a table with grouped Application Exceptions that occurred during analyzed period.

Table 3 Application Exception Types

Application Exception Type	Work Time [h]	Work Time [%]
Application	1735	46%
Browser	994	27%
Selector	536	14%
Credentials	214	6%
Files Access	19	1%
Internal	23	1%
Other	222	6%

Source: Own data

The most significant are issues with accessing the application (46%). Second are errors due to connection issues when performing a business process that requires a use of an internet browser (27%). Selector errors (16%) refer to a situation when certain element of an user interface cannot be identified by the RPA software. The reason may be changes in the interface.

Business Errors

Usually, this group refers to two types of events. In the first a bot identifies that provided data requires to follow the process path that it was not programed to perform. It stops to process current item and reports accordingly. The reason for a second type of events is providing a bot with wrong or insufficient input data. This could be a situation in which earlier tasks that should result in providing input for the process executed by a bot were not finished.

Table 4 Business Exception Types

Business Exception Type	Work Time [H]	Work Time [%]
Out of scope	2437	60%
Incorrect input data	1648	40%

Source: Own data

Losses Summary

Table 5 Loses Summary

Group	Lose	Work Time (h)	Work Time (%)
License	Empty runs	23413	66%
License	Unscheduled runs	4052	11%
Business Exception	Out of scope	2437	7%
Application Exception	Application	1735	5%
Business Exception	Incorrect input data	1648	5%
Application Exception	Browser	994	3%
Application Exception	Selector	536	2%
Application Exception	Other	222	1%
Application Exception	Credentials	214	1%
Application Exception	Internal	23	0%
Application Exception	Files Access	19	0%

Source: Own data

The biggest group of loses is Licenses. It is responsible for 77% of the total loses. First improvement actions should focus on this area, especially “Empty runs” (66%) where planned time for bot runs is overestimated.

1.4 Findings and next actions

The OEE calculation showed that utilization of Virtual Machines in first half of the 2022 is on a very low level (23%). The biggest issue is with Performance (41%) as the bot schedule should be improved. Quality (61%) is also a source of losses. Only Availability (91%) is on a right level.

Next steps would be a deep analysis of the current situation and a start of continues improvement project. Willmott has proposed a 9-Step model [Willmott 1994] that can help to better utilize RPA resources. In the first step the project is started and future measures, e.g. costs, OEE are defined (1). Next is calculation of OEE (2) and identification of loses (3). Those two steps are already done. The continuation is a critical assessment where all machine elements (bot code) and environmental factors (business requirements) are checked. The goal is a deep understanding of all components (4). After that an initial clean-up (5) happens followed by inspections and identification of contamination sources. In case of RPA it can be reorganization of schedule and bot assets focusing on biggest issues. Next is a refurbishment plan (6), a systematical improving of the current state and a development of asset care (7). This should cover maintenance activities, safety (e.g. data security), quality (e.g. robot runs, code standards). Taking all that has been learned in previous step will result in development of best practice routines and standards (8). The last step is problem prevention (9). OEE leads to identification of losses that are connected with certain issues. Those can be challenged by lean problem identification and solving tools like 5 why and A3 analysis. After implementation of such program utilization of RPA Virtual Machines (and licenses) should be improved.

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