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Data Strategy in Service Development: Case Study for a Facility Management Service Company Utilizing IoT

Abstract: Digital servitization is a key context for the application of data management, analytics and machine learning in service value creation, thereby contributing to improve competitive position. The recent technology development in the area of Internet of Things and cloud computing provides numerous opportunities for digital servitization, and on the other side, a new approach for service design is needed to utilize these opportunities properly. This paper aims to apply the data strategy framework in service design for facility management services in order to ensure the fulfillment of business requirements. The data strategy framework consists of two phases: from the business requirements to work process and from data to actions. This paper demonstrates the usefulness of a data strategy framework for the development of the facility management service having different types of requirements to manage and analyze the data to reach original business requirements. The main contribution of this paper is to demonstrate how the digital servitization can improve the competitive position of the company by a proper service design using data strategy framework.

Keywords: digital servitization, service design, facility management services, data management, lean service development

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1 Introduction

This paper aims to present a method on how to utilize data in order to improve competitive position on top of the existing service portfolio, applied to one case study for a facility management service company. Servitization is the process in which either

- intangible service components are incorporated to a manufacturing company's existing products or
- pure services are provided to customers.

During the last decades, servitization has been a global trend among many traditional manufacturing companies, with the main interest in creating a competitive advantage in traditional product business. On the other hand, several pure service companies exist, whose offering includes only services without any tangible products, and whose competitive advantages has been based on resilient, in-depth customer relationships. Their services aim to improve the value of their customers' assets. Recently, the competition in this sector has increased due to globalization, digitalization, and newcomers to the local market. Therefore, innovation to improve a competitive position for such local service providers is necessary to ensure the sustainable regional development.

The case study is conducted for facility management services, where the personnel are responsible for operating the building maintenance of multiple buildings owned by their customers. The data management process is applied to the maintenance operation of a building. Actually, the facility management services market is changing in Finland; currently, the market is divided between private and public companies, and there is a trend to move toward private own companies. The winners in the new changing market are the players who can manage their service operation most effectively; therefore, utilizing data for efficiency improvement purposes is a critical success factor. On the other side, the buildings have a lot of data, which could be used to improve the service operation. Naturally, this has not been optimally used yet due to the new technology.

We argue that the data-driven service operation can be used to improve the competitive position by having the right data strategy in place. The competitive position improvement means to improve competitiveness by reducing costs or to improve the value of the customer's assets. Many literature reviews aim to emphasize servitization as one key differentiation factor, especially for manufacturing companies, by bundling the product and services together into one solution. Nevertheless, less attention has been paid to pure service companies, which are not manufacturing

companies by nature, and how they can differentiate themselves by using the data in their market place.

Our research question is: *How is data strategy created and how is datadriven service operation for a pure maintenance company implemented in order to improve the competitive position in their market place?*

In this paper, the data strategy framework is applied to the development of the facility management service. Special attention will be paid to the special business requirements related to facility management services. The purpose of research is to figure out elements which will be used to improve the company's competitive position. The service operation improvement is a new differentiation possibility for facility management service companies.

2 Theoretical background

2.1 Data as a driver for pure maintenance companies

The theoretical background follows the same approach as in Pulkkinen [1], where the service development was shown from the small or medium-sized enterprises' (SMEs) points of view; as a result, the data strategy framework was created. In this paper, the data strategy framework is applied to the pure service companies.

The literature review presented in this chapter is aimed to provide a high-level of understanding of service development and how useful they are in the context of pure service companies. Naturally, improving the competitive position using data differs between product companies and maintenance companies. The core of product companies is their product, and in order to create customer value, they create a solution bundling the products and services together. The solution aims to create benefit for their customer, and this should differentiate them from their competitors and finally to improve their competitive position. The pure service companies do not have the product, and their offering is only services to be provided to their customers. Therefore, their competitive position is based fully on the services and how it creates customer benefit and differentiates them from their competitors.

