

INFORMATION SYSTEMS IN MANAGEMENT OF POLISH RAILWAY COMPANIES OF PKP GROUP IN ASPECTS OF TECHNOLOGY AND ECONOMY

MICHAŁ HENRYK RUDOWSKI

Institute of Computer Science, Warsaw University of Technology

Paper presents selected management information systems in the railway industry companies arising from the transformation of the Polish State Railways into PKP Group. Hardware and software solutions used by this systems and benefits of implement them are also pointed out. Takes into account the areas of financial management as well as the areas of operational management, specific for their activities. These issues are presented in the context of technology and economy. It has been proved that the organizational solutions imply the impossibility of efficient use of resources allocated to information systems due to consummate the benefits of consolidation, virtualization and cloud computing is impossible.

Keywords: managing systems, railway industry, consolidation, virtualization, cloud computing.

1. Introduction

IT is a very important part of modern enterprise and its quality and Total Cost of Ownership (TCO) may determine a competitive advantage in the market. IT solutions are particularly significant in companies on the railway market like PKP Group companies. Modern IT has a number of solutions that increase productivity and significantly lowering TCO, which is the sum of capital and operating costs.

Currently the leading role is played by systems operating in the cloud environment with the ability to provide both highest availability and highest performance for the various applications while reducing costs thanks to consolidation, virtualization, automation of service delivery and management. Cost savings are also result of economy of scale - the provisioning of a large number of services to many different entities.

The aim of this paper is to present new technical solutions in information systems management implemented in PKP Group companies and to assess the validity of the costs from the perspective of entire Group rather than a single company. The paper presents the most important new technical solutions applied in the last three years in major PKP Group companies. In second chapter author indicates literature where information about the initial situation of companies after the creation of the PKP Group can be found. Third chapter presents selected systems as the most interesting in terms of technological, functional and likely to have the greatest relevance for entities which implement these solutions. Author has selected solutions: HP Cloud Matrix in PKP Informatyka, SAP HANA in PKP PLK, Corporate Data Warehouse in PKP Cargo and Oracle eBS ERP system, Data Warehouse, Oracle Business Intelligence and Oracle Hyperion in PKP Intercity. Author appreciates the quality, modernity, efficiency and reliability of the solutions used in various companies. In chapter five, author quoted a 10 Laws of cloudonomics formulated by J. Weinman, vice-president of AT&T. Author also pointed out that the group companies, though some of them rightly take great selection of technology solutions, waste their money on IT, as a set of uniform solutions for the corresponding benefits could be realized with the use of smaller investment funds and other resources. In summary, author tries to show the way for the integration of IT systems in the hybrid or public cloud, by contracting the operation and maintenance to specialized IT provider, which would be required (and would be able to) to meet all the requirements of PKP Group companies. Author explains why it is not valid economic strategy to use many diverse solutions without a common IT strategy, under which it would be possible to consolidate systems within the selected technologies and to obtain the benefits of successively implemented: consolidation, virtualization, automation and optimization of systems and business processes, leading to processing in the cloud model - Cloud Computing (CC).

2. Information Management Systems in PKP Group Companies in the First Years of their Business

January 1, 2001 pursuant to the Act of 8 September 2000 on commercialization, restructuring and privatization of the state enterprise PKP (Polskie Koleje Państwowe) national railway company was converted into a joint stock company. October 1, 2001 it was divided into a number of companies. This law was inspired

by Council Directive of 29 July 1991 on the development of the Community's railways (91/440/EEC) requiring the separation of passenger transport role, freight transport role and rail infrastructure management role. The following entities were created:

- PKP SA – ownership supervision (coordinates the activities of other companies, sets goals and is responsible for privatization,), property management,
- PKP PLK (Polish Railway Lines) - the infrastructure manager,
- PKP Cargo - the main freight carrier and logistics operator,
- PKP Intercity - nationwide qualified and interregional passenger carrier,
- PKP Przewozy Regionalne (PKP Regional Services) - passenger carrier, regional and inter-regional trains. Separated from the PKP Group in 2008.

