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## *Editors' Remarks*

**********

## The Secret of the Machines

(MODERN MACHINERY)

**by Rudyard Kipling**

We were taken from the ore-bed and the mine,
We were melted in the furnace and the pit—
We were cast and wrought and hammered to design,
We were cut and filed and tooled and gauged to fit.
Some water, coal, and oil is all we ask,
And a thousandth of an inch to give us play:
And now, if you will set us to our task,
We will serve you four and twenty hours a day!

We can pull and haul and push and lift and drive,
We can print and plough and weave and heat and light,
We can run and race and swim and fly and dive,
We can see and hear and count and read and write!

Would you call a friend from half across the world?
If you'll let us have his name and town and state,
You shall see and hear your crackling question hurled
Across the arch of heaven while you wait.
Has he answered? Does he need you at his side?
You can start this very evening if you choose,
And take the Western Ocean in the stride
Of seventy thousand horses and some screws!

The boat-express is waiting your command!
You will find the *Mauretania* at the quay,
Till her captain turns the lever 'neath his hand,
And the monstrous nine-decked city goes to sea.

Do you wish to make the mountains bare their head
And lay their new-cut forests at your feet?
Do you want to turn a river in its bed,
Or plant a barren wilderness with wheat?
Shall we pipe aloft and bring you water down From the never-failing cisterns of the snows,
To work the mills and tramways in your town, And irrigate your orchards as it flows?

It is easy! Give us dynamite and drills!
Watch the iron-shouldered rocks lie down and quake
As the thirsty desert-level floods and fills,
And the valley we have dammed becomes a lake.

But remember, please, the Law by which we live,
We are not built to comprehend a lie,
We can neither love nor pity nor forgive.
If you make a slip in handling us you die!
We are greater than the Peoples or the Kings—
Be humble, as you crawl beneath our rods!–
Our touch can alter all created things,
We are everything on earth—except The Gods!

Though our smoke may hide the Heavens from your eyes,
It will vanish and the stars will shine again,
Because, for all our power and weight and size,
We are nothing more than children of your brain!

**********

**A Choice of Kipling's Verse (1943)** [♣]

This 16th volume no. 3 presents actual papers on two main topics of Journal specialization, namely, **Operation Research and Modelling and Computer Simulations and Innovative Technologies.** Contributors of this issue represent scientific institutions of Latvia, Israel, Kazakhstan and UK (Scotland).

Our journal policy is directed on the fundamental and applied sciences researches, which are the basement of a full-scale modelling in practice.

This edition is the continuation of our publishing activities. We hope our journal will be interesting for research community, and we are open for collaboration both in research and publishing. We hope that Journal's contributors will consider the collaboration with the Editorial Board as useful and constructive.

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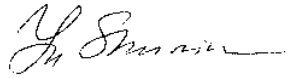

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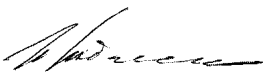

**I. V. Kabashkin**

[♣] **Rudyard Kipling** (1865–1936) was born in Bombay, India, at the end of the year 1865. Rudyard Kipling is one of the best-known of the late Victorian poets and story-tellers; he was awarded the Nobel Prize for literature in 1907.

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# FINANCIAL MODELS OF HUMAN BEHAVIOUR IN DESIGN OFFICE
# Part II. Projects' Executors as Active Players

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The developed models are a further extension of the model presented in [1]. The general idea centres on determining quasi-optimal estimates of random activity durations from the executors in order to maximize both the project's utility and the executors' personal profit. Here both the executors and the design office are active players.

**Keywords:** active systems; active players; PERT-COST projects; project activity of random duration; activity executor; estimation of p.d.f. activity duration

## 1. Introduction

In [1, 4] we have outlined several problems connected with human behaviour in project management (PM). Now we will present another problem in that area referring to multilevel stochastic project management. This paper is a research development of [1] and refers to the theory of active systems [2, 4].

Assume that the project management system (design office) $S$ comprising several simultaneously realized stochastic network PERT-COST projects at the lower level and the company personnel at the upper level, receives at the end of the planning period an award $W_S$, depending on the portfolio's utility $U_S$. Usually a certain pregiven part of $W_S$ remains at the company's disposal, while the other part (call henceforth those two parts $W_{SI}$ and $W_{SII}$, correspondingly) is dispersed among the projects. If $n$ projects $G_k(N,A)$, $1 \le k \le n$, with utilities $U_k$ participate in this division, each project $G_k(N,A)$ receives an award estimated as

$$W_{IIk} = W_{SII} \cdot \frac{U_k}{\sum_{k=1}^{n} U_k}, \quad 1 \le k \le n. \tag{1}$$

Here the calculation is carried out for each project $G_k(N,A)$ (see [2, 4]), with budget values $C_k$, due dates $D_k$ and reliability values $R_k$ being *preplanned and predetermined*.

Similarly to [1] we will assume that each activity $(i,j)$ entering a PERT-COST project has a random duration with p.d.f.

$$p_{ij}(t) = \frac{12}{(b_{ij} - a_{ij})^4}(t - a_{ij})(b_{ij} - t)^2. \tag{2}$$

Note that in accordance with the theory of active organization systems [2, 4], all executors at the medium PM level, i.e., practically all executors responsible for operating project's activities $(i,j)_k$, $1 \le k \le n$, are playing their active game similar to that outlined in [1]. They deliberately overestimate their activity durations by prolonging the right "tail" of the beta p.d.f. (2), i.e., parameter $b$. This results in overestimating the due date $D_k$ and enables the project's personnel both comfortable (non-intense) working conditions accompanied by guaranteed awards. However if the project's personnel would be informed *beforehand* that in case of executing the project within a *shorter preplanned time* their award share would be significantly higher, than for a longer preplanned $D_k$ (and this is one of the psychological backbones of the theory of active systems!), the players might become interested in changing their game strategy. Namely, we suggest that each activity executor be allowed to determine several (two-three) estimates $b$:

- the basic one ($b$) which practically guarantees a quiet life for the executor;
- the intermediate estimate $b^* < b$ which actually enables to operate the activity with p.d.f. duration (2), $b = b^*$, but by means of a higher labour productivity, and
- the minimal value $b^{**} < b^* < b$, which requires from the executor to work in the most exhausting manner, i.e., with the utmost labour productivity.