As described by Pulkkinen [1], the most famous strategic program to improve manufacturing industries' competitive position by using data is the program called Industry 4.0, which originates in Germany and aims to upgrade Germany's industrial capabilities with the help of a smart factory concept [2]. Industry 4.0 has also received much attention in many other countries, where similar programs have been initiated. Industry 4.0 means 4th Generation Industrial Revolution, where "software embedded intelligence is integrated in industrial products and systems" [3]. Thus, Industry 4.0 has been discussed a lot in the literature [3-6] and [7], but these are mainly focused on the industrial manufacturing companies and how to create competitive advantage in their market place. They have very limited experience in the area of pure service companies outside of the manufacturing environment. Actually, we believe that the strong emphasis of Industry 4.0 has moved the focus strongly to manufacturing companies, at the expense of pure service companies and how the data could be used to build benefits for customers and improve the competitive position.

One main reason for the increased amount of data is the development of The Internet of Things (IoT) technology and of ICT technology. This has been the focus of several of the literatures [5, 8] and [9]. A major part of these focus on technical implementation to collect data and neglect the business-level objectives. In addition to this, less focus has been put on service development with the help of IoT and ICT technology. Nevertheless, some papers already exist in this area, discussing how IoT-based solutions are cost effective for improving the competitive position in different areas of service operations [3] and [1].

We argue that the data-driven service operation can be used to improve the service performance in pure service companies by having the right data strategy in their practical implementation. In the current literature, little attention has been paid to pure service companies, which are not the manufacturing companies by nature, and how they can improve their service execution. Therefore, we apply the data strategy framework for a pure service company.

2.1 Data strategy framework

Pulkkinen [1] presented the general data strategy framework. The data strategy consists of two phases:

- Phase 1: from business requirements to work process
- Phase 2: from data to actions

Phase 1 pays a lot of attention to knowledge that is needed to fulfill the business objectives and how this knowledge is utilized in work processes. This knowledge creates the basis for the data-driven service operation; on the other side, the knowledge needs to be directly connected to the business objectives. This phase consists of three steps that are presented in Fig. 1:

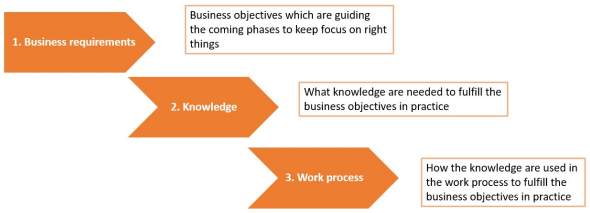

Fig. 1. Three-step model in data strategy framework to create knowledge, starting from business objective and ending with work process. Slightly modified from source [1].

Phase 2 focuses more on technical implementation and restrictions to implement data-driven service operation in practice. Therefore, a lot of attention is paid to data availability and data quality and how to turn data into a positive user experience by using automatic controls, analytics, and machine learning. Phase 2 consists of three phases presented in Fig. 2:

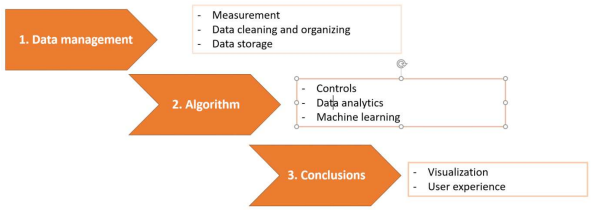

Fig. 2. Three-step model in data strategy framework, from data to conclusion. Slightly modified from source [1].

The presented data strategy framework is a practical method to develop the Proof of Concept (POC) in developing the data-driven services. This way, the feasibility of the solution to fulfill the business requirements can be ensured, and the technical restriction can be identified before the final solution development.

2.2 Lean service development

The lean approach has been applied in many areas, like manufacturing and software development, where different agile methods are popular nowadays. The origin of the lean approach is in Toyota manufacturing and applying the same approach to software development was done later [10] and [11-13]. The lean approach has also been applied in service development [14].

The key idea in the lean approach is to improve efficiency by reducing waste. Poppendieck [15] translated the seven wastes of manufacturing for software development in contrast to operating with a mass production paradigm, which is presented in Table1.

Table. 1. A summary of eliminating waste in manufacturing and software development.

Seven wastes in Manufacturing	Seven wastes of software development
1.Overproduction	1.Extra features
2.Inventory	2.Requirements (e.g. story cards detailed only for current iteration)
3.Extra processing steps	3.Extra steps
4.Motion	4.Finding information
5.Defects	5.Defects
6. Waiting	6.Waiting, including customers
7. Transportation	7.Handoffs

The lean service development combines lean principles, lean software development, and lean service creation, where we start from business objectives following lean principles and using lean service creation methods, and moving toward drastically improved service operation in order improve the competitive position of a pure service company.

