# Applications Unleashed 2025 Beyond the Prompt\_









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# Artificial Intelligence







## Panta Rei: Everything is in Motion

A new kind of competitor has emerged—an AI-powered organization that is faster and more agile than ever before. How should traditional companies respond to this new challenge?

#### A Changing Ecosystem Requires Adaptation

Change is difficult to see when you're in the middle of it. The business landscape is evolving competitors come and go, industries shift, and unexpected disruptions arise. What once seemed like small market fluctuations can quickly turn into existential threats.

Even well-established organizations begin to struggle—not because they have changed, but because the world around them has. A common response is to resist change and stick to what has always worked. Companies try to survive by making their existing processes more efficient, implementing cost-cutting measures, and streamlining operations. However, this only delays the inevitable. Profit margins shrink, tensions rise between management and employees, and even minor mistakes have major consequences. Overly aggressive cost-cutting turns once-thriving businesses into struggling discount brands, and ultimately, many are downsized to the brink of collapse.

In this shifting environment, adaptation is no longer optional—it's essential. Survival of the fittest isn't about being the strongest, but about being the most adaptable.

#### The First Digital Wave

The internet revolution began 25 years ago, leading to the rise of countless online businesses. The Dotcom bubble eventually burst, but just like past economic bubbles—such as the Dutch tulip craze of the 17th century—something valuable remained. Out of the chaos emerged industry giants that reshaped the global economy.

Companies like Amazon, Google, Meta, Klarna, and Booking.com built their business models entirely on digital foundations, disrupting traditional industries. Online platforms and e-commerce giants gradually pushed physical retail stores out of business. Digital-native companies fundamentally changed the competitive landscape, making it impossible for traditional businesses to compete without transforming.

Established brands had two choices: evolve or collapse. Some, like Blokker and V&D, tried to survive through endless price wars but ultimately failed. Others, leveraging their heritage, managed to survive as niche or government-protected entities, but at the cost of their long-term independence.





For many businesses, digital transformation has been more about playing catch-up rather than true innovation. Even after 25 years of internet evolution, 20 years since Thomas Friedman's The World is Flat, and a decade after Leading Digital by Didier Bonnet, digital transformation remains a challenge for traditional companies.

Without competition, public sector organizations can maintain their relevance. But for private companies, survival is a constant battle. Many firms have spent years in "crisis mode," relying on marginal efficiency improvements instead of making bold, future-proof investments.

Short-term urgency often wins over long-term strategy—until survival is no longer guaranteed.

#### The Second Digital Wave: AI Disruption

In 2023, AI became a tangible, real-world technology. ChatGPT demonstrated that artificial intelligence is no longer science fiction but an everyday tool. Just as the internet became mainstream in 1999, AI is now at the forefront of global transformation.

Now, consider this scenario:

Imagine a startup launching today in a small office or even a garage. It is built entirely on AI, using advanced algorithms for hyper-personalization and real-time decision-making. Within five years, it could completely disrupt your industry.

This startup doesn't follow traditional rules. Operating from the cloud, it moves across jurisdictions, bypassing regulations that established companies must follow. It's one of thousands of AI-driven startups emerging worldwide. Most won't survive—but one will, and that one could be the wrecking ball that shatters your business model.

What will that startup do? How will it change your industry? And most importantly—how will your company prepare for it?

Change is no longer a distant threat—it's happening faster than ever. The ancient Greek philosopher Heraclitus famously said, "Everything flows like a river"—2,500 years later, this is still true.

The internet-driven disruption of the past was just a preview. The impact of AI-driven businesses will be even greater. While many companies are still struggling with their first wave of digital transformation, the second wave—AI transformation—is already upon us.

AI is an unstoppable force reshaping entire ecosystems.

So, what will you do—whether as an employee, manager, policymaker, or investor—to prepare for this new reality?

What will that startup do? How will it change your industry? And most importantly—how will your company prepare for it?

#### About the author



#### Henk Vermeulen | Managing Consultant, Capgemini Al Futures Lab

Henk Vermeulen graduated in 1996 with a degree in business economics and organizational studies. He joined Capgemini and spent over 15 years in ERP implementation before shifting his focus to innovation and emerging technologies. His work explores the significance of technological advancements and their real-world impact. Today, he supports Capgemini's strategic labs in pioneering the next wave of innovation.

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## Generative Al in Software Development: Today, Tomorrow and in the Future $\mathbf{02}$

How AI is transforming the way we build software and what we can expect

Imagine a world where software development is no longer inhibited by repetitive coding, bottlenecks in requirements, or running tests. A world in which functionality can be delivered faster with more focus on the values and where business analysts, developers and testers can deal with more challenging tasks. Generative AI (GenAI), with its ability to automate and assist, is

#### Highlights:

- GenAI takes software development to the next level by automating routine tasks and improving the productivity of business analysts, architects, developers, testers, and DevOps engineers.
- Tools like GitHub Copilot and Amazon Q Developer offer advanced code assistance, increasing development speed by up to 34% and noticeably improving software quality.
- By 2026, as many as 80% of organizations are expected to deploy generative AI to dramatically accelerate the Software Development Lifecycle (SDLC).
- Multi-agent systems, powered by generative AI, have the power to fully automate the SDLC.

not just a trend; it's a profound shift that promises to reshape the Software Development Lifecycle (SDLC) as we know it today.







GenAI's impact on software development goes beyond coding—it has the potential to transform the entire SDLC. We are witnessing the first stages today, with tools like GitHub Copilot and Amazon Q Developer improving developer productivity. These AI assistants not only reduce manual coding but also become indispensable team members who provide support around the clock.

The adoption of GenAI within software engineering is currently still in its infancy. Research by the Capgemini Research Institute1 among more than 1000 companies shows that 27% of organizations are exploring the potential through pilot projects, while 11% have already integrated generative AI into part of their software development process. However, the adoption rate is expected to rise sharply, with predictions that around 80% of organizations will use GenAl by 2026.

Today, the most widely implemented use case for generative AI in the SDLC is coding assistance (39%). This popularity is largely driven by the maturity and availability of tools like GitHub Copilot and Amazon Q Developer. These code assistants not only reduce manual coding effort but also improve software quality by bringing in code suggestions based on widely recognized best practices. Developers can stay within their integrated development environments (IDEs) while accessing a wealth of information that previously required them to look elsewhere or ask for help from more experienced colleagues. In this way, generative AI currently enriches the developer with tools and knowledge that are available 24/7.

Organizations that adopt GenAI have seen a 7-18% improvement in productivity in software engineering, according to Capgemini Research Institute research estimates. The time savings are greatest for specialized tasks such as coding, where up to 34% time savings are possible, with an average of 9%. Creating and updating documentation shows similar results, with a maximum potential for time savings of 35% and an average of 10%. This study focused specifically on time savings in various software engineering tasks

through the use of GenAI tools and did not look at potential cost savings, which can differ significantly.

A growing trend within software engineering is Documentation as Code. Documentation is created and managed in the same way as the code itself: it is stored in the same version control system and follows the same process. This ensures that documentation is easily kept up to date, promotes collaboration and makes it easier to keep track of versions. Markdown plays an important role within Documentation as Code. It is a simple and easy-to-use language that can be used to describe technical documentation and diagrams, sequence diagrams, class diagrams, and entity-relationship diagrams (ERD). Because it resembles a natural language, it is accessible to both developers and non-technical users.

GitHub, Copilot and ChatGPT use large language models (LLMs) that are trained on public data, including a wide range of markdown code. This allows them to generate documentation and diagrams of existing code, or a specific user story based on a prompt. This allows developers to easily update or generate documentation directly within their workflow, without any additional steps or manual processes.

#### Below is an example of a sequence diagram in Mermaid generated by ChatGPT (40).

#### Can you generate a sequence diagram in mermaid for the below user story?

As a customer, I want to apply a discount code at checkout to receive a discount on my purchase. The discount can either be a percentage of the total amount or a fixed value. Each discount is personal and securely stored in the loyalty latabase, ensuring it is uniquely tied to the customer. The primary purpo the discount code is to encourage customers to complete their purchase. Criteria: The code is valid and linked to the customer. The prompt to generate a Sequence Diagram in Mermaid Natural Language

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#### • The sequence diagram in Mermaid Natural Language generated by ChatGPT (40)



• The sequence diagram that can be generated by any Mermaid compatible viewer.







GenAI also plays a crucial role in reducing onboarding time for new developers. Using AI, they can get instant explanations of the source code, receive personalized guidance on where to integrate new functionality, and seamlessly adopt existing coding and naming conventions.

However, GenAI's increase in developer productivity may lead to bottlenecks at other stages of the SDLC. As developers speed up source code production, business analysts may struggle to keep up with the creation of functional requirements, and testers may struggle to test the plethora of new features. This imbalance can hinder the overall flow of the development process and negate overall productivity gains.

To harness the full potential of generative AI, organizations must integrate this technology into all phases of the Software Development Lifecycle (SDLC). By using GenAI for tasks such as business analysis, requirements creation, and testing, organizations can achieve holistic productivity improvement.

#### The Future

GenAl's impact on the SDLC doesn't stop at coding. It has the power to reshape the entire lifecycle, from requirements gathering, design, coding, testing, deployment, to maintenance. GenAI can influence various aspects of software engineering, such as assisting in generating user stories, validating requirements, supporting architectural decisions, identifying bugs, and enforcing coding standards.





It can also streamline documentation processes by automatically generating user manuals, technical manuals, change logs, and annotated code comments.Looking ahead, there are several use cases where generative AI can make a significant contribution, including:

- Analytics: GenAI can analyze large amounts of existing documentation, feedback, and usage data to automatically generate requirements. By processing conversations from (user) interviews and brainstorming sessions, AI can convert these insights into well-structured requirements documents and transform them into user stories that are aligned with the Definition of Ready (DoR) and Definition of Done (DoD) and best practices that apply within an organization.
- Validation: GenAI can analyze user stories and generate detailed test schedules that cover all functional requirements. It can also perform consistency checks on the requirements to identify conflicts and ambiguities. As fine-tuned models become more mainstream, industry-specific models will ensure that generated requirements and validations are specific to the needs of each sector or application.
- Deployment and Operations: AI can optimize CI/CD processes and pipelines by predicting potential issues and suggesting improvements. Based on application performance and profiling data, source code

can be analyzed to recommend optimizations that improve performance and efficiency.

The future of software development will go beyond what we envision today, integrating all the capabilities discussed and more. Multiagent systems (MAS) will be central, with different stages of the SDLC being managed by AI agents built for specific purposes, potentially supported by fine-tuned LLMs to further increase their effectiveness. Human intervention remains crucial to reduce AI hallucinations, ensure more substantiated answers, and ultimately increase productivity.

Imagine a new approach to software development, where natural language becomes the primary interface for development. Agents that work together, an agent for generating user stories, an agent for coding, an agent for testing, an agent for deployment, and an agent that orchestrates everything and thus touches the entire SDLC. This will change the interaction between product owners, business analysts, developers and testers.

- Product Owners will receive actionable insights (analytics) to support decisionmaking and strategies, making them better able to steer based on business value
- Business analysts will better understand trends and preferences, allowing them to translate these insights into detailed ideas and even test schedules, leading to faster iterations and improved product-market fit.





#### • Architects are supported in analyzing stakeholder input and generating architectural diagrams, data models, and proposed technology stacks based on project requirements, speeding up the design process and adhering to best practices.

- Developers still benefit from code assistants, but now with additional context from earlier stages. Experienced developers will focus more on optimizing AI agents and handling complex design and review tasks rather than writing the bulk of the code. For specific features, logic, or UI needs, developers will spend more time on business requirements, design, and team management.
- Testers not only use GenAI for test generation, but also synthetic test data generation, predictive bug detection, and a continuous feedback loop that analyzes test results and suggests improvements.

Tools like GitHub Copilot Workspace already offer a taste of the future—a "Copilot-native" developer environment where developers can brainstorm, plan, build, test, and execute code using natural language. This includes various AI agents that perform all tasks from start to finish, with developers maintaining control over the process.



Multi-agent system representation of a futuristics Software Development Workbench







Finally GenAI is poised to revolutionize the SDLC by automating coding tasks, improving quality, and extending its influence across the entire lifecycle—from requirements collection to deployment and maintenance. While the current adoption is still in its early stages, the use of code assistants such as GitHub Copilot is already increasing productivity and reducing onboarding times. However, this increase in efficiency can cause bottlenecks in other SDLC phases, such as business analysis and testing.

To fully harness the power of GenAI, it must be integrated into all phases of the SDLC. In the future, AI will not only perform repetitive coding tasks, but also generate functional requirements, create architecture design, predict bugs, and optimize deployment. Multiagent systems will take this further by orchestrating every aspect of development seamlessly and intelligently.

As we look at the next 5 to 10 years, software engineering will increasingly revolve around collaboration with intelligent systems. Human developers will move from manual coding to guiding and driving agent-based GenAI. They will focus on optimizing these systems by training models and determining which AI models or solutions are the best fit for specific parts of the Software Development Life Cycle (SDLC). This allows developers to shift their focus to strategic improvements, creativity, and high-level decisionmaking. Business analysts will convert user feedback directly into functional requirements, while testers will benefit from predictive AI models that continuously improve test coverage and proactively identify bugs. Architects will rely on AI-generated designs, reducing the time spent on manual tasks. This AI-driven transformation will allow for faster, more creative development cycles and better alignment with business goals. GenAI will become an essential partner in the SDLC, fundamentally redefining how software is conceived,

built, and maintained—challenging us to rethink not only our processes, but our entire approach to software development. Will we embrace this evolution and make room for an AI-driven SDLC that increases both productivity and creativity?

1: Gen Al in software – Capgemini CRI Report

#### About the authors



#### **Donald Hessing** | Vice President Head of Microsoft, CTO Cloud & Custom Applications

Donald leads the Microsoft cluster within the Cloud & Custom Applications department. In addition, as CTO, Donald is responsible for the department's vision and technology strategy. He specializes in software engineering, enterprise architecture and strategy development from business to technology.

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#### Arin Roy | Tech Lead and Lead Architect -Cloud Native and Generative AI

As Tech Lead and Architect for Cloud Native. Arin focuses on cloud native and Generative AI solutions in Microsoft Azure. Arin has more than 15 years of experience with Microsoft's technologies. That experience helps him to design and implement enterprise-ready digital cloud solutions for his customers.

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## Four practical steps towards your own GenAl Factory 03

A Guide to Integrating Generative AI Efficiently and Responsibly into Your Organization

#### Highlights:

- Generative AI requires a deep understanding of machine learning and data science. Start with a Discovery Workshop to identify potential use cases.
- Use a GenAI Factory approach for rapid prototyping and scalability. Leverage enterprise-grade Cloud-native building blocks like Azure, AWS, and Google Cloud.
- Transparency, inclusivity, robust data management, continuous monitoring, and clear ethical guidelines are essential for building trust and accountability.
- Continuously optimize AI solutions and use human-in-the-loop feedback mechanisms to align the technology with user needs and ethical standards.
- Just start developing your own GenAI solutions with this guide under your arm. The most important thing is to start and learn as you go.







#### Generative Artificial Intelligence (AI) has been the talk of the town in many companies for a number of years. From a niche development, this advanced technology grew into an essential part of the business process, which offers tools such as natural language processing, image generation and predictive analysis. The great appeal of Generative AI lies in its ability to stimulate creativity and streamline operations. Efficiency and innovation are given a huge boost thanks to GenAI.

