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# ASSUMPTIONS CONCERNING A SOFTWARE SUPPORTING THE PRIMARY INTRAMURAL TEACHING SUBSIDY DISTRIBUTION AT A WROCŁAW UNIVERSITY OF SCIENCE AND TECHNOLOGY FACULTY

Assumptions concerning a software supporting the primary intramural teaching subsidy distribution at a Wroclaw University of Science and Technology faculty compatible with a distribution algorithm are described. Strategic goal, main problems, roles and operational tasks of this support are identified. Selected business processes and system use cases are analyzed. Concepts as well as introductory system architecture accommodating the necessity of the subsidy distribution algorithm updating are elaborated. Proposals important from the point of view of the dean's financial assistant preparing analytical data concerning subsidy distribution for the faculty provisional as well as final budged version are formulated.

**Keywords:** *university budget decisions, financing of teaching, subsidy distribution algorithm, software architecture*

## 1. Introduction

At the beginning of 2017 significant changes in the rules for financing, basic units of universities in Poland came into force. There has been a deep reorientation of the basic distribution of the primary teaching subsidy (PTS). The algorithm positively assesses the limitation of the scale of didactic activity (up to 13 students per full-time teacher) and prefers the staff effectively raising funds for research and highly rated in the categorization process. Changes were introduced "from day to day", although PTS

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– remaining the main source of faculty's revenues (compare [5, p. 80]) – in more than 90% is rigidly allocated for financing wages!

Rectors and deans of the faculties, for the first time for almost forty years, are forced to analyse the real threats of exemptions for excess employees, generated by the rules of earlier algorithms. When preparing different management scenarios, they should understand (identify and analyse) existing algorithms and use them in budget decisions. This increases the complexity of the system of distribution of the primary intramural teaching subsidy at the university faculty (PTSDS). A well-functioning computerized system is a helpful tool in this situation.

According to historical practice, the Ministry's authorities left the universities to themselves in solving the problem of supporting the budgeting process of faculties with the IT system. Naturally, apart from reporting supported by the POL-on ministerial system. This is partly understandable due to the complexity of such an undertaking and the need to analyze, among others, the following problems:

- the university and faculty subsidizing systems have the structure of a complex, heterogeneous hierarchy; various algorithms can be applied within the university and its faculties,
- changes in algorithms at various levels of management are frequent[2], extensive and deep, and not always resulting from applicable law; it discourages rationalization and automation of support processes, although the need to implement a flexible software model that ensures the effectiveness of change is evident,
- the implementation by of unjustified or too frequent organizational restructuring results in changes in the organizational structure that are not conducive to the necessary standardization of management business processes of universities and departments through IT.

The above considerations justify the purpose of this work which is to formulate the assumptions of an effective IT system supporting the distribution of PTS in a faculty of Wrocław University of Science and Technology. This is an important undertaking, since the division of this category of university revenues into individual unit's budgets invariably determines the effectiveness of their functioning in the basic process areas, such as: didactics, research and organization, and management of a university [1].

## 2. The PTS distribution system at the Faculty

Wrocław University of Science and Technology (WUoS&T) is one of the largest universities in Poland, with almost 1800 scientific and didactic employees with at least PhD degree, more than thirty thousand students studying at 16 faculties. In addition to

[2]The ministerial algorithm in the last 10 years has been changing on average every two years, and in the period 2013–2017 was updated three times (cf. [2, 11]).

didactic activity on the market of academic universities, the chain of added value created by it includes activities in the field of scientific research and organization and management of the university. Particularly in the latter field, WUoS&T set the directions of development, and introduces its own solutions. An example are IT systems supporting university management, historical WASC and ASOS [3] and the currently implemented EdukacjaCL and JSOS 2.0 [5]. These solutions did not include IT support for the PTS allocation, both at the university level and at its faculties.

Regardless of the methodology used to design the system, it is a good practice to perform a business analysis before making assumptions and specifying the needs of its users (e.g., [8, 12]). The results of business analysis are such elements of business motivation (BMM) as: goals, roles, important processes, problems related to their implementation, and critical success factors.

