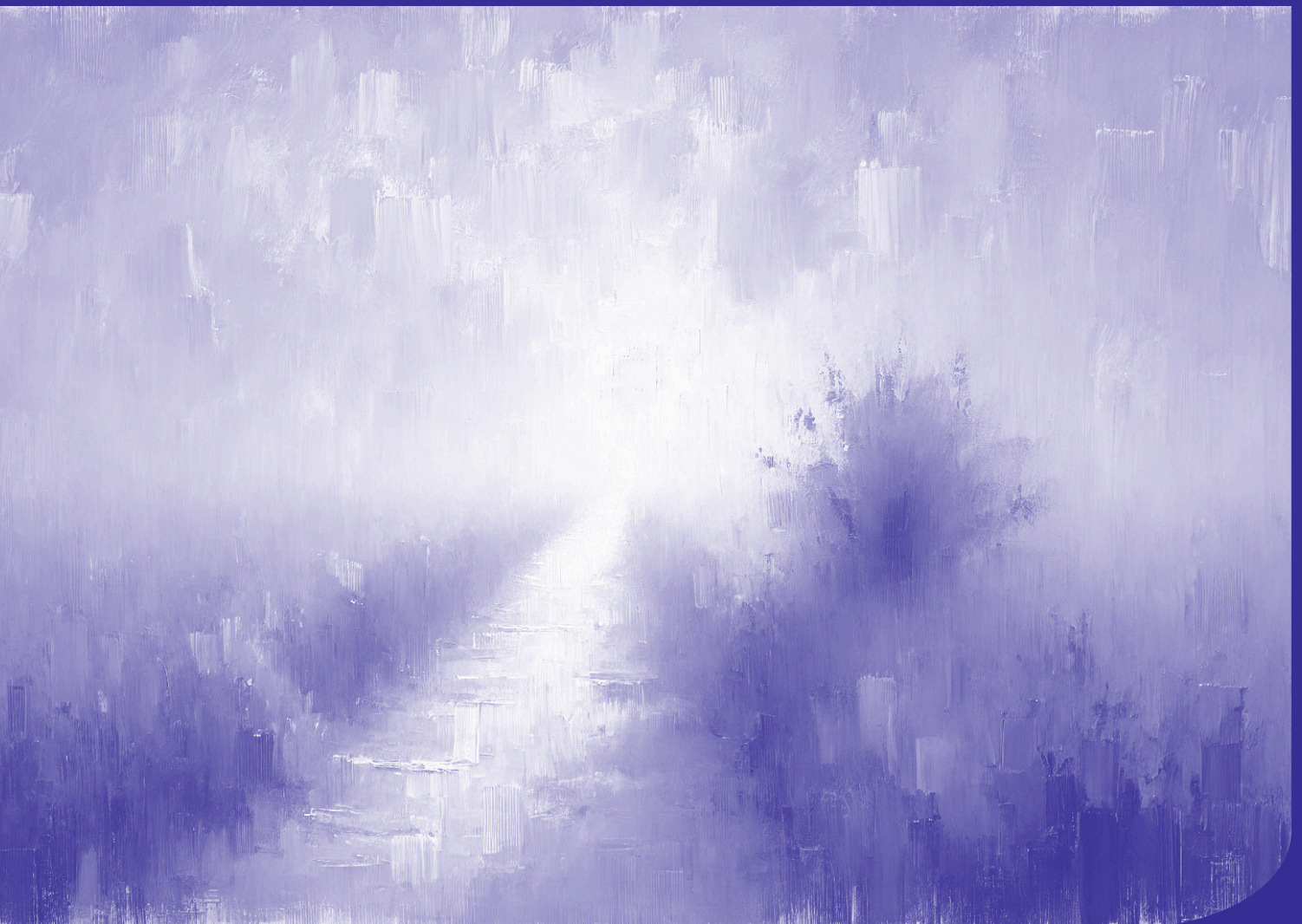




# YEARBOOK 2024

## Research & Innovation

Research and Technological Innovation Department  
Berger-Levrault



# Editorial | Research, Innovation & Application



**Christophe Bortolaso**

*Director of Applied Research  
Berger-Levrault*

Dear readers,

Welcome to this first 2024 edition of the **Yearbook**, an annual retrospective constituting an important milestone, reflecting the energy and ambition that drives the Research and Technological Innovation Department (DRIT) of Berger-Levrault. We wish to share with you our most ambitious projects and our most innovative initiatives. **Each of our actions addresses societal and technological challenges while exploring the available perspectives.**

Beyond our constant desire to understand and illuminate the path for Berger-Levrault, we have always placed impact-driven research at the heart of our actions. However, the year 2024 represents a decisive turning point in our approach to research and innovation. This year is marked by **the fulfillment of numerous tangible research and innovation initiatives, now accessible to our clients through our products.**

Among the key highlights, we can obviously mention the various applications of the Intelligent Assistant, our generative AI solution integrated within WeMagnus and Legibase. But this year revealed other successful projects like RemoteAssist, our remote maintenance solution, the integration of BL.Optim our optimization engine within CARL Source, and the deployments of MixedR, our augmented reality solution. Let us also mention the various implementations of our code generation tools within the development teams. These examples fully illustrate that **research, innovation, and industrial scaling** are not only possible, but they pertain to what can be reached daily.

In this first edition, each presented project showcases our expertise while also demonstrating our commitment to **developing sustainable and inclusive solutions that address today's and tomorrow's societal challenges.** This Yearbook also aims to demonstrate that innovation inevitably involves accepting risks and the ability to navigate constant uncertainty. To overcome these challenges, the interests of our users and clients are integrated at every stage of the process. Indeed, it is often in the field that the most complex and stimulating fundamental research problems arise.

This Yearbook also highlights the cross-disciplinary nature of our innovations, particularly artificial intelligence, software engineering, digital frugality, and Industry 5.0. **These themes resonate directly within the products and services developed by Berger-Levrault,** highlighting their relevance in a rapidly evolving world.

As you browse through these pages, you will discover a selection of our most ambitious initiatives, concrete achievements, and bold forecasts, all targeting **the resolution of societal challenges and the tangible improvement of our clients' daily lives.**

Happy reading!

# Summary

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# Mission

Together, let's imagine today the needs of tomorrow.

Since 2010, BL has been committed to research and aims **to revolutionize our clients' professions and the uses of our solutions**. Our research and innovation teams place **interdisciplinary** and **collaborative approaches** at the heart of their methodology, relying on a strong commitment to our users.

Innovation is an ambitious encounter between an invention and a market. In the digital realm, innovating often means **establishing previously unexplored connections** between the challenges faced by our users and clients and the opportunities enabled by technology.



## A team with great agility and versatility to carry out highly concrete actions

**Field observations and ethnology** to understand usage contexts and identify needs;

**Adopting experimental protocols** to test state-of-the-art technology against real-world conditions beyond laboratories and clean rooms;

**Software design and development** to create exploitable, scalable, and solutions that we can industrialize;

**User-centered evaluation** to rigorously assess the impact and value of our solutions in our clients' daily lives

**Exploring new domains**, designing solutions that are both simple and accessible, sharing and transmitting knowledge, and training on new uses, all of which illustrate our mission

We aim to **transform the collective imagination into concrete actions that integrate into the daily reality of all our users**.

What we strive for has a name : **impact-driven research!**

# Values

## Synergy & Collaboration, for open and impactful research

Our teams are driven by the ambition **to transform our clients' professions and reinvent the use of our solutions**. To achieve this, our Directorate of Research and Technological Innovation places **synergy and collaboration** at the core of its approach.

At Berger-Levrault, scientific research reflects **an ambitious and resolute openness to the world**. Advancing our company requires **a pioneering spirit** capable of exploring new paths.

Our **approach** is entirely **holistic**, founded on curiosity, boldness, and unwavering commitment. Each project aims to deepen our understanding to better **pave the way for innovation**.

"They did not know it was impossible, so they did it"  
Mark Twain | Writer

### Excellence

Because we combine rigor and agility, our multidisciplinary team leverages its advanced scientific and technical expertise to deconstruct knowledge and progress in an enlightened manner.

### Trust

By placing ethics and sovereignty at the heart of every project, we build solid partnerships based on transparency, allowing us to confidently move forward into the future.

### Boldness

Because we embrace invention, we constantly strive to push our limits and challenge our confirmation biases by combining anticipation and ambition.

### Benevolence

Our attentive and open listening amplifies our creativity, enabling us to forge impactful innovations for our clients.

