Hyperscalar Research

Advances in Process Automation

Reviewing the state of the art

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01 | Introduction

As businesses continually strive to find greater efficiencies in complex time-consuming business processes, increasingly they look towards software enabled *process automation* to reduce friction and accelerate some, or all of these processes. Some of the main areas we see being automated today include:

- Document automation
- Workflow automation
- Process automation
- Call automation
- Image recognition automation
- Conversation, Transcription and Translation automation

Business processes (sometimes referred to as 'workflows') that have a high proportion of repetitive, mundane tasks can often benefit by using process automation, guided by a set of rules. In doing so we would expect to improve efficiency, task throughput, and potentially make the process less error prone (through aspects such as operator fatigue). If successful, businesses can then make choices about whether to re-deploy existing staff, or amplify throughput based on the productivity gains.

Arguably at the forefront of this movement lies Robotic Process Automation (RPA). RPA is an emerging technology geared towards improving processes by automating repetitive, replicable, and routine tasks in a business workflow. Alongside RPA (sometimes used interchangeably) is Intelligent Process Automation (IPA). IPA refers to a broad umbrella of technologies, designed to enhance RPA with cognitive abilities. IPA encompasses machine learning (ML), smart workflow management, and RPA. There are also terms such as '*hyperautomation'* and '*cognitive RPA*' that are used to refer to IPA. For the purpose of this paper, we use the term **cognitive automation** to refer to the broad set of intelligent automation tools.

Automation is not a new development; there have been several attempts in the past to build heavyweight application-specific solutions that incorporate workflow automation, screen scraping etc. However, from an evolutionary viewpoint, RPA as it stands today has mutated from these legacy (largely monolithic) systems, incorporating some of the best features in order to provide performant, scalable, and secure automation, whilst gradually introducing more artificial intelligence in order to improve agility, reduce human intervention and social impact.

In this paper, we discuss:

- Various technologies that complement and support cognitive automation
- How these tools help improve business process
- Important use cases
- Some of the key challenges in implementation
- How these techniques are evolving into a much broader integrated automation capability, through the use of AI and ML.

02 | Automation technologies

Robotic process automation

RPA in its naïve form is essentially driven by hard-wired behaviour that does not require built-in judgement or domain knowledge in order to automate repetitive tasks – hence the term 'robotic'. RPA is typically enabled using the following steps:

1. A single, repetitive task/process is identified as a suitable target for automation.
2. RPA bot(s) are used to record this business process as a 'task'.
3. Any checkpoints in the process that require human intervention are identified.
4. Tasks are linked together to streamline workflows (or parts of the workflow) to improve efficiency, with breakouts introduced for human oversight.
5. Once tested and the behaviour verified, RPA is put into production.
6. The process may be continuously refined to maximise efficiency and accuracy.

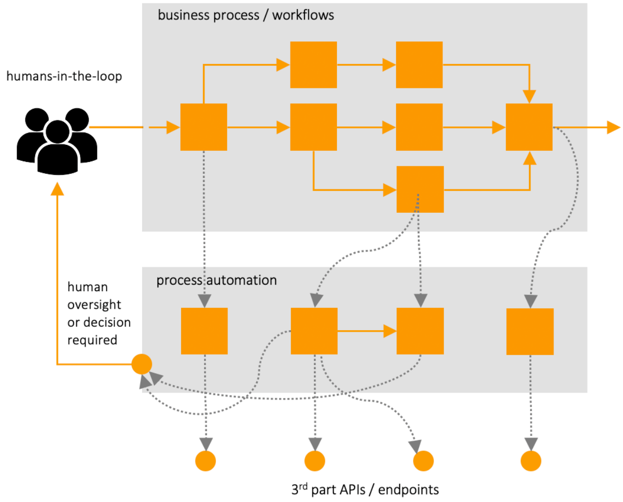
RPA provides human-bot collaboration i.e. it allows users to automate front-end and back-end tasks by interacting with systems and applications utilising the same interfaces a human does to capture and manipulate the required information for a given process.