3 Methodology

The case study is conducted for facility management service, where the personnel are responsible for operating the building maintenance of multiple buildings owned by their customers. This company is called facility management service provider in the paper.

This study aims to develop an overall understanding of how to create added value with the help of data by the facility management service provider. We accomplish this objective by combining action research consisting of projects related to the facility management services in two cities in Finland. Action research means that the knowledge is created in the context of practice and requires researchers to work with practitioners [16]. To achieve our research objective, researchers in academia are required to participate in real-world cases. Therefore, our researchers have been working in the development project, aiming to create added value for the facility management service providers' customers.

The selected methodology to develop data strategy for the facility management service provider is the data strategy framework according to Pulkkinen et al. [1], where the framework was developed as a result of a case study. The case study was to develop data strategy for SMEs [1], and the result was presented on a general level, fitting to different environments.

4 Results

The results of our research form a data strategy framework for the facility management service provider. The data strategy consists of two phases: the first phase is presented in chapter 4.1 and the second phase in chapter 4.2.

4.1 Data strategy framework, from business requirements to work process

Step 1 – Business requirements: Facility management service is facing a big change in Finland. Big cities have a huge fleet of buildings, and they have had their own department taking care of their facility management services. Now cities have begun to privatize facility management service departments, aiming at cost savings through competitive bidding. The facility management services cover different areas, like technical maintenance, outdoor-area maintenance, facility management, and even energy savings belongs to some companies' offerings. There are different types of companies in the marketplace, like city-owned previous municipal service providers, small and big private-family-owned companies, and big international companies. The offering can vary to some extent, but the core part of their offering is the same, including the areas mentioned above. In addition to this, some companies also have cleaning services, laundry services, and catering services.

The nature of the facility management service is that the company provides services to their customer and their customer owns the buildings that are the object of those services. On the other side, the buildings are big assets to their owner and a bad quality of services may result in big economic losses, even long after the services have been provided. There are many examples of this when bad indoor air quality has ended with a situation where the health of people working in the building is compromised, and in some ultimate cases, the buildings cannot be used for their original purpose anymore. Therefore, the building owners need to carefully select their facility management service provider in order to have the right balance between low cost and high quality. Low-cost service is often emphasized as a short-term target, but the understanding of good quality is spreading among building owners as a result of several bad experiences .

Therefore, the value proposition of facility management service providers consists of minimizing the cost of services and maximizing the facility management value. According to Niemi et.al. [17], the most significant costs for the building owners are heating, including electricity, repairs, administration, and maintenance. The report is related to residential homes and costs may vary between buildings, especially buildings made for different purposes; but we strongly believe the same topics are valid for other buildings, even if the share of the topics may be different.

In order to provide value for their customers, the facility management service provider tries to reduce the costs mentioned above for the building owners. In this research, we focus mainly on the heating and maintenance costs to which the facility management service provider can influence directly. In addition, we will look at the repair costs to which the facility management service provider can indirectly affect.

As a summary, we can state that the value proposition of the facility management service provider is to directly reduce the heating and maintenance costs and indirectly and positively affect repair costs.

Step 2 – Knowledge: Next, we need to create the knowledge needed to reach our goals. First, heating, including the electricity, is a very wide topic, and there are many possibilities to positively affect the heating costs. In this study, we consider two areas: air condition and lighting. Air condition is one big electricity consumer, and it has a direct impact on the heating. The more air is taken out of the building, the more new fresh air is heated, which consumes electricity. In addition to this, reducing unnecessary air conditioning also reduces electricity consumption. The knowledge needed for the right air conditioning is the amount of the people in the room, which is related to the CO2 level. The more people in the room, the higher the CO2 level and vice versa. Therefore, we can state that the knowledge needed for the right air conditioning is the CO2 level in the room. The lighting is also one electricity consumer in the buildings, and the smart lighting systems developed lately have also opened the possibility to reduce electricity consumption. Naturally, the key idea in saving is to reduce lighting when daylight is available, and to make this happen we need to know about the brightness.

The technical maintenance is labor-intensive work, and big cities especially have many buildings requiring several people to take care of their daily maintenance. To gain an understanding of the workload, one big city in Finland has about 20,000 failure messages to manage and repair every year. Therefore, it is obvious that efficient technical maintenance is very important to reduce costs in this area. The good approach to improve efficiency in maintenance tasks is lean service creation presented in chapter 2.2, and applying the seven wastes in manufacturing to lean service creation, we can present following:

Table. 2. A summary of eliminating waste in service creation.