### Responsibility

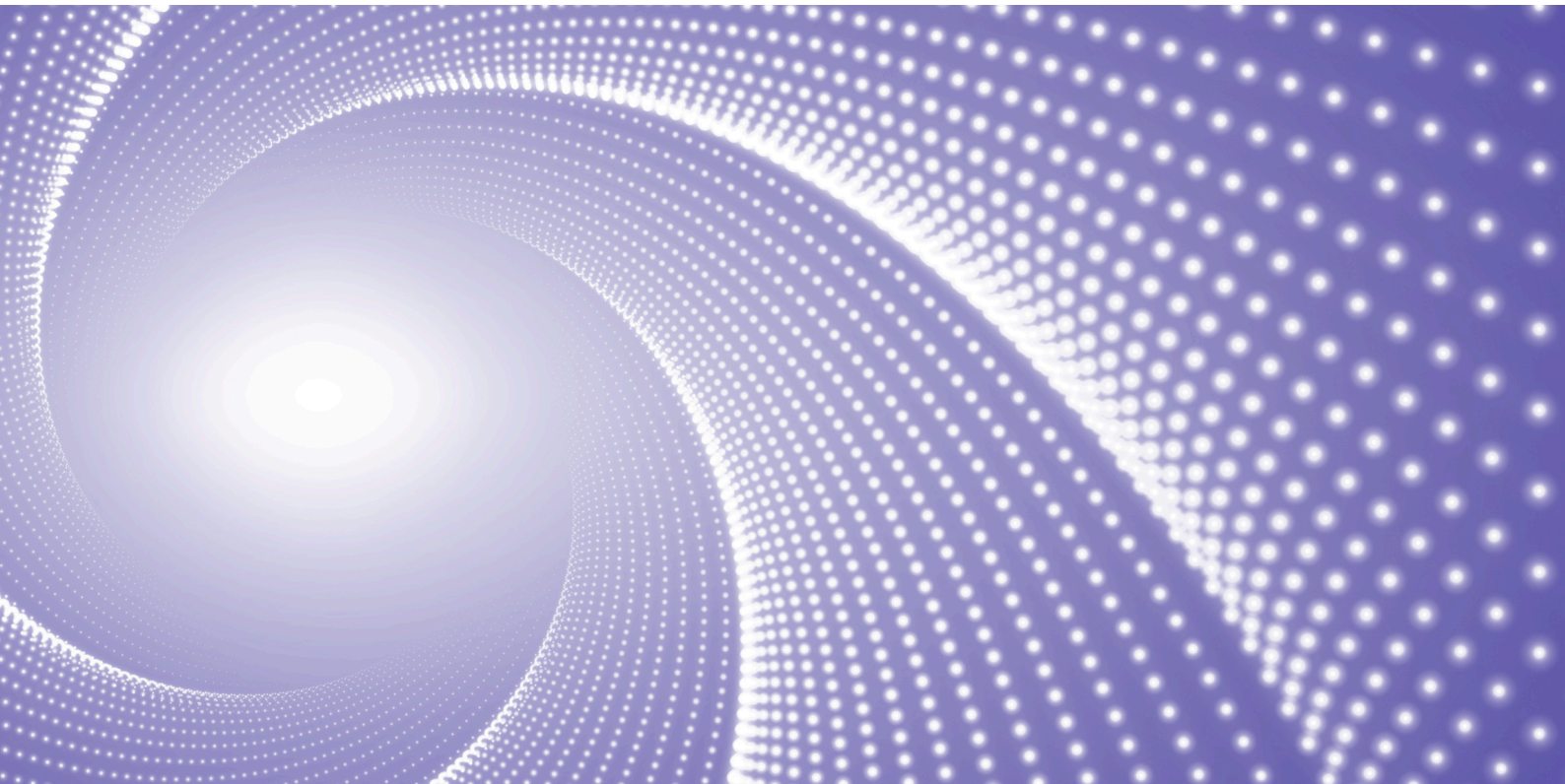
We are committed to a proactive approach aimed at promoting a positive and sustainable impact in scientific, societal, and environmental fields.

# Artificial Intelligence



# Artificial Intelligence | Everyday "Companion" Technology

Artificial intelligence has gradually embedded itself into our daily lives, often without us being fully aware of it. Whether it is searching for emails on Outlook, GPS navigation, Instagram's news feed, the embedded systems in our vehicles, or the smart thermostats in our homes. AI is already **highly present, discreetly optimizing and enriching our everyday experiences**. Statistics show an exponential growth in the integration of AI into the applications we use daily, illustrating its massive and continuous adoption.



However, this is only the beginning. What once seemed impossible is now not only conceivable but accessible. Algorithms that were once considered too complex to program now enable functionalities to classify, correlate, decode, extract, organize, synthesize, extrapolate, optimize, and more. Large amounts of free-text data, previously unexploited by our historical solutions, are now becoming gold mines of usable information. Scanned documents and images are transformed into **rich sources of structured data**. Previously inextricable numbers can now reveal significant trends. Video and sound, once confined to the role of passive media, can be analyzed, transcribed, and converted into actionable data.

**AI is thus expanding the boundaries of digital technology**, paving the way for a better understanding and utilization of the most tangible aspects of our reality.

## Training, Production & Transformation

This digital transformation is driving **a new revolution in computing**, where traditional development methods are being radically redefined. AI no longer relies on limited code manipulations. It is fueled by vast amounts of data; it is no longer programmed but trained. It no longer generates information in the traditional sense but produces probability-based results.

One of the major challenges in designing AI models is **our ability to reduce error rates to achieve performance comparable to human capabilities**. In natural language processing, this includes minimizing "hallucinations," those misinterpretations that can mislead users. These advancements represent a genuine paradigm shift, redefining the foundations of software development and the creative space.

"The true power of artificial intelligence lies in its ability to transform the invisible into the visible, to leverage this illumination to reveal opportunities where there were only data, and to make possible what once seemed unimaginable."

Mustapha Derras | Director of Research and Technological Innovation, Berger-Levrault

## Reliability, Precision & Resilience

In this profound transformation, the AI Laboratory at Berger-Levrault is pursuing an ambitious mission: to develop robust, sovereign, and seamlessly integrated artificial intelligence technologies within our products while focusing on solving our clients' operational challenges.

By "robust," we mean **reliable, precise, and resilient technologies**; by "sovereign," we seek the highest possible technological independence **to ensure data security and confidentiality**.

We aim to ensure that each innovation is not merely a technical achievement but has **a concrete and positive impact on the challenges our clients face every day**.



# Answer Engines

In fields where quick access to information is essential, such as customer support or reception in town halls, AI excels in its ability to understand a query in natural language and quickly **provide answers to all types of questions**. In 2024, the DRIT developed a brand-new response engine based on a "retrieval augmented generation" (RAG) system.

This artificial intelligence system is designed to answer any question formulated in natural language by skillfully combining a document base, embedding models, and the power of large language models (LLM). The assistant uses RAG to search for the most relevant information sources, extract the key information, and generate a summarized response. This corresponds to the creation of a **"librarian" robot**.



This year, our teams have leveraged and improved RAG techniques in numerous use cases, making it a daily asset for our support services across different business units. This solution allows them to directly benefit from online help, FAQs, knowledge bases, product documentation, etc.

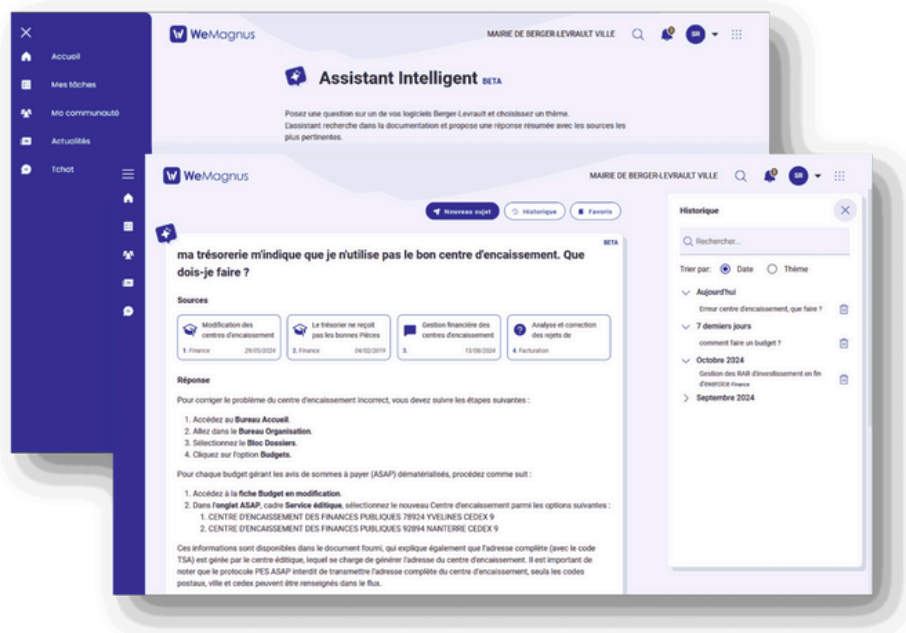
The support service of the Local Government BU **surpassed 10,000 queries in November 2024**, enabling us to ensure the robustness of our technical architecture supporting these developments.

## Intelligent Assistants, Reliable and Sincere Companions

This feature is also integrated into several of our products, such as WeMagnus and Legibase, under the generic name "Intelligent Assistant." The goal is to provide reliable answers to municipal secretaries' questions, among others, saving them valuable time while offering an exceptionally rich and different interaction experience on a daily basis.

Beyond speed, the quality and comprehensiveness of the responses stand out from the "traditional" solutions commonly used. This solution will soon be available for COBA in Quebec and for CARL SaaS at the beginning of 2025. We will continue activities aimed at industrializing the underlying technological platform, named **AI Gen Foundation**, in tribute to Isaac Asimov's renowned novel.

In 2024, we also observed the emergence of numerous RAG implementation proposals in scientific literature and industry. However, our observations are clear: the key to obtaining precise, high-quality, and hallucination-free responses lies not only in the LLM's ability to properly process its context but, more importantly, **in the quality, homogeneity, and proper preprocessing of documentary data.**



That is why our research and innovation teams have focused on developing numerous algorithms integrating advanced retraining techniques, prompt engineering, as well as data preparation, augmentation, and segmentation methods. Thanks to our deep data enrichment processes, we achieve **90% reliability**, far exceeding the default relevance rates of language models.

Extract from an automatically generated response on WeMagnus

Our approach is also distinguished by our ability to respond with "I don't know," significantly reducing so-called "hallucinations".