*Elements of business motivation for PTSDS at the WUoS&T Faculty.* Since 2016, the Faculty of Computer Science and Management at WUoS&T (F8WUS&T) has been contributing to the achievement of 12 strategic goals[3] following the University's mission. In connection with the subject of this work, the most important of them is the objective No. 12. Increasing the University's revenues from the Key Performance Indicator (KPI) defined as the value of received subsidies [10]. It is achieved from a complex process: Preparation, development and preparation of revenue sources for the department's budget. PTS is the highest-value subsidy that determines the survival of F8WUS&T. It is the only stable source of its revenues. In the years 2016–2017 with large revenues for research activities, its share in the total revenues of F8WUS&T was over 72%. The weight of its division is the main reason for the complexity of its service system. Among other reasons one can indicate: the two-level nature of budgeting, the extent of processes, the public availability of procedures and tasks, and the large number of roles that supports them.

The following roles appear in PTSDS (Table 1): Dean of Faculty (DoF), Dean's Assistant on Budgets (DAoB), Head of Department (HoD), Faculty Committee on Budgets (FCoB), Faculty Council (FC), Chancellor's Assistant on Budget (CAoB), Chancellor (Ch), Senate Budget Committee (SBC), Senate (US), POL-on reporting system (POL-on) and TETA budgeting system (TETA-B).

[3] 1. Increasing the level of correlation of the university activity with the needs of the market. 2. Improving the quality of education through didactic interdisciplinarity. 3. Internationalization of the university. 4. Increasing the level of entrepreneurship and involvement of students and doctoral students in research processes. 5. Extending supplementary education offer. 6. Developing laboratories in the field of competency (priority) specializations, advanced technologies with a recommendation for their accreditation. 7. Increasing academic activity and raising the prestige of the university in the country and in the world. 8. Increasing the level of commercialization and application of research. 9. Focusing on cooperation with the region. 10. Building principles of cooperation based on partnership and mutual trust. 11. Improving the adaptability level of the organization and competence model. 12. Increasing the university revenues [10].

Table 1. Significant business processes and roles that support them in the PTSDS system

| PS | Process | Roles |
|---|---|---|
| 01 | Acquiring elementary budgetary data[4] in organizational units about the state of resources included in the PTS distribution | DAoB |
| 02 | Analysis, verification and acceptance of acquired elementary data for PTS distribution | DAoB<br>DoF |
| 03 | Records of accepted data in reporting systems | DAoB |
| 04 | Formal verification of the results of aggregation procedures for elementary reporting data for the distribution of PTS at a faculty level | DAoB |
| 05 | Verification of results of aggregation procedures for elementary reporting data for the distribution of PTS at a faculty level | DAoB<br>FCoB |
| 06 | Development of a budget provisional draft based on reporting data and budget implementation | DAoB |
| 07 | Analysis of the provisional draft for the Faculty Council, its possible update and acceptance/rejection | FCoB |
| 08 | Analysis of the provisional opinion of the FCoB by the Faculty Council, its possible update and acceptance/rejection | FC |
| 09 | Preparation and transmission of input data and parameters (including subsidy level) for the distribution of PTS for the faculty | Ch |
| 10 | Simulation analysis and preparation of the preliminary draft of the distribution of the PTS reviewed to the Faculty Council | DAoB |
| 11 | Developing, reviewing and agreeing data and parameters (including the subsidy level) for the distribution of PTS for the faculty units | DoF,<br>DAoB<br>HoD |
| 12 | Analysis of the draft of the distribution of the PTS reviewed for the Faculty Council, its update and acceptance rejection | FCoB |
| 13 | Analysis, update and acceptance/rejection of the Faculty Council's resolution on the faculty budget project (including the distribution of PTS) | FC |
| 14 | Analysis and acceptance/rejection of the faculty budgetary resolution (including the distribution of the PTS) | SBC |
| 15 | Preparation, analysis, update and acceptance/rejection of the draft budget resolution (including the distribution of the PTS) into the University Senate | SBC |
| 16 | Analysis and acceptance/rejection of the draft budget resolution (including the distribution of PTS) by the University Senate | US |
| 17 | Records of budget data in reporting systems | POL-on |
| 18 | Migration of budget data to the operational accounting system | TETA-B |

Those roles support interconnected business processes dependent on data. Data is created, analysed, controlled and accepted in various university organizational units. The structure of these processes is hierarchical with cycles and can be mapped using a dependency network. Table 1 lists the important processes identified in the PTSDS. Three main

[4]For instance, data on employment, student numbers, income and expenses, etc.

knowledge processing phases can be identified in PTSDS: Report creation and record keeping (processes 01–05), preparation of a provisional budget (processes 06–08), and carrying out the distribution of PTS in the budgeting of faculties and universities (processes 09–18).