#### Challenges in integrating Generative AI:

The integration of generative AI into business process has enormous potential. However, it is not so easy

to translate that potential into suitable use cases. In their quest for effective GenAI solutions and their implementation, organizations face several barriers:

- Organizations lack the in-house expertise to understand GenAl's full potential and limitations
- Integrating GenAl into the existing IT landscape can be tricky
- There are concerns about data privacy and the ethical aspects of GenAl
- The search for use cases that add value and stimulate innovation is difficult
- Organizations must make significant financial investments for the implementation of AI solutions

#### Our approach in four practical steps:

Generative AI in 4 practical steps:

In this article, we describe how organizations can work on









#### Step #1 – Find the Right Use Cases

Generative AI is a complex field that requires a deep understanding of machine learning, data science, and artificial intelligence. Many organizations lack the expertise needed to fully understand the possibilities and limitations of generative AI. This knowledge gap can make it difficult to understand how AI enables you to seize opportunities or solve specific business problems.

**Discovery Workshop:** Your organization's GenAl journey should start with a Discovery Workshop. Such a workshop provides insight into what GenAl can do for your organization, and a platform for an exploratory dialogue with experienced professionals. In the Discovery Workshop, various generic use cases from different sectors are shared and off-the-shelf solutions are presented. In this way, the workshop helps identify potential use cases for your organization.

**Next phase:** Once the use cases have been determined, it's time for the next phase.

## Step #2 – Start small, but build in the ability to scale up

While most organizations start with a few specific use cases, new use cases inevitably emerge over time. To avoid having to develop each proof of value (PoV) or pilot to prove the potential and effectiveness of identified use cases separately, we recommend that you adopt a GenAI Factory approach. The GenAI Factory approach facilitates rapid prototyping, translating ideas into a PoV

without having to set up the entire infrastructure over and over again. In this way, this concept provides an organizational and technical structure to scale multiple initiatives from PoV to production.

#### Enterprise-Grade Cloud-Native Building Blocks:

By using enterprise-grade Cloud-native building blocks (e.g., Azure, AWS, Google Cloud, Databricks), scalability is guaranteed from the start, following the start-right, stay-right principle. This method guarantees a robust foundation and is therefore essential for the long-term success of our GenAI initiatives.

The backbone of our GenAI Factory consists of a solid infrastructure of advanced hardware, software, and network resources. This infrastructure allows us to efficiently develop and deploy advanced AI solutions without the need for custom solutions for each new use case.

The GenAI Factory concept is structured around several key components:

- GenAI Governance: An umbrella entity responsible for consolidating and managing all GenAI activities within the organization.
- Business Impact & Value Measurement: A central and neutral team that prioritizes and measures the business impact of all GenAI use cases.

- Agile Development & Operations: Focuses on bringing the best use cases into full production and continuously upgrading existing projects.
- Standardized Technology: Radical standardization results in a coherent strategy around technology, and guaranteed compliance with regulations.
- Workforce Enablement: Training to build your workforce's GenAI skills and increase the adoption of technology platforms and assets.

By integrating these components, the GenAI Factory concept allows for efficient scaling of AI initiatives, allowing your organization to maintain compliance and continuously innovate – without customization for each new use case.

#### Step #3 – Integrate responsible and ethical AI

The rapid development of artificial intelligence (AI) is ushering in a transformative era of unprecedented innovation. But we all have a great responsibility in this. We cannot stress enough the importance of responsible and ethical AI; it forms the basis for sustainable trust in and accountability for our AI systems.

Only if we deploy and develop AI technologies responsibly can we mitigate potential risks such as bias, privacy violations, and unforeseen, negative consequences. By prioritizing ethical considerations, you not only protect shared societal values but also promote adoption and trust in AI solutions.

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#### Guiding principles for responsible and ethical AI development:

- 1. Transparency:
  - Make AI algorithms and decision-making processes understandable for all stakeholders. Transparency in every step of the process increases trust.
  - Provide clear documentation. And make sure you can explain how AI systems work. This promotes trust and accountability.

#### 2. Inclusivity:

- Involve diverse teams in the development and implementation of AI technologies.
- Make sure AI is trained with different perspectives, to avoid bias.

#### 3. Robust Data Management:

- Pay attention to data governance, to ensure data privacy and security.
- Maintain strict ethical standards when collecting and using data.
- Implement strict protocols for data anonymization, consent, and access control.

#### 4. Continue monitoring en auditing:

- Implement mechanisms for the regular evaluation of Al's performance and its impact on users.
- Ensure that AI systems adhere to ethical standards.
- Take effective action quickly if AI systems deviate from ethical standards.

#### 5. Clear ethical guidelines and principles:

- Establish guidelines for AI development and deployment.
- Align these guidelines with societal values and human rights, so that AI technologies contribute to the greater good.

#### 6. A culture of ethical AI:

- Foster a culture that emphasizes ethical AI within the organization.
- Educate employees about the ethical implications of AI.
- Encourage employees to speak up when confronted with unethical practices.
- Ensure that ethical considerations are embedded in the organizational culture so that responsible AI practices are consistently implemented.

#### Step #4 – Focus on User Adoption and Value Creation

The successful adoption of generative AI within your organization stands or falls with user adoption. To ensure this in the long term, you must continuously optimise AI solutions. Human-in-the-loop (HITL) mechanisms for feedback are indispensable in this regard. If you succeed in this, you will maximize the return on AI investments and stimulate significant value creation.

#### Human-in-the-Loop Feedback Mechanism:

Human-in-the-loop feedback mechanisms are crucial in refining AI systems. Through HITL, you make human expertise and opinions part of the AI life cycle. This allows the technology to develop in the right way, in line with the wishes of users and ethical standards. And this allows you to address potential instances of bias and increase the accuracy and relevance of the system.

Feedback loops can be set up at different stages of AI deployment. During the initial stages, user feedback helps identify relevant issues and refine the functionalities of the AI

solution. As the system matures, continuous feedback ensures that the AI adapts to changing requirements. Moreover, in this way you ensure that AI remains effective in solving complex problems.

#### Value creation through continuous optimization:

To truly benefit from GenAI, organizations must focus on constant optimization. This includes not only technological sophistication but also aligning AI capabilities with business objectives. Optimization is a requirement to continue to maximize and guarantee the efficiency and effectiveness of the AI solution.

Data-driven insights are of great importance here. You gain that insight by analyzing performance metrics and user interactions. This allows you to identify areas for improvement and take the right measures. In this way, you continue to work on user satisfaction and operational efficiency. Continuous optimization ensures that AI investments remain relevant and continue to contribute to the strategic goals of the organization.





#### Fostering a culture of innovation:

Generative AI thrives on a culture of innovation. A culture that encourages experimentation, encourages learning and promotes the adoption of new technologies. As a leader, you play an important role in supporting AI initiatives. For example, by freeing up the necessary resources, and creating an environment in which employees feel empowered to discover and innovate.

Training and education are essential in fostering this culture. Employees need to understand the possibilities and limitations of AI, and the ethical considerations that come with it. By providing your employees with the necessary knowledge and skills, your organization can promote the responsible and effective application of Al.

The road to successful AI adoption: Ultimately, the successful adoption of GenAI depends on the integration of Human-in-the-loop feedback mechanisms, and a relentless search for value creation. By prioritizing user feedback and continuously optimizing AI solutions, you can unlock the full potential of the technology. This will not only drive user satisfaction but also promote the growth of your

business and build competitive advantage.

Organizations that embrace these principles are well-positioned to navigate the complexities of AI implementation and reap the benefits of their investments in generative AI. As technology evolves, you need to stick to these principles. This ensures that AI systems remain adaptive, ethical and impactful.

#### Conclusion:

There is a great future for Generative AI. As the development of technology progresses, AI systems will become more and more sophisticated. They will be able to perform increasingly complex tasks. GenAI is here to stay; every organization needs to invest in it to stay relevant. Our 4-step approach can provide inspiration to get started with this promising technology.

In this article, we discussed all the phases involved in the successful, ethical implementation of AI in your organization. From the initial inspiration and problem identification phase, through the development and acceleration of solutions that offer added value, to the final upscaling and integration. This gives you a practical approach to sustainably embed the transformative potential of GenAI in your organization.

#### About the authors



#### Sjoukje Zaal | Chief Technology Officer Gen AI Cloud Northern and Central Europe

As Chief Technology Officer at Capgemini, Sjoukje brings more than 20 years of experience in architecture, development and consultancy, with a strong focus on AI, data and innovation. She also leads Capgemini's architecture community in the Netherlands. In addition, Sjoukje is director of the Global AI Community, where they encourage knowledge sharing and collaboration. As an international speaker, event organizer, and author, she is passionate about advancing thought leadership and shaping the future of technology.

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#### Douwe van de Ruit | Lead Architect Gen Al Cloud Northern and Central Europe

Douwe is a Principal Consultant specializing in generative Artificial Intelligence and Cloud technology. He is currently Lead GenAI for the NL & NCE Cloud CoEs. Prior to joining Capgemini, Douwe worked as a solution architect with a strong focus on the adoption of emerging technologies. With more than 20 years of experience in the IT sector, he focuses on discovering and unlocking value through innovative solutions.

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# O4 Al and exam stress: How smart machines are assessed

Using our own learning ability to test AI solutions.



#### Highlights:

- To test AI, we cannot compare an expected result with the given result. After all, an AI system can give a completely different answer tomorrow.
- Insight into the process of arriving at an AI solution helps to set up structured testing for AI as well.
- Test data and training data are crucial for the successful execution of an AI testing strategy.
- Testing AI needs its own approach. By looking at how we learn and apply knowledge in combination with examination, a good method is needed to measure and continue to monitor the quality of AI.

Structured testing is our basis for defining a testing strategy<sup>1</sup>. A good or bad result after performing a test gives us all the information we need to work on the quality of a product. A product can be anything from a banking app, a customer service website, an application that tracks all the parts that go into an automobile manufacturing process to an MRI machine for a hospital. When developing an AI solution, testing is crucial<sup>2</sup>.

<sup>2.</sup> Testing in the digital age; AI makes the difference, 2028; ISBN, 9789075414875









<sup>1.</sup> TMAP: Quality for DevOps Teams, 2020 ; ISBN, 9789075414899



Of course, it must be ensured that the functional and nonfunctional specifications are met, but testing AI solutions is different from what we are used to.

There is a big difference between an AI solution and the traditional more deterministic solution:

• The behavior is much more difficult to predict. At one time, an outcome may differ from another. We have to take into account test situations that cover this. You can limit this by staying away from continuously learning systems that have a time parameter in their outcomes. In that case, the algorithm learns with the training data set and we then test the outcome as we were used to for non-AI systems. A structured test strategy can work well with this. The box below graphically shows how we distinguish between training data and test data as part of the entire dataset (see figure 1 and the text box "The dataset explained").

• There is no black and white outcome for a given situation. Test predictions are no longer 1 or 0 but have a bandwidth. Make sure your test cases reflect this behavior well.

• Non-linear behavior of AI solutions can result in so-called hallucinations. Hallucinations are outcomes that are created by an AI but do not exist. A bibliography link in a scientific article can be perfectly recreated by an AI with all the associated look and feel. If it is then a link to a non-existent article with a madeup title and a randomly generated link (which does look like a real link) then we speak of a hallucination.

• In addition to a training dataset, we need a test dataset to test input-output combinations. The number of combinations is likely to be much higher for AI systems than for non-AI systems to cover this. Automation for testing these situations is essential.

#### The dataset explained

The dataset contains all the data available to the AI solution. Often it is a company's historical data and must be processed to be useful. Raw data often contains incomplete items or incorrectly tagged items. These must first be edited to serve as correct input. After all, wrong input leads to wrong output.

#### Trainingsdata

Training data is a subset of the dataset. This data is used to train the model during the product development process



The dataset explained









#### What needs to be tested?

When developing an AI solution, the testing task is a crucial activity. Whoever performs this task must ensure that the functional and non-functional specifications are fulfilled. Due to the complex operation of an AI system, many more input values must be tested to verify a robust solution.

Some examples of questions we might ask when testing AI include:

- What are the acceptance criteria?
- How can we design test cases that test these criteria with minimal effort?
- Are there different datasets for training data and test data?
- Do the test dates sufficiently represent the expected dates?
- Are the test and training dates in accordance with the legal framework?
- Are the training dates biased?
- What is the expected result of the model?
- Is the model under- or over-fitted?
- Does the solution behave ethically?
- Is the performance and robustness of the solution good enough?

#### Test objects in AI systems

AI systems contain many components, just like classic software solutions. But the components and especially their role and properties are different. See below for an overview and a brief description of the components to be tested in an AI system.



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**<sup>3.</sup> Underfitting** occurs when a model is too simple to learn the underlying structure of the data. This means that the model is not able to recognize patterns in the training data, resulting in poor performance both on the training data and on new data. Overfitting, on the other hand, occurs when a model performs too well on the training data, but generalizes poorly to new data. This means that the model has learned too much detail and noise from the training data, so it doesn't perform well on new data.

#### Definitions model of testing AI solutions.

#### Learned data

After training an AI solution, a specific input-output relationship is established. The data that now comes out of the system based on training data is called learned data.

#### Testdata

Test data is another subset of the dataset and is used to verify that the model is working as intended.

It is essential not to use training data as test data because verifying whether the AI has learned what it needs to make decisions requires different data than the training data. If learning has been done with test data, the test will always show an outcome that is correct. The learned part will produce the same result with the same data.

#### Expected result

Based on test data and a trained system, the output is predicted. This is the so-called expected result. Expected results are compared to actual results. This can be done through research, continuous inspection, or classic validation. Continuous inspection can also be done on solutions in the use phase.

#### Operational data

The data in the field. Actual values used by the AI solution.

#### Model

The model consists of the algorithms that are used, with which the AI learns from the given data.

#### Training (fase)

The training is the process in which the algorithm learns from data and makes predictions.

#### Test (phase)

After the model has been trained, it can be tested using test data.

#### Use (phase)

The AI system now creates with real data output. When the input is found that cannot be processed into any output, it will step out of its routine and a notification will be given. This is useful input for testing new versions of the solution.

#### Broncode (Algorithm)

An AI system has far fewer lines of code than traditional solutions. Still, there is source code that can contain errors and therefore unit testing and other relevant tests must be present at the development level.

#### Infrastructure

The infrastructure has a strong link to the non-functional specifications of a product, which must be checked and tested.

#### Specifications

The specifications in the field of AI must be carefully inspected. The technology is new, so it's possible that the expectations are unrealistic or outside legal or ethical boundaries.

#### Input/output values

The most basic test objects are the input and output values. This is where the acceptance criteria are verified. The input values in AI solutions are crucial because it is unknown how the data is processed.





Learning is a skill that humans have possessed for thousands of years, and over the years, we have gained a lot of insight into how humans learn. Now that we are creating machines that learn, we also want to test whether the machine has learned well. With a background in software testing, it may seem logical to approach AI testing as software testing. But for people with an educational background, it makes much more sense to approach a learning machine in the same way as a student.

What would the latter mean for testing AI? It starts with the learning objectives. What should the system learn? This concerns desired competencies, desired performance level and the way of learning (e.g. supervised, unsupervised or through rewards).

When the system learns, we want to know how well it learns. This is a matter of measuring. Just like when humans learn, we can make the system take an exam to show its abilities. And ofcourse we do provisional exams before the final exam to monitor the learning curve. All this can be seen as a performance analysis of the intelligent machine.

This performance analysis can be displayed via a dashboard that shows the relevant aspects and the progress over time. This can also be used to determine when the intelligent machine has learned enough to provide business value.