The year 2024 marks the beginning of a journey, as these tools will radically transform numerous everyday activities in the future, involving writing, information gathering, and natural language interaction across all our products.

## READ MORE

- [WeMagnus AI presentation interview](#)
- [BL software innovations in ARG](#)
- [AI WeMagnus press release](#)
- [Generative AI for Legibase Communities](#)

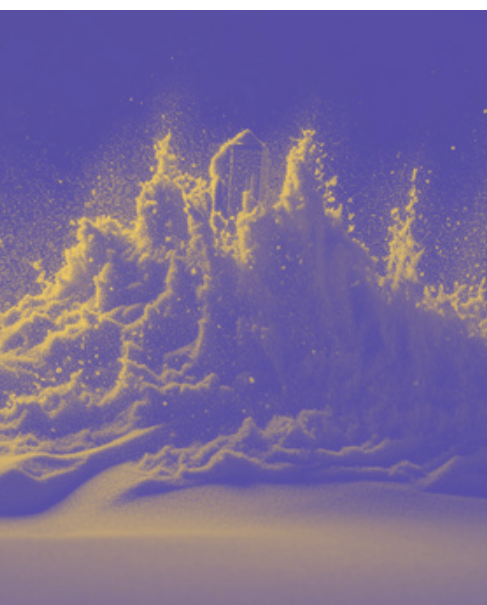


**Aikaterini** Batziakoudi   **Ali Can** Kocabiyikoglu   **Florent** Mouysset   **Mokhtar B.** Billami   **Julien** Breton   **Mehdi** Kandi   **Nihed** Bendhaman   **Pascal** Zaragoza   **Romain** Liron   **Stéphanie** Rey   **Valérie** Michel-Pellegrino   **Vincent** Laval

# Could this be the End of Structured Data?

The internal Coruscant project was born from few simple questions: "*Who enjoys filling out forms?*" or "*Are the data in our products easily accessible?*".

Our management software remains primarily an assembly of tables, input fields, and multiple-choice options that trap a vast amount of highly valuable data. Moreover, it is the implementation of these products that has allowed our users to "encode" valuable information into these same structured databases, thereby organizing our services and businesses.



## Genesis of the Project

However, when we closely observe the field and our users, the reality is quite different. Many valuable pieces of information are captured in numerous formats other than those designed for this purpose and often outside our management software, in spreadsheets and various forms!

A striking example is when we analyze the content of "free text" fields in our own software, we quickly notice that they are filled with dense and valuable information. Even more surprising, this observation transcends all industries, whether in local government, healthcare, or industry.

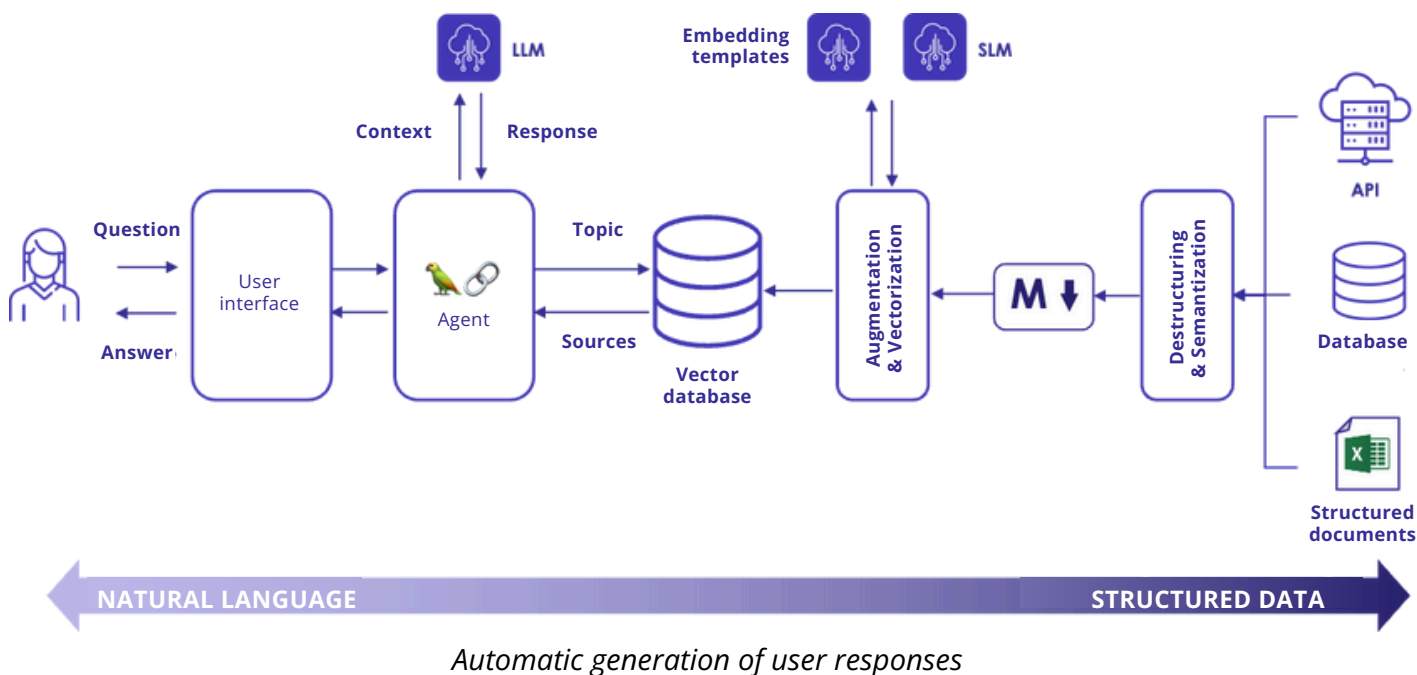
The internal **Coruscant** project (a reference to the home planet in Star Wars) was born from these findings, with a simple ambition: to create the necessary link between structured and unstructured data within management software, enabling our users to express themselves in natural language when utilizing these same data.

## Converse in Natural Language with our Management Products

In the field of **industrial maintenance**, we can consider, for instance, the efficiency of maintenance technicians. Their efficiency largely depends on their ability to quickly access the history of interventions they have conducted. It is crucial for them to rapidly identify proven solutions for comparable failure symptoms. Indeed, why spend time diagnosing the cause of a failure if the same problem has already been resolved multiple times on the same type of equipment? However, conducting such searches and accessing this information is highly laborious, complex, and **requires an in-depth analysis of past interventions or knowledge bases** when available. This example highlights **how optimizing these processes is crucial** to reducing costs and improving responsiveness and intervention quality.

We could multiply such examples that illustrate two conclusions drawn from decades of digitalization. The first is simple: information is available, recorded, and materialized after years of using management solutions. The second is equally undeniable: these data are not easily accessible, and even less so for our users.

The project thus has a clear ambition: **enable natural language conversations with our products.**



**The challenge** for our research and innovation teams is **to make structured databases and APIs compatible with natural language interfaces.** The fundamental principles of agentic AI, combined with data restructuring, are essential to realizing this vision.

The first research results and prototypes developed in 2024 indicate that we are much closer to our goal than expected. Indeed, if tomorrow I can "operationalize" the management of my municipality, healthcare institution, or industry through free text and voice commands, who will still need to fill out forms?

## READ MORE

- [Understanding AI for Maintenance](#)
- [BL.Assistant: Process automation](#)



**Ali Can**  
Kocabiyikoglu



**Katarzyna**  
Borgiel



**Mokhtar B.**  
Billami



**Pascal**  
Zaragoza



**Vincent**  
Laval



**Younes**  
Zegaoui

# Our 5 years Predictions

- 🧠 Structured databases will see their usage significantly decrease in favor of **a combination of loosely structured information and AI**
- 🧠 Graphical interfaces will be replaced, at least partially, **by natural language text** and/or voice interfaces
- 🧠 Large language models will **reduce their energy consumption** by a factor of 100
- 🧠 30% of the **functionalities** of our management products will be **automatable** and may disappear in favor of workflow control functions.