Honouring the active systems theory applied to our case, we suggest to each activity executor to proclaim beforehand the three estimates for the right bound of the corresponding p.d.f. (2) for that activity. Such an action would result [4] in diminishing the due date $D_k$ for each project and, later on, in increasing the corresponding utility function for that project as well, i.e., in changing the system's utility $U_S$ to $U_S^*$ and $U_S^{**}$, correspondingly. Since $U_S^{**} > U_S^* > U_S$ holds, the corresponding awards $W_S$ would increase as well, namely

$$\begin{cases} W_S^* = W_S \cdot \dfrac{U_S^*}{U_S}, \\ W_S^{**} = W_S \cdot \dfrac{U_S^{**}}{U_S}. \end{cases} \tag{3}$$

Thus, each project $G_k(N,A)$ would be granted an essentially higher award, but only on condition that the project executers decided to *declare* beforehand the appropriate improvement of the former due date $D_k$ (to be changed to $D_k^*$ or $D_k^{**}$) with subsequently implementing this amended due date as a *plan parameter*.

According to the active systems theory [2], only the project's personnel and nobody else can undertake such an alternative decision: either working harder and earning more or just leaving things as they stand now. It goes without saying that an individual project's decision does not influence other projects. Note that in the course of undertaking such a game the pregiven reliability values $R_k$ for each project remain the same, independently of the due dates' changes.

Let us formulate in appropriate terms the problem under consideration. Two cases will be examined:

A. Case of a single project (a two-level on-line control model), and
B. Case of several projects (a three-level on-line control model).

## 2. Notation

Let us introduce the following terms (for simplicity we will omit index $k$):

$(i,j) \in G(N,A)$ – activity entering the project;
$t_{ij}$ – random duration of $(i,j)$;
$c(i,j)$ – budget assigned to activity $(i,j)$;
$c(i,j)_{\min}$ – the minimal budget with which activity $(i,j)$ can be operated (pregiven);

$c(i,j)_{\max}$ – the maximal budget to operate $(i,j)$ (pregiven);

$b_{ij}^{*} < b_{ij}$ – the modified right bound of the beta-distribution (2) for each activity by means of intensifying the labour productivity of operating $(i,j)$ as compared to the existing one (received from executors of all activities $(i,j) \in G(N,A)$);

$b_{ij}^{**} < b_{ij}^{*}$ – practically the minimal right bound of (2) which can be achieved by executing $(i,j)$ with the utmost labour productivity (received from all executors as well). $T\{G(N,A)/c(i,j),b_{ij}\}$ – the project's random completion time on condition that the project budget value $C$ is reallocated among activities $(i,j)$ and regular or "curtailed" values $b_{ij}$ are used in calculating $T$.

## 3. Case of a Single Project

Note [3–4] that $b_{ij}$ actually depends on budget values $c(i,j)$ assigned to activity $(i,j)$ which are unknown beforehand. Therefore we suggest expressing $b_{ij}^{*}$ and $b_{ij}^{**}$ in relative terms, e.g., $b_{ij}^{*} = 0.95 b_{ij}$, $b_{ij}^{**} = 0.90 b_{ij}$. When interacting with project's decision makers, one have to bear in mind that consecutive diminishing the right "tail" $b_{ij}$ will sooner or later lead to the equilibrium value $b_{ij}^{***}$ where even working with the utmost intensity may result in failing to meet the project's target on time. Each executor must be aware of such a situation to refrain himself from getting too close to the regarded equilibrium point by estimating $b_{ij}$. Note that the concept of equilibrium plays an essential role in the theory of active systems.

The problem's formulation is as follows: minimize the $p^{*}$-th quantile of $T\{G(N,A)/c(i,j),b_{ij}\}$

$$\min\left\{W_{p^{*}}\left[T\{G(N,A)/c(i,j),b_{ij}\}\right]\right\} \tag{4}$$

subject to

$$b_{ij} > b_{ij}^{***}, \tag{5}$$

$$\sum_{\{i,j\}} c(i,j) = C, \tag{6}$$

$$c(i,j)_{\min} \le c(i,j) \le c(i,j)_{\max}. \tag{7}$$

Thus, $\{c(i,j)\}$ have to be reallocated among all $(i,j)$ optimally, together with the optimal combination of $\{b_{ij}\}$ for all activities $(i,j) \in G(N,A)$.

To solve problem (4–7), one has to check all combinations $\{b_{ij}^{**}, b_{ij}^{*}, b_{ij}\}$ submitted by the executors, with subsequently choosing the optimal set $\{b_{ij}\}$ delivering minimum to (4) by solving optimisation problem

$$\min\left\{W_{p^{*}}\left[T\{G,N,A\}_{c(i,j)}\right]\right\} \tag{8}$$

subject to (6–7) with fixed $\{b_{ij}\}$.

After determining the optimal sequence $\{b_{ij}\}$ the latter has to be sent to the executors in order to confirm the possibility of realizing the process of the project. The optimal value (4) has to be considered as the new preplanned due date $D$ (lower than the former value). If for some activities $(i,j)$ there are objections from the corresponding executors, restriction (3) has to be corrected and optimisation problem (4–7) resolved, until no contradictions take place any more.

We recommend solving problem (4–7) in two stages. At the first stage a cyclic coordinate search algorithm CCSA [4–5] is implemented in the space of $\{b_{ij}\}$, $(i,j) \in G(N,A)$, while for a fixed set of $\{b_{ij}\}$ the problem has to be solved at the second stage. In order to simplify the problem's solution one has to apply for all activities $(i,j) \in G(N,A)$ one and the same relations connecting $b_{ij}^{*}$, $b_{ij}^{**}$ and $b_{ij}$, e.g., $b_{ij}^{*} = 0.95 b_{ij}$, $b_{ij}^{**} = 0.90 b_{ij}$. Thus, problem (1–8) has to be solved only for three combinations.

