Intelligent Process Automation Framework

Supporting the transformation of a manual process to an automation

MASTER THESIS

BOERSMA, E STUDENT M-BIT
24 August 2020

Intelligent Process Automation Framework

Supporting the transformation of a manual process to an automation

Master Thesis

August 2020

Author

Name	E. Boersma (Elodie)
Programme	MSc Business Information Technology
Institute	University of Twente PO Box 217 7500AE Enschede The Netherlands

Graduation committee

Name	Dr. F.A. Bukhsh
Department	University of Twente Faculty of Electrical Engineering, Mathematics & Computer Science
Name	Dr. A.B.J.M Wijnhoven
Department	University of Twente Faculty of Behavioural, Management and Social Sciences
Name	J. van Essen
Department	Baker Tilly IT Advisory

Preface

After six years, my life as a student at the University of Twente comes to an end. In these six years, I have learned a lot about myself and had many adventures. After finishing the bachelor programme of Industrial Engineering and Management, I found my passion which is the application of IT to support business processes. Therefore, I pursued the master programme in Business Information Technology.

This thesis is the result of seven months of work. This thesis is completed with the support of multiple persons. Before I thank them individually, I would like to thank all the supervisors for ensuring that I can graduate during the COVID-19 pandemic. Even though their schedules were drastically changed, they were able to make time to offer me proper guidance during the thesis. I am grateful for the following persons:

First of all, my supervisors from the UT, Faiza and Fons. Their critical questions and advice have helped me to take steps in the right direction. They have been willing to think along about how the assignment can best be formulated and what options there are to tackle a problem.

Secondly, I am thankful for my official supervisor from Baker Tilly, Jan-Willem. All my questions about the processes and how everything works within the organisation were always clearly and quickly answered.

Thirdly, my buddy/unofficial supervisor from Baker Tilly, Rick. The meeting every week was convenient and helped me with the content of my thesis, and the arrangement that needed to be done to make the process as smooth as possible.

Lastly, I would like to thank my family and friend for supporting me during my student life and especially in the last seven months.

Elodie Boersma

23-8-2020

Executive summary

Automating processes is becoming more popular in the audit industry. Baker Tilly would like to process their data efficiently to start with continuous approaches. This research focuses on processing the data efficiently by standardising and automating the process.

Problem domain

In the current situation, Baker Tilly receives from its customer data differently. This data is then manually mapped to their reporting code, prepared in TimeXtender, and eventually send to Qlik Sense. In Qlik Sense, a standard dashboard is created to give customers advice. Because every customer sends their data differently, the standardised dashboards are challenging to achieve since KPIs are calculated in different ways. It is now impossible for Baker Tilly to try benchmarking with the customers' data.

Method

To process the data-efficient, the following question is answered in this research:

What is an appropriate framework to create a strategy for the transformation of a manual data process to an intelligent automated process in audit services?

This question is answered by doing a literature study about automation in the audit industry. It is found that in the audit industry, many processes need human expert judgments and reasoning. Therefore, AI could be a part of the solution to have minimal human intervenes in the process. After the literature study, the framework is designed. This literature showed the new concept of Intelligent process automation (IPA). This IPA fits in the current problem of Baker Tilly. Therefore, the IPA framework is designed and consists of four phases: process determination, workflow analysis, automation technology selection, and proposal formation.

Evaluation

The framework is evaluated by doing interviews with experts. The feedback of the experts is applied to create a revised framework. This revised framework is then applied to the process of Baker Tilly to show what is needed to be able to realise the automation. A proposal is the result. The outcome of this proposal is then discussed with the experts of Baker Tilly. The experts were positive about the proposal.

The contribution of this report can be divided into a relevance in theoretical and practical:

Theoretical:

- Extending the limited research on Intelligent process automation (IPA)
- Extending the limited research on automation for audit advice and compliance engagements
- An IPA framework that is for non-assurance services and takes the practical problems of companies into account.

Practical:

- A proposal for Baker Tilly to transform their data process to intelligent process automation.

Table of Content

List of Figures

List of Tables

1. Introduction

This research is conducted for Baker Tilly, which is an audit and tax advice company. Besides tax and audit, the company also focusses on several services: advisory healthcare, public advisory sector, corporate finance, employment advisory, Interim financials, IT advisory, subsidy compliance, VAT & customs advisory. This research is commissioned by the IT advisory service. IT advisory focusses mainly on data analytics strategies and IT-audits. The target group of the company is small and medium enterprises (SMEs) and family businesses.

In general, many SMEs are using less advanced technology than large enterprises (Bianchi and Michalkova, 2019). For creating their financial statement, they often ask accountants to do this for them. Erasmus University has conducted a study in collaboration with the NBA (Royal Dutch Professional Organisation of Accountants) (2019) about the option to offer more service to SMEs. They concluded that the accountants, who are doing the assignment for Dutch SMEs, should be ready to use continuous reporting when doing a compliance audit. Continuous reporting is reporting the newly digitised data consistently. Currently, advice can only be given from the financial statement is provided. By realising continuous reporting, accountants can offer more advice to SMEs. For example, they can show what products are selling better than others during a season. Continuous reporting can be done by automating the data processes. Fenwick and Vermeulen (2019) stated that artificial intelligence (AI) and data analytics could significantly contribute to the communication processes in continuous reporting. The study of the NBA and Erasmus university (2019) also agree that the use of AI could provide better continuous reporting. They suggest AI could be used for control options or checks of the data. Some of the big four companies are already trying to use AI for their auditing procedures.

According to Roohani (2003), it is inevitable that accounting firms need to take proactive steps for increasing the timeliness of business reporting; otherwise, the customer will go somewhere else to get relevant information and advice. However, an accountant should consider the requirements and preferences of SMEs before implementing the extra service. These preferences can differ between SMEs because of the difference in industries (Goumas et al., 2018). In addition, the trust of the SMEs is essential in the process, as they can be skeptical about new data-driven services. Processes of SMEs are often based on experience, which is usually the consequence of the lack of IT expertise (Goumas et al., 2018). Therefore, when a new service or tool is implemented, SMEs need to be sure that it is of high quality, sound design, and a reasonable price (Hoque, 2001).

This research will focus on the accountants for SMEs and how they could make use of new technologies, to offer SMEs timeless and valid business reporting.

1.1 Baker Tilly

In the past few years, new approaches and technologies are needed in the changing audit industry. Customers are expecting more of the audit companies in terms of IT and advice. In order to increase the efficiency and effectiveness of the company processes, innovative technologies should be implemented. The emerging technologies let to Baker Tilly's

Figure 1 Logo of Baker Tilly

curiosity to make the data processes more efficient in order to integrate new technologies and provide more advice to customers. For the future, the IT advisory department is expecting an increasing complexity in the data processes. More data is getting available (big data), and more data sources need to be processed. Thus, more problems are arising. To create efficient data processes and to be able to handle the increase in data, getting standardised and reliable processes is of great importance. When this is achieved, among other things, the IT department sees opportunities ahead. For example, continuous monitoring, continuous auditing, continuous reporting, benchmarking, and advising their customer in their expertise by creating dashboards that show predictions. These predictions could be about the purchasing department of the customer, the selling of articles, or bankruptcy of customers.

1.1.1 Problem domain

Given the information by the NBA and the upcoming technologies, Baker Tilly concluded that the process of providing advice about the data received from the compliance audit should be more efficient. Customers have their data in financial administrations. However, every customer uses other software. The most used software are AFAS, Exact, and NMBRS. The information in these administrations is all the transactions made in the past year. The administrations are used to create a financial statement and all reports that are important for taxes. The financial statement shows the balance, income statement, and cash flow statement.

When accountants at Baker Tilly, are working on the compliance audit, they often are trying to offer more advice to customers instead of only creating the financial statement. They receive much information from the customer, which gets lost when they book the ledger accounts to the general ledger, which is eventually used for the financial statement. The loss of information often depends on the size of the customer and how big the general ledger would be with all the mutations of the sub administrations. Information that is in the financial sub administration could be used when providing further advice. Since every customer stores their data differently, it takes much effort to create a dashboard for providing the customer with further advice.

Due to differences in received data of customers, the data processes are inefficient and result in dashboards that could be missing data or using the wrong data to give advice. Figure 2 shows the causes and problems that are occurring at this moment. Additionally, Baker Tilly is not ready for future innovations (e.g., continuous reporting, benchmarking) due to the inefficient way of processing data and the differences in processing data per customer. As mentioned before, continuous reporting is becoming more popular and needed. To be able to get prepared for this and to have valid dashboards, the processes need to get more efficient in order to eliminate mistakes. Since every customer is storing their data differently, they receive different input data for each new customer. For example, customer X is using the ledger account with the code 1600 for creditor, and customer Y is using 1600 for income tax. Furthermore, not every customer stores the same information. Therefore, the KPI calculations for the dashboards are often done differently per customer. After receiving the data from the customers, the ledger accounts are mapped to a reporting code manually. When a ledger account is mapped to the wrong reporting code or skipped, the dashboard is using the wrong data or is missing data.

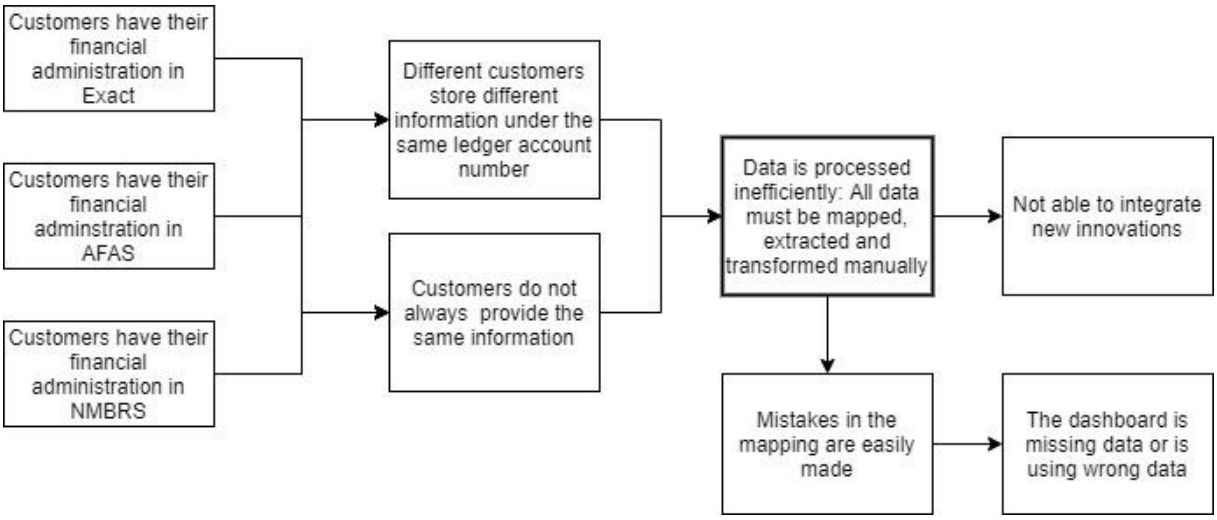

Figure 2 Problem cluster

Baker Tilly wants to provide more advice to customers to be able to realise the opportunities that they have identified. Therefore, most of the processes need to be automated (NBA, 2019). The problem that should be solved in this research is the inefficient way of processing data. Baker Tilly would want to have a plan on how they could process data efficiently. This plan should include how the problems that occur because of differences in customer data could be fixed in order to achieve continuous reporting. The main problem will be handled in this research by searching for the best way to process data efficiently and how this could be automated.

1.1.2 Research objective

This research is focused on how a data process can be made more efficient in an audit service. Because audit services often need human judgment, there will be looked into the possibilities of technologies that can mimic humans. To offer support on the transformation of manual processes to automated processes, a framework is needed that helps by making decisions about the technologies and the process for this transformation. The output of this framework is a strategy to realise automation effectively and efficiently. For Baker Tilly, it means that this strategy could lead to a more efficient way of processing data and to take a step towards continuous reporting. This research needs to investigate when and how the technologies for automation are useful and contribute to efficiency. However, on the other hand, the specific characteristics and requirements of audit services must be included as well. The main objective of this research can be formulated as:

<Improve> the transition of a manual data process to an automated data process.
<by> designing an intelligent process automation framework
<that satisfies> the needs of the audit industry
<to> support audit companies by making decisions and creating a strategy when automating data processes to continuous reporting.

The outcome of this research will be a proposal for the implementation of automation.

1.2 Structure report

The structure of this thesis is as follows. The second chapter provides some background information as a foundation for defining the research methodology. The third chapter explains the literature that is necessary for this research. The fourth chapter uses the results of the previous chapter to create a framework. In the fifth chapter, the framework is evaluated by interviews. After the evaluation interviews about the designed framework, the feedback gathered by these interviews is used for revising the framework. This revised framework is applied to the process of Baker Tilly. The output, a proposal, is then also evaluated in interviews and included in the fifth chapter. The sixth chapter provides a conclusion and some recommendations. A pictorial representation of the structure of the thesis is in Figure 3.

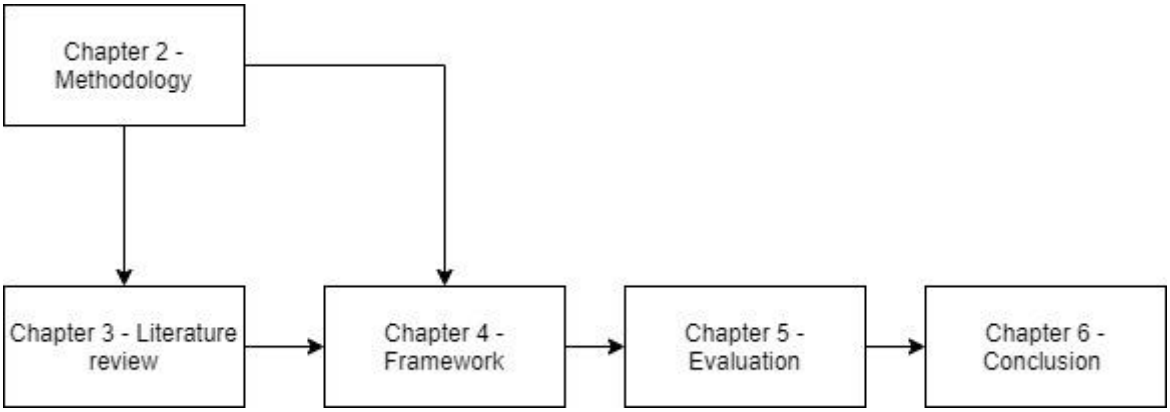

Figure 3 Connections among chapters

2. Methodology

This chapter provides some background that is necessary to be able to create the right research questions. The second part of this chapter provides the research design and the research questions.

2.1 Background

Automations are arising in the audit industry. It will be a matter of time when continuous approaches are the standard for audit firms. These upcoming approaches are mainly continuous auditing and continuous monitoring. Information about how these approaches have been developed in order to transfer a manual process into a (partly) automated process in audit, could be useful for this research. These approaches are discussed below. In order to support automation, AI plays a fundamental role. Therefore, we have discussed AI in the section too.

2.1.1 Automation Approaches in Audit

The audit industry is automating tasks that are taking much time for accountants. The automation approach is called continuous auditing, which means “any method used by auditors to perform audit-related activities on a more continuous or continual basis” (Coderre, 2006). Continuous auditing is used for control audits and automates repetitive control tasks. Continuous monitoring and continuous auditing are comparable in their primary objective: constant supervision of data on a (near) real-time bases against a set of prearranged rule sets (Kuhn & Sutton, 2010). The difference between the two is that continuous monitoring is used as a management function for having an overview of the KPIs, and continuous auditing is supporting the auditors (van Hillo & Weigand, 2016). According to Kuhn and Sutton (2010), Continuous reporting could be an excellent addition to continuous auditing and monitoring: "Continuous reporting, on the other hand, is the continuous reporting of information about defined phenomena and in a continuous auditing context includes the notification of rule violations occurring as a result of continuous monitoring." Others describe continuous reporting as: "Making digitized information available through electronic channels simultaneously with its creation” (Elliot, 2002). At the macro level of these three approaches is continuous assurance (CA), to make sure that they are reliable (Alles et al., 2004). This component checks if the approaches are working correctly to reach high quality. Berahzer and Armstead (2013) showed a framework about the connection between the three approaches concerning CA. For all three approaches, CA is essential for getting the trust of managers, but also to interact with auditors when irregularities are found that needs checking by the auditor. The architecture of all the approaches is shown in figure 4. More information about these approaches is provided in chapter 3.

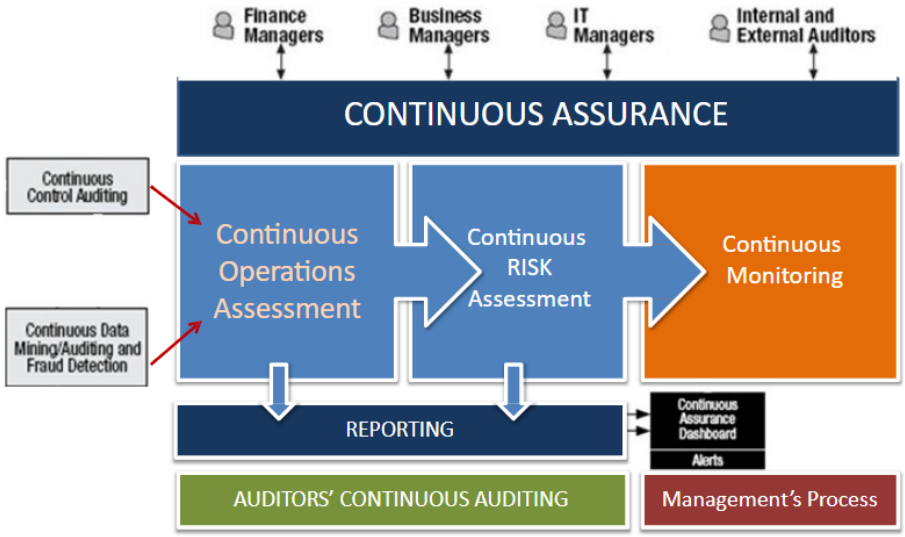

Figure 4 Architecture Continuous Assurance. *Source: Cisa 2013*

2.1.2 Artificial Intelligence

Auditing is often an industry that is lagging in the usage of revolutionary technologies compared to other industries (Oldhouser, 2016). AI is one of these technologies. However, investments by the larger companies in the audit industry are made to use AI for the repeating tasks. AI can perform human-like activities but automated. The activities are performed more effectively and efficiently (Issa et al., 2016). Next to that, AI can be used for different algorithms; Machine learning and deep learning are examples of these. Machine learning algorithms are known for predictions. When using continuous auditing and a machine learning algorithm; transactions can be analysed and be put in different categories: high risk, medium risk, low risk (Bowling, 2016).

Currently, AI in audits is mostly used for extracting, validating, and comparing data (Brennan et al., 2017). Therefore, the human auditor has more time to focus on areas which require higher-level judgement. Payment transaction testing can be automated by AI and does not have to be a task of the auditor anymore (Brennan et al. 2017). "AI tools can spot if a company records unusually high sales figures just before the end of a reporting period or disburses unusually high payments right after the end of the reporting period" (Rapoport, 2016). Previous research shows that companies are now investing in AI to use for contract analysis; this will lead to an increase in efficiency when analysing many documents (Yan & Moffitt, 2016). Besides, transaction records and textual analysis, audit companies can do more with AI. For example, weather data can be collected and used to predict sales (Yoon, 2016). However, the opportunities mentioned above are hardly used by audit companies.

Challenges AI

The challenges for AI right now are different for each company. Where large companies have enough accurate and complete data for AI, smaller companies need to gain accurate data (Starlie, 2020). This difference shows that data, budget, and time requirements are challenges for developing and implementing AI.

The AI framework of Zheng et al. (2019) (figure 5) showed the issues for AI in financial services.

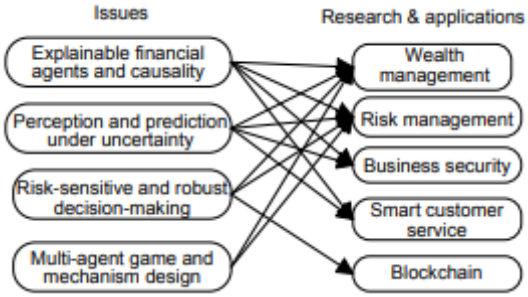

Figure 5 Open issues regarding the framework Source: Zheng et al. (2019)

For the audit industry, the explainable financial agents and causality are necessary. The first mentioned challenge is the black box that is often happening. It means that data goes in the algorithm, and a decision comes out without an explanation. Pedreschi et al. (2018) stated that it is essential to have an open infrastructure to share data and the explanation of algorithms. In this way, researchers can work on the black boxes to be able to explain these more. Zheng et al. (2019) explain that the causality is vital for better understanding the black box: "The key to designing explainable agents is to provide causal inference to better understand the real-world environment and support interactive diagnostic analysis." The Black box is often still happening. It would mean that there is less assurance about the outcome because of the lack of transparency. The second challenge, the perception, and prediction under uncertainty, is mainly applicable to the financial market. The fluctuations in the financial market are creating uncertainties for investors, which makes it harder to predict (Zheng et al., 2019). the third challenge is risk management, which is crucial for AI. The algorithms must be risk-sensitive and robust to uncertainty and errors when making decisions (Zheng et al., 2019). The fourth issue, multi-agent game, and mechanism design is also interesting for the financial market because of the many parties involved. Knowing the impact of a decision a party can do is essential when playing in the financial market (Zheng et al., 2019).

The last challenge, which is defined by Jarrahi (2018), is the implementation of AI. Computers can do human activities. However, employees do not always accept or agree with this. Many discussions did happen if AI will contribute to or replace human contributions.

2.1.3 Background Conclusion

With all the approaches to improve the audit processes, assurance plays a vital role when automating an audit process. AI is becoming more popular for some of the approaches because it supports them and increases efficiency. To be able to let an (intelligent) automation work, trust, commitment, reliability, and quality are essential for all the approaches.

2.2 Research Methodology

The research methodology contains a research design and research questions. These questions are based on the main problem of Baker Tilly, the research objective, and the background theory. Both subjects are explained below.

2.2.1 Research design

Throughout the whole research, the design science methodology of Wieringa (2014) is applied. This methodology walks through the phases of the design science cycle when designing an artifact. The design cycle is shown in figure 6. Wieringa (2014) describes design science as: "Design science is the design and investigation of artifacts in context." The artifact is designed to let the design project contribute to the achievement of a goal. The development of this artifact goes through the different stages of the design cycle. The Problem investigation is at the beginning of the designing process. This stage identifies the problems, stakeholders involved, and the objectives of the research. The Treatment design is the phase where the requirements are set, and the artifact is designed. After the design, the artifact will be evaluated and validated, which is done in the Treatment validation phase. When the outcome of this phase shows that the artifact does not produce the right artifact, the cycle can be iterated. After the Treatment validation, the design cycle is done. Since the design cycle is a part of the engineering cycle, the Treatment implementation and Implementation evaluation are not executed in this research because they are only part of the engineering cycle.

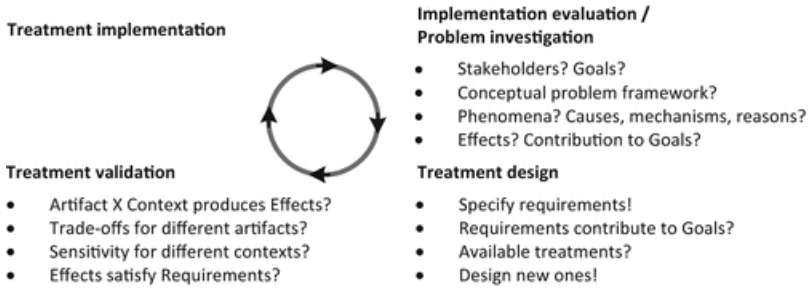

Figure 6 Design cycle *Source: Wieringa (2014)*

2.2.2 Research questions

The research questions are based on the research objective and background information. The research objective is defined in chapter 1 section 1.1.2 and is to support Baker Tilly in the design process for creating an automated process. Therefore, the main research question is:

What is an appropriate framework to create a strategy for the transformation of a manual data process to an intelligent automated process in audit services?