# Our Scientific Papers 2024

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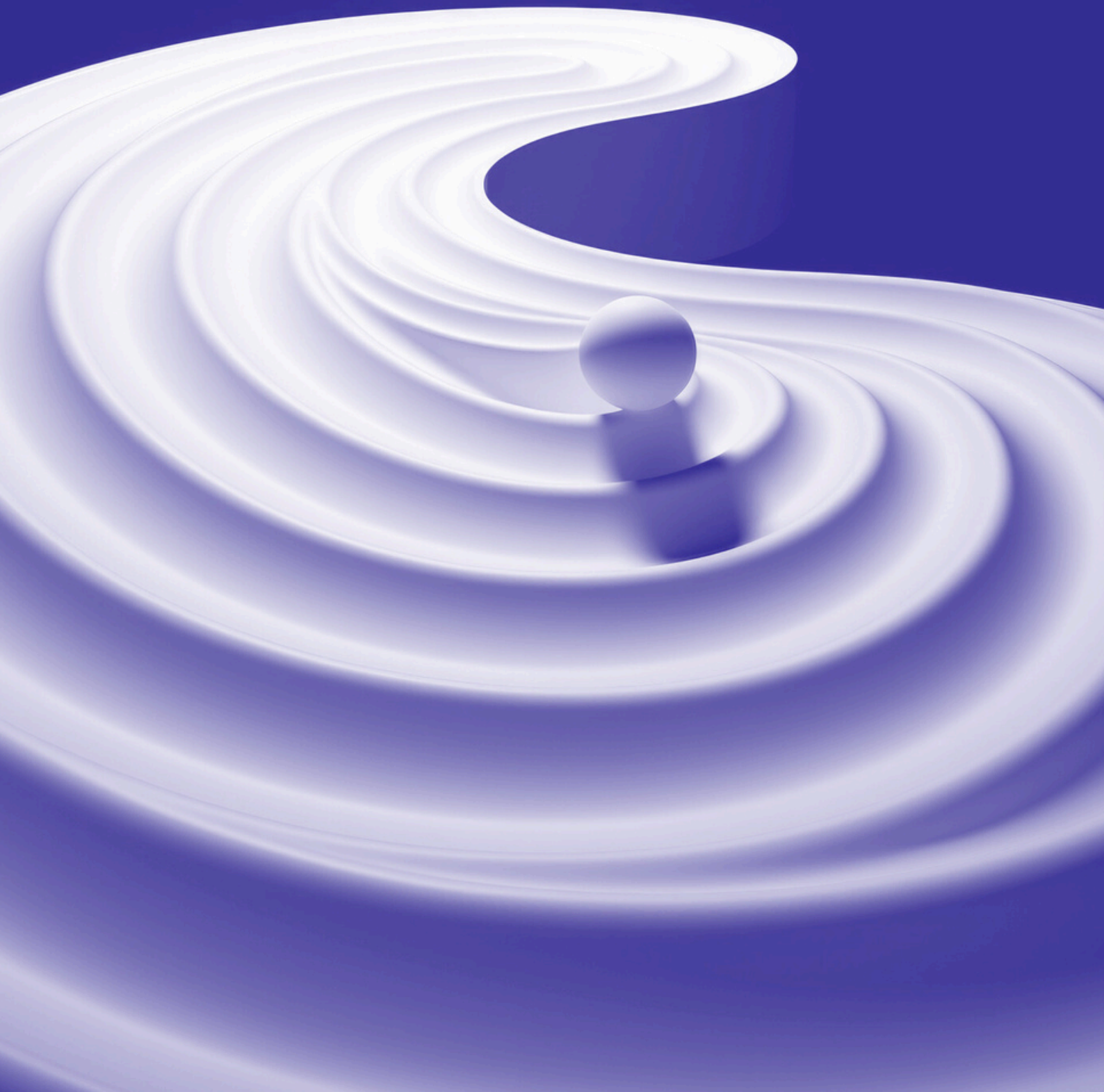
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Breton, J., Billami, M. B., Chevalier, M., & Trojahn, C. (2024). Leveraging Semantic Model and LLM for Bootstrapping a Legal Entity Extraction: An Industrial Use Case. 20th International Conference on Semantic Systems (Semantics2024). <https://2024-eu.semantics.cc>

# Software Engineering



# Software Engineering | Towards Sustainable Design Practices

The second quarter of the 21st century, which we are now entering, brings with it an explosion of managed cloud services, new programming languages, an increasing standardization of web tools, and a proliferation of high-quality open-source libraries. Yet, despite these advances that should have heralded a revolution in software development, we still face familiar challenges: we continue to write code, install systems, create interfaces, and index databases.

## Trends

This recent evolution should have established a new paradigm, making software development a mere task of assembling components, as if building with ready-made bricks.

However, this is far from reality, and **developing software has never been more complex and demanding**. Developers must now address a multitude of interwoven constraints: interoperability, cybersecurity, service-orientation, multi-tenancy, responsiveness, scalability, regulatory compliance, accessibility, traceability, service continuity, among others.

More recently, a new requirement has emerged—**digital frugality**. With digital technologies already accounting for over 4% of global greenhouse gas (GHG) emissions, it is becoming imperative to adopt more responsible practices.

"Technologies are advancing, freeing us from the most complex tasks, but it is our responsibility to make them sustainable for the future"

Satya Nadella | CEO, Microsoft

## Digital Frugality to optimize Productivity

To address these challenges, we have decided to tackle two key issues:

### Enhancing the productivity and capabilities of our developers by expanding the set of tools at their disposal

This includes code and test generators, advanced analysis bots, intelligent integration aids, reverse-engineering tools, system data visualization means, and even automatic security vulnerability detection mechanisms during code writing. We have a wealth of solutions to develop such tools, leveraging platforms like Moose, dedicated code LLMs, Git and JIRA APIs, or even the Language Server Protocol for seamless IDE integration.

Our ambition is to make these advanced functionalities available as close as possible to developers' daily work—directly within development environments such as IDEs and repository managers—thus **simplifying and automating the most complex tasks**.

### Proactively adopting a digital frugality trajectory

European and national regulatory pressure will impose new standards, and increasing technological stack layers make eco-responsible design choices increasingly difficult.

While performance, maintainability, and security remain crucial, **reducing the energy footprint of our applications** is also essential. Additionally, digital resources and energy are becoming costly and will have an increasing financial impact. Beyond environmental responsibility, the economic viability of our choices is at stake. To this end, we are developing specific recommendations and solutions **to optimize the energy efficiency of systems**.



The GL Lab is therefore positioned at the forefront of providing developers with tools that not only **enhance their efficiency** but also guide them toward sustainable design practices. Our ambition is to design **energy- and infrastructure-efficient SaaS systems** that meet the growing regulatory and societal expectations for digital frugality.



# Augmented Developers

Since their market release in 2022, generative AIs have been successful and have immediately seen global adoption. In 2023, OpenAI recorded well over 21 million active users on ChatGPT. While Large Language Models (LLMs) are capable of generating meaningful text based on probabilities, they also excel at completing portions of code written by our developers.

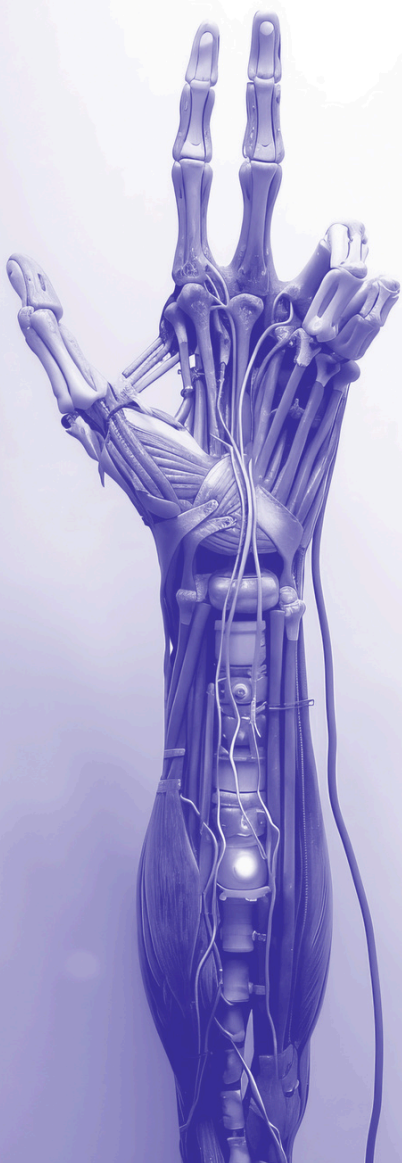
## Search by & for our Developers

At the beginning of 2024, to study the ability of LLMs to support the work of our developers, we invited 20 of them to participate in **an observation study over three months**. Each participant received access to GitHub Copilot and Codium, two tools that integrate LLMs into the development environments VsCode and IntelliJ. The participants were tasked with working "normally" with these tools without specific instructions. We monitored **their usage on a weekly basis**, using questionnaires and informal experience feedback to analyze the situation. We also measured the number of lines of code, commits, merge requests, code churn, and other indicators to understand the effects of these tools in particular.

Three months of study were enough to demonstrate the daily adoption of these tools by developers. They even recommend their widespread use among all developers. But do these tools have a significant impact on the productivity of our participants?

Indeed, production data remains stable. The slight variation noticed can be explained by other external factors, such as a more or less intense development period or the presence of observation bias. These initial conclusions confirm those found in the literature, which show **a significant impact on developers' perception of productivity** [1][2].

We also demonstrated, by analyzing several million lines of code and tens of thousands of commits, that **these assistants did not affect the quality of the produced code**. These findings call for great caution in drawing conclusions. This is why it is necessary to extend this study to a larger panel of participants while continuing an in-depth follow-up on the implementation of these tools.



We also found that code generation tools based on AI do not provide a simple and native means to "control" the generated code. Indeed, how can we ensure that artificial intelligence will produce code that complies with a product's architectural standards and the company's frameworks? The GL Lab has therefore set itself **the objective of developing tools** that combine the capabilities of models obtained through standard static code analysis and LLMs **to generate code that is immediately compatible with Berger-Levrault's standards.**

```
TS sentiments.ts × TS time.ts

1 // Determine whether the sentiment of text is positive
2 // Use a web service
3
4 async function isPositive(text: string): Promise<boolean> {
5
6     const response = await fetch(`http://text-processing.com/api/sentiment/`, {
7         method: 'POST',
8         body: `text=${text}`,
9         headers: {
10             'Content-Type': 'application/x-www-form-urlencoded',
11         },
12     });
13     const json = await response.json();
14     return json.label === 'pos';
15 }
```

*Code completion generated by artificial intelligence*

In 2024, the introduction of these new assistants, "compatible" with our code generation standards, has highlighted the immense potential for improving developers' daily work, making their tasks easier and more efficient. In the future, these assistants, whether they use LLMs or not, could **become the pair programmers of our developers**. Imagine robots capable of reviewing merge requests, assistants generating unit tests, or even integrated development environments (IDEs) that autocorrect themselves to comply with programming standards and corporate frameworks! This **vision of an augmented developer** could materialize much faster than we imagine.