## 4. Case of Several Projects

Analysing such a case results in an essentially more complicated solution. We suggest for projects $G_k(N,A)$ participating in a game similar to that outlined above, as it was stated for the case of one single project, to question all executors responsible for operating activities $(i,j)_k$, $1 \le k \le n$, regarding their psychological possibilities of shortening the corresponding right "tails" $b_{ijk}$. We suggest to obtain from each executor several (two-three) relative estimates, i.e., $b_{ijk}$, $0.95 b_{ijk}$, $0.90 b_{ijk}$, which, on their opinion, may be achieved by the appropriate intensifying effort. Thus, if the $k$-th project incorporates $n_k$ activities and then at the first level a cyclic coordinate descent algorithm has to be implemented in the $N = \sum_{k=1}^{n} n_k$ – dimensions space in order to obtain for each combination $\{b_{ijk}\}$ one of those three values under examination, namely:

- the existing estimate $b_{ijk}$;
- the slightly curtailed $0.95 b_{ijk} = b_{ijk}^{*}$;
- the essentially curtailed $0.90 b_{ijk} = b_{ijk}^{**}$, $(i,j) \in G(N,A)$, $1 \le k \le n$.

Each coordinate $\{b_{ijk}\}$ serves as the output value of the CCSA algorithm [4] and the input value for the PERT-COST algorithm outlined in [1, 4]. Thus, the problem is to determine optimal values $\{c(i,j)_k\}$ and $\{b_{ijk}\}$ in order to maximize the utility of the projects' portfolio by using the model outlined in [1]. After determining the routine feasible combination of estimates $\{b_{ijk}\}$ by applying CCSA, we solve

$$\max\left\{\sum_{k=1}^{n} \rho_k U_k\right\} \tag{9}$$

on the basis of intermediate models outlined in [1]. The optimal combination of $\{b_{ijk}\}$ and $\{c(i,j)_k\}$ has to be determined in order to solve problem (9) by obtaining a preliminary optimal solution:

To minimize for all $n$ projects $G_k$, $1 \le k \le n$, values

$$D_k = W_{p_k^{*}}\left[T\left\{G_k(N,A) / c(i,j)_k, b_{ijk}\right\}\right] \tag{10}$$

subject to

$$b_{ijk} > b_{ijk}^{***} \quad \text{(obtained from all executors)}, \tag{11}$$

$$\sum_{k=1}^{n}\sum_{\{i,j\}_k} c(i,j)_k = C, \tag{12}$$

$$c(i,j)_{k\min} \le c(i,j)_k \le c(i,j)_{k\max}. \tag{13}$$

Note that after reallocating cost resources among the projects values $W_{p_k^*}$ are obtained and later on minimized independently. Moreover, after determining $\{b_{ijk}\}$ by means of CCSA we may further improve them by solving problem (10–13). After solving that problem for the group of $n$ projects the optimal portfolio utility's value [1] has to be maximized. Since values $\sum_{\{i,j\}_k} c(i,j)_k = C_k$ and $p_k^*$ are practically not changed essentially in the course of "curtailing" parameters $b_{ijk}$ (this affects only the due dates $D_k = W_{p_k^*}\left[T\left\{G_k(N,A)/c(i,j)_k, b_{ijk}\right\}\right]$, $1 \le k \le n$), increasing the utility of the projects' portfolio can be undertaken only by shortening the activities' "tails".

## 5. Conclusions

The problem outlined in the paper is a complicated one since considering psychological interactions and human behaviour changes on-line control problems essentially. However, solving that problem results in improving the hierarchical project management system's utility.

What is, in essence, the similarity and the difference between the theory presented in [1], and the model outlined in the present paper? Both models refer to stochastic project management. In [1] the Centre (company) is an active player, while in our case players are system's active elements (projects). Being different in nature, they are similar in results: the PM in both cases raises its utility *without any antagonistic losses among all reciprocating elements entering the PM*.

## References

1. Greenberg, D. & Golenko-Ginzburg, D. (2012). Financial models of human behaviour in design office, Part I: Design office as an active player. *Computer Modelling and New Technologies*, 16(1), 7–13.
2. Burkov, V. N. (1977). *Fundamentals of the Mathematical Theory of Active Systems*. Moscow: Nauka. (In Russian)
3. Golenko-Ginzburg, D. (2010). *Stochastic Network Models in R&D Projecting*. Voronezh: Nauchnaya Kniga. (In Russian)
4. Golenko-Ginzburg, D., Burkov, V. & Ben-Yair, A. (2011). *Planning and Controlling Multilevel Man-Machine Organization Systems under Random Disturbances*. Ariel, Israel: Elinir Digital Print, Ariel University Center of Samaria.
5. Luenberger, D. G. (1984). *Linear and Non-Linear Programming*. 2nd ed. Reading, MA: Addison-Wesley.

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# PREDICTION LIMITS FOR A NUMBER OF FUTURE FAILURES UNDER UNCERTAINTY

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In this paper, we present an accurate procedure to obtain prediction limits for a number of failures that will be observed in a future inspection of a sample of units, based only on the results of the first in-service inspection of the same sample. The failure-time of such units is modelled with a two-parameter Weibull distribution indexed by scale and shape parameters $\beta$ and $\delta$, respectively. It will be noted that in literature only the case is considered when the scale parameter $\beta$ is unknown, but the shape parameter $\delta$ is known. As a rule, in practice the Weibull shape parameter $\delta$ is not known. Instead it is estimated subjectively or from relevant data. Thus its value is uncertain. This $\delta$ uncertainty may contribute greater uncertainty to the construction of prediction limits for a future number of failures. In this paper, we consider the case when both parameters $\beta$ and $\delta$ are unknown. In literature, for this situation, usually a Bayesian approach is used. Bayesian methods are not considered here. We note, however, that although subjective Bayesian prediction has a clear personal probability interpretation, it is not generally clear how this should be applied to non-personal prediction or decisions. Objective Bayesian methods, on the other hand, do not have clear probability interpretations in finite samples. The technique proposed here for constructing prediction limits emphasizes pivotal quantities relevant for obtaining ancillary statistics and represents a special case of the method of invariant embedding of sample statistics into a performance index. Two versions of prediction limits for a future number of failures are given.

**Keywords:** Weibull distribution, parametric uncertainty, future number of failures, prediction limits

## 1. Introduction

This paper extends the results of Nelson [1]. Nelson's prediction limits were motivated by the following application. Nuclear power plants contain large heat exchangers that transfer energy from the reactor to steam turbines. Such exchangers typically have 10,000 to 20,000 stainless steel tubes that conduct the flow of steam. Due to stress and corrosion, the tubes develop cracks over time. Cracks are detected during planned inspections. The cracked tubes are subsequently plugged to remove them from service. To develop efficient inspection and plugging strategies, plant management can use a prediction of the added number of tubes that will need plugging by a specified future time.

