Building Smarter Cities Through AI-Driven Digitization: A Case Study

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Abstract: The concept of Smart (or Smarter) Cities is widely recognized in contemporary society. The integral relationship between Smart Cities and digitization has been extensively researched, establishing it as a fundamental condition for developing modern, effective, and sustainable services within the intricate environment of a Smart City. This paper focuses on the implementation methods of digitization. Numerous cities are transitioning their agendas from traditional (analogue or paper-based) to digital platforms. However, the impact of such digitization can vary significantly. In many instances, cities develop a one-to-one digital replica of an analogue or paper service, neglecting to explore the potential for improved service utilization or integration with other services. This often overlooks the opportunity to leverage synergistic effects that could enhance value for all stakeholders, including citizens, administration, and business entities. We aim to investigate the digitization process at the Official Board of a municipality, using the results from a Hackathon organized in Brno, Czech Republic, as an example of an innovative approach to such solutions. We intend to discuss the methods of digitization provision and based on the case study suggest a best practice approach to avoid common mistakes and issues arising from an incorrect approach to digitizing public services.

1 INTRODUCTION

The concept of smart cities has gained considerable attention in recent years, driven by rapid urbanization and the need for sustainable urban development. A smart city uses technology and data analytics to improve the quality of life for its citizens (Adje et al., 2023), enhance urban services, and ensure efficient resource management. Digitization, the process of converting information into digital formats, is a critical component of smart cities. It enables system integration and real-time data analytics for decision-making (Belli et al., 2023).

Digitization encompasses a broad spectrum of technologies and applications, including Internet of Things (IoT) devices, sensors, data analytics platforms, and artificial intelligence (AI) (Dhiman and Alghamdi, 2024). These technologies collectively contribute to smarter infrastructure, improved public services, and environmental sustainability. For example, IoT devices and sensors continuously collect data on urban parameters such as air quality, traffic flow, and energy use (He et al., 2023). This data is processed using analytics platforms to enable optimized decision-making. AI further enhances smart cities by providing predictive analytics and optimizing resource allocation (Lehtiö et al., 2023), such as predicting traffic congestion patterns (Jiang et al., 2022) and balancing energy supply and demand and the efficient use of renewable energy sources (Zavorka and Paar, 2022).

Traditional urban management approaches often fall short in addressing the complexities of smart cities. Therefore, studying how digitization contributes to smarter cities is essential. Through a case study, we can gain insight into best practices, identify potential barriers, and propose strategies for possible implementation. This paper explores digitization as a critical building block in smarter cities through a case study in the Czech Republic. Specifically, it examines the role of digitized services in the official boards of cities and municipalities and how digital technologies and AI are integrated into urban planning and management. The paper discusses the challenges faced in the digitization process and the opportunities for future urban development.

The rest of the paper is organized as follows: Section 2 reviews the relationship between smart cities and digitization, especially the SMART principles in the context of the Czech Republic. Section 3 ad-

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dresses digitization priorities from both the city and citizen perspectives. Section 4 conducts a case study on official board digitization, including identified issues, proposed solutions, and future plans. Finally, Section 5 concludes the paper and outlines lessons learned from the case study and future works.

2 SMART CITIES AND DIGITIZATION

Smart cities rely heavily on information and communication technology (ICT). Effective use of any technology requires data, which can be derived from the city's behavior, stakeholder inputs, and city agendas. The trend of smart city services is closely linked to digitizing all city processes.

The challenges of digitization are well reflected by the service researchers. Many of them interconnect the value of digitization with urban development (Bayat and Kawalek, 2023) and as the aspect of the globalization of the public sector (Läpple, 2001). There are two aspects of the digitization of city services: the digitization of the public services (aimed at citizens or other other service consumers) and the digitization of inner services (processes) of the city. The success of this process is critical for the acceptance of digital services by the public, even if they could be very innovative and potentially valuable (Rajagopalan and Ravi, 2020).