*The main problems in the context of the functioning of the system.* The main problem is the lack of professional software supporting PTSDS when creating the faculty budget and the University budget. At each level of PTSDS, processes are supported by home-made autonomous solutions that use MS Excel spreadsheets. Elimination of this problem is a critical factor in increasing the efficiency of PTS distribution.

Due to the lack of professional IT support for the functioning of PTSDS, labour intensity and time of execution increase, and, as a consequence, the necessary services are omitted in the course of the processes described in Table 1. This is illustrated by the following categories of problems:

- Difficulty or failure to perform the necessary control and integration procedures (compare processes: 02, 04, 05, 12, 15, 17 and 18 in Table 1).
- Difficulty or failure to perform necessary analyses (processes 10 and 12 in Table 1).
- High costs of necessary analyses of what-if class in the context of the impact of PTS division on fixed expenditure of units (especially remuneration, compare [2]). Rekuć and Szczurowski proposed a set of analyses in this scope [9]. This could be the study of the dependence of the increase/decrease in PTS subsidies on the increase/decrease of the following factors: student and doctoral student cardinality, participation in classes at 'foreign' faculties, cost of study programs, the number of employees and the size of research grants and categorization evaluation of the unit.
- Lack of possibility to use data warehouse (OLAP analysis).

Another category of problems is generated by the restructuring of WUoS&T since 2014. Its effect is the increased complexity of PTSDS. The transition from the slender institute structure to the flattened chair structure has contributed to the increase in the number of roles involved in business processes. At every level of management, there has been a significant deepening of the natural conflict of interests in the subsidy allocation game between F8WUS&T units and between WUoS&T faculties. The changes in the PTS distribution algorithm have become important elements of this game. The rules of this game can be simpler if the algorithm is the same at both levels of the university management. And ideally in line with the ministry's proposal.

## 3. Algorithm of the primary teaching subsidy distribution

The history of application in WUoS&T for a two-tier parametric subsidy model in the faculties management system using algorithms of PTS distribution dates back to the 1980s. In this model, the first distribution takes place at the university level using the UA (PTS) algorithm. Distributed funds augment to the budgets of the faculties. The second distribution is carried out using the FA (PTS) algorithm, which divides the PTS subsidy between the faculty's units. The discussion of the form of algorithms in the period 2007–2017 includes, for example, works: [7, 2, 11].

By 2007, the formal forms of the UA (PTS) and FA (PTS) algorithms were almost convergent and in line with the ministerial algorithm. After 2007, this compatibility ceased to be the rule. Probably the university legislature did not keep up with the five-fold changes that took place at the level of the ministry between 2007–2017. Since 2014, the idea and formal formula of FA (PTS) has been completely different from the UA formula (PTS)[5]. In connection with the topic of this paper, it is logical to adopt three important conceptual assumptions. Firstly, the recent changes in the algorithm are so deep that there will be a quick return to the use of the ministerial form of the algorithm at both management levels of WUoS&T. As a consequence, the assumptions for the PTSDS software with currently valid formulas for FA (PTS) are not derived. Secondly, the analysis is based on the UA (PTS) algorithm, which is almost in line with the ministerial algorithm. It is therefore assumed that FA(PTS) ≅ UA(PTS). In order to simplify the analysis, after the work [11], a generalized form of this algorithm is assumed and on its basis the assumptions for the software will be formulated. Thirdly, the most important is the assumption about the interchangeability of the form of the algorithm in the proposed PTSDS software. The assumptions will be the result of analysis and generalization of the concept in earlier forms of the algorithm and will be presented graphically as concepts of software domain ontology. Thanks to this approach, a software architecture model will be created that increases the chance for effective updating of the IT system, forced by changes to the PTS division algorithm.