Nelson presents simple prediction limits for the number of failures that will be observed in a future inspection of a sample of units. The past data consist of the cumulative number of failures in a previous inspection of the same sample of units. Life of such units is modelled with a Weibull distribution with a given shape parameter value.

Prediction of an unobserved random variable is a fundamental problem in statistics. Hahn and Nelson [2], Patel [3], and Hahn and Meeker [4] provided surveys of methods for statistical prediction for a variety of situations on this topic. In the areas of reliability and life-testing, this problem translates to obtaining prediction intervals for lifetime distributions. Nordman and Meeker [5] compared probability

ratio, simplified probability ratio and likelihood ratio methods proposed by Nelson [1], assuming known the Weibull shape parameter $\delta$.

In this paper, we use a frequentist procedure, which is called 'within-sample prediction of future order statistics', when the time-to-failure follows the two-parameter Weibull distribution indexed by scale and shape parameters $\beta$ and $\delta$. We consider the case when both parameters $\beta$ and $\delta$ are unknown. The technique proposed here for constructing prediction limits emphasizes pivotal quantities relevant for obtaining ancillary statistics and represent a special case of the method of invariant embedding of sample statistics into a performance index applicable whenever the statistical problem is invariant under a group of transformations, which acts transitively on the parameter space (Nechval *et al*. [6–7]).

Conceptually, it is useful to distinguish between "new-sample" prediction, "within-sample" prediction, and "new-within-sample" prediction. Some mathematical preliminaries for the within-sample prediction are given below.

## 2. Mathematical Preliminaries for Within-Sample Prediction

**Theorem 1.** Let $X_1 \le ... \le X_k$ be the first $k$ ordered observations (order statistics) in a sample of size $m$ from a continuous distribution with some probability density function $f_\theta(x)$ and distribution function $F_\theta(x)$, where $\theta$ is a parameter (in general, vector). Then the joint probability density function of $X_1 \le ... \le X_k$ and the $l$th order statistics $X_l$ $(1 \le k < l \le m)$ is given by

$$g_\theta(x_1,\ldots,x_k,x_l) = g_\theta(x_1,\ldots,x_k)\,g_\theta(x_l \mid x_k), \tag{1}$$

where

$$g_\theta(x_1,\ldots,x_k) = \frac{m!}{(m-k)!}\prod_{i=1}^{k} f_\theta(x_i)[1-F_\theta(x_k)]^{m-k}, \tag{2}$$

$$g_\theta(x_l \mid x_k) = \frac{(m-k)!}{(l-k-1)!(m-l)!}\left[\frac{F_\theta(x_l)-F_\theta(x_k)}{1-F_\theta(x_k)}\right]^{l-k-1}\left[1-\frac{F_\theta(x_l)-F_\theta(x_k)}{1-F_\theta(x_k)}\right]^{m-l}\frac{f_\theta(x_l)}{1-F_\theta(x_k)}$$

$$= \frac{(m-k)!}{(l-k-1)!(m-l)!}\sum_{j=0}^{l-k-1}\binom{l-k-1}{j}(-1)^j\left[\frac{1-F_\theta(x_l)}{1-F_\theta(x_k)}\right]^{m-l+j}\frac{f_\theta(x_l)}{1-F_\theta(x_k)}$$

$$= \frac{(m-k)!}{(l-k-1)!(m-l)!}\sum_{j=0}^{m-l}\binom{m-l}{j}(-1)^j\left[\frac{F_\theta(x_l)-F_\theta(x_k)}{1-F_\theta(x_k)}\right]^{l-k-1+j}\frac{f_\theta(x_l)}{1-F_\theta(x_k)} \tag{3}$$

represents the conditional probability density function of $X_l$ given $X_k = x_k$.

**Proof.** The joint density of $X_1 \le ... \le X_k$ and $X_l$ is given by

$$g_\theta(x_1,\ldots,x_k,x_l) = \frac{m!}{(l-k-1)!(m-l)!}\prod_{i=1}^{k} f_\theta(x_i)\,[F_\theta(x_l)-F_\theta(x_k)]^{l-k-1} f_\theta(x_l)[1-F_\theta(x_l)]^{m-l}$$

$$= g_\theta(x_1,\ldots,x_k)\,g_\theta(x_l \mid x_k). \tag{4}$$

It follows from (4) that

$$g_\theta(x_l \mid x_1,\ldots,x_k) = \frac{g_\theta(x_1,\ldots,x_k,x_l)}{g_\theta(x_1,\ldots,x_k)} = g_\theta(x_l \mid x_k), \tag{5}$$

i.e., the conditional distribution of $X_l$, given $X_i = x_i$ for all $i = 1,\ldots, k$, is the same as the conditional distribution of $X_l$, given only $X_k = x_k$, which is given by (3). This ends the proof.

**Corollary 1.1.** The conditional probability distribution function of $X_l$ given $X_k = x_k$ is

$$P_\theta\{X_l \le x_l \mid X_k = x_k\} = 1 - \frac{(m-k)!}{(l-k-1)!(m-l)!} \sum_{j=0}^{l-k-1} \binom{l-k-1}{j} \frac{(-1)^j}{m-l+1+j} \left[\frac{1-F_\theta(x_l)}{1-F_\theta(x_k)}\right]^{m-l+1+j}$$

$$= \frac{(m-k)!}{(l-k-1)!(m-l)!} \sum_{j=0}^{m-l} \binom{m-l}{j} \frac{(-1)^j}{l-k+j} \left[\frac{F_\theta(x_l)-F_\theta(x_k)}{1-F_\theta(x_k)}\right]^{l-k+j}. \quad (6)$$

