APPLYING THE ARCHITECTURAL APPROACH TO THE DESIGN OF A DIGITAL PLATFORM: THE CASE STUDY OF AN AVIATION HOLDING COMPANY

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Abstract: This article presents an example of effectively applying the architectural approach to the design of a digital platform to aggregate digital services in an industrial enterprise, based on the case study of an aviation holding company. It reviews options for the further design of IT processes to support digital services provided by a digital platform created with the frameworks Cobit 5 and ITIL 3. The architectural models reviewed in the paper are built using the enterprise architecture modeling language ArchiMate.

Key words: enterprise architecture; digital services; digital platforms; Industry 4.0; ArchiMate.

JEL: O0, O3, L8.

Integration of information technologies into the core processes of organizations in order to automate and optimize those processes and gain further competitive advantages is the underlying principle of the Industry 4.0 concept. Within the context of the fourth industrial revolution, enterprises today need to employ a new approach based on the creation of cyber-physical

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systems. End users thus have real-time access to a tremendous volume of automatically collected output data, which they can later analyse.

The concept of Industry 4.0 has been subject to extensive scientific research. K. Shvab's (Shvab, K., 2016) was the first economist who analysed the underlying principles of the phenomenon. His publications were followed by multiple research papers studying the nature of human–machine interaction (Gorecky, D. Schmitt, M. etc., 2014); the operation of self-aware machines (Bagheri, B. Yang, S., 2015), the organisation of 'smart' manufacturing (Zhong, R.Y. Trappey, C.V., 2017), etc.

A digital platform may be approached as a way of doing business. It may also be provided to end users as a service. Researchers use the term 'Business platform as a service' to refer to the manner in which the service is provided, based on the deployment of a large-scale digital platform and related services.

In contrast to the digital platform concept, the model of a 'Business platform as a service' has not been researched in depth, despite the examples of its successful implementation into business practice. BT Broadband, the provider of telecommunication services, for instance, already has experience in employing this model in the sphere of telecommunications (Reichert, C., 2017).

A digital platform ensures the virtualization of a significant part of core business processes within enterprises. The virtualization of business processes is achieved by providing end users with convenient digital services that would minimize financial and transaction costs. Within the context of Industry 4.0, virtualization may be considered as a key instrument for enhanced value creation in enterprises (Kagermann, H., 2014).

The widespread use of digital services in manufacturing enterprises today is the result of the synthesis between the major principles of the economy of services and the underlying ideas of the concept of Industry 4.0 (Lapierre, J., 2000). Some authors approach digital services as the next stage in global economic development, since their digitalization provides an opportunity to reduce a number of costs while at the same time preserving the traditional features of those services and the value they generate (Spohrer, J., Maglio, PP, etc., 2007). Furthermore, a lot of researchers have come to the conclusion that digital services can both raise the productivity of business operations and compete with human efficiency and decision-making. They have identified four key areas where enterprises are adopting digital services: the creation of digital workplaces; the creation of value added; the 360° customer view (i.e. adapting to user needs) and Internet of Things scale automation (Robin Purohit).

As a means of aggregating digital services, innovation platforms provide the basis on which businesses create innovative ecosystems (Evans, P., Gawer, A., 2016) to develop complex technologies and products. According to some formal documents in Russia, digital platforms enable different stakeholders to share and exchange data in order to design, forecast and develop multifunctional services and create new products and services (Programme for the Development of Digital Economy in the Russian Federation).

The intensive virtualisation and adoption of digital platforms has led to the appearance of a wide range of digital copies of conventional physical objects, such as documents, products, models, etc. End users thus have access to the digital twins of objects (a term used by professionals), the design and analysis of digital twins often being fully automated and taking place in real time.

The use of digital twins in civil and military aviation, and in space exploration, has attracted keen scientific interest. Some scientists believe that the concept of digital twins is a key aspect of the further development of civil aviation (Tuegel, E. J. Ingraffea, A. R. etc., 2011), as well as of military aviation and space exploration (Glaessgen, E. H. Stargel, D. S., 2012) due to their convenience and the simulation opportunities they provide. The possibility for manufacturing driven by digital twins and Big Data technology has also been researched (Fei Tao, Jiangfeng Cheng etc., 2018).