The main challenge in this research is to answer how tasks that are usually done manually by a human (with cognitive capabilities), can be automated in a way that the quality and reliability of the process will be the same or even better. Transparency is an essential concept in order to meet this challenge.

Since the automation would concern financial data in an audit service, the first step in gathering knowledge for the strategy is knowing how previous automation in the audit industry is realised. In the control audit, the assurance makes sure that the data and process reach some level of quality and reliability. Therefore, it is useful to know how the control audit automated the assurance services to CA services and how this is managed.

1. **How is continuous assurance realised and managed in audits?**

AI can help with efficiency and continuity. As shown in the background information, AI could support automation because it can mimic humans. Therefore, knowing how it is already used in audits could be helpful for this research. It could be included in the automation plan. The second sub-question is:

2. **How are AI techniques supporting automation in audits?**

Understanding the (intelligent) automation techniques, and how it is possible to have a component that supervises the process, a design for the strategy can be created:

3. **How could the critical factors for automation be implemented in an intelligent automation framework to support the automation strategy for a company?**

To ensure that the framework could be applied to the processes of audit companies with the preferred result, the framework should be evaluated. The key factors or phases should be evaluated separately and as a whole in the framework. Therefore, the last sub-question is as follows:

4. **How could the framework be evaluated?**

2.2.3 Research methodology

The first two questions are knowledge questions. These questions will be answered by doing a literature study. After that, the framework is designed for creating an automation strategy. The last question is the evaluation question of this research. The evaluation will be done by discussing the framework with experts, using the feedback to design a revised framework and by evaluating the framework on the effectiveness and usability by interviews. After the interviews, the framework is revised. This framework is applied to the process given by Baker Tilly and will also be evaluated by interviews. Figure 7 shows how these questions are covering the phases of the design cycle.

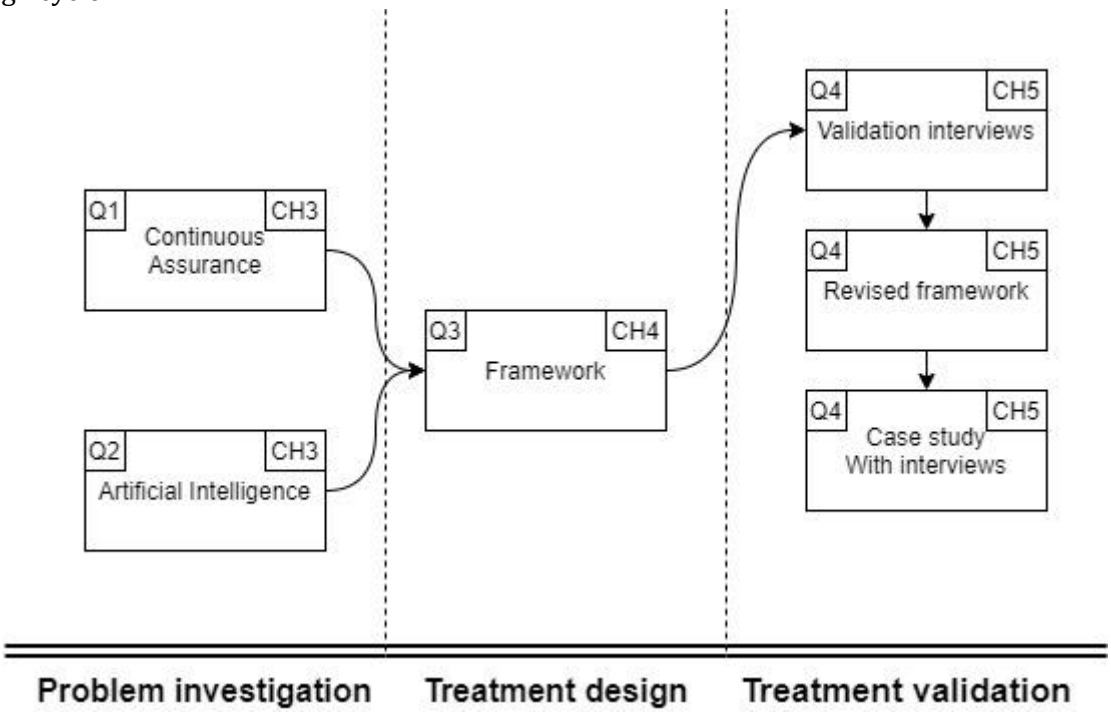

Figure 7 Structure research questions

2.3 Summary

This chapter explained the background knowledge of CA and AI, and this knowledge is used for defining the research questions. The research questions are divided into two categories, one about CA and one about AI. Next to that, the research questions about the key aspects of a framework are the design question. After answering the design questions, the artifact will be evaluated if it is applicable in practice by having interviews. Since the research questions are determined, the literature review for answering the first two knowledge questions is the next step for this thesis. The knowledge questions are explored in the following chapter.

3. Literature review: Knowledge questions exploration

In order to answer two knowledge questions, a systematic literature review is performed. This literature review is based on the steps provided by Xiao and Watson (2017). The purpose of this literature review approach is to find relevant articles for this research. The steps from the paper are followed for both subjects of the two knowledge questions. More information about the systematic approach and the results can be found in Appendix A. The results that are useful for this research are further discussed below.

3.1 From assurance to Continuous assurance

Assurance plays an essential role in the control audit. In the audit industry, assurance leads to a written report where irregularities and other detections are shown. Some suggest that this dashboard or report should be generated on demand (Ezzamouri & Hulstijn, 2018). When going from assurance services to CA, Lin et al. (2010) agree with the importance of reporting. It is an effective way of detecting fraudulent financial reports on time because of transparency.

Moreover, CA has led to a change in the audit profession for the automation of processes. When developing CA in the organisation, it required a revaluation of auditing, specifically on how data is made available to the auditor, how specific signals are managed, what reports need to be issued, and the checks that are necessary to carry out (Marques et al., 2013). Hence, it can be said that CA is the component that makes sure that Continuous approaches are transparent and reliable.

The transitioning to new auditing and reporting models is not only about changing the audit approach, but also the mindset of personnel. Continuous auditing and CA are the approaches that are involved in transitioning from traditional audit to a more real-time audit. Both approaches support reporting on the effectiveness of a system producing data in short time frames (Alles et al., 2003). The difference between the two approaches is that continuous auditing is focused on the data and CA on the process and risk management. Because of the process-based approach, CA can detect more irregularities since it can analyse several business processes. Therefore, CA is often signified as a top-down model since the strategic and operational goals of the enterprise are the fundamentals of CA (Hardy, 2011).

3.1.1 Assurance

Assurance services concern financial and non-financial information in discrete events, processes, or systems, e.g. decision models. The purpose of assurance services is the improvement of information. This information can be direct (product information) or indirect (someone's allegation about the product) and can be about internal or external processes according to the decision-maker (Alles et al., 2002). Coderre et al. (2005) argued that assurance should be considered as a judgment about transactions, business processes, risks, or performances by a third party. During internal controls, the assurance service should be implemented in such a way that it achieves the objectives of the categories defined by Flowerday and Solms (2005): Effectiveness and efficiency of operations and reliability of financial reporting. In order to realise this, Alles et al. (2002), defined the three crucial components that are included for providing assurance. These three components cover the phases that are done during a traditional audit:

- Capturing data that concerns transactions, processes, and environment that are the subjects of assurance. These tasks need to be done by the customer.

- Monitoring and analysing the data to confirm the reliability of the data. The assuror does this task.
- Communicating the outcome to the customer.

The internal control framework (Flowerday & Solms, 2005) divided the audit process into five components to ensure assurance. It should be noted that all components can be adapted and customised to the company's needs. Their five components are the total environment of the company, risk assessment, the control environment, information (processing and communication), and monitoring. The first component, the environment of the company, shows the attitude of the management towards the controls. Risk assessment, the second component, includes all the risks of internal and external sources. The plans of the companies should be developed in a manner that it identifies, measures, evaluates, and responds to risk. The third component is the control environment. The control activities are at every level, from transactions to processes and systems. The fourth component, information (processing) and communication, is about the effective ways of communication in a company. This component includes internal communication but also external communication, for example, with suppliers. The last component is monitoring which is about the assessment of the effectiveness and quality of the performance of a system. The components of both studies are fairly equal. The risk assessment, control environment, information processing and communication, and monitoring have the same goal as the three components defined by Alles et al. (2003).

For CA, it needs to be specified which processes have to be continuous in order to have a CA approach. Therefore, both research (Alles et al. 2003; Flowerday and Solms, 2005) went to the next phase, which is defining the components and objectives of CA based on the abovementioned components.

3.1.2 Dimensions Continuous Assurance

The term “continuous” in CA is not fully defined and open for interpretation. The frequency will range from a real-time or near real-time review, to a periodic analysis of snapshots or summarised data (Vasarhelyi et al., 2010; Hardy, 2011). Holstrum and Hunton (1998) focused on three scenarios concerning the development from traditional audit to automated services attended by CA. These three scenarios are the future of current services, extensions of current lines, and completely new lines of service. The first scenario is also acknowledged by Vasarhelyi et al. (2010). It is that the natural pattern of the process being audited is transformed into a new way where real-time data is processed; the timing of IT and business processes need to be considered. The second scenario is related to the assurance services of risk assessments and business performance measurements. It is about how CA could contribute to a more comprehensive risk assessment (Holstrum and Hunton, 1998). The third scenario, which is entirely new lines of service, could include performance measurement of indirect events.

CA is often defined as a system or framework that is based on continuous monitoring and continuous auditing. Continuous monitoring does the monitoring of data and processes in a company. Continuous auditing detects anomalies in the data. Those two combined leads to an approach that analyses the business process and their data, which makes it possible to work well in all possible scenarios defined by Holstrum and Hunton (1998) (Hardy, 2011). Coderre et al.

(2005) showed an architecture of CA where CA covers three activities: Continuous controls assessment, Continuous risk assessment, and assessment of continuous monitoring (figure 8). Vasarhelyi et al. (2010) defined the components of CA as Continuous Control monitoring, Continuous Data Assurance, Continuous Risk Monitoring and Assessment. For both the architectures applies that these activities evaluate the state of controls, adequacy, performance, and risks of organisations.

Figure 8 Architecture of CA *Source: Coderre et al. (2005)*

Objectives

Marques et al. (2013) specified the objectives of CA into dimensions: Monitoring, Compliance, Estimation, and Reporting. These dimensions can also be found in the proposed four levels of audit objectives for CA by Vasarhelyi et al. (2004) and Alles et al. (2004). The first level, transactional verification, is comparable with the monitoring dimension of Marques et al. (2013). The objective has a primary purpose of identifying irregulars during business transactions by monitoring and analysing data. Compliance verification is the second level which verifies if the measurement rules are correctly applied. The data should fulfil the requirements, rules, and conditions. Rikhardsson and Dull (2016) called the second level: Continuous Compliance Monitoring. They suggest that information technology should be used to generate detailed classifications of supervisory compliance issues and to update regulatory changes. The third level is estimate verification. This level evaluates if the accounting estimates are reasonable. These estimates need to be made since not every account receivable may be collected or ever loan is paid off. The final level, judgment verification, gathers enough evidence to give judgment for audit risk reduction. Bumgarner and Vasarhelyi (2018) added to this level that more technology should be used. Since technology is becoming more available nowadays, the fourth level should use algorithms to assess judgments and risk evaluations. Monitoring to ensure data reliability is not enough anymore, monitoring risks (environmental and rare high impact risks) should be included. Vasarhelyi et al. (2004) generated a table that shows the levels and characteristics of these four levels; this is shown in figure 9.

	Level 1 Transactional Verification	Level 2 Compliance Verification	Level 3 Estimate Verification	Level 4 Judgment Verification
Procedures	Rule/waterfall review of data	Formalization of standard relationship with XML derivative	Upstream/down-stream verification	
	Process interruption	Continuity equations	Continuity equations	Continuity equations
	Value chain transaction tracking	Structural knowledge	Value chain relationships	Expert systems
Degree of automation	High	Mixed	Mixed	Low
New paradigms procs., techns.	Continuous reconciliations	Continuity equations	Continuity equations	Continuity equations
	Invisible tracking/ transparent markers		Extensive use of exogenous data	Use of exogenous data
	Automatic confirmations			
	Rule-based trans. evaluation			
		Time-series/cross-sectional analysis	Time-series/cross-sectional analysis	Time-series/cross-sectional analysis

Figure 9 Characteristic of each level of Continuous assurance *Source: Alles et al. (2004)*

The degree of automation is significantly more at the first level than the others (higher levels). When the complexity of the objective of a level increases, the degree of automation decreases. However, Vasarhelyi et al. (2004) indicated that even though the complexity could be high, some part s of the levels could be formalised and automated. Due to CA, auditors are expected to explain their assumptions and judgments explicitly. Documenting these steps could be the first step towards automating more complex audit tasks (Vasarhelyi et al., 2004)

3.1.3 Continuous approaches

As mentioned before, CA is the product of the combination of continuous monitoring and continuous auditing. The first objective, transactional verification, is only possible when continuous monitoring of the transaction data is done well. Continuous monitoring is often used for management to keep an overview of the performances of their company. When companies are already using continuous monitoring, the auditor does have to perform fewer activities to accomplish continuous auditing and monitoring. However, the auditor must check whether the continuous monitoring process is reliable. Coderre (2005) gives examples for procedures that can be used to see if the process is reliable: "Review of anomalies detected and management's response, Review and test of controls over the continuous monitoring process itself, such as Processing logs/audit trails, Control total reconciliations, Changes to system test parameters." Some of these procedures could be done by using control charts, which encourages the identification of processes when they show some deviations. When this happens, it would be easier to stop the process and limit the consequences. Therefore, the combination of continuous monitoring with controls and auditing approach is of great importance (Ezzamouri & Hulstijn, 2018).

Continuous auditing

Many customers did switch from traditional accounting systems to revolutionary real-time accounting systems. Since continuous auditing is becoming more popular, Chen. S (2003)

predicted that Certified Public Accountants (CPA) should be ready when the financial industry moves to Continuous auditing. Changes such as making more effort for making sure that companies are trusting and are committed to CPA firms need to be considered. The changes are necessary since audit firms will have more access and insight into information about companies. The continuous auditing approach supports auditors to reduce or eliminate the time between an occurrence and the notification of the event. When continuous auditing is applied, more technologies are used to validate the accuracy of the financial statement of a company. These companies need to trust the technologies, and auditors need to be sure that the techniques produce reliable results (Flowerday et al., 2006). The demand for continuous auditing is increasing, and it is a considerable subset of CA (Vasarhelyi et al., 2004). Continuous auditing assures reliability, security, integrity, and persistence under the condition that it should be adopted entirely into the internal control procedure (Yeh et al. 2010). For verifying that a real-time accounting method is producing reliable and accurate financial information, the testing of controls must be done concurrently with significant tests of transactions (Helms and Mancino, 1999; Rezaee et al., 2001). The assurance is one of the most significant challenges of continuous auditing, according to Chan and Vasarhelyi (2018). They proposed that a combination of continuous auditing and continuous monitoring can help by convincing management that continuous auditing is a profit driver and that the information that is needed can make sure that there is assurance and also can show the performance of the company.

Furthermore, the value of continuous auditing relies on the relationship between assurance quality and assurance cost. It creates a positive value when the cost of internal controls and compliance is reduced, and the effectiveness of the audit process is increased (Rikhardsson and dull, 2016; Chan and Vasarhelyi, 2011). The value and impact also depend on the size of the company. The main difference between small and large companies is that for small businesses, the adoption of these new technologies is not done in a well-defined strategic, aligned process. These poorly adaptions are also showing a decrease in the value of the continuous auditing approach (Rikhardsson and Dull, 2018).

Continuous Reporting

Continuous reporting can be of great value; it can shorten the process of creating financial statements because data is given more often (NEMACC, 2019). However, the value of continuous reporting decreases a lot when too many measures are tracked (Jacobides & Croson, 2001; Hunton et al., 2004). Viewers could become too dependent and addicted to the small changes when new data is updated. They could make choices only based on that data. Roohani (2003) stated that the reduction in the value of continuous reporting is a function of different factors, for example, inadequate measures or alignment and noisy measures. It is, therefore, crucial that the right metrics are being used for choosing and measuring the KPIs. According to Roohani (2003), when data is transactional, or the performance of a customer is easy to measure, the demand for continuous reporting and data level assurance will be high. Hunton et al. (2004) mentioned that the assurance of continuous reporting is a combination of the data level assurance but also about how to transfer the information and advice to the companies. For instance, when does the management thinks the report is sufficiently reliable, and under which circumstances they do not feel that? What factors need to perform well to get the reliability above the preferred threshold?

3.1.4 Implementation

CA has been claimed and assumed to play an increasingly vital role to support the management and the usage of resources efficiently and effectively (Marques et al., 2013). The value of CA concerns the relationship between assurance cost and assurance quality. When CA reduces the cost of internal control and the cost of compliance and increases the effectiveness of the audit process, the positive business value is created (Alles et al., 2002; Chan and Vasarhelyi, 2011). Lin et al. (2010) add to these needed characteristics some requirements based on the standards of quality by ISO (International Organization for Standardisation)[1]; Functionality, Usability, Maintainability, Portability, Reliability, and Efficiency. These standards are used to evaluate on CA frameworks. When providing CA services, the requirements are, usability, maintainability, and Reliability. Figure 10 shows the requirements to evaluate the quality of each standard. These requirements are continuous and automatic mapping, integrity, usability, understandability, operability, maintainability, portability, reliability. For every requirement, a description has been provided in order to be able to measure if a CA framework meet the requirement.

ISO/IEC 9126	Requirements	Description
Functionality	R1. Continuous & Automatic Monitoring	*A CA framework should support continuous and automatic monitoring.*
Functionality	R2. Integrity	*A CA framework has to ensure the integrity of information. In this paper "integrity" refers to the combined requirements of data integrity and process integrity.*
Usability	R3. Usability	
	R3.1. Understandability	*The data extracted by the CA framework should be easy to interpret and understand.*
	R3.2. Operability	*The CA framework should allow auditors to change the auditing rules without stopping the EDP system and ensure the independence of auditing operations.*
Maintainability	R4. Maintainability	*The concept of maintainability means that a module can be modified for specific tasks, can fulfil the user's modifications needs and can reduce implementation costs.*
Portability	R5. Portability	*The concept of portability means that a module can be reused, and thereby reduce implementation costs.*
Reliability	R6. Reliability	*The CA framework should not affect the normal operations of the original EDP system.*
Efficiency	--	*Since we view efficiency as an implementation issue, we do not discuss in this paper.*

Figure 10 CA technical requirements based on ISO/IEC 9126 Source: Lin et al. (2010)

The more accurate, more supportive, and timelier approach does have some challenges when implementing (Alles et al., 2003). The implementation process has faced many challenges. Multiple studies did a research on defining when CA would be profitable to use. Others did research on the experience of companies that already did the implementation.

[1] https://www.iso.org/standard/22749.html

Challenges

Alles et al., 2002 did research on the economic factors when implementing CA. They concluded that the most critical factor for CA to be beneficial is demand. However, this is not the only factor to have a viable CA. Viability is the function of the quality of supply, demand, and the infrastructure to be able to realise CA. CA techniques may add value, but they are not always cost-effective (Chan and Vasarhelyi, 2011). This is because of the costs of handling the detected exceptions that can be too high. Other problems that arise when implementing CA is about the analytical criteria that need to be set to identify an exception. The exceptions need to be managed in a way that it will not become information overload.

Another key challenge is accessing quality information in an appropriate format (Hardy, 2011). Since customers are using many systems, data is coming from many systems in different formats. Marques et al. (2013) showed that an ontological model could be the key to understand the essence of the transactions, processes and their relationships and characteristics. Hardy (2011) suggests that methodologies from information management and design are needed to support the CA approach in having a good overview of the information and the ability to generate the relevant reports.

Alles et al. (2004) showed that CA could be more vulnerable to collusive fraud or auditor incompetence because of its almost complete dependence on automated procedures. The default is defined and set for the automated analysis. All the transactions that meet the standard will be accepted without any further review. When a default setting is incorrect, transactions that would usually be seen as an exception are now accepted. When there is fraud between auditors and managers, this fraud could be done without being recognised. The possible manipulation of the CA systems is one of the weaknesses. It makes it less effective than a manual audit system, which always can raise questions about transactions that already have been accepted. Alles et al. (2004) argued that this weakness could be overcome by expanding CA in order to allow a third-party review of the audit. When logging the audit, the audit trail is provided. The log captures the decisions that affect the audit and will be set in a read-only file. This file could be used to determine if the audit went well.

Hardy (2013) did empirical research about the challenges when implementing CA in an organisation. Four themes were identified:

- *The multiplicity and messy nature of CA*: the implementation of CA is a messy process where CA is framed according to the identified users, the purpose, the technologies utilised, information types, frequency, and the level of integration. This messy nature would suggest that guidance with a strategic plan should be represented. In the observed cases, the nature of CA shifted because of negotiations throughout the whole process. Because of the shifting nature of CA, new possibilities for CA were defined and showed new or different assurance processes where the auditors were strategists.
- *Developing and leveraging a data analytics capability, managing exceptions and multi-stakeholder interactions*. As mentioned before by Alles et al. (2004), the flood of exceptions is one of the challenges of working with CA. This flood of exceptions has consequences for the understanding of the strategy, methods, and technologies in

order to identify, design, and build suitable analytics. Furthermore, the massive amount of information also has a consequence on the judgments to evaluate the exceptions.

- *That information thing: messy data complex IT environments and information needs:* This challenge is mentioned before by Hardy (2011) which stated that the data quality, accessibility, and availability is a key challenge when implementing CA. Additionally, data privacy and security are also issues. Guidance is needed for organising data and protecting data that is stored by the auditors. Data privacy results in complexity because of the privacy laws; this has consequences for providing governance guidance. It is stated that dashboards are the appropriate tools to assist in providing advice by visualising data.
- *Senior Management support and developing a strong business case:* During all the observed cases, the senior management support is critical to have a CA strong business case. As mentioned in Alles et al. (2004), even though the efficiency of CA is recognised, the identification of the costs and benefits was difficult.

3.1.5 Conclusion

CA consists of continuous monitoring and continuous auditing. These two can be divided into the following three components: Continuous control monitoring, continuous risk assessment, and continuous control assessment. The objectives of these components are transaction verification, compliance verification, estimation verification, and judgment verification. To assess the CA, the requirements for a quality software model can be used When CA is implemented well, the effectiveness and efficiency of the processes are improved radically. However, when a company is ready to transform the assurance service to CA, the key challenges will be the demand, supply, infrastructure, the messy nature of CA, managing exceptions, information needs, and support of senior management.

3.2 Artificial intelligence in the audit industry

AI supports the elimination of human errors when processing data. This increases the reliability of accounting information. Therefore, applying AI increases efficiency and is mostly used for tasks that are time-consuming (Zemankova, 2019). AI is becoming more popular, and the evolution of the technology in the audit profession has been growing. The big four accounting companies have executed several projects.

AI was firstly used in the 1980s in the accounting and auditing industry. Abdolmohammadi (1999) identified that applications of computer-based support systems in the audit could increase the effectiveness and efficiency of decision making in audits. He particularly did research on decision support systems and knowledge-based expert systems. Zemankova (2019) concluded that in the 1980s, AI was mainly developed to increase the competition, specialise in the field of auditing, and increase efficiency that does not come at the expense of effectiveness. Baldwin Morgan (1995) showed that expert systems have a greater impact on the effectiveness, expertise, and education rather than efficiency. Many sources have defined AI, a widely used deifinition in the last few years is from Kaplan and Haenlein (2018) which defined AI as: “a system's liability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation”.