Seven wastes in Manufacturing	Seven wastes of software development	Seven wastes of service creation
1.Overproduction	1.Extra features	1.Extra services not paid by customer
2.Inventory	2.Requirements (e.g. story cards detailed only for current iteration)	2.Services done too often
3.Extra processing steps	3.Extra steps	3.Extra steps
4.Motion	4.Finding information	4.Finding something
5.Defects	5.Defects	5.Don't fulfill customer's expectation
6. Waiting	6.Waiting, including customers	6.Waiting
7. Transportation	7.Handoffs	7.Transportation

Finally, we can state that the needed knowledge to improve efficiency in technical maintenance, while reducing costs at the same time, are extra services not paid by customers, services done too often, extra steps, finding something, waiting, and transportation.

The repair cost is actually the biggest cost element in the study of the building life-cycle costs [17], and we state that Indoor Air Quality (IAQ) indirectly affects this. The reason for our statement is that there are several cases in Finland where bad IAQ has ended with a situation where people cannot use the building anymore, and the owner was forced to make significant repairs to make the building useable again.

IAQ involves many parameters and measurements, and some of those are presented in Table 3. There are certain tolerances to all parameters defined in standard [20], and having parameters inside the tolerances, we can guarantee healthy conditions for the people using the building. So, we can state that the knowledge to avoid unnecessary repairs is the tolerances for the IAQ. On the other side, it is obvious that this is not all of the needed knowledge to avoid unnecessary repairs. and there are several other factors also affecting repairs.

Table. 3 IAQ measurements

Measurement	Description
Temperature	Temperature inside room/building.
CO_2	CO_2 level inside a room/building. Shows room utilization and HVAC system performance.
Humidity	Humidity effects user satisfaction and building condition as in some cases high humidity can cause mold [19].
TVOC	Total Volatile Organic Compounds display purity of the air.
PM2.5/PM10	Small particle measurements show performance of HVAC system and cleaning. Can be thought of as dust level.
Pressure difference	Pressure difference can be used for analyzing air flow inside the building. It is also an important metric in building condition and HVAC system monitoring.

Step 3 – Work process:

In this step, the created knowledge is connected into a work process to reach the original objective defined in step 1, business requirements. First, we can divide the usage of data into two different categories: automatic and manual. Automatic means that traditionally there is a control loop, where a control algorithm automatically controls the process without people. Manual means that people need to be connected to the evaluation of result before conclusion. Nowadays, machine-learning algorithms are taking a bigger role in many environments, and it can help the people make the conclusion, or in some cases, the machine-learning algorithm has even replaced people in the work process.

In our research, the objective to reduce the energy with the help of air conditioning and lighting is a typical example of where automatic control algorithms are used. Nevertheless, this does not mean that people can be completely forgotten. Technical maintenance people need to be aware of such controls, and they need to have the capability to tune and modify the control when needed.

The objective to reduce the maintenance cost through Lean Service Creation is a typical process, where the people are at the center of the process. Therefore, all data needed to optimize the maintenance tasks need

to be presented to maintenance people in the right way and at the right time. In practice, this means that the seven wastes in service creation (extra services not paid by customers, services done too often, extra steps, finding something, waiting, and transportation) need to be analyzed thoroughly, waste by waste. It is then decided how it impacts the work process and the required data is presented to the maintenance people so they can reach a seamless work process with high efficiency.

IAQ is a wide topic and, typically, the problems in IAQ require a comprehensive analysis where several different people and organizations are participating in the evaluation. Therefore, a specific process involving all relevant organizations needs to be defined, and seamless data sharing through the entire process is a very effective method in managing IAQ problems.

As a summary, we can state that the three different objectives, meaning energy savings, reducing maintenance costs, and ensuring IAQ within tolerances, require very different approaches from the work process point of view:

- Energy saving is attained with automatic control, without directly impacting people.
- Reducing maintenance costs requires a new data-driven work process, where the right data presented at the right time to all maintenance people is necessary.
- Problems in IAQ require the involvement of several organizations, and sharing information among them needs to be defined carefully.