Smaller entities were founded as well: passenger carriers (WKD, SKM), and freight carrier (LHS) which benefited from a dedicated infrastructure. In addition, several infrastructure companies like PKP Energetyka (energy and electricity), Telekomunikacja Kolejowa (Communication and railway traffic control) and PKP Informatyka (IT). PKP Informatyka took over the information technology services for the companies, but without a monopoly position.

Information systems in PKP Group were mostly distributed in both the general management field and in operational management field (core business). Dispersal and diversification were common problem due to the technical and organizational reasons. Most of that systems were obsolete.

Issues of management information systems in the first decade of the operations of the PKP Group author presented in [1]. Selected systems supporting logistics in certain companies of PKP Group (PKP Cargo, PKP PLK) are also described in [2]. Information contained therein relate to a randomly selected systems and probably derived from literature research only. It is correct that the Aviator system was awarded, but it never passed beyond the pilot phase. Project SŁAWMIK developed in 2009-2010, which was to include some Aviator's functionalities, was abandoned after the analysis stage. Some of the functionalities of these systems are implemented within the project EKL (Electronic Logistics Book). In the report of the Railway Business Forum "Polish Railway Problems in the Area of Information Technology" [3] describes a number of systems. The report includes some errors and shortcomings. Because it's comprehensive approach and a wide range of data it is important source of information about the state of the IT systems in companies of the PKP Group at the end of the first decade of the twenty-first century. It is important that most of the proposals contained in that report are still current. Also situation with the lack of strategy in the IT area has not improved.

3. New IT Solutions for Management Information Systems of PKP Group Companies

This chapter presents new technological solutions which has been introduced recently in selected PKP Group companies. These systems were introduced both for applications previously used, as well as for new ordered to be developed on the basis of universal solutions. The following significant new solutions of companies PKP Informatyka, PKP PLK, PKP Cargo and PKP Intercity were presented:

- comprehensive, versatile software and hardware solution for cloud computing service provisioning - HP Cloud Matrix in PKP Informatyka,
- specialized appliance (hardware and software solution) for decision support applications - SAP HANA in PKP PLK,
- specialize appliances (hardware-software solutions) for databases, OLTP, OLAP and BI systems - Oracle Exadata and Oracle Exalytics in PKP Cargo,
- virtualized hardware and software environment for ERP, BI and Hyperion applications using: Sparc T4 and SunFire 4170 servers, Solaris and Linux operating systems in PKP Intercity.

Each of these solutions was the leading solution in its category. Due to their diversity, existence of IT strategy in PKP Group can be doubted.

3.1. PKP Informatyka – cloud computing technology

VMware ESX hypervisor began IT revolution. The solution is allowed to run multiple independent operation system environments on a single physical server. Virtualization solutions are known for over 50 years and have been used e.g. in IBM mainframes. An increase of performance by commonly used x86 computers and dissemination of intelligent storage arrays have caused widespread use of such solutions in IT of most companies. Initially, virtualization was used only for test and development systems, where there was always a need to have multiple environments with the low performance requirements. Later with the development of virtualization techniques and products, it was obvious that use of these solutions allows for significant savings in IT infrastructure, data center costs (area, energy, effort), not only for test, development and training systems but also for production systems including database systems, which due to the intensive use of disk I/O subsystems considered difficult to virtualization.

PKP Informatyka have used virtualization since 2001 using VMware and other vendors' products. Since 2009 the company makes extensive use of these solutions for their own use and to provide services to its customers. With the consolidation of data processing systems, virtualization of storage and operational systems, tasks and services provisioning automation, advanced admin tools to manage the hardware and software environment became possible service by providing system

