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FOREWORD

Dear Readers,

We would like to thank everyone who participated in publishing of SMACS journal in the passing year 2011. We address special thanks to the authors and reviewers whose efforts enabled us to prepare numbers 4 and 5 of the journal. Let us remind here that it was possible to publish those numbers in English thanks to the subsidy obtained from MNiSW (Ministry of Science and Higher Education) within IndexPlus programme, which enabled us to cover increased costs of the edition. We hope that thanks to the English edition, our journal shall be recognizable also abroad. We are very pleased of the cooperation with new authors from Czech Republic and Slovakia. We would like to express particular thanks to our friends from The University of Žilina in Slovakia for their enthusiastic response to our invitation to publish in our journal.

In the coming New Year 2012, we wish all the authors, readers and academic societies you come from, many enterprising plans and their successful accomplishment.

SMACS Editors-in-chief
Jacek Czerniak, PhD. Eng.
Marek Macko, PhD. Eng.

Studies and Materials in Applied Computer Science, Vol. 3, No. 5, 2011
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SUBMITTED ARTICLES

MODELING OF MULTIAXIAL STATE OF STRESS AND DETERMINE THE FATIGUE LIFETIME FOR ALUMINUM ALLOY DURING CYCLIC LOADING UNDER IN-AND-OUT OF PHASE SHIFT Φ = 0° AND Φ = 90°

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Abstarct: *This article deals with determining of fatigue lifetime of structural materials during by multiaxial cyclic loading. The theoretical part deals with the fatigue and with the criterions for evaluation of multiaxial fatigue lifetime. The experimental part deals with modeling of combined bending - torsion loading and determining the number of cycles to fracture in region low-cycle and high-cycle fatigue and also during of loading with the sinusoidal wave form under in phase φ = 0° and out phase φ = 90°.*

Keywords: *sinusoidal cyclic loading, multiaxial fatigue, stress, structural material*

1. INTRODUCTION

Fatigue failures in metallic structures are a well-known technical problem. In a specimen subjected to a cyclic load, a fatigue crack nucleus can be initiated on a microscopically small scale, followed by crack grows to a macroscopic size, and finally to specimen failure in the last cycle of the fatigue life. Understanding of the fatigue mechanism is essential for considering various technical conditions which affect fatigue life and fatigue crack growth, such as the material surface quality, residual stress, and environmental influence. This knowledge is essential for the analysis of fatigue properties of an engineering structure [1, 2].

Fatigue under combined loading is a complex problem. A rational approach might be considered again for fatigue crack nucleation at the material surface [3]. The state of stress at the surface is two-dimensional because the third principal stress perpendicular to the material surface is zero [4]. Another relatively simple combination of different loads is offered by an axle loaded under combined bending and torsion. This loading combination was tested in our and also in many others experiments [5, 6, 7]. In spite of this fact, fatigue mechanisms are still not fully understood. This is partly due to the complex geometrical shapes and also complex loadings of engineering components and structures which result in multiaxial cyclic stress-strain states rather than uniaxial.

2. CRITERIA

Criteria valid for the fatigue lifetime calculation can be classified in three different categories: strain based methods, strain-stress based methods and energy based approaches.

Goodman used main stresses for evaluating the fatigue under multiaxial loading. Normal stresses are calculated for each plane and their ranges are used for calculation of fatigue lifetime. If the point of the combined stress is below the relevant Goodman line then the component will not fail. This is a less conservative criteria based on the

material ultimate strength yield point Sut. To establish the factor of safety relative to the Goodman´s criteria can be written as:

$$\frac{K_f \times \sigma_{amp}}{S_e} + \frac{\sigma_{mean}}{S_{ut}} = \frac{1}{f_f} \qquad (1)$$

Sines published his works throughout the fifties of the last century. His criteria are very much alike, utilizing the amplitude of second invariant of stress tensor deviator (which corresponds to the von Mises stress) as the basis. Another term is added to the equation in order to cope with the mean stress effect – while Sines prefers the mean value of first invariant of stress tensor (i.e. hydrostatic stress σh). His resulting failure criterion can be expressed as:

$$\frac{\Delta\tau_{oct}}{2} + \alpha \times (3 \times \sigma_h^{mean}) = \tau_f' \times (N_f)^b \qquad (2)$$

Findley criterion is the first critical plane criterion. He suggested that the normal stress σn, acting on a shear plane might have a different linear influence on the allowable alternating shear stress, Δτ/2. Criterion has the following form:

$$\frac{\Delta\tau}{2} + k \times \sigma_n = \tau_f' \times (N_f)^b \qquad (3)$$

Minimum circumscribed ellipse (MCE) – The origin of this method goes out from minimum circumscribed circle method (MCCM). This method was first presented by Papadopoulos. Its major feature is its explicitness in determination of mean shear stress. Papadopoulos later shows that such minimum circumscribed circle can be obtained by a search through all pairs and triads of points in the shear stress path, but such an approach can be very lengthy. The contrast in comparison with MCCM is clear – it should offer a better solution of phase shift effect problems. Nevertheless, as regards the definition of mean shear stress, it does not offer any new approach. For proportional loading this will always be a straight line and for non-proportional loading histories will have some complex shape.

$$\tau_a = \sqrt{R_A^2 + R_B^2} \qquad (4)$$

Brown and Miller [8] observed that the fatigue life prediction could be performed by considering the strain components normal and tangential to the crack initiation plane. Moreover, the multiaxial fatigue damage depends on the crack growth direction. Different criteria are required if the crack grows on the component surface or inside the material. In the first case they proposed a relationship based on a combined use of a critical plane approach and a modified Manson-Coffin equation, where the critical plane is the one of maximum shear strain amplitude. Criterion, which was created, has the following form:

$$\frac{\Delta\gamma_{max}}{2} + S \times \Delta\varepsilon_n = A \times \frac{\sigma_f - 2 \times \sigma_{n,mean}}{E} \times (2 \times N_f)^b + B \times \varepsilon_f' \times (2 \times N_f)^c \qquad (5)$$

Smith, Watson and Topper (SWT) created a parameter for multiaxial load, which is based on the main deformation range Δε1 and maximum stress σn,max to the main plane. Criterion has the following form:

$$\sigma_{n,max} \times \frac{\Delta\varepsilon_1}{2} = \frac{\sigma_f'^2}{E} \times (2 \times N_f)^{2b} + \sigma_f' \times \varepsilon_f' \times (2 \times N_f)^{b+c} \qquad (6)$$

Fatemi and Socie [9] observed that the Brown and Miller's idea could be successfully employed even by using the maximum stress normal to the critical plane, because the growth rate mainly depends on the stress component normal to the fatigue crack. Starting from this assumption, he proposed two different formulations according to the crack growth mechanism: when the crack propagation is mainly MODE I dominated, then the critical plane is the one that experiences the maximum normal stress amplitude and the fatigue lifetime can be calculated by means of the uniaxial Manson-Coffin curve; on the other hand, when the growth is mainly MODE II governed, the critical plane is that of maximum shear stress amplitude and the fatigue life can be estimated by using the torsion Manson-Coffin curve [9]. Criterion has the following form:

$$\frac{\Delta\gamma}{2} \times \left(1 + k \times \frac{\sigma_{n,max}}{\sigma_y}\right) = \frac{\tau_f'}{G} \times (2 \times N_f)^{b_\gamma} + \gamma_f' \times (2 \times N_f)^{c_\gamma} \qquad (7)$$

Liu created a virtual model of the deformation energy, which is a generalization of the axial energy on the basis of prediction of fatigue life. Criterion has the following form:

$$\Delta W = 4 \times \sigma_f' \times \varepsilon_f' \times (2 \times N_f)^{b+c} + \frac{4 \times \sigma_f'^2}{E} \times (2 \times N_f)^{2b} \qquad (8)$$

Where γ_f' is the fatigue ductility coefficient in torsion; ε_f' is the fatigue ductility coefficient; σ_f' is the fatigue strength coefficient; σ_h^{mean} is the mean hydrostatic stress; σ_n is the

normal stress; $\sigma_{n,max}$ is the maximum stress; $\sigma_{n,mean}$ is the mean stress; σ_y is the stress in the direction of the axis y; τ_a is the equivalent shear stress; τ_f' is the fatigue strength coefficient in torsion; Δy_{max} is the maximum shear strain range; $\Delta\varepsilon_1$ is the principal strain range; $\Delta\varepsilon_n$ is the normal strain range; $\Delta\tau/2$ is the alternating shear stress; $\Delta\tau_{oct}$ is the octahedral shear stress; ΔW is the virtual strain energy; N_f is the number of cycles to fracture; S_e is the modified fatigue strength; S_{ut} is the ultimate tensile strength; f_f is the factor of safety applicable the fatigue; E is the elasticity modulus in tension; G is the elasticity modulus in torsion; R_A is the major axis of the ellipse; R_B is the maximum distance of stress point; b is the fatigue strength exponent; b_γ is the fatigue strength exponent in torsion; c is the fatigue ductility exponent; c_γ is the fatigue ductility exponent in torsion; *A, B, S, k, α* are material parameters.