## READ MORE

- [1] A. Ziegler et al., « Measuring GitHub Copilot's Impact on Productivity », Communications of the ACM, vol. 67, n° 3, p. 54-63, 2024.
- [2] M. Coutinho & all., « The Role of Generative AI in Software Development Productivity: A Pilot Case Study », 1st ACM International Conference on AI-Powered Software, 2024, p. 131-138.



**Benoit**  
Verhaeghe



**Boubou T.**  
Niang



**Ikram**  
Boukharouba



**Kilian**  
Bauvent



**Nicolas**  
Hlad



**Quentin**  
Capdepon

# Energy Efficient Software

Software consumes more than **6% of the world's energy**, with an annual increase of 6%. Regulations on the energy consumption of digital systems are evolving rapidly (REEN Law, RGEN, European Regulation, etc.). At the same time, our clients are showing increasing interest in the environmental footprint of our solutions. It is therefore essential to consider reducing the energy consumption of software, just as we do with other properties such as security or maintainability.

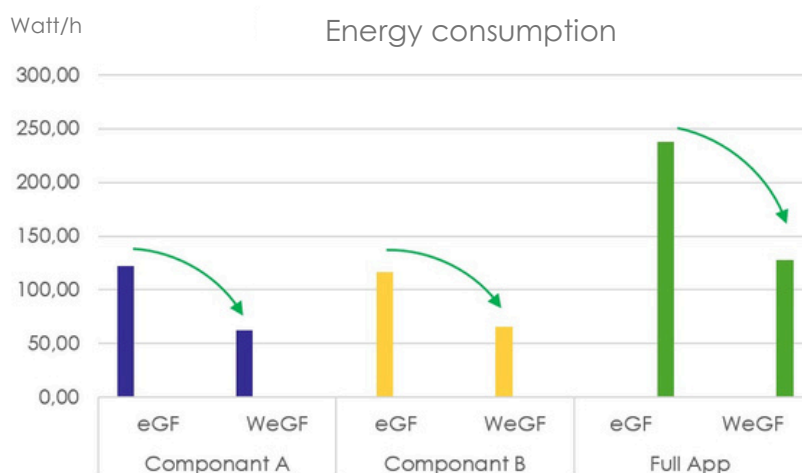
But how can we achieve this?

Do you know how **to measure the energy consumption of software**? What technological or architectural choices will have the most energy-efficient consequences? Would it be possible to optimize code to make it more environmentally friendly?

**Energy frugality** has been a priority for our research and innovation teams since 2020. In 2024, we decided to push the boundaries and develop a set of tools dedicated to measuring, comparing, and optimizing the energy consumption of our solutions.

## Our SaaS-Web WeGF Use Case

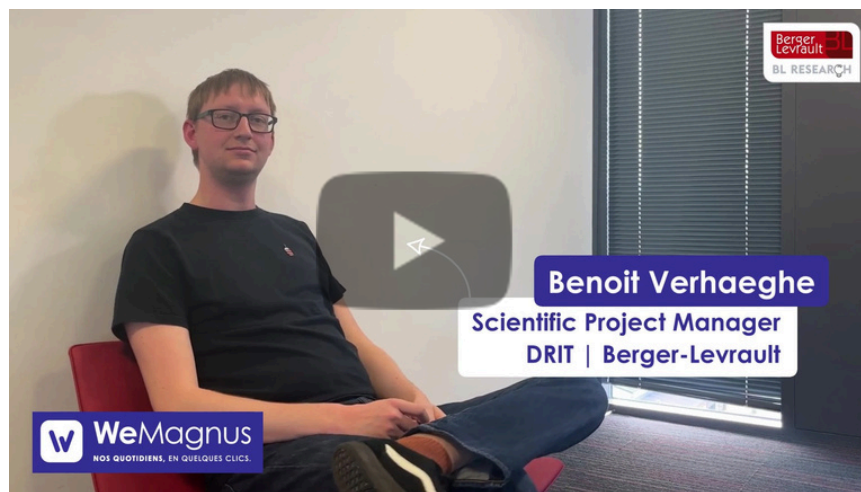
This year, we compared the energy footprint of one of our SaaS-Web products (WeGF) with its predecessor developed as a rich client (eGFEvolution). In the case of WeMagnus, the initial results appear very promising. The modernization of the front-end—everything directly accessible to users through their web browser—and the implementation of a shared cloud architecture have led to a **21-fold reduction in overall energy consumption**. These gains are partly achieved through better software architecture and rationalization of hardware resources. These measurements, made possible by sensors deployed in our production environments, now allow us to continuously monitor the kWh consumption of our SaaS products.



Energy consumption trends between eGF and WeGF

It is imperative not to stop at this stage. First, we want to demonstrate how it is possible to measure and meet regulatory and client requirements. Furthermore, we aim to implement a **concrete plan to optimize our solutions and reduce their carbon impact** as they transition to SaaS mode. To this end, we have also implemented tools to detect energy-intensive anti-patterns in CI/CD processes and code. The next step will be to identify these bad practices early in the development process within the developers' IDE and propose automatic corrections to build more efficient applications

We have also undertaken a comparative study of equivalent technologies. For example, we examined the energy efficiency of REST JSON calls versus calls using Protobuf (Protocol Buffers). The results are surprising, as we observed a significant reduction in energy consumption with Protobuf, without compromising performance. Being more energy-efficient does not necessarily mean being slower.



*Interview with Benoit Verhaeghe - Eco-design for the WeMagnus product*

We are entering a new era with an ambitious process focused on Digital Frugality. This project requires a comprehensive approach, as there are still few ready-to-use technologies and methods to measure, design, and optimize software. Of course, this initiative is not limited to solving technical problems. We also consider feature economy, which will shape the software of tomorrow by ensuring that they use only the computational resources strictly necessary.

## READ MORE

- [Measuring energy consumption of our software](#)
- [Eco-responsible digital transformation for small communities with WeMagnus](#)



**Anas**  
Shatnawi



**Bachar**  
Rima



**Benoit**  
Verhaeghe



**Boubou T.**  
Niang

# Our 5 years Predictions

- 🤖 We will **increase tenfold the number of robots supporting developers** in their daily tasks.
- 🤖 Each application will have its own "**eco-index**".
- 🤖 **Project management** will be largely **automatable**, including ticket creation, schedule generation, and workload estimation.
- 🤖 Architects will have the ability **to reorganize code using blueprints and data visualizations**.

# Our Scientific Papers 2024

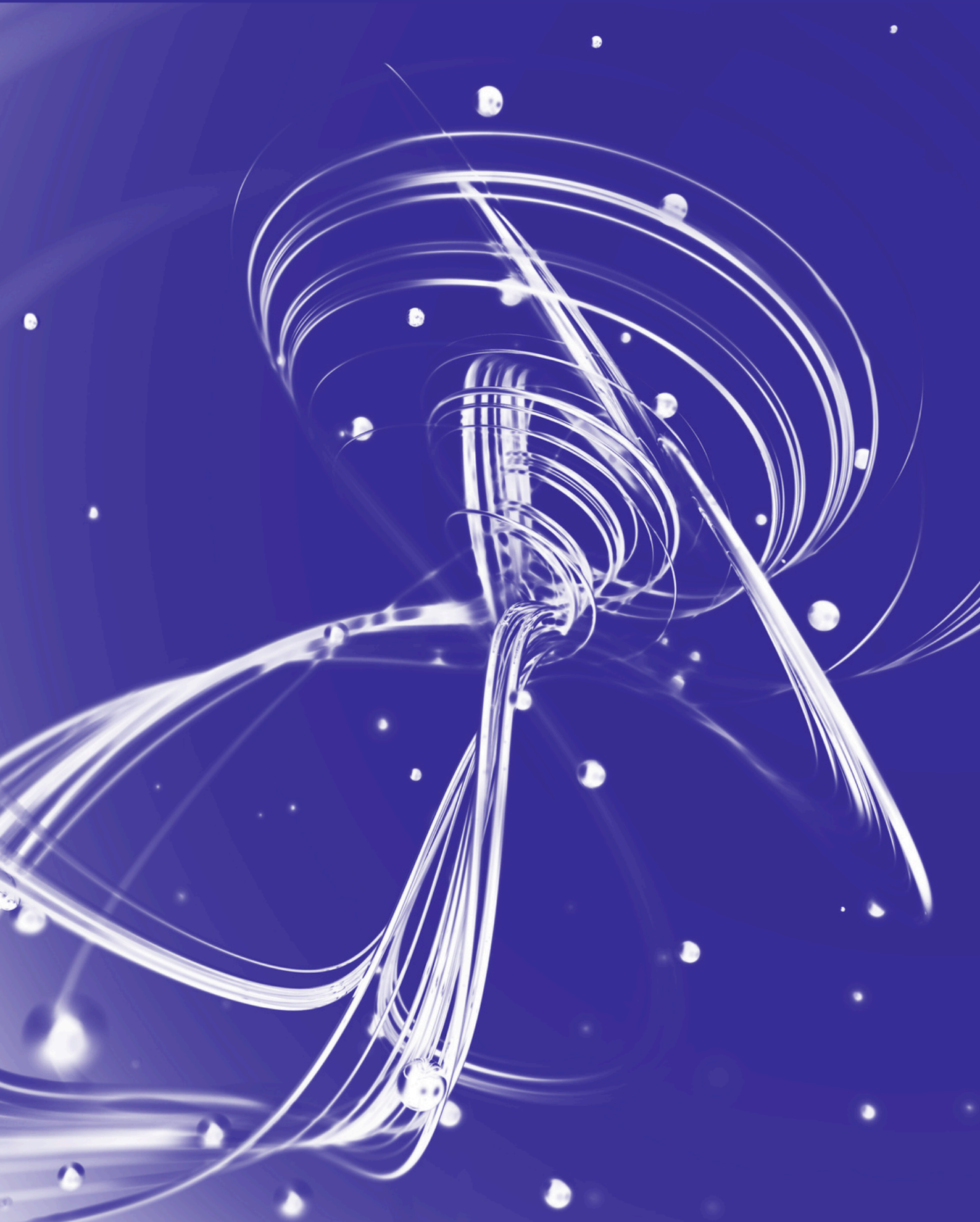
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# Industry 5.0



# Industry 5.0 | The Era of Human-Machine Collaboration

The industry is on the verge of experiencing a new wave of transformations. After mechanization (Industry 1.0), electrification (Industry 2.0), automation of production lines (Industry 3.0), and digitalization (Industry 4.0), Industry 5.0 marks **a new turning point** towards organizing efficient collaborations between humans and machines. This innovative approach redefines industrial processes by establishing **three core priorities** for transformation: **humans, resilience, and sustainability**. Unlike Industry 4.0, which focused on automation and productivity, this new 5.0 ambition aims to foster more natural interactions tailored to users' real needs, while integrating environmental constraints and Europe's competitiveness challenges.