Creating digital platforms implies high costs for companies. Furthermore, entities may face serious problems during the design process as managers and other stakeholders also need to take into consideration the large number of enterprise elements that will be affected by such a transformation. Good awareness about major elements, the relationships between them and the manner in which they influence one another often determines the success or failure of transformation itself.

One of the most effective solutions to similar problems is applying the architectural approach since it opens up an opportunity for conducting a complex analysis and modeling and designing an enterprise. The architectural approach makes it possible to study the elements of enterprises as architectural objects whose coordinated interaction ensures the creation of their value chains. Some scientific research into applying the architectural approach to provide digital platforms as services has been conducted as well, for instance, in the sphere of service management with cloud technologies (Boniface, M. Nasser, B. etc., 2010) or in the sphere of technological infrastructure management (Keller, E. Rexford, J., 2010).

We illustrate the application of the architectural approach by employing the enterprise architecture modeling language ArchiMate to design a digital platform. The enterprise in our example is an airline holding company where the entire production cycle of a new aircraft takes place. The numerous production processes and operations, which an aviation holding company carries out, may be summarized as the design of various components and assemblies; the design, testing and refinement of prototypes; serial production and ensuring the exploitation of aircrafts.

At a certain point, the managers of the holding company realized that having a digital platform built would enable the engineers in the company to use virtual models, i.e. digital twins of physical components and assemblies, in the design, prototyping, refinement and testing processes.

Before the transformation of the holding company, all design and refinement works were done by employing traditional design tools, the models thus created often being incompatible with each other or failing to meet certain technical requirements, including due to the impact of the human factor. The situation was further complicated by the fact that the partners and design offices involved in the basic processes of the holding company used their own designing tools and devices. In result, the holding company had to allocate enormous resources to gain access to information (about models, technical assignments, test conditions, etc.) and to design and build the models, to test their compatibility and validate them.

In most enterprises, prototyping and testing are conducted in the 'traditional' manner, i.e. with physical models. The aviation holding company in our example did not make an exception and often had to manufacture physical components and assemblies, which had to be replaced with new ones as soon as some minor changes in the initial design were made. Manufacturing single copies of numerous components and assemblies and the need to frequently replace them incurred considerable costs, therefore a decision was made to add to the designed digital platform the functions required for conducting virtual tests of by using digital twins of physical components and assemblies.

A decision to implement a digital platform implies raising the level of IT management in enterprises significantly since their core processes become more reliable on IT components: implementing the digital services used by a digital platform implies complying with high requirements to the Service Level Agreement (SLA). Poor quality of IT management could directly affect the ability of a holding company to create value or generate profit through its core activity.

In addition to introducing new IT management processes, the company had to assign a new role to the person responsible for service level management, a responsibility that would be shared by both new partners and the support staff already employed by the business entity.

Figure 1 presents the target architecture model of a business platform integrating design, prototype and test services that was created with the ArchiMate modeling language. The target objects in the architecture model are highlighted in red:

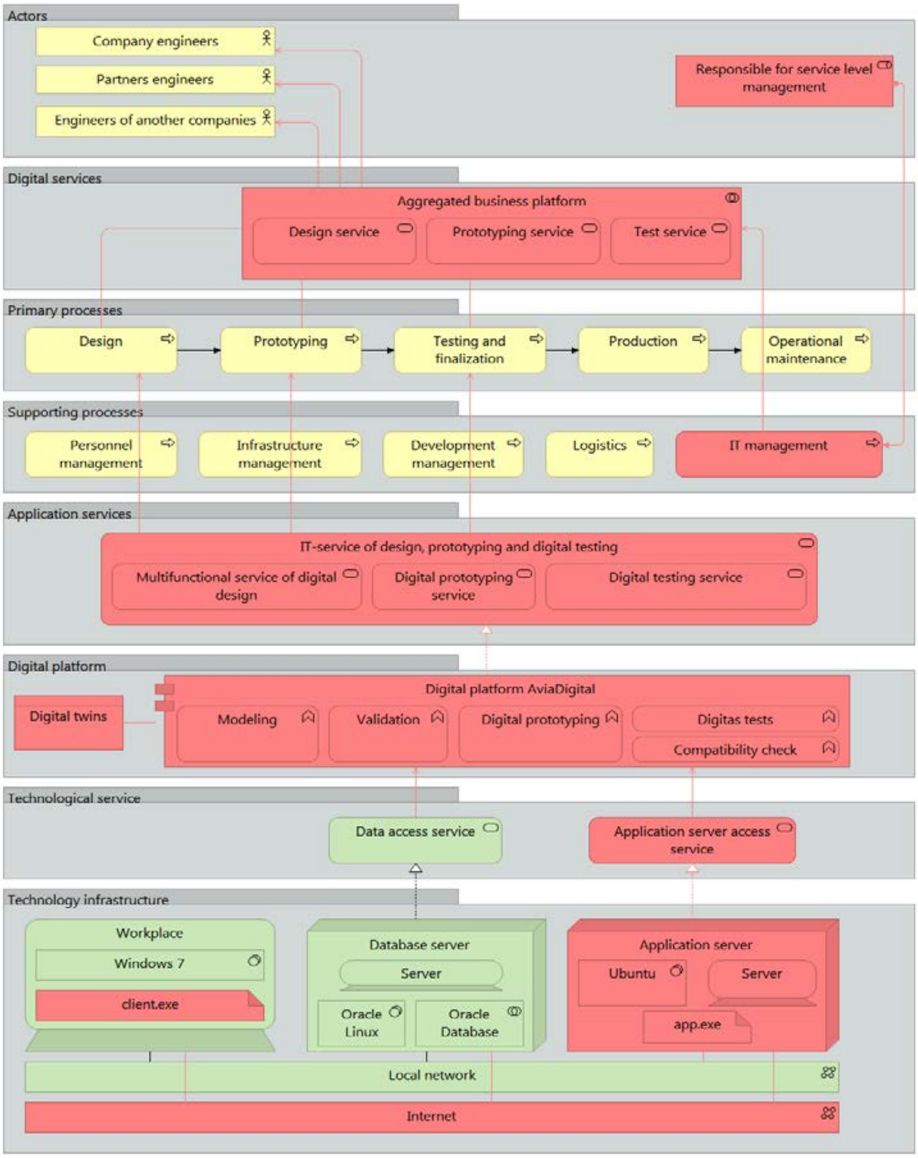

Fig. 1. An architecture model of a business platform integrating design, prototype and test services

By the time a decision was made to transform the entity in order to create a digital platform, the aviation holding company already had a developed technological architecture, some of its elements being presented in figure 1: a local network; automated workstations; a database server; system software, etc. As a result of implementing the transformation project, an application server was added to the existing technological infrastructure. Additional setup of the existing database server was also made and automated workstations were installed.

As obvious from the model presented in Figure 1, the services of the business platform will be used by engineers and designers in the aviation holding company, by partner engineers and by engineers in partner design offices.

Digital services create value for end users due to reduced transaction and financial costs in result of using a unified information environment to design, prototype and test models. In the case of the aviation holding company, a decision was made to use digital services for implementing first-level processes like ‘Designing’, ‘Building prototypes’ and ‘Testing and refining prototypes’. They were also expected to reduce a number of related risks such as failures to meet deadlines, exceeding approved budgets on prototypes or tests, incompatibility of models, non-compliance of components and assemblies with standards, etc.

Some new IT processes, which will be discussed in detail later in the article, were also introduced into the activity of the holding company in order to provide digital services for designing, prototyping and testing.

The model illustrates the implementation of core processes through the deployment of digital services, including a multifunctional digital design service; a digital prototyping service and a digital tests service:

- The multifunctional digital design service will support the major functions, which engineers use when designing aircraft components and assemblies. The service will support these major functions in the offline tools which have been used by engineers so far;
- The digital prototyping service will generate virtual models of prototypes based on digital models created by engineers. A digital prototype will share the major characteristics of a real physical model, which will reduce the costs of creating a ‘physical’ version of the prototype.

- The digital tests service will make it possible to conduct virtual tests of components, assemblies and aircrafts based on created virtual prototype models. Although the aviation holding company will still have to do 'real' tests, identifying problems in components and assemblies as early as at the stage of virtual tests will lower risks and financial costs.

We will provisionally label the digital platform whose services will ensure the implementation of the business platform model as a service AviaDigital. The digital platform will support the following core functions: modeling, validating, digital tests, compatibility verification and digital prototyping. The users of the platform will be able to work with the digital twins of the physical objects – components and assemblies.