**Corollary 1.2.** Let $X_1 \le \ldots \le X_k$ be the first $k$ order statistics in a sample of size $m$ from the two-parameter Weibull distribution with the probability density function

$$f_\theta(x) = \frac{\delta}{\beta}\left(\frac{x}{\beta}\right)^{\delta-1} \exp\left[-\left(\frac{x}{\beta}\right)^{\delta}\right] \quad (x > 0), \quad (7)$$

where $\theta = (\beta,\delta)$, $\beta > 0$ and $\delta > 0$ are the scale and shape parameters, respectively. Then the conditional probability distribution function of $X_l$ given $X_k = x_k$ is

$$P_\theta\{X_l \le x_l \mid X_k = x_k\} = 1 - \frac{(m-k)!}{(l-k-1)!(m-l)!} \sum_{j=0}^{l-k-1} \binom{l-k-1}{j} \frac{(-1)^j}{m-l+1+j} \left[\exp\left(-\frac{x_l^\delta - x_k^\delta}{\beta^\delta}\right)\right]^{m-l+1+j}. \quad (8)$$

**Theorem 2.** If in (8) the scale parameter $\beta$ is unknown, then the predictive probability distribution function of $X_l$ based on $(x_k,\delta)$ is given by

$$P_\delta\left\{\left(\frac{X_l}{X_k}\right)^\delta \le \left(\frac{x_l}{x_k}\right)^\delta\right\} = 1 - \frac{m!}{(l-k-1)!(m-l)!}$$

$$\times \sum_{j=0}^{l-k-1} \binom{l-k-1}{j} \frac{(-1)^j}{m-l+1+j} \left(\prod_{s=0}^{k-1}\left[\left(\left(\frac{x_l}{x_k}\right)^\delta - 1\right)(m-l+1+j) + (m-k+1+s)\right]\right)^{-1}. \quad (9)$$

**Proof.** We reduce (8) to

$$P_\theta\left\{\left(\frac{X_l}{X_k}\right)^\delta \le \left(\frac{x_l}{x_k}\right)^\delta \middle| \left(\frac{X_k}{\beta}\right)^\delta = \left(\frac{x_k}{\beta}\right)^\delta\right\}$$

$$= 1 - \frac{(m-k)!}{(l-k-1)!(m-l)!} \sum_{j=0}^{l-k-1} \binom{l-k-1}{j} \frac{(-1)^j}{m-l+1+j} \left[\exp(-w[v^\delta - 1])\right]^{m-l+1+j} = P_\delta\left\{V^\delta \le v^\delta \mid W = w\right\}, \quad (10)$$

where $V = X_l / X_k$ is the ancillary statistic whose distribution does not depend on the parameter $\beta$. Since $X_k$ does not depend on $V$, $W = (X_k / \beta)^\delta$ is the pivotal quantity, whose distribution is known and does not depend on the parameters $\beta$ and $\delta$, we eliminate the parameter $\beta$ from the problem as

$$P_\delta\{X_l \le x_l\} = \int_0^\infty P_\theta\{X_l \le x_l \mid X_k = x_k\} g_\theta(x_k)dx_k, \tag{11}$$

where

$$g_\theta(x_k) = \frac{m!}{(k-1)!(m-k)!} F_\theta^{k-1}(x_k)[1-F_\theta(x_k)]^{m-k} f_\theta(x_k), \quad x_k \in (0,\infty), \tag{12}$$

represents the probability density function of the $k$-th order statistic $X_k$. Indeed, it follows from (12) that

$$g_\theta(x_k)dx_k = \frac{m!}{(k-1)!(m-k)!}\left[1-\exp\left(-\left(\frac{x_k}{\beta}\right)^\delta\right)\right]^{k-1} \exp\left(-\left(\frac{x_k}{\beta}\right)^{\delta(m-k)}\right)\exp\left(-\left(\frac{x}{\beta}\right)^\delta\right)d\left(\frac{x}{\beta}\right)^\delta$$

$$= \frac{m!}{(k-1)!(m-k)!}[1-e^{-w}]^{k-1}e^{-w(m-k+1)}dw = g(w)dw. \tag{13}$$

It follows from (10) and (13) that

$$P_\delta\{V^\delta \le v^\delta\} = \int_0^\infty P_\delta\{V^\delta \le v^\delta \mid W = w\} g(w)dw$$

$$= 1 - \frac{m!}{(l-k-1)!(m-l)!}\sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left(\prod_{s=0}^{k-1}\left[\left(v^\delta-1\right)(m-l+1+j)+(m-k+1+s)\right]\right)^{-1}. \tag{14}$$

Now (9) follows from (14). This ends the proof. ∎

**Corollary 2.1**. If the parameter $\delta = 1$, i.e. we deal with the exponential distribution, then the predictive probability distribution function of $X_l$ based on $x_k$ is given by

$$P\left\{\left(\frac{X_l}{X_k}\right) \le \left(\frac{x_l}{x_k}\right)\right\} = 1 - \frac{m!}{(l-k-1)!(m-l)!}$$

$$\times \sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left(\prod_{s=0}^{k-1}\left[\left(\frac{x_l}{x_k}-1\right)(m-l+1+j)+(m-k+1+s)\right]\right)^{-1}. \tag{15}$$

**Theorem 3.** Let $X_1 \le ... \le X_k$ be the first $k$ ordered observations from a sample of size $m$ from the two-parameter Weibull distribution (7). Then the joint probability density function of the pivotal quantities

$$W_2 = \frac{\delta}{\hat{\delta}}, \quad W_3 = \left(\frac{\hat{\beta}}{\beta}\right)^{\hat{\delta}}, \tag{16}$$

conditional on fixed $\mathbf{z}^{(k)} = (z_i, \ldots, z_k)$, where $Z_i = (X_i/\hat{\beta})^{\hat{\delta}}$, $i = 1,\ldots,k$, are ancillary statistics, any $k$–2 of which form a functionally independent set, $\hat{\beta}$ and $\hat{\delta}$ are the estimators of $\beta$ and $\delta$, based on the first $k$ ordered observations ($X_1 \le ... \le X_k$) from a sample of size $m$ from the two-parameter Weibull distribution (7), such that $W_2$ and $W_3$ are the pivotal quantities (in particular, the maximum likelihood estimators of $\beta$ and $\delta$,

$$\hat{\beta} = \left( \left[ \sum_{i=1}^{k} x_i^{\hat{\delta}} + (m-k) x_k^{\hat{\delta}} \right] \Big/ k \right)^{1/\hat{\delta}} \tag{17}$$