For learning, the system receives specific training data that forms the basis for its learning process. But algorithms are also selected that best suit the purpose of the intelligent machine.

During testing, the testers enter specific test data into the system to verify that the responses are as expected. And based on the analysis of the learning abilities and results, new training data is created to further improve the learning process and test data is created to be used in a subsequent exam.

#### Examination

People learn all kinds of skills, and some of them have to be proven such as, for example, the skills to drive a car. In that case, they are examined to assess whether they perform well enough. After they pass the exam, we trust that people will always make the right decisions in the future.



The exam checks whether you have learned and can apply a set of rules correctly. The interesting thing is that, for example in driving, the real learning only really starts after the exam. Over time, driving will put you in many situations where you need to apply these rules. Even after a lifetime of driving, you haven't experienced all the possible situations you can end up in. No two people have the same experiences with driving. Nevertheless, we trust that all people with a driver's license apply the rules correctly in every new situation.

The same mindset can be applied to AI solutions, and we can distinguish between:

- examination of AI
- periodic examination of AI
- continuous examination of AI





#### Examination of AI

Just like with humans, we also want to know whether an intelligent machine is performing well enough. Testing is of course the basic approach to evaluating quality. Since it is not possible to test all the possibilities, we can use the approach of examination to decide whether the artificial intelligence can be trusted to perform the task. Once the AI passes the exam, it can be used in live operations.

#### Periodic examination of AI

If an AI algorithm is used to learn with data and the outcome is frozen, the intelligent machine does not change its behavior after the exam. However, if the intelligent machine continues to learn, we will have to retake exams from time to time.

With an intelligent system, a periodic exam is quite possible, provided that the exam itself can also be carried out by an automated system. This allows a test to be carried out quickly and it is not boring to have to perform the same test continuously. It is therefore possible to add continuous variation (to a stable test basis) to keep the continuous learning system sharp and to see if all responses remain within set examination limits.

#### Continue examinering van Al

In periodic examinations, a fundamental question is how often this exam should be taken. This has to do with the periodicity of the use of the intelligent machine, but most machines will function continuously. It will probably be necessary to carry out continuous "operational review". Especially with closed-loop AI and other forms of AI systems that continuously improve their behavior, it is important to implement continuous monitoring of the results to verify that the results remain within the tolerances defined as "good behavior."

#### Did the AI system pass or fail its exam?

"Does the AI system have exam stress?" is therefore not such a strange question. Perhaps examination should be included in the product development cycle. A regular regression test does not give confidence that evolving AI solutions are as robust and "correct" as you would like. An exam is designed to have confidence that the person being examined (or in this case, AI solution) can perform the task now and in the future.

Re-examination is also a good idea. Keep the level of knowledge up-to-date and check whether new insights and new situations are still being handled according to the examination standard. Als may have to take a lot of exams at a much higher frequency than humans. With test automation, we can easily implement a mechanism of regular AI examination with a high frequency (daily or even hourly!).

By taking many exams, we can continuously look at the report of the AI. Just like at school, it can be determined whether the AI has passed or failed to move on to the next period or the next level where its environment slowly but surely becomes more complex.

#### Over de auteur



**Tom van de Ven |** Portfolio director Capgemini Engineering (NL) Tom is Portfolio Director for Capgemini Engineering and High-Tech enthusiast. He speaks and inspires for and about tech and is the author of the books IoTMap and Testing in the digital age.









# 05 *Gen AI:* the truth does not claim itself

Generative Artificial Intelligence (AI) has made significant strides in recent years and has become a powerful tool in various domains, from art and literature to science and technology. Generative AI can summarize texts, generate illustrations, and come up with unexpected solutions to existing problems. It is mainly because of the latter that the use of generative AI is so attractive to business.



- Truthful Artificial Intelligence (AI) is essential for critical applications
- Al systems must be fed with true and up-to-date information in order to learn.
- Strict training, validation and testing procedures are necessary.
- Domain experts will have to check the veracity of the AI answers.
- AI will never always be able to speak the truth because the world is too complex.







#### Language models and generative AI

Generative AI is essentially a "language model". It learns to extract the underlying structure based on statistical analyses of existing objects, such as text fragments, and to generate new language based on this. These can be texts, but also visual or musical language. Because knowledge is also hidden in the text fragments with which AI learns, generative AI is also used as a knowledge system. We can give an AI assignments to come up with answers to our questions. These answers are based on what the AI has learned. This knowledge with which programmers have fed the AI will then be ingeniously merged and reproduced by the Generative Al system.

"We think people fail, but technology doesn't." - Marleen Stikker<sup>1</sup>





But generative AI models often present inaccurate answers and pretend that these answers are correct. This phenomenon is called AI hallucinations. AI hallucinations happen when an AI makes up answers to a question instead of offering accurate information. Al hallucinations can vary in severity<sup>2</sup>, from the AI getting small details wrong in an answer, to making up the entire response. They are often caused by limited information in the system, biases in training data, and problems with the algorithm.

Hallucinations can be combated in several ways. On the input side by using correct, correct and up-to-date data. So not the entire internet as a data source, but carefully selected data sources of which the correctness is high. For example, in health care, peer-reviewed articles and handbooks are used. On the output side, the answers can be compared with, for example, the results from other knowledge systems, or it can be checked whether there is evidence – substantiation – in the data sources for the answer.

#### The Truth Problem of AI

This brings us to the core of AI's truth problem<sup>3</sup>. Even manufacturers of AI, such as OpenAI, warn that the answers their AI can provide could be wrong. And given the statistical operation of these AI algorithms, it will get better over time, but never completely perfect. When we want to write a fairy tale or create a fantasy image, veracity is not that important. But when it comes to AI-based decisions with major consequences, correctness is essential when using generative AI.

When Generative AI draws a hand with six fingers, it's funny. But in many domains, correctness is more important. Domains such as medical diagnostics, healthcare, financial decisions, legal applications, education, research, and media and information dissemination. In all these domains, mistakes can lead to serious consequences, ranging from health risks and financial losses to legal complications and the spread of disinformation: *fake news*.







<sup>1.</sup> https://waag.org/nl/article/technologie-kan-ook-falen/

<sup>2.</sup> https://www.palantir.net/blog/practical-ai-hallucination-awareness

<sup>3.</sup> https://charitydigital.org.uk/topics/generative-ai-content-the-need-for-accuracy-11306

# 01

#### 1. Medical Diagnostics and Healthcare

In healthcare, generative AI can be used to analyze medical images, make diagnoses, and recommend treatments. In this context, correctness is of vital importance. An incorrect diagnosis or treatment plan can have serious consequences for the patient's health and can even be life-threatening. Therefore, AI systems in healthcare must be thoroughly tested and validated to ensure that they deliver accurate and reliable results.

A concrete example is an AI system that analyzes an X-ray of a patient and wrongly concludes that there are no signs of cancer, while in reality a tumor is present. This can lead to the patient not receiving the necessary treatment, which can significantly worsen the patient's prognosis.

02

#### 2. Financial decisions

Generative AI is increasingly being used in the financial industry for tasks such as predicting market trends, managing investment portfolios, and detecting fraud. In this sector, errors can lead to significant financial consequences, both for individuals and for companies. Correctness is crucial here to ensure that investments are safe and that financial decisions are based on accurate data and analytics.

#### 03

#### 3. Legal applications

In the legal industry, generative AI can be used to draft legal documents, analyze case law, and provide legal advice. Incorrect information or interpretations can lead to legal complications, wrong decisions, and even lawsuits. Therefore, it is essential that AI systems are accurate and reliable in this context to support legal professionals in their work.

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Insufficient clarity on the underlying data from pre-trained models, potential biases, and a lack of inclusivity pose legal and reputational risks to organizations, as do "hallucinations" and the potential for data breaches. (Capgemini<sup>4</sup>)

# 04

#### 4. Education and research

Generative AI can be a valuable tool in education and research, for example in generating educational materials, summarizing scientific articles, and supporting research projects. In this context, correctness is important to ensure that students and researchers have access to accurate and reliable information. Errors in teaching materials can lead to misunderstandings and wrong conclusions, which can undermine the quality of teaching and research.

05

#### 5. Media and information dissemination

In the media industry, generative AI is used for writing news articles, creating content, and disseminating information. Accuracy is of great importance here to ensure the integrity of the information and to prevent the spread of disinformation. False or misleading information can lead to loss of trust in the media, public "confusion", political deception, and even civil unrest.

4. https://prod.ucwe.capgemini.com/wp-content/uploads/2023/07/GENERATIVE-AI\_-Final-Web-1-1.pdf

5. https://www.capgemini.com/insights/research-library/ai-and-the-ethical-conundrum/



8000000 800000 8000000 **Customers expect** transparent and honest NAMES OF DES Al interactions, with clear accountability. (Capgemini<sup>5</sup>)



#### Testing, testing and more testing

valuable insights into the AI's real-world Correctness is fundamental in generative AI, especially performance. Users can report errors and make in domains where the consequences of errors can suggestions for improvements, which can help to be severe. Ensuring the accuracy and reliability of AI further refine the AI. systems is essential to maximize the benefits of this 5. Bias-mitigation techniques: Techniques such as technology and minimize the risks. By implementing data augmentation, fairness requirements, and strict validation and testing procedures and constantly bias-detection algorithms can help reduce bias in striving to improve, we can ensure that generative AI generative AI models. Audits and bias assessments makes a positive and trustworthy contribution to our should be an ongoing part of the testing process. society. Below I list some steps and methods that are commonly used:

- 1. Comparison to the Gold Standard: A common method is to compare the output of the AI to a "gold standard" or reference. This involves comparing the generated results with a set of preapproved and correct answers created by experts.
- 2. Dual modeling: Dual modeling in AI testing refers to the use of two different models used together during the testing process. One model is usually the Al system being tested and the other is a reference or oracle model. The oracle model is considered the source of truth and is used to verify the output of the tested AI system.
- 3. Human evaluation: Human evaluators, often experts in the relevant domain, assess the AI's output for accuracy, relevance, and coherence. This can help identify errors that may not be detected by automatic methods.

4. User feedback: End-user feedback can provide

6. Testing in different scenarios: It is important to test the AI in a wide range of scenarios and contexts to ensure that it is robust and reliable. This may involve exposing the AI to different types of inputs and situations to see how well it performs under different conditions.

Continuous improvement, the ongoing process of analyzing performance, identifying opportunities, and making incremental changes – helps keep the AI system fit. This ensures that the AI stays up-to-date and can deal with new challenges and changes in the environment.

#### The role of domain experts

By combining these validation ¬methods, developers and researchers can effectively assess and improve the correctness of generative AI systems. But the developers and researchers must then know what

correct information is. This means that they must have domain knowledge. Domain experts also ensure that the AI applications are in line with the business objectives and processes. They also play an important role in developing guidelines for the responsible use of AI. Their expertise ensures that AI applications are used effectively, ethically, and responsibly.

The role of domain experts in developing generative AI is therefore crucial. They bring specialized knowledge and experience that are essential for designing, training, and implementing AI systems that deliver reliable and accurate results. Domain experts help define the right datasets, validate the output, and ensure the relevance of the AI applications to specific industries or fields.

If you want to know if an X-ray has been correctly interpreted by the AI, you will need a medical specialist or researcher to check the AI. You can't have that done by a random data analyst or prompt engineer. We often think that an AI system can take over work from experts, but as long as the correctness of the results of AI is not guaranteed, experts will have to be more involved.

The rise of generative AI highlights the importance of trustworthy data, as Al insights are only as powerful as the data they feed. (Dutch IT Leaders<sup>6</sup>)





#### **Content curation**

Generative AI does amazing things by "reading" all of your business information and finding the answer(s) to one or more questions. But the content that the Al reads must be accurate to arrive at an accurate answer. Curated content is approved, accurate, and quality content and contains the right answers for the organization.

The most important task of a curator<sup>7</sup> in the museum consists of, among other things, choosing the objects to be shown - also called "meaningful choice" - for an exhibition. "Meaningful choice" is an activity that is also needed in AI systems. The so-called content curator determines which information is relevant, reliable, complete, up-to-date and accurate – i.e. correct and true. It is precisely this information with which we want to train the AI. Because this determines the correctness of the results to a large extent.

While content curators can make valuable contributions, they are not a requirement for success in the content curation strategy<sup>8</sup>. Factors such as cost, presence of in-house expertise, and checking for personal bias should also be considered when deciding whether or not to appoint a content curator.

Employees - who read and process all the articles and insights you hope to unlock - can also do curation work. With the right process and technologies, these individuals are able to manage content as effectively as a separate content curator.

But despite everything, content curation an expensive and time-consuming – but bitterly necessary – affair. Only with a good cost-benefit analysis can it be shown whether the investments at the front end of the AI yield cost benefits at the back end<sup>9</sup>.

#### Always correct?

Will AI ever become perfect and flawless? It's an interesting question. AI systems, including generative AI, are designed to perform tasks that normally require human intelligence. While AI can improve significantly and become more sophisticated, it is unlikely that AI will ever be completely flawless. This is due to several factors:

- 1. Complexity of the world: The world is extremely complex and changeable, which means that AI must be able to deal with an infinite number of scenarios and variables.
- 2. Limitations of data: AI learns from data. If the data is incomplete, biased, or incorrect, it can affect the performance of Al.
- 3. Changing contexts: What is considered "correct" can change depending on the context, culture, or time, making it difficult for AI to always be "perfect."
- 4. Unpredictability: Unforeseen events or situations that are not included in the training data can lead to errors. Past performance is no guarantee of future performance.

It is important to keep improving AI systems and AI can be designed to be exceptionally accurate in many learning from mistakes to increase their reliability cases, but the possibility of completely eliminating and effectiveness. Therefore, ongoing collaboration



errors is not realistic. The question is, is this bad? People are not flawless either. It goes too far to go into this in more detail, but as long as people "blindly" believe the results of Generative AI, there is reason to be vigilant. Especially when AI does not indicate when it is uncertain about an outcome and starts bluffing.

At the moment, a whopping 73 percent of consumers rely on AI-generated content. However, this trust comes with risks, especially when the AI model is capable of hallucinating in areas that the user has limited knowledge of. (Capgemini<sup>10</sup>)

between AI developers, domain experts, and users is essential to optimize AI systems and minimize error margins.

#### Conclusion

Correctness is a fundamental aspect of generative AI, especially in domains where the consequences of errors are severe. Ensuring the accuracy and reliability of AI systems is essential to maximize the benefits of this technology and minimize the risks. By implementing strict training, validation, and testing procedures, and by constantly striving for improvement, we can ensure that generative AI makes a positive and trustworthy contribution to our society.

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#### Example: Improving speech recognition

How user feedback has led to improvements in an AI system in speech ¬recognition technologies, such as those of virtual assistants such as Siri, Google Assistant and Alexa.

Problem: In the initial stages, many users had issues with the accuracy of speech recognition. The AI systems had difficulty understanding different accents, dialects, and speaking styles, which led to frustration among users.

User feedback: Users started giving feedback about the issues they were experiencing. They reported specific instances where the AI didn't recognize or misinterpret their speech. This feedback was collected through various channels, such as app reviews, forums, and instant notifications within the apps.

#### Improvements:

1. Training with diverse data: Based on the feedback, developers trained the AI systems with a much more diverse dataset that included different accents, dialects, and speaking styles. This helped the AI perform better in real-world scenarios.