The target objects identified at the level of technological architecture of the aviation holding company include:

- An 'Automated workstations' unit – the access to the digital platform will be ensured with the operating system Windows 7.
- A 'Database server' unit consisting of a server as a physical object and installed Oracle Linux and Oracle Database systems. The aviation holding company already has this unit and the systems installed on it, although the digital platform will operate with database designed especially to that purpose.
- An 'Application server' unit, which consists of the server as a physical object, the Ubuntu system and the system files of the digital platform. It is part of the target architecture since prior to the implementation of the project the aviation holding company has not used an application server of similar capacity – most of the applications were offline and installed on the engineers' workstations.
- A local network connecting the automated workstations of external users, the database server and the application server.
- An internet network connecting the automated workstations of external users, the database server and the application server.

The technological services for access to data and to the application server will ensure the interaction between the digital platform AviaDigital and the objects of the technological architecture.

It should be noted that these significant changes in the architecture of the enterprise during the transition to the business platform model as a service did not require any major requalification or retraining of the engineers or designers working for the company. Rather, they needed to get used to working with the new tools for designing, prototyping and testing and to learn about their functions and the new modes of accessing and working with data.

Although the successful implementation of a digital platform requires computing the financial indicators of a similar transformation project, including personnel, software and hardware costs, economic effectiveness indicators, etc., these will not be subject to a detailed analysis in our article.

Our next step will be to describe how the issue of developing auxiliary processes for IT management was resolved. These auxiliary processes were also necessary for the effective operational management of the relations between the engineers in the company as the end users of digital services and the external providers of digital services. To find a solution at a business architecture level, new auxiliary processes were introduced into the aviation holding company. The contents of these processes were determined by the managers' decision to implement practices for service level management based on the Service Level Agreement and to actively apply the principles of the services-oriented approach in IT management.

In order to improve IT management in the enterprise, Cobit 5.0 and ITIL frameworks were used. The Cobit 5.0 framework focuses on processes for governance (which are a responsibility of the Board of Directors) and management. The Cobit 5.0 reference model presents 37 governance and management processes, some of which were implemented by the aviation holding company in our case study. Taking into consideration the complex structure and the practices, which had already been established at the enterprise, a decision was made not to stick to one framework only but to introduce some auxiliary IT processes based on the ITIL v3 Library, despite the scope of Cobit 5.0 and the solutions offered by the framework.

The auxiliary IT processes that were selected to support IT services included:

- Change management (code BAI06 in the Cobit 5 reference model), since the need of designing, prototyping and testing options is very likely to change over time (Cobit 5.0, 2012).
- Problem management (code DSS03 in the Cobit 5 reference model). The SLA requirement implies that the complex nature of digital

services and the large number of their users (including external ones) will make it possible to reduce to a minimum the number of occurring problems which IT support specialists will have to deal with (Cobit 5.0, 2012).

- Service agreement management (code APO09 in the Cobit 5 reference model). The existence of SLA implies the need to manage it, therefore the introduction of that IT processes was a must (Cobit 5.0, 2012).
- Availability and capacity management (code BAI04 in the Cobit 5 reference model). Due to the large number of external users and the predicted high load of the service, availability and capacity management might prove to be a major challenge to the enterprise. Hence the decision to introduce the process (Cobit 5.0, 2012).
- Release and deployment management. This process was selected due to the predicted need to frequently change the digital services (ITIL v3, 2011).
- Incident management. The users of the services will probably face errors and violations whose recurrence will have to be prevented (ITIL v3, 2011).

It was decided that the new IT processes would be performed by a technical support specialist and a methodological support specialist.

To support the IT processes listed above highly specialised software is required. At present, there is a wide range of products on the market to select from. In this article, however, we use a general example, which we provisionally call 'An IT management system' that has the following key software functions: incident management; SLA management; release and deployment management; availability and capacity management; problem management; change management.

The introduction and operation of the IT management system also requires purchasing and deploying additional IT infrastructure: a system server, a database server, appropriate software, etc.