It is important to note that digital service is just one perspective of how we can look at the smart city, or it is one context from many others because a smart city is a typical multi-contextual environment (Walletzký, Leonard et al., 2023). Therefore, digitization can be an essential part of smart city services, reflecting the needs of agents from other domains or contexts, where those contexts can play a major role in the acceptance of the final digital service (Badr et al., 2021). The digitization of the smart city services is a typical example of a service that directly influences the willingness of stakeholders e.g. typically citizens, but also tourists, business entities etc. to collaborate with the municipality and adapt their behavior for better value co-creation (Polese et al., 2018). Therefore, the digitization of city services needs reflect a wider context of the city environment and collaboration with the whole landscape of academia, government, industry, and public sector (Walletzký et al., 2022).

2.1 Application Context in Czechia

This paper explores a case study based on the context of the Czech Republic. That is why we present the Czech Republic's latest official methodology for smart city development, titled as *Smart Cities Concept - resilience through SMART solutions for municipalities, cities, and regions*. It was issued by the Ministry of Regional Development of the Czech Republic, and approved by the Czech government on the 10th May 2021 (Ministry of Regional Development, 2021).

This methodology takes into account Czechia's uncommon settlement structure, which is formed by more than 6000 municipalities. The concept also considers that the municipalities are scaled differently, and addresses the need to faciliate innovative solutions that would be valuable for all scales, altogether with the public administration at all levels. It also emphasizes citizen-centric approach and its goal is to raise the citizen's quality of life, quality of available services and to create good living conditions regardless of the size or location of the municipality (Ministry of Regional Development, 2021). To achieve this goal, the concept uses smart solutions, which represent innovative approaches to problem-solving in municipalities. A solution can be SMART only if it respects the SMART principles, which are a base for the whole concept. There are seven SMART principles, which are translated from Czech by (Schwarzová, 2023):

1. **The Principle of Direction Change:** this means creating the conditions so that, where it is possible and efficient, services are delivered to people, and work and business can be carried out from home or a place close to home.
2. **The Principle of Resilience:** this is the resilience of people and communities, the local economy, the environment, and cohesion in the territory based on digitization and innovative solutions.
3. **The Principle of One Solution with Multiple Effects:** a solution is expected that will bring several significant effects (solving multiple needs at once) with a holistic approach.
4. **The Principle of "Short Distance":** everything that can be provided locally must be provided locally or at the shortest possible distance (using rule 3E - economy, efficiency, effectiveness).
5. **The Principle of Cooperation and Financial Sustainability for the Aim of achieving Effectiveness of the Solution:** it is about cooperation with all partners in the territory, the usage of multi-source financing regarding its long-term sustainability.
6. **The Principle of Cohesion and Complementarity, Horizontal and Vertical Interconnection:**

the new solution leads to a leveling of opportunities, reduces tensions, solutions follow each other, cooperation and interconnection at all levels and all levels of public administration is a basic prerequisite for achieving resilience and cohesion.

7. **The Principle of Evidence-Based Solutions Based on Facts, Openness and Data Sharing, Transparency, and Equal Opportunities:** data is generated that is understandable and accessible for innovative applications and the development of people's lives, communities, and businesses (Sharing is caring).

The structure of the concept is layered (Figure 1), with the SMART solutions on the top, as an overlapping roof above all the other parts. Below them is a covering cross-sectional area, connecting the SMART solutions together. It is titled the resilience, a direct link to the name and goal of the concept. Under these layers, there are three pillars of sustainable development, representing the most important elements - people and communities, local economy, environment for living. These pillars focus on achieving resilience through the citizen's point of view. Each of these pillars and the cross-sectional area is furthermore divided into 4 components with different focuses. The Smart Cities Concept recognizes digitization as one of the integral parts of building smarter cities, including it as one of the components of the Pillar B (Local economy), which is related to competitiveness of Czechia's cities, municipalities and regions. Our paper highlights the components of Pillar B: (1) Business is a natural part of the life of a municipality, city, and region, (2) Citizens and municipalities / cities / regions as energy supplier partners, (3) Raw materials and recycled materials in the circular economy, development of the bioeconomy, (4) ICT infrastructure - a basic prerequisite for the success of digitization (Ministry of Regional Development, 2021).