Due to the extensive use of AI, many possibilities and implications are found. Many AI terms have been mentioned in the literature. Sutton et al. (2016) provided a summary of these terms and created an "Artificial Intelligence Tree" to show the interrelationships across the different terms and other technologies in the AI domain. Figure 11 shows this tree. It must be noted that AI is not limited to these technologies and algorithms. The figure shows that AI research in accounting is divided into machine learning techniques and knowledge-based systems. Sutton et al. (2016) claimed that machine learning terms are more used for data analytics research, while knowledge-based systems are more searched for the use of traditional AI applications. An example of a knowledge-based system is an expert system. An expert system can be defined as "software-intensive systems that combine the expertise of one or more experts in a specific decision area in order to provide a specific recommendation to a set of problems which assists the user in making a better decision than when unassisted"(Hunton et al., 2004). The expert systems mimic human judgments by. It must be noted that the scope of AI in accounting research is not limited by the terms included in this AI tree. More information about machine learning and the applications of AI in the accountancy industry will be further discussed below.

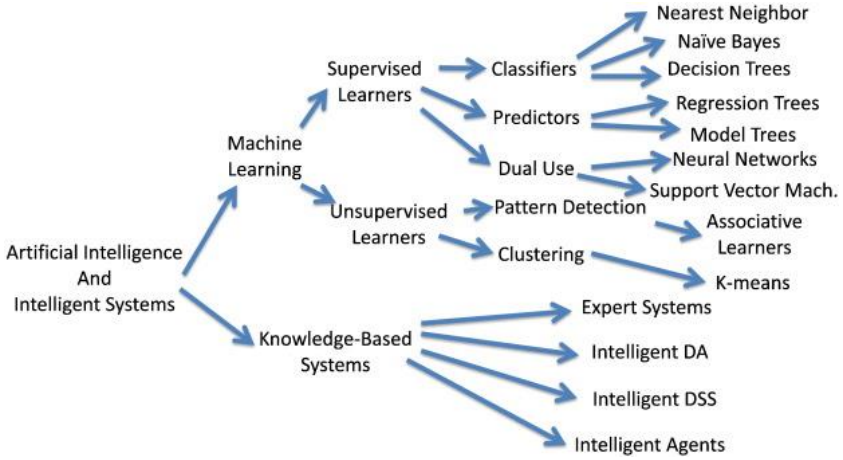

Figure 11 The branches of AI Source: Sutton et al. (2016)

3.2.1 Machine learning

Machine learning is extensively applied in cognitive analytics and is the most popular associated AI technique (Moll & Yigitbasioglu, 2019). Machine learning applies probabilistic frameworks to derive possible models from explaining the observed data (Ghahramani, 2015). When the best possible model is chosen, it is often used to make predictions. Many algorithms have been developed (Gudivada et al., 2016). All these algorithms work with the input data called examples, which represents a data point, and is compound of several feature values and possibly several target values. All the feature values of an example together form a feature vector. As shown in figure 9, machine learning can be used for different kinds of learning, which are mainly applied for Data mining (Amani & Fadlalla, 2017; Gudivada et al., 2016). To be able to do this, a large amount of data is needed. Unsupervised learning algorithms are used for data sets where the responses are unlabelled. A supervised learning algorithm learns from the examples, which consists of the relations between the inputs and outputs. The objective of supervised learning is to minimalize the error. A training data set n consists of the input(i) and output(o) which makes n $\{(i_1, o_1), (i_2, o_2) \ldots,(i_n,o_n)\}$(Gudivada et al., 2016). Figure 9 shows some examples of the algorithms for unsupervised and supervised learning. Besides unsupervised and supervised

learning, semi-supervised learning could also be a possible solution for processing data. Semi-supervised learning algorithms will also use data for learning; however, it selects the data from which to learn by itself. The benefit of this compared to supervised learning is that the algorithm avoids the situation where a lot of data needs to be labeled before it can be trained (Settles, 2009). The last popular kind of learning is reinforcement learning, which is learning how to do an action in an unknown environment. It is a kind of tool that learns how an agent should react in an environment based on trial-and-error learning (Gudivada et al., 2016). Multiple studies showed that one of the hardest parts of machine learning is to choose the right model or algorithm because of the many choices (Kokina & davenport 2017; Gudivada et al., 2016; Sutton et al., 2016; Amani & Fadlalla, 2017). Appelbaum et al. (2018) summed up most of the algorithms of supervised learning. These are Bayesian theory, probability theory, Naïve Bayes, deep learning, fuzzy artificial neural networks, random forest, and decision trees. They also summed up some unsupervised learning techniques, which are Predictive process discovery, Clustering, Real-time process analysis, text mining, and visualisation.

Data mining and Machine learning

Data mining and machine learning are often combined applied. Data mining is extracting patterns from data to discover hidden patterns that provide knowledge in a high amount of data (Jiawei & Kamber, 2001). Data mining is useful for companies to be able to focus on the essential information that is available in their database. However, Jackson (2002) stated that data mining is not covering all the aspects that are necessary for making decisions. The knowledge of the business, understanding of data, and analytical methods is still crucial. Data mining consists of three objectives (Amani & Fadlalla, 2017). description, the first objective is finding patterns in the data. The second objective is a prediction which is done by applying variable in the database to predict unknown or future values of other variables. The last objective, prescription, is about giving the best solution for the problem. To achieve the objectives, different data mining tasks can be performed. Amani & Fadlalla (2017) defined the following data mining tasks:

- Classification: mapping data to qualitative discrete attribute sets of classes (this can be binary or multi-classes)
- Clustering: dividing data into classes or groups
- Prediction: obtaining a future numerical value or non-numerical value, which is called respectively forecasting and classification
- Outlier detection: obtaining data that deviates drastically from the average
- Optimization: searching for the best solution among the resources
- Visualisation: visualising data in a way that it is possible to understand the data
- Regression: valuing dependent variables from a set of independent variables.

To complete these tasks, data mining techniques are needed. There exists a wide variety of techniques, and some examples are given by Amani & Fadlalla (2017). This is shown in figure 12.

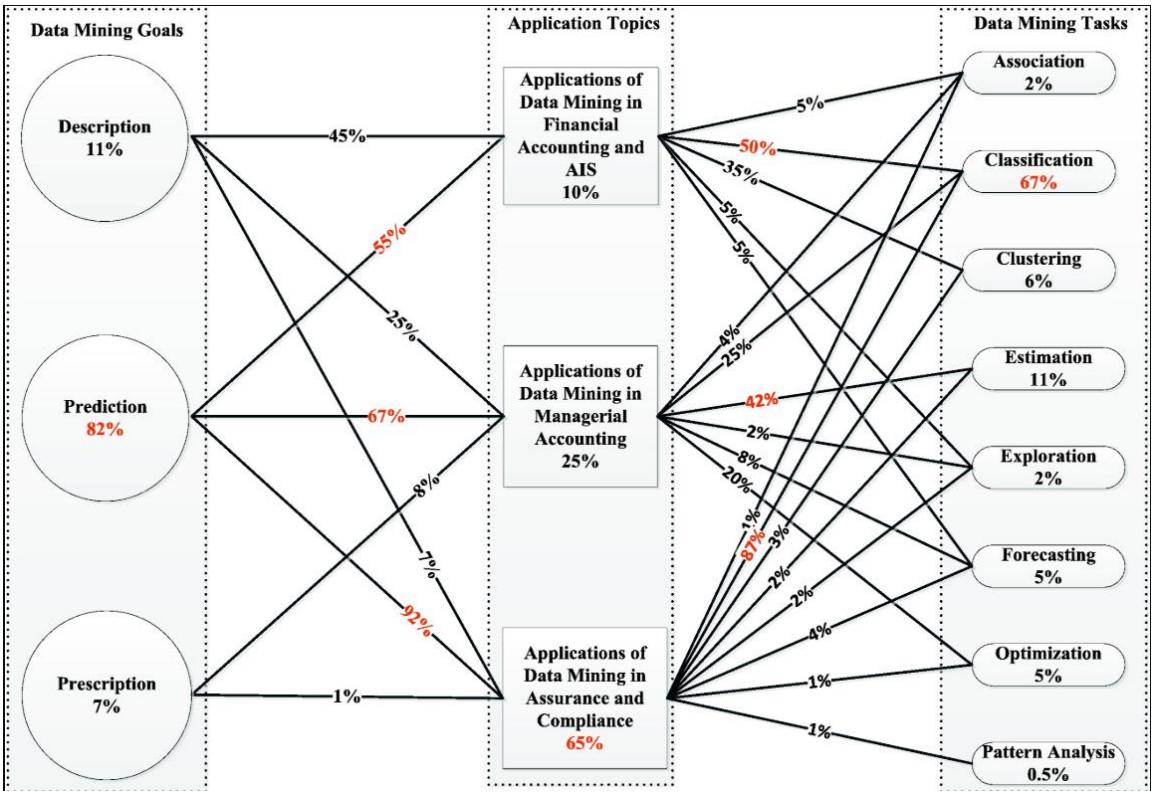

Figure 12 Data mining goals and tasks source: Amani & Fadlall 92016)

They concluded that the usage intensity is highest in the assurance and compliance domain. The goal intensity (the prediction domain) is the inevitable data mining goal that is mostly used for the applications. The tasks that are mainly used is the classification task.

Some examples of data mining techniques to complete a data mining task are Artificial neural networks, Genetic algorithms, decision trees, association rules, regression, naïve Bayes, Support vector machines (Baldwin et al., 1995, Kokina & Davenport, 2017; Amani & Fadlalla, 2016). As can be compared with figure 9, a lot of these data mining techniques are machine learning algorithms.

3.2.2 AI technologies for audit tasks

There are four types of AI technologies that are mostly applied in audits (Kirkos, Spathis, & Manolopoulos, 2007) (Omoteso, 2012) (Zemankova, 2019) (Baldwin et al. 2007). These are Genetic algorithms/programming, fuzzy systems, neural networks, and Hybrid systems. More information about these technologies is written below.

Genetic algorithms

Genetic algorithms are search algorithms that are built on the process of natural selection. The goal of the algorithm could be to find the optimal or near-optimal. Due to be able to learn class boundaries that are non-linear functions, solutions can be found that could not be done by linear methods (Hoogs et al. 2007). The algorithms are mainly used for bankruptcy or comparable audit tasks to decrease the risks (Zemankova, 2019). Hoogs et al. (2007) show that the genetic algorithm can also be applied for fraud detection since there are not clear variables that indicate

fraudulent behavior. The genetic algorithm can, because of its flexibility, combine the logic to handle missing data and the classification of the output structures. By using a problem domain language, the algorithm can support the understanding of the results for users.

Fuzzy systems

Fuzzy systems can assess functions with limited data by taking qualitative factors into account. Fuzzy systems model the cognitive process and assign degrees of possibility in reaching conclusions (Lenard et al., 2000). Fuzzy logic could, for example, be used by accountants to assess materiality. The fuzzy systems will not provide binary decisions but will assess the materiality on a continuous scale from 0 to 1 (Zemankova, 2019). Another example is fuzzy clustering, where data is grouped to a certain class. In contrast to normal clustering, fuzzy clustering provides the degree to which a data point fits in a certain cluster of data instead of providing only the cluster which fits best (Lenard et al., 2000). This shows that fuzzy logic is an AI model that provides a method of assessing a company's capability to continue as a moving concern

Neural Networks

Neural Networks (NN) attempts to mimic the human brain and are mainly applied for risk assessment. The technology supports auditors by approach risk assessment tasks in a more systematically and consistently manner. Neural networks have the ability to learn, generalise, and categorise data that could be used for control risk assessments, determining errors and frauds, financial distress, and bankruptcy. It contains neurons (interconnected processing units) that are acting independently to a set of input signals (Kirkos et al., 2007; Omoteso, 2012). Since each neuron is responding to a signal, the combined input signal is calculated. This is used for predictions of large datasets based on historical trends and events (Omoteso, 2012). Each connection is linked with a numerical value which is called the weight. A neural network is based on layers that contain at least an input and output layer. The Network needs to be trained by letting the input layer apply a pattern that will be calculated by the output layer. The output will be compared to the desired outcome, the errors will be solved. This is an iterative process that will be finished when the error rate is at an acceptable level (Kirkos et al., 2007). NN are popular when predictions and classification need to be realised because it can handle noisy and inconsistent data. (Koh & Low, 2004; Kikos et al., 2007). NNs are often used for making audit judgments since it can be used to develop fraud classifications and reducing control and detection risks (Omoteso, 2012; Koh, 2004).

Deep learning is a deep neural network that can be applied for analysing complex data through hierarchical layers. The difference between NNs and deep learning is the number of layers. Where NNS mostly has two hidden layers, deep neural networks have three or more connected layers, as shown in figure 13 (Najafabadi et al., 2016; Sun & Vasarhelyi, 2018). Besides the weights, deep learning is also executing the nonlinear activation function to convert the input signals and calculate the losses in order to improve the error rate and prediction accuracy. The losses are calculated by computing the difference between the actual output and calculated output by calculating the Mean square Error or Logloss (Sharma, 2017). Deep learning is a compelling tool and has been effectively executed in several industries i.e. Financial, advertising, and automotive (Najafabadi et al., 2016).

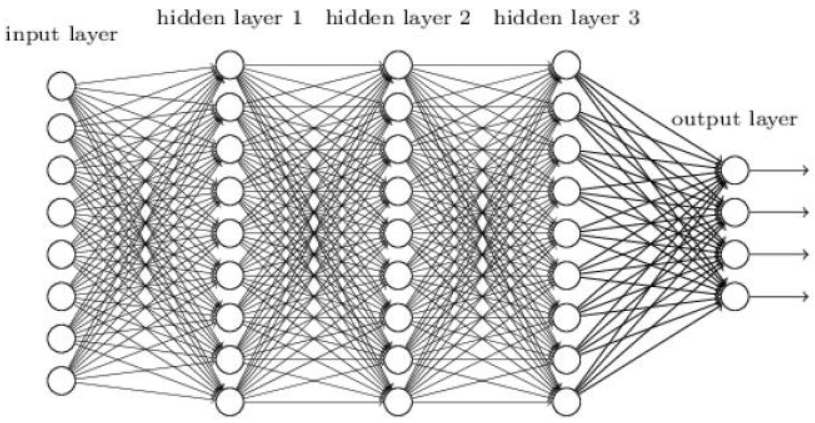

Figure 13 The structure of a neural network Source: Nielsen, 2015

Neural networks and deep learning can also be used for classification data (Kirkos et al., 2007; Sun & Vasarhelyi, 2018). Classifying is often used in data mining, which uses algorithms to extract patterns from data (Jiawei & Kamber, 2001). Classifiers that can be used in AI are part of the supervised learning.

Hybrid systems

Hybrid systems are a combination of the previous three mentioned technologies. This combination is used when a qualitative judgment and quantitative analysis is necessary. Zemankova (2019) stated that this combination could be used in a way that a generic algorithm will ensure efficient use of known control variable relationships. The neural network would then be used to recognise patterns in a large number of control variable relationships, which is impossible to express as a set of rules. Hybrid systems could also be the combination of an expert system and statistical models. Fuzzy clustering could, for example, be used to

3.2.3 Intelligent process automation

Robotic process automation (RPA) are mostly used when a part of a process which is rule-based need to be automated (Huang & Vasarhelyi 2019). IEEE corporate advisory group (2017) defined RPA 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". Examples of processes that can be automated by RPA are audit data preparation, file organisation, integration of data from multiple files, copying and pasting data. Criteria for being able to automate a process with RPA are that it is a well-defined process, high volume, and highly repetitive (Lacity et al., 2015). Vitharanage et al. (2020) agreed with Lacity, and added structured data input, standardised processes, low levels of exception handling, interact with multiple systems.

The difference between AI and RPA is that RPA is process-driven, and AI is data-driven, which requires data to learn patterns to make human decisions (Zemankova 2019). Because of the two technologies complement each other. Berruti et al. (2017) took advantage of this by proposing Intelligent Process Automation (IPA). This is a combination of cognitive automation, deep learning, machine learning, and RPA. Berruti et al. (2017) stated that the essence of IPA is to "take

the robot out of the human". It supports simplifying interactions and improves the speed of a process. Thus, the information that is sensed can be sent to the thinking component to be processed, and the acting component can then carry out the corresponding action, achieving end-to-end process automation. IPA is a product of five core technologies: RPA, advanced analytics/machine learning, smart workflows, cognitive agents, and natural language processing (NLP)/natural language generations (NLG). RPA are the robots that replace manual clicks, text-heavy communication can be interpreted because of the NLG, rule-based decision do not have to be preprogrammed because of machine learning, the cognitive agents offer customer suggestions, and the smart workflows offer real-time tracking of handoffs across systems and people. Zhang (2019) adds Natural language processing (NLP) and Computer vision as two AI technologies that are possible to integrate into an IPA solution.

Guidelines

Berruti et al. (2017) showed the essential steps to creating value with a successful IPA. The first step is to align on the IPA's role in the model. The second step is to design the full portfolio of the IPA solution. It is possible to use a combination of the IPA technologies. However, the impact and value are maximized when all the IPA technologies work together. The third step is to build the minimum viable product (MVP) before making it complex. Capturing value and building momentum is the fourth step and is about the long term and short-term benefits. A detailed roadmap for the implementation needs to be formed. This should also include how certain modules could capture value. The fifth step is embedding lasting capabilities to achieve sustainability. Berruti et al. (2017) suggests creating a centre of excellence (CoE) to manage and support the transformation and deployment of IPA by capability building, certification, and standards, and creating reusable solution patterns. Additionally, business controls need to be placed, critical business-analysis and digital skills need to be embedded. The last step is to coordinate communications and change management. Communication is needed for the successful implementation and execution of the new IPA model.

Zhang (2019) showed that before implementation, the workflows need to be defined. Zhang defined the primary workflow as an audit engagement and the secondary workflow is divided into the four audit phases: audit planning, internal control testing, substantive testing, and audit conclusion. Every workflow contains other lower levels workflows which includes the standard audit tasks. Figure 14 shows the structure of the levels of the audit workflows.

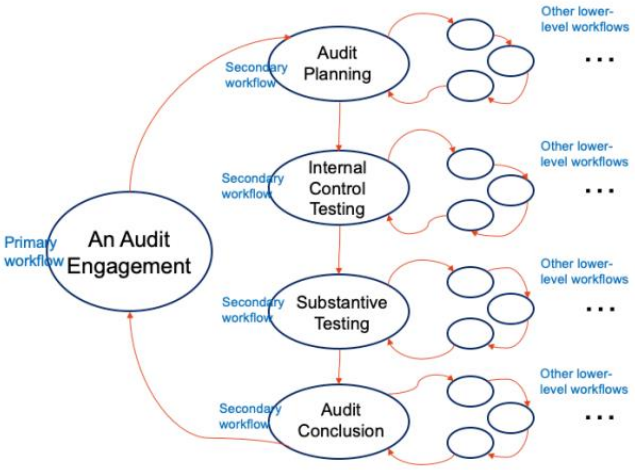

Figure 14 The audit workflows Source: Zhang (2019)

Suitable tools need to be considered. Figure 14, the automation continuum, can be used as a guide to choose the right tools.

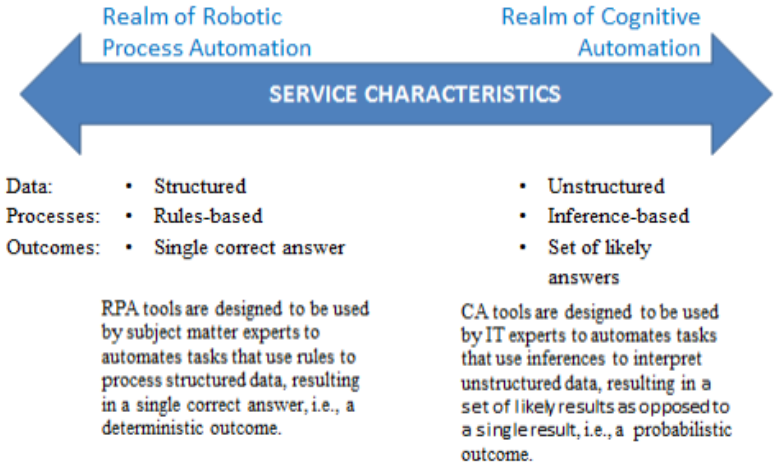

Figure 15 Automation continuum Source: Lacity and Willcocks (2016)

When professional judgment is needed during the workflow, an auditor is included. This action is called auditor in the loop and is only used for an auditor's judgment. Davenport and Kirby (2016) showed common audit tasks with cognitive technologies that could be used. Table 1 shows the level of intelligence for each task type. When the levels of intelligence are more complex, AI technologies are mainly applied.

Table 1 Cognitive technologies for task types *Source: Davenport and Kirby (2016)*

Levels of intelligence Task type	Human support	Repetitive task automation	Context Awareness and Learning	Self-aware Intelligence
Analyse Numbers	BI, data visualisation, hypothesis-driven analytics	Operational analytics, scoring, model mgmt.	Machine learning, Neural networks	Not yet
Digest words, images	Character and speech recognition	Image recognition, machine vision	Natural language processing, deep learning	Not yet
Perform Digital Tasks	Business process management	Rules engines, robotic process automation	Not yet	Not yet
Perform Physical Tasks	Remote operation	Industrial robotics, collaborative robotics	Fully autonomous robots, vehicles	Not yet

Zhang (2019) defined how RPA and IPA could be used for an audit task. By firstly identifying the task in the workflow, choosing a suitable tool and integrate it in the RPA. Zhang (2019) concluded that IPA could provide assurance because of the cognitive agents that could show the irregularities. Alongside, it supports audit in a manner to make it more efficient and effective by using RPA for the scheduled tasks. However, there is also a possibility that efficiency and effectiveness is significantly reduced because of an occurred error that could disable the bot (Lacity and Willcocks, 2017). Two other mentioned disadvantages of using AI in the audit are errors that are built in the bots could reduce the effectiveness, and auditors could rely too much on the bot's judgments instead of their own (Zhang, 2019). As Zhang (2019) mentioned, IPA is still a new upcoming technology that needs to be tested on how it can be helpful in certain processes, what the impact and effect would be on the quality. Zhang concluded that there are too many uncertainties, for now, to be able to conclude the effect of IPA on the audit.

3.2.4 Continuous activities

AI could support continuous activities by delegating tasks to intelligent agents. These agents will be more consistent and accurate, and human judgments error will be eliminated. Additionally, the process reusability is enhanced, which can be realised by capturing expert knowledge through ontologies (Ghiran, Silaghi et al. 2011). These intelligent agents could support IT audit automation to create a continuous auditing approach. The role that AI can play to reach a formal process of

continuous auditing is, for example, the task of understanding the normative process. Natural Language Processing techniques are used to interpret unstructured data and assess the risks and install controls of the process that needs to be examined (Jans & Hosseinpour, 2019). Baldwin et al. (2007) and Zemankova (2019) added some other opportunities for AI during an audit; these are reducing risk assessment, obtaining audit evidence, classification, and bankruptcy prediction. Appelbaum et al. (2018) were more specific and claimed that these above-described activities, and other continuous activities in audits can be achieved with the use of regression, descriptive statistics, probability models, expert systems, decision trees, belief networks, process mining, visualization, text mining, and clustering.

3.2.5 Ethics

Many studies are done about the ethical side of using AI techniques in audits. Many argue that the role of an accountant will shift, the ability for effective accounting and auditing engagements will drastically shift (Kokina & Davenport, 2017). Davenport and Kirby (2016) claimed that the audit industry would not lose many jobs because it will only be enriched with augmentation by technology instead of full automation. They stated that the following jobs will remain in the accounting profession:

- Monitoring and improving the performances and results of the intelligent accounting systems
- Selecting the right tools for the external and internal audit processes.
- Doing tasks that are not possible without the support of AI systems. Also, when AI systems could do less judgment, time-consuming tasks, the accountant could do the tasks that are now impossible to perform because of the lack of time.

To be able to fulfill these jobs, more understanding of how to work with AI is needed. Krumwiede (2017) concluded from their survey that many accounts think they have a good understanding of AI but are not able to work with it due to a lack of skills.

3.2.6 Conclusion

AI supports the transformation of the audit industry. AI consists of many different branches. Machine learning is a well-known AI tool. Machine learning can often be used with data mining in order to reduce the risks of audit tasks. Not only AI, but also RPA is a well-known tool for automation. The combination of RPA and AI leads to a new upcoming tool: IPA. IPA is not applied very often, and research is limited. IPA has not been applied in the assurance services. Although there is a lot of potential for IPA and other automation, the accountant will not lose it jobs. The audit industry needs the judgment of human experts.