*Generalized form of the algorithm.* In order to generalize the FA (PTS) algorithm form, the results of the work [11], as well as the internal document [4], were used. According to the rules there, the PTS subsidy with the value of $D_i$ is divided for organizational units in accordance with the following formulas[6]

$$d_{i,t} = \begin{cases} (1-e_t)d_{i,\,t-1} \text{ for } d_{i,\,t} < (1-e_t)d_{i,\,t-1} \\ D_t\left(C_t\dfrac{d_{i,\,t-1}}{D_{t-1}} + (1-C_t)\sum_{j=1}^{L}\left(w_j UZ_{j,\,i,\,t}\right)\right) \\ \quad \text{for } (1-e_t)d_{i,\,t-1} \le d_{i,\,t} \le (1+e)_t\, d_{i,\,t-1} \\ (1+e_t)d_{i,\,t-1} \text{ for } d_{i,\,t} > (1+e_t)d_{i,\,t-1} \end{cases} \tag{1}$$

[5]Detailed characteristics are included elsewhere [9, 11].

[6]The value of the subsidy to divide $D_t$ is reduced by the budget reserve. At the level of the ministry, the budget reserve rate recorded in the act is 2%. At the university, there are no regulations, only custom and calculation of indirect costs. Both at the level of the management board of WUoS&T and F8WUS&T, the usual budget reserve rate is almost 30%.

$$Sp_{i,t} = \rho\left( \sum_{j=1, j \neq i}^{LJ} \Delta_{i,j,t} - \sum_{m=1, m \neq i}^{LJ} \Delta_{m,i,t} \right) \quad (2)$$

$$\Delta_{i,j,t} = \frac{1}{720} \sum_{K_{li} \in K_i} u_{li,j,t} g_{li} ks_{li} \quad (3)$$

where,

$D_t$ – the subsidy to be actually distributed among the faculty units,

$i$ – the number of the academic organizational unit (JO),

$t$ – the year of the subsidy's allocation, $d_{i,i}$ – the subsidy granted to the $i$-th JO,

$e_i$ – tolerance of deviation $d_{i,i}$ from $d_{i,i-1}$; ($e_{2018} = 0.03$ in WUoS&T),

$C_i$ – constant transfer of subsidy from the previous year (in WUoS&T $C_{2018} = 0.50$),

$UZ_{i,i,i}$ – the share of $i$-ths JO in year $t$ according to $j$-th criterion (component), respectively: the student-doctoral component ($j = 1$), the staff component ($j = 2$), the research component ($j = 3$) and the internationalization component ($j = 4$),

$w_i$ – the weight of the $j$-th criterion of the unit's utility, $L$ – the number of criteria for JO ($L = 4$), $LJ$ – the number of JOs participating in the PTS distribution, $K_i$ – a collection of courses offered by $i$-th JO, $K_i = \{K_{1i}, K_{2i}, ..., K_{li}\}$,

$l_i$ – the number of courses offered by $i$-th JO,

$Sp_i$ – a correction of the number of conversion students for $i$-th JO,

$\Delta_{i,i,i}$ – the number of conversion students for $i$-th JO for teaching in $j$-th JO in year $t$,

$u_{li,i,i}$ – the number of students from $j$-th JO participating in the $K_{li}$ course (without repetition of the course) in the year $t$,

$g_{li}$ – semester course size $K_{li}$ (h),

$ks_{li}$ – cost-efficiency ratio of the course $K_{li}$,

$\rho_i$ – conversion parameter for inter-faculty settlements ($\rho_i = 0{,}9$).

In 2018, in line with Eq. 1, the subsidy $d_{i,2018}$$i$-th JO in 50% depends on subsidies from the previous year, and in 50% on the value of its four-factor utility $UZ_{i,i,2018}$. The value of 50% of the $C_i$ parameter, as well as the other four parameters values in the algorithm formulas ($e_i$, $w_i$, $\rho_i$ and $k_{sli}$) are taken from the ministry and the university regulations. Naturally, decision-makers may retreat from this assumption and adopt their own parameter values, which, for example, would better divide the subsidy due to the significant strategic goals of the university. An analysis (theoretical validation) and estimation of the parameter values would be necessary. For example, simulation methods, *ceteris paribus*, can be used, including testing the sensitivity of a target variable ($d_{i,i}$) to one or more parameters. The use of classical empirical methods is unlikely here. There is no reliable historical data, because of the high variability of the algorithm. In the years 2013–2018, it changed many times, also as to the number and form of factors' utility formulas ($UZ_{i,i,i}$). It is also necessary to analyze the sensitivity of parameters describing these factors. In addition, the analysis may cover more than 20 constants, occurring in detailed calculation formulas $UZ_{i,i,i}$ used by the ministry. The decision-maker at the university can, after all, consider these constants as parameters for the relationship between the algorithm and the objectives of the university search. An example of the "what-if" analysis results of the significant impact of the reference number of students and doctoral students per academic teacher ($M_i$ = 13) on the value of the staff factor ($UZ_{2,i,i}$) includes the work [11].