## Maintenance, Digital Twins and more...



With this in mind, maintenance activities must evolve to reintroduce operators "into the loop." The goal of **Maintenance 5.0** is to become **more intelligent, resource-efficient, and resilient** in facing economic and energy challenges. Practically, this translates into solutions that empower maintenance technicians with digital augmentation, providing them with intuitive interactions, enriched and contextualized data, as well as physical and cognitive tools to support them in their daily tasks.

For Berger-Levrault, this means developing innovative interaction modalities such as augmented reality solutions that create **a seamless continuum between physical machines and the information system**. More importantly, it entails a fundamental transformation in the use of "standard" software solutions, which must integrate into this new generation of interactivity.

**Digital twins** will likely play a central role in this evolution. No longer merely inert representations, they will become dynamic entities capable of facilitating modeling, simulation, forecasting, and planning actions in the physical world. These informational replicas will enable smarter asset management, promoting equipment circularity, failure anticipation, and optimizing resource lifespan while reducing environmental impacts. They will serve as the primary realistic and efficient link between human operators and digital environments.

## The Role of AI in Industry 5.0

**Multimodal artificial intelligence** will play a key role in this equation. With AI, machines are now equipped with capabilities **to capture "portions" of the physical world through smart sensors** (IoT). These sensors provide real-time data on aspects such as sound and video while also detecting subtler elements like vibrations or temperature, or even imperceptible factors such as CO2 levels or certain inaudible or invisible frequencies. The digital twin will thus allow for a holistic vision and a more refined analysis of situations to enhance decision-making and improve operator efficiency in complex environments.

"The coupling of man and machine begins to exist from the moment a coding common to both memories can be discovered, so that a partial convertibility of one into the other can be achieved, making synergy possible."

Gilbert Simondon | Philosopher

Industry 5.0 heralds an era where technology and humanity co-evolve to collaboratively address economic, social, and environmental challenges. By fostering interaction between humans and digital systems, this approach places individuals at the heart of transformations, aiming to establish a sustainable, inclusive, and competitive industrial future rooted in our territories.

For CARL-Berger-Levrault, this already translates into numerous solutions in the commercialization phase or currently being tested by several clients. For example, MixedR enhances operators' capabilities with augmented reality, Optim optimizes resource usage and planning, already contributing to reduced consumption of various resources through its meta-heuristics. BL.Predict is a central element of this strategy, equipping us with an IoT platform aligned with our future ambitions, facilitating the reduction of energy impacts for buildings and industries.

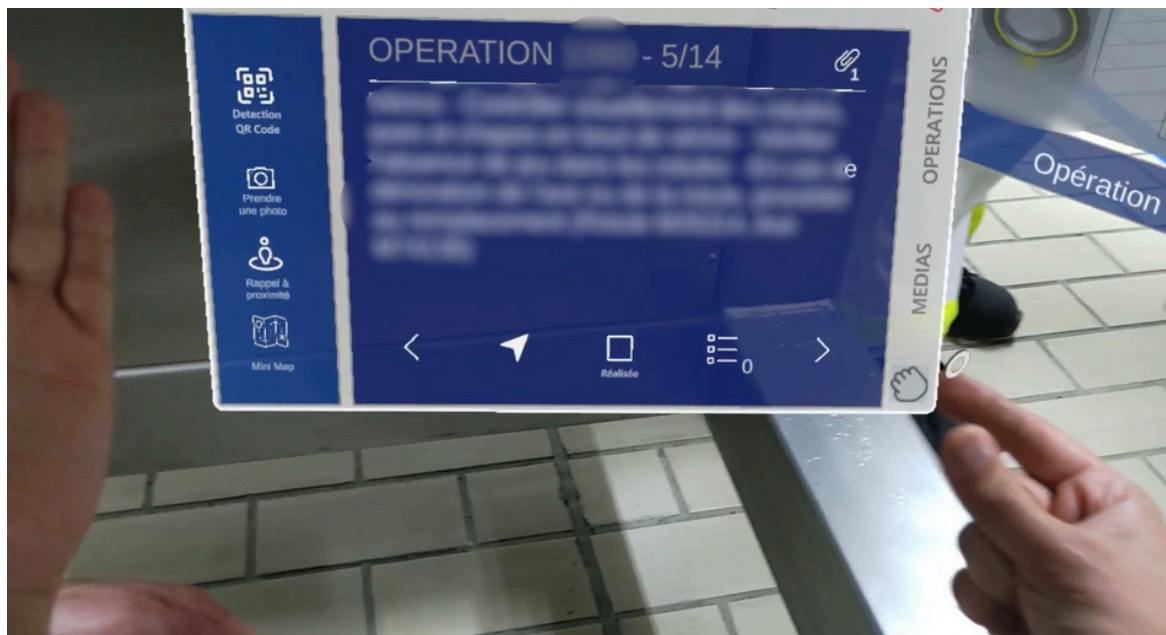




# The Best of Both Worlds

Industrial operations often face complex processes, high costs, and the risk of human errors that can lead to downtime and reduced efficiency. MixedR addresses these challenges by minimizing equipment downtime, improving intervention accuracy with real-time data, and optimizing inventory management through an immersive augmented reality interface.

The promise of MixedR is to bring CMMS data into the technician's field of view, allowing them **to keep their hands free while accessing all necessary information at any time**. MixedR utilizes mixed reality devices, such as the Microsoft HoloLens, to provide immersive experiences. Through precise techniques that anchor digital information and real-time visualizations into the physical world, technicians can instantly access essential information directly extracted from the CARL Source database.



*Production line maintenance operation assisted by Augmented Reality*

Beyond its technological prowess, combining network management, 3D display, and mid-air interaction, MixedR has proven its effectiveness through concrete deployments with major CARL clients. By facilitating **quick and intuitive access** to critical information, MixedR helps reduce human errors, improve productivity, and promote safer operations.

We have simplified access to cutting-edge expertise by integrating an AI-powered assistant into the headset while allowing users to connect with human experts when needed.

## Redefining Interactions to support Performance

MixedR is only at the beginning of its journey. Our teams are also exploring various interaction techniques to facilitate interface manipulation in space. Interacting with a set of floating windows is a fundamentally different experience from using a smartphone, keyboard, or mouse. Therefore, it is essential to reinvent interaction paradigms to democratize the use of augmented reality.

Our researchers are focusing on exploring "opportunistic interactions" on various available surfaces in the environment (wall, table, chair, glass) or even on the body, transforming any surface into a means of selection, validation, and access. Ultimately, do I even need a smartphone if I can simply use my arm or leg?



*Research on augmented maintenance via touch input with Tripad*

### READ MORE

- [Augmented reality for remote assistance](#)
- [Tripad: Augmented reality touch input in industrial maintenance](#)



**Housseem E.**  
Saidi



**Mehdi**  
Ayadi



**Camille**  
Dupré

# Planning: An Industrial and Environmental Challenge

In a socio-economic environment where constraints are increasing and needs are diversifying, companies face the challenge of managing complex schedules. Particularly in maintenance, **the role of a planner proves to be highly demanding:** assigning the appropriate skills to necessary interventions, responding quickly to corrective maintenance requests, anticipating preventive interventions without overloading daily schedules, minimizing travel time to reduce fuel consumption and CO2 emissions, respecting working hours, intelligently distributing workload among employees, and managing multi-site or complex operations, including teams working in 24/7 shifts.

In this context, creating an effective schedule represents a significant challenge. How can one optimize production operations in such a setting?