4.2 Data strategy framework, from data to actions

Step 1- Data management:

The main goal of the data management phase is to evaluate the data availability for the intended purpose. In the case of a facility management service provider, the data availability is a critical issue, because assets, data sources, data measurements, and even data itself are owned by their customer. Therefore, the facility management service provider is very much dependent on their customer regarding strategically critical elements in their offering. In addition to this, there are typically several technical restrictions and challenges to get high-quality data for the intended purpose. Next, we evaluate our case from this point of view.

Data for the air condition and lighting control are CO2 and brightness correspondingly. They are standard measurements nowadays, and in the case of modern air condition and light control systems, the measurements are already integrated into the system, or they are quite easy to add on as an extra feature. Therefore, technically needed data is a standard feature, but they are tightly integrated to their customer's infrastructure.

Data for the maintenance efficiency improvement is a very wide topic, and it can be divided into two different areas. First, the data from the building and surrounding systems, like building automation systems, needs to be collected. Partly, the data can already exist or some new measurements need to be added. All of this data needs to be collected and stored into data storage, from where it can be used to optimize service execution. The implementation of this can be very expensive and time consuming, requiring deep technical knowledge. Second, the data needs to be collected from or sent to the facility management service provider's own operative IT systems, like ERP, CMMS systems, etc. As a summary, it is a very big effort to make all needed data available for service execution optimization, and it will require several interfaces between different systems. The final solution is integrated into their customer's operative systems and their own IT systems. This can be possible only in the case of a long-term partnership between the facility management service provider and their customer.

IAQ measurements have been developed very fast during the last years. The price has decreased, a battery lifetime has become longer, and the wireless technology is standard for data communication. All of these measurements are easy to install by the facility management service provider, and they are widely used nowadays. The measurement for the temperature, CO2, humidity, and pressure are all proven design technology, but TVOC and PM2.5/PM10 have still more uncertainty regarding trustworthy results.

Step 2 – Controls, analytics, and machine learning:

Regarding energy savings, the needed CO2 and brightness measurements are integrated into the customer's air condition and lighting control systems. A simple controller controls the air condition based on the CO2 levels in the air condition system or in the building automation system. Similarly, the lighting is controlled in a modern light control system. This means that the energy-saving implementation is a small investment, and it can be very difficult to sell this as a service to the customer. Technically, the implementation is very easy and straight forward if air condition and lighting control are implemented with modern technology. The older the technology, the bigger the investment is needed to reach the energy-

saving goals. In our case, the energy savings was 24% in CO2 control compared to constant air conditioning, and 60% in light control compared to continuous lighting. Therefore, reasonable pay-back time can be reached depending on the investment cost. CO2 control implementation needs to take into account the IAQ, because control can have some affect on air quality, and it can even cause some damage to the building in the end. This is the feature that has some value to the customer, and which can be sold as services to the customer on the top of the investment for the energy savings.

Maintenance optimization through lean principle, presented earlier, is a comprehensive approach concluding with new processes to execute service operations. Actually, the scope of our research is to explore the data and how it can be used to improve the service execution efficiency. The measured and stored data is used to create a deviation, and each deviation initiates a work order to eliminate the deviation. The deviation is e.g. an increased pressure difference over a filter in the air condition machine, which indicates the need to replace the contaminated filter. Then, the filter is replaced at exactly the right time, not too early or too late, which is typically the case if it's done according to a time schedule. This is one example of moving from the scheduled maintenance to predictive maintenance, where maintenance action is done based on the real demand and not based on the schedule. Another example is to use a machine-learning algorithm to anomaly detection. This means that the algorithm learns the normal behavior of some measurements, like e.g. water or energy consumption. Then, the algorithm is used to follow these measurements, and it indicates abnormal behavior to further the investigation to the maintenance people. The benefit of this approach is to have the automatic follow-up for the huge amount of measurements, which would be very time consuming and costly to make by people.

IAQ evaluation and deciding corrective actions is a comprehensive process requiring the involvement of several organizations, and a large amount of the data is available for this evaluation. On the other side, the IAQ problems are typically very demanding, and a root cause, as well as corrective actions, requires deep knowledge. Therefore, it is obvious that the analytics can be used to get a better understanding of the situation when a large amount of data is available. The large amount of data has two dimensions: first, the history data for the corresponding building, and second, the data from similar buildings. Nevertheless, the expert knowledge is always needed to make final conclusions, and analytics using the data can only support the expert in gaining a better understanding of the system.