The lack and the variability of empirical data significantly limits the possibility of measuring four-factor utility from the point of view of the decision-maker distributing the subsidy. However, thanks to the software structure proposed in this work with an exchangeable subsidy distribution algorithm module, one can create data warehouses (data marts) dedicated to the measurement and the usability analysis due to the important university strategic goals, operationalized by the KPI. Warehouse dimensions will be historically occurring factors (concepts) – not just ministerial ones. On the other hand, their attributes will be the describing variables contained in formulas. The flexibility of storing the values of these variables will partly determine the usability capability. The flexibility of storing the values of these variables will partly determine the usability measurement possibility.

Equations (2) and (3) supplement the student-doctoral criterion of the ministerial algorithm, for settlements between units for mutual teaching services. At WUoS&T, they are called inter-faculty settlements. The usability components will be used to identify components in the proprietary PTSDS software architecture. Their domain scopes will be defined in the form of concepts.

## 4. Concepts and preliminary proposals for PTSDS software

The basic assumptions for the PTSDS software architecture at WUoS&T will be described in the PTSDS using case model and a set of concepts describing the subject domain of the system software. The models (Fig. 1Fig. 4) are based on the generalized structure of the algorithm which determines the natural boundaries of the components of the proposed system architecture. After analyzing the processes, the components of the list presented in Table 1, general assumptions about the environment of the system supporting the distribution of subsidies and its functions can be formulated. This model is shown in Fig. 1.

For this purpose, the case model was used, assuming that the system's environment are actors – the performers of certain processes from this table, and cases determining the system functions necessary for actors to fulfil their roles in the processes of Table 1. Eight main actors of the system and several other actors, who can use it directly or indirectly are identified. In order to determine the cases of the system, the actor's participation in the process and the task the actor performs in the process was determined.

As a consequence, 13 use cases are proposed. These cases are determined by the general name. Their precise characterization would require identification of the domain – conceptions, and the structure of the actor's interaction with the system. Bearing in mind the purpose of this work – formulating the assumptions of the flexible system for the division of teaching subsidies - the concepts and structure of interaction should be formulated in such a way that the mechanism of the system update can be clearly defined when the subsidy division algorithm changes. The algorithm has undergone and can undergo further change. However, there are usability components that are characteristic of universities, which will always be a key part of this algorithm.