- 2. Algorithm Adjustment: The algorithms were modified to better deal with variations in speech. This included improvements in the way the AI recognizes and processes phonetic patterns.
- 3. Contextual understanding: User feedback also led to improvements in the contextual understanding of the AI. This means that the AI became better able to understand the context of a conversation and therefore provide more accurate answers.
- 4. Continuous updates: Based on ongoing feedback, the developers continue to update and improve the systems on a regular basis. This ensures that the AI continues to adapt to the changing needs and expectations of users.

#### Result

Thanks to these improvements, the accuracy of speech recognition technologies has increased significantly. Users now experience fewer errors and a more seamless interaction with their virtual assistants. This example illustrates how valuable user feedback can be in refining and improving AI systems.

# Go ahead, I'm listening...

#### Over de auteur



#### **Reinoud Kaasschieter** | Enterprise Architect and AI expert

Reinoud is an enterprise architect in the Dutch public sector and an expert in the field of artificial intelligence and ethics. He actively shares his knowledge and insights by publishing and speaking about AI and ethics, both within Capgemini and beyond.

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# Ready, set, go! Preparing customer data for Gen Alin CX 06

What steps can be taken now to get a head start in the Gen Al-driven race to the CX top



#### Highlights:

- Gen AI promises to revolutionize the way companies shape customer interactions
- A crucial condition for delivering on that promise is the availability of accurate, structured and accessible customer data
- Companies that invest in their data quality now are taking a first step towards an unparalleled competitive advantage in customer experience (CX)
- A Customer Data Platform (CDP) can help you get that edge

Hyper-personalization, real-time recommendations, and auto-generated content are no longer in the future, but are becoming the new norm in customer experience (CX). However, even Gen AI crashes if customer data is scattered, outdated, or incomplete. Companies that already put their customer data in order are in pole position to realize the potential.

#### With blinders on

Gen AI is the buzzword of 2024 and its importance for marketing, sales and service is already quite widely recognized. In particular, we see fairly small-scale Proof of Concepts in which (Gen) AI is applied within a limited field to increase employee productivity and save costs. Gen AI is therefore often approached 'with blinders on': companies are feasting on what is directly in sight, so that it can be applied practically in the short term.







#### Most used contemporary applications of (Gen) AI within CX

- **Content creation and copywriting:** From creating different variants of product descriptions to filling in the background of a campaign photo
- **Campaign optimization:** Suggest the most appropriate times of the day to send emails, but also recommendations to adjust the contact pressure
- **Chatbots:** Used in particular to answer customer service questions or to make recommendations
- Translation and transcriptions: Including capturing customer service conversations or translating marketing materials for global companies
- Sentiment and data analysis: From estimating a customer's state of mind to analyzing data at scale to recognize patterns

#### Changing the road ahead

This focus can probably be defended from the 70-20-10 ratio for the innovation horizons, which prescribes to devote only 10% of the attention to disruptive innovation. Still, it doesn't hurt to take off the blinders and take a look at how Gen can use AI to disrupt CX. It then becomes clear that the true power of Gen AI lies in analyzing vast amounts of data and then using those insights to be

creative and adaptive themselves. That is, generating new content and interactions and adapting them at lightning speed based on experimentation and feedback. Despite the fact that this takes place in an aggregated way, it offers enormous opportunities to personalize on an individual level. Imagine that the tone, message, timing, and channel are tailored to a customer's needs, across marketing, sales, and service. Gen AI is the first technology to enable such a data-driven approach with this scale and speed.

#### **Overcoming obstacles**

The truth is that we are not there yet. There are still significant technical challenges to achieve the promised real-time adaptivity. In short, to be able to analyze and respond to the enormous amounts of data without delays. In addition, there are understandably concerns about privacy, security and ethics, where companies are wary of the strict regulations and the risks of introducing bias into their models. Expertise and infrastructure must also be built up to implement and manage Gen AI. But perhaps the biggest challenge, and one that is often overlooked, is data quality and access. Many organizations have to deal with disorganized, incomplete, or outdated data. They have enormous challenges in integrating data across marketing, sales and service, which means that there is no complete customer view. And with that, the data foundation that Gen AI needs to work its magic is missing.



#### Checkbox: Is your customer data ready for Gen AI in CX?

- **Relevant:** Data should directly contribute to customer insights and interaction optimization
  - Accurate: The data must be up-to-date and free of errors and biases
  - **Complete:** Relevant customer characteristics, behaviors, and preferences should be captured as comprehensively as possible
  - Accessible: Data should be easily accessible, without silos or barriers between different departments
  - **Real-time:** Data should be updated in real-time as much as possible in response to changing customer behavior
- **Consistent:** Data should be captured in a standardized and uniform manner





#### A Customer Data Platform as a turbocharger

The good news is that the challenge of data quality is increasingly being recognized, so CX vendors are jumping on it. Microsoft, Salesforce and Adobe, among others, offer a CDP (Customer Data Platform) as a central data foundation within their stack. A CDP enables companies to centralize, enrich and use all customer data for better interactions across the entire customer journey. It builds 360-degree customer profiles by combining data from different sources and channels, such as CRM systems, e-commerce platforms, websites, apps, social media, and physical interactions in stores. This gives companies a good insight into who their customers are and what motivates them. A CDP then offers extensive integration options to activate this data in other CX tools, for example in the form of personalized emails, product recommendations or real-time push notifications.

#### Out of the starting blocks

Of course, a CDP is not a panacea – here too, "Garbage in, garbage out" applies. If the data you enter is of low quality, incomplete, or erroneous, the resulting customer profiles will also be unreliable or useless. However, a CDP can help you get started on data quality in several ways:

- A CDP is ideally suited to collect and consolidate data across different sources in one central place. This reduces the risks of outdated or duplicate data and ensures that a single system is available as input for Gen AI;
- CDPs normalize and standardize customer data so that all data comes in a consistent format. Gen AI models receive uniform data and do not have to deal with different data formats, which increases reliability and effectiveness;
- Customer Data Platforms are made to receive and send data in real-time. This also makes up-to-date data available for Gen AI to respond quickly to changing customer behavior;
- A CDP can help tremendously with the challenge of identity resolution (matching multiple customer profiles and tracing them back to the same person) and managing customer data according to legal and privacy regulations. This prevents duplication and ensures that only authorized data is used in AI processes.

And last but not least: A CDP can also deliver value in the short term. The use cases are not limited to Gen AI-generated content. Better customer insight also helps to improve 'oldfashioned' human-to-human interactions. This allows a CDP

to build a nice bridge between the innovation horizons and ensure future-proofing and practical applicability in the short term (especially for the decision-makers with blinders on).

#### Full speed ahead

The race to the top is never without obstacles, but it helps enormously if you start from a head start. A strong customer data foundation can provide that edge for Gen AI in CX. Companies would do well to evaluate their customer data for accuracy, completeness, accessibility and consistency. A CDP can then help to improve this. In this way, companies can already lay the necessary foundation for Gen AI to provide personalized customer experiences. At the same time, this can also help to have more relevant interactions in the short term. So why wait? Ready, set, go!

#### About the author



#### Mandy Steenbergen | Marketing & CX Architect

Mandy is a Marketing & CX Architect within the Digital Customer Experience practice. She helps clients design and execute transformations to improve the digital experience.

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#### Harness the power of GenAl $\mathbf{07}$ for operational resilience and regulatory compliance

Generative AI: Strengthening Business Operations with Resilience and Compliance

Companies need to innovate digitally to stay competitive. GenAI tools offer solutions to improve (digital) operational resilience and regulatory compliance. This article explores how GenAI can revolutionize business operations, predict disruptions, and comply with regulations.

#### Highlights:

- AI tools and techniques are transforming business processes by increasing resilience and ensuring compliance.
- High-quality data and structured data management are crucial for accurate AI insights.
- Addressing privacy issues, bias and transparency is essential for successful AI implementations.
- Targeted training programs help employees make effective use of generative AI tools.
- By overcoming data, ethics, and training challenges, companies can gain a competitive advantage.





#### GenAI tools

GenAI, as a subfield of artificial intelligence, focuses on generating new content – text, images, and code – based on existing data. These tools use machine learning algorithms to generate outputs that mimic human creativity and problemsolving skills. In the context of business operations, GenAI tools can analyze vast amounts of data, recognize patterns, and provide actionable insights to improve decision-making processes.

#### Improving operational resilience

Operational resilience is an organization's ability to anticipate, prepare, respond to, and recover from disruptions. This resilience is crucial for maintaining business continuity and minimizing the impact of unexpected events. In the digital age, the importance of digital components in operational resilience is increasing. GenAI tools improve this resilience by using predictive analytics to predict disruptions and enable proactive measures.

For example, Alaska Airlines uses GenAI to analyze flight data, weather patterns, and maintenance data, allowing for proactive maintenance and schedule adjustments. Duke Energy uses GenAI to inspect infrastructure, predict failures, and optimize maintenance by analyzing weather patterns and equipment performance.

#### **Predictive analytics**

GenAI tools also help analyze historical data and identify trends that may indicate potential disruptions. One example of this is Walmart, which is using GenAI to optimize its supply chain. By analyzing vast amounts of data, Walmart's AI systems can predict potential supply chain disruptions and suggest alternative suppliers or routes. But I think of Amazon, which uses GenAI to accurately forecast customer demand. By analyzing historical sales data and market trends, Amazon can predict which products will be in high demand and adjust inventory levels accordingly.

#### Realtime monitoring

Real-time monitoring is essential for maintaining operational resilience. GenAI tools can continuously monitor various aspects of business operations, such as production processes, inventory levels, and customer interactions. By detecting deviations and deviations from normal patterns, signals from these tools can alert decision-makers to potential problems, allowing for early interventions.

In manufacturing, GenAI tools can monitor production lines in real-time, tracking metrics such as machine performance, product quality, and production speed. If an anomaly is detected, such as a sudden drop in production speed or an increase in defective products, the system can alert operators to investigate and resolve the issue, minimizing downtime and maintaining product quality.

Rolls-Royce uses GenAI to monitor real-time data from the engines and can therefore detect anomalies and predict potential failures before they occur. BMW, on the other hand, has implemented AI-driven robots at its Spartanburg plant to optimize production processes.

Retailers and warehouses use GenAI to continuously monitor inventory levels. For example, IKEA uses AI analytics to predict product demand and ensure timely replenishment. This prevents shortages and ensures that customers can always find the products they need.

Gen AI tools helpen ook bij het analyseren van







#### Automated response mechanisms

In the event of a disruption, GenAI tools can automate response mechanisms to minimize downtime and ensure business continuity. If a critical system fails, these tools can automatically redirect tasks to backup systems or initiate predefined recovery procedures.

A recent study shows how Siemens is using GenAI tools to improve operational resilience: The company uses an integrated AI assistant for field maintenance workers, which uses predictive models to predict system failures and send repair teams to the right locations. In addition, the AI assistant provides on-the-spot knowledge about, for example, repair procedures using GenAI models to minimize downtime and ensure business continuity by reducing the need for manual intervention.

#### Ensure regulatory compliance

Regulatory compliance is crucial to business operations, as noncompliance can lead to heavy fines and reputational damage. GenAI tools simplify regulatory compliance by automating tasks and keeping organizations informed about changing regulations.

Compliance with new EU regulations, such as the EU Corporate Sustainability Due Diligence Directive (CSDDD) in 2024, is an example of this. This directive requires companies to address human rights and environmental impact in their operations and supply chains, with GenAI playing a crucial role.

For example, EnerSys, a leading manufacturer of industrial batteries, uses GenAI to improve their sustainability data collection



and reporting. Their AI-powered platform, ESG Flo, processes energy bill data across 180 locations worldwide, improving data accuracy and auditability.

The NIS 2 Cybersecurity Directive imposes stricter requirements, including mandatory incident reporting and enhanced security measures. IBM uses its Watson AI to help businesses comply with cybersecurity regulations. It achieves this by analyzing vast amounts of data to detect potential security incidents. This allows them to ensure that all mandatory incident reports are submitted in a timely manner.

Another example is Darktrace, which uses AI to monitor network traffic in real-time and detect anomalies. This proactive approach enables businesses to quickly identify and respond to potential security threats, thereby complying with the enhanced security measures required by NIS 2.

Splunk also offers AI-driven solutions that help organizations automate their compliance processes. Splunk's AI tools can continuously monitor and analyze security data, helping businesses comply with the latest cybersecurity regulations and report incidents as required.

These examples demonstrate how GenAI tools are already being used by leading companies to automate compliance tasks and improve cybersecurity measures.

Regulations such as the Digital Operational Resilience Act (DORA) and MiFID in the EU impose strict compliance obligations. GenAI tools help by automating compliance monitoring, conducting real-time risk analysis, and ensuring compliance with regulatory frameworks.







For example, HSBC uses AI to monitor transactions in real-time and detect suspicious activit0ies such as money laundering or fraud. Similarly, JPMorgan Chase uses GenAI tools to automate compliance reports and quickly identify irregularities to comply with regulations such as MiFID II. Deutsche Bank's AI platform tracks regulatory changes and adapts compliance strategies, keeping the bank ahead of the curve and avoiding penalties.

#### Challenges and strategies for implementation

While the benefits of GenAI tools are significant, their implementation comes with challenges. Three elements are discussed below.

#### Data quality and integration

GenAI tools require high-quality data for accurate insights, but ensuring data quality and integration is complex. Organizations should implement robust data governance practices and establish data governance structures with clear policies and regular audits. Advanced integration techniques such as Extract, Transform, Load (ETL) processes and the use of data lakes facilitate seamless data exchange. Addressing these challenges ensures that GenAI tools work effectively and deliver valuable insights.

#### Ethical considerations

The use of GenAI tools raises ethical considerations in terms of data privacy, bias, and transparency. Organizations must implement ethical guidelines and ensure that AI algorithms are fair, transparent, and accountable. Regular audits and monitoring can help to identify and reduce any biases in AIgenerated output.

#### Staff training

The implementation of GenAI tools requires a skilled workforce. Organizations should invest in targeted training for relevant employees to ensure effective use of these technologies.

#### About the authors



#### Rahul Rauniyar | Senior Managing Consultant - IT Security Strategy, Risk & Compliance at Capgemini

Rahul is a Senior Managing Consultant at Capgemini NL and leads the IT-security Strategy, Risk & Compliance team in the financial sector. As a DORA Offer Lead, he helps clients improve their digital resilience and compliance. With generative AI, he accelerates compliance processes and strengthens security across industries.

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#### Marieke van de Putte | Global Portfolio Lead Continuous Compliance | Operational Resilience

Marieke van de Putte is a Registered Controller, Cyber Executive and Global and NL Domain Lead for Continuous Compliance. She has more than 25 years of experience advising multinationals in the field of security, risk management and compliance. She is also a board member of Alguity in the Netherlands.

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## **The Retail Revolution with** *Generative AI* - **Driven Robotics** 08

From personalized recommendations to efficient automation

#### Highlights:

- AI-driven robotics is transforming retail with personalized service and efficiency
- RAG combines AI models with real-time data for better product recommendations
- Multi-agent systems optimize complex retail tasks through Chain of Thought prompting
- Practical example: Robot as interactive shopping assistant at major Dutch retailers
- Future of retail: Synergy between advanced AI solutions and human interaction

In the rapidly changing world of retail, the traditional shopping experience is increasingly influenced by technological innovations. One of the most exciting developments in this field is the integration of AI-driven robotics, which can not only transform the way retailers interact with their customers but also take an innovative step towards efficiency and personalized service.

This article explores the integration of generative AI and robotics in the retail sector, with a specific focus on Retrieval-Augmented Generation (RAG) for product recommendations, AI and Retail, and the use of multi-agent systems.