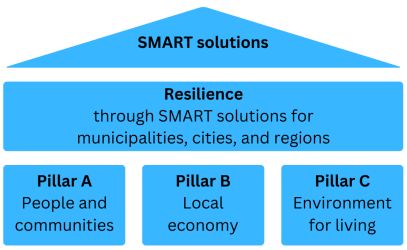

Figure 1: Structure of the Smart Cities Concept. Based on (Ministry of Regional Development, 2021), (Schwarzová, 2023).

The fourth component is directed on the importance of having a sufficient infrastructure for the information and communication technologies (ICT). It sets the infrastructure as a prerequisite for the success of digitization and aims to achieve three set goals: (1) Sufficiently sized ICT infrastructure is available throughout the whole territory of the Czech Republic. (2) Cities, municipalities and regions have the necessary infrastructure and ICT equipment for their activities. (3) The ICT infrastructure enables the safe development of digital services at the level of cities, municipalities and regions.

These goals are supported by actual implementation of SMART solutions in the municipalities, cities and regions (Ministry of Regional Development, 2021). The process of services digitization in a municipality can encompass multiple domains - healthcare services, social services, transport services, etc. In this case study, we are focusing on the digitization of government services, more specifically, the local administration services in cities or municipalities.

2.2 Government Services Digitization

Digitizing government services provides citizens with quicker and easier access to information, enabling them to be better informed about city processes (Neis et al., 2023). A key focus is on creating an environment where citizens can participate in the co-creation of public services in their municipality (Viale Pereira et al., 2018).

Findings of (Twizeyimana and Andersson, 2019) suggest that the usage of digitized services in form of e-government can improve the public services, administration and through that, it enhances the overall well-being of the society and citizens. The authors of (Neis et al., 2023) further build on that analysis, and present possible advantages and challenges in digitization of government services. Firstly, for the advantages, it can lead to the improvement of public services and administrative efficiency, which can encompass for example increased quality of the services, boosted responsiveness to citizen's needs, reduction of administrations costs or more efficient data storage. Using automated electronic services that remove the human link can also help with minimizing the possibility of corruption, more ethical behavior and increasing the trust in administrations services.

In order to utilize digitized government services to their full potential, it is also needed to be aware of the possible challenges. The challenges do not need to pertain solely to the technical process of digitization. A significant challenge stems from the digital literacy of citizens. In digitizing the services in local administration that are needed for every citizen, there is a need to consider the citizens that can lack

the minimal digital literacy, for example the usage of the internet. This can create a problem called digital exclusion. The services also need to be planned accessibly, to bring equal value to citizens with various disabilities. Furthermore, transparency of the service processes also plays a role, and can lead to more active participation of communities. As for the administrative digitization itself, it needs to adhere to the legislative and policies, and stay up to date with the current laws. Citizens' data, their personal information, must be protected by sufficient security to build the trust of citizens (Neis et al., 2023).

3 PRIORITIES OF DIGITIZATION

3.1 Point of View from Cities

From the city's perspective, there are two main viewpoints: politicians and administration.

In the politicians' perspective, they are firmly focused on everything that can be sufficient for the citizens. Not because they primarily reflect their position, but because they want to be elected again. Therefore, many politicians tend to shorten the digitization to portals for citizens or services for the citizens. In many cases, they do not understand the links and relationships between services and underestimate the administrative and process support of the services for citizens. Also, because they are trying to act as experts (but they are not), they often support the service with a very limited or hardly achievable effect. This can result in unsuccessful services that citizens refuse to use. For example, in one Czech municipality, politicians decided to create their own portal for citizens to make access to city services easier. The registration process was so complicated that almost all citizens refused to use the application.

Administrators, on the other hand, mostly employ a rational approach and see digitization as a complication, requiring changes to existing IT systems and processes. There is also a typical problem - so-called "resort-ism", the tendency to view problems only from their specific department's perspective and not holistically. This is the source of many problems and issues hidden from the view of citizens.