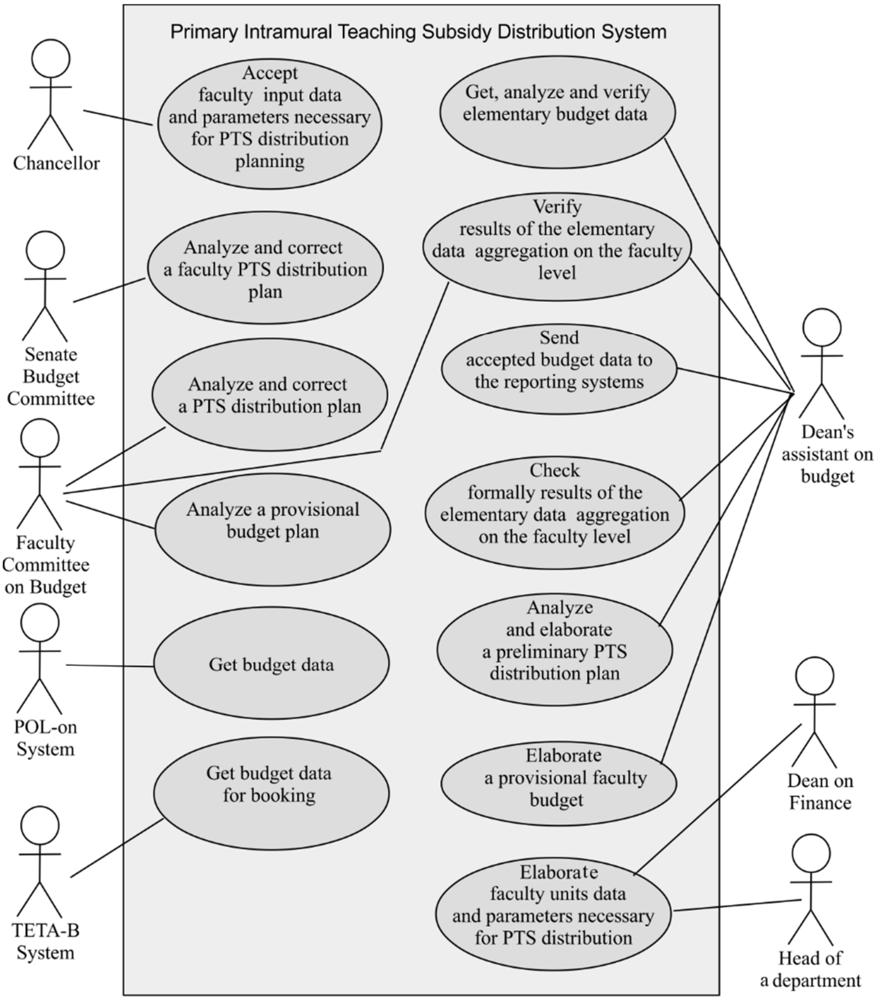


Fig. 1. A preliminary case model of the PTS distribution support system

In this context, based on the work [11], in Fig. 2a the basic classification of components occurring in the 2016 algorithm is presented. An analysis of this classification indicates that in each new version of the PTS distribution algorithm three key permanent components will be mapped: Student-doctoral component, Staff component, and Research component. That is why their main concepts are identified. A general, conceptual model of the proposed three components is shown in Fig. 2b.

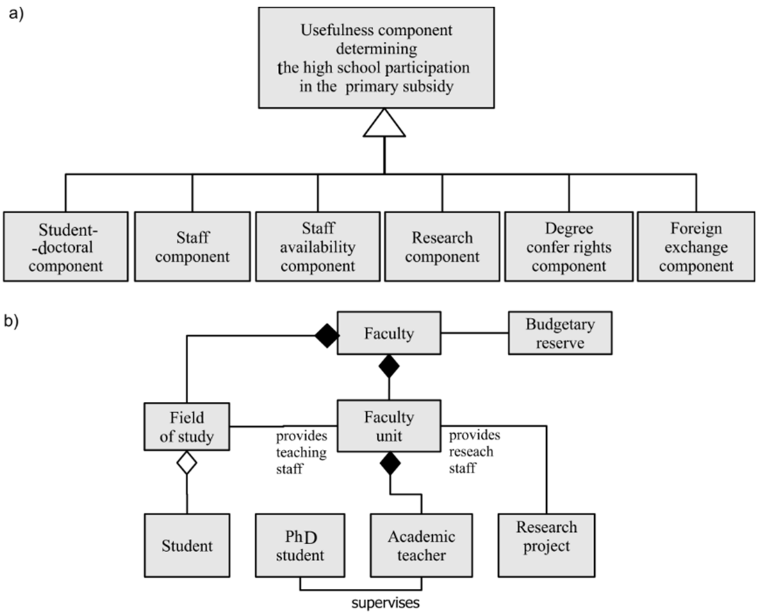


Fig. 2. Conceptual components of the algorithm: a) from 2016 year, b) general, chosen for the subsequent consideration

Figures 3 and 4 show the extension of the model from Fig. 2b to detailed concepts. It was supplemented with three concepts: Faculty, Faculty unit, and Budgetary reserve because they represent concepts that are particularly important for the algorithm under consideration.

Fig. 3 shows the concept structure for the student and doctoral components. This component has been extended with the notion related to the criterion of interdependence of the unit and inter-faculty settlements (Eqs. (2) and (3)). The concept of academic teacher is related to the faculty concept through courses that are taught at various faculties by various academic teachers.