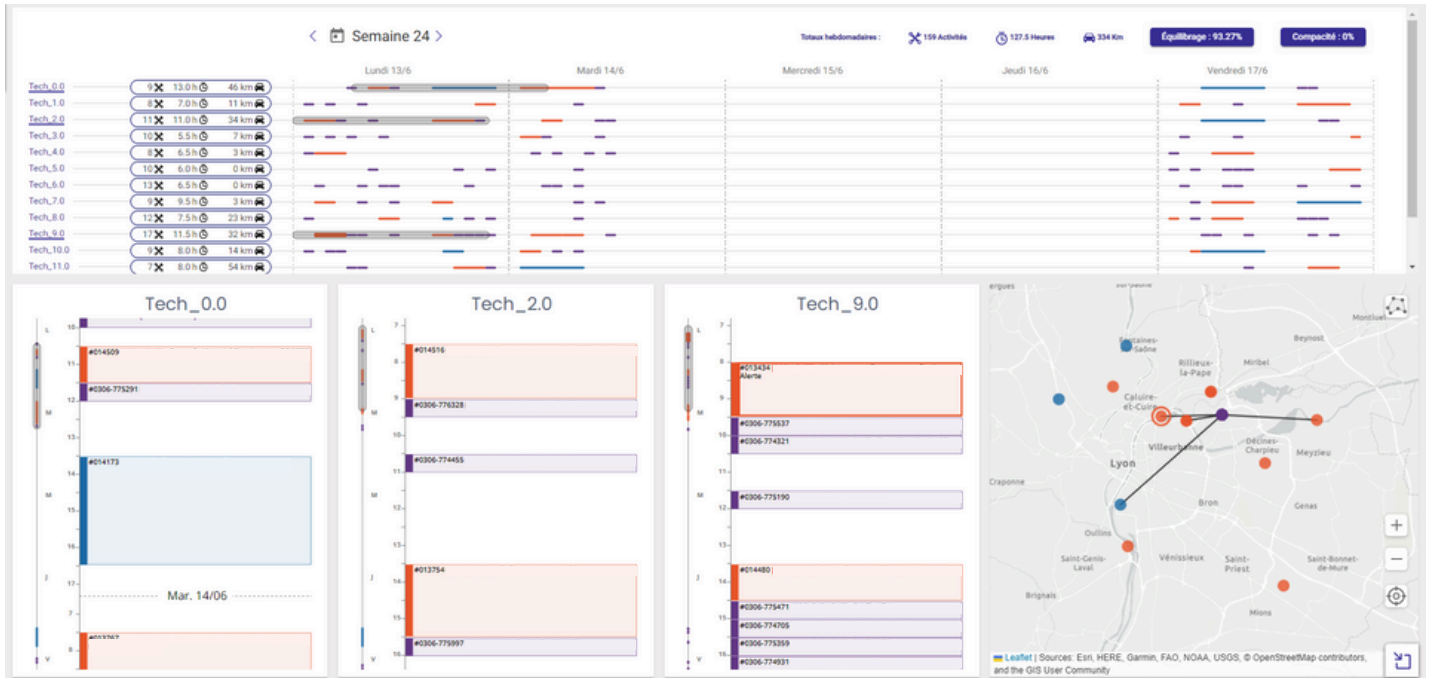
**BL.Optim** addresses these challenges by providing an innovative solution that **automates scheduling and optimizes resource allocation**, aiming to maximize efficiency while reducing costs. This platform relies on artificial intelligence algorithms, known as meta-heuristics, specifically designed to solve problems where testing all available options would be impossible.



## Iterative Work to integrate our Customers' Realities

In 2024, our teams tested this solution across numerous CARL client cases, both in the food industry and facility management. This in-depth work allows us to confront the highly demanding realities of the field with the capabilities of optimization algorithms. Thus, we have precisely modeled our clients' constraints to generate **schedules that meet all organizational requirements and the specificities of maintenance team management.** Beyond this initial success, BL.Optim has significantly reduced travel time, minimized necessary resources, and freed up time for maintenance teams.

This iterative process, oscillating between fundamental research and field innovation, has enabled us to develop a highly flexible solution that effectively adapts to the diverse needs of our clients. This ensures both **performance and scalability through continuous improvements**. Moreover, our teams are working on a method to translate operational and regulatory requirements into mathematical modeling plans, thereby fueling our algorithms.



Overview of a schedule generated by the BL.Optim platform

Given the industrial performance demands ahead of us, as well as the energy and ecological constraints we must address, the challenges of scheduling are far from resolved. That is why we will continue to push the boundaries of the state of the art by integrating real-time rescheduling capabilities into our algorithms to address unforeseen events. We will also develop **simulation tools** to understand, verify, and make explainable the choices and options explored by these algorithms, which are gradually integrated into our daily operations.

## READ MORE

- [Simulation and analysis of disruptive events with BL.Optim](#)
- [Use case of home healthcare planning with the new BL.Optim model](#)



**Clément**  
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**Florent**  
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**Housseem E.**  
Saidi



**Kevin**  
Ducharlet



**Liwen**  
Zhang



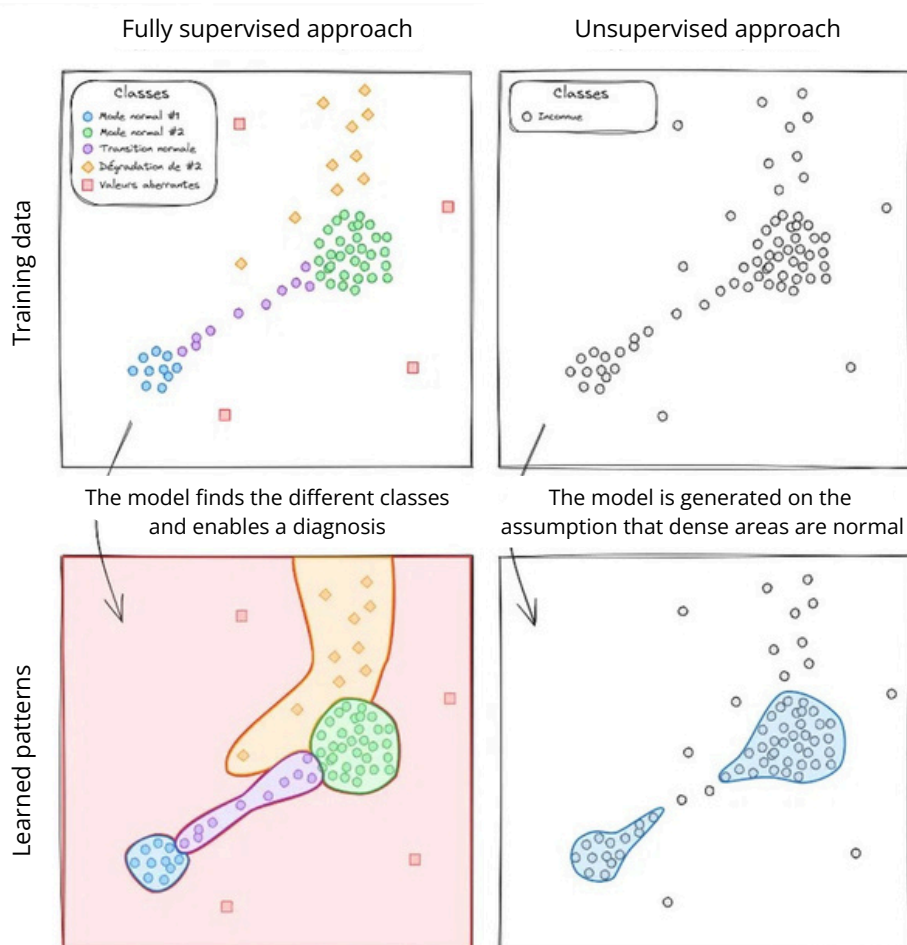
**Sara**  
Maqrot

# Federated Learning to Serve Predictive Maintenance

Combined with the Internet of Things (IoT), AI enables the analysis of data from various sensors and **the prevention of potential equipment failures** before they occur. AI transforms this data into precise insights, allowing managers to plan targeted interventions, thereby minimizing unexpected interruptions and associated costs. This principle, known as predictive maintenance, not only optimizes operational maintenance performance but also **extends the lifespan of critical equipment**.

## Automate Machine Behavior Discovery

In practice, this translates into **the development of anomaly detection algorithms**. We have developed unsupervised methods to identify anomalies in sensor network data streams, leveraging hybrid artificial intelligence approaches. In recent years, we have experimented with several innovative algorithms, such as DyCF and DyCG, which exploit the properties of the Christoffel function and reduce the need for parameterization.



*Different degrees of supervision for anomaly detection*

Anomaly detection is a complex challenge influenced by context, where failures in identical machines may manifest differently. To be effective, artificial intelligence must address contextual specificities while generalizing common elements. This is why our research teams are focusing on **federated learning in predictive maintenance**. Moreover, this approach allows models to be trained on edge devices, reducing data transmission costs and privacy risks. It harnesses local data to create a robust global model while respecting the diversity of equipment and industrial contexts



In 2024, we tackled concrete challenges related to baggage conveyor monitoring by leveraging the promises of federated learning. We examined optimal moments for training models and selecting edge devices while considering airport schedules across different time zones. Our analysis revealed that the best training periods are not limited to nighttime but vary depending on time zones and estimated processing time. For instance, data from the airports of Zagreb and Christchurch show that certain periods of the day can be particularly advantageous.