Even though it could be that digitization has many obstacles in the cities, the truth is the opposite. The previous two bullets present a typical "negative" approach to digitization; every service designer (or architect) should reflect it. There are also many examples of a very positive approach and synergy among the politicians and administration that support digitizing and creating new, innovative applications. However, this process is susceptible to the support of both sides - politicians and administration.

3.2 Point of View from Citizens

The citizens' point of view is a little bit easier. They want to get an effective tool that enables them to get all information and any interaction with the city quickly, effectively and with fewer resources. This is also the problem - because they must accept the digital services of the city, they must understand the value proposition, and they must have the capabilities to participate in value co-creation (Caputo et al., 2017). Many municipalities and their representatives do not take into consideration that citizens or generally the final receivers of the services must also use their resources to create the collaboration path for the value co-creation (Polese et al., 2018) and only way how to achieve this is to formulate proper value proposition - understandable and acceptable for the citizens. Then, the citizens will be willing to use their resources (information and knowledge) to participate in the value co-creation. The other aspect of digitization is also the social dimension, where many people can feel less comfortable or have problems trusting digital services. That also leads to ethical problems that can also harm the successful digital service that is not thoroughly followed with the ethical consequences (Badr et al., 2021).

4 CASE STUDY: OFFICIAL BOARD DIGITIZATION

4.1 Legislative in Czechia

The official board in cities and municipalities can be defined as a publicly accessible surface on which the administrative office publishes documents, such as legal regulations, municipality decisions and other documents of administrative offices or courts. These published documents are usually in paper form. In the Czech Republic, the administrative offices are required by law to have an official board. The official board needs to be: accessible nonstop, secured against unauthorized handling of documents, available through a remote access, marked as an official board and contain the contact information for the administration office responsible .

"Electronic" official board is not defined in the legislative. It is considered to be the fulfillment of

a legal obligation to publish the content of the official boards in a way that allows remote access. In most cases, the administrative office creates webpages where they simultaneously publish the content of the physical official board in an electronic form (Ministry of the Interior, 2009).

4.2 Case Study

The study of this article focuses on the city of Brno, which is situated in the southern part of Czechia. Its official number of residents with permanent residence is more than 400 000 people, however, during the working week there are approximately 500 000 people in the city (Data Brno, 2024a). The city itself is divided into 29 self-governing municipal districts, each with their own mayor, council, and coats of arms (City of Brno, 2024b). The overarching and highest government body for all city districts is the Brno City Assembly (City of Brno, 2024a).

The official boards are an integral part of the communication from the city towards the citizens. However, there is often a problem with their usability and user friendliness in the remote electronic form. The current management of the City of Brno wants to improve on the electronic official boards, which led them to connect the topic of their modernization with this year's city Hackathon, called Hack Brno. This Hackathon was organized by the city of Brno with the cooperation of the non-profit organization Czechitas and Brno.AI platform. The main challenge and assignment was to create an application, tool, or analysis which would be based on the open data of the city and which would bring value to the city and its residents. The participants formed teams and had 24 hours to work on their projects. The winning team, in which one of the authors has participated, created a proof-of-concept solution that has brought several improvements to electronic official boards (Data Brno, 2024b).

4.2.1 Identified Problems

At first, the team has analyzed the current state of the official board of Brno. Brno City has its official board (City of Brno, 2024c) and furthermore, each of the 29 municipal districts has its own official board that can differ in style (Municipal district Brno - Jih, 2024; Municipal district Brno - Žabovřesky, 2024). That means that there are 30 official boards in operation simultaneously. The current electronic official boards meet the minimum requirements mandated by legislation, which were listed in the previous section. They publish the official documents in a PDF format, accompanied with the relevant metadata structured as Region, Category, Title, Reference number, Originator and the Publication period of the document. The users can filter through these documents based on chosen metadata. The electronic official boards also provide a search option as a result of all the document contents.

4.2.2 Proposed Solution

Based on the assignment of the hackathon, the proposed solution utilizes the available artificial intelligence technologies to provide intelligent data extraction and analysis. It aims to counter the overflow of official boards in Brno by congregating the data in one board that will be searchable.