3. NUMERICAL CALCULATIONS AND RESULTS

In ANSYS software was created the model of the test bar. The real geometry of this component is shown in Fig.1. The rod bar had a circular shape with a defined section, in which was expected an increased concentration of stress and creation a fatigue fracture [10, 11].

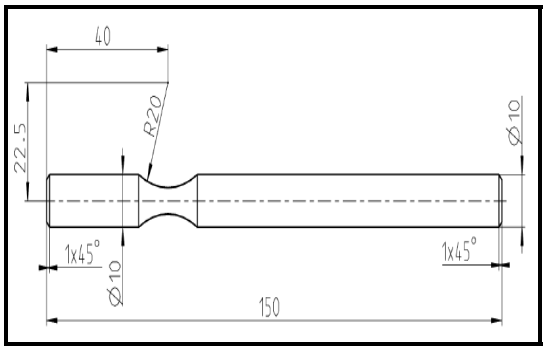

Figure. 1 Geometry of the test bar.

The ends of this model were loaded by reversed bending moment on the one side and by reversed torsion moment on the opposite site. The values of presented stresses and strains in the middle of the rod radius were taken from computational analysis using finite element method. We used the following parameters in finite element model: used material was aluminum alloy EN AW 2007.T3 (AlCu4PbMg) with Young's modulus $E = 0{,}817.10^{11}$ Pa, Poisson number $\mu = 0{,}3$ and with the strength limit $R_m = 491$ MPa. From computational analysis can be seen that the area with greatest concentration of stresses or eventually the place with the higher deformation was localized in the middle of the rod radius (see Fig.2).

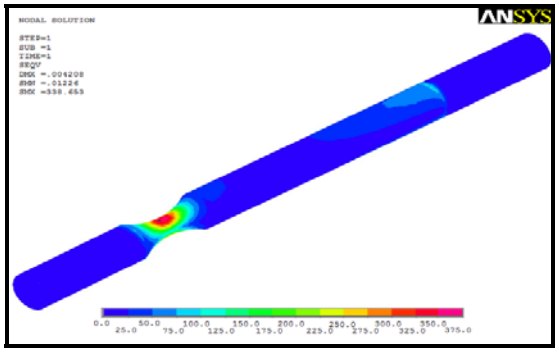

Figure. 2 Result of FEM analysis.

Obtained values of the stresses from finite element analysis were next computational analyzed using Fatigue Calculator software. This is a program which can quickly calculate fatigue lifetime of selected material. After starting the calculation, Fatigue Calculator displayed the number of cycles to failure for different models of damage. In our calculation we considered with all multiaxial criteria described above which can be applied to low-cycle and also to high-cycle fatigue region. All the tests were performed under controlled bending and torsion moments. Frequency of each analysis was equal to 30 Hz. It was first detected the number of cycles to fracture for multiaxial low-cycle fatigue with amplitudes in the phase shift 0° and then out of the phase shift 90° for stress. The same was done for multiaxial high-cycle fatigue.
The obtained number of cycles are processed into Wöhler curves $\sigma - log\ N_f$ for multiaxial cyclic combined bending - torsion loading. For multiaxial low-cycle fatigue with phase shift 0°, Wöhler curves are shown in Fig.3. For multiaxial low-cycle fatigue with phase shift 90°, Wöhler curves are shown in Fig.4.

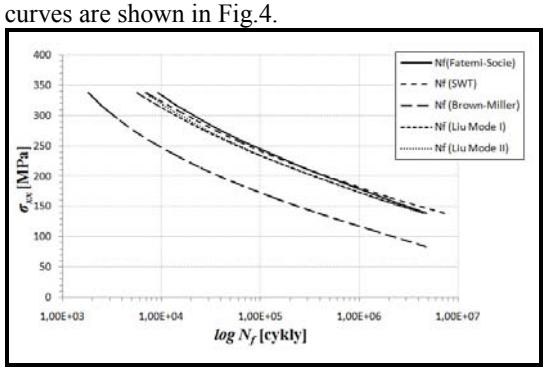

Figure. 3 Wöhler curves for multiaxial low-cycle fatigue with phase shift 0°.

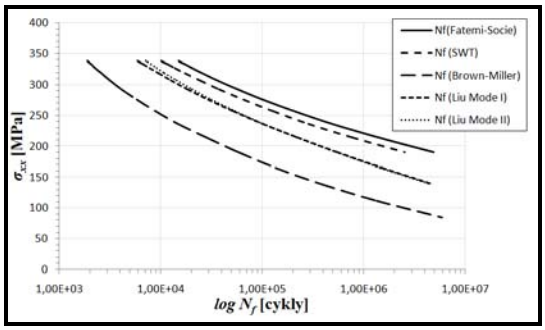

Figure. 4 Wöhler curves for multiaxial low-cycle fatigue with phase shift 90°.

For multiaxial high-cycle fatigue with phase shift 0° and with phase shift 90°, Wöhler curves are shown in Fig.5 and in Fig.6.

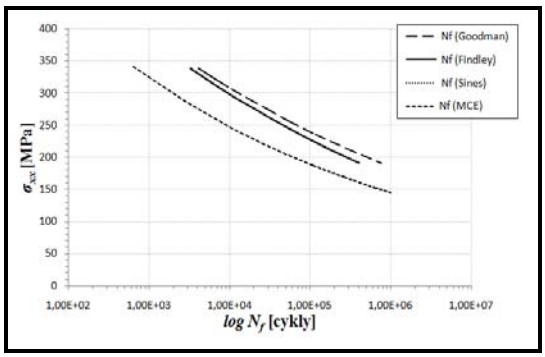

Figure. 5 Wöhler curves for multiaxial high-cycle fatigue with phase shift 0°.

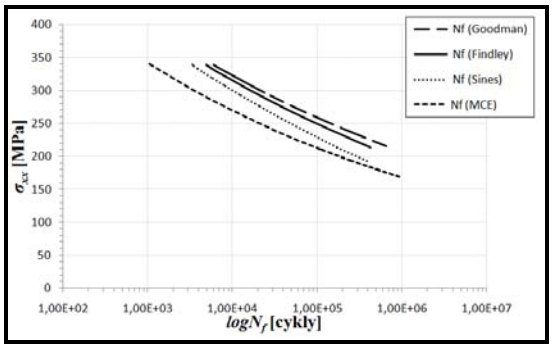

Figure. 6 Wöhler curves for multiaxial high-cycle fatigue with phase shift 90°.

4. CONCLUSION

All multiaxial models applied to fatigue lifetime calculation of aluminum alloy EN AW 2007.T3 increases with decreasing stress amplitude continuously in the cycles of number region.

Comparing Wöhler curves for low-cycle fatigue (see Fig.7), for amplitudes of the load with phase shift 0° (solid lines) and for amplitudes of the load with phase shift of 90° (blank lines), it can be seen that some models (such as Fatemi-Socie and SWT) give higher resistance to fatigue damage in the phase shift than the synchronized load amplitudes. This may be caused by, that the bending loading and neither torsion loading not active with the maximum value on the sample at the same time during the phase shift, but alternately. In this way, as if the sample was loaded by lower value of stress or deformation in a given time (phase shift of 90°). For other models, this shift of amplitudes did not cause any significant changes and the differences are minimal.

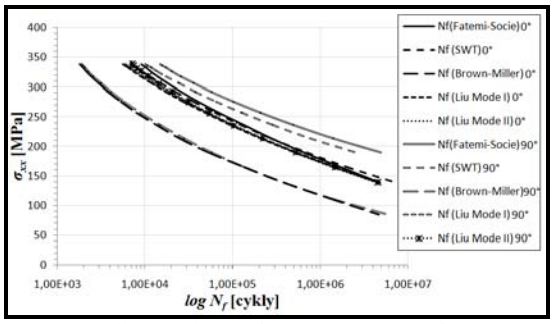

Figure. 7 Comparison of Wöhler curves for multiaxial low cycle fatigue.

Comparing Wöhler curves for high-cycle fatigue (see Fig.8), for amplitudes of the load with phase shift 0° (solid lines) and for amplitudes of the load with phase shift of 90° (blank lines), it can be seen that all models (except for Sines) gives a higher resistance against fatigue damage in the phase shift than in the synchronized amplitudes of loading. Probably the reason will be same as for low-cycle fatigue.

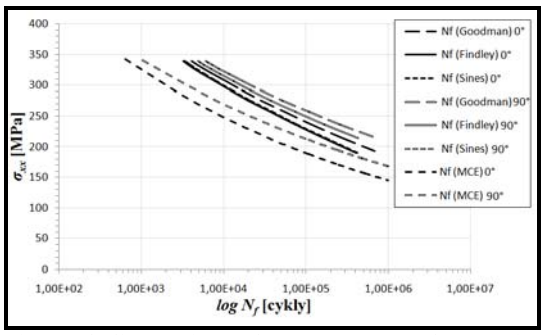

Figure. 8 Comparison of Wöhler curves for multiaxial high cycle fatigue.