3.3 Summary

The CA literature showed how automation is done during control audits. The literature showed what aspects are important and what the main objectives are. The implementation of CA has its challenges which are also identified. The literature about AI showed how AI can be used to support automation and what the possibilities are. IPA is defined as new upcoming technology. IPA will be further applied in this research since it could be helpful to the problem of Baker Tilly. Since IPA is a new technology, there is not much knowledge of how it could be integrated. Therefore, the next chapter will look into this by creating a framework.

4. Intelligent Process Automation Framework

In this chapter, the design for the intelligent automation framework is created. The requirements of the framework are defined. With these requirements and the literature review, an IPA framework that support companies by developing an intelligent automation strategy is created.

For the intelligent automation that is needed for Baker Tilly, an IPA solution will be created. IPA will be one of the best solutions because the process uses different tools since the automation does not fully have to be intelligent automation (there are parts that just need to be automated) the combination of RPA and AI will fit perfectly.

4.1 Intelligent automation implementation Framework

This framework is created for Baker Tilly, where they want to know what a useful framework is for making the right decision to transform a manual process to an automated report in order to reach continuous reporting. The framework that supports this is explained in this paragraph.

4.1.1 Goal and requirements of the framework

There is not much information in the literature when creating an IPA solution. The combination of AI and RPA in an audit process is not applied and documented. The knowledge gap is how a well over thought decision could be made when choosing an (intelligent) automation for a process with many tasks. This research creates a framework which has the objective to support the organistion on how data processes could be made more efficient and automated.

In order to achieve this objective, a quality IPA framework should be created. The requirements of the framework are based on the ISO/IEC 25010:2011 'Systems and software quality requirements and evaluation'. These standards are created for systems quality models but are also good guidelines for other services. If the framework is validated and will be implemented, a software model will be the result. To be able for the software model to meet the requirements of the ISO/IEC 25010:2011, which were very helpful in improving the CA systems (Lin et al. (2010), the development of the framework should also pay attention to these standards. Moreover, the requirements will be used to evaluate the framework. The characteristics in the document that are suitable for this research are shown in table 2.

Table 2 Requirements of the IPA Framework

ISO/IEC 25010	Requirement	Description
Functionality suitability	• Completeness	An IPA framework should support functions that meet the needs of the user. These functions include covering all the specified tasks and user objectives and providing correct results.
Compatibility	• Interoperability	An IPA framework should be able to exchange information between the components/robots.
Usability	• Usability	An IPA framework should be used to achieve the goals of the users with effectiveness and efficiency.

Reliability	• Maturity	An IPA framework should not affect the normal operations of the tools in the process.
Maintainability	• Maintainability • Reusability	It should be possible to modify the IPA component for a specific task. IPA components should be reusable when building a solution.
Portability	• Portability	Workflows of an IPA can be reused in new IPA solutions

The objective has multiple purposes. The goals are based on the studies of IPA, RPA but also on the implementation lessons learned from CA:

- Determine if it is possible to automate the process
- Determine the requirements of the automated situation.
- Define the sub-goals of each task of the process.
- Determine the appropriate ways and tools to automate the tasks in the process.
- One detailed proposal of the plan that shows the timeline of the data flow and tasks of the whole automated process

These goals are covered in the four phases of automation (figure 16): Process determination, Workflow analysis, Automation technology selection, and Workflow connections.

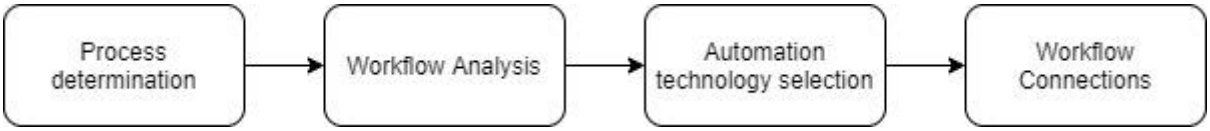

Figure 16 The four phases of the automation framework

The process determination inspects if the process could be automated and determines the objectives of the process and the requirements for automating the process. This phase is the setup of the automation and is needed to create an effective and efficient process that is focused on reaching the defined objective (Vasarhelyi, 2019). The Workflow analysis defines the smaller steps of the process and shows the contribution to the main objective by identifying the subgoal that needs to be achieved. This step is needed to be able to show what a part of the process does, how it fits in the big picture, and provides the opportunity to do the automation step by step (Zhang, 2019). The automation technology selection phase ensures that the right tools and techniques are used. The information about the workflows is needed to define the right techniques (Lacity and Willcocks, 2017). This information makes the process efficient and reliable. The last step is the workflow connection that makes sure that all the workflows with the right tools are placed in an appropriate timeline to make sure that the order of the workflows is done accordingly. The last step in this phase is checking if the workflow meets the requirements and objective. If it is the case that the timeline is not appropriate, the steps of workflow analysis and process determination should be rechecked. The sub-steps of each phase are shown in figure 17. The phases and steps will be further discussed in more detail.

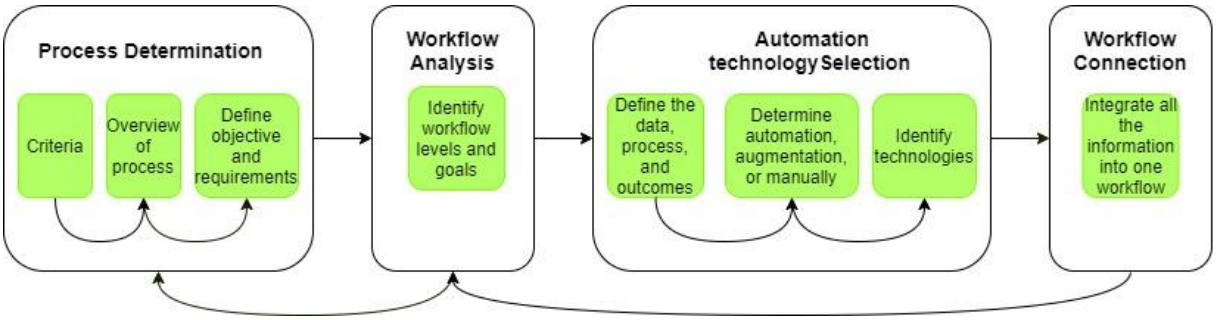

Figure 17 Intelligent Process automation framework

4.1.2 Process determination

The first phase includes three steps. For this phase, it is essential to have a decent overview of the process that needs to be automated. The criteria need to be met, the objective determined, and requirements defined in order to be able to automate the process. Appendix B.1 shows a flowchart of this phase.

Criteria

As learned from previous experiences, automating processes can be expensive and will only add value when there is a satisfying demand for the solution. Alles et al. (2004) showed that demand is crucial for making sure that the process will work. Therefore, the first criterium is that there should be demand from multiple stakeholders. Based on the mentioned requirements in chapter 3, three more criteria are applicable for all components of IPA. These three criteria are data accessibility, well-defined processes, and if digital tasks need to be performed. After knowing if there is a demand for process automation, the data accessibility is checked. It is stated by Lacity et al. (2015) that data accessibility is a significant obstacle for realising AI technologies. The second criterium is that the process should be well defined (Lacity et al., 2015). Well-defined means that it should be able to describe every step of the process accurately. This description is necessary for the rest of the framework to choose the most efficient way to automate the process. The literature showed that when there is no digital task that needs to be done, automation will be more efficient by using back end connections or using only an AI application or technology without the robots (davenport & Kirby, 2016).

Overview of the process

An overview of the process should be provided in a high-level overview. For this high level, the stakeholders and their actions need to be defined in a proper timeline. The literature about CA showed that the possible mistakes in the current situation where actions are mostly done manually could be identified. The identification of possible human mistakes provides the opportunity to reduce or eliminate the mistakes and improve the process when automated

(Zemankova, 2019). This information can be used when choosing a specific tool or technique for automation or when identifying the workflows.

Define the objective and requirements:

The objective of the current situation needs to be defined. This objective will be needed for the requirements that will be determined for the automated process. The requirements are divided into process-related requirements and technical requirements. The requirements will be used for the validation and to make sure that the process is effective.

4.1.3 Workflow Analysis

Zhang (2019) showed that dividing a process into sub workflows makes it easier to automate because the small workflow will each have their specific action that will be automated step by step. The workflow will be ordered in levels. The primary workflow and secondary workflow need to be determined first. After this, there must be looked at if the workflow could be any more specific. If yes, a third level will be created. The question should be asked again until the answer is no. For every workflow, a goal must be determined. It should also be stated how this workflow goal contributes to the main objective of the process to make sure that it is necessary to improve the effectiveness of the automated process (Horkoff & yu, 2016). Appendix B.2 shows the flowchart of this phase.

4.1.4 Automation technology selection

This phase has essential steps since the technology and agents will be chosen. The steps in this phase are discussed in more detail below. A flowchart of this phase can be found in Appendix B.3.

Define the data, process, and outcome

Every workflow has different tasks that need to be determined in this phase. Additionally, the right tools, RPA or cognitive agent, and techniques, e.g. ML, NLP need to be chosen. To be able to choose this, the datatype, outcomes, and if the process is rule-based or inference based needs to be verified (Zhang et al. 2019; Syed et al. 2020). The data type could be unstructured (i.e. text, pictures) or structured (i.e. numbers). Furthermore, it must also be determined if the task is inference-based or rule-based. A task is rule-based when the decision logic is according to business rules (Syed et al. 2020). Inference based tasks are based on evidence and reasoning (Lacity & Willocks, 2017). Table 3 shows guidance in this process. This figure is based on the automation continuum of Lacity et al. (2015) and the cognitive computing guide from davenport and Kirby (2016). Cognitive agents are defined as learning robots; RPAs are robots who do rule-based, repetitive tasks.

Table 3 Tools choices

Datatype	Process	Outcome	Tool
Structured	Rule-based	Single	RPA
	Inference-based	Single	Cognitive agents
		Multiple	Cognitive agents
Unstructured	Rule-based	Single	RPA, NLP, NLG, Computer vision
	Inference-based	Single	Cognitive agents
		Multiple	Cognitive agents

Determine automation, augmentation, or manually

Since the framework is mainly focused on audit services, there are also criteria for choosing to do a task manually and not automate it. As the literature of CA and AI showed, when high complexity judgment of a human is needed, it could be better to let the human do that part of the process instead of an (intelligent) robot, especially in the audit industry. It is also possible that the auditor only needs to give judgment about exceptions. This concept is called human in the loop and is also an option for every task.

To choose whether to automate, augment or do it manually is done based on the following aspects:

1. This task of the process/workflow is too specific, e.g. when there is an understanding of the strategy or methods of customers needed
2. It will not be supporting efficiency or effectiveness.
    - Likely to have many errors (Lacity and Willcocks, 2017)
    - The auditor could do it faster (because of the many exceptions)

Identify technologies

When the right tool has been chosen, the technique is, especially for cognitive agents, crucial. For the cognitive agents, ML and NLP is mainly the case. As shown in table 2, NLP is only applied for unstructured data since the technique is needed for computers to understand the data, which is already the case when using structured data. ML is the last technique that is mostly used for classifying data. Since ML has many algorithms, table 4 is created to guide the search to the right ML algorithm. After knowing the right learning, the algorithm could be chosen. It can also happen that multiple algorithms could be used, then a test with these algorithms could be done. The algorithm that fits best could then be chosen.

Table 4 Machine learning techniques

Characteristic	Supervised learning	Unsupervised learning	Reinforcement learning
Data	Labelled data	Unlabelled data	No prespecified data
Mining tasks	Regression, Classification	Clustering, Pattern detection	Reward-based
Training	External supervision	No supervision	No supervision
Method	Map labelled input to known outputs	Recognise patterns and learns the output	Trial-and-error method

4.1.5 Workflow connections

The last phase aims at creating a well-defined workflow that shows how the IPA will work. This phase has a defined proposal as output. By integrating all the tasks in one workflow, the timeline is defined. After this, the last check needs to be done to see if the solution meets the requirements and if the timeline still makes sense. If this is the case, the decisions could now be executed. However, if the requirements are not met or the timeline has some activities that do not fit well, the first or second phase needs to be revised. It could mean that some requirements or workflows should be modified. It also means that some tasks need to be revised before creating the timeline again. Therefore, it is possible to go from the last phase to the second or first phase. After this phase, the framework is applied, and the plan to create an IPA solution is defined. This IPA solution should improve the process in a way that fewer mistakes are made, less time is needed, and human actions are reduced in order for a company to use their employees for more challenging and judgmental jobs. Appendix B.4 shows the flowchart for this phase.

4.2 Summary

The framework that is designed in this chapter includes the following phases: process determination, workflow analysis, automation technology selection, and workflow connections. These phases cover the main goals of the framework. To be sure of this, the framework needs to be evaluated. This evaluation will be done in the next chapter.

5. Evaluation

In this chapter, the framework is evaluated by interviews. After the interviews, the feedback is processed, which results in a revised framework. This framework is applied to the case of Baker Tilly to show how the steps could be executed. Because some steps in the framework cannot be realised in the time frame of this research, the results of the applied process, a proposal, are discussed with employees of Baker Tilly by validation interviews.

5.1 Evaluation framework

This study was conducted to support Baker Tilly in showing how a process could be more efficient by automating it. A proposal to support the company will be the result of the designed framework. If the management of Baker Tilly approves the proposal, they could test it and eventually implement the solution in their systems. Since this framework could be used by employees of the company, evaluation interviews are done. The interviews were done online via StarLeaf. The interviews took between 35 to 60 minutes. The nature of the interviews was semi-structured which means that questions that were not prepared beforehand could be asked. More information about the setup of the interviews, the background of the interviewees, and the exact questions with answers of each expert can be found in Appendix C. The results per phase are discussed below.

5.1.1 Process determination:

All experts agreed that the process determination is one of the most critical phases because it defines the rest of the automation. One of the experts stated that it is of great importance to have a consensus on the goal and the way to approach it. When implementing new technology in an organisation, there is only one opportunity and when that goes wrong, the implementation is not possible. The majority of the experts agreed that awareness in the organisation is necessary for this stage. Therefore, the step to create an overview of the process which includes the stakeholders, is crucial because it lets the stakeholder think about their actions and if they could be automated.

The first step in this phase is obtaining if the process meets the criteria. The experts have different opinions about these steps; some stated that the process should be defined before the criteria, the others were mentioning that the objective of the process could be determined earlier in the process, right after clarifying if there is a demand for the process. One respondent stated that when implementing these kinds of technologies more often, some criteria will be added because of the exceptions that will occur in the real-life situation.

5.1.2 Workflow analysis

The workflow phase was accurate according to the respondents. One respondent stated that by keeping it simple, it is easier for everyone to understand, which makes it easier to embed it in the organisation. All the experts approved the step of identifying the sub-goals. One expert, however, stated that the goals of each workflow should be evaluated in a later stage (workflow connections). When in the last phase of the framework, it could then be checked if the goals were reached, which shows the effectiveness. Now it is only focusing on what the workflow would contribute to the whole objective to see if the workflow is necessary. That expert claimed that more could be done with these goals to see if an IPA solution might work.

5.1.3 Automation technology selection:

For the IT experts, this was one of the most exciting phases because of the choice to automate, augment or keep doing a part of the process manually. The flowchart to choose whether an RPA or cognitive agent would be necessary was found to be very clear and useful. The option to still do a specific task manually was also the right decision according to the respondents. Some said that the vendor selection should be implemented as well. This vendor selection, however, does not have to be in this phase; the next phase is also good.

5.1.4 Workflow connections

The last phase of the framework also turned out to be right, according to the interviews. One expert prefers to have the data flow already earlier in the process. The others did not agree with this because it also shows which robots communicate with each other or have to wait for each other. However, two aspects were mentioned during several interviews that should also be included in the framework. The first one is the awareness of the organisation. According to the expert, awareness is always essential when transforming processes with new technology. The other aspect that is mentioned is how it could be embedded and implemented in the organisation. The questions that still need to be answered is: What methodology needs to be applied? According to another expert, it should be an iterative methodology. When implementing new technology into an organisation, the awareness within the organisation must also be incorporated in this implementing methodology. Since the phase is the end product of the framework, the implementation methodology should be included in this stage.

5.1.5 Framework

The overall framework has a logical order, and the phases are aligned with each other. Most of the experts think that, when the solution of this framework is realised, it supports the data processes to be more efficient and effective. The framework is plausible, and the phases cover almost all the essential aspects when thinking about implementing new technology into the data processes of an organisation. The benefits of this framework are that a structured way is identified to create a realisable case. The company could provide advice about financial and non-financial information on a regular basis.

On the other hand, some aspects should be added to the framework. For example, the framework could be continuously be improved. When implementing an IPA solution on a process by using this framework, it will provide new insight and show what can be considered further in more detail, what is going well and what is missing in the framework. The identified aspects that are now missing are awareness in the organisation and an implementation methodology.

5.1.6 Conclusion interviews

The respondents were positive about this version of the framework. All the workflows were evaluated in detail by showing the flow charts of each phase. Therefore, every step is discussed during the interviews. Additionally, the framework as a whole was evaluated. Every step that was already in the framework was seen as correct, necessary, and useful. However, the last phase is not complete. Additionally, the order of the steps presented in the first phase was not entirely logical, according to a few experts. The goals of each workflow should also be evaluated at the end-stage of the framework. Furthermore, the implementation methodology and awareness in the framework is missing. As of last, multiple implementations need to be executed in an organisation before a framework can be fully validated.

5.2 Requirements

In this paragraph, the identified requirements are validated. These requirements were based on the ISO/IEC standard requirements for quality systems. Although the framework is not implemented in an organisation, the framework is clear enough to be able to identify if a requirement is met:

- *Functionality suitability - completeness*: The framework makes it possible to have each task identified with a specific goal by the user.
- *Compatibility – interoperability*: In the last phase of the IPA framework, it will be shown how the robots and components can interact with each other.
- *Usability – usability:* The goals of the workflows are identified, which shows the contribution of every specific workflow to the main objective, when it is in a later stage evaluated, the effectiveness can be measured. Furthermore, based on the interviews, the efficiency will be achieved.
- *Reliability* – maturity: because the IPA solution is based on the RPA software, the normal operations of the tools will not be affected.
- *Maintainability – maintainability*: The IPA framework makes it possible to identify for each task the best solution for an IPA. When a task is modified, the framework could be used again to identify the difference in the best solution and modify the robot.
- *Maintainability – reusability*: When two workflows are similar, the same robot could be used.
- *Portability – portability*: Because of the framework, the plan to automate is documented. Which means that workflows with their information about the used robot are documented. This documentation can be useful if there is a similar workflow in another IPA solution. The robot could be reused for the new IPA solutions.

5.3 Revised Framework

The revised framework is shown in figure 18. The aspects that were missing by the experts are now included in the framework. The process determination is modified, awareness and implementation methodology are added to the last phase, which name is changed to proposal formation since the focus is not only on connecting the workflow but also finishing the proposal. The revised flow charts of the process determination and the proposal formation can be found respectively in Appendix D.1 and D.2.

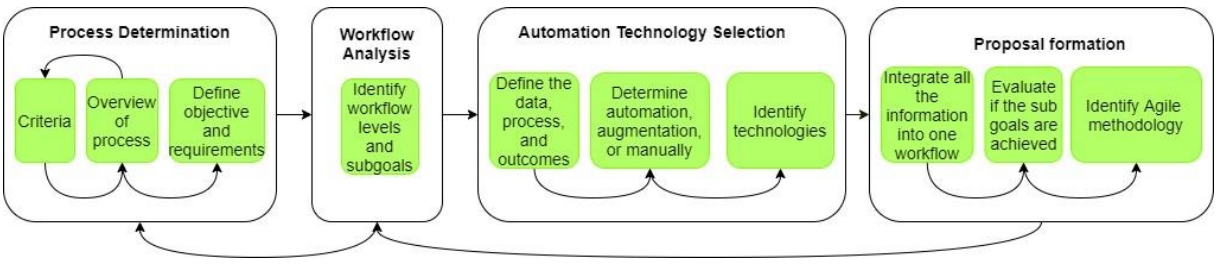

Figure 18 Revised IPA framework

The process determination phase is now as follows: the first step is to ask if there is a demand for automating the process. Then, the second step is now to create a high level of the process with the stakeholders and the objective. When this is realised, the process is assessed on the other criteria (data accessibility, and if there are digital tasks) and performing the remaining steps. The possible human mistakes in the process and the requirements for the automated process are identified.

The last phase has also been changed. In this phase, proposal formation, the information of the previous phase will be integrated into one workflow. After that, it will be evaluated if the subgoals of the workflows are achieved. A plan for the implementation methodology will be defined after. In the implementation methodology, awareness in the organisation will be included. When following the advice of the experts, an iterative method should be used. Therefore, an agile method shall be chosen. Vendor selection is also included in the revised framework. It is part of the implementation strategy because when all the robots and data flows are defined, the vendor can be selected.

5.4 Demonstration framework

The revised framework is applied to the data process of Baker Tilly. The output of the framework shows how the efficient data process could be and what is necessary for having a smooth implementation in an organisation. This process is during a compliance engagement. During these engagements, Baker tilly has much information about customers and are willing to use this information to provide more advice. The information about the process is gained from the consultants from IT advisory.

5.4.1 Process determination

This section will describe if the criteria for the process mentioned above are met, it shows an overview with a high level, and it defines the objective and requirements.

Criteria part 1

The framework shows that a process needs to meet three criteria. The first criteria, which is that there should be a demand to automate this process. The demand for a more efficient data process comes from the SMEs consultants and the IT consultants. The SMEs consultants want to offer more to their customers, such as continuous reporting. The IT advisors would like to automate the process to do less repetitive tasks and more challenging tasks. Additionally, both consultants agree that when they could be able to automate this process, they stand out from the competition.

Overview of the process

In paragraph 4.1, the process is partly explained. However, for the importance of the case, the whole process is provided below.

Every company needs to have a financial statement in the Netherlands. However, not all companies do have the knowledge or time to create a financial statement. Therefore, accountant companies are offering compilations audit. During these kinds of audits, the customer sends the data from their financial administration. The accountants support their customers by preparing the financial statement and the compilation report. The compilation report includes the nature of the engagement, the responsibilities of the management and the accountants. At the end of the compliance engagement, the accountant will read the financial statement in view with his understanding of the organisation of the customer to make sure that the financial statement is complete. Since the main objective is to have a complete financial statement, the accountant will not check all the data on the transactional level, as is done during a control audit. The accountant will check if the data is complete and if the balances and profit and losses are provided according to the government rules. To be able to do this, the accountant needs to be sure to have all the data. Suppose the information provided by the management of the customer is not complete, or the

customer is refusing to make any modifications to the financial statement. In that case, the accountant will withdraw from the engagement and inform the supervisory board. The accountant will not give judgment, expression, or conclusion on the financial statement during a compliance engagement. When the customer requests an opinion about the financial statement, they will need to get an audit or review engagement.

It often occurs that the customer would like to have some advice on their performances. Baker Tilly is willing to provide more advice during a compliance audit. The ledger account of a customer includes much information that could be used for a dashboard to show the performances. In the financial administration, e.g., Exact, the ledger accounts can be mapped to a reporting code. Baker Tilly has defined their reporting codes. An example of the reporting code is AA.A.A.A0300, which are the cumulative depreciation. The reporting code must be entered manually for each ledger account in order to map the data. When all the ledger accounts are mapped to a reporting code, the data of the ledger account is exported to TimeXtender. TimeXtender is a data management platform[2] that supports the process of preparing and managing data. A project repository is created in TimeXtender, and the time interval of when the data need to be updated can be set. In TimeXtender, the data will be extracted by setting the useful data to the next layer. In these layers, the data can be arranged under several headers in different layers. When the correct data is extracted, and the layers are generated, the data can be loaded into Qlik Sense. Similar to importing data to TimeXtender, when exporting data to another tool, a time interval on when the data need to be exported again can be set. In Qlik Sense, the calculations for the KPIs that are used are already defined. The ledger accounts are shown in Qlik Sense and need to be dragged to the KPIs. Figure 19 shows the above-described process.