environments, databases, applications and other on-demand services in the cloud. In 2012 PKP implemented system called HP Matrix Cloud. Dual-processor HP BL460c G7 servers and vConnect network switches (LAN&SAN) were installed in the HP c7000 enclosure with hypervisor VMware ESX, operating systems MS Windows Server 2008 DC and RH Enterprise Linux. Disk subsystem was provided by the extension of the HP EVA (Enterprise Virtual Array) 8400 disk array. The whole solution was managed by HP Insight Dynamics software, which gave the system the functionality of cloud computing (CC). In this way the cloud was built to provide internal services within the company and was to be widely used and developed in order to provide CC services for customers – companies of PKP Group. Within a few months the number of concurrently running virtual environments on this infrastructure has exceeded 100. The creation and providing to the customer operation system environments running Windows or Linux lasted for tens of minutes of notification. Unfortunately, the new board, who led the company in 2012-2014 at the end of 2012 decided not to promote the CC services for external clients. Currently, only virtualized with VMware ESX blade servers are used for the services provisioning. Advanced software providing functionality of cloud computing (HP Insight Dynamics) is not used, and trained staff performs other administrative and design tasks in different organizational units.

3.2. PKP PLK - implementation of SAP HANA

The PKP PLK operated since 2007 as one of the largest SAP ERP and SAP BW environments in Poland. Specific requirements in this environment have occurred, in a finance controlling at SAP BW. Despite the use of efficient HP Server 8640 and efficient HP EVA 8100 disk array and the distribution of logical disk volumes on a large number of physical devices, duration of the monthly billings for the entire company was unsatisfactorily long, reaching up to several hours. This time had an upward trend with increasing data size and functionality of the system. Therefore, in 2013 it was decided to migrate the system SAP Business Warehouse on a new hardware platform. SAP HANA platform has been chosen. SAP HANA is specialized data processing appliance characterized in that all the processed data is stored in the operating memory (RAM). This allows much faster data access.

Implementation of SAP HANA, which were implemented in 2014 shorten the duration of monthly controlling operations of the company PKP PLK from tens of hours to dozens of minutes. Also, the implementation of other operations in a data warehouse system was dramatically shortened (30 to 50 times). This is an example of how the use of appropriate new technology allows for significant improvement in processing performance and quality of service. SAP HANA platform not only increased the computing performance of analysis for SAP BW, as well as improved use of work time, allowing employees to better meet the information needs, faster providing detailed analysis, allowing accurately plan and control business process-

es. Ultimately use of SAP HANA allows better utilization of the potential of implemented SAP solutions. Implementation of SAP HANA was part of a larger project whose aim was to consolidate and replacement of IT infrastructure for all business applications in the company. The increase in the amount of data PKP PLK needed to manage business processes and investment processes required to consolidate and optimize IT infrastructure in order to reduce operational costs and increase of system performance. After the implementation of SAP HANA better utilization of SAP transactional applications is possible. Conducting of more complex analyzes, and quickly generated reports are also possible.

The investment was carried out after the depreciation of existing hardware, in the period when modernization of equipment was planned. PKP PLK, along with the modernization took over the equipment and administration tasks from PKP Informatyka.

3.3. PKP Cargo - Exadata and Exalytics with Oracle Business Intelligence

In the last few years PKP Cargo the number of significant projects related to new hardware and software solutions were deployed. One of the most important is Corporate Data Warehouse using specialized equipment Exadata and Exalytics.

From 2013 PKP Cargo with support of PKP Informatyka and Oracle implements a project of the Corporate Data Warehouse based on Oracle Business Intelligence and Oracle Database. The software is installed on a specialized hardware optimized specifically for these products Oracle Exalytics and Oracle Exadata. Exalytics, is a system optimized for decision support applications: data warehouse and business intelligence, in particular for Oracle Business Intelligence. Exalytics processes the data in memory. Exadata is a special machine (appliance) designed for Oracle Database with Real Application Clusters and Active Data Guard options, with a special smart disk system (storage servers) running on Oracle Automatic Storage Management. It is optimized for OLTP and data warehouse and it allows simultaneous processing both of these types of databases. Performance of Exadata is not available while using other equipment. Additionally, the system will use replication Golden Gate tool and Oracle Data Integrator as the integration platform. The scope of the data warehouse will cover all activities of PKP Cargo: freight trade services, operations and maintenance of rolling stock, finance, human resources, materials management, purchasing and management support. The data sources will be company transaction systems including: SWHOPT, SANKO - system based on IBM Maximo solution, SAP ERP, Logistics Electronic Book. The aim of implementation of data warehouse is to support the efficiency and competitiveness of the company by optimizing business processes, improving the quality of services and better control of the results.