It was observed that a phase shift 90° is the cause of "rotating" curves of fatigue life, which may have an impact on partial increase of fatigue life for the area of low-cycle and high-cycle fatigue.

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CROWDSOURCING IN RESCUE FIRE SERVICE – PROPOSED APPLICATION

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Abstarct: *This article describes the author's proposal to apply crowdsourcing in Polish rescue fire service. This article also describes basic principles for implementing an crowdsourcing information platform in rescue fire service as well as the scheme of its implementation. The Author of this paper also describes the genesis of this proposal related to the evaluation of research conducted by the author on text mining analysis and extraction of information in the design of information systems.*

Keywords: *crowdsourcing, design of information system, information system, text data mining, methods of analysis of textual data, exploratory analysis of text data, text analyzing*

1. INTRODUCTION

This article describes the possibility to apply crowdsourcing in Polish rescue fire service.Crowdsourcing is a form of cooperation that involves outsourcing of conventional tasks and duties of company or institution employees to a distributed undefined group of people or community [1, 2].Those tasks are presented to the community in form of open calls. The community solves the tasks and returns the results to the source of the problem to be solved.Thus the community may be treated as the collection of agents, who can assist the institution in selected rescue fire service tasks as well as corresponding information systems [3-6].It may also act as the second, important pillar of the decision support systems based on agents, where, apart from software solutions, also community-related aspects are included [3].The author has not found in the professional literature so far any proposal of community activation and engagement in assistance of initiatives associated with community-based information platforms.Community-based IS can be defined for the purpose of this paper as systems which, either directly or indirectly influence social aspects, e.g. on the system safety.Those systems may be assisted by the community at the stage of their construction, supplementation and verification of information they contain, as described further in this paper.

The created framework of the crowdsourcing platform was discussed based on a sample use of the framework components in relation to IS designed by the author concerning *water intake points – Hydrants* [7].The author designed the system based on exploration analysis of textual data, where an additional information extraction process was introduced in order to supplement the system with information on selected topics [8, 9].The Project was intended to eliminate current shortcomings of the event recording system used by the rescue fire service (PSP), EWID-99 (shortly EWID) [10-13], which, after appropriate analyses, has not been approved as the operating data base used for real-time assistance of rescue-and-fire-fighting actions [7].Based on the analysis of the currently used event recording system as well as information collected, a different solution was proposed, i.e. an operating data base, or more specifically, IS concerning *water intake points – Hydrants.*That system gave grounds for the *case based reasoning system – CBR* [6, 14-16], which not only includes information on recommended way of neutralising the hazards, but also information on *water intake points – Hydrants* in order to use them for tanker filling up during PSP interventions. Results of the Author's research showed that the current event recording system includes, among others, information on *water intake points – Hydrants*

checked during rescue and fire-fighting actions. 975 out of total 12753 studied segments (sentences describing rescue-and-fire-fighting actions) included information on a hydrant location.759 out of 975 segments concerned hydrant location expressed by the statement that a hydrant was present at a given street, e.g. *hydrant at Mickiewicza street 26* while 216 hydrants were located at street crossings, e.g. *intersection of Kordeckiego and Mickiewicza streets*.

In point 2 of this article, the author presented assumptions for the general PSP crowdsourcing platform.He also presented types and roles of the platform users, i.e. PSP on one side and the community network, hereinafter referred to as a community on the other side.Then the author described usage of the platform and the framework of the application used to platform implementation.Further in this paper, the author puts forward the proposal to make available to PSP and to the public the information platform with a working name "Namierz Hydrant" -NH (locate a hydrant), used for verification and updating of data collected during, among others, information extraction process and for recording and storage of information on new *water intake points – Hydrants* depending on their location, e.g. within the community member place of residence etc.Hence this solution is a voluntary, community-based action the aim of which is to assist the conventional PSP structure and IS implemented in PSP. The action is undertaken by external bodies which are not directly associated with PSP and its aims.

2. CROWDSOURCING PLATFORM FOR THE RESCUE FIRE SERVICE (PSP) – PROPOSED APPLICATION

General diagram including the idea of the designed crowdsourcing platform assisting selected PSP activities was presented in Figure 1.

The diagram of the general platform of crowdsourcing for PSP presented in figure 1 includes two participants or parties of the collaborative.The first party includes PSP entities, such as firemen and activists of the volunteer fire department (OSP).They were called *internal participants* as they participate in the rescue-and-fire-fighting system and they are part of the system internal structure [17].The other party is the community beyond that structure, which may be stimulated to engage in common actions associated with selected PSP goals.At the beginning of each cooperation cycle, the list of open problems is defined.This task shall be implemented by the rescue fire service (PSP).When that list is defined, it is made accessible to the community (*external participants*).Those participants accomplish the defined goals and return the results of their completed works to *internal participants*.

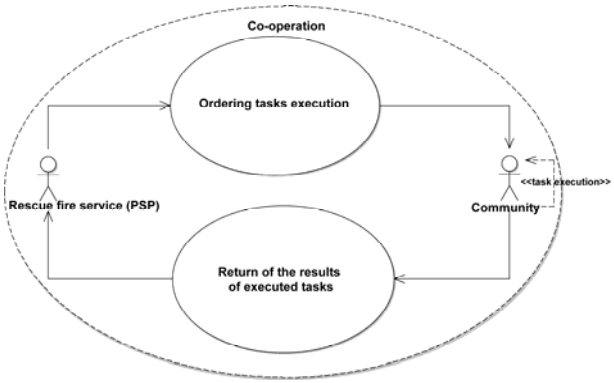

Figure 1 General diagram including the idea of the designed crowdsourcing platform assisting selected PSP activities.

That highly abstract model of cooperation was proposed by the author for the purpose of the assessment of research on information extraction performed by him [8].Moreover, the model has been further developed in order to verify the possibility to apply community networks in research on their use as an aid for selected aspects of rescue fire service (PSP) activities as well as for verification and supplementing community-based PSP information systems (IS) with new data.The designed framework of the crowdsourcing platform was further discussed based on a sample IS designed by the author during earlier research, concerning *water intake points – Hydrants* [7].That system can be used to store information on hydrant location in form of a catalogue implemented in an *noSQL ("not only SQL"*) database [18, 19].Data is stored in that catalogue in form of attribute-value records, and includes such attributes like:hydrant location, type, reasons for malfunction etc.

Figure 2 shows the diagram of the implementation of crowdsourcing platform in the rescue fire service (PSP).The diagram was presented in form of the *activity diagram* using *unified modelling language – UML* [20].

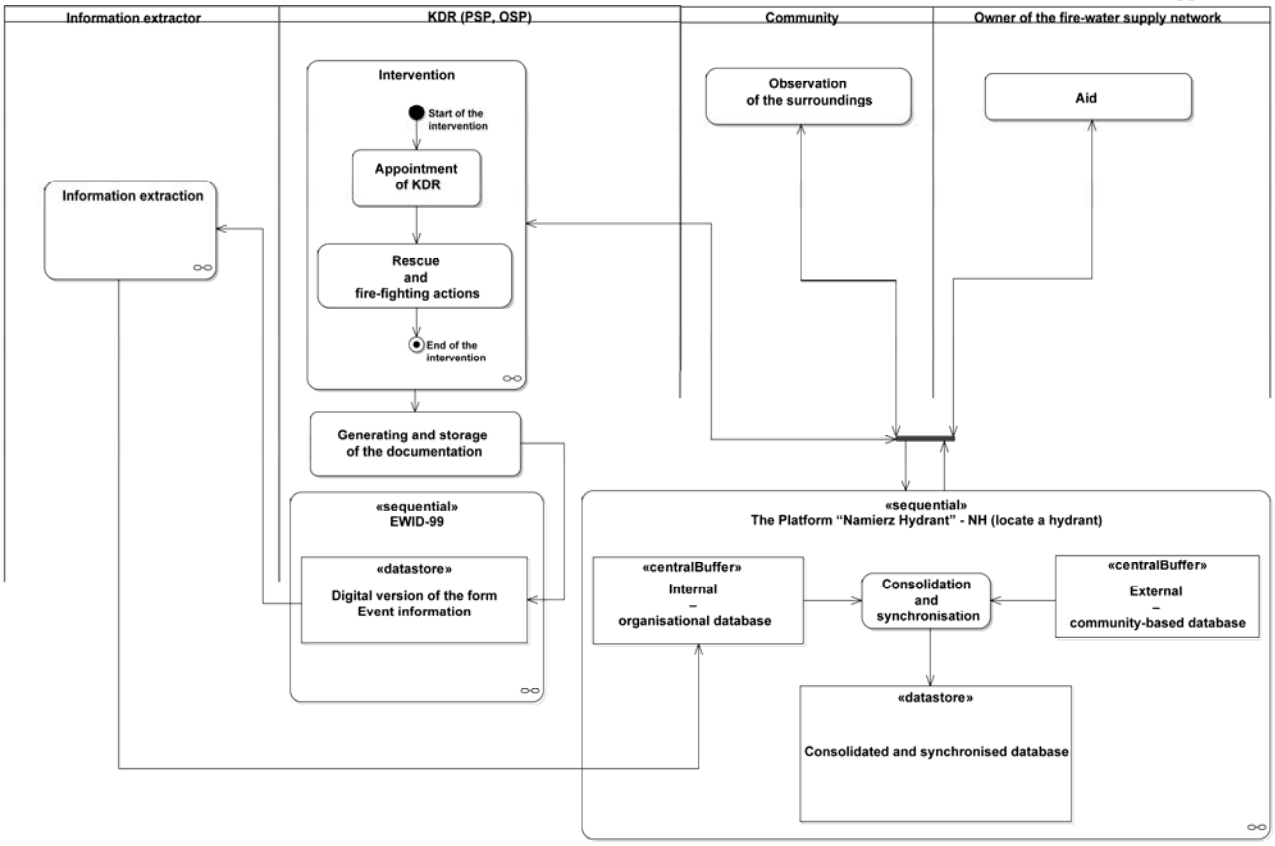

Figure 2 The diagram of the implementation of the PSP crowdsourcing platform.Source:own study]