and

$$\hat{\delta} = \left[ \left( \sum_{i=1}^{k} x_i^{\hat{\delta}} \ln x_i + (m-k) x_k^{\hat{\delta}} \ln x_k \right) \left( \sum_{i=1}^{k} x_i^{\hat{\delta}} + (m-k) x_k^{\hat{\delta}} \right)^{-1} - \frac{1}{k} \sum_{i=1}^{k} \ln x_i \right]^{-1} \tag{18}$$

respectively, lead to the pivotal quantities $W_2$ and $W_3$) is given by

$$f(w_2, w_3 \mid \mathbf{z}^{(k)}) = \vartheta^{\bullet}(\mathbf{z}^{(k)}) w_2^{k-1} \prod_{i=1}^{k} z_i^{w_2} w_3^{k w_2 - 1} \exp\left( - w_3^{w_2} \left[ \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right] \right)$$

$$= \vartheta^{\bullet}(\mathbf{z}^{(k)}) w_2^{k-2} \prod_{i=1}^{k} z_i^{w_2} w_3^{w_2 (k-1)} \exp\left( - w_3^{w_2} \left[ \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right] \right) w_2 w_3^{w_2 - 1}$$

$$= f(w_2 \mid \mathbf{z}^{(k)}) f(w_3 \mid w_2, \mathbf{z}^{(k)}), \quad w_2 \in (0, \infty), \quad w_3 \in (0, \infty), \tag{19}$$

where

$$\vartheta^{\bullet}(\mathbf{z}^{(k)}) = \left[ \int_0^{\infty} \Gamma(k) w_2^{k-2} \prod_{i=1}^{k} z_i^{w_2} \left( \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right)^{-k} dw_2 \right]^{-1} \tag{20}$$

is the normalizing constant,

$$f(w_2 \mid \mathbf{z}^{(k)}) = \vartheta(\mathbf{z}^{(k)}) w_2^{k-2} \prod_{i=1}^{k} z_i^{w_2} \left( \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right)^{-k}, \quad w_2 \in (0, \infty), \tag{21}$$

$$\vartheta(\mathbf{z}^{(k)}) = \left[ \int_0^{\infty} w_2^{k-2} \prod_{i=1}^{k} z_i^{w_2} \left( \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right)^{-k} dw_2 \right]^{-1}, \tag{22}$$

$$f(w_3 \mid w_2, \mathbf{z}^{(k)}) = \frac{\left[ \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right]^{k}}{\Gamma(k)} w_3^{w_2 (k-1)}$$

$$\times \exp\left( - w_3^{w_2} \left[ \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right] \right) w_2 w_3^{w_2 - 1}, \quad w_3 \in (0, \infty). \tag{23}$$

**Proof.** The joint density of $X_1 \le \ldots \le X_k$ is given by

$$f_{\theta}(x_1, \ldots, x_k) = \frac{m!}{(m-k)!} \prod_{i=1}^{k} \frac{\delta}{\beta} \left( \frac{x_i}{\beta} \right)^{\delta - 1} \exp\left( - \left( \frac{x_i}{\beta} \right)^{\delta} \right) \exp\left( - (m-k) \left( \frac{x_k}{\beta} \right)^{\delta} \right). \tag{24}$$

Using $\hat{\beta}$ and $\hat{\delta}$ (the maximum likelihood estimators of $\beta$ and $\delta$ obtained from solution of (17) and (18)) and the invariant embedding technique [8–14], we transform (24) as follows:

$$f_\theta(x_1,\ldots,x_k)\,d\hat{\beta}\,d\hat{\delta} = \frac{m!}{(m-k)!}\prod_{i=1}^{k} x_i^{-1}\delta^k \prod_{i=1}^{k}\left(\frac{x_i}{\beta}\right)^{\delta} \exp\left(-\sum_{i=1}^{k}\left(\frac{x_i}{\beta}\right)^{\delta} - (m-k)\left(\frac{x_k}{\beta}\right)^{\delta}\right) d\hat{\beta}\,d\hat{\delta}$$

$$= -\frac{m!}{(m-k)!}\hat{\beta}\hat{\delta}^k \prod_{i=1}^{k} x_i^{-1}\left(\frac{\delta}{\hat{\delta}}\right)^{k-2} \prod_{i=1}^{k}\left(\frac{x_i}{\hat{\beta}}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)}\left(\frac{\hat{\beta}}{\beta}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)(k-1)}$$

$$\times \exp\left(-\left(\frac{\hat{\beta}}{\beta}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)}\left[\sum_{i=1}^{k}\left(\frac{x_i}{\hat{\beta}}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)} + (m-k)\left(\frac{x_k}{\hat{\beta}}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)}\right]\right)\left(\frac{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)}{\beta}\left(\frac{\hat{\beta}}{\beta}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)-1} d\hat{\beta}\right)\left(-\frac{\delta}{\hat{\delta}^2}d\hat{\delta}\right)$$

$$= -\frac{m!}{(m-k)!}\hat{\beta}\hat{\delta}^k \prod_{i=1}^{k} x_i^{-1} w_2^{k-2} \prod_{i=1}^{k} z_i^{w_2} w_3^{w_2(r-1)} \exp\left(-w_3^{w_2}\left[\sum_{i=1}^{k} z_i^{w_2} + (m-k)z_k^{w_2}\right]\right) d(w_3^{w_2})\,dw_2$$

$$= -\frac{m!}{(m-k)!}\hat{\beta}\hat{\delta}^k \prod_{i=1}^{k} x_i^{-1} w_2^{k-2} \prod_{i=1}^{k} z_i^{w_2} w_3^{w_2(k-1)} \exp\left(-w_3^{w_2}\left[\sum_{i=1}^{k} z_i^{w_2} + (m-k)z_k^{w_2}\right]\right) w_2 w_3^{w_2-1}\,dw_2\,dw_3. \qquad (25)$$

Normalizing (25), we obtain (19). This ends the proof.

It will be noted that more general case of distributions indexed by location and scale parameters has been considered in [15].