#### The Rise of AI in Retail

The integration of AI in the retail sector is not a recent phenomenon. As early as the early 2000s, retailers began using machine learning to provide personalized recommendations and optimize inventory management. As technology developed, the complexity and power of these applications increased. However, in recent years, the introduction of generative AI has accelerated this trend. Generative AI, capable of producing creative and advanced output based on vast amounts of data, can be combined with robotics to revolutionize retail.

While AI solutions like chatbots and predictive analytics are the new normal, the use of AI-driven robotics is a relatively new development. These robots are no longer limited to simple, repetitive tasks; thanks to the integration of LLM agents with access to Large Language Models such as Anthropic's Claude 3.5 Sonnet or OpenAl's ChatGPT-40. Robots can be used more easily as a communication medium due to the extensive real-time content generation such as the social robot Nadine. (Hangyeol Kang, 2024)

#### **Product Recommendation RAG**

One of the most promising applications of generative AI in retail is Retrieval-Augmented Generation (RAG). This is a technique in which a Gen AI model retrieves relevant information from a vector database (retrieval) and then uses it to generate new content (generation). In a retail context, this means that Large Language models (LLMs) are able to provide personalized product recommendations based on both previous customer interactions and real-time product information.

Imagine that a customer is looking for a new winter coat. A traditional AI recommendation system would rely on search history and previous purchases to recommend similar products. However, with RAG, the system can go much further. It can retrieve product information in real-time, for example, about the latest collection of jackets that have just arrived. Then, the AI model can generate a recommendation based not only on what the customer has previously viewed, but also on what's currently available in the store. This results in much more relevant and therefore more personalized recommendations. (For another example, see figure)



What is RAG in Al (Aquino, 2024) https://qdrant.tech/articles/what-is-rag-in-ai/









A Multi-agent system

#### Multi-agent Systems: The Key to Advanced **Retail Automation?**

In addition to RAG, there is another technology that could fundamentally change the retail sector: multiagent systems (MAS). A multi-agent system consists of multiple autonomous agents with different toolsets that communicate and collaborate with each other to perform complex tasks. These systems use a technique called 'Chain of Thought' prompting, where the agents 'think out loud' and iterate about their thought process. Think of it as a multi-disciplinary team that divides and solves complex tasks among themselves. An example of a multi-agent system within the retail sector could be a store system in which the shopping experience and operations are optimized. A store assistant agent who has contact with the customer (text or voice) for finding products or a storage management agent who has knowledge about stocks and places orders when necessary. A pricing and promotion agent that deals with dynamic pricing and personalized discounts. A payment agent who can recognize products using computer vision and ensures that all products are on the receipt. And to complete the process, a feedback agent who gives feedback throughout the process to ensure that everything runs as it should.



















#### Practical application: Dutch retail cases

So how is Robotics used in Retail? Within Capgemini, a demonstrator has been developed for a use case at one of the largest retailers in the Netherlands. In this project, a robot acted as an interactive shopping assistant with knowledge about products available at this retailer. Users could approach the robot to obtain gift recommendations based on budget, the occasion and the preferences of the person receiving the gift. In addition, several questions could be asked about topics such as specific product information, shopping routes and even specific promotions.

In another Dutch retailer, the robot was also used as an interactive shopping assistant and as a nutrition expert. Users could ask questions about allergies and dietary restrictions/preferences. For example, questions could be asked such as: "If I have a nut allergy, can I consume < specific product>?", "I want to make a certain dish, what would be an alternative product based on the aforementioned allergy?"

#### Conclusion

The integration of generative AI and robotics in the retail sector marks a new phase of technological innovation. By adopting techniques such as Retrieval-Augmented Generation (RAG) and multi-agent systems, retailers can not only provide personalized product recommendations, but also optimize their inventory management, pricing strategy, and customer service.

The use of AI-driven robotics offers a unique opportunity to not only enrich the shopping experience but also increase efficiency and customer satisfaction. The practical examples for Dutch retailers show that these technologies are no longer a pipe dream. The future of retail lies in the synergy between advanced AI solutions and human interaction, setting a new standard for both convenience and innovation.

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#### Over de auteur



#### Randy van Breugel | Data Scientist, AI-Engineer,

Randy is a Data Scientist within Capgemini Engineering's Digital Manufacturing practice. He specializes in the implementation of Generative AI solutions for the retail sector and also focuses on complex data issues for customers in the manufacturing and pharmaceutical industries.

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# Software Development



Applications Unleashed 2025

# Using Gen-A/to improve legacy software

A new approach to modernizing legacy software by combining the power of AI with traditional tools. The project by Capgemini Engineering, TNO-ESI and Philips shows how Large Language Models are transforming the future of software maintenance.



### Highlights:

- Maintenance of legacy code is a critical challenge
- LLMs combined with graph databases offer a revolutionary approach to code analysis and understanding
- Our hybrid system enables natural language querying of complex codebases, dramatically improving efficiency
- This technology is especially impactful in high-value industries such as medical device manufacturing
- The future of software engineering lies in the synergy between AI and traditional analytics tools







Gen Als positively influence the way we interact with software. By combining Al with traditional tools, we are transforming the approach to technical debt and code complexity in various industries, making software maintenance more efficient and accessible.

#### The challenge of legacy code

In the fast-paced world of technology, legacy software reveals a unique paradox. It is the backbone of important systems in various industries, from healthcare to finance, and embodies years of accumulated knowledge and intellectual property. Yet it is also a growing burden, requiring increasingly complex maintenance and consuming enormous resources.

#### The scale of the problem

- Currently, software maintenance takes up much of the development cycle [1]
- Gartner predicts that by 2025, technical debt will continue to rise. This puts pressure on IT budgets [2],
  [3]
- In medical device manufacturing, legacy software is crucial for functionality and safety. On the other hand, it is difficult to maintain.

This is not just a technical problem. It can also have an impact on important challenges within companies, such as innovation and competitiveness.

### The innovative use of LLMs in RENAISSANCE

Capgemini Engineering, TNO-ESI and Philips are pioneers in a revolutionary approach to this structural problem. By making the most of the qualities of Large Language Models (LLMs), not only is the legacy code maintained, but the technology is taken further.

#### The power of AI in code analysis

LLMs such as GPT-4 and Code-Llama have shown remarkable results in understanding and generating code. The research by Capgemini Engineering, TNO-ESI and Philips has shown that these models are able to:

- 1. Generate accurate architecture diagrams from raw source code
- 2. Create detailed UML diagrams, which provide visual representations of complex systems
- 3. Interpret and explain natural language code patterns
- 4. Transform code and generate documentation

However, the statistical nature of LLMs can sometimes lead to errors. This entails a risk. A risk that should be avoided as much as possible in healthcare. Within this industry, a common mistake, such as an LLM that "hallucinates" or simply "fabricates" data, could have deadly consequences. That is why it is important to take safety measures.

#### Hybrid intelligence: The best of both worlds

Our solution is a hybrid approach that combines the strengths of traditional static analysis tools with the intuitive power of LLMs. It works as follows:



#### Code as data

We convert complex codebases (especially C++) into an AST (abstract syntax tree) by means of graph databases. However, creating queries for a graph database is a complex and challenging matter. This approach captures the complex relationships and dependencies within the code and makes them questionable.



#### LLMs as interpreters

We use LLMs as an "intermediary" between developers and the AST. They understand both natural language queries and code structures, allowing for intuitive interaction with complex systems.



#### Deterministic algorithms and human eyes for verification

The created power of AI is formed by combining it with RENAISSANCE, specialized algorithms to check the results and generate a visual output. In this way, users can quickly test answers for facts.







#### Impact in practice

In practice, this would mean that a senior engineer working on important software for medical devices could ask a concrete question. Instead of ploughing through thousands of lines of code for hours, the simple question "What is the relationship between the various components of the heart rate monitoring module?" can be asked.

The system would then:

- 1. Interpreting the question using an LLM
- 2. Search the AST for relevant information
- 3. Bringing the results together
- 4. Present these in a clear, readable format

This approach is not only faster; it improves the effectiveness of the process. By providing the engineers with advice, they can focus on innovation instead of getting bogged down in large amounts of code archaeology.



#### The technical background

The system works as follows:

#### 1. Static analysis and graph creation

- We use the static analysis tool RENAISSANCE to parse the codebase
- This generates a detailed Abstract Syntax Tree (AST)
- The AST is then converted into a graph database, usually using Neo4j
- This graph shows functions, variables, dependencies and files

#### 2. The use of LLM

- We leverage LLMs' knowledge of programming languages and software architecture principles
- The LLM communicates with the graph database via a custom API
- The LLM translates the user's questions into the query language Cypher. The useful information is then shown in a graph.

#### 3. The formation of the results

- The search results in a subgraph formed from the LLM-generated query
- A visualization of the subgraph is presented to the user. In addition, the system provides an answer and explanation.



#### Considerations and future directions

As we push the boundaries of AI in software engineering, it's important to also consider the implications that come with it.

- Job displacement: The system makes code maintenance more efficient. However, this is by no means about replacing engineers with this technology. Instead, the focus is on increasing their capabilities. Moreover, this technology takes work off their hands so that they can concentrate on more creative tasks.
- Data security: When dealing with proprietary code, especially in sensitive industries, data protection is of great importance. Our system is designed with robust security measures to ensure the confidentiality of code.
- AI bias: Capgemini Engineering, TNO-ESI, and Philips are actively exploring ways to detect and mitigate biases that LLMs may introduce during the process.

For the future, the three partners are investigating:

- The increased use of LLMs in the software development cycle
- Extending RENAISSANCE to use multiple programming languages side by side without any problems
- Developing AI-supporting code-refactoring tools that can automatically suggest and implement improvements

• Automated testing to continuously develop our system and improve our performance.

#### The way forward

The merger of LLMs with traditional software engineering tools seems to be a small improvement. On the other hand, it is a major paradigm shift. As RENAISSANCE will be refined and the capabilities of this technology expanded, the boundaries of software maintenance and development will be pushed.

This approach has the potential to...

- Dramatically reduce the cost and time associated with maintaining legacy systems
- Extend the lifespan of key software systems
- Bridging the gap between old codebases and modern innovations
- To make the understanding of code more widely known, making complex systems accessible to more professionals

In conclusion, the development of RENAISSANCE by Capgemini Engineering, TNO-ESI and Philips shows that we are on the threshold of a new era in software engineering, with extensive possibilities and opportunities. The partners not only maintain code but unleash the full potential of decades of software development; One step at a time, one query at a time.



#### About the author



#### Joe Reynolds | Data Scientist

As a data scientist, Joe specializes in applying machine learning techniques to solve existing problems in innovative ways. His background in physics and his lifelong interest in computing have given him a passion for the effective use of new technologies.

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# Defeat the Legacy Software Beast with R.E.B.O.R.N.

Keep your code up to date while allowing your teams to focus on what truly matters—developing great software!

#### The Challenges Faced by Software Development Teams

Imagine a software development team fully occupied with delivering new features and fixing critical bugs, leaving them no time or focus to update their software to the latest architectural, quality, and technology standards. Continuously postponing these software evolution tasks inevitably turns their code into legacy software.

Legacy software is notoriously difficult to expand with new functionality, slowing down a company's ability to innovate and turning outdated code into a direct business risk.

#### The R.E.B.O.R.N. Solution

R.E.B.O.R.N. is a holistic approach to software evolution, seamlessly integrating into development cycles. Dedicated service teams work within customer organizations to perform software analysis and refactoring, ensuring that code meets modern standards.

Automation is at the heart of R.E.B.O.R.N., enabling efficient analysis and refactoring of large codebases.

Customized tools, tailored to specific technologies and customer environments, allow these teams to execute large-scale transformations that would otherwise be impractical if done manually. By automating these processes, development teams are freed to focus on their core tasks.

#### The R.E.B.O.R.N. Engine

The R.E.B.O.R.N. Engine provides a framework for developing and integrating customized automation tools. It includes powerful libraries and frameworks such as TNO-ESI's Renaissance, which accelerates the analysis and refactoring of C/C++ code.

Renaissance extracts knowledge from source code and stores it in a graph database, making it easy to query and visualize. It also offers an API for scalable, automated refactoring, using proven compiler technologies (such as direct manipulation of the Abstract Syntax Tree) to accurately and deterministically identify and modify code patterns.



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#### Accelerating Developers with Automation

When integrated into a developer's CI/CD environment, the R.E.B.O.R.N. Engine automates repetitive, time-consuming, and error-prone tasks, boosting developer productivity.

#### Automated Code Analysis

R.E.B.O.R.N. enhances reverse-engineering capabilities, helping developers understand how software is structured, identify dependencies, locate technical debt, and detect outdated technologies. By extracting structural and static knowledge from code and architectural artifacts, the system organizes this information into a graph database. This allows teams to generate detailed reports and visualizations, making analysis faster and more efficient.

#### Automated Code Refactoring

Refactoring involves finding and replacing inefficient code patterns within a software codebase. This includes:

- Fixing code smells
- Migrating code to new APIs
- Upgrading to modern inter-process communication frameworks
- Transitioning test cases to new testing frameworks
- Improving code quality

These tasks, traditionally performed manually, can now be executed with greater efficiency and accuracy through automation.

#### **Real-World Impact**

tasks, allowing them to focus on higher-value work that drives innovation.

From a management perspective, the burden and risk of legacy software is significantly reduced. With greater focus, commitment, and speed, businesses can extend the lifespan of their software—preserving it as a strategic asset rather than allowing it to become a liability.

#### Conclusion

R.E.B.O.R.N. and the R.E.B.O.R.N. Engine represent a major breakthrough in combating legacy software and modernizing codebases. By equipping developers with powerful automation tools, we can defeat the legacy software beast and pave the way for a more innovative and efficient future.

## Developers and architects in high-tech industries appreciate how R.E.B.O.R.N. relieves them from time-consuming analysis and refactoring

#### About the author



#### Niels Brouwers | Solution Architect MDE & Automated Software Rejuvenation

Niels holds a master's degree in computer science and is a Solution Architect at Capgemini. He is passionate about accelerating software development through higher levels of abstraction and increased automation. His expertise includes modeldriven engineering and extracting models from codebases to analyze and refactor largescale software systems.

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# OpenRewrite: Automating Code Refactoring for Modern Applications

Transform Your Java CodeBase with Powerful, Declarative, and Safe Refactoring Recipes

In today's software-driven world, automation is integrated into most solutions, yet software engineers and architects still face challenges with updating dependencies, applying security patches, and upgrading frameworks. Many enterprises grapple with legacy code, making technical debt a constant concern. Updating dependencies across multiple build files and handling major framework upgrades often requires developers to manually review and adjust class files, properties, and build files like pom.xml or build.gradle.

## What is OpenRewrite?

**OpenRewrite** is an automated refactoring ecosystem specifically created to tackle the challenges of largescale source code refactoring. It offers a wide array of recipes that can automatically modify Java code as well as various build configuration files, including pom.xml and build.gradle. Being an open-source initiative, it facilitates semantic analysis and code refactoring, allowing users to engage with and contribute to the project during their free time. This tool empowers individual developers to search for and rectify code within a single repository at a time.

Furthermore, OpenRewrite seamlessly integrates with build tools and can be incorporated into diverse workflows, ranging from continuous integration setups to extensive refactoring across multiple microservices and repositories.