RPA is most often deployed where there are tedious and repetitive processes that take up valuable staff time and have the potential for human error.

RPA bots can automate a wide range of tasks, including:

- opening email, email attachments
- logging into web sites or enterprise applications
- moving files and folders, filing in forms
- reading from and writing to databases and spreadsheets
- connecting to other systems via APIs and initiating processes
- extracting structured data from documents to collecting social media stats
- making routine calculations

Whilst RPA is often deployed to automate parts of a core business process (within applications such as Salesforce or Microsoft Dynamics for example), when deployed, it is typically integrated with several other internal systems to populate fields, transfer data and initiate end to end processes.



For example, depending on the path taken within the core business application, a trouble ticket may be opened up by RPA on a 3rd party customer support system, using an API call, with some initial details of the customer passed through to populate the case. The newly generated case ID may also be pulled back into the business application to ensure the systems are synchronised.

RPA tools typically need to integrate data from many sources including external websites, portals, and various 3rd party applications, and works on either structured or semi-structured data, relying on tools and techniques such as:

- Headless web scraping, to extract data and then record it
- Macro script
- BPM/Workflow automation
- API call integration

The scope for integration and added value is potentially enormous, and today we see RPA being further integrated with conversational tools and technologies, joining up both front and back office tasks within organisations, driving down call handling and task times.

Task automation can be web-based, desktop-based, or mobile-based. Web automation tends to be the most widely used and most straightforward in terms of complexity. RPA operates on legacy desktop systems, with challenges around operating system and version compatibility, as well as the potential for security obstacles (for example, if escalated privileges are required). Note that mobile automation tools also presents a number of additional complexities owing to restricted resources and smaller screens.

Cognitive automation = RPA + ML

RPA in its basic form can be quite fragile, and inflexible to changes in the underlying application or workflow – for example when the underlying application is updated. This can make the process of maintaining RPA tasks quite challenging, especially if there are frequent changes to the core application (e.g. especially user interface changes, page or form ordering changes, API changes etc.). Cognitive process automation essentially combines process insights (from RPA) and data insights (from ML), with the purpose of making RPA smarter, less fragile - evolving the toolset to include greater cognitive capabilities and the ability to deal with changes and exceptions more robustly.

RPA, when enhanced with ML, leads to intelligent-cognitive automation [1]. Cognitive automation has the ability to build relationships and find similarities between items, by learning from association. It can also provide insights on which parts of the workflow can be automated.

For example, we might consider using computer vision with machine learning to detect if data entry fields have been moved or renamed; dealing with these changes dynamically and without having to re-record that segment of the process flow.

Cognitive automation is an evolving field and relies on a range of techniques such as ML, Natural Language Processing (NLP), Understanding and Generation, and Optical Character Recognition (OCR). Today we see that RPA products are beginning to be enhanced with AI techniques such as NLP, image detection for transcribing text, sentiment analysis, and translation services, with the potential to provide a much richer degree of end-to-end automation. With accurate data annotation, machine learning models and AI models can make increasingly accurate decisions, and when combined with the fundamental processes of RPA businesses, achieve truly Intelligent Automation.

Components of cognitive automation

Cognitive automation is a dynamic field comprising many components and technologies such as:

- Conversational Chatbots
- Intelligent document automation
- Deep learning (especially CNNs and RNNs)
- Probabilistic graphs
- Transfer Learning

- Reinforcement learning

We discuss these in turn below.

Conversational AI/Chatbots use a combination of NLP, Natural Language Understanding (NLU) and Natural Language Generation (NLG) [2,3].

- **NLP** - the ability of machines to ingest, process and interpret human input and language.
- **NLU -** the ability of machines to take unstructured and or unpredictable data and turn it into structured data, with the goal of comprehending the semantics based on context. For example, understand what the user typed or said in the chat, despite human errors and mispronunciations.
- **NLG** - the ability of machines to generate or write natural language that humans can understand.