**Theorem 4.** If in (8) both parameters $\beta$ and $\delta$ are unknown, then the predictive probability distribution function of $X_l$ based on $(x_k, \hat{\delta})$ and conditional on fixed $\mathbf{z}^{(k)}$ is given by

$$P\left\{\left(\frac{X_l}{X_k}\right)^{\hat{\delta}} \le \left(\frac{x_l}{x_k}\right)^{\hat{\delta}} \middle| \mathbf{z}^{(k)}\right\} = 1 - \frac{m!}{(l-k-1)!(m-l)!}$$

$$\times \int_0^\infty \sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left(\prod_{s=0}^{k-1}\left[\left(\left[\frac{x_l}{x_k}\right]^{\hat{\delta}}\right)^{w_2} - 1\right](m-l+1+j) + (m-k+1+s)\right]\right)^{-1} f(w_2 \mid \mathbf{z}^{(k)})\,dw_2. \qquad (26)$$

**Proof.** We reduce (9) to

$$P_\delta\left\{\left(\frac{X_l}{X_k}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)} \le \left(\frac{x_l}{x_k}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)}\right\} = 1 - \frac{m!}{(l-k-1)!(m-l)!}$$

$$\times \sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left(\prod_{s=0}^{k-1}\left[\left(\left(\frac{x_l}{x_k}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)} - 1\right)(m-l+1+j) + (m-k+1+s)\right]\right)^{-1}$$

$$= 1 - \frac{m!}{(l-k-1)!(m-l)!}\sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left(\prod_{s=0}^{k-1}[(v_2^{w_2}-1)(m-l+1+j) + (m-k+1+s)]\right)^{-1}$$

$$= P\left\{V_2^{W_2} \le v_2^{w_2}\right\}, \qquad (27)$$

where $V_2 = (X_l / X_k)^{\hat{\delta}}$ is the ancillary statistic whose distribution does not depend on the parameters $\beta$ and $\delta$. Since the pivotal quantity $W_2$, whose distribution is given by (21), does not depend on $V_2$, it follows from (21) and (27) that

$$P\left\{V_2 \le v_2 \mid \mathbf{z}^{(k)}\right\} = \int_0^\infty P\left\{V_2^{W_2} \le v_2^{w_2}\right\} f(w_2 \mid \mathbf{z}^{(k)}) dw_2, \tag{28}$$

where the unknown parameters $\beta$ and $\delta$ are eliminated from the problem. Now (26) follows from (28). This ends the proof.

## 3. Prediction Limits for a Future Number of Failures

Consider the situation in which $m$ units start service at time 0 and are observed until a time $t_c$ when the available Weibull failure data are to be analysed. Failure times are recorded for the $k$ units that fail in the interval $[0, t_c]$. Then the data consist of the $k$ smallest-order statistics $X_1 < \ldots < X_k \le t_c$ and the information that the other $m-k$ units will have failed after $t_c$. With time (or Type I) censored data, $t_c$ is prescribed and $k$ is random. With failure (or Type II) censored data, $k$ is prescribed and $t_c = X_k$ is random.

The problem of interest is to use the information obtained up to $t_c$ to construct the Weibull within-sample prediction limits (lower and upper) for the number of units that will fail in the time interval $[t_c, t_w]$. For example, this $t_w$ could be the end of a warranty period.

Consider the situation when $t_c = X_k$. Under conditions of Theorem 4, the lower prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ is given by

$$L_{\text{lower}} = l_{\max} - k, \tag{29}$$

where

$$l_{\max} = \max_{k<l\le m} \arg\left(P\{X_l > t_w \mid \mathbf{z}^{(k)}\} \le \alpha\right). \tag{30}$$

The upper prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ is given by

$$L_{\text{upper}} = l_{\min} - k - 1, \tag{31}$$

where

$$l_{\min} = \min_{k<l\le m} \arg\left(P\{X_l > t_w \mid \mathbf{z}^{(k)}\} \ge 1-\alpha\right). \tag{32}$$

In the above case, where both parameters $\beta$ and $\delta$ are unknown, the prediction limits (lower and upper) for the number of units that will fail in the time interval $[t_c, t_w]$ are based on $(x_k, \hat{\delta})$ and conditional on fixed $\mathbf{z}^{(k)}$.

If $l$, which satisfies (30), does not exist then $l_{\max} = k$ and the lower prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ is given by

$$L_{\text{lower}} = l_{\max} - k = 0. \tag{33}$$

If $l$, which satisfies (32), does not exist then $l_{\min} = m + 1$ and upper prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ is given by

$$L_{\text{upper}} = l_{\min} - k - 1 = m - k. \tag{34}$$

## 4. Second Version of Prediction Limits for a Future Number of Failures

In this section, we wish to show how to obtain the second version of prediction limits for a future number of failures. The methodology is based on the following results.

**Theorem 5.** Let $X_1 \le \ldots \le X_k$ be the first $k$ ordered observations from a sample of size $m$ from the two-parameter Weibull distribution (7). Then the joint probability density function of the pivotal quantities

$$W_1 = \left(\frac{\hat{\beta}}{\beta}\right)^{\delta}, \quad W_2 = \frac{\delta}{\hat{\delta}}, \tag{35}$$

conditional on fixed $\mathbf{z}^{(k)} = (z_i, \ldots, z_k)$, where $Z_i = (X_i / \hat{\beta})^{\hat{\delta}}$, $i = 1, \ldots, k$, are ancillary statistics, any $k$–2 of which form a functionally independent set, $\hat{\beta}$ and $\hat{\delta}$ are, for instance, the maximum likelihood estimators for $\beta$ and $\delta$ based on the first $k$ ordered observations ($X_1 \le \ldots \le X_k$) from a sample of size $m$ from the two-parameter Weibull distribution (7), which can be found from solution of (17) and (18), is given by

$$f(w_1, w_2 \mid \mathbf{z}^{(k)}) = \vartheta^{\bullet}(\mathbf{z}^{(k)}) w_2^{k-2} \prod_{i=1}^{k} z_i^{w_2} w_1^{k-1} \exp\left( - w_1 \left[ \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right] \right)$$

$$= f(w_2 \mid \mathbf{z}^{(k)}) f(w_1 \mid w_2, \mathbf{z}^{(k)}), \quad w_1 \in (0, \infty), \quad w_2 \in (0, \infty), \tag{36}$$

where

$$\vartheta^{\bullet}(\mathbf{z}^{(k)}) = \left[ \int_0^{\infty} \Gamma(k) w_2^{k-2} \prod_{i=1}^{k} z_i^{w_2} \left( \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right)^{-k} dw_2 \right]^{-1} \tag{37}$$

is the normalizing constant, $f(w_2 \mid \mathbf{z}^{(k)})$ is given by (21),

$$f(w_1 \mid w_2, \mathbf{z}^{(k)}) = \frac{\left[ \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right]^k}{\Gamma(k)} w_1^{k-1} \exp\left( - w_1 \left[ \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right] \right), \quad w_1 \in (0, \infty). \tag{38}$$