The objective of the process mentioned above is to provide standardised dashboards to customers to be able to give them more advice. When this goes well, opportunities such as benchmarking could be realised.

[2] https://www.timextender.com/

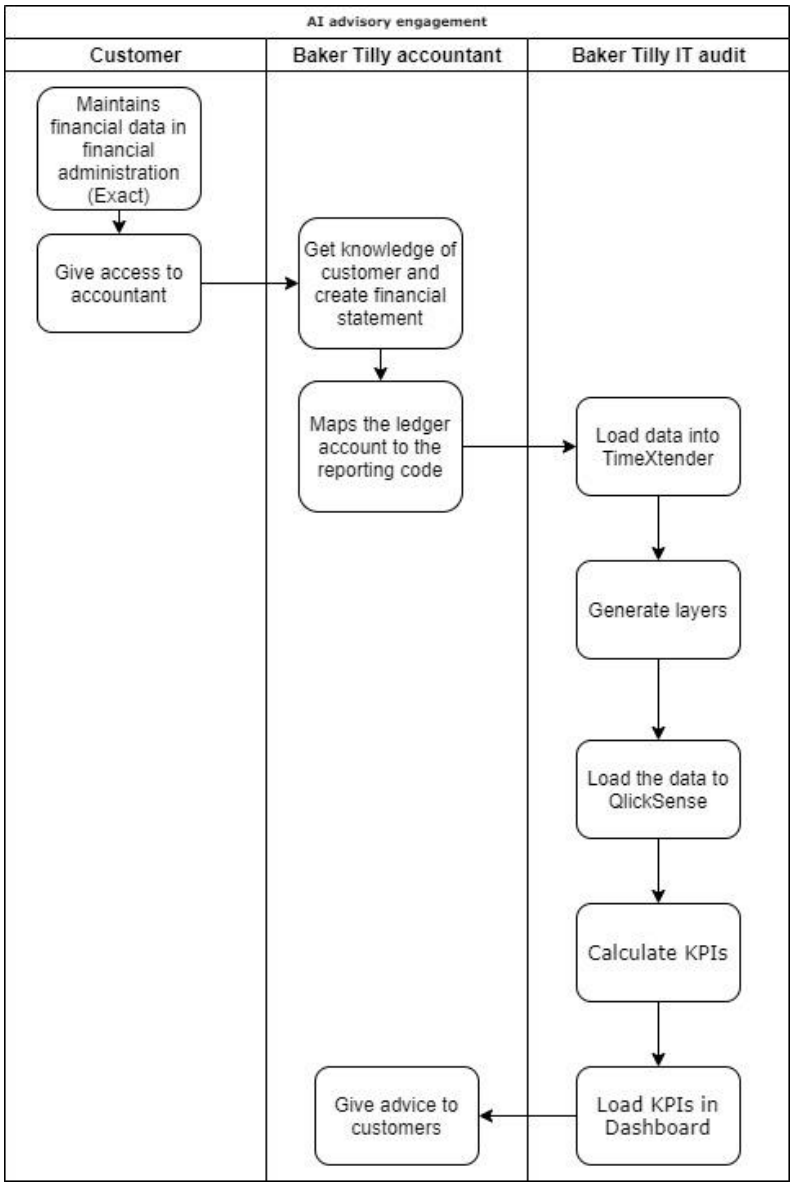

Figure 19 Current situation

Criteria part 2

The overview of the process shows that the process is well-defined. It is clear what actions are done by the customer, accountant, and IT auditor. The process also shows that the data of customers is accessible for the accountants and IT auditors. Therefore, this criterion is also met, and there can already be concluded that automation is possible. Since there are digital tasks that need to be done, the IPA framework can be used to create efficient automation. An example of the digital task is in TimeXtender the data need to be put in the right tabs.

Possible human mistakes

During the above-described process, there are some uncertainties which could lead to invalid dashboards. The mistakes that have been made in the past are:

- A ledger account that has not been mapped to a reporting code. This mistake will result in data that does not have a reporting code and will not be included in the data that is exported to TimeXtender.
- Another possible mistake is when the wrong code is mapped to a ledger account. The data will be sent under the wrong code and will be used in the dashboard for the wrong purposes.
- The reporting code has not been entered correctly. Since the code is manually put in the system, an accountant can make a typo.
- KPIs are calculated wrong because the reporting code systematics is quite fragile. The reporting codes of Baker Tilly do not have a clear guide. Two accountants may map the same ledger account to a different reporting code. Therefore, KPIs need to be calculated differently every time.
- Not all the correct data is loaded into TimeXtender or Qlik Sense. There is never a check if all the data is loaded from Exact to TimeXtender or from TimeXtender to Qlik Sense. When not all the correct data is loaded, the whole dashboard does not make any sense.

Objective and Requirements automated process

Since this process is going from being manual to an automation, the objective can be determined when knowing the objectives of the IPA, how the IPA supports the solution, and the steps that need to be taken to realise the solution. The determination of the objectives, in this case, is based on the CA literature, AI literature, and the framework.

In this situation, an auditor does not have to check the data on the transactional level. The compliance auditor identifies the data to be able to create the financial statement that is built following the rules of the government. The IT auditor who does the advisory part of the engagement, checks if all the mappings are done, performs the ETL process and creates the dashboard. When this is automated, and something went wrong, there should be a component that will notice the mistake. Additionally, when AI is used for automation, the literature showed that it is better to have a transparent or explainable process. Hence, a component that can ensure and control this should be included. This component will be the equivalent of CA in an automated control audit, where CA ensures that the process is reliable and transparent. It is essential to give sound advice that can only be reached by having a reliable process and a certain quality of the data. The reliability of the process is about making sure that data is transformed, transferred, and stored well. The quality of the data is, similar as with CA, about the data that is provided by the customer. When the assurance service was transformed to CA, the question that needed to be answered was: "Which processes need to be automated, and how would this be regulated?"(Alles et al., 2002). The objectives were therefore introduced and were dividing the process of continuous auditing and monitoring into specific steps. For each step, it was said what the goal was and how it could still meet the assurance requirements given by the government. In this case, audit services are often receiving data from customers, preparing the data, and reporting this data. The process of getting the data from the financial administration to the dashboard is about monitoring and analysing data to provide insight regarding performances. This process could be summarised to continuously monitoring. The result of this continuous monitoring will result in continuous reporting where information of the performances is reported to the customer. This

process can be divided into capturing data, ETL, and providing a dashboard or report. Therefore, the objectives of this component are:

- Mapping verification: Mapping to standard code and checking if the mapping went well
- ETL verification: Verifying if the right data is extracted and transformed into the right format before it is loaded to the report
- Judgment verification: The report needs to be created, and the results need to be communicated to the customer.

Since the levels are not similar to the CA dimensions, the component cannot be called CA. The component makes sure that there is a particular certainty of the process and the data; as a result, the component will be called certainty.

The transformation from the current situation to the automated situation will be supported by an IPA solution. IPA could support continuous monitoring and continuous reporting in order to have automation with reasonable certainty. Because of the different tools and tasks during the processes, the combination of AI and RPA will fit. The roles of the technologies of the automation solution are shown in figure 20. Although this figure is based on the current situation, it can still be used to show how IPA supports the automation in audit services, namely at the bottom to support the continuous approaches. If Baker Tilly would want to apply IPA later on in control audits, the CA framework could be used, and the IPA components would also be at the bottom to support continuous monitoring and continuous auditing.

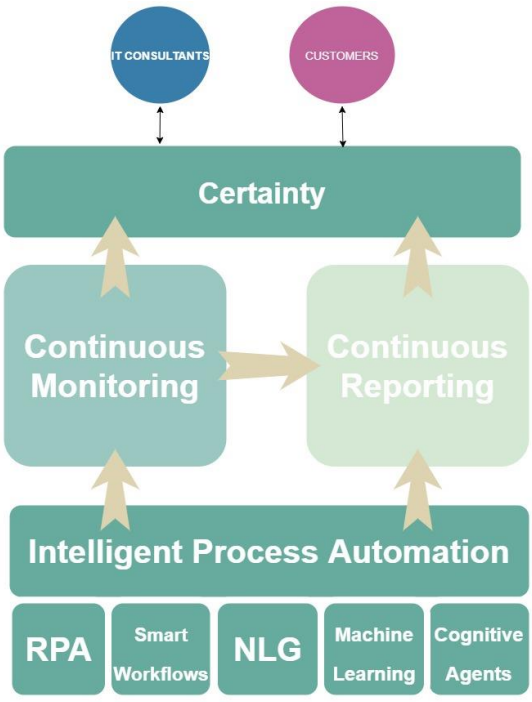

Figure 20 Role of the technologies

The last step in the process determination phase is to define the requirements for the design and integration of the automation. These requirements are based on the requirements given by Baker Tilly IT consultants, and the certainty objectives. The requirements are divided into process-related requirements and technical requirements.

Process related requirements:

- Human actions should be minimal. The only human action that is allowed to intervene in the automated process is when expert judgment is needed, or the process is too complicated for an agent.
- The KPIs should not be measured differently anymore. A set of standard KPIs is already defined; the calculations of the KPI should always be in the same way.
- The process needs to be understandable for IT consultants who also use TimeXtender and Qlik Sense.
- The process needs to be understandable for the accountants.
- The solution should be possible to be able to do it for more than one customer.

Technical requirements:

- The process should be transparent. The steps that were executed during the automation should be traceable.
- Checks that make sure that the data is complete and correct should be included.
- Make still use of the tools (TimeXtender and Qlik Sense)
- It should be made possible that in the future, modifications can be easily made.
- Systematics to map the data to the customer must be applied.

5.4.2 Workflow Analysis

In the new situation, the current process is transformed into a workflow with some adjustments to make it appropriate for automation. In order to create the certainty described above, the possible mistakes need to be eliminated to reach the mapping verification, the ETL verification, and to be able to provide valid advice. This certainty will lead to a less time consuming and more reliable process. The workflows are designed in a way that the primary workflow is the advisory engagement; the secondary flows are divided among Exact, TimeXtender, and Qlik Sense. Since all these workflows can be more specific, a tertiary level is included. The workflows are now specific enough that they all have one goal. First, the primary workflow and an overview of the workflow will be provided. After this, the workflows will be discussed in more detail below. It is shown in figure 21 that there are three levels needed before the workflow is specific enough to have one goal.

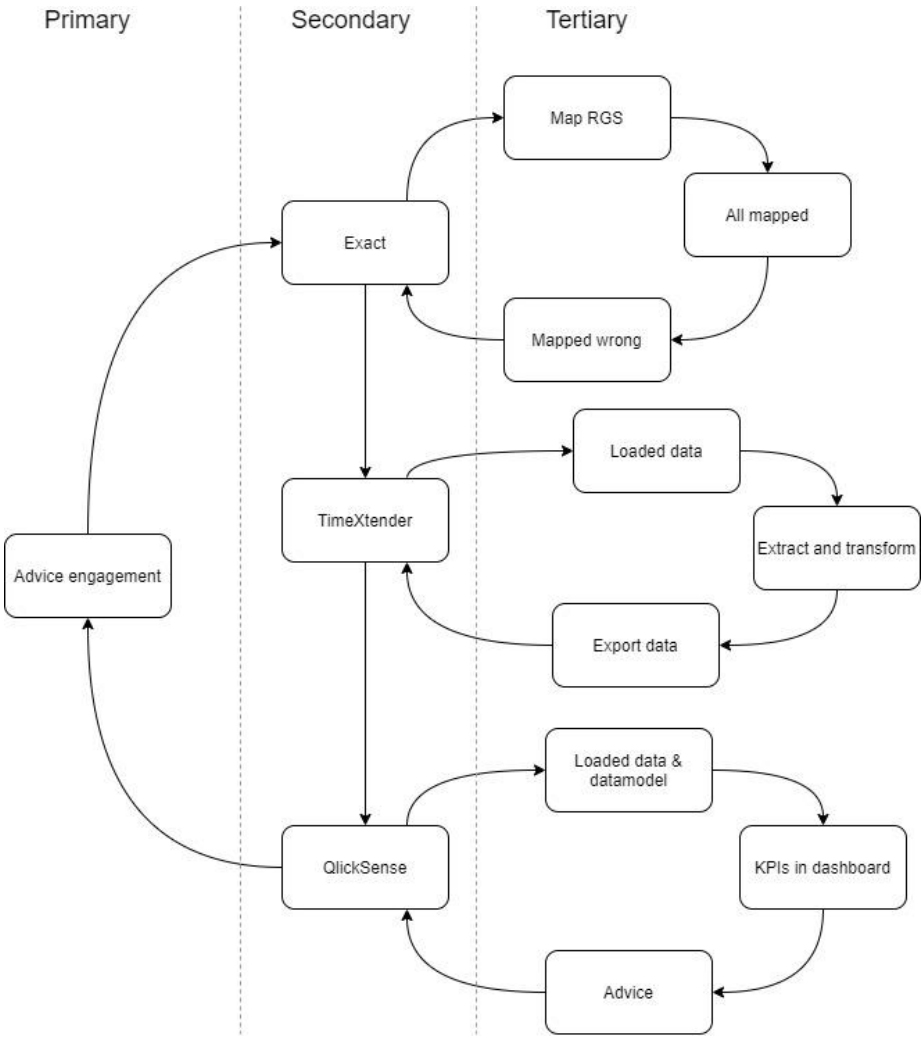

Figure 21 Workflow levels

The primary workflow is called the advice engagement and is the high-level description of the process. The new process is that when the data of the customer is in Exact and accessible for the accountants, the ledger accounts need to be mapped to an RGS code. To eliminate one of the possible mistakes (KPIs that cannot be calculated) standard systematics will be used, which means that the ledger accounts will be mapped to a reference ledger scheme. In the Netherlands, this scheme is getting more popular because it makes it possible to map the general ledger to a standardised ledger which is also accepted and represented by the tax authorities, the chamber of commerce, and the Dutch banks. More information about the development, layout, and (dis)advantages of RGS can be found in Appendix E. The IPA will provide the best option for every mapping. The IPA will conclude if all the mappings are done by checking this. It must be checked if the mapping with RGS went well and the ledger accounts are mapped to the right RGS codes (this eliminates two other possible human mistakes).

A ledger account needs to be mapped to RGS only the first time. After that, Exact knows which ledger account is linked to the RGS codes. When the mapping is done, the data is loaded into TimeXtender. In TimeXtender, a project is created where the data source is connected to the

project by the ODX server. In the settings of the project, it can be set in what time interval the data in TimeXtender is updated by refreshing the connection between Exact and TimeXtender. Since this is a one-time job that is done when setting up the connections before the automation, it is not included in the workflows. Before the data in TimeXtender is extracted, it will first be checked if all the data is loaded. When this is done successfully, the data will be extracted. After the extraction, the transformation is done by generating the layers just as in the current situation. The extraction and transformation process will be documented in order to keep the transparency. When the layers are generated, it is loaded in Qlik Sense.

Similarly, like loading data to TimeXtender, loading data in Qlik Sense can be set to a time interval to update the data. This setting is also not included in the workflows since it is set when setting up the process. In Qlik Sense, the data that is loaded, and the data model needs to be checked on completeness and changes. The KPIs need to be calculated and put into a standardised dashboard. The standardised dashboards are already defined. When the dashboard is finished, conclusions can be drawn, and advice can be given. Every time a new ledger account is created, this process could be applied. All three processes in the secondary workflow can be applied. The workflows are discussed more in detail.

Exact

During the process Exact the following tasks are identified:

- Map RGS
- Check if all ledger accounts are mapped
- Check if there are any wrong mappings

These three tasks will be discussed in more detail, and the goal regarding the certainty is defined.

Map RGS

Every Ledger account needs to be mapped to an RGS code. Exact have already all the RGS codes implemented. Therefore, only the right RGS code needs to be chosen. In Exact, there are two possibilities to map the ledger account. The first one is to do it entirely manually. In figure 22, The ledger account 'Inventaris' needs to be mapped to an RGS code. The RGS codes are ordered on their rubrics. Therefore, 'Inventaris' can be found intangible fixed assets. For this ledger account mapping, the right RGS code is the one of 'Inventaris' which is shown in figure 23. The other option for mapping ledger accounts is to make use of the RGS suggestions of Exact. For every ledger account, Exact provides three suggestions of what they think is the best RGS option. If the user does not agree with the suggestions, it can still select another suggestion. An example of the RGS suggestions is shown in figure 24.

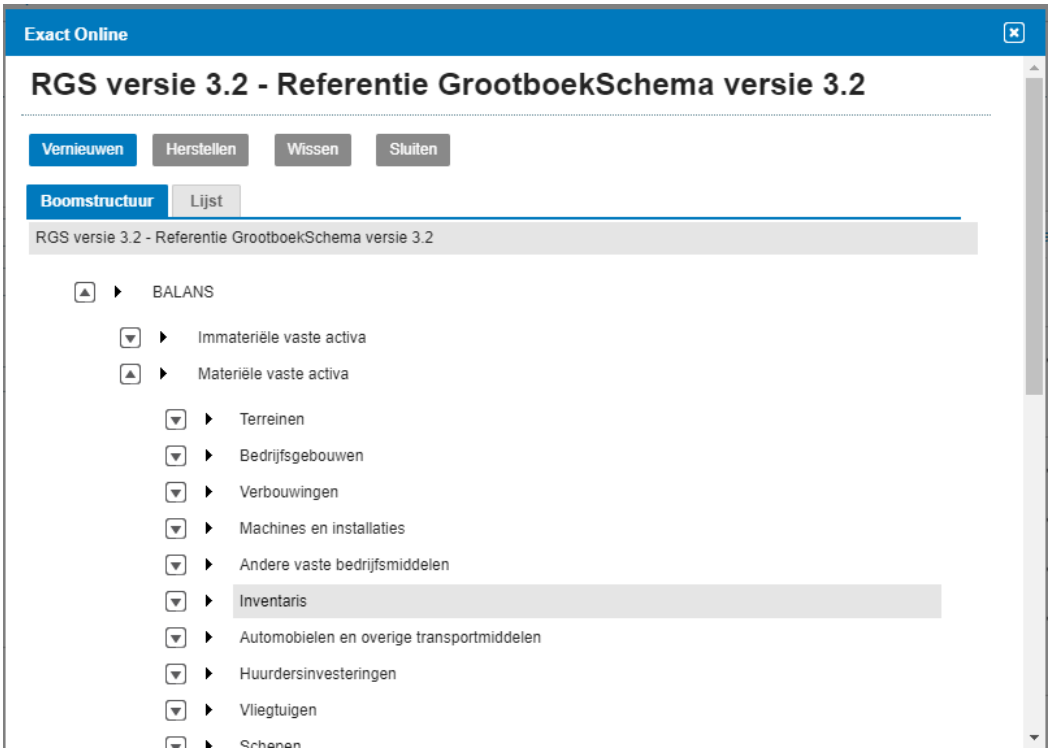

Figure 22 RGS structure

Figure 23 RGS code for Inventory

Code	Omschrijving	Actie
BMvaBeiVvp	Verkrijgings- of vervaardigingsprijs inventaris	Selecteer andere
BMvaMeiVvp	Verkrijgings- of vervaardigingsprijs machines en installaties	
BMvaObeVvp	Verkrijgings- of vervaardigingsprijs andere vaste bedrijfsmiddelen	

Figure 24 RGS suggestions for Inventory

The RGS developers[3] provided some points of attention when a ledger account needs to be mapped to an RGS code. These points are:

- A ledger account could be mapped to several RGS codes. A solution for this is to split the account.

[3] https://www.referentiegrootboekschema.nl/aandachtspunten-bij-koppelen-grootboekrekeningschema

- Several ledger accounts could be mapped to one RGS code. It is possible to use extensions to the RGS code. These extensions need to be done manually.
- There is not an RGS code for the ledger account. A request to the developers is needed to add a new RGS code to solve this.
- A ledger account with a positive or negative budget. When an account contains a cover code, both the codes need to be mapped.
- The RGS code has a confusing description. There can be two codes with the same description because these codes are from different levels.

The goal of this workflow is to make it as easy as possible for the accountant to map the ledger accounts. This goal belongs to the mapping verification. To make sure the mapping has the best fit, the mapping will be done by searching for the RGS option and then looking at the RGS suggestions of Exact. If both have the same suggestions, the chances are high that it is the best option. When the best option is not in the suggestions of Exact, then the ledger account will be mapped to the RGS code that was determined by Baker Tilly.

Check if all ledger accounts are mapped.

One of the possible mistakes in the current situation is that not all the ledger accounts are mapped to the reporting code. This mistake is often noticed when the data is already loaded in TimeXtender, the right ledger account needs to be searched for again, which takes some time. In order to avoid this scenario, it will be checked if all the codes are mapped, which can be seen in Exact. If not, all mappings are done. The ledger accounts that are not connected need to be shown and suggestions need to be provided by using the previous workflow. The goal of this workflow is regarding the mapping verification by eliminating the possible mistakes.

Wrong mappings

A wrong mapping is when the wrong RGS code is connected to the ledger account. This wrong mapping can happen because of confusing descriptions, any of the other points of attention, or if the ledger account does have a very branch-specific characteristic. Checking if the mapping is wrong can only be done by a component that has an excellent knowledge of the numbers for individual ledger accounts.

The goal is to look at the numbers of the ledger account that is mapped to the RGS in order to verify that the mapping is done well. Therefore, this workflow is needed for mapping verification.

TimeXtender

In TimeXtender, the data is prepared for the dashboard. The needed data is extracted and put in the right tabs to be able to create useful tables that could be sent to a BI tool. Figure 25[4] shows how the preparation could be. When data is uploaded, it can be put to the next tabs to extract the useful data. After that, in the work area, tables can be created. Eventually, in the data movement pane, the tables that will be exported to the BI tool are shown.

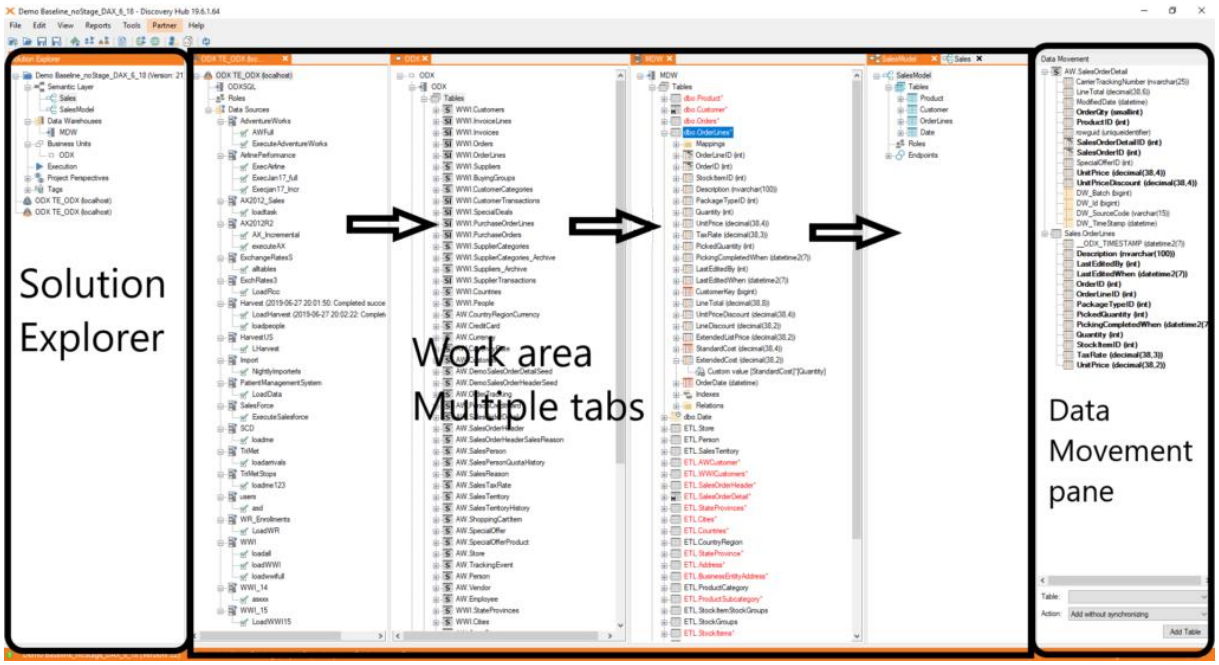

Figure 25 TimeXtender tabs

The workflows that are executed in TimeXtender are:

- Loaded data
- Extract and transform
- Export data to Qlik Sense

Loaded the data

When the data is loaded into TimeXtender, it needs to be checked on completeness. The completeness can be checked in the ODX tab (this contains the data exported from Exact). If all the ledger accounts are present, it can be concluded that the data is complete.