The elements described above are presented as an architecture model. Figure 2 shows the architecture model of service level management which was designed with the ArchiMate modeling language. For greater convenience, target architecture elements in terms of IT management are highlighted in green:

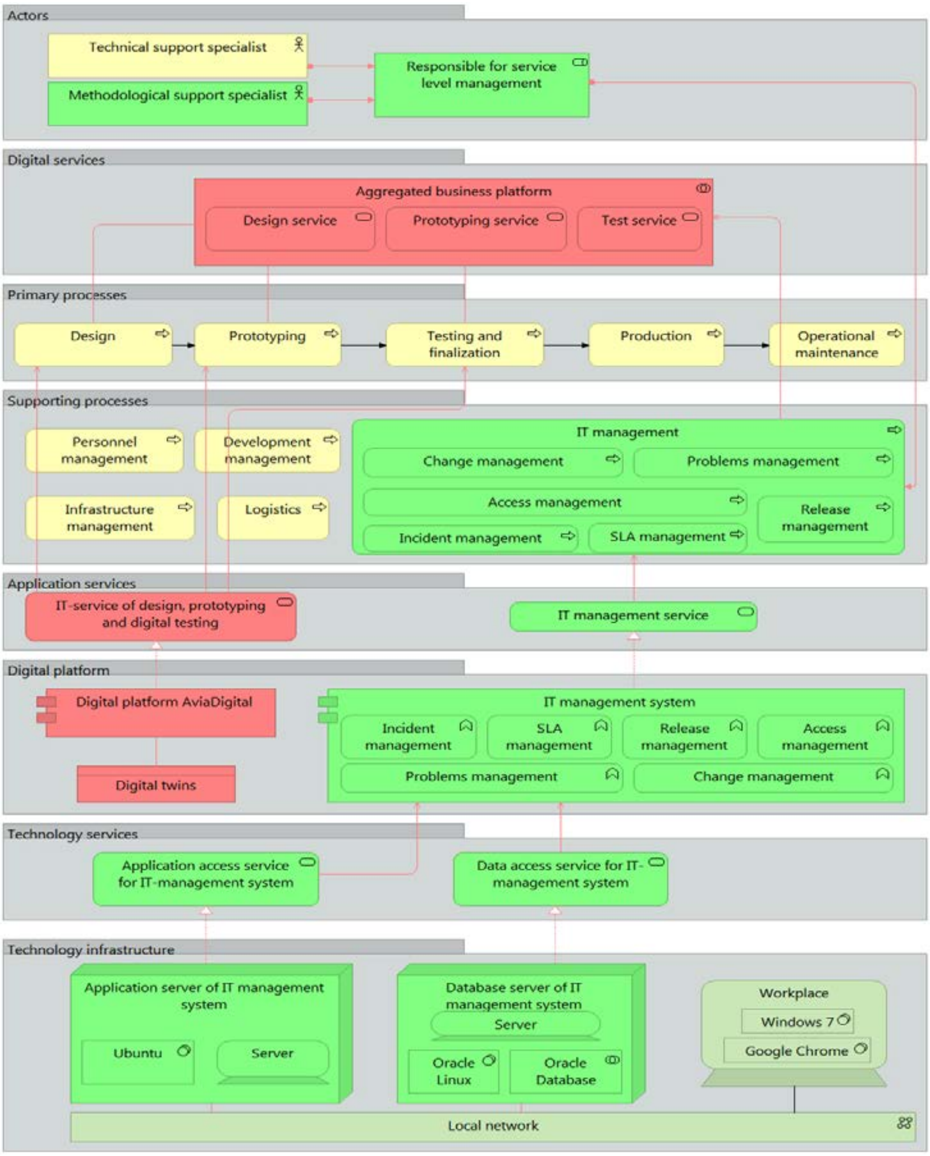

Fig. 2. Architecture of a management model at the level of design, prototype and test services

The role of the 'Person responsible for service level management' presented in Fig. 2 will be taken on by two people – a Technical support specialist, already available at the enterprise, and a Methodological support specialist.

At the closing stages of designing the digital platform, a target model of the enterprise architecture was created. The model included both the digital platform and aggregate services and the target architecture objects related to IT management. A detailed presentation of the technological layer is not necessary at this stage, as its objects were illustrated in detail in the models presented earlier in this article. Instead, Figure 3 gives an overall idea about the target architecture of the top level of the aviation holding company.

The model illustrated in Figure 3 integrates the key objects of the target architecture of the aviation holding company and gives an overall idea about the architecture of the company after implementing the transformation project. The layered model proved to be useful to the top managers of the company as well as the partners responsible for executing the transformation project, including the designer of the architecture of the enterprise, the project manager and the person in charge of the technical support office.

This is an example of the key options for applying the architectural approach and popular frameworks and reference models to the implementation of digital platforms in large enterprises. The effectiveness of the approach depends on a number of factors, such as its explicitness, formalization, the integration of different operations within the enterprise, the availability of reference models and best practices, as well as ready access to toolkits for architectural modeling and design.