In the hackathon project, significant improvements were made to the user interface to enhance usability and ensure a consistent experience across all official boards. While many of these enhancements focused on the technical aspects of the project, the interface redesign aimed to create a more user-friendly and unified experience.

A main task and challenge of the hackathon was the effective utilization of artificial intelligence. This was accomplished through the implementation of Azure AI Document Intelligence (DI) and Azure AI Search. Given the tight 24-hour timeframe of the hackathon, we selected Azure services to speed up the development process and allow us to focus more on providing the solution rather than tackling the complexities of model fine-tuning, data indexing, search engine tuning, and infrastructure setup. Utilizing Azure's prebuilt AI services enabled rapid development and deployment, which was crucial under the hackathon's time constraints.

The DI service was used to convert PDF documents into a structured JSON format, a crucial step given the variability in document templates across different districts. By defining a standardized JSON structure, the project was able to eliminate these discrepancies and unify the data. Creating custom models for DI was necessary to achieve this data unification. These models were trained to extract the required information from each document and populate the corresponding fields in the JSON objects. The resulting JSON objects were then stored in a database.

Training custom models, instead of using a pretrained one, for our use case was necessary, but it introduced additional complexity to the project. The DI requires at least five training documents to be labeled by hand for each document type, and there are numerous document types, such as city inquiries, lost and found notices, announcements, public decrees, job offers, etc. Each document type has a specific structure, and each municipality may have different templates

for the same category. This variability makes training custom models to achieve acceptable accuracy and confidence scores a significant challenge.

Figure 2: Example of Training Data for Document Intelligence - Lost and Founds.

In Figure 2, various colors are used to represent different categories of information extracted from the document. For example, red indicates a contact person, orange denotes a phone number, green signifies an email contact, blue represents the date when the items were found, and purple highlights the items listed in the document. The number and types of labels in the document may vary depending on the category. Confidence scores are provided after building a custom model and include (Microsoft, 2024):

- **Document Type Confidence Score:** The document type confidence is an indicator of closely the analyzed document resembles documents in the training dataset. When the document type confidence is low, it is indicative of template or structural variations in the analyzed document.
- **Field Level Confidence:** Each labeled field extracted has an associated confidence score. This score reflects the confidence of the model on the position of the value extracted.
- **Word Confidence Score:** Each word extracted within the document has an associated confidence score. The score represents the confidence of the transcription.
- **Selection Mark Confidence Score:** Each selection mark has a confidence score representing the confidence of the selection mark and selection state detection.

Using a custom model for each category seemed to be the optimal approach. This strategy led to achieving confidence scores of over 85% with fewer than 10 documents as training data. While this score was sufficient for the proof of concept, for production use across all 30 municipalities, it is imperative to train on a larger number of documents per category to accommodate the discrepancies in documents from different municipalities.

With the custom models created, built, and deployed, the API served as the primary means of communication between the Document Intelligence (DI) service and the application. The response from the DI service is a large JSON object that includes content for every label detected in the document, along with a confidence rating. This JSON is then transformed by the mapper into the resulting JSON structure.

The source structure for this JSON is defined in a Java class corresponding to each category. As an example, the class for the job offer category is depicted in Figure 3. The structure of the class varies for each category. These classes were created, and the finalized content for each category should be reviewed and discussed with stakeholders.

```
@Data
public class JobPosting {
    private String job_position;
    private String job_description;
    private String job_contact_person_name;
    private String job_contact_person_phone;
    private String job_salary_condition;
    private String job_start_date;
    private List<String> requirements;
    private List<String> job_benefits;
    private List<String> application_requirements;
    private String job_application_description;
}
```
Figure 3: JobPosting Class Definition.

Azure AI Search service was implemented over finalized JSON data, enabling intelligent search capabilities. This service allowed users to perform searches across documents using natural language queries. For instance, a query such as ”I lost my cell phone” would return a list of records from the official boards categorized under lost and found, specifically identifying documents that mentioned a phone in the attachments. The application can be deployed without requiring any actions from the municipality and can be used simultaneously with the current solution. Data for the project are scraped from the official API of the official boards, ensuring seamless integration and up-to-date information without disrupting existing workflows.