As a summary, we can state that there are very different types of approaches for using data to create value:

- Energy savings is done based on automatic control integrated into the building infrastructure.
- Maintenance operation efficiency improvement based on the new data-driven processes, where simple logic using limit-value or machine-learning algorithms are used
- IAQ problem solving based on the analytics, where analytics have the role to support decision makers

Step 3 – Conclusion:

User experience is very critical to ensure a successful data strategy implementation in practice. This means that the result of analytics & machine learning need to turn into usable information for users. Poor implementation of user interface may easily destroy the value created by analytics & machine learning.

The control for the air condition and the lighting is done automatically without the involvement of people. Therefore, the user interface is not so critical in this case, and technical maintenance people need to have access to the system for maintenance and tuning purposes. On the other side, the energy-saving information is very interesting, and it can be presented to the customer, especially if the solution has been sold as aiming at cost savings.

The user interface plays an important role in data-driven maintenance operations aiming at efficiency improvement. The work orders generated as a result of analytics need to be presented seamlessly to technical maintenance people. The mobile user interface is the best solution for this. This user interface needs to be very clear, precise, and easy to use by the technical maintenance people.

Experts do IAQ problem solving and people from several organizations participate in the evaluation. Therefore, the user interface needs to be more flexible and needs to provide the possibility to analyze the situation using data from different points of view. There are different analytics tools providing a good user interface, like PowerBI and Tableau, developed for this purpose.

5 Discussion

We can state that the data strategy framework presented in Pulkkinen et al. [1] is applicable for the

facility management service provider. Actually, the different areas for creating added value were the reduction of heating, including electricity, and maintenance costs, also positively affecting repair costs. These areas require a very different data management process but nevertheless, we can state that the data strategy framework was applicable to this case study regardless of the different nature of these areas. This can be seen as the strength of the presented data strategy framework.

We want to highlight a few observations discovered during the study. The data quality is a very critical success factor. Our approach was emphasizing that the data is correct from the business requirement point of view, and even this was quite easy to forget during the process. So, one thing we learned is to make it very clear from the beginning, our business objective, and keep this in mind through the whole process. On the other side, the data quality from the technical point of view was also very critical, and it's important to check this from different points of view, like completeness, timelines, validity and accuracy. This is one area which needs further studies to improve the overall data strategy framework process.

In our study, the measurable results were identified for the energy savings, like air condition and lighting optimization. The air condition optimization was done in an old school building, and the lighting optimization at the sheet metal center. Naturally, the results were achieved in these specific environments, and the extendibility of results to other applications need further research. On the other side, our objective was not to figure out scientifically accepted energy-saving opportunities, but only to demonstrate the applicability of the data strategy framework in this context.

One our results was the seven wastes of services derived from the lean manufacturing principle. This was not yet implemented in the real environment and, therefore, this needs further research to demonstrate the validity. Actually, this is the most challenging objective, where several aspects need to be taken into account, like old maintenance traditions , current IT systems used in the company, and how to manage the information in a modern environment, which includes legacy systems, etc. So, the maintenance efficiency improvement can be seen as a bigger challenge in the company to make the digital transformation, which will require strong leadership to manage the whole transformation. Definitively, this is one important research topic in the future, and this would serve the needs of many companies nowadays.

6 Conclusion

Many companies have been adopting a service business strategy, especially in the mature industries, in order to differentiate their offering and enhance customer engagement for decades already. Therefore, servitization has been a global trend among many traditional manufacturing companies, and a great deal of research has been made for service development. However, until now, such research has not been made for the pure service companies, having only service offerings without manufacturing.

Our research focuses on improving the competitive position utilizing data for the facility management service providers, who are providing pure services for their customers. The research was based on action research with the facility management service providers in a changing market. The facility management service provider has a strategy of sustainable growth in the long term, which requires improving their competitive position in their market. The competitive position improvement is created by utilizing the data in their service operation to reduce the heating and maintenance costs and to positively affect repair needs.

The result of the study is that the selected data strategy framework was applicable in the area of the facility management services. The facility management service provider has different areas to improve the competitive position, as mentioned above, and they result in very different data-driven services. However, the framework was applicable to all these areas, emphasizing the strength of the data strategy framework to be applicable in different environments.

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