In accordance with the diagram of the implementation of the PSP crowdsourcing platform shown in figure, 2, there are four main participants of the process.Parties participating in the cooperation process include:

−Information extractor, which is a programming unit (software), designed to extract information from electronic, digital section of the event recording system EWID in form of The event information, and, more precisely, from the field:Descriptive data for the event information [17].Based on earlier analyses of that section, the author created selected model of the domain in form of water intake points – Hydrants, which, in the discussed drawing. The model is represented by The internal – operating database, which fulfils the postulate of the operating database [17].This database collects data on water intake points – Hydrants, such as e.g. their location, condition or type.Information from text (fields Descriptive data for the event information) is extracted into model created in that way and stored there using information extractor developed by the author.That process was demonstrated using the following example.It was assumed that the report on the rescue and fire-fighting action is available in the following form:PSP activities consisted in unfolding and putting the ladder up the balcony on the second floor to make it available to the police.The police squad was commanded by comm.----- Hydrant no. 11210 in working order, at Łukowska street 28.Weather conditions:western wind 2m/s, dense mist, temp.-8 C.".The following information is extracted from such report:hydrant identification number – 11210, its location – Łukowska street 28 as well as its condition: in working order or out of order.Moreover, in the geocoding process [21-23], data on relative location of a hydrant are obtained using latitude and longitude:latitude coordinate - 52.2382943, longitude coordinate – 21.1003158. Relative location of the water intake point – Hydrant is recorded in the event recording system with reference to some object, which is often the block of flats of a given number at a given street.Thus the

absolute location defines exact location of the water intake point – Hydrant without the reference to other points.

−The rescue action leader (KDR) represents the internal participant from the structure of PSP or OSP, who is appointed during the intervention at the event place in order to manage the rescue and fire-fighting action [17].Following each intervention, simplified diagram of which is shown in figure 2, KDR generates event report recorded in the event recording system EWID.As provided above, from text section of the documentation, i.e. Descriptive data for the event information, describing the rescue and fire-fighting action with natural language, the information on water intake points – Hydrants, is extracted and stored in The internal organisational database.During intervention, information on the location of water intake points – Hydrants can be retrieved from the data base created in that way, in order to tank up water to the fire tank truck.Apart from extraction of data on hydrants using NH platform, rescue action leaders (KDR) can also verify hydrant data, e.g. change relative location to absolute one, assess information obtained from community networks or add new records describing hydrants found in the area of performed rescue and fire-fighting actions.

−The community as well as an additional partner which is The owner of the fire-water supply network make up the group of external participants.Using NH platform, the community can send data on lo

cation and description of water intake points – Hydrants found, e.g. in their area of residence.This task is executed by providing the community with appropriate tools included in the graphical user interface – GUI, as well as mobile applications in order to allow remote recording and transferring such information to the system and storage in the external community-based database.The community performs also such tasks like verification, up-date and correction of information obtained as a result of information extraction process.The participant, who is the owner of the fire water supply system, is obliged by the low to inspect the condition of the fire-water network annually, including hydrants [24].Due to these reasons, that owner may support the process of consolidation and synchronisation of data on water intake points – Hydrants found using data stored in the owner's databases.The owner can also receive information from consolidated and synchronised databases, e.g. on damaged or malfunctioning hydrants.

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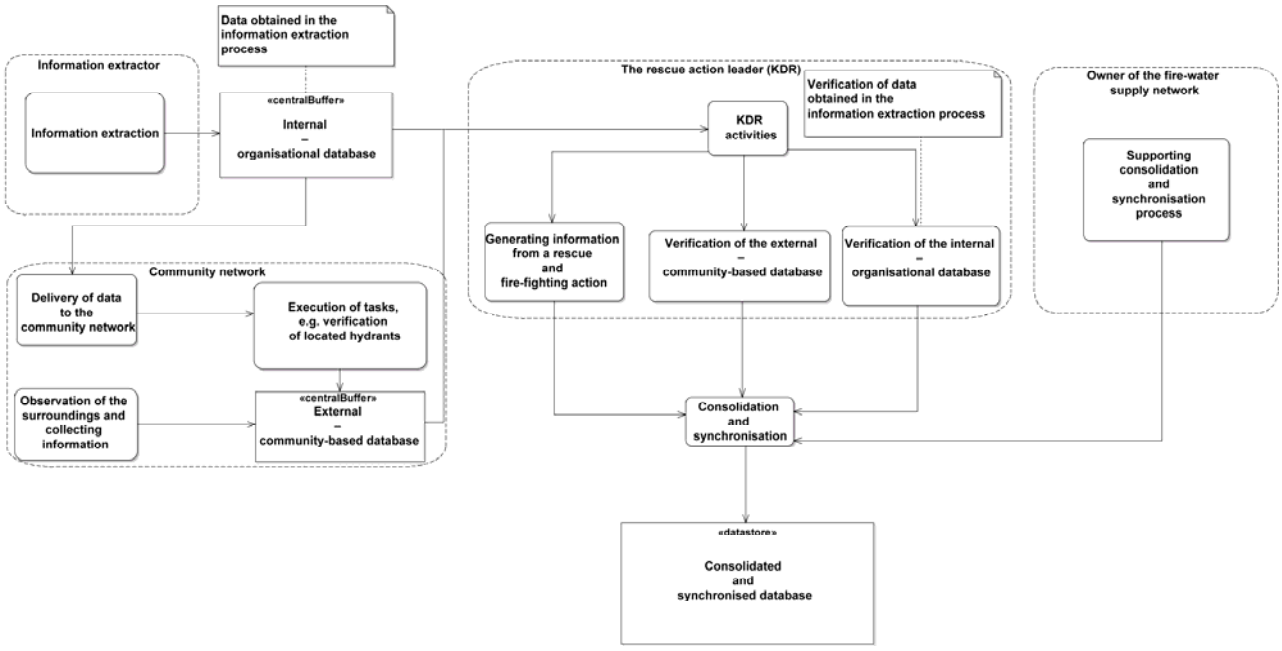

Figure 3 Information assessment and approval strategy – the rescue action leaders (KDR) as the hub. Source:[own study]

The last aspect to be discussed concerns the way and strategy of evaluation and approval of data obtained from the information extractor and the community-based network.The assessment and verification is necessary as obtained information may be unreliable, i.e. it may not completely reflect actual absolute and accurate location of water intake points - Hydrants.This inaccuracy results from the fact that the information extractor records the relative location of hydrants and from the inaccuracy of global positioning system – GPS (available in mobile equipment), used by community network members to determine location of hydrants.The proposed strategy of monitoring, assessment and correction of the obtained data was presented using the activity diagram shown in the figure 3

Figure 3 shows graphic representation of the proposed verification and approval process used to verify and approve information obtained from the information extractor and from community networks. Its main component is the rescue action leader (KDR), who is the hub, i.e. some kind of vertex of the graph which has most of or a lot of links with other nodes, graph components or elements of the studied process. The discussed figure shows that KDR, apart from generating information on water intake points – Hydrants, also assesses information obtained from External – community-based databases, which include information on those points. Those bases are populated with data obtained from the community-based direct initiative, participants of which observe their surrounding and record appropriate data on water intake points – Hydrants located there.That information may also be obtained from indirect initiatives, i.e. those generated by the internal participant e.g. in form of the list of hydrants to be inspected, which was created using the information extraction system, i.e. information from the Internal - organisational data base unverified by KDR yet.Information obtained both from the External and the Internal database are verified by KDR and then consolidated and synchronised in order to create verified, consolidated and synchronised record of water intake points – Hydrants.The owner of the fire water supply network may participate in the consolidation and synchronisation process by providing additional attributes e.g. in form of accurate, absolute location of water intake points – Hydrants.