Although the Corporate Data Warehouse in Oracle technologies and system SANKO in IBM technologies are implemented by PKP Informatyka, IT infrastruc-

ture will be located at PKP Cargo and PKP Cargo will administer and operate of these systems itself. Moreover, the exploitation of the old management systems implemented as project OMIS administered by PKP Informatyka is to be transferred to PKP Cargo on Exadata machine. Transfer will be possible after the adjustment and test applications on the version of Oracle Database 11g or 12c.

3.4. PKP Intercity – virtual Solaris and Linux environments for management systems

After 5 years of Oracle eBS implementation and organizational changes in PKP Intercity Oracle eBS system operated on Sun M4000 servers became inadequate in terms of functionality, performance and technology. After the reorganization, PKP Intercity was one of the largest operators in the passenger transport sector. Therefore, in 2012 INTER12 project was started to implement a new versions of Oracle EBS, Oracle Business Intelligence and to implement Oracle Hyperion. The new infrastructure was purchased. Solution architecture consists of 4-processor high-performance Sparc T4-4 servers and three dual-processor SunFire X4170 servers and StorageTek 2540 M2 array. Applications were placed in the Solaris11 and Oracle Linux virtual environments.

According to the author, in this case it would be better to use of a single infrastructure consisting of a 4-processor x86 servers which would provide equal performance at a significantly lower cost. It was also necessary to use a higher class disk array. Used array StorageTek 2540 M2 had no possibility of extension and the only way to increase the capacity of the volumes is to change the drives to a larger capacity. This kind of change unfortunately does not improve performance.

After the project was finished in 2014 PKP Intercity took over PKP Informatyka system administration. PKP Informatyka provides only the colocation of equipment in the server room because PKP Intercity does not have its own data center that meets the requirements for this type of systems.

4. Ten Laws of Cludonomics and economical evaluation of the technological and organizational changes in the IT of PKP Group companies

Cloud Computing is not only trend but economic necessity. We are all users of systems in this model, as the Internet and mobile devices users. Also SMEs often are CC users, because many previously inaccessible services due to the cost barrier became available through cloud computing. Cheaper and more available are development services provided by IT companies using a shared virtualized infrastructures in the cloud model. This happened thanks to the CC, which thanks to the consolidation of resources, virtualization, automation and simplification of procedures, self-service and use of appropriate tools for system management and service

delivery. This results in better use of hardware, software, human, energy and others resources and gives great savings. Competition in the provision of services transform into lower prices, increase in the quality of services and much shorter time to deliver the services. CC model introduces not only the consequences of technology. It introduces the principle of ergonomics use of resources. It changes the optics of looking at the IT economy and it is now an economic necessity.

Joe Weinman developed the following Ten Clodonomics Laws [4].

“Clodonomics Law #1: Utility services cost less even though they cost more.

An on-demand service provider typically charges a utility premium - a higher cost per unit time for a resource than if it were owned, financed or leased. However, although utilities cost more when they are used, they cost nothing when they are not. Consequently, customers save money by replacing fixed infrastructure with clouds when workloads are spiky, specifically when the peak-to-average ratio is greater than the utility premium.

Clodonomics Law #2: On-demand trumps forecasting. The ability to rapidly provision capacity means that any unexpected demand can be serviced, and the revenue associated with it captured. The ability to rapidly de-provision capacity means that companies don't need to pay good money for non-productive assets. Forecasting is often wrong, especially for black swans, so the ability to react instantaneously means higher revenues, and lower costs.

Clodonomics Law #3: The peak of the sum is never greater than the sum of the peaks. Enterprises deploy capacity to handle their peak demands – a tax firm worries about April 15th, a retailer about Black Friday, an online sports broadcaster about Super Sunday. Under this strategy, the total capacity deployed is the sum of these individual peaks. However, since clouds can reallocate resources across many enterprises with different peak periods, a cloud needs to deploy less capacity.