4.2.3 Further Plans

The team’s results from the Hackathon were sufficient as a proof of concept, and the evaluators’ feedback highlights the potential for a nationwide deployment of such upgraded electronic official boards for the future. However, several challenges need to be

addressed before moving forward.

To address these challenges, we decided to create the data extraction process with custom logic instead of relying on multiple models within Document Intelligence (DI) tools. This approach mitigates the high costs associated with DI tools while providing a more flexible and efficient solution tailored to our use case. Since using commercial AI tools can be costly, identifying open-source alternatives can enhance efficiency in the long-term operation of the service. Another significant challenge is the variability in document structures across different categories and municipalities. This can be done by standardizing the document structures, which would be advantageous for all stakeholders. Also, it would enable citizens to have a consistent understanding of what to expect in official documents.

We have moved beyond the commercial tools during the Hackathon proof-of-concept phase to ensure greater flexibility and alignment with the project's long-term goals. Further, we are developing the system entirely on open-source technologies, which allows for deeper customization and integration explicitly adapted to our use case.

Optimizing the data extraction process from PDF documents is one key objective, which is to address complex elements such as tables and images often present in municipal board notices. The challenge lies in transforming tabular data into textual formats that is suitable for embeddings. The process requires converting the structured data from tables into coherent text representations while preserving semantic relationships. These text representations will then be encoded into embeddings, ensuring that the contextual and relational information from the original tables remains intact and meaningful for downstream tasks.

Besides table parsing, the focus will be on detecting and correcting errors in the extracted text. The validity and accuracy of text involve implementing a classification system to identify and filter out invalid extractions, such as incomplete words, invalid characters, or non-text elements. These improvements will contribute to a more reliable and accurate data extraction process. The revised and corrected text will be used to generate sentence-level embeddings for semantic search. These embeddings will be linked to the original text segments to keep traceability and effective information retrieval within the system. Furthermore, applying representative search queries' scenarios can be used to test the system's semantic search capabilities. These queries evaluate the system's ability to retrieve relevant results from the embedding database, which provides a reliable benchmark for semantic search performance.

5 DISCUSSION

In the last section, we showed the development of an application that could be a typical example of digitization. However, we have also revisited many aspects that may block its successful deployment to the service structure of the municipalities. Also, the usage of AI and machine learning presents a game changer in different aspects of human life. We may always consider the issue related to the typical resistance to changes. Overcoming resistance to change within organizations in the development process is essential to ensure effective implementation.

The case study we presented was highly successful. It wins the first prize at the hackathon and receives positive feedback from public institutions. There were even offers to deploy the solution in municipalities. However, some challenges remain, such as finishing the student-developed application, deciding who will maintain and improve it, and considering if and how the university should be involved in the process.

Digitization of municipalities and states brings many possibilities but also questions and obstacles. We stand before a new situation where universities should play a more active role, not only supporting research transfer but also helping students find innovative ways to participate in research as partners with municipalities and society.

The development of the digitized application for municipal official boards highlights how municipalities handle and share public data. The project has seen initial success but faces challenges related to deployment and long-term sustainability. Differences in document structures across municipalities may require multiple custom models for document processing. The cost of commercial AI tools makes it essential to consider open-source alternatives. Since the success of such a digitization project depends on the involvement of city stakeholders, their active engagement is important for continuous improvement and effectiveness of the application.

6 CONCLUSION

In this paper, we have studied the development and implementation of a digitized application for municipal official boards. This case study demonstrates its initial success for public service efficiency and accessibility. The hackathon project has proven the feasibility of this application. Some lessons learned can be derived as scalable model training, cost-effective AI solutions, and stakeholder engagement. Further,

it can be seen that a close partnership between universities, municipalities, and technology providers is essential for innovations.

As future work, we plan to refine the data extraction process with custom logic rather than relying on multiple models within Document Intelligence tools. This decision aligns with our goal to mitigate costs and ensure greater flexibility.

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