### Hoe werkt OpenRewrite?

OpenRewrite genereert een geavanceerde versie van de Abstract Syntax Tree (AST): de Lossless Semantic Tree (LST). Deze LST biedt diepgaande structurele informatie, terwijl de oorspronkelijke formatting van de code behouden blijft. Daardoor kunnen ontwikkelaars:

- Code wijzigen terwijl consistente opmaak behouden blijft
- Metadata (bijv. build-markeringen) aan treeelementen toevoegen voor dieper inzicht
- Recipes toepassen voor de refactoring van code in zowel bron- als build-bestanden







#### How OpenRewrite Works

**OpenRewrite** essentially generates a sophisticated version of the **Abstract** Syntax Tree (AST), known as the Lossless Semantic Tree (LST). This LST provides in-depth structural information while preserving the original formatting of the code, enabling developers to:

- Modify code while maintaining consistent formatting
- Attach metadata (e.g., build markers) to tree elements for deeper insights
- Apply recipes for refactoring code in both source and build files

#### **OpenRewrite in Action**

Integrating OpenRewrite is straightforward. Developers can incorporate it into their build process using either Maven or Gradle plugins. Once the plugins is configured, OpenRewrite recipes can be applied directly to the project.

#### **Real-World Applications**

OpenRewrite can be used for various enterprise applications such as:

- Upgrading Spring Boot: Seamlessly migrate between major versions of Spring Boot
- Switch Junit Versions: Automatically update testcases from Junit4 to Junit5
- Java Versions Upgrades: Migrate code to use newer Java versions(e.g., JDK 1.8 to 11/17/21)
- Fixing Code Smells: Automatically apply fixes for issues identified by static code analysis tools
- Log4j to SL4J Migration: Update logging frameworks for improved performance and security

The development of recipes began with the Java language, and over time, they have been broadened to support various technologies such as Kotlin, Quarkus, Micronaut, Scala, SQL, Node.js, Maven, Feature Flags, Jenkins, Gradle, Groovy, and many more.

#### Benefits

- Scalable: OpenRewrite can be applied across multiple repositories and large-scale projects.
- **Consistency:** Ensures uniform application of code standards, formatting, and migration across the entire codebase.
- Customizable Recipes: Developers can create and modify their own recipes to suit specific needs.

#### Challenges

**Recipe Stability:** As OpenRewrite is evolving, some recipes may not always be stable. Keeping the tool and recipes up to date is essential for smooth refactoring.

Automated Refactoring: Recipes automate what would normally be manual, error-prone work, allowing developers to focus on building new features.

The Moderne platform is available for the refactoring of large codebases and various types of projects.

#### About the author



#### Mahendra Rao Bandaru | Senior Architect

Mahnedra is a Technical Solution & Application Architect with 17.5 years of extensive experience in Architecture, Solutioning, Specializing in Java, Spring Framework, Spring Boot, Web Services, Kotlin, Microservices, Angular, React, and AWS Cloud. During his 5+ years at Capgemini he has been involved in multiple engagements across customers, focusing on delivery and growth. In his spare time, he is an opensource contributor for spring projects like spring boot migrator, spring rewrite commons, OpenRewrite Projects, and Contributor Editor at foojay.io (OpenJDK community).

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## **Error-Free Controller Software Within Reach with** 1) Synthesis-Based Engineering (SBE) and Poka Yoke

Cyber-physical systems—such as tunnels, industrial printers, and wafer scanners—depend on reliable controller software to operate safely and correctly. However, developing such software is becoming increasingly complex due to growing performance demands and an expanding range of system functions. Developers must anticipate all possible scenarios and ensure that the controller makes the right decisions. Unfortunately, current development approaches often result in late-stage error detection, leading to delays and high costs.

#### A Smarter Approach: Synthesis-Based Engineering (SBE)

SBE is a modern engineering method that shifts the developer's focus from how a system should be implemented to what it needs to do. Instead of manually programming the controller's behavior, SBE automatically generates a control model based on predefined system requirements—at the push of a button.

This process, called synthesis, is a mathematical algorithm that systematically evaluates all possible scenarios, guaranteeing that every situation is handled correctly.

adoption poses challenges as it differs from traditional development techniques. To address this, Capgemini is collaborating with TNO's Embedded Systems Innovation group in the Poka Yoke project. Poka Yoke, a Japanese concept meaning "mistakeproofing", focuses on designing systems that prevent human errors. This project aims to bridge SBE with familiar specification languages like UML and SysML, making it more accessible to developers. By combining intuitive specification languages, simulation, and SBE, the vision of error-free controller software is becoming a reality.

The resulting control model can be simulated and analyzed, allowing for rapid feedback cycles. From this validated model, a correct software implementation is automatically generated.

By reducing manual effort and lowering costs, SBE enables the development of higher-quality controllers with greater efficiency.

#### Bridging the Gap with Poka Yoke

While SBE is gaining traction in the industry, its

#### Over de auteur



#### Yuri Blankenstein | Lead Digital Engineer

Yuri was an experienced lead digital engineer at Capgemini. He worked as a scientific programmer translating academic research results into practical automation solutions. With an expertise in process optimization, he helped organizations work more efficiently by converting complex scientific insights into scalable technological innovations. During his time at Capgemini, Yuri was driven by the belief that technology and science together are the key to continuous improvement and working smarter.

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## **13** Battery-free Internet of Things

Save the environment and eliminate maintenance

### Highlights:

- The reliance on batteries for the operation of IoT devices comes with significant drawbacks.
- The core of battery-free IoT technology lies in energy harvesting techniques
- An important condition of battery-free IoT devices is that they are extremely energy-efficient.
- The biggest challenge, however, lies in the acceptance of battery-free IoT by customers.
- Integration with AI and Machine Learning will give battery-free IoT an increasingly important role.

The Internet of Things (IoT) has taken off in recent years. With billions of connected devices worldwide, it's changing the way we communicate, work, and live. However, the reliance on batteries for the opera-tion of IoT devices comes with significant drawbacks. In this article, we will discuss the rise of battery-free IoT , with a specific focus on two applications that show how this technology can transform the IoT world.

Batteries are a huge environmental burden. They have a limited lifespan, need to be replaced or re-

charged regularly, and disposed of. Additionally, the need for frequent battery replacement or charging can increase the cost and complexity of IoT deployments, especially in large-scale applications.

The solution to these problems comes in the form of battery-free IoT devices. By harvesting energy from the environment, such as from solar energy, thermal energy or vibrations, these devices can work com-pletely autonomously, so without the need for batteries.







#### The technology behind battery-free IoT

The core of battery-free IoT technology lies in energy harvesting techniques. Energy harvesting is the capture of small amounts of energy from the environment. There are several technologies for energy harvesting, including:



#### Solar energy

Solar cells can convert light into electricity. While this is not new, there have recently been significant improvements in the efficiency of solar cells (especially those for indoor use), which makes them more attractive for IoT applications. The number of variations in design (glass, foil, transparency) and materials (silicon, organic) has also increased considerably.Thermoelektrische energie



#### Kinetic energy

Kinetic energy can be converted into electricity by means of piezoelectric materials or magnets that move within a coil. This approach is suitable for IoT devices that are placed in machines or vehicles. Light switches based on this idea have been in use for years.



#### Radio frequency (RF) energy

Ambient radio signals, such as those coming from Wi-Fi routers or cellular networks, can be harvested energy. IoT devices can also be irradiated with special transmitters in order to receive energy.



#### Thermoelectric energy

This technology uses temperature differences to generate electricity via the Seebeck effect. This can be used in industrial environments where temperature differences are present, such as heating installations.



#### Plant energy

Energy can also be extracted from the chemical processes that take place in the soil (plant-e from Wageningen).

The harvested energy can be stored in supercapacitors or in hybrid supercapacitors (Small Lithium Batter-ies, Solid State Lithium batteries and Lithium Ceramic Batteries which, unlike ordinary Lithium-Ion batter-ies, can last tens of thousands of charging and discharging cycles and cannot explode or ignite).

#### **Energy-efficient IoT devices**

An important condition of battery-free IoT devices is that they are extremely energyefficient. Because the energy generated is often very limited, these devices must be designed for maximum energy effi-ciency. This means that they are active for a short time and have long periods of sleep or ultra-low energy expenditure between active periods. The microcontrollers and sensors used are therefore optimized for ultralow energy consumption, often by using state-ofthe-art technologies such as sub-threshold IC design, super-efficient radios and energy-efficient wireless communication protocols such as Bluetooth Low Energy. Developments in the field of energy efficiency are continuing. In the field of Artificial Intel-ligence (AI) op IoT devices (Edge AI), the chips are becoming more powerful and energy-efficient, so that this technology can also be used on battery-free IoT devices. This is not about training the models (that's where most of the energy goes) but about running the trained models on incoming data. That is much more energy-efficient, see for example the chips from efficient.computer and Innate who are satisfied with less than 1 mW.





#### The Benefits of Battery-Free IoT

The transition to battery-free IoT devices offers several key benefits:



#### Application 1: Smart Agriculture

One of the promising applications of battery-free IoT is in smart agriculture. Farmers are increasingly using IoT devices to collect data on soil moisture, temperature, and other crucial factors that affect crop yield. However, traditional IoT devices require regular battery replacement, which is labor-intensive and therefore costly.

Battery-free IoT devices can solve this problem by using solar energy or plant energy. For example, sen-sors that measure soil moisture can be equipped with small solar cells or plant energy, which generates enough power to power the sensors and transmit collected data.

The advantages of this are clear. Farmers can continuously collect data without having to worry about maintenance. This can lead to more accurate management of water and other resources, which not only increases yields but also improves the sustainability of agriculture.



### Application 2: Smart Cities and Infrastructure

Smart cities are another area where battery-free IoT solutions can offer significant benefits. In urban settings, IoT devices are used for a wide range of applications, from monitoring air quality and traffic flows to managing street lighting and waste disposal.

A specific example is the use of battery-free sensors for monitoring the structural integrity of bridges and buildings. For example, these sensors can use vibrational energy generated by traffic or wind to mon-itor the integrity of structures in real time. This can allow cities to identify problems before they develop into dangerous situations, which can ultimately save lives and prevent costly repairs.

Another interesting example is the use of battery-free sensors for managing street lights. These sensors can use solar energy to control lighting based on ambient lighting conditions, helping to save energy and increase the efficiency of city management.





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#### The Benefits of Battery-Free IoT

The transition to battery-free IoT devices offers several key benefits:

Maintenance-free Because no batteries are required, there is no need for regular replacement or re-charging. Because updating the software does not require physical proximity (via the radio link), the op-erational costs for this are waived.

Sustainability Batteries (think tens of billions of discarded batteries per year!) are a huge source of chemical waste, which is toxic and explosive. Recycling is not 100% possible. The use of battery-free de-vices significantly reduces the environmental impact of IoT devices. When operations on the data take place on the edge node, less energy is used in the data center. This reduces the environmental impact of the data center.

**Operational reliability** In many cases, battery-free devices can be more reliable because they are not dependent on an energy source that can fail. This is especially important in applications where continu-ous operation is crucial.

**Scalability** By eliminating the need to replace batteries, large-scale IoT deployments can be carried out more easily and cheaply.

#### Challenges and future developments

While battery-free IoT is promising, there are still challenges to overcome. One of the biggest challenges is the limited amount of energy that can be harvested from the environment. This limits the complexity of the tasks these devices can perform and can mean that they can collect or transmit data less frequently.

To be able to deal with a shortage of energy (for example at night in the case of solar cell as an energy source), techniques such as intermittent computing and energyconscious scheduling can prevent many problems, for example, a meeting room display can turn off the display in the evening and at night, and only perform functions when the energy is available.

There is also the issue of standardization. While there are different protocols and technologies for bat-tery-free IoT, there is not yet a widely accepted standard that can ensure interoperability between dif-ferent devices and systems.

To show what is possible, a prototype battery-free meeting room display has also been built, with which a lot of experience has been gained.

The biggest challenge, however, lies in the acceptance of battery-free IoT by customers. These mainly look at the initial cost price and not at the Total Cost of Ownership over the age of the device. The cost of maintenance and sustainability play no or only a very small role in the decision-making process between battery-powered and battery-free IoT. The difference in manufacturing costs between the two will, with wide acceptance of this technology, become smaller and smaller, so that the argument of cost price will lose more and more power.





#### AI and Machine Learning Integration

The integration of AI and Machine Learning also plays an important role in the future of battery-free IoT. By using machine learning algorithms to recognize patterns in the collected data and using AI to opti-mize energy management, devices can become even more efficient, leading to smarter and more auton-omous IoT systems. The future of battery-free IoT depends on further improvements in energy-harvesting technologies and energy-efficient electronics. In addition, the development of new radio technologies, communication protocols, and network architectures specifically designed for batteryfree devices are crucial to the wider adoption and implementation of this technology. Because the attention of the chipmakers is increasingly focused on this, it is also becoming cheaper. (Ambiq Micro, Onio, Silicon Labs, Nordic Semiconductor, OnSemi, STMicrolectronics).

#### Conclusion

Battery-free IoT is an exciting step forward in the evolution of the Internet-of-Things. By using energy harvesting techniques, IoT devices can operate without the drawbacks and limitations of batteries, which significantly increases their usability and durability. Integration with AI and Machine Learning will give battery-free IoT an increasingly important role. While there are still challenges that need to be addressed, battery-free IoT offers a good solution for the scalable and sustainable rollout of IoT across vari-ous industries. Capgemini is happy to take on these challenges, and also offers help in the form of a two-day Ultra Low Power hands-on workshop that provides an overview of the most important aspects of the design of Ultra Low Power systems and practical examples that show how to minimize the energy con-sumption of embedded systems.



#### TL;DR

Battery-free IoT devices draw energy from the environment, allowing them to operate without batteries. This makes maintenance unnecessary, is sustainable and increases operational reliability. Smart agricul-ture and smart cities are some of the applications. The future of IoT will improve significantly through the application of this technology.

#### About the author



## Herman Roebbers | Embedded Systems and Ultra Low Power expert

Herman Roebbers is the Ultra Low Power expert of Capgemini Engineering Netherlands. He is a consult-ant for embedded systems and has worked on first-of-a-kind systems and NWO research projects.

He also gives guest lectures and writes articles. He also gives the workshop "Ultra Low Power for the IoT".

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# Fuel Cells in Mobility: Opportunities and Challenges

Although fuel cells have been around since the late 19th century, the recent push for an energy transition as a solution to climate challenges has put them back in the spotlight. The question many people ask themselves is: what is the problem we are trying to solve, and why are we putting so much effort into researching fuel cells?

Fuel cells offer a sustainable solution for mobility by converting hydrogen and oxygen into electricity, with water as the only by-product. Compared to combustion engines, which can only achieve an efficiency of up to about 30%, fuel cells can be up to 75% efficient thanks to their direct conversion of chemical energy into electricity.

Compared to battery electric vehicles (EVs), fuel cell vehicles offer some distinct advantages in specific applications. While EVs are efficient for shorter distances and everyday use, fuel cell

vehicles have a longer range and can be refueled quickly, making them ideal for long-distance driving and heavy transportation such as trucks. These advantages make fuel cell vehicles an excellent green choice for applications where long charging times or limited battery range are a limitation.

The future of fuel cells focuses on developing more cost-effective solutions and independence from rare earth materials, such as platinum and nickel.

In short, fuel cells represent a viable middle ground between e-fuels and batteries and are especially suitable for niche applications where energy needs are high, and infrastructure is limited. It is essential to clearly communicate both the opportunities and challenges of fuel cells, so that their contribution to sustainable mobility and their obstacles to wider implementation become clear to a wider audience.