Clodonomics Law #4: Aggregate demand is smoother than individual. Aggregating demand from multiple customers tends to smooth out variation. Specifically, the “coefficient of variation” of a sum of random variables is always less than or equal to that of any of the individual variables. Therefore, clouds get higher utilization, enabling better economics.

Clodonomics Law #5: Average unit costs are reduced by distributing fixed costs over more units of output. While large enterprises benefit from economies of scale, larger cloud service providers can benefit from even greater economies of scale, such as volume purchasing, network bandwidth, operations, administration and maintenance tooling.

Clodonomics Law #6: Superiority in numbers is the most important factor in the result of a combat (Clausewitz). The classic military strategist Carl von Clausewitz argued that, above all, numerical superiority was key to winning battles. In the cloud theater, battles are waged between botnets and DDoS defenses. A botnet of 100,000 servers, each with a megabit per second of uplink bandwidth, can

launch 100 gigabits per second of attack bandwidth. An enterprise IT shop would be overwhelmed by such an attack, whereas a large cloud service provider - especially one that is also an integrated network service provider - has the scale to repel it.

Clouconomics Law #7: Space-time is a continuum (Einstein/Minkowski). A real-time enterprise derives competitive advantage from responding to changing business conditions and opportunities faster than the competition. Often, decision-making depends on computing, e.g., business intelligence, risk analysis, portfolio optimization and so forth. Assuming that the compute job is amenable to parallel processing, such computing tasks can often trade off space and time, for example a batch job may run on one server for a thousand hours, or a thousand servers for one hour, and a query on Google is fast because its processing is divided among numerous CPUs. Since an ideal cloud provides effectively unbounded on-demand scalability, for the same cost, a business can accelerate its decision-making.

Clouconomics Law #8: Dispersion is the inverse square of latency. Reduced latency - the delay between making a request and getting a response - is increasingly essential to delivering a range of services, among them rich Internet applications, online gaming, remote virtualized desktops, and interactive collaboration such as video conferencing. However, to cut latency in half requires not twice as many nodes, but four times. For example, growing from one service node to dozens can cut global latency (e.g., New York to Hong Kong) from 150 milliseconds to below 20. However, shaving the next 15 milliseconds requires a thousand more nodes. There is thus a natural sweet spot for dispersion aimed at latency reduction, that of a few dozen nodes - more than an enterprise would want to deploy, especially given the lower utilization described above.

Clouconomics Law #9: Don't put all your eggs in one basket. The reliability of a system with n redundant components, each with reliability r , is $1-(1-r)^n$. So if the reliability of a single data center is 99 percent, two data centers provide four nines (99.99 percent) and three data centers provide six nines (99.9999 percent). While no finite quantity of data centers will ever provide 100 percent reliability, we can come very close to an extremely high reliability architecture with only a few data centers. If a cloud provider wants to provide high availability services globally for latency-sensitive applications, there must be a few data centers in each region.

Clouconomics Law #10: An object at rest tends to stay at rest (Newton). A data center is a very, very large object. While theoretically, any company can site data centers in globally optimal locations that are located on a core network backbone with cheap access to power, cooling and acreage, few do. Instead, they remain in locations for reasons such as where the company or an acquired unit was founded, or where they got a good deal on distressed but conditioned space. A cloud service provider can locate greenfield sites optimally.”

Ten Laws of Clouconomics specified above describes and regulates the basic principles of management of IT resources in the Clouds. The above-mentioned laws are fully consistent with the experiences of the author. Comparing these truths based on experience and common good practices with the activities in PKP Group it is clear that PKP Group goes in wrong direction. It should be noted that PKP Informatyka is not using it's cloud infrastructure properly and other projects described in this paper reduce the share of PKP Informatyka as a IT services provider for PKP Group companies in the field of: data center, system administration and applications maintenance. Furthermore, PKP Informatyka transferred own building with the largest and best equipped data center to another company. Other companies have to create or lease such centers or services. Scattered companies of PKP Group will not have a significant impact on service providers, and use of different technologies exclude full integration of services in a common infrastructure.