Fig. 4 shows models for the components: Staff component and Research component. One can consider the composition of these components because there is a close relationship between the concept of academic teachers and research projects. Historically, however, both concepts were separated.

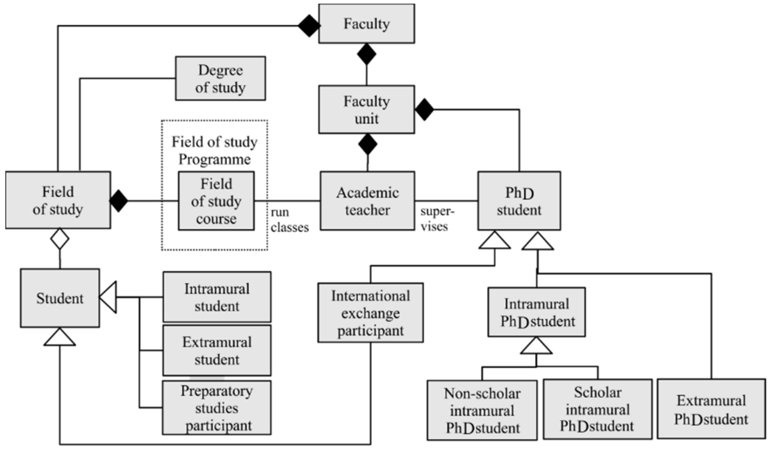


Fig. 3. Conceptual model of the student-doctoral component algorithm

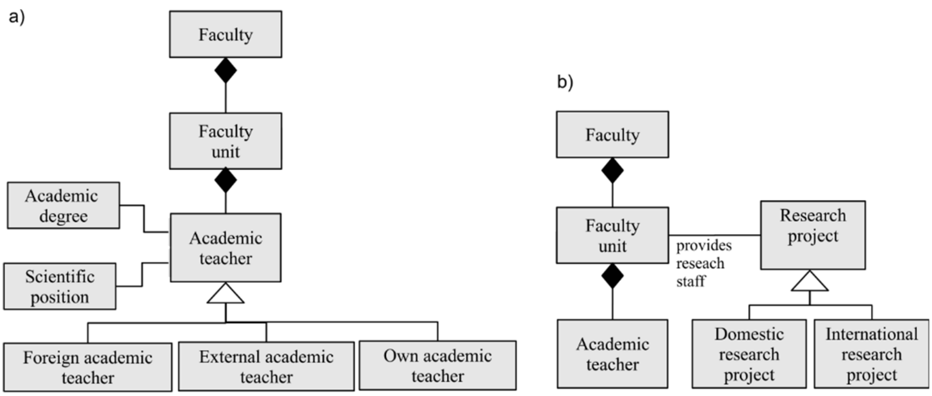


Fig. 4. Conceptual model of the algorithm's staff component (a) and research component (b)

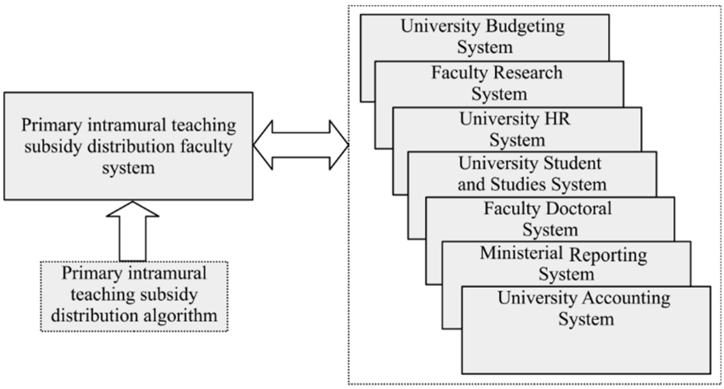


Fig. 5. The context of data exchange with other systems

The models depicted in Figs. 1–4 include invariant components of the subsidy distribution algorithm, because they represent those variables that should always be taken into account when making decisions on the distribution of subsidies between faculty units.

The last important issue, merely signalled in this work, is the identification of the layer of cooperating information systems. The PTSDS software, along with the PTS division algorithm module, will exchange data with many faculty, university and ministerial systems (Fig. 5). The necessary services for this will be extracted in accordance with the SOA paradigm (compare, for example [1]) with the scope of databases, generally defined in concepts for which necessary interfaces will be constructed.