We also compared Clustered Federated Learning with Traditional Federated Learning using our FeDStack algorithm. The results indicate that federated learning significantly improves conveyor performance compared to traditional learning, while Clustered Federated Learning further enhances this improvement due to the statistical homogeneity of the data

By integrating these approaches, **AI is revolutionizing industrial maintenance practices** by offering solutions that combine **precision, sustainability, and compliance with operational constraints**. Whether through proactive anomaly detection or collaborative training of predictive models, AI is establishing a new and essential standard for optimized industrial asset management

## READ MORE

- [Federated Learning, a security asset for local data maintenance](#)
- [Automated anomaly detection with BL.Predict](#)
- [Alstef Groupe story: CMMS to maintain baggage sorting systems](#)



**Youssef**  
Miloudi



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**Mehdi**  
Kandi



**Kevin**  
Ducharlet



**Karim**  
Boutamine



**Jean-Michel**  
Joerger



**Hamza**  
Safri

# Our 5 years Predictions

- 🧑‍🔧 **Augmented reality and voice interaction** are becoming increasingly prevalent **in the daily tasks of maintenance technicians.**
- 🧑‍🔧 **CMMS tools are enhanced with numerous AI models** to anticipate failures, optimize scheduling, and automatically manage inventory.
- 🧑‍🔧 **CMMS** collects information from various data sources, pooling commonalities between equipment manufacturers and thereby opening up **a data-driven economy.**

# Our Scientific Papers 2024

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# Impact





# Ecosystem & Partnerships

The DRIT partner ecosystem enables the organization of **dynamic collaborations** between the public and private sectors. These diverse stakeholders represent a strategic asset that **fosters innovation and delivers tangible solutions to current technological challenges**. However, these interactions primarily serve to accurately identify the real challenges that express difficulties or expectations from our users.

## Public Partnerships

Our research and innovation teams have been working closely with universities and research institutes for over 15 years. Among these, we count the **National Institute for Research in Digital Science and Technology (Inria)**, with which we signed a strategic partnership agreement in 2021 to develop digital solutions derived from research. We also conduct numerous doctoral theses in collaboration with Inria, focusing on concrete and innovative applications, particularly in Software Engineering and Industry 5.0.

Notably, since 2022, Berger-Levrault has been co-leading a **joint research team** named Reflective Evolution of Eternal Software Systems (EVREF), allowing us to contribute to all our work in software engineering. The year 2024 marks a further strengthening of our collaboration with Inria with the sharing of our long-term roadmap in Artificial Intelligence.

Similarly, a five-year framework agreement has been established with **the French National Centre for Scientific Research (CNRS)** to conduct joint research projects.. These agreements enable us to benefit from cutting-edge scientific expertise and actively contribute to the advancement of both fundamental and applied research.



*Inria & Berger-Levrault meeting as part of the strategic partnership for a more responsible digital world*

# Private Partnerships

Our research and innovation team also relies on a network of innovative companies, technology startups, clients, and industrial partners. This ecosystem fosters the implementation of applied research projects and the development of products and services that directly address market needs. For

For example, we collaborated with **Adeunis** to develop a **connected maintenance solution** based on IoT technologies, enabling **real-time supervision of building technical equipment**. This partnership facilitated the implementation of a predictive maintenance solution by leveraging sensor data, thereby improving intervention responsiveness and reducing costs associated with unexpected failures.

Some industrial partners support us in deploying Minimum Viable Products (MVPs) to evaluate innovations under real-world conditions. For instance, For example, major companies in the food and retail industries participated in the implementation of MixedR, our augmented maintenance solution. Similarly, local authorities and major international groups collaborated on the development and deployment of BL.Predict, an IoT platform dedicated to predictive maintenance of equipment.

These synergies are actively pursued and help **accelerate the adoption of innovations by users**. More importantly, they align our research investments with market expectations for innovation.



*Smart Delta P - A collaboration between Adeunis & Carl Berger-Levrault*

Bringing together academic experts and industrial partners around Berger-Levrault's core fields is at the heart of Berger-Levrault's innovation strategy. This approach embodies Berger-Levrault's commitment to pushing the boundaries of technology while staying closely connected to real-world applications.



Anaïs Vatinel



Thierry Thepaut

# Highlights | International Resonance



25/03 - 28/03 | France

Global Industrie **stand** with CARL Berger-Levrault, to **promote BL.Predict**, our AI/IoT platform for equipment and infrastructure management

Youssef Miloudi, Thierry Thepaut



29/04 - 01/05 | United Arab Emirates

International Conference on **Distributed Computing in Intelligent Systems and the Internet of Things** | DCOSS-IOT

Hamza Safri : *"A workflow Management System Approach To Federated Learning"*



11/05 - 16/05 | United States of America

International Conference on **Human Factors in Information Systems** | ACM CHI 2024

Camille Dupré : *"TriPad: Touch Input in AR on Ordinary Surfaces with Hand Tracking Only"*



25/06 | On-Line

Webinar co-hosted with CARL Berger-Levrault unveils the current challenges and prospects of **maintenance 5.0**

Christophe Bortolaso, Laurent Truscello  
*"Explore the benefits of AI applied to CMMS!"*

# Highlights | International Resonance



08/07 - 11/07 | France

International Conference European Smalltalk **User Group** | ESUG 2024 & **Best Paper Award** to Gabriel for his work on **unit testing of software applications**

Gabriel Darbord "*Modest-Pharo: Unit Test Generation for Pharo Based on Traces and Metamodels*"



12/09 | France

Launch of Inria's P16 project on digital sovereignty, to develop **open source and interoperable digital technologies**

Christophe Bortolaso | Partenariat stratégique Berger-Levrault et Inria



06/11 | France

Awarding of **the Science Ouverte Prize** to Benoit for his Berger-Levrault thesis (defended in 2021) on **software graphical interfaces**

Benoit Verhaeghe : "*Incremental approach for application GUI migration using metamodels*"

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Gaëlle  
Baudry

# It's in the Press!



Berger-Levrault et Inria : un partenariat stratégique pour un numérique plus responsable



le 2 octobre 2024, par Thomas Calvi.

Depuis 2017, l'éditeur de logiciels Berger-Levrault, et Inria, l'Institut national de recherche en sciences et technologies du numérique, travaillent de concert pour accélérer le développement de solutions numériques basées sur l'IA destinées aux acteurs des collectivités, de la santé et de l'industrie auxquels Berger-Levrault adresse. Ils ont récemment présenté les résultats concrets de leur collaboration.

## L'IA générative au service des pratiques métier des utilisateurs de Légibase Collectivités



## Du machine Learning à l'IA générative – L'innovation au service de la maintenance

Comment le Machine Learning et l'IA générative redéfinissent la maintenance pour plus d'efficacité.



## L'assistant intelligent de WeMagnus : une innovation numérique pour simplifier la vie des secrétaires généraux de mairie



# Innovate to Reinvent: Berger-Levrault Challenge

What justifies a Research and Innovation (R&I) approach in a company like Berger-Levrault beyond the widely accepted assertion that it is a real growth driver for the company? Why invest in research activities that are evidently complex, slow, difficult to manage, and organized over long periods? In other words, does Berger-Levrault really need such an approach to bring strong differentiators to its markets and to innovate?

To fully grasp the stakes, let us recall some contextual elements characterizing Berger-Levrault's markets and businesses. First, we produce management tools, solutions that often require a high level of business expertise and client-specific knowledge. Additionally, our solutions primarily address everyday activities, from city management to industrial maintenance. These are processes that inevitably have a direct impact on citizens' daily lives, employees' work, and the overall functioning of services and operations. Despite appearances, these processes are inherently complex, as they are directly tied to highly operational considerations of daily life. It is also important to remember that research often struggles to address this type of highly tangible and operational complexity.



**Mustapha Derras**

*Director of Research &  
Technological Innovation  
Berger-Levrault*

Finally, revolutionizing these fields seems difficult, as they are often entrenched in established habits and formats that impose multiple constraints and obligations, adding further challenges to our work.

It is precisely this demanding yet seemingly ordinary context that drives genuine, disruptive innovation in established products and solutions. Transformative approaches are likely to bring the key differentiators for each of our solutions. We are not merely seeking to improve existing solutions but to establish new, solid foundations that enable truly novel and bold transformations. By avoiding simplistic approaches, Berger-Levrault positions itself beyond mere technological or functional evolutions, adopting a comprehensive perspective that values deep reinvention of industries.



The Research and Technological Innovation Department (DRIT) aims to **create new platforms** that will propel all our businesses toward emerging paradigms, including AI, next-generation algorithms, distributed cloud architectures, and the various new constraints shaping our daily lives. Unlike past technological evolutions, a new dynamic is emerging, combining multiple advancements and creating an entirely new digital approach. This transformation will not merely improve current practices but will completely redefine them—restructuring industries, reconfiguring processes, and gradually establishing a fully renewed digital landscape across both public and private institutions. Business opportunities abound, yet they are no longer as immediate and straightforward to define and develop as before. This new wave of transformation will require **more advanced client support** as well as **stronger technical and industry-specific expertise**. This revolution is likely to reshape the entire landscape over the next decade.

It is precisely within this perspective that the DRIT's purpose is anchored. The DRIT is driven by the ambition to deploy solutions that not only follow these new trends but also stand at the forefront of this technological revolution. Its role is reinforced by nearly 15 years of building strong methodologies, fostering an agile dynamic, and developing advanced technical and intellectual expertise, accompanied by a constantly evolving mindset—an essential ingredient for success. We firmly believe that this ability to evolve and reinvent ourselves continuously is our greatest asset in facing future upheavals.

This adaptability, this readiness to anticipate and seize new opportunities, will enable us to remain leaders in our markets. **Berger-Levrault is prepared to take on this challenge**, and we are convinced that innovation through research is not merely an option but an imperative necessity to secure our collective future and thrive in an increasingly complex environment.



To conclude, I propose a synthesis of the ideas of Jean-Baptiste Lamarck & Charles Darwin:

"It is not the strongest who survive, nor the most intelligent, but those who withstand increasing complexity, adapt best, and respond most quickly to change. They take the greatest advantage of it and invariably prepare for the next transformation."

Jean-Baptiste Lamarck + Charles Darwin | Naturalities



*#InnoByBL*

## **YEARBOOK 2024 - Research & Innovation**

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