The direction of IT general movement towards private cloud, hybrid or public, is not dictated by fashion, but tangible benefits of sequentially executed within the implementation process in the cloud model: consolidation, virtualization, automation, self-service, optimal management. Meanwhile, PKP does not use technology at the infrastructure services gives companies to self-realization, which at their best intentions and efforts leads to waste of resources: infrastructure, human resources, especially financial ones. Scattered infrastructure and reducing the role of potential infrastructure providers, PKP Group companies are forced to significantly increase the TCO of their systems both investment costs and ongoing maintenance costs. The Company may not benefit from economy of scale, because each of the described solution is small compared with major players in the IT market and each solution requires different qualifications. High demands on reliability, safety, that railway IT service providers are faced would be much easier and cheaper to fulfill by combining efforts of companies and concentrating them at the selected vendor. Also, the formal and legal requirements, can easily ensure that using the services of a subsidiary, in which the development and quality of service can have a direct impact.

The direction of IT move towards private, hybrid or public clouds, is not dictated by economy. Benefits of sequentially implemented: consolidation, virtualization, automation, self-service, optimal management are undisputed. Meanwhile, PKP Informatyka does not use CC technology and force other companies to self-realization of IT services. Other companies even at their best intentions and efforts will be wasting IT resources, human resources and financial resources. Scattered infrastructure and reducing the role of potential infrastructure provider for PKP Group companies force significantly increase the TCO of their systems both investment costs and operational costs. The PKP Group Companies may not benefit from economy of scale, because each of the described solution is small compared with major players in the IT market, each solution requires different infrastructure,

software and qualifications of the personnel. High demands on reliability and safety for the IT service provider on the railway market much easier and cheaper could be fulfilled by combining the services for the companies and concentrating them at the selected providers. Also, the formal and legal requirements can be easier ensured using the services of a subsidiary, in which customer can have a direct impact for the development and quality of service.

6. Summary

Since 2012, a lot of changes occurred on the management of PKP Group companies. New managers put a lot of emphasis on intensifying joint operations of amongst group companies in order to reduce costs by exploiting economies of scale. Similarly, it could be in IT area. Unification of IT systems is a difficult task and feasible only in the long term. It would bring many benefits in terms of resources needed: office and data center space, IT infrastructure, software, services, employment. The use of common data centers would facilitate cooperation inside PKP Group. Management systems of all companies needs modernization and integration. Many interfaces between them were built but the needs are still unmet as quantitatively as well as qualitatively. Some applications use SOA solutions but with different standards.

Development and dissemination of virtualization techniques to maintain high availability and performance allows the implementation of management systems on the standard uniform infrastructure which is called converged infrastructure. With the use of possibilities offered by consolidation, virtualization, and automation is possible to achieve huge savings comparing to previous physical systems. A few years ago, the needs for consolidation, virtualization and unification of the management systems in the PKP group companies were recognized [5,6], but these activities are proceeded too slowly, and now reverse trend seems to dominate. The use of converged infrastructure in the area of network active devices through the storage to servers and operating systems reduce capital and operational costs. Consolidation and virtualization of systems, and automation of their maintenance operations allows processing systems in the cloud environment, which gives more substantial savings by automating processes and systems management functions. It is also possible to consolidate IT on the selected hardware and software platform around such platform like Oracle Exastack (Exadata, Exalogic and Exalytics) or SAP HANA. It is necessary, however, that the choice of a very limited number of solutions spanning the entire needs. Many global corporations (eg. Hewlett-Packard) carried out the consolidation referring giant benefits.

The largest companies can afford private cloud implementation and it may yield many advantages. The implementation of one cloud instead of many, will be even more economical solution which directly follows from the Cloudonomics

Law #4. Smaller companies should use dedicated services provided by Cloud Computing services provider. Only one company should be such provider in the PKP Group. This company should be specialized as CC services provider not only for the group companies, but for other public and commercial entities as well. There are available modern information technologies prepared for safe sharing of resources between different customers.

The article shows that IT of PKP Group companies couldn't not gain a competitive advantage if IT strategy will not change. The companies will continue to spend their IT budgets for unnecessary costs caused by a lack of standardization, consolidation and lesser scope of virtualization, automation and optimization of services and management processes. It is direct shown by most of Ten Clodonomics Laws.

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