#### Over deauteur



#### Nipun Kaushik Electro Mechanical Engineer

Nipun is a member of the hydrogen competence within the center of Excellence and Sustainability at Capgemini Engineering NL. His background is in Automotive Engineering and Energy Transition. The article is the result of Nipun's research work at Eindhoven University of Technology, presented at the Hydrogen Technology Expo Europe 2024 in Hamburg.

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## Abundance of sustainability software in a popcorn market

How to choose the right software to support your sustainability policy, emission reduction and compliance, tailored to the needs of all stakeholders.

The range of new ESG\* software is like popcorn. So much has become available in response to the increasing pressure on companies to be transparent about their sustainability efforts. With this overwhelming range of solutions, the choice is therefore becoming increasingly complex.

How do you choose ESG software that, in line with the architecture, provides output for obligation reporting (CSRD), facilitates emission reduction targets and possibly supports the eco-design of products?

It starts with considering the needs of different stakeholders. IT teams look at the existing IT architecture and the possibilities for data collection. Sustainability managers want visibility into emissions across the value chain and easy-to-use workflows. For finance or procurement, automated, reliable reporting is essential for compliance and planning.

Quality of data is of great importance here. ESG data can easily come from 40+ sources, requiring effective data management and data governance, as well as an adequate application architecture to ensure reliable information.

insights are important:

- Inventory of reporting wishes and obligations. These often depend on the sustainability strategy, market needs and sectorspecific requirements;
- Characteristics of the current operation or business operations; (market) characteristics, the supply chain, the geographical spread;
- The requirements for advanced reporting and visualization at company, process and/or product level related to the (future) decarbonization efforts.
- The IT architecture requirements, data management and data governance;
- Implementation and management budget.

- The lack of this can lead to a labor-intensive process, compliance issues, and delays in obligation reporting.
- When making the right software choice, the following

By carefully mapping these insights and translating them into requirements, you can make an informed selection of ESG software that suits your organization

#### About the author



#### Josieke Moens | Director, Lead Sustainable Business

Josieke Moens is Lead Sustainable Business at Capgemini, and has been working on making companies more sustainable since 2006. She has developed expertise in implementing ESG transitions. Her passion lies in helping organizations to grow while making a positive contribution to society and the environment. Josieke's strength lies in developing impactful sustainability models with a view to organizational change and innovative strategy, so that the necessary decabonization is accelerated.

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<sup>\*</sup>ESG data refers to information about a company's performance in three key areas: Environmental, Social, and Governance. This data is used by investors, analysts, customers, and other stakeholders to assess an organization's sustainability and social ethical impact

## Repair the non-repairable, with additive manufacturing 16

How can AM be a valuable "(P)Layer" of the sustainability business?



### Highlights:

- Additive manufacturing (AM), also known as 3D printing, is not a "one size fits all" technology. Understanding its benefits and limitations is essential to deploy it as a sustainable solution.
- The goal of AM is not to replace traditional production methods, but to complement them and expand production capabilities.
- AM can repair specific damages that conventional methods can't handle, such as cracks in metal parts, complex geometries, and wear on precision components.
- AM processes monitor hundreds of process parameters. Understanding and modeling their influence leads to better life cycle assessment (LCA), predictability and process stability.







#### Additive manufacturing (AM), also known as 3D printing, is a printing process in which materials are added layer by layer to turn a digital design into a three-dimensional object. The step into the world of AM is a complex decision, treating it as a disruptive technology that introduces design, operational, and strategic changes to an organization. AM can be considered a powerful tool to solve challenges in development and production and is the way to achieve sustainable innovation and evolution.

AM was a real game-changer technology in the 90s and has since revolutionized the way materials are selected, produces complex parts and even developed assemblies. While in the early stages AM focused on applications with plastic materials and rapid prototyping, today it is available for a multitude of metal materials, biomaterials, ceramics, concrete. Printers are integrated into production lines at manufacturers in the aerospace, mechanical, automotive, marine and defense industries.

Not only has the material portfolio become larger for AM, but also the way in which different material layers are built on top of each other. Complex AM parts are built in powder beds and can be formed by techniques such as direct energy deposition, material sintering, melting, jetting, or photopolymerization, to

name a few. AM equipment can use raw materials in the form of powder, wire, or rods, which are melted by lasers, electric or plasma arc, electron beams, or kinetic energy. The combination of different energy sources, movement techniques and material shapes determines the specific AM technology.

ISO/ASTM 52900, the first standard to define AM technologies, classifies AM into 7 key technologies, from which more than 20 other subtypes have been developed in recent years.



The 7 types of AM infographic from Hybrid Manufacturing Technologies (<u>https://hybridmanutech.com/resources/</u>)



Understanding the benefits and limitations of these technologies is key to the decision to step into the world of AM and use it smartly and efficiently to solve urgent challenges. AM is therefore not a "one size fits all" technology.

#### Sustainability of AM

The need to shift to circularity, reduce waste and gain more clarity in LCA, drives innovation. AM is getting a lot of attention within this topic, as it can produce complex, lightweight parts that are not possible with conventional production methods. However, converting a conventional design to an AM design and printing the part instead of machining or casting does not immediately lead to a "green solution". The goal of AM is not to replace traditional production methods, but to add value to complement them. Strict comparisons between production methods are like comparing apples with oranges, because sustainability in AM is expressed in many more ways.

Starting with raw materials for AM, a lot of effort is put into obtaining powders and filaments from recycling and reuse. Since material quality is essential for a successful AM process, traceability is made transparent, improving the entire LCA of the AM process.

The material efficiency of AM, quantified by low buy-to-fly ratios, means not only that AM parts have an optimized shape and topology, but also that they require fewer finishing operations (e.g. machining), resulting in less material waste. By printing a large and complex part such as a blisk or turbine, only about 5% of waste is generated during post-processing, compared to 60-80% in traditional machining. Reduced machining effort results in energy-efficient operations.

Comparison: subtractive (conventional) vs. additive manufacturing









#### AM allows the combination of different materials in a single print. This property opens the door to optimized material use, as low-grade base materials can be combined or coated with high-performance alloys to improve the performance of parts or to extend their lifespan. Parts can be upgraded by adding material and value exactly where it is needed.

#### Sustainable AM operations

Strategically deploying AM in operations, such as decentralized spare parts production and repair, greatly improves the availability of items with long delivery times. It reduces risks in supply chains and leads to circularity.

Given the advantages and limitations of the different AM technologies, Direct Energy Deposition (DED) is best suited for repair applications. DED works with a relatively simple kinematics: an energy source (laser or electron beam) is activated and a feeding system (nozzle/extruder) delivers the powder or wire to the target surface (in case of repair, to the damaged surface). The activated energy source creates a weld pool on the target surface and in which the metal layer is deposited and a strong metallurgical bond is formed. Flexibility is a key advantage of the DED nozzles: they can be integrated into multi-axis CNC machines or placed on robotic arms to perform local, multi-axis deposition.

The AM repair is relevant for metal parts that are considered nonrepairable, wear-prone parts, parts with surface scratches, dents or parts that need to be upgraded.

First, a feasibility check is carried out, analysing the material compatibility, the root cause and form of the defect, the frequency of damage and the demand for parts. For commonly used materials such as Titanium, stainless steel and Inconel, the process parameters are well defined. However, for difficult-to-weld metals such as aluminum and special tool steel, the development of process parameters is necessary to implement repair on a larger scale.

Once the feasibility has been analyzed, a business case is built to align R&D, application and management on the repair strategy, cost allocation and results. If the business case is assessed positively, the repair flow can start.

In our technology demonstrator, an often damaged aluminium component was examined for repair, in collaboration with the Fraunhofer ILT in Aachen, Germany. Aluminum is not only challenging to print, but the repair also competes with the stable and productive high-speed machining as well as with the replacement of these parts.

In the first part of the project, the parameters were refined. The laser beam power and powder mass flow were adjusted to obtain a porous free deposition of aluminum layers. The hardness of the deposited layers was also analysed and was comparable to the hardness of the base material. After parameter selection, the damaged part was prepared for repair: the damaged areas were cleaned and pre-milled for better access to the tool.

Critical contact	
	Dam P

The repair workflow

The AM repair is relevant for metal parts that are considered non-repairable, wear-prone parts, parts with surface scratches, dents or parts that need to be upgraded.







This step was followed by the application of aluminium layers to rebuild the geometry and a final milling operation to obtain the required dimensional tolerances.

This demonstrator highlights the potential of DED in overcoming material and cost challenges, but does not have the repair qualification in scope. In order to release this method on a larger scale, it is necessary to perform tests to analyze the mechanical properties of the printed areas, such as tensile strength, fatigue. Non-destructive testing, such as CT scans, is necessary to evaluate the microstructure and the quality of the deposit.

#### **Future prospects**

Taking AM repairs to the next level can be done through automation and the use of the power of AI. The development of evaluation tools can speed up decision-making, parameter selection, and overall repair time.

Models trained to detect in-situ deposition errors can be used to correct and adjust parameters during deposition, significantly increasing the quality of the process. \*

Standardization of AM is a joint effort, universities and research institutes work closely with industry. Capgemini sees AM as a strategic asset and has joined local and international AM consortia to define industry implementation strategies and standards for AM repairs.

1.Pandiyan, V., Cui, D., Richter, R.A. et al. Real-time monitoring and quality assurance for laser-based directed energy deposition: integrating co-axial imaging and self-supervised deep learning framework. J Intell Manuf (2023). https://doi.org/10.1007/s10845-023-02279-x

Deshpande, S., Venugopal, V., Kumar, M. et al. Deep learning-based image segmentation for defect detection in additive manufacturing: an overview. Int J Adv Manuf Technol 134, 2081–2105 (2024). https://doi.org/10.1007/s00170-024-14191-6

#### About the author



#### Adrienn Matis | Technical Lead Additive Manufacturing, GBL

Adrienn is Technical Lead for AM in the Global Business Line. She is responsible for the competency development and execution of a technical strategy for AM for the GBL, coordinated by the CTO for Manufacturing & Operations. Adrienn has a mechanical engineering background and is currently also working on her PhD in the field of AM.



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## Design for Sustainability

More than 70% of a company's ecological footprint comes from its products. This includes the supply chain, production and the use phase. It is of great importance for the world to reduce this. Sustainability is becoming a new dimension, which must be balanced with traditional KPIs: performance, cost and time.

#### If sustainability is included in the design process, this also brings new challenges, namely:

- as an important driver?
- data and tooling?

Design For Sustainability includes specific methods, tools and skills to be able to include sustainability issues from the first design phases.

Systems Engineering plays an important role in this. If,

• What exactly are the sustainability goals?

• How do you measure sustainability goals?

• How do you build better solutions with sustainability

• How do you deal with the ever-increasing amount of



#### Engineering viewpoints





#### Sustainabilty backbone

#### for example, sustainability aspects are included in the development of a drone, the complete system must be viewed (holistically). If it is decided to replace the drive with a fuel cell, this will have an impact on the range, weight and safety of the entire system. If other 'green' materials are used, this has an impact on weight and range.

Design decisions must be able to be validated with LCA (Life Cycle Analyses) and circularity assessments. For this purpose, a digital backbone has been developed which is an

extension of PLM systems. With this backbone, we are able to measure and validate design decisions from the conceptual design phases. This backbone makes the connection between design and assessments by sharing the common characteristics of models (via ontologies).

#### In short

D4S is a structured, holistic approach, based on systems engineering to allow projects to adapt to sustainability goals

#### About the author



#### Lambert Verhagen | Technology Leader Complex Systems Engineering

Lambert has been working on complex systems since the 90s in various fields such as lithography, maritime and tunnels. Multidisciplinary and system architecture are recurring aspects in his work. Connecting both technology and people is what drives him. From an early age, he has been committed to sustainability. With D4S, all of this comes together.

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# **Business** Agility\_





## De "Augmented" Architect Primus inter pares en hofnar

### Highlights:

- Change: the new constant
- Generative AI: a new, potentially disruptive force for the organization and the architect
- Automate, Assist, and Augment: How Generative AI Supports the Architect's Work
- Successful application of Generative AI: only with a robust and scalable organization, processes and infrastructure
- Primus inter pares and court jester: the role of the Augmented architect in an environment where everyone uses Generative AI

We live in a complex, turbulent world in which ever-faster change has become the norm. The big challenge for organizations is to keep the complexity of their digital ecosystems both manageable and flexible at the same time.

The architect plays a key role in this. But is he or she sufficiently equipped for this?





#### Change: the new constant

The world around us is changing faster and faster and these changes are having an increasing impact on our society. Change is the new constant and being prepared for disruptive forces is vital to survive and thrive.

To be able to cope with this, an organization must be able to move with changes, but also to reinvent itself. To do this, an organization must be well informed, be able to make decisions quickly and effectively, and be able to speed up in the chosen direction with the right knowledge and skills.

#### Architecture is becoming increasingly important

Change is not possible without an effective architecture; The blueprint of the organization, the production processes and the products and services must be effectively applicable at all times.

The architect plays a key role in this, which has already changed considerably in recent years.

Whereas in the past the architect mainly played a (pre-)prescriptive and (retrospective) controlling role in programs and projects, now the architect, as a "servant leader", often sails along with the Agile teams in the production process. Decisions are largely made within the teams and architecture is delivered just in time and just enough (Just-in-time, Just-enough).

This requires the architect to have an enormous capacity for absorbing signals, information and skills.

#### The power of Generative AI

A new, potentially disruptive force has been added to that playing field: Generative AI. This new technology makes it possible to collect and apply large amounts of knowledge. This gives the opportunity, especially for smaller organizations, to catch up with larger competitors more quickly.

The architect who does not use Generative AI will eventually be replaced by the architect who does use this technology.



#### Automate and assist

Generative AI applications are excellent at processing, supplementing, summarizing, and converting large amounts of documentation to various formats and styles. Think of summarizing conversation reports, personalized reporting to different stakeholders, generating overviews and illustrations.

This is very valuable, because the architect must be able to grasp the essence of large amounts of information quickly and discuss it effectively with a range of stakeholders.

In practice, architecture tools (such as BizzDesign, Sparx, Orbus, Ardoq) already offer the possibility to assist the architect with the application of architectural languages, making models, documenting and performing simple analyses.

AI can also support the architect's advisory role. This includes helping to draw up impact analyses, risk analyses, drawing up basic advice, conducting reviews and even generating scenarios, designs and program code.

This saves the architect a lot of time, but to become an "augmented architect" more is needed...

Only when the architect can do more than he/she can do now through the use of AI do we speak of augmenting. Think, for example, of gaining new insights into complex situations that help with decision-making, or (semi) automatic decision-making.

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#### Just imagine...

possibilities.

For example, an architect can go through different scenarios together with a CEO as a stakeholder in a virtual reality environment. Because actors, business processes and IT solutions are visualized, user stories and their implementations come to life. Details of the proposed architecture can be requested on site, challenges can be made transparent, and scenarios can be drawn up and adapted so that the CEO has optimal insight into the journey to the future of his organization. With the architect as tour guide.

Future scenarios are generated based on real-time analysis of architectures/designs, implementations and relevant influences. Models and analysis results are converted into software with which a VR platform creates a virtual environment in which striking examples are visualized. An effective collaboration between AI and other technologies.

And if we look even further into the future, AI platforms can be integrated with sensors that can provide real-time data to add even more value to scenarios.

A personal AI assistant that helps the architect map out the pain points of a complex system, suggests improvements and describes alternative scenarios.