3. SUMMARY, CONCLUSIONS AND FURTHER RESEARCH AND DEVELOPMENT

This article describes the proposed crowdsourcing for Polish rescue fire service (PSP), developed on the basis of the problem connected with assessment of information retrieved from the process designed by the author for exploration-based analysis of textual documentation in form of Descriptive data for the event information.To facilitate verification of information concerning location of given Water intake points – Hydrants as well as to make generation of that record easier, it was proposed to include into that process, apart from KDR, also the community.In the proposed solution, data from both of those sources are subject to final verification and approval by KDR.As seen above, the platform can be easily scaled by introduction of new users, such as e.g. the owner of the fire water supply network, who may provide or retrieve information useful for him e.g. on damaged water intake points - Hydrants.The proposed solution is a ready framework of the application developed by the author for assessment of the IS concerning water intake points – Hydrants implemented and populated using the information extractor.IS assessment, testing and verification phase is the next step after it has been designed and implemented (coded) during software generation stage [25, 26].Thanks to introduction of community-based components, this phase offers new opportunities and approach to IS assessment, verification and testing problems.Possible further research in that scope shall include development and supply of an appropriate IT solution in form of NH platform designed for collection, verification and consolidation of data obtained from the community network.It is also necessary to consider ways to activate and encourage the community to carry out defined tasks.Whereas the consolidation process itself must include the existing record of water intake points – Hydrants, supplemented (populated) with data collected during the information extraction process as well as data entered by the rescue action leaders (KDR) after individual interventions or with data supplied by the owner of the fire water supply system.The quality of data obtained from the information extractor and from community networks shall also be the problem to be solved in the studied platform.Further research is also necessary to confirm if or to what extent information obtained from those sources complies with the actual state and if it is sufficient for the rescue action leader (KDR) to find water intake points – Hydrants at or on the way to the place of the event.If tests are successful, then it would be possible to relieve KDR of additional verification operations.It seems to be justified to assume that shortcomings of the process related to the fact that the relative location is recorded by information extraction or resulting from possible inaccurate fixing the

position of the water intake point – Hydrant by the community network members do not disqualify use of those solutions in practice.Sometimes it is sufficient to know approximate location of a given object to be able to find it.Finally, social aspect of the proposed further research on the developed IS should be emphasized.The definitions of such words like "state" and "national" provided in the Polish language dictionary mean internally organised independent society dwelling specified territory, having its own government and law.So, activities of the State (National) Rescue Fire Service (PSP) may, by all means, include community initiatives which can be executed using the PSP crowdsourcing platform discussed and described above.

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ACTIVE OBJECT DESIGN PATTERN

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Abstract: *Abstarct: Parallelization of software plays nowadays a major role in software efficiency increase. The paper aims to present an active object design pattern and to point out its usefulness in parallel programs design. The ProActive system is also roughly presented, together with the implementation of discussed design pattern.*

Keywords: Concurrent programming, functional programming, active object, ProActive, confluence

1. INTRODUCTION

It's a cliche to say that currently – as the processor clock frequency growth has slowed down – the main method for software efficiency increase is its parallelization [1]. However, software parallelization is not easy. A programme using parallelism is not a sequence of individually executed commands, which are relatively easy for analysis, but is comprises of numerous concurrently executed operations.

2. THREADS AND LOCKSA

The most fundamental tools available in programming languages such as threads and locks , are tools of very low level. Moreover, their use results in elimination of the sequential programme properties, such as: comprehensibility, predictability and determinism [2]. When a software developer uses those mechanism, he or she is additionally burden with the necessity to ensure appropriate synchronisation of individual threads. While use of lock mechanisms results in such problems, like [1] [3]:

- correctness of two separately analysed functions in which locks were used does not mean that the code using those functions is correct; to illustrate that problem, one can consider the following example, noted in pseudocode for simplification:

```
global a, b;
function1 () {
   lock (a); /* 1 */ lock(b);
   /* operations... */
      unlock(b); unlock(a);
    }
function2 () {
   lock(b); lock(a);
   /* operations... */
   unlock(a); unlock (b);
}
```

Obviously, when analysed separately, functions behave as expected. However, if they are called successively in the following way: function1(); function2(), this may cause potential deadlock. The problem is caused by (potentially possible) expropriation of the function function1 at place marked (1) as well as by calling the code of the function function2, and as consequence: causing the situation, when

function1 waits for release of the object b, while function2 – of the object a,

- use of locks assumes that the developer shall always obey the discipline, i.e. shall: observe the convention assuming that access to resource shared by threads shall be synchronized each time, i.e. appropriate locks shall be applied and released each time such resource is read or written. Maintaining such convention, particularly in case of groups, can be very difficult,
- the last problem of design nature is the fact that locks are used globally, i.e. each code fragment using shared resource should comply with appropriate access protocol; as a consequence, it is impossible to specify exact code fragment responsible for blocking access as it is distributed over the entire programme – which obviously makes the analysis even more difficult.

3. ASYNCHRONOUS CALLS, FUTURES

As a result of the aforementioned problems, it is necessary to introduce higher level programming abstractions [1] [4]. Threads represent only "sequential processes that share memory" [5]. They neither force use of good practises or prevent use of bad practices thus causing aforementioned problems. Therefore it is recommended to use higher level abstractions using mechanisms such as: asynchronous calls and futures.

Both concepts are used in the active object pattern, so it is purposeful to describe them roughly here.

Asynchronous call of a function (method) assumes that it does not block operation of the calling thread. It simply continues operation and the method works concurrently in a separate execution thread.

Whereas the result of asynchronous operation can be achieved using future object. Generally it gives access to one operation – get – which gets the result of the asynchronous call; if it is impossible to get the result (because the asynchronous operation has not been finished yet), the thread getting the result is locked until the result is accessible. It is worth noting that, retrieving the future object does not have locking character itself.

Use of the aforementioned structures is presented in the following programme developed in Java language:

```
class Foo implements Callable<Integer>
{
    public Integer call() {
        Thread.sleep(3000);
/* simulation of the load operation */
        return 42;
    }
}

public class Main {
    public static void main(String[]
args)
{
        FutureTask task = new
FutureTask(new Foo());
/* creating future object */

Executors.newSingleThreadExecutor().
submit(task);
/* execution of the operation in a
separate thread, main thread is not
locked and can execute other operations
*/

System.out.println (task.get());
/* (locking) retrieval of the future
object value */

}
}
```

4. ACTIVE OBJECT

First of all, active object pattern assumes that method execution shall be separated from its calling. The intention of that separation is to facilitate synchronous access to shared resources by methods called in different execution threads [6] [7]. Active object has its own execution thread as well as a message queue. Method is called asynchronously: i.e. it does not lock the calling thread but places appropriate message in the message queue of the active object. They are handled sequentially and managed by the scheduler, so messages do not have to be handles in order of their placement in the queue but use of different handling policies is also possible. Whereas the value returned by (asynchronous) calling of the method can be retrieved using futures objects.

The chart of classes implementing the active object pattern was shown in the diagram UML (acc. to [8] [6]).

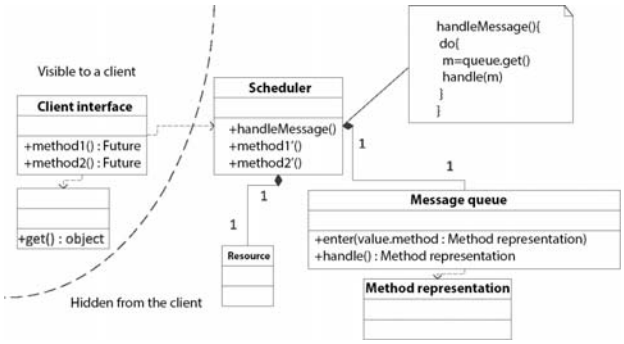

Figure 1 UML diagram of the active object pattern.

Thus the pattern includes the following components:

- Client interface – operated on the client side; creates an object representing the call of an appropriate method and placing it in an appropriate message queue of the active object; returns future object enabling access to the value returned by the method; it constitutes implementation of the design pattern proxy [9],
- Method representation – the component constructed by the client interface, constituting the abstraction of the method call, which is placed in the message queue of the active object,
- Message queue – includes all calls of methods for a given active object.
- Scheduler – calls individual methods represented in the message queue, according to the assumed policy,
- Resource – represents resource, access to which is modelled using active object pattern,
- Future – gives access to the value returned by the method call.

5. FUNCTIONAL LANGUAGES, PROACTIVE AND CONFLUENCE

Functional languages are characterized by high parallelization potential [1] [10]. Programmes developed in such languages like Haskell or OCaml may be, de facto, parallelized totally without the software developer interference. It results from the fact that those languages assume use of immutable objects, while operation performed on those objects are not associated with any side effects. . Thanks to absence of side effects, operations making up the programme may be executed in any order and may be freely interleaved. Hence there is no need to synchronize individual execution threads as they cannot interfere to each other at all. That property is called confluence . It is no doubt that such property significantly facilitates design and analysis of concurrently operating programmes.