There are several popular frameworks for chatbots including:

- IBM Watson
- Microsoft Bot
- Amazon Lex
- Google DialogFlow
- Oracle Chatbot
- Facebooks Wit.ai.

Intelligent Document automation uses OCR and Intelligent Character Recognition (ICR).

- **OCR -** can be used effectively to read, interpret and digitize information printed or typewritten text, but starts flagging exceptions if the input information fluctuates too much – say with handwritten text.
- **ICR -** can be used to learn different styles and types of handwriting.

Deep learning techniques such as Recurrent Neural Networks (RNN) and Convolutional Neural Networks (CNN) play a big role in NLP. They can be used by themselves or together in a hybrid model for NLP, NLU, and NLG.

- **RNNs** are multi-layer neural networks that are used to analyse sequential input like speech, text and have applications in speech recognition, language modelling. [4]
- **CNNs** are multi-layer neural networks that use filters (kernels) to extract relevant features from input data and have applications in semantic parsing, sentiment analysis, and sentence modelling. [5]

Probabilistic Graph Models (PGM) – Although most models in NLP are trained on labelled text (supervised learning), a primary application is to interpret unstructured text via unsupervised or deep learning. One emerging area is based on probabilistic graph modelling that is popularly used in speech processing. The graph models can be directed (Bayesian) or undirected (Markov Models) and the latter is used commonly in Google Voice Search and Apple Siri. PGMs are used for applications that require understanding if a particular document is relevant to a given query, tag/classify images, model a collection of documents etc. [6]

Transfer learning (TL) - A machine learning technique wherein new tasks are learned based on previously learned tasks i.e. as opposed to traditional ML where models are trained for specific tasks, knowledge from one task is applied or transferred to another related task. This is typically used when there is not enough training data, or time to learn new tasks. TL has a big role to play in RPA for example, where bots for *similar* tasks don't have to be trained from scratch, but the role of TL in RPA remains a field for future research. [7]

Reinforcement learning (RL) - This is an area of research that has not been explored much at all. RL comprises of various components like agents, environment, episodes, states and rewards [8]. RPA bots can be trained for better performance by maximising utility via maximising rewards.

03 | Automation benefits

Today RPA and emerging cognitive automation solutions help organisations to establish an agile foundation for automating repetitive tasks, thereby resulting in increases in productivity and reduced errors. Automation promises to free up staff to do more challenging work. Some of the key benefits are highlighted below:

- **Error reduction**: Reduce the risk and cost of human errors, typically by removing operator fatigue and ensuring high consistency and accuracy. Human errors can be extremely costly to businesses. RPA bots can be extremely accurate, although organisations must ensure that the original processes being recorded and automated are completely error-free (otherwise RPA will simply replicate these errors faster).
- **Improved productivity and service levels**: RPA can significantly boost productivity in organisations that rely on heavy use of manual processes, freeing up valuable resources to work on more business critical and proactive tasks, rather than spending time on mundane, repetitive ones.
- **Scalability**: During bursts and slack periods, RPA systems can either deploy more or less bots as the load dictates, leading to greater cost efficiencies with the ability to scale on demand.
- **Faster Training and Onboarding**: New staff can be onboarded faster since there is less to learn and less to get wrong.
- **Unattended automation**: For processes that do not require human intervention, automated responses and triggers can significantly lower communication overhead and save business significant costs and time.
- **Reduced data leaks**: Reduced data leaks from lowered human presence in the execution of tasks/workflows (e.g. sensitive data is potentially less exposed).

In order to fully realise these benefits these deployments require strong analysis, planning and testing, as we discuss in the next section.

04 | Preparing for automation

Before implementing process automation, it is particularly important to perform analysis on existing flows, set appropriate expectations, and plan thoroughly. One needs to identify:

- The business processes that are most suitable for automation.
- The business processes that would derive most benefit from automation.
- The potential costs and risks.
- Processes that require human-in-the-loop decisions or oversight.
- Whether a centralised or federated model is appropriate.
- Long-term maintenance needs and impacts.
- The total ROI of automation, considering all of the points above over the lifespan of the deployment.