The goal of this workflow is to eliminate the possible mistakes that can happen in the current situation in order to have a reasonable certainty on the ETL level. This workflow contributes to the ETL objective.

Extract and transform

In TimeXtender, the data is extracted, the transformation is not about transforming the data format but generating the layers, by using multiple tabs, in order to create the tables with the data

[4] Source: https://omnidata.com/tag/discovery-hub/

that is needed for the dashboard. Therefore, the extract and transform are in one workflow. The goal of this workflow is to transform the right data into useful tables and therefore contribute to the ETL verification by performing a part of the ETL process.

Export data to Qlik Sense

All the data that is put in the tables in the previous workflow need to be exported. Therefore, the data need to be placed in the data movement pane before it can be exported to Qlik Sense. The goal is the last process of ETL because the data will be loaded into Qlik Sense.

Qlik Sense

Qlik Sense is a BI tool where KPIs can be calculated, and the dashboard can be created. The IT consultants are using standard dashboards to show the performances of the customer. The workflows that are needed for this are:

- Data models
- KPIs in dashboard
- Advice

Check loaded data and data model

In Qlik Sense, the data is again checked on completeness by checking the data model.

The goal is to make sure that the data model is complete to be able to calculate the KPIs. Therefore, it contributes to the ETL verification because it makes sure that the loaded data is complete and in the right format (data model).

KPIs in Dashboard

It is possible in Qlik Sense to use the same KPI calculation for other projects. Therefore, the data only needs to be dragged to the rightful position in the dashboard. The goal is to provide a valid dashboard. Therefore, this workflow contributes to the Judgement verifications.

Give advice

When the dashboard is finalised, conclusions can be drawn about the visualisations. These conclusions will be based on exceptional values on the dashboard, customers strategy, and their performances.

5.4.3 Automation technology selection

For every workflow, the data structure, process, and outcome need to be identified. In this paragraph, every workflow will be assessed to decide if it is beneficial to automate, augment or to do it manually. Additionally, the appropriate tools based on the above-described information will be selected. The results are shown in Table 5.

Table 5 Suitable tools per Workflow

Tertiary workflow	Data	Process	Answer	Automate/ Augment/ Manually	Technique	Tools	Auditor in the loop?
Map RGS	Unstructured	Inference	Single	Augment	Cognitive agent	ML, NLP	Yes
All mapped	Structured	Rule	Single	Automate	RPA	-	-
Wrong mapped	Structured	Inference	Single	Manually	-	(ML)	-
Loaded data	Structured	Rule	Single	Automate	RPA	-	-
Extract & transform	Structured	Rule	Single	Automate	RPA	-	-
Export data	Structured	Rule	Single	Automate	RPA	-	-
Loaded data & data model	Structured	Rule	Single	Automate	RPA	-	-
Get KPIs in dashboard	Structured	Rule	Single	Automate	RPA	-	-
Advice	Structured	Inference	Multiple	Manually	-	(ML)	-

Exact

Map RGS- The description of the ledger account needs to be mapped to the RGS code. The description is text, and every customer uses their descriptions. The data is, therefore, unstructured data. Because every customer uses their descriptions but also their ledger account numbers, the mapping for every customer is different. Natural language processing can be used to make unstructured data interpretable for computers. The process of mapping RGS is an inference based because the mapping is based on some rules but mainly on experiences. Because of the knowledge gained from experience about the ledger account and in which rubric or sub rubric it should be mapped, machine learning can be applied to map the data by using a data mining technique. The mappings will only get better when the experience is involved. Therefore, a cognitive agent could be used to make the description of the ledger account interpretable and learns from the mappings. Since it needs to be mapped to a specific RGS code, the data should be

labelled in order to use a classification algorithm. It will happen that some specific mappings need to be done. An auditor should do these mappings. Therefore, the auditor in the loop is applicable.

When using a machine learning algorithm, the ledger accounts of every customer is mapped with the same reasoning. When it is done manually, there is a small chance that one accountant would map a ledger account different than another accountant. Because of the cognitive agent, this chance is now minimal.

All mapped - To check whether all the RGS codes are mapped, rules can be followed. Also, the process is structured, and there is one single outcome. This task can be automated by using an RPA. This task is simple, where no human judgment is needed.

Wrong mapping - This is a complex task where the data is structured since the ledger accounts have the RGS code mapped, and the content consists of numbers (budgets). To see if a mapping is done correctly, knowledge about the content, RGS codes, customer strategy, and the description is needed. This process is inference based. There is a single correct answer. Because this process is very specific per customer, the option to do this manually is chosen. However, there is a possibility to use reinforcement learning and to build a system that learns from the decision of the auditor. It will take a long time before the computer can take over.

TimeXtender

When there are for automations for many customers, it can be made easier to automate the tasks in TimeXtender. Because the data that is uploaded in TimeXtender is standardised, the data is structured. Since Baker Tilly wants to show the standardised dashboard, rules could be made for all three tasks in TimeXtender. The loaded data could be checked on completeness when the RPA opens the OXD server. Then rules about which data should be put in a predetermined task make it easy for the RPA to set up the extraction, transformation, and export in TimeXtender. It must be noted that TimeXtender is mainly a lot of work at the set up of the automation. Therefore, the RPA robot can be used when a new automation needs to be done, or a new rule is defined that need to be implemented for every customer.

Qlik Sense

Similar to TimeXtender, the set up for the dashboard is also possible with the use of RPA because of the structured data, the rule-based process, and the single outcomes. Rules to create or check the data model can be set, and rules to which data should be used for which KPI. The last task in advising the customer. The data is still structured in the (standard) dashboard; the process is an inference based because it needs to draw conclusions from the KPIs in the dashboard, and based on those conclusions and the knowledge of the customer, advice can be given. The best option to do this part is manual since Baker Tilly prefers to advise a person. However, it can be helpful that exciting data could be found by a robot and passed to the accountant.

5.4.4 Proposal Formation

In this phase, the data flow and tools are shown in a diagram. This diagram could show if the timeline is correct. It could also show if some of the requirements are met. In order to see if all the requirements are met, an interview with an accountant and IT consultant has been conducted. Besides the timeline, the workflow goals are evaluated, and an implementation strategy is defined. The data flow can be found in Appendix F. The timeline is correct.

Subgoals

The workflow goals are all achieved. The mapping verification objective will be achieved by having the same agent reasoning who does all the mapping, to verify if they went well. A check for all mappings and if mappings are done wrong is included. For the ETL verification, the workflow goals are also achieved. The data is checked on completeness, and since it is standardised, the RPA workflow can generate the layers and load it to Qlik Sense, where the completeness is also checked. Then the KPIs in the dashboard is done in a standardised manner to create a valid dashboard which is needed for the judgment verification and to give valid advice, which also contributes to this objective. Therefore, all the objectives are achieved.

Requirements

In this step, there will be checked if the requirements are met. Some of the processes and technical requirements are validated in the interviews. More information about these requirements can be found in the paragraph 'Improvement recommendation'

Process requirements:

- Human actions are indeed minimal; the only human actions are when an expert judgement is needed or when the process is too complicated.
- Since the data is standardised in Exact, the KPIs can be calculated in the same way.
- After the interview, the IT consultant was able to understand the process, just like the accountants.
- As long as there is a new OXD server for each project, multiple customer processes can be automated concurrently.

Technical requirements:

- The process could be transparent when the robots document what they are doing. This documenting often happens when vendors are chosen. When an RPA is built from scratch, this should be implemented as well in order to meet the requirement of a transparent process.
- Checks are executed to see if the data is complete and correct.
- TimeXtender and Qlik Sense are still in use in the automated process.
- When something in the process would changes, the robot tasks can be easily modified. If for example, a check does not have to be done anymore, this check can be removed. In the data, flow is shown that the data is not dependent on the checks. However, if a check will be removed, there must be looked at the impact on the objective.
- RGS is the systematics that is used to standardise the data of the customer.

Implementation methodology

The IPA solution could be implemented by using an RPA vendor with the possibility of including Machine Learning and other AI techniques. Alternatively, The IPA solution could be realised by building an RPA in a programming language, e.g. Python, and using the libraries for Machine learning and AI techniques. Baker Tilly is using now UiPath, UiPath has made it possible to implement AI on the RPA layer. Therefore, UiPath would be the best option. If UiPath would not be approved, it is possible to choose others. Criteria for this can be ease of use, the features, the price, and maintainability.

As was decided with the experts during the framework evaluation interview, when introducing new technology. The Agile method will be best to follow when the IPA solution would be implemented. The agile method is an iterative process that has found to be the best by the experts based on their experiences with testing and implementing new technology. Anand & Dinakaran (2016) compared six of the most known agile methodologies. The comparison is shown in table 6. In this process, an iterative process is preferred. The time per iteration is a few weeks; the team size will be five persons, the team communication is informal, the customer involvement is limited because the dashboards are already standardised, and much has to be arranged internally. The project size is a bit complex. Table 7 shows that SCRUM could fit perfectly. In a scrum methodology, continuously testing is done, which results in much feedback.

Table 6 Agile comparison methodologies Source: Anand & Dinakaran (2016)

Characteristic	SCRUM	XP	FDD	TDD	DSDM	KANBAN
Approach of Development	Iterative and incremental	Iterative and incremental	Iterative and incremental	Iterative	Iterative and incremental	Incremental
Time period for one iteration	2-4 weeks	1-6 weeks	<2 weeks	Reasonable Amount of Time based On product Built	2-3 days	Time taken From the start of work until Bugfix is live
Team Size	7+/-2	<20	Many Members (More than One team)	First 2/3 developers Get used to TDD. Later members are added accordingly	Independent Teams of any size	Any skilled or cross-functional team can work
Project Size	All types of projects	Small Projects	Complex projects	Small scale projects	All types of projects	Small projects usually with < 3000 LOC
Team Communication	Informal	Informal	Based on Documentation	Open communication b/w managers and developers about issues	Based on documentation	Informal face to face
Customer Involvement	Product owner acts on behalf of cuatomerthroughtout the process	Throughout the process	Customer through reports	Involved only at acceptance testing	Involve in frequent releases	Customer through incremental release

Additionally, a scrum team consisting of different project members with different backgrounds (Anand & Dinakaran, 2016), would help when the new technology must be understandable for persons with different backgrounds. Also, because of the many testing, more awareness of the organisation is included. When testing a lot of the components, by multiple persons makes sure that they are ready and are willing to work with the new technology.

5.4.5 Improvement recommendations

The outcome of this demonstration is the proposal for how an IPA solution for Baker Tilly could work. When the management would approve this business case, the following step would be to realise this proposal to a real-life working solution. For this research, the case was created. Before the management could approve, the IT experts and accountants need to be sure that it will work. Therefore, interviews are done with the expert to validate if this would work and if they think that when more aspects are defined, such as the costs, time to create, and when to implement (high peaks of works during Christmas/new year's). The interviews for this were also semi-structured and took about 30 minutes. More information about the prepared questions, the answers, and the background of the experts can be found in Appendix G. The results are discussed below.

Process determination

The experts agreed with the choices that have been made in this phase. Some were enthusiastic about the use of systematics. They all agreed that the IT consultant and the accountant should

understand the process. For the IT consultant, it is essential to understand every step of the process. For the accountant, it is essential to understand it globally. One critical note that was mentioned by an expert is that the conditions of the set up for this process are not clear enough. For example, the connections between Qlik Sense and TimeXtender should already be prepared.

Workflow Analysis

All experts agree. This workflow was clear and a good basis for the rest of the process.

Automation Technology Selection

This phase was also clear to the experts. Many of them mentioned that it is very crucial to provide advice face to face and that robots should not do it. After explaining that it was possible to provide advice in person, but the bot could support the accountant by mentioning what the exciting values are, some were a little convinced that this may still be an option.

Proposal formation

The diagram was clear to the experts. One of the experts mentioned that it could also be interesting to create a diagram when more of these processes are done. Because the data warehouse would be sophisticated then and the ODX servers of TimeXtender need to be used as efficiently as possible (an ODX server can open only one project). The new steps, evaluating the workflow goal and the implementation methodology, were also positively received. The Scrum methodology was by them seen as a severe option. The last note that was said during an interview about the implementation was that the old generation finds it challenging to try new technologies. They will often do the steps themselves when a new tool is introduced because they have a hard time, trusting technologies and are controlling in nature.

Overall

The last comments of each interview were about the overall process. All experts were positive about the process because it brings structure, and to be able to provide advice regularly, they are distinguished from their competitors. For some customers once per 10 weeks is enough to update the dashboard. For others, once per two weeks will be okay. Another expert was enthusiastic about this process because they would be able to provide customers with less money advice by using the standardised dashboards. Most of the experts were already thinking about more options that could be done in the future., such as predictions and benchmarking.

5.4.6 Conclusion Demonstration

The IPA could work in this process. This demonstration showed how Baker Tilly could do an automated solution. It shows what should be thought about and what the possibilities are. Therefore, experts were excited about the solution. It is a good starting point for Baker Tilly to do more innovations soon.

5.5 Summary

After the interviews to evaluate the framework of chapter 4, a new revised framework has been created. This framework is used for the case of Baker Tilly. After all the necessary steps for the proposal are identified. A new set of interviews are done. The results of this interview were positive. The conclusion about the framework can now be drawn in the following chapter.

6. Conclusion and Recommendation

This chapter discusses if the combination of the literature and the final design is working well. The research questions of chapter 2 are answered, a recommendation is given to Baker Tilly, and the contribution, future work and limitations are discussed.

6.1 Research questions

This research successfully developed an intelligent process automation framework. The process followed the design science circle of Wieringa (2014). This paragraph will explain how this research answers the research questions which were introduced in chapter 2.2.2. The main question will be answered, followed by the sub-questions that are related to the answer to the main question.

What is an appropriate framework to create a strategy for the transformation of a manual data process to an intelligent automated process in audit services?

This main question is answered in chapter 4, where the framework is designed. This framework is built on the background knowledge gathered by a systematic literature review in chapter 3.

1. **How is continuous assurance realised and managed in audits?**

The first research question was answered by doing a literature review on continuous assurance. It was noticed that continuous assurance could be realised by continuously monitoring data and auditing data. CA assures that the automated task of the process is of high quality and reliable. One of the biggest challenges of CA was that it added no value to an organisation because there was no demand for it. Therefore, the designed framework makes sure that this is well over thought.

2. **How are AI techniques supporting automation in audits?**

During the literature study, it was found that AI is mostly done for reducing risks and eliminating human errors. Because the accountancy often needs human judgment, AI supports the accountant by analysing data and showing the exceptions. New and upcoming technology is IPA which is also used for the framework.

3. **Which key factors should be implemented in an intelligent automation framework to support the automation strategy for a company?**

The literature showed that before a process can be automated, the company first needs to be sure how the automated process could add value and what problems can arise when implementing new technology. Furthermore, the literature showed that dividing the process into smaller processes could make it easier to automate. Therefore, the framework covers the following phases: process determination, workflow analysis, automation technology selection, proposal formation.

4. **How could the framework be evaluated?**

The evaluation is done in two parts. Firstly, the framework is shown to experts who gave their opinion. Their feedback has been applied to a revised framework. This framework is then applied to a process. The outcome of the process, which is a solution that could work when it is realised in the real world, is again evaluated with experts to see if it has any potential.

6.2 Recommendation

This research delivered a robust framework. Through this framework Baker Tilly can automate processes. If they want to implement it, the following recommendations could help.

Firstly, try to find test data before implementing it. Since there is no test data available now, the research was not able to create a prototype because it would immediately change customer data.

Secondly, when doing tests, keep an extra eye on the criteria. There is a big chance that not all criteria are included in this framework because when implementing these kinds of technologies more often, exceptions or errors are found, which could be avoided when the criteria section was complete. Thus, write every exception down in order to define all the criteria.

Thirdly, if this works with Exact, then try it also the other financial administration software. The main difference will be that a robot needs to go to another site and click on other buttons that need to be determined. The inference of the mapping will be the same.

6.3 Contribution

This thesis has a scientific and practical relevance. Both are explained in this paragraph.

Scientific

The research on IPA is limited. Therefore, this thesis is extending the limited knowledge of IPA by providing requirements of an IPA solution, and by a validated framework. In the literature, there is no clear framework of an IPA for not assurance services. An approach to apply IPA on a predefined automation audit task was found. Conclusions from that research were that there was too little information to know if it would have affected the audit industry.

The knowledge gap is a good structure for IPA solutions when it could be made applicable to companies. A framework that includes the steps to make sure that the right process is chosen and guidance is offered. This framework showed how this could work during a whole process with multiple tools involved. Because of the validation at a company, the aspects that are important for a company to be able to make the IPA work were also included in the framework. Therefore, this framework could be integrated into a company; it shows how awareness could be reached by first doing an extensive procedure determination, which has never been done for IPA and shows what implementation methodology could be used. The last theoretical contribution is that research on compliance audits is minimal. This research shows how an advice and compliance audit can be supported by automation and what the objectives are to create a quality process.

Practical

The practical contribution of this thesis is that Baker Tilly has a plan to automate the data process efficiently. If this work well, the framework could be used for other processes and audit services.

For the future, they have a better understanding and more knowledge for realising an automation solution. For example, the need for test data or the knowledge of new technologies are now known in the organisation.

6.4 limitations and future research directions

The limitation and future work can be

The first limitation is the literature. The articles that were searched were only in English. Additionally, four databases that are available for UT students were used for the literature study. Lastly, many articles in the accounting industry are restricted. These restricted articles also result in a limitation for this research since it makes it less possible to provide the state of the art of the IT in the audit industry.

The second limitation is that the framework is evaluated and validated by interviews. A limitation of this is that the experts could be biased and that the researcher interprets all the answers that are given during the interviews. Also, the experts were very open to new technologies; in the accounting industry, there are enough persons who are against new technology to do audit tasks. Their arguments are not heard in this research. Preferably an implementation of the IPA solution would be the best option because then the criteria in the first phase could be supplemented. This was unfortunately not possible in this research because the customer data would be changed, and some steps of the framework (e.g. the implementation methodology) would take multiple weeks that would no longer fit in the duration of this research. Therefore, future work could implement this framework and test it with multiple processes at the same time to validate it.

Because there is so little known about the IPA, the future research direction can go in many directions. A few examples are to research the critical success factors of IPA for multiple industries, a methodology to sustain and maintain the IPA bots, or a methodology to support adoptions.

7. References

Hoque, Z., Mia, L. and Alam, M. (2001) Market Competition, Computer Aided Manufacturing and Use of Multiple Performance Measures: An Empirical Study. The British Accounting Review, 33, 23-45. https://doi.org/10.1006/bare.2000.0149

Berahzer, D. and Armstead, C. (2013) Dashboarding: Increasing the Visibility of Audit Recommendations Monday May 6 th, 10:30 am – 12:00 pm. - ppt download. (2013). Retrieved March 17, 2020, from https://slideplayer.com/slide/10707726/9.

Chen S. (2003). Continuous Auditing: Risk, Challenges, and Opportunities. International Journal of Applied Management and Technology, 1(1).

James E. Hunton, Arnold M. Wright, and Sally Wright (2004) Continuous Reporting and Continuous Assurance: Opportunities for Behavioral Accounting Research. Journal of Emerging Technologies in Accounting: December 2004, Vol. 1, No. 1, pp. 91-102.

Ghobadian, A. and Gallear, D. (1997), "TQM and organization size," International Journal of Operations & Production Management, Vol. 17 No. 2, pp. 121-163. https://doi.org/10.1108/01443579710158023

R. J. Wieringa, (2014) Design science methodology for information systems and software engineering, 1st. Springer-Verlag Berlin Heidelberg, ISBN: 9783662438398. DOI: 10.1007/978-3-662-43839-8.

Hardy, C. A. (2011, July). Exploring Continuous Assurance In Practice: Preliminary Insights. In PACIS (p. 74).

Bianchini, M., & Michalkova, V. (2019). Data Analytics in SMEs. OECD SME and Entrepreneurship Papers. DOI: 10.1787/1de6c6a7-en

Abouzeedan, A., Klofsten, M., & Hedner, T. (2013). Internetization Management as a Facilitator for Managing Innovation in High-Technology Smaller Firms. Global Business Review, 14(1), 121–136. DOI: 10.1177/0972150912466462

Chan, D. Y., & Vasarhelyi, M. A. (2018). Innovation and Practice of Continuous Auditing. Continuous Auditing, 271–283. DOI: 10.1108/978-1-78743-413-420181013

Coderre, D., Verver, J. G., & Warren, J. D. (2006). Continuous auditing: implications for assurance, monitoring, and risk assessment. Altamonte Springs, FL: Institute of Internal Auditors.

van Hillo, R., & Weigand, H. (2016). Continuous auditing & continuous monitoring: Continuous value? In S. Espana, J. Ralyte, & C. Souveyet (Eds.), Proceedings of the 10TH IEEE International Conference on Research Challenges in Information Science (RCIS 2016) (pp. 27-37). (International Conference on Research Challenges in Information Science). IEEE. https://doi.org/10.1109/RCIS.2016.7549279

Roohani, S. J. (2003). Trust and data assurances in capital markets: The role of technology solutions. Smithfield, RI: Bryant College & Pricewaterhouse Coopers.

Dai, W. (2010). The Impact of Emerging Technologies on Small and Medium Enterprises (SMEs). Journal of Business Systems, Governance and Ethics, 4(4). DOI: 10.15209/jbsge.v4i4.171

Engelken, M., Römer, B., Drescher, M., Welpe, I. M., & Picot, A. (2016). Comparing drivers, barriers, and opportunities of business models for renewable energies: A review. Renewable and Sustainable Energy Reviews, 60, 795–809. DOI: 10.1016/j.rser.2015.12.163

Flowerday, S., Blundell, A., & Solms, R. V. (2006). Continuous auditing technologies and models: A discussion. Computers & Security, 25(5), 325–331. DOI: 10.1016/j.cose.2006.06.004

Goumas, S., Charamis, D., & Tabouratzi, E. (2018). Accounting Benefits of ERP Systems across the Different Manufacturing Industries of SMEs. Theoretical Economics Letters, 08(06), 1232–1246. DOI: 10.4236/tel.2018.86081

Marques, R. P., Santos, H., & Santos, C. (2013). A conceptual model for evaluating systems with continuous assurance services. Procedia Technology, 9, 304-309.

NEMACC (2019), "Op weg naar continuous reporting" Retrieved from https://www.nba.nl/globalassets/themas/thema-mkb/nemacc/publicaties/continuous-reporting-eindrapportage.pdf

Alles, M. G., Kogan, A., & Vasarhelyi, M. A. (2002). Feasibility and Economics of Continuous Assurance. Continuous Auditing, 149–167. DOI: 10.1108/978-1-78743-413-420181007

Ibrahim, F., Ali, D. N. H., & Besar, N. S. A. (2020). Accounting Information Systems (AIS) in SMEs. International Journal of Asian Business and Information Management, 11(2), 51–67. DOI: 10.4018/ijabim.2020040104

Nielsen, M. A. (2015). Neural networks and deep learning (Vol. 2018). San Francisco, CA: Determination press.

Kim, H., & Park, Y. (2010). The effects of open innovation activity on performance of SMEs: the case of Korea. International Journal of Technology Management, 52(3/4), 236. DOI: 10.1504/ijtm.2010.035975

Kuhn, R., & Sutton, S. G. (2009). Continuous Auditing in ERP System Environments: The Current State and Future Directions. SSRN Electronic Journal. DOI: 10.2139/ssrn.1511990

Elliot, R.K. (2002), "Twenty-First Century Assurance," Auditing, 21(1): 139- 146.7.