## 5. Conclusion

The results of the performed analyses, despite their basic character, may have practical significance in modelling the software of the primary teaching subsidy distribution system at a faculty of Wrocław University of Science and Technology.

Within the scope of analyses and formulated models, the following important research results can be highlighted:

- Generalization of the formula of the primary teaching subsidy distribution was done.
- It was justified that the interchangeability of algorithm (as a module in the software) is crucial in the IT system; this is why the importance of the generalization of the algorithm and the suggestion of its invariant elements were emphasized.
- From the algorithm, utility components characteristic of the University, which will always be a key part of its formula, were extracted.
- Inter-faculty settlements concerning each university were accounted for in the system software components.
- Merger of inter-faculty settlements with the student-doctoral component concept was made.

While implementing the system, there may still be many problems that have not been discussed in this paper, or have been described at a too basic level, e.g.:

- the problem of interaction with systems in the environment (university and ministerial),
- recognition of more detailed descriptions on the class attributes level,
- decide how the SOA mechanisms should be taken into account when designing the system.

Summing up the performed research, it should be stated that the design and implementation of the system under consideration will not be part of simple ventures. The main obstacle to overcome will be providing an easy system upgrade with the changing algorithm of teaching subsidy distribution.

## References

[1] BRZOSTOWSKI K., REKUĆ W., SOBECKI J., SZCZUROWSKI L., *Service discovery in the SOA system*, [In:] *Intelligent information and database systems*, ACIIDS Second International Conference, Hue City, Vietnam, March 24–26, 2010, LNCS, Lecture Notes in Artificial Intelligence, 2010, 5991, 29–38, http://dx.doi.org/10.1007/978-3-642-12101-2_4

[2] CIEŚLIŃSKI J., *The primary teaching subsidy allocation algorithm for Polish academic universities*, Nauka, 2016, 1, 159–180 (in Polish).

[3] GRUDZEWSKI W.M., *IT system for managing the higher technical school ASOS on the example of the Wrocław University of Technology*, Biblioteka WASC, Politechnika Wrocławska, Wrocław 1974 (in Polish).

[4] *Internal regulations on the method in which subsidy are allocated into tasks related to the teaching of full-time students, the teaching of participants in full-time doctoral studies, the educating of academic staff and the maintenance of the university, including repairs, so-called Primary Subsidy*, Document of the Rector's and Dean's College, Wrocław University of Science and Technology, 20.04.2017 (in Polish).

[5] JSOS 2.0, http://panda.wcss.wroc.pl/bulk/upload/31/file/Portal_dla_prowadzących_ JSOS2_0.pdf, [last accessed 13.05.2018].

[6] KWIEK M., ANTONOWICZ D., BRDULAK J., HULICKA M., JĘDRZEJEWSKI T., KOWALSKI R., KULCZYCKI E., SZADKOWSKI K., SZOT A., WOLSZCZAK-DERLACZ J., *Draft assumptions to the Law on Higher Education*, Adam Mickiewicz University, Poznań 2016.

[7] MIŁOSZ H., STEFANIAK J., *Subsidy allocated – is it fair?* Forum Akademickie, Warsaw 2007 (6), 48–49 (in Polish).

[8] REKUĆ W., SZCZUROWSKI L., *Ontology as a formal representation of business analysis dimensions in Management Information System Development*, Social Sci., 2015, 89 (3), 99–113.

[9] REKUĆ W., SZCZUROWSKI L., *A simulator supporting primary subsidy distribution on a faculty at Wrocław University of Technology*, Oper. Res. Dec., 2015, 25 (4), 35–49.

[10] Development Strategy 2016, http://bip.pwr.edu.pl/strona-glowna/strategia-rozwoju (in Polish) [last accessed 13.05.2018].

[11] SZCZUROWSKI L., REKUĆ W., *Changes in the staff factor of the primary teaching subsidy allocation algorithm for Polish universities*, Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, Wrocław 2017 (481), 106–120 (in Polish).

[12] WELLS D., *Extreme programming: A gentle introduction*, 2013, http://www.extremeprogramming. org/, [last accessed 26.07.2014].

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