Challenges in process automation

There are a number of challenges typically encountered in process automation selection and deployment projects:

Vendor confusion: There is a lot of investment going into RPA, with many vendors (new and old) marketing the addition of cognitive capabilities and plug-and-play AI capabilities within their solutions. It can be difficult for potential clients to assess which solutions are best suited for their needs, and what the difference is between various solutions. Cognitive automation is essentially a superset of RPA and incurs additional challenges around bias and explainability as part of their more advanced AI solutions. It is therefore prudent with all of these products to do some market research first before drawing up a shortlist, then trial some solutions through a Proof of Concept (PoC) process to ensure deployment success.

Maintainability: Deployments can be quite fragile to underling changes in applications and services (for example a software update to the core application being automated). Cognitive Process Automation should in theory be less fragile to such changes than legacy RPA. However, depending on the level of cognitive assistance in the product, and the balance between recorded and dynamic features, there may be an ongoing burden to fix and test broken processes and tasks.

Regulatory complexity: The quickly evolving nature of automation technologies introduces the potential for complexity in how regulations and compliance should be best handled and verified. Since a number of repetitive or time-consuming processes may be handled automatically 'behind the 'scenes' this could reduce errors significantly, but also has the potential to obscure important process exceptions and anomalies that require human oversight. Hence careful planning, and attention to where automation should 'break out' into human decision making is vital to ensure compliance.

Unstructured data handling: RPA typically requires bots to extract and create structured data from unstructured content. Unstructured content includes emails, IM, voice, video, images etc. Transcribing unstructured data into structured content is done using OCR or NLP. This will require thorough testing to ensure correct parsing, transcribing, annotation and translation.

Identifying processes to automate: Process Mining is key to identify the right set of processes to be automated and can be an expensive affair. While this can be done manually, there is a massive shift towards adding cognitive capabilities based on ML to figure out which of the processes can be automated completely. The benefits and ROI of automation can therefore differ significantly from process to process.

Hyper connectivity: RPA bots typically switch back and forth between various systems. If the process is not fully automated (or resilient) and needs significant human intervention at different checkpoints, or to correct errors, then if one part of the system repeatedly breaks down – or is heavily dependent on humans-in-the-loop – then the efficiency of the entire RPA process may be affected. This may be a case of introducing further automation or extending API capabilities. In some cases it may be necessary to improve data quality to minimise these kind of interventions.

Automation beyond UI layer: Most automation solutions today focus heavily on the user interface layer. Ideally, workflow automation needs to happen on multiple layers and interfaces, such as the operating system and network layer, and we expect this area to improve and extend over time.

AI-specific challenges

With the increasing use of AI in process automation, there can be additional challenges such as:

Lack of Training Data (the cold start problem): Before implementing cognitive automation with heavy reliance on techniques such as supervised ML, organisations will need to determine if there is enough training data for conversational and other AI related pieces to operate robustly - or whether the system can be 'booted' via techniques such as transfer learning.

Drift: Cognitive automation needs to deal with high volumes of data on which the ML models are trained. This in turn requires continuous data transformation and dealing with the drift that occurs with the underlying data and models [9].

Bias: As discussed in [9], the data on which the ML models are run are potentially subject to inherent bias. Bias present in the models and data will lead to skewed results when transitioning systems from RPA to cognitive automation. There may be associated ethical issues also as discussed in [9].

Explainability: Explainability of AI decisions is key to identifying the decisions made by the ML models aimed towards making RPA smarter. However, this is an extremely challenging problem and an area for future research [9].

It is notable that several RPA vendors are gravitating towards integration with major cloud stack provider offerings from Amazon, Microsoft and Google, instead of continuing to develop some of these core capabilities from scratch (for example, by leveraging Amazon AWS tools such as Comprehend, Reckognition, and Textract). Over time this will lead to underlying features being further commoditised, and made 'best-practice', given the substantial resources of the major cloud vendors.