This part of the paper includes some remarks regarding theoretical implications of some implementation of the active object pattern, i.e. that used in ProActive system [9]. ProActive is a Java language library, that facilitates concurrent and distributed programming, provides access to elements associated with data protection and migration [11]. It has evolved from the library which is the implementation of the active object pattern described in theoretical studies of Caromel i Henrio [10]. Currently it is categorized as middleware used while working with computational grids.

Theoretical grounds for active object implementation in ProActive is provided by ASP calculus, which constitutes formalization and enables accurate studies on active object properties. More detailed description of it can be found in [10], or a brief description in [12].

First of all, it should be noted that implementation of the active object pattern used in ProActive is characterized by certain differences from the pattern presented above. It assumes that the application is structured into so called subsystems. A subsystem consists of a single active object and some (≥ 0) passive objects (in practice: "common" Java objects without own execution threads and message queues). Only active objects are visible beyond the subsystem. Passive objects belong to certain subsystems, but if they are moved to other subsystems (by calling active objects' methods from another subsystem, within which they are transferred as arguments), deep copy mechanism is used. Only active objects are transferred using reference.

The consequence of such solution is strict separation of individual subsystems. And – in consequence – ensuring confluence properties in appropriate conditions. So the order of calling different methods for different active objects does not influence programme operation, which results from isolation of the methods. That order has little influence on the client side as well – as methods are called asynchronously and they return future objects, hence do not lock client threads. On the other hand, of course, that property is not maintained when methods called for the purpose of the active object modify its state (change values of the object fields). In such a case, results obtained as a result of the call of methods of a given active object depend on the order they were handled by the scheduler.

6. CONCLUSION

Sutter [3] presented very picturesque analogy. He stated that programming using locks is similar to structural programming using goto command. However, the kind of abstraction we need for concurrent programming should correspond to relation between object-oriented programming and structural programming.

It seems that the active object pattern can be regarded as such a solution. Use of the discussed pattern facilitates programming of parallel applications by elimination of the necessity to synchronize the access to shared resources (on the client side). It also enables quite easy use of multi-processor and multi-core architecture of computer systems – all you need is to assign a single active object to a single processing unit [6]. Analogous method is used also in development of distributed processing software (active object mapping – processing node – is sufficient here, taking into account multi-processor character of such nodes) [11]. Active object patterns can be applied in fields where applications of high responsiveness are required, and the architecture capable of supporting multiple independent tasks is desired: e.g. when creating graphic user interfaces or web services [13].

Java developers can use its implementation within advanced project, such as ProActive. They can also use sample code presented in [6]. The paper [7] includes the discussed pattern implemented in C++ programming language. Developers using other languages may use diagrams and assumptions described in the study herein as well as information available in [8] and [6].

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USING AN INFLECTION DICTIONARY FOR A DESIGN OF A VISUAL DICTIONARY OF VERBS AND THEIR ATTRIBUTES

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Abstarct: *Authors of this paper present a development of a visual web dictionary based on automatic extraction of verbs and their attributes from texts using the inflection dictionary of Polish language. Entries of the designed dictionary are based on triples: subject (agent) + predicate (action) + object/tool. The paper describes a prototype implementation of such a dictionary. In the paper the background for the research is presented as well as the considered problem is outlined. Moreover, the structure of the inflection dictionary of Polish language is described along with the classification of computer dictionaries. In the implementation part of the paper, the architecture of the developed web dictionary and the extraction algorithm are described.*

Keywords: *web dictionaries, visual dictionary, inflection dictionary of Polish language*

1. INTRODUCTION

Dictionaries of different kind have been developed for many centuries. A new branch of linguistics developed in that period - lexicography – describing dictionary development practice and theory [8].
Currently we deal with extraordinary progress in that field. This progress manifests both in the increased number of published dictionaries, constantly increasing automation of the material collection and processing as well as improved dictionary entries description [8].
Internet has become one of the most popular media nowadays. More and more authors, also of scientific studies, use electronic references (sources). Completely new types of dictionaries have been developed in recent years: electronic dictionaries, which are often multimedia and web dictionaries. As a result of diversity of available web dictionaries as well as quick and easy access to them, more and more people use then as potential source of information. However, expansion of modern solutions can be seen mainly in foreign dictionaries available in English. Whereas such diversity is not seen among Polish dictionaries.
Authors of this paper present preliminary results of the research on the development of the visual verb dictionary using Inflection dictionary of Polish language [4].
In order to present the area of research, main classification of electronic dictionaries was provided in the paper herein. Moreover, operation of the Inflection dictionary of Polish language used to develop the dictionary of verbs and their attributes was briefly presented. Main part of the paper includes description of the algorithm of Polish web dictionary of verbs and their attributes as well as presentation of the prototype implementation of the dictionary.

2. MOTIVATION

One says that one picture is worth a thousand words. This is to give better picture of the quantity of information that can be presented in graphic form. Although visual dictionaries are more and more popular, particularly in the English language part of the Internet, one can observe absence of Polish equivalents of such dictionaries.

The project of Polish visual dictionary of verbs presented in this paper, can be, in its final version, useful both for those who learn Polish as a foreign language (as self-study resource) and for those who study Polish as a mother tongue (as a verbal expression aid in writing essays). Moreover, for IT specialists dealing with natural language processing, such dictionary would be particularly useful if the dictionary was provided with an appropriate programming interface.

3. SUBJECT OF THE RESEARCH

Research described in the paper herein concerns the project of the visual web dictionary of verbs and their attributes. More precisely, the issue concerns fully automatic computerized extraction of information from a text, in form of the following triples:

- subject (agent)
- predicate/action,
- object/tool.

The main tool used in the extraction process is the Inflection dictionary of Polish language, described in more detail further in this section.
Polish language is commonly considered as a difficult and complicated. This results from the fact that most of words are subject to inflection, which makes Polish an inflecting language. To properly extract information from a text, we need an inflection dictionary.
The Inflection dictionary of Polish language, developed between 1996 and 2001, includes nearly 120 thousand entries and over 440 inflection patterns. Each entry is an exhaustive and complete collection of inflection patterns of a given word, including its inflexional description. The dictionary was developed as a result of joint research performed in the Department of Information Technology of AGH and the Department of Computational Linguistics of the Jagiellonian University under supervision of Prof. Wiesław Lubaszewski [4]. Word inflexion patters are stored in the dictionary in form of inflexion pattern tree, the fragment of which is presented in the figure 1.

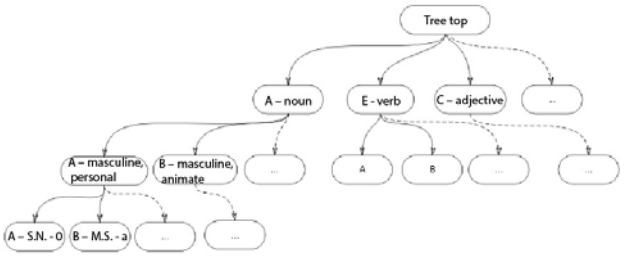

Figure. 1 Fragment of the top part of the word classification system.

Letters of the consecutive nodes of the tree make up the label identifying a given inflexion pattern [3]. For example, from all outermost left branches of the tree we obtain the label AAAAAA, which indicates that the subject-matter word is:

- a noun,
- gender: masculine, personal,
- the singular nominative has zero suffix: S.N. – 0,
- the plural nominative has -owie suffix: P.N. – owie,
- the singular vocative has –e suffix: S.V. - -e,
- the singular dative has –owi suffix: S.D. – owi.

Presented label corresponds to such words like e.g. poseł (member of parliament), bohater (hero), kawaler (bachelor), inżynier (engineer) and the like. The description of the pattern, i.e. also the label, is complete up to the leaf (node), from which it is impossible to pass to further nodes. Each leaf of the tree is provided with an appropriate set of suffixes, comprising of suffixes assumed by words subject to inflection. For the aforementioned label AAAAAA, the suffix vector assumes the following form:

- Nominative, singular -0,
- Genitive, singular - a,
- Dative, singular -owi,
- Accusative, singular - a,
- Instrumental, singular -em,
- Locative, singular -e,
- Vocative, singular -e,
- Nominative, plural -owie,
- Genitive, plural -ów,
- Dative, plural -om,
- Accusative, plural -ów,
- Instrumental, plural -ami,
- Locative, plural-ach,

- Vocative, plural -owie.

In the discussed research, the algorithm of relation extraction from text was created and the dictionary prototype was implemented using the Inflection dictionary of Polish language.