Lee, S., Park, G., Yoon, B., & Park, J. (2010). Open innovation in SMEs—An intermediated network model. Research Policy, 39(2), 290–300. DOI: 10.1016/j.respol.2009.12.009

Meijer, L., Huijben, J., Boxstael, A. V., & Romme, A. (2019). Barriers and drivers for technology commercialization by SMEs in the Dutch sustainable energy sector. Renewable and Sustainable Energy Reviews, 112, 114–126. DOI: 10.1016/j.rser.2019.05.050

Pihkala, T., Ylinenpaa, H., & Vesalainen, J. (2002). Innovation barriers amongst clusters of European SMEs. International Journal of Entrepreneurship and Innovation Management, 2(6), 520. DOI: 10.1504/ijeim.2002.000499

Rutherford, K., Parkhill, J., Crook, J., Horsnell, T., Rice, P., Rajandream, M.-A., & Barrell, B. (2000). Artemis: sequence visualization and annotation. Bioinformatics, 16(10), 944–945. DOI: 10.1093/bioinformatics/16.10.944

Simpson, D., Benedictow, A., Berge, H., Bergström, R., Emberson, L. D., Fagerli, H., … Wind, P. (2012). The EMEP MSC-W chemical transport model – technical description. Atmospheric Chemistry and Physics, 12(16), 7825–7865. DOI: 10.5194/acp-12-7825-2012

Teirlinck, P., & Spithoven, A. (2013). Research collaboration and R&D outsourcing: Different R&D personnel requirements in SMEs. Technovation, 33(4-5), 142–153. DOI: 10.1016/j.technovation.2012.11.005

Thomas, A. J., & Webb, D. (2003). Quality systems implementation in Welsh small- to medium-sized enterprises: A global comparison and a model for change. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 217(4), 573–579. DOI: 10.1243/095440503321628251

Weber, R., Hunton, J., Wright, A., Wright, S., Boritz, J. E., No, W. G., … Lambeton, B. (2003). Trust and data assurances in capital markets: the role of technology solutions. Smithfield, RI: Bryant College.

Oldhouser, M. 2016. The Effects of Emerging Technologies on Data in Auditing. Master's thesis, University of South Carolina. Available at: http://scholarcommons.sc.edu/etd/3342

Issa, H., Sun, T., & Vasarhelyi, M. A. (2016). Research Ideas for Artificial Intelligence in Auditing: The Formalization of Audit and Workforce Supplementation. Journal of Emerging Technologies in Accounting, 13(2), 1–20. doi: 10.2308/jeta-10511

Jarrahi, M. H. (2018). Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making. Business Horizons, 61(4), 577–586. doi: 10.1016/j.bushor.2018.03.007

Pedreschi, D., Giannotti, F., Guidotti, R., Monreale, A., Ruggieri, S., & Turini, F. (2019). Meaningful Explanations of Black Box AI Decision Systems. Proceedings of the AAAI Conference on Artificial Intelligence, 33, 9780–9784. doi: 10.1609/aaai.v33i01.33019780

Storlie, M. D. (2020, February 28). Internal audit: How AI could impact data analytics. Retrieved from https://www.wipfli.com/insights/articles/ra-internal-audit-how-ai-could-impact-data-analytics

Vasarhelyi, M. A., Alles, M. G., & Kogan, A. (2004). Principles of Analytic Monitoring for Continuous Assurance. Journal of Emerging Technologies in Accounting, 1(1), 1–21. doi: 10.2308/jeta.2004.1.1.1

Zheng, X.-L., Zhu, M.-Y., Li, Q.-B., Chen, C.-C., & Tan, Y.-C. (2019). FinBrain: when finance meets AI 2.0. Frontiers of Information Technology & Electronic Engineering, 20(7), 914–924. doi: 10.1631/fitee.1700822

Bowling, S., Meyer, C., & Cgma. (2019, June 1). How we successfully implemented AI in audit. Retrieved from https://www.journalofaccountancy.com/issues/2019/jun/artificial-intelligence-in-audit.html

Brennan, B., Baccala, M., & Flynn, M. (2017, February 6). Artificial intelligence comes to financial statement audits. Retrieved from https://www.cfo.com/auditing/2017/02/artificial-intelligence-audits/

Rapoport, M. (2016). Auditors count on tech for backup. Wall Street Journal

Yan, Z., and K. Moffitt. 2016. A Framework for Performing Audit Procedures on Contracts. Working paper, Rutgers, The State University of New Jersey.

Yoon, K. 2016. Three Essays on Unorthodox Audit Evidence. Doctoral dissertation, Rutgers, The State University of New Jersey.

Fenwick, M., & Vermeulen, E. P. (2019). Technology and Corporate Governance: Blockchain, Crypto, and Artificial Intelligence. SSRN Electronic Journal. doi: 10.2139/ssrn.3263222

Zemankova, A. (2019, 8-10 Dec. 2019). Artificial Intelligence in Audit and Accounting: Development, Current Trends, Opportunities and Threats - Literature Review. Paper presented at the 2019 International Conference on Control, Artificial Intelligence, Robotics & Optimization (ICCAIRO).

Kirkos, E., Spathis, C., & Manolopoulos, Y. (2007). Data Mining techniques for the detection of fraudulent financial statements. Expert Systems with Applications, 32(4), 995-1003. doi:https://doi.org/10.1016/j.eswa.2006.02.016

Omoteso, K. (2012). The application of artificial intelligence in auditing: Looking back to the future. Expert Systems with Applications, 39(9), 8490-8495. doi:https://doi.org/10.1016/j.eswa.2012.01.098

Lin, C. C., Lin, F., & Liang, D. (2010, July). An analysis of using state of the art technologies to implement real-time continuous assurance. In 2010 6th World Congress on Services (pp. 415-422). IEEE.

Horkoff and yu https://link.springer.com/content/pdf/10.1007/s00766-014-0209-8.pdf

R. Vijay Anand and Dr. M. Dinakaran, "Popular agile methods in software development: review and analysis," International Journal of Scientific and Technical Advancements, Volume 2, Issue 4, pp. 147-150, 2016.

Agostinelli S., Marrella A., Mecella M. (2019) Research Challenges for Intelligent Robotic Process Automation. In: Di Francescomarino C., Dijkman R., Zdun U. (eds) Business Process Management Workshops. BPM 2019. Lecture Notes in Business Information Processing, vol 362. Springer, Cham. https://doi.org/10.1007/978-3-030-37453-2_2

Xiao, Y., & Watson, M. (2017). Guidance on Conducting a Systematic Literature Review. Journal of Planning Education and Research. doi:10.1177/0739456x17723971

Alles, M., Kogan, A., & Vasarhelyi, M. (2003). Black box logging and tertiary monitoring of continuous assurance systems. Information Systems Control Journal, 1, 37-41.

Ezzamouri, N., & Hulstijn, J. (2018, May). Continuous monitoring and auditing in municipalities. In Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age (pp. 1-10).

Vasarhelyi, M. A., Alles, M., & Williams, K. T. (2010). Continuous assurance for the now economy. Sydney, Australia: Institute of Chartered Accountants in Australia.

Holstrum, G. L., & Hunton, J. E. (1998). New forms of assurance services for new forms of information: the global challenge for accounting educators. The International Journal of Accounting, 33(3), 347-358.

Alles, M. G., Kogan, A., & Vasarhelyi, M. A. (2004). Restoring auditor credibility: tertiary monitoring and logging of continuous assurance systems. International Journal of Accounting Information Systems, 5(2), 183-202.

Rikhardsson, P., & Dull, R. (2016). An exploratory study of the adoption, application and impacts of continuous auditing technologies in small businesses. International Journal of Accounting Information Systems, 20, 26-37.

Bumgarner, N., & Vasarhelyi, M. A. (2018). Continuous Auditing—A New View1. In Continuous auditing. Emerald Publishing Limited.

Yeh, C. H., & Shen, W. C. (2010). Using continuous auditing life cycle management to ensure continuous assurance. African Journal of Business Management, 4(12), 2554-2570.

Helms, G. I., & Mancino, J. M. (1999). Information technology issues for the attest, audit, and assurance services functions. The CPA journal, 69(5), 62.

Rezaee, Z., Elam, R., & Sharbatoghlie, A. (2001). Continuous auditing: the audit of the future. Managerial Auditing Journal.

Jacobides, M. G., & Croson, D. C. (2001). Information policy: Shaping the value of agency relationships. Academy of management review, 26(2), 202-223.

Hardy, C. (2013) The messy matters of continuous assurance.

Abdolmohammadi, M. J. (1999). A comprehensive taxonomy of audit task structure, professional rank and decision aids for behavioral research. Behavioral Research in Accounting, 11, 51.

Baldwin-Morgan, A. A. (1995, February). Studies of the impact of accounting-related expert systems: Comparison of methods. In Proceedings the 11th Conference on Artificial Intelligence for Applications (pp. 72-77). IEEE.

Kaplan, A., & Haenlein, M. (2019). Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. Business Horizons, 62(1), 15-25.

Moll, J., & Yigitbasioglu, O. (2019). The role of internet-related technologies in shaping the work of accountants: New directions for accounting research. The British Accounting Review, 51(6), 100833.

Ghahramani, Z. (2015). Probabilistic machine learning and artificial intelligence. Nature, 521(7553), 452-459.

Gudivada, V. N., Irfan, M. T., Fathi, E., & Rao, D. L. (2016). Cognitive analytics: Going beyond big data analytics and machine learning. In Handbook of statistics (Vol. 35, pp. 169-205). Elsevier.

Amani, F. A., & Fadlalla, A. M. (2017). Data mining applications in accounting: A review of the literature and organizing framework. International Journal of Accounting Information Systems, 24, 32-58.

Settles, B. (2009). Active learning literature survey. University of Wisconsin-Madison Department of Computer Sciences.

Kokina, J., & Davenport, T. H. (2017). The emergence of artificial intelligence: How automation is changing auditing. Journal of Emerging Technologies in Accounting, 14(1), 115-122.

Appelbaum, D. A., Kogan, A., & Vasarhelyi, M. A. (2018). Analytical procedures in external auditing: A comprehensive literature survey and framework for external audit analytics. Journal of Accounting Literature, 40, 83-101.

Jiawei, H., & Kamber, M. (2001). Data mining: conceptsand techniques. M], SanFrancisco, Morgan Kaufman Publish—ers, 10-120.

Jackson, J. (2002). Data mining; a conceptual overview. Communications of the Association for Information Systems, 8(1), 19.

Hoogs, B., Kiehl, T., Lacomb, C., & Senturk, D. (2007). A genetic algorithm approach to detecting temporal patterns indicative of financial statement fraud. Intelligent Systems in Accounting, Finance & Management: International Journal, 15(1-2), 41-56.

Lenard, M. J., Alam, P., & Booth, D. (2000). An analysis of fuzzy clustering and a hybrid model for the auditor's going concern assessment. Decision Sciences, 31(4), 861-884.

Koh, H. C., & Low, C. K. (2004). Going concern prediction using data mining techniques. Managerial Auditing Journal.

Najafabadi, M. M., Villanustre, F., Khoshgoftaar, T. M., Seliya, N., Wald, R., & Muharemagc, E. (2016). Deep learning techniques in big data analytics. In Big Data Technologies and Applications (pp. 133-156). Springer, Cham.

Sun, T., & Vasarhelyi, M. A. (2018). Predicting credit card delinquencies: An application of deep neural networks. Intelligent Systems in Accounting, Finance and Management, 25(4), 174-189.

Huang, F., & Vasarhelyi, M. A. (2019). Applying robotic process automation (RPA) in auditing: A framework. International Journal of Accounting Information Systems, 35, 100433.

Lacity, M., Willcocks, L. P., & Craig, A. (2015). Robotic process automation: mature capabilities in the energy sector.

Vitharanage, I. M. D., Bandara, W., Syed, R., & Toman, D. (2020). An Empirically Supported conceptualisation of robotic Process Automation (RPA) Benefits. In ECIS.

Berruti, F., Nixon, G., Taglioni, G., & Whiteman, R. (2017). Intelligent process automation: The engine at the core of the next-generation operating model. Digital McKinsey, March.

Lacity, M., & Willcocks, L. P. (2017). Robotic process automation and risk mitigation: The definitive guide. SB Publishing.

Ghiran, A. M., Silaghi, G. C., & Tomai, N. (2011, June). Deploying an Agent Platform to Automate the IT Infrastructure Auditing Process. In International Conference on Business Information Systems (pp. 266-277). Springer, Berlin, Heidelberg.

Jans, M., & Hosseinpour, M. (2019). How active learning and process mining can act as Continuous Auditing catalyst. International Journal of Accounting Information Systems, 32, 44-58.

Baldwin, A. A., Brown, C. E., & Trinkle, B. S. (2006). Opportunities for artificial intelligence development in the accounting domain: the case for auditing. Intelligent Systems in Accounting, Finance & Management: International Journal, 14(3), 77-86.

Appelbaum, D. A., Kogan, A., & Vasarhelyi, M. A. (2018). Analytical procedures in external auditing: A comprehensive literature survey and framework for external audit analytics. Journal of Accounting Literature, 40, 83-101.

Krumwiede, K., & Lawson, R. (2017). 13 Management accountants in the United States. The Role of the Management Accountant: Local Variations and Global Influences.

ISO/IEC 25010:2011 (en), Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — System and software quality models

Appendices

Appendix A – Systematic literature review

This literature review is based on the steps of Xiao and Watson (2017) are applied:

Identification

The two knowledge questions need to be answered. These knowledge questions are the formulation of the problem. For this research, multiple databases will be used. In these databases, the same queries are applied. When all the articles are downloaded, the duplications are removed, the articles are filtered on the title and the keywords, the articles are filtered based on the abstract and conclusion, and the last step is to filter the articles based on the full text.

Search the literature

The databases that were applied in this literature study are ACM Digital Library, Scopus, IEEE, and Science direct. The keywords that were used are:

- For CA: "continuous assurance" AND ("automated audit" OR "audit")
- For AI: ("Artificial intelligence" OR "AI") AND ("Technique" OR "Technology" OR "Technologies") AND ("auditing process" OR "audit process")

Articles were only downloaded when they were in English, and open access, and belonged in the accounting/auditing literature.

Screening

When all articles were downloaded, the duplicates were removed. The articles were filtered on the title and keywords; after that, they were filtered on the abstract and conclusion. To find articles with good quality, and that has useful information, all articles that are left were fully read and filtered.

Inclusion

Due to some cross-references, a few extra studies were included. The tables show the results of the literature study.

"continuous assurance" AND ("automated audit" OR "audit")

ACM Digital Library	8
Scopus	20
IEEE	4
Science direct	54
total	86

Table 9 Number of articles per database

Articles after duplication removal	77
Title and keyword selection	48
Abstract and conclusion selection	32
Full text	20
Cross-reference	27

Table 10 Number of articles during the screening process

("Artificial intelligence" OR "AI") AND ("Technique" OR "Technology" OR "Technologies") AND ("auditing process" OR "audit process")

ACM digital Library	8
Scopus	93
IEEE	3
Science direct	74
total	178

Table 11 Number of articles per database

Articles after duplication removal	169
Title and keyword selection	89
Abstract and conclusion selection	51
Full text	34
Cross-reference	38

Table 12 Number of articles during the screening process

Appendix B – Framework flow charts

Appendix B.1 Process determination

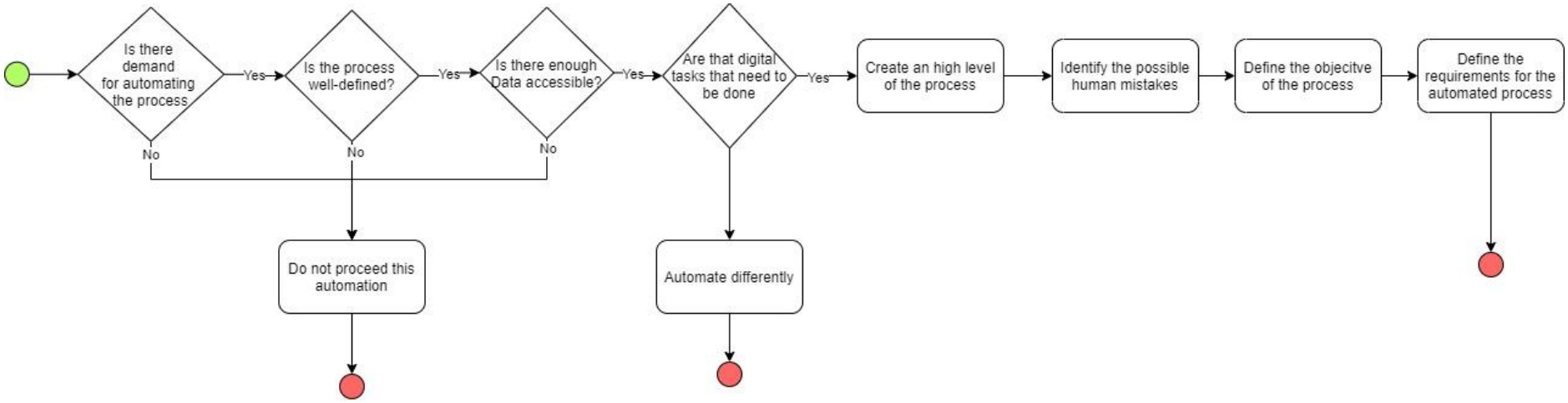

Figure 26 process determination flowchart

Appendix B.2 Workflow Analysis

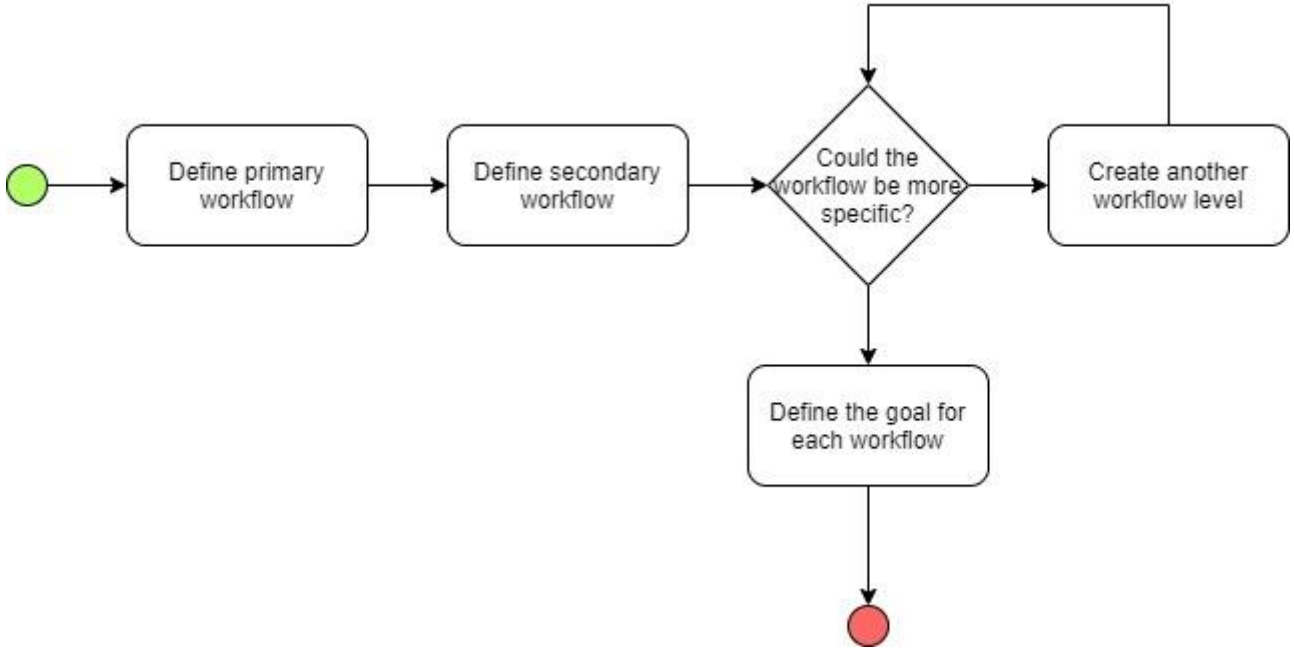

Figure 27 Workflow analysis flowchart

Appendix B.3 Automation technology selection

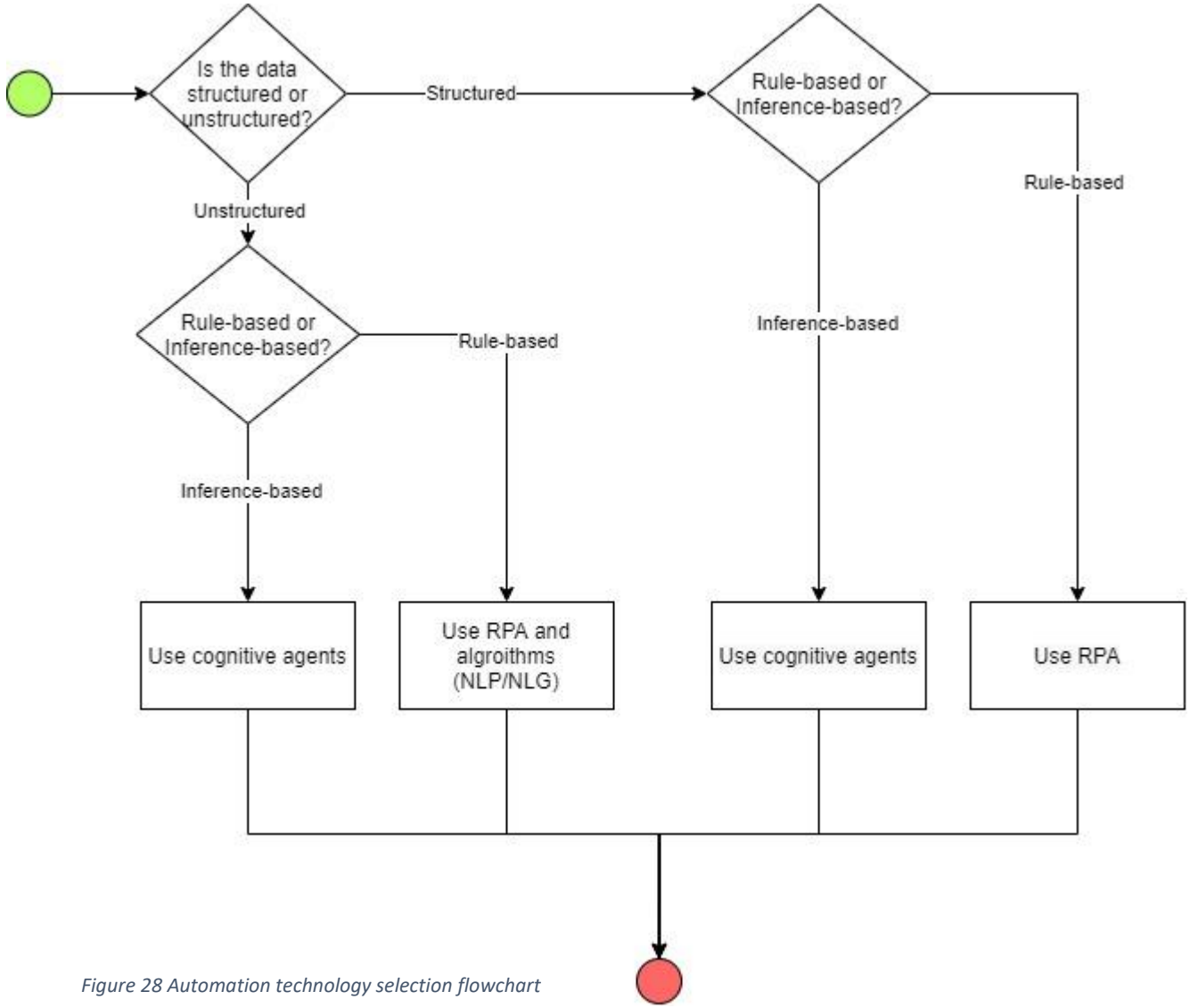

Figure 28 Automation technology selection flowchart

Appendix B.4 Workflow Connections

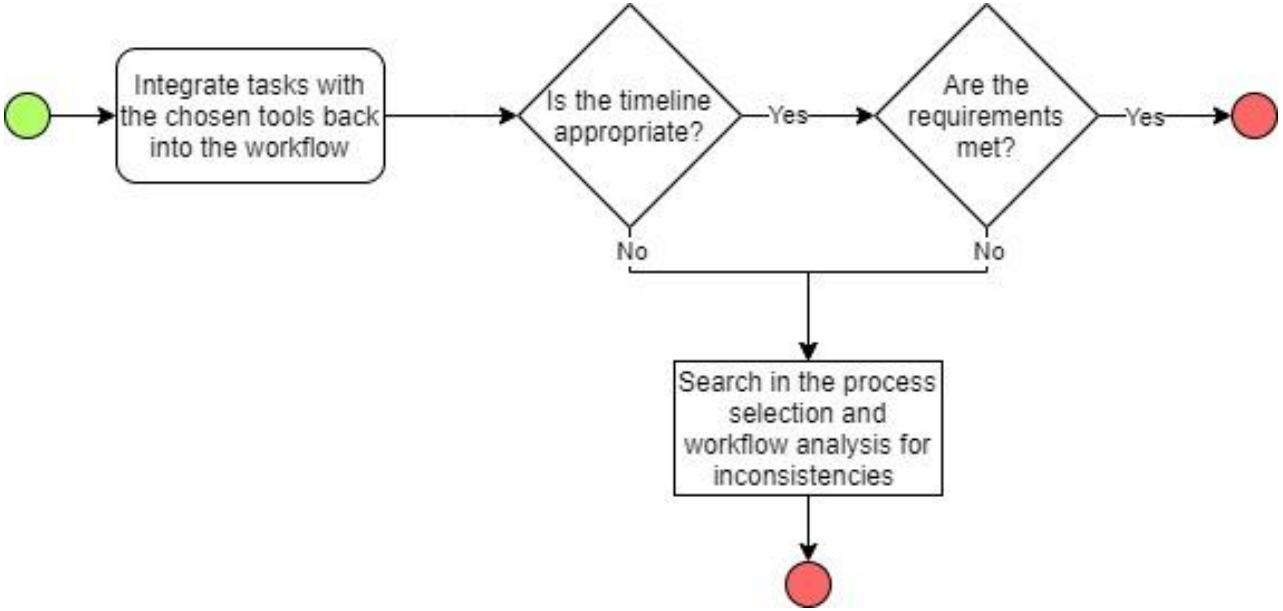

Figure 29 Workflow connections flowchart

Appendix C – Evaluation interview framework

Expert validation is one of the ways to validate an artifact. The artifact design is shown to experts who are able to understand how the artifact could interact with the context (Wieringa, 2014). This artifact will be validated by qualitative interviews. The setup of the interview is done by the stages described by "Qualitative Research Practice: A Guide for Social Science Students and Researchers" by Ritchie et al. (2003). The six stages are:

1. *Arrival and introductions*: Start of the interaction, the researcher is responsible for making it friendly and positive. Thereafter, the expert and researcher will introduce themselves.
2. *Introducing the research*: The research topic is introduced, the scope of the interview is set and it is noted that it is not a survey, but the aim is to hear the views and experiences of the expert in their own word.
3. *Beginning the interview*: The beginning of the interview will start with some opening questions about the experience of the expert.
4. *During the interview*: The expert is guided to the significant themes by the researcher. Mostly open questions need to be answered by the expert
5. *Ending the interview*: The researcher will indicate if the end of the interview is approaching.
6. *After the interview*: The research will thank the expert for participating. Furthermore, the researcher will let the expert know how the information will be treated and used.

The interview will be done semi-structured, which means that it is possible for the researcher to ask more in-depth questions that are not defined before the interview.

The evaluation interviews will be done for the framework. The goal of each interview is mentioned. The interviews should measure if the requirements of the framework are met. The requirements are functionality, suitability, compatibility, usability, reliability, maintainability, portability.

Profile of the interviewees are:

Table 8 Profile of the experts

Expert	Expertise	Job title	Experience
1	RPA, Data analytics, data warehousing, Automations of the data processes	Consultant IT advisory	2 years
2	RPA, Data warehousing	Consultant IT	2 years
3	Control Audit, Functional management IT	Business consultant – IT internal	20 years
4	Data analytics, IT control audits	Senior consultant IT advisory	10 years
5	IT systems, automation application testing,	Supervisor be in control / (SME advisor/accountant)	10 years

Questions Framework

- The goal of the interview: evaluate the framework
    - In order to find out if the experts think that the framework does support automations well, the researcher needs to find out if all the phases are clear and the goal of each phase is in alignment with the other phases

Questions:

1. Do you think the goals are complete and do you think that the phases of the framework are covering the goals?
2. Does the framework explain the function and steps of the procedure selection well? Explain
3. Does the framework explain the function and steps of the Workflow analysis well? Explain
4. Does the framework explain the function and steps of the automation technology selection well? Explain
5. Does the framework explain the function and steps of workflow connections well? Explain
6. Are the phases clearly aligned? Explain
7. Do you think applying the framework would result in a more efficient and effective process than the current situation? Why do you think that?
8. Would you add any specific aspect to improve the framework?

Answers

Table 9 Answers to the questions

Q	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
1	Yes, the goals look clear, and the phases are clearly aligned.	Yes, it is very global.	Yes, the phases are clearly shown and are in alignment with the goals.	Yes	Yes, these are usual goals when creating an automatization
2	Yes, although the objective should maybe be defined earlier in the flow chart after asking if there is a demand for the process automation.	Yes, but keep in mind that there is a possibility that there could be more criteria. You will find this out when it is tested on several processes.	Yes, it is very important to ask if there is a demand. But it is even more important to define the process, and that everyone is doing the process in the same way. It happens to often that people want a new it features but does not about what else is involved.	Yes, good to identify the parameters first before going further with the automatization.	Well over thought. Indeed, the criteria is very important. Also, the identification of the possible human mistakes important to create a more efficient process.
3	Yes, clear	Yes, just clear. But I think that the subgoals should come back in the last phase to see if all these goals are achieved.	Yes, good that it is a simple phase. This keeps it easier to explain the steps. Keep it simple.	Yes, just seems right.	Yes, this phase is clear.
4	Yes, the data and process defining is a good step to define what technology and algorithm could be useful. However, I miss the vendor selection in this phase. We are using UiPath for RPA so this would be the best option to apply. Since auditors already know the software.	Yes, But I doubt if a cognitive agent should be used when a process is inference based. Maybe it is just better to let the accountant do the inference-based tasks	Yes, when I look at the flow chart, I think that you cover all the information that is needed for knowing which robot could be used.	Yes, I think you covered all the information well that is needed to decide which technology could be useful.	The only thing that is missing in this phase is which vendor to choose.

5	Looks good, however, in practice, it often occurs that besides the timeline, it should also be noted how long robot x is waiting on robot y. This could then be more optimised when there are multiple complex processes.	I think this should be in the framework earlier. The data flow should be earlier. Maybe at the workflow analysis.	Yes, the data flow looks good. However, testing is not included. You could describe how to test which methodology to use. Testing is always underestimated. The testing would also help by creating awareness in the organisation.	Good that the requirements and the timeline is checked. To see the one workflow as the solution.	How to implement is missing in this phase. What methodology could be used? Maybe Agile.
6	Yes	Yes	Yes, I do not think anything is missing between the phases.	Yes	Yes
7	Yes, this would make the implementation first way more efficient. Also the IPA solution will eventually make it more efficient.	Maybe when it is implemented well.	Yes, All the aspects are well thought out. Especially, the first phase is important to have an efficient solution.	Yes, when the efficiency will improve, also the (it)auditors who will do this work usually could do something else. So much more advice could be given to customers when this is implemented.	Yes, if the solution would work well, the process would be more efficient. The repetitive tasks can be done by the computer, which means that the accountant can do other work which improves productivity.
8	Awareness in the organization, embedding a new technology in an organisation.	When implementing a framework like this, there will be some problems. These need to be solved which is now not included in the framework. It can only be included when it is implemented.	Awareness of the people and in the organization. Also, it misses how it could be implemented, with what kind of methodology, such as agile, or waterfall etc.	No, it looks good to me.	It looks good, but the aspect of how awareness in an organization will be managed is missing in the final step.

Appendix D – Revised framework flowcharts

D.1 Revised Process determination

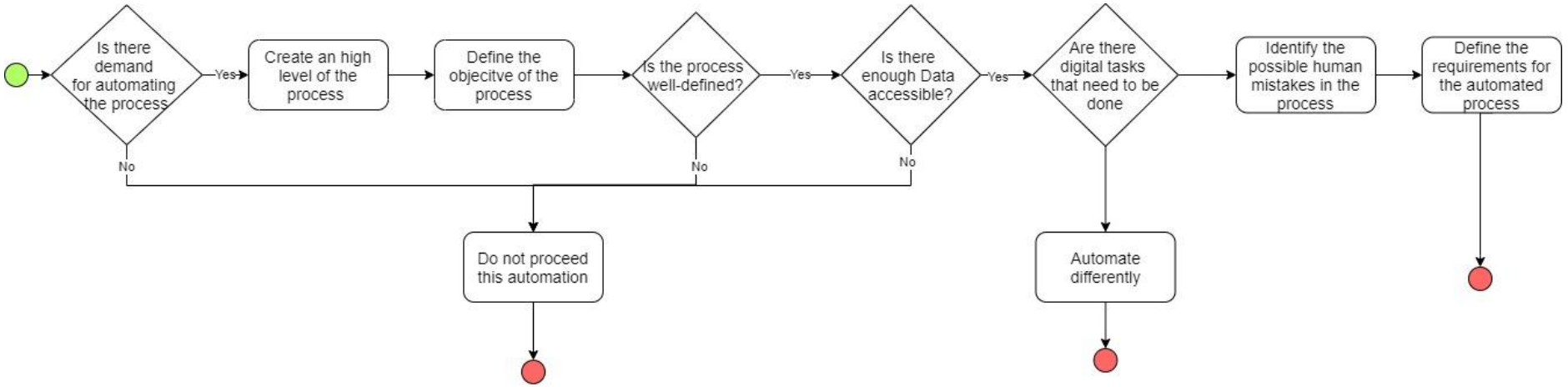

Figure 30 Revised process determination

D.2 Revised Proposal formation

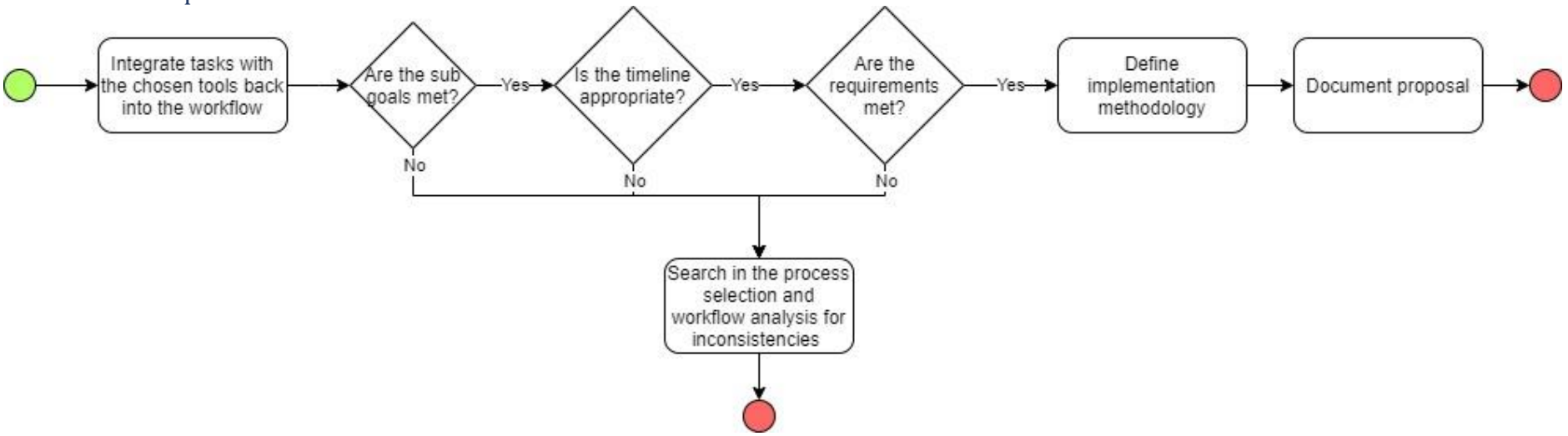

Figure 31 Revised proposal formation

Appendix E – RGS

In the Netherlands, companies are not obligated in the way they organise their accounting. There are some rules, but everyone implements this in their way. However, the chamber of commerce, the tax authorities, CBS (Statistics Netherlands) and banks, do want the information of the companies in the same format, namely SBR reports. Therefore, the need to standardise the financial administration was increasing. To meet this need, the Referentie grootboek schema (RGS)[5] was introduced by the Dutch government, software suppliers, chamber of commerce, and banks. RGS is not the first attempt to standardise general ledgers. However, there is a difference between previous efforts and RGS. Previous attempts were trying to create a bridge to connect the financial administration and the final reports that need to be submitted to the government and other parts. RGS does it differently. RGS is created with the idea to project the various financial reports on the structure of the administration. This approach makes it possible to bring coherence between the financial administration and the concepts used in those financial reports.

RGS has five hierarchic levels[6]:

1. Accountability (profit loss account or Balance)
2. Main rubric
3. Rubric
4. Account
5. Mutation

A company does not have to use all the levels. For a small company, the first level could be enough. To be flexible, the mutation level is added to let the user decide how detailed the general ledger could be.

For each general ledger account, the following attributes are defined: account number, description and the reference code. The reference code is composed of four reference tables, which include a three-letter code and a description. By combining a unique element from the main rubric reference table, a unique element from the rubric reference table, a unique element from the account reference table, and a unique element from the mutation reference table, a ledger account is created. The description of the general ledger accounts is composed of the descriptions of the reference tables in such a way that the context of the general ledger account can be deduced from the description. As a result, the accounts are tightly defined in this way. Figure D.1 shows a

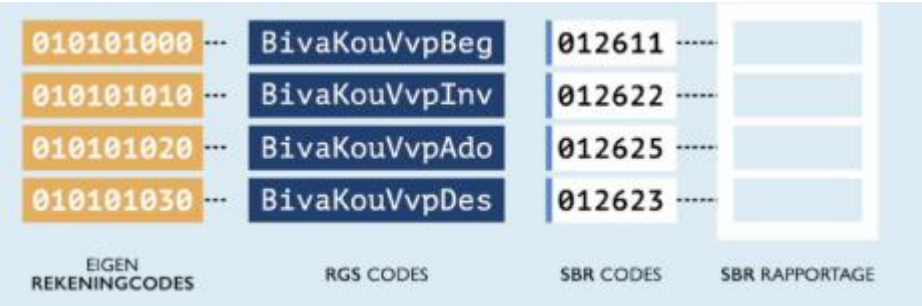

Figure 30 RGS codes Source Referentiegrootboekschema.nl

[5] The Dutch Reference Classification System of Financial Information (RCSF)

[6] https://www.referentiegrootboekschema.nl/handleiding-referentie-grootboekschema

graphical example of how the code of a general ledger account is mapped to an RGS code which is connected to the SBR code.

A survey has been conducted by the developers of RGS[7]. They received 107 respondents of accountants. The reason why they were using RGS was for benchmarking, investment in the future, efficiency, and being able to report faster. The reasons why some the respondents did not use RGS are because they created their standard, the software did not support RGS, they have no time to transition to RGS, or RGS does not meet their needs. The experience benefits which were identified in this survey are the simplification of the process, improved comparability of numbers, improved exchangeability of data between administrations but also when they switched software. There were a few respondents who did not notice any apparent benefits.

The disadvantages that were identified were that RGS does not match in real life because it is not specific enough, too extensive, or because of the order or terminology. Another identified disadvantage was that the implementation would take much time, and it demands care and quality, no added value, and the input should be of good quality in order to have a good quality output.

7 https://www.referentiegrootboekschema.nl/sites/default/files/kennisbank/Gebruikersonderzoek%20RGS_%202018_resultaten_samenvatting.pdf

Appendix F – Data flow

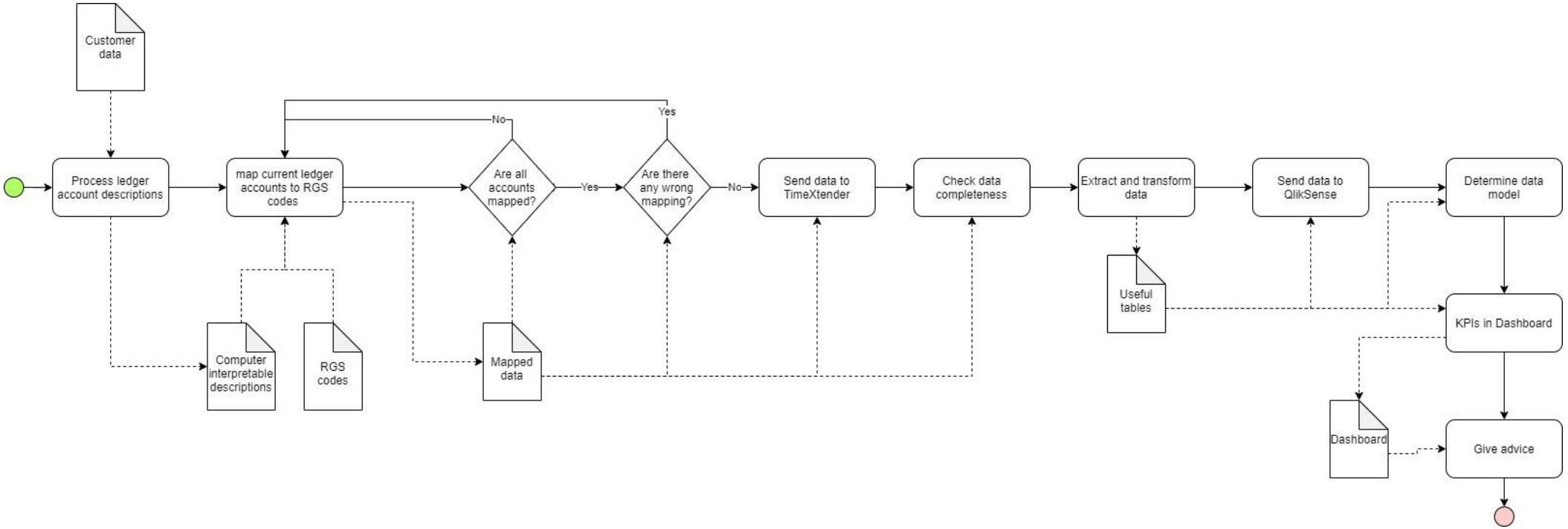

Figure 32 Data flow

Appendix G – Demonstration interviews

Expert validation is one of the ways to validate an artifact. The artifact design is shown to experts who are able to understand how the artifact could interact with the context (Wieringa, 2014). This artifact will be validated by qualitative interviews. The setup of the interview is done by the stages described by "Qualitative Research Practice: A Guide for Social Science Students and Researchers" by Ritchie et al. (2003). The six stages are:

1. *Arrival and introductions*: Start of the interaction, the researcher is responsible for making it friendly and positive. Additionally, the expert and researcher will introduce themselves.
2. *Introducing the research*: The research topic is introduced, the scope of the interview is set and it is noted that it is not a survey, but the aim is to hear the views and experiences of the expert in their own word.
3. *Beginning the interview*: The beginning of the interview will start with some opening questions about the experience of the expert.
4. *During the interview*: The expert is guided to the significant themes by the researcher. Mostly open questions need to be answered by the expert
5. *Ending the interview*: The researcher will indicate if the end of the interview is approaching.
6. *After the interview*: The research will thank the expert for participating. Furthermore, the researcher will let the expert know how the information will be treated and used.

The interview will be done semi-structured which means that it is possible for the researcher to ask more in-depth questions that are not defined before the interview.

The framework is used to describe how continuous reporting would be done. To evaluate if the framework is used well and shows the advantages of using this framework for continuous reporting in an audit service. IT and SMEs experts are asked for this interview.

- The goal of the interview**:** Determining if this process would be applicable in practice**.**
- Questions:
    1. Are there any choices that are made in the procedure selection that you have a different opinion about? Which choices?
    2. Are there any choices that are made in the workflow analysis that you have a different opinion about? Which choices?
    3. Are there any choices that are made in the tasks automation selection that you have a different opinion about? Which choices?
    4. Are there any choices that are made in the workflow connections that you have a different opinion about? Which choices?
    5. Do you think that information about the process is still missing?
    6. Do you believe that this solution could work in practice?
        - If yes, do you think that is more efficient and effective than the current situation?
        - If no, why do you think this would not work?
    7. How do you think this continuous reporting will affect the advice to customers?

When having all the information from the experts, it can be concluded if the framework is valid in supporting the user to reach continuous reporting.

The backgrounds of the experts are:

Table 10 profile of the experts

Expert	Expertise	Job title	Experience
1	RPA, Data analytics, data warehousing, Automations of the data processes	Consultant IT advisory	2 years
2	RPA, Data warehousing	Consultant IT	2 years
3	Control Audit, Functional management IT	Business consultant – IT internal	20 years
4	Data analytics, IT control audits	Senior consultant IT advisory	10 years
5	IT systems, automation application testing,	Supervisor be in control / (SME advisor/accountant)	10 years

Table 11 Answers of the experts

Q	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
1	The condition could maybe be a bit better, so what is already done or connected before this process could start.	Accountants need to understand it indeed, but not exactly how it works. They should know how the process works globally.	Smart to use systematics this reduces a lot of mistakes that could lead to invalid dashboards.	There are multiple sources per customer. This could be interesting for the next steps when this solution could work.	The assumptions that you have done, could be explained better.
2	Looks good. Maybe show the trigger which starts this process. when this will be used for multiple processes, a big data warehouse will be created. So, a trigger on how to start a process or update a process could also be interesting to know	Yes, it is clear.	It is good. The most important steps are in Exact.	Good to have an overview like that.	This is clear and shows a good basis for the following steps.
3	It seems right. It is important that giving advice is done face-to-face. Maybe indeed supporting the accountant by showing interesting data.	Maybe look at when it is efficient to use the RPA in TimeXtender and Qlik Sense. When the process is done the first time, the data does not have to be dragged all the time because of the triggers in TimeXtender and Qlik Sense	It seems right, when mapping RGS, it is important to keep the judgement of the accountant indeed.	I think the advice would always be manual because that will be in person.	Good to use RGS.
4	good to have a diagram like that	This is a good diagram, however, when multiple	This is clear, the implementation	This is clear. When implementing it make sure	Scrum could be useful. Think about which

		processes are done in TimeXtender, new projects need to be created. Showing the implementation methodology is	methodology is a good one. We know Scrum. And then, testing with a few accountants and IT consultants is very important.	that the older generation trusts new tools less, and they will gain that trust by first checking if it calculates or in this case, map the RGS right.	backgrounds expertise you need in the development team.
5	No, I think you cover enough	No, I think when we are going to build it, we still have to deal with some exceptions.	I think that this is for now clear enough indeed.	There is enough information, yes.	The essential information is covered in this proposal.
6	This brings some structure to the process. It is useful, when we want to build this there will probably some things that were not seen beforehand. These are mostly exceptions.	When there are more customers, this could be a bit more efficient.	Yes, definitely.	Yes, this will be more efficient in the end.	Yes, accountants will be mainly asking for their judgment and can finish more work on a day.
7	When we could provide more advice to them, we distinguish ourselves from the competition.	Providing advice on a regular basis could help the customer to make more strategic decisions.	Benchmarking, therefore important that RGS is used because then the source of the dashboard is standardised in the same way. RGS is very essential for this.	When you provide standardised dashboards, customers who have less money could also get some standard advice that could help them. Distinguish from the competition.	Benchmarking and more options will be coming available such as predictions.