Security and privacy challenges

In terms of security and governance there can be challenges such as:

Privileged Access: RPA software bots often require privileged access to perform required tasks, such as logging into ERP, CRM or other business systems to access information or to move data through a process from one step to the next.

Credentials are typically hard-coded directly into the script or into the rules-based process the bot follows, or the script may include a step to retrieve the credentials from another location.

RPA credentials are often shared between bots so they can be used over and over again. Clearly, numerous bots being in production can exacerbate the problem.

This can to an extent be mitigated by using the **principle of least privilege** and granting access only to specific applications.

Privacy Concerns - While most RPA vendors tout privacy-first design via the use of encryption for the Personally Identifiable Information (PII) data of customers, role-based access control and audit logs, when bolstered with intelligence, cognitive automation presents many privacy challenges. For instance, privacy preserving NLP techniques [10] become crucial especially in applications where say customers are identified by their voice.

Note that some of the recent developments in this area use NLP and feature recognition techniques that can identify features such as PII, sensitive user data, and domain-specific information – allowing this to be annotated and redacted if necessary, during the automation process.

05 | Use cases

Process automation (including RPA and cognitive automation) are well-suited to applications that have a high rate of transactions and/or involve repetitive routine tasks, across both industry and government sectors. Some of the more common use cases are highlighted below:

Banking: RPA based KYC for document validation to quickly identify prospects with suspicious records, and reject their applications, use of OCR to process invoices/checks for faster crediting, automated notifications to customers upon missing information etc, automated detection, flagging and resolution of fraud and AML alerts.

Call Centre: Process automation can be used together with Conversational Chatbots, NLP and translation services to provide front to back office automation, enabling reduction in call handling times and improving customer experience.

Healthcare: RPA can be used for automated entry and claim processing, faster front-end patient handling, and can be augmented with blockchains for secure storage of medical records on the ledger. RPA can also be supplemented with AI vision and document classification techniques to provide searchable metadata and bulk classification of documents and images.

Insurance: Process automation can be used for efficient claim processing and regulatory compliance by automating manual, repetitive reporting requirements. Again, similar to the call centre case, RPA can be integrated with front office automation to provide enhanced efficiencies from front to back office. We are also seeing early use of blockchain 'smart contract' automation in this sector to complement RPA.

IoT: RPA can automate maintenance, diagnostics, anomaly detection and troubleshooting for sensors and identify bottlenecks in a supply chain.

Supply chain management: RPA can free up employees by providing automated warehousing and reducing human error in repetitive processes.

Digital Twins: Digital twins are virtual counterparts for physical assets. Cognitive automation has a big role to play in automating processes for the digital twin counterparts, thereby resulting in more automated and efficient maintenance of the physical equivalents.

Trade and Contracts: Process automation (e.g. RPA Bots) in conjunction with blockchain smart contracts can be used to collate information from different contracts into databases. When both parties have signed, and all conditions of the contract are met, ownership is recorded, and secure access permitted to the official document recorded on the blockchain.

Government: There is huge potential for cognitive automation in the Government sector (central and locally), to reduce fraud, waste and human error, and improve overall efficiencies. Here algorithmic transparency and explainability can play an even more important role; for example, by supporting AI based automation when used for public policy making. Technologies such as blockchain may also be integrated to provide 'tamper-resistant' verification of important data and decision-making events. Blockchain digital currency token and smart contract automation could also be used for example in distributing and tracking benefits, or in securing supply chain agreements.

06 | Conclusions

Automation techniques such as RPA can extend the life and utility of legacy business processes, as well as improving efficiencies and reducing errors across all busines processes – especially those that rely heavily on humans-in-the-loop to handle high volumes of data processing through repetitive tasks. That said, RPA - at least in its naïve form- may not be suitable for every application.