4. TYPOLOGY OF COMPUTER DICTIONARIES

During development of the dictionary, it is worth to take note of its position in the dictionary classification system. Dictionaries can be classified according to different criteria. A detailed typology of dictionaries can be found in monograph [8].
One of the important criteria, modern dictionaries can be classified by, is their form. According to that criterion, dictionaries can be divided into conventional (paper) and electronic (computer) ones. The later group is relatively new type of dictionaries. Although first electronic dictionaries of Polish language [1] designed as an aid not only for native speakers but also for foreigners occurred as early as at the end of the 20th century, it was not until last decade when revival in that field has been observed (the review of selected web dictionaries of Polish language is provided in the publication [2]). However, quantity and diversity of those dictionaries is not equal to English language publications even today.
It is worth to specify it more precisely, that the term electronic dictionary is much wider and it can apply to different types of dictionaries, such as [8]:

- dictionary modules, e.g. in text editors or OCR software,
- computer software on CD/DVD disks,
- dictionary applications available on the Internet,
- electronic equipment designed for translation from/to a foreign language,
- predictive text systems, e.g. T9 for SMS messages.

To differentiate the above types of electronic dictionaries from each other, dictionaries from point 2 are identified as computer dictionaries, while those from point 3 as web dictionaries. Moreover, as regards their functioning, dictionaries listed in point 3 are called online dictionaries, whereas the remaining as offline dictionaries. From the point of view of that classification, the dictionary being developed is a Web dictionary available online.

5. ALGORITHMS FOR EXTRACTING RELATIONS FROM TEXTS

Automatic analysis of compound sentences is a very complex task that requires use of machines capable of handling problems of high computational complexity. Studies on automatic syntax analysis of sentences have been performed in different Polish scientific centres. Information on their results are provided, e.g. in publications [5, 6, 7].
As even rough syntax analysis considerably exceeds the scope of research of the authors of this paper, they focused on development of the algorithm executable using The Inflection dictionary of Polish language only.
To allow quick implementation of the algorithm for determining verb arguments based on the verb use in the sentence, the form of considered sentences was limited. The general chart of the sentence processing algorithm is presented in figure 2.
To enable detection of the agent, verb and object (tool/instrument), the type of processed sentences was limited to those in third person, including explicit subject. Although it seems to be significant limitation, most of texts are in third person.

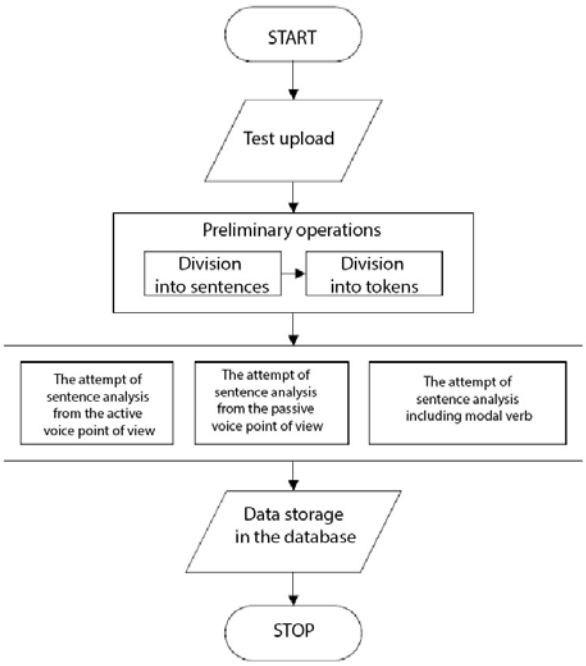

Figure. 2 General chart of the text processing algorithm.

The main reason for excluding first person sentences from the analysis is the problem with determining the subject of

the sentence. Even if there is an explicit subject, like in the sentence Ja wypiłem mleko (I drank milk), we are unable to determine who or what is "I" only on the basis of that sentence (this results from the context only and it may just as well be a man, a cat or even a personalised object).
The analysed sentence can be written in any tense. The analysis takes into account compliance of the number and person between the subject and the predicate, e.g. in case of the following sentences:

- Piekarz piecze chleb (A baker bakes a bread).
- Piekarz piekł chleb (A baker baked a bread).
- Piekarz będzie piekł chleb (A baker will bake a bread).

the first part of the analysis concerns compliance of the person, number and gender for the noun piekarz (baker) and the verb piec (bake). The second part of the analysis concerns the object. Depending on the case, the object is classified as:

- the object (accusative), e.g. pożycza książkę (lends a book),
- instrument/tool (instrumental), e.g. gra na trąbce (plays a trumpet),
- (dative), e.g. daje książkę koleżance (gives a book to a fiend).

If a sentence assumes the following form:

- Piekarz będzie piekł chleb (A baker will bake a bread).

then that sentence will be analysed in the modal verb phase of the analysis, described further in this paper.
The analysed sentence can be written both in active and in passive voice. Due to significant differences in the structure of active and passive voice sentences, passive voice sentences must be analysed separately. For instance, for sentences

- Piekarz piecze chleb (A baker bakes a bread).
- Chleb jest pieczony przez piekarza (A bread is baked by a baker).

From the human point of view, the verb piec (bake) has two arguments in both sentences: the agent piekarz (baker) and the object chleb (a bread). However, the indirect object of the active voice sentence becomes the subject of the passive voice sentence, while the agent is expressed using the structure przez (by) + dative (as in the above example) or using the instrumental case (e.g. when the agent is a tool or an impersonal force: Jan został uderzony kamieniem. (John was hit with a stone) or Jan został porażony piorunem.(John was hit by a thunderbolt)). Hence, during the passive voice sentence analysis, its components are determined as follows:

- the potential object is the subject of the sentence: in nominative and is compliant with the verb,
- potential agent is expressed in dative following the word przez (by) or in instrumental case,
- while the potential verb is expressed by participle following the auxiliary verb być (be) or zostać (become)

Although the passive voice sentence is analysed using the constructed algorithm, then from the computer analysis point of view, the passive voice may turn out to be little useful as the argument expressing the agent is often omitted there, like in sentence Ten piękny obraz został namalowany w 2010 roku (That beautiful painting was painted in 2010). In that sentence, the agent is not necessary at all. As it is known from the common sense, the agent is some painter but it is impossible to extract that information directly from this text.

The developed algorithm is able to properly extract information from sentences of any mood. In case of indicative and imperative mood, the detection algorithm is the same as in the following sample sentences:

- Ten mężczyzna kupi mleko (This Man shall buy milk).
- Niech ten mężczyzna kupi mleko (Let this man shall buy milk).

There will be no difference between the above sentences for the detection algorithm. While in case of the conditional mood, the algorithm shall consider another form of the verb (compliant as regards the person, the number and the gender):

- Mężczyzna kupiłby mleko (The man would buy milk).

If a modal verb is detected, the algorithm analyses the sentence from the modal verb point of view. The implementation treats all verbs requiring presence of other verb in infinitive as modal verbs. The modal verb is not

stored after extraction. It is only used to indicate that the verb in infinitive form should be extracted from the sentence.

6. EVALUATION

The set of several dozen sample sentences was prepared as part of the test phase of the discussed algorithm. Detection results were manually verified for those sentences. In case of simple sentences comprising single-meaning words, all detections were performed correctly.
To increase clarity of the presented information, the results are displayed in form of a graph. The figure 3 shows a sample graph developed for the dictionary entry grać (play). The graph was generated automatically based on several sentences including the verb grać.

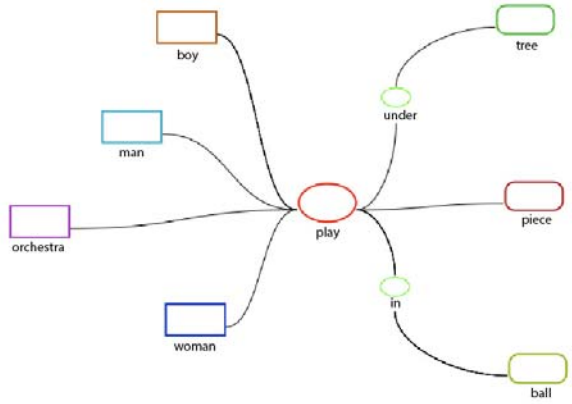

Figure. 3 Sample graph generated by the application.

The dictionary entry (verb) is displayed in the form of an ellipse in the centre. Nouns are presented in form of rectangles. Those with sharp corners are subjects of activities, while those with fillet corners – objects or tools.
However, there are many problems related to extraction of relations between words of the text. They result from ambiguity of words and functioning of the Inflection dictionary of Polish language, which analyses forms for all meanings of a given word in such a case.
There are words of numerous meanings, the inflexion of which is complicated, because it depends on the meaning, e.g. inflexion of *admirał* (admiral of the navy) slightly differs from the *admirał* (butterfly species). As a result, two known records are returned for the entry *admirał*.
The same situation occurs, when words are different, but they have some common form. For instance, the verb *mieć* (to have, to be the owner) and maić (to decorate something with green branches, leaves or with flowers) in Polish have a common form *mają*. That form, in a sample sentence below: *Nauczyciele mają czas na poprawę do końca tygodnia.* (Teachers have some time to check the test by the end of the week), can be interpreted two ways. Hence the graph includes two forms (as shown in the figure 4).