In combination with other technologies, this offers many

### Context is crucial

Knowledge of context (the problem and solution domain) is crucial for high-quality support by AI. Basically, AI systems don't have this context, but architects do. After all, they receive information from a wide range of sources that may be relevant to their work and they bring knowledge and situational experience from the past.

#### An end to the Babylonian confusion of tongues?

Generative AI can bring together knowledge from many different sources of information, be gueried on it, and also publish information in different formats. This allows the architect to bring together architectures, designs, scenarios and even code and use them as a "golden source" for descriptions and analyses. This closes the conceptual "gaps" between the different levels of abstraction.

And again, this can be achieved by cleverly combining technologies. Consider, for example, the use of Graph databases for maintaining architectural models. Such databases, even more than AI language models, are suitable for storing complex networks of concepts and relationships (which are essentially architectural models). Moreover, they can be questioned much more effectively and, unlike language models, provide precise answers. In combination with Generative AI, these architecture models can be queried in natural language, and reliable answers are given.



#### A virtual team for complex problems

Complex and extensive problems in which important architectural decisions have to be made often require specialist knowledge, a special solution strategy, and human intervention.

This can only be achieved by cleverly combining technologies. This is where AI Agents come into the picture: processes that are able to perform tasks autonomously, or in collaboration with other Agents, by making (limited) decisions based on context, inputs and predefined goals. For example, an Agent who, in response to changes made to an architectural model, checks these changes and proposes improvements and submits them to an architectural team. Or an Agent who, based on areas of interest and the communication preference of a stakeholder, automatically generates an up-to-date and accessible description of the architecture for him/her.

With AI Agents, the architect has a team of virtual employees available, as it were, who constantly collect new insights, test quality, map out scenarios and communicate this effectively with the architect.

Ecosystems of Agents can reach a large size, even simulating the behavior of entire systems (Agent-

Based Modeling). This makes it possible to work out scenarios to support decision-making.

#### AI is evolving rapidly

The AI landscape is evolving rapidly. FromLarge Language Models to ecosystems of smaller, more effective and efficient models (Small Language Models), combined with AI agents.

#### De Augmented architect: Primus inter pares and court jester

However, the architect is not the only one who will make use of these new technologies. Anyone can be augmented.

Software developers, designers, managers and And as impressive as Generative AI is, it is not a business stakeholders will also be able to expand panacea. The architect remains responsible for the quality of the architecture. The critical attitude, What consequences does this "broad augmention" such as that of a court jester, remains necessary. have for the role of the architect? Will the role of The architect will have to know the possibilities and limitations of AI, and be able to advise the organization with both feet on the ground.

their architectural knowledge and skills. the architect degenerate into a self-service function within the organization?

#### The changing role of the architect

A number of questions no longer have to be left to the architect by "augmented" colleagues, but in

#### order to make effective use of AI, reliable and upto-date knowledge and insights will still have to be made available. In addition, when using Generative AI, the effective formulation of questions (called prompts) and the correct interpretation of answers are crucial. Managing the conversations between AI and the users is something in which the architect will continue to play a key role.

In order to continue to function effectively, the architect will therefore have to continue to delve into the relevant business domains, into AI and the associated production processes of both applications and knowledge (models).

#### Calling for court jesters with knowledge and skills

This also means daring to openly question plans, contradicting strong opinions and being able to proclaim one's own vision. Just like a court jester used to do at the court.

#### Over de auteur



#### Hans van Rijs | Managing Consultant, Architect

Hans is a Solution & Enterprise Architect, with a background in software engineering & project management. In addition, he likes to share his knowledge as a trainer at the Capgemini Academy. He is a member of The Open Groups O-AA standard Working Group, part of Capgemini's Architecture Community of Practice and, as a coach of a team of talented colleagues

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## AI unleashed: Achieving extreme agility 19

## AI as an engine for ultimate innovation

Tesla does it: implementing 27 hardware and software changes per day in production. Space-X does it: 10,000 hardware changes to the largest rocket in 69 days. Klarna does it: 2.3 million customer service calls in 35 languages per month.

#### Highlights:

- Autonomy will be the driving force behind innovation.
- With a Digital Self Management system, everyone gets up-to-date, actionable information pushed to an app.
- Combine AI with CRM and ERP systems.
- Work with micro-objectives.
- More data do not always make an AI system smarter.



#### Over the past 20 years, many companies have moved from traditional waterfall project management to modern methods that have significantly increased their agility and innovative power. Many organizations have embraced agile frameworks such as Scrum, SAFe, LeSS, and "Spotify" and have matured in them.

But sometimes the curious manager asks, "What comes after "Agile"? How can we innovate even faster? Can AI help us?"

Agility is critical. If you can't innovate quickly or if you can't respond quickly to change, then the future looks dark.

In this article, we pay attention to the following factors that increase our innovative power: Autonomy, AI, modularity and short feedback loops.

#### More autonomy = More innovative power

If employees are allowed to decide for themselves what they develop and how they do it, it saves meetings, waiting time and frustration. Based on the high-level objectives, employees are often very good at thinking about what it takes to achieve them. Would it be possible for us to let employees do the procurement themselves, for example, if something needs to be purchased for their project, such as a robot arm? As long as all information such as costs, benefits, effectiveness, efficiency are readily available, everyone should be able to make smart decisions.



#### De Tesla case study 1:

Tesla has been working for years on a "Digital Self-Management (DSM)" system. Every employee gets apps on his or her phone that show live KPIs about costs, benefits, objectives, problems, bottlenecks, test results, quality, supplier performance, etc. As an employee, you come to the factory in the morning, you check your apps, see where the bottlenecks are, and determine where you can be helpful that day and where you can add value.

Tesla has relied heavily on AI to extract data from all these systems and generate "actionable, up-to-date insights".

Actually, the DSM system is the modern version of the "Obeya room". The Japanese word 'obeya' means 'large room'. This is often a physical space, although virtual spaces are also increasingly seeing the light. It's a place where organizational information is visually brought together on boards or walls, so teams and management can discuss and plan for it.

However, the Digital Self Management system continuously pushes the most up-to-date information to everyone's phone. As David Marquet<sup>1</sup> said: "Move the authority to where the information is" or in this case "Move the information in order to empower".



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#### Intelligence from CRM and ERP systems

To increase innovative power, it is therefore necessary to use the data from CRM, ERP and other systems in a smarter way, so that employees become more decisive, can innovate faster and make better decisions.

It is already possible to get real-time advice from Microsoft's AI with Co-pilot about developments in the world that will challenge the supply chain in the near future. Think of a notification to employees of a logistics company about a news article announcing major works on the adjacent highway and the effect this has on the schedule. Companies are also increasingly using AI within the customer service domain. CRM systems are getting closer and closer to the point where AI takes over all the tasks of the customer service agent. Klarna conducts millions of AI customer service calls in 23 countries in 35 languages per month. The company Bland AI goes further and has an AI tool in the market that talks to customers, as a first-line

customer service or sales representative. To be clear, the AI tool talks.... not the employee.

Increasingly, systems are being integrated with AI or are built to be compatible with third-party AI software. For example, Microsoft Dynamics users can use Co-Pilot and Salesforce users have Einstein Copilot at their disposal.

The first step that companies will have to take is to delve into the licensing structure that the suppliers offer. In most cases, additional licenses will have to be purchased to use the AI solution.

The second point of attention has everything to do with data. AI works with company data. Organizations need to ask themselves the following questions: Are there systems that need to be integrated? Which APIs need to be configured for the AI to have access? Are there any Sharepoints that need to be configured? Is our data harmonized? Answers to these questions will lead to gaps in the data management strategy optimized for AI.

+<sup>1</sup> Turn the Ship Around!: A True Story of Turning Followers into Leaders Hardcover – May 16, 2013 by L. David Marquet (Author)

In the next step, we can look further at, for example, implications for RBAC (Role Based Access Control). AI will have to be given access to data that belongs to the user who is currently using AI. Of course, it is not the intention that a Purchasing employee gains access to sensitive HR information of fellow colleagues by asking AI: "What is the annual salary of employee X?". AI must be linked to the user's access rights. The question is how this can be set up in specific situations and in specific CRM or ERP systems. A step further is to think of dynamic RBAC, where location, time and data type determine Al access, or separate environments for certain sensitive information.

#### Case Study: The Sales Assistant in the Pharmaceutical Industry

Recent developments make it possible for AI models to answer open-ended questions.

At a biopharmaceutical company, a salesperson asks an AI-based system what the latest diabetes disease and prescribing trends are in their region. The system translates this query from natural language into computer code, which is then executed to analyze the latest data. The insights obtained are shared with the seller: "Diabetes prevalence has increased by 6%, but the treatment rate has decreased by 12%. The system also automatically indicates which medications are most commonly prescribed and which therapies are recommended. Using scientific articles and news reports, the system immediately identifies an opportunity for the seller: "There is a growing interest among healthcare providers in learning about alternative approaches". The seller can ask further questions at this time, to know more about these news articles, or to know more about the opportunities in the market. The salesperson is ready for action and asks: "Which prospects should I approach?" The system responds with suggestions, such as which healthcare providers the vendor should visit in person and which ones the vendor should contact via email. The salesperson combines these insights with their own experiences and is then better prepared for relevant, insightful and productive customer interactions.



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#### Short feedback loops

The Digital Self Management system, as used by Tesla, continuously provides new "actionable insights" and that requires rapid innovation cycles. And rapid innovation is achieved by creating a proof of concept in a short period of time, quickly collecting feedback, and then, if the first impression is good, continuing to iterate.

We often see that organizations attach an objective to this: "Improve the XYZ by 10% in the next quarter". But why shouldn't we be able to work with micro-objectives? "Reduce the weight of the car by 10 grams in a 3-hour iteration". If it is achieved, the team has something to celebrate, and the dopamine rush is the biggest motivator.

#### De Tesla case study 2

Tesla's focus is on innovation speed and in order to be able to innovate quickly, short feedback loops are vital. They are investing heavily in test automation and the more that can be automated, the better. Hardware, robots, software, interfaces, and apps, engineers are constantly updating automated tests. Even the inspection of the paint of Teslas is automated. Regulatory compliance is automated. Test driving is automated. Cars are in fact testing themselves. And AI analyzes the test results.

"Ka-Chow, I'm okay!" (from the film "Cars")

#### Modularity

We all know it: Waiting for another team to finish. Only then can we move forward and that is not good for innovation. The more a system consists of independent modules, the better it is and the less waiting time we go through. Modules with clear interfaces. A team should be able to easily make a change to, for example, the headlights of a car, without having to deal with dependencies with other teams or approval procedures. They don't need to set up meetings to agree with other teams, and they don't need complex, expensive planning sessions. They decide for themselves because they believe that this will make the vehicle better. The support is provided by AI assistants.

But how do we make a smart AI assistant? Training with more data does not necessarily result in a smarter AI system. The error sensitivity of AIs can be significantly reduced by limiting the accessibility of data. For the development of an AI assistant, it is much better to train it on a specialist dataset. The better and more accurate the AI assistant's answers, the more responsibilities we can give to such an assistant. In doing so, we are effectively creating an AI concierge. An AI concierge also provides advice based on situational factors and previous choices made. The next step is an AI agent. The AI agent performs actions independently, without human input. These are, for example, AI marketing agents, AI warehouse planner agent or an AI customer service agent, such as Klarna's.

### "The future of AI will be on less data, not more".

The innovation machine of the future will not use today's agile frameworks, but will work with dynamic, autonomous teams, who can make improvements in very short cycles; cycles of hours instead of days or weeks. The engine of this machine is called AI.

<sup>2</sup> by H. James Wilson, Paul R. Daugherty, and Chase Davenport

January 14, 2019, Harvard Business Review, https://hbr.org/2019/01/ the-future-of-ai-will-be-about-less-data-not-more

#### Over de auteurs



#### ZAHIR WANGA | Group Portfolio Manager

Zahir is Group Portfolio Manager at Capgemini and deals with the solutions that Capgemini has to offer on a daily basis. Zahir has a broad orientation in the field of business and IT and constantly stays up-todate with the latest developments.

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#### **RIK PENNARTZ** | Applications Unleashed Chief editor, agile coach & Scrum Master

Rik is an agile coach and specializes in forming high performing teams in an innovative environment. Rik is also the initiator of the Applications Unleashed report.

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## Values-driven architecture

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Young consumers, including Gen Z and millennials, are strongly attracted to brands Incorporating values into the Enterprise Architecture will lead to better economic and companies that strive for higher goals.<sup>1</sup> Important values such as integrity, value chains and to greater satisfaction for all stakeholders, both internal and innovation and sustainability must be central to business operations. I agree with external. Enterprise Architecture should not only create economic value, but also realize core value chains that benefit the lives of customers, employees and Simon Sinek, the well-known management guru, that companies don't exist just to make money.<sup>2</sup> everyone else involved.

#### Every organization has its own values. These are the fundamental principles that an organization and its employees adhere to in their behavior, work, and decision-making.<sup>3</sup>

The goal of Enterprise Architecture is to enable the organization to achieve its mission, business strategy, and goals as effectively as possible.<sup>4</sup> Therefore, core values must also be integrated into the enterprise architecture. I propose the following steps to do this:

- 1. Identify the core values,
- 2. Define architecture principles that reflect these values,
- 3. Embed values in governance,
- 4. Integrate your values into the designs,
- 5. Make your values your own and communicate about them,
- 6. Align goals and measurement criteria with the values,
- 7. Promote ethical decision-making, and
- 8. Continuously improve.

By applying 'Design for Values'<sup>5</sup>, in which products and services are created that realize social and moral values, this process is greatly facilitated.



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#### Over de auteur



**Reinoud Kaasschieter** | Enterprise Architect and AI expert

Reinoud is an enterprise architect in the Dutch public sector and an expert in the field of artificial intelligence and ethics. He actively shares his knowledge and insights by publishing and speaking about AI and ethics, both within Capgemini and beyond.

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# Colophon

Arin Roy

#### The Capgemini Applications Unleashed Team 2025

Editor in Chief: Rik Pennartz

- Design: Puja Sengupta, Johanna Achterberg, Arundhati Bhattacharya
- Branding: Els van der Velden, Pamela Datta

Project and Marketing Management: Thomas de Klerk, Rebecca Scott

#### Thought leaders:

Henk Vermeulen Donald Hessing Douwe van de Ruit Sjoukje Zaal Tom van de Ven Reinoud Kaasschieter Mandy Steenbergen Marieke van de Putte Rahul Rauniyar Randy van Breugel

Mahendra Rao Bandaru Niels Brouwers Joe Reynolds Yuri Blankenstein Lambert Verhagen Josieke Moens Nipun Kaushik Herman Roebbers Adrienn Matis Hans van Rijs Rik Pennartz Zahir Wanga

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Ron Tolido Roger Wannee Sjoukje Zaal Gerard Peters Han Konings Fina Piazza Thijs Geurts





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Capgemini is a global business and technology transformation partner, helping organizations to accelerate their dual transition to a digital and sustainable world, while creating tangible impact for enterprises and society. It is a responsible and diverse group of 340,000 team members in more than 50 countries. With its strong over 55-year heritage, Capgemini is trusted by its clients to unlock the value of technology to address the entire breadth of their business needs. It delivers end-to-end services and solutions leveraging strengths from strategy and design to engineering, all fueled by its market leading capabilities in AI, generative AI, cloud and data, combined with its deep industry expertise and partner ecosystem. The Group reported 2024 global revenues of  $\in$  22.1 billion.

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Capgemini Nederland B.V. Postbus 2575 - 3500 GN Utrecht Tel. + 31 30 203 05 00 www.capgemini.nl