Organisations need to carefully evaluate solution capabilities, set expectations appropriately, and understand the product roadmap before they invest. We see this space developing rapidly over the next few years as broader technologies and AI techniques are further integrated, expanding the role of RPA from front to back-office, becoming much more robust and insightful as it evolves.

Over time it's likely that many of the underlying components, especially those used repeatedly, will become commodity 'no-code' solutions, driven by templates and APIs, and packaged within cloud ML stacks. We expect these tools to increase over time in quality, sophistication and intelligence, and we are already starting to see the beginnings of this transition in the cloud, with new products and tools emerging in conversational bots, document classification and annotation, and call centre automation.

Cognitive Process Automation has the promise to eliminate a great deal of routine administrative, provide significant additional operational efficiencies and scale, as well as greater insights. [11] discusses a number of opportunities for research into this field, which remains largely unexplored.

This is a highly attractive market for automation solution providers, workflow providers, and cloud providers - given that the potential business benefits for clients can be substantial – if deployed well. This is a real problem worth solving. With the recent advances in machine learning and cloud compute there is clearly more that can be done to automate process flow, and we expect this to continue to be a highly competitive and evolving field. According to Automation Anywhere, the potential economic impact of knowledge work automation is expected to be $5-7 trillion by 2025. According to Grand View Research, the global robotic process automation market size is expected to reach $11 billion by 2027, expanding at a CAGR of 34% from 2020 to 2027 [12].

The convergence of process automation and blockchain is especially interesting. RPA bots (also called *digital workers*) could for example be trained to carry out tasks based on the transactions recorded on a blockchain, with all actions and decisions stored on the blockchain, providing an immutably audit trail for future analysis and compliance purposes. If those bots are also AI-enabled, then this provenance history can support AI 'explainability' [9]. Blockchain 'smart contract' logic is also a natural fit in supporting and verifying workflow automation, as well as offering the potential for binding legal agreements, and asset or value disbursements.

Combining all these technologies to achieve business efficiencies and cost reduction may seem like a no-brainer, but organisations also need to adopt a socially responsible, accountable and ethical approach to automation – since the promised efficiencies are likely to lead to a shift in the job market, and may remove or obscure important areas of human oversight. Automation needs to be planned and deployed in a socially responsible manner, and organisations should be considering how best to upskill their workforces and redeploy staff on more creative and intellectually demanding tasks, and there remain a wide variety of business functions that are likely to be out-of-bounds for AI for quite some time.

07 | Further research

There are a number of research challenges with the addition of cognitive capabilities to RPA, particularly in relation to the underlying ML algorithms:

- Selecting and optimising the most appropriate techniques for each automation subtask – whilst keeping the system performant
- Assessing the full utility of deep learning techniques in automation and user interface modelling
- Finding the optimal blend of machine learning and conventional heuristics in ensuring consistent robustness and error-free behaviour
- Exploring the potential for techniques such as reinforcement learning, for example by integrating with user behavior
- Assessing how effective, flexible and reliable plug-and play AI (so-called 'no-code' solutions) are when it comes to automation.
- Instrumenting these systems to enable high quality feedback and optimisation opportunities
- Assessing the potential for emerging techniques such as federated learning with IPA/RPA. For example, financial institutions could train AI models for AML using edge devices, manufacturing companies using automation for IoT device maintenance and repair. These use cases could benefit from federated learning to aggregate findings in a privacy-preserving manner [13].
- The addition of cognitive capabilities to RPA - while preserving privacy, algorithmic transparency and explainability - remains a work in progress.
- We are starting to see early implementations of process automation involving the use of blockchain, with the ability to autonomously execute or trigger processes through smart contract logic. There can be significant benefits in using blockchain (such as immutability and shared consensus), but also several challenges to be considered (such as privacy, ability to update contract logic, ability to selectively redact, and rollback processes).

We expect this to be a fascinating area to watch as it evolves over the next few years, as new techniques and advances are introduced and complementary technologies are further integrated, as the field of process automation matures.

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