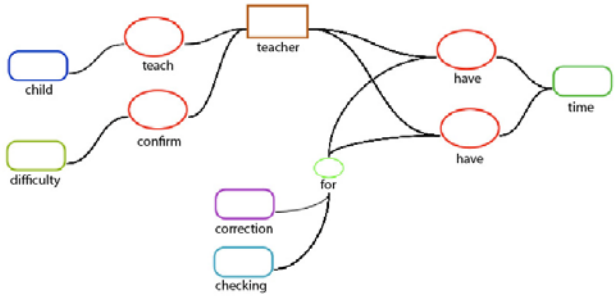

Figure.4 Sample graph showing incorrect determination.

Another important problem concerns situation, when different parts of speech are returned for a given word. It is extremely difficult task to determine, which one is correct. For example, the word jak returns known form of an adverb (which is much more frequent) as well as a noun (animal species). Thus we are able to determine many sentences with jak as a potential subject.
As it can be seen in the above examples, fully automatic generation of the entry description results in some senseless or totally incorrect matches, which are caused, among other things, by incorrect matching of the meaning or inflexion group during word detection.

7. SUMARY AND CONCLUSIONS

Authors of this paper proposed the idea of a visual dictionary, which, according to the general classification of dictionaries provided in the article [8] can be categorized as a nest-type dictionary. This type is specific, e.g. for synonym dictionaries and facilitates illustration of formal relations between entries.
The developed dictionary automatically generates visual description of each entry (in form of a graph), thanks to which it increases its advantage over paper dictionaries and even over digitalised versions of paper dictionaries. Using an appropriate internet robot, i.e. so called web crawler, capable to collect only simple sentences from the Internet, dictionary entries can be expanded as consecutive web pages are browsed.
Operation of the algorithm was evaluated using several dozen selected sample sentences. In case of simple

sentences comprising single-meaning words, all detections were performed correctly. Regrettably, in other cases, fully automatic generation of dictionary entry descriptions results in partially incorrect detection. Currently, the only solution of that problem is to manually verify stored entry descriptions. To extend the dictionary discussed in this paper, a thoroughly prepared corpus including simple sentences and the hardware capable to process huge amount of information would be required.

It is possible to improve the applied algorithm by manual development of the dictionary of verbs including information on the cases individual verbs are associated with, which would significantly increase word matching correctness. Moreover, it is still considerable challenge to analyse more complex sentences, in particular compound clauses.

Other dictionary extension options may take into account frequency of verb use and their individual attributes as well as prevalence of relevant combinations, which would have effect on selection of a given combination depending on the type of the statement.

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FUZZY LOGIC CONTROL SYSTEM OF THE FEEDER FOR THE STONE CRUSHING LINE

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Abstarct: *This paper presents the control system in the stone crushing line and its model devel0ped using Matlab-Simulink software. The simulation was performed using a fuzzy controller, which includes fuzzification block., an inference block and a defuzzification block.*

Keywords: *Fuzzy logic, fuzzy control, Matlab-Simulink*

1. INTRODUCTION

Unlike classical logic, fuzzy logic does not assume that there can be only two values of a given logic sentence, i.e. 0 or 1, but it allows other values between 0 and 1. The principle of excluded middle is denied here. Thus a logical sentence can be true to some extent.
Use of fuzzy logic is justified in cases where it is difficult to determine value of some quantity. It is used in such fields of science like information technology, automatic control engineering and bio-engineering.

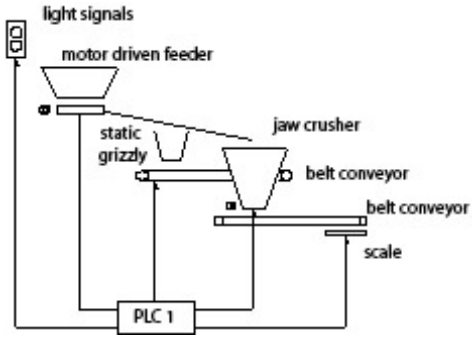

Figure. 1 The stone crushing line.

2. THE STRUCTURE OF THE SYSTEM

This paper describes application of fuzzy logic in automatic control, more specifically, fuzzy logic control of the stone crushing line feeder. The speed of material conveyed on the belt conveyor is important in that case. When material consists of fine stones mainly, speed of its movement is relatively high as it can be almost defined as sand and its further crushing is not necessary. The belt drive motor operates at high gear. Whereas, when the belt is covered with rock, it moves slowly as the crusher needs more time to appropriately crush the material. Then the belt drive motor operates at low gear. How can we apply fuzzy logic to that system? The idea of fuzzy logic application in that system is based on two reasons. First, changes of the material mass conveyed on the belt are random. Secondly, the signal sent by the scale to the controller is significantly delayed – about 20s. The course of the process was shown in Figure 1. The system consists of three parts: the stone crushing section, the stone sorting section and the belt conveyor section. Individual sections are controlled by separate controllers (this results from the size of the entire system – about 300 metres). Information on the controlled process is transmitted from each PLC through Ethernet network to PC and between controllers.
TCP/IP, OPC and ETCP protocols are used for communication.

3. SYSTEM MODEL

The model of the process was developed using Matlab-Simulink software. It was assumed that 2- or 4-gear motor would be used. The drawing below shows the model developed using the aforementioned tool. The "Fuzzy Logic Controller with Ruleviewer" block is available in Matlab software. That block allows easy development of such models. Apart from the fuzzy controller, the figure also shows "standardised error – motor gear".

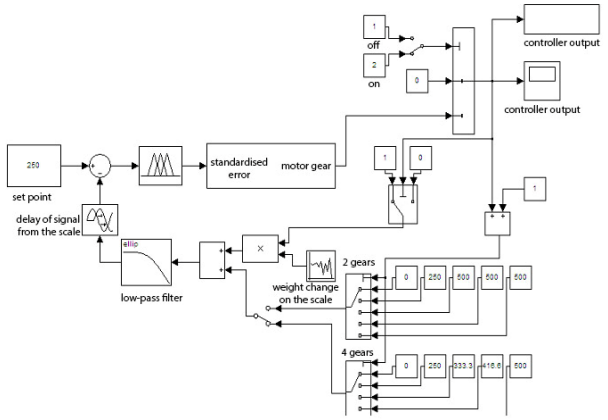

Figure. 2 The stone crushing line model developed using Matlab-Simulink software.

It was created in order to average output values of the controller and to minimize number of motor gear shifts. Moreover, the figure shows the set point block, "2 gears" block and "4 gears" block (this is determined by the engine used for simulation), the "weight change on the scale" block (which is, in principle, the generator of pseudo-random numbers – used to simulate weight changes on the scale), the "low-pass filter" block (signal smoothing) as well as "scale signal delay" block. The set point is expressed in tons per hour and it represents the average output. The figure 3 shows the structure of "standardised error – motor gear" block, which is in fact a simple counter - the gear shift signal occurs when upper or lower counter limit value is achieved. Then signal of gear shift into upper or lower gear is appropriately generated.

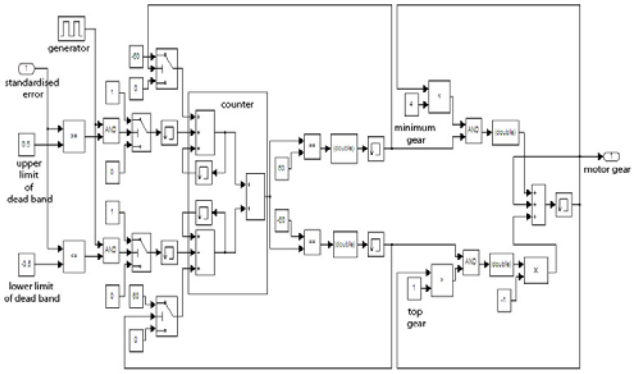

Figure. 3 The stone crushing line model developed using Matlab-Simulink software.

4. FUZZY CONTROLLER

The „Fuzzy Logic Controller with Ruleviewer" block provides possibility to develop models of three blocks: fuzzification, inference and defuzzification. The control error signal is fed to the fuzzification block input. While the output from the block represents the degree of membership in individual fuzzy sets.

Then the output signal of the fuzzification block is fed to the input of the inference block, where the following 3 simple rules were formulated (where u- the capacity, y – error):

IF (u indicates high capacity) THEN (y is the standardised error = -0.5).
IF (u indicates fair capacity) THEN (y is the standardised error = 0).
IF (u indicates low capacity) THEN (y is the standardised error = 0.5).

Then the output signal of the inference block is fed to the defuzzification block input. There are several defuzzification methods, e.g. the smallest of max (SOM) method, the largest of max (LOM) method, the middle of max (MOM) method, the centre of gravity method, bisector of area and of heights. The middle of max method was used in the study.

5. SUMMARY

The simulations confirmed that fuzzy controller yields satisfactory results. However, earlier simulations performed using PID controller yielded slightly better results. Nevertheless, fuzzy logic is still used in different fields of science.

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