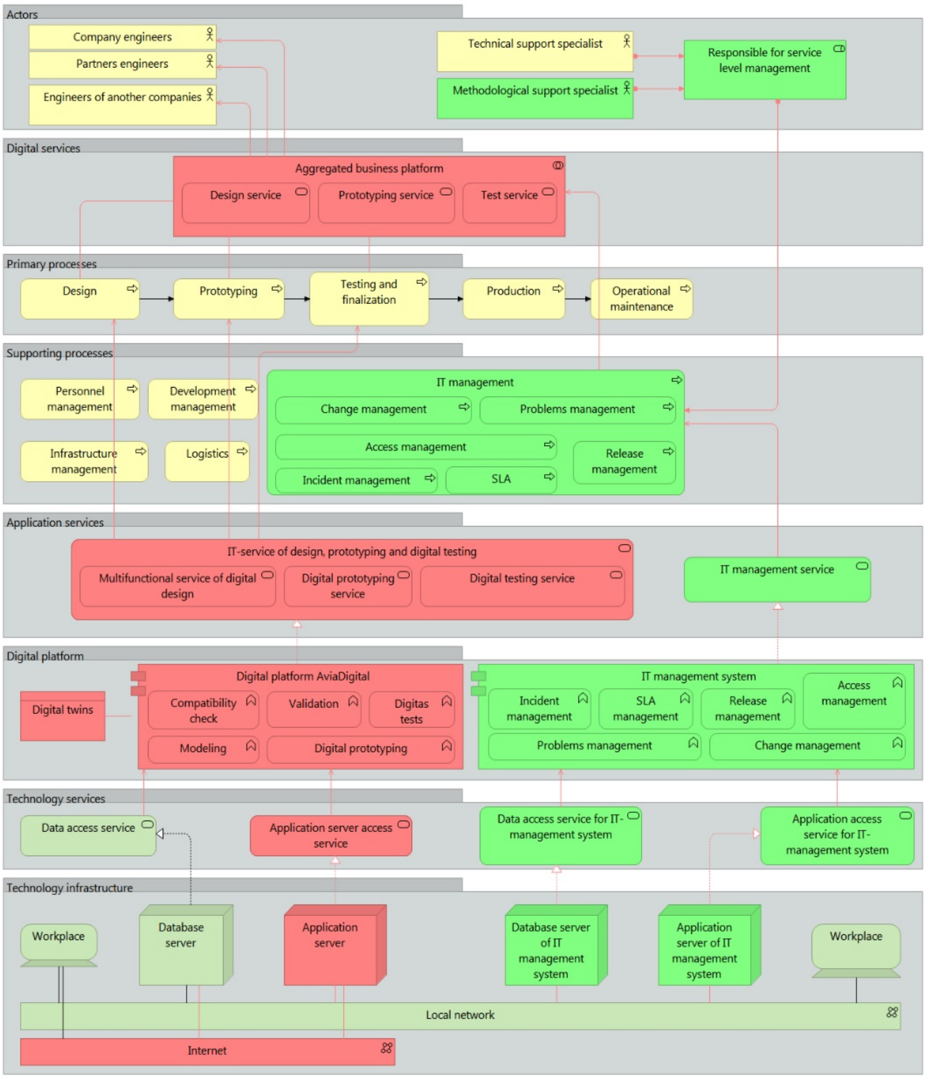

Fig. 3. A layered target model of the architecture segment of the aviation holding company

Conclusion

This article:

- Gives an overview of up-to-date scientific trends in the research of Industry 4.0, digital platforms, digital services and digital twins.
- Uses a case study to illustrate the opportunities provided by architectural modeling for designing digital platforms in large enterprises. The case study of the aviation holding company shows the end results of the transformation of the company by employing an aggregator business platform.
- Presents the overall impact, which the transformation had upon the architecture of the enterprise after the implementation of a digital platform.
- Gives a solution to the issue of ensuring high level of IT and digital services management by employing established frameworks and best practices.

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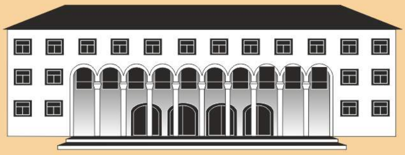

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