**Proof.** The joint density of $X_1 \le \ldots \le X_k$ is given by

$$f_{\theta}(x_1, \ldots, x_k) = \frac{m!}{(m-k)!} \prod_{i=1}^{k} \frac{\delta}{\beta} \left( \frac{x_i}{\beta} \right)^{\delta - 1} \exp\left( - \left( \frac{x_i}{\beta} \right)^{\delta} \right) \exp\left( - (m-k) \left( \frac{x_k}{\beta} \right)^{\delta} \right). \tag{39}$$

Using the invariant embedding technique [8–14], we transform (39) to

$$f_{\theta}(x_1, \ldots, x_k)\, d\hat{\beta}\, d\hat{\delta} = \frac{m!}{(m-k)!} \prod_{i=1}^{k} x_i^{-1} \delta^k \prod_{i=1}^{k} \left( \frac{x_i}{\beta} \right)^{\delta} \exp\left( - \sum_{i=1}^{k} \left( \frac{x_i}{\beta} \right)^{\delta} - (m-k) \left( \frac{x_k}{\beta} \right)^{\delta} \right) d\hat{\beta}\, d\hat{\delta}$$

$$= - \frac{m!}{(m-k)!} \hat{\beta} \hat{\delta}^k \prod_{i=1}^{k} x_i^{-1} \left( \frac{\delta}{\hat{\delta}} \right)^{k-2} \prod_{i=1}^{k} \left( \frac{x_i}{\hat{\beta}} \right)^{\hat{\delta} \left( \frac{\delta}{\hat{\delta}} \right)} \left( \frac{\hat{\beta}}{\beta} \right)^{\delta(k-1)}$$

$$\times \exp\left( - \left( \frac{\hat{\beta}}{\beta} \right)^{\delta} \left[ \sum_{i=1}^{k} \left( \frac{x_i}{\hat{\beta}} \right)^{\hat{\delta} \left( \frac{\delta}{\hat{\delta}} \right)} + (m-k) \left( \frac{x_k}{\hat{\beta}} \right)^{\hat{\delta} \left( \frac{\delta}{\hat{\delta}} \right)} \right] \right) \left( \frac{\delta}{\beta} \left( \frac{\hat{\beta}}{\beta} \right)^{\delta - 1} d\hat{\beta} \right) \left( - \frac{\delta}{\hat{\delta}^2} d\hat{\delta} \right)$$

$$= - \frac{m!}{(m-k)!} \hat{\beta} \hat{\delta}^k \prod_{i=1}^{k} x_i^{-1} w_2^{k-2} \prod_{i=1}^{k} z_i^{w_2} w_1^{k-1} \exp\left( - w_1 \left[ \sum_{i=1}^{k} z_i^{w_2} + (m-k) z_k^{w_2} \right] \right) dw_1 dw_2. \tag{40}$$

Normalizing (40), we obtain (36). This ends the proof.

**Corollary 5.1.** If the parameter $\delta$ is known then

$$W_1 \sim f(w_1) = \frac{k^k}{\Gamma(k)} w_1^{k-1} \exp(- w_1 k), \quad w_1 \in (0, \infty). \tag{41}$$

**Theorem 6.** If in (8) the scale parameter $\beta$ is unknown, then the predictive probability distribution function of $X_l$ based on $(\widehat{\beta},\delta)$ and conditional on fixed $x_k$ is given by

$$P_\delta\{X_l \le x_l \mid X_k = x_k\}$$

$$= 1 - \frac{(m-k)!}{(l-k-1)!(m-l)!}\sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left[1+(m-l+1+j)\frac{x_l^\delta - x_k^\delta}{k\widehat{\beta}^\delta}\right]^{-k}. \tag{42}$$

**Proof.** We reduce (8) to

$$P_\theta\{X_l \le x_l \mid X_k = x_k\} = 1 - \frac{(m-k)!}{(l-k-1)!(m-l)!}\sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left[\exp\left(-\left[\frac{\widehat{\beta}}{\beta}\right]^\delta \frac{x_l^\delta - x_k^\delta}{\widehat{\beta}^\delta}\right)\right]^{m-l+1+j}$$

$$= 1 - \frac{(m-k)!}{(l-k-1)!(m-l)!}\sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left[\exp\left(-w_1\frac{x_l^\delta - x_k^\delta}{\widehat{\beta}^\delta}\right)\right]^{m-l+1+j}. \tag{43}$$

Now, we eliminate the unknown parameter $\beta$ from the problem and find (42) as

$$P_\delta\{X_l \le x_l \mid X_k = x_k\} = \int_0^\infty P_\theta\{X_l \le x_l \mid X_k = x_k\} f(w_1)dw_1. \tag{44}$$

This ends the proof.

**Corollary 6.1.** If the parameter $\delta$ =1, i.e. we deal with the exponential distribution, then the predictive probability distribution function of $X_l$ based on $\widehat{\beta}$ and conditional on fixed $x_k$ is given by

$$P\{X_l \le x_l \mid X_k = x_k\}$$

$$= 1 - \frac{1}{\mathrm{B}(l-k, m-l+1)}\sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left[1+(m-l+1+j)\frac{x_l - x_k}{k\widehat{\beta}}\right]^{-k}, \tag{45}$$

where

$$k\widehat{\beta} = \sum_{i=1}^{k} x_i + (m-k)x_k. \tag{46}$$

**Theorem 7.** If in (8) both parameters $\beta$ and $\delta$ are unknown, then the predictive probability distribution function of $X_l$ based on $(\widehat{\beta},\widehat{\delta})$ and conditional on fixed $x_k$ and $\mathbf{z}^{(k)}$ is given by

$$P\left\{X_l \le x_l \mid X_k = x_k; \mathbf{z}^{(k)}\right\} = 1 - \frac{m!}{(l-k-1)!(m-l)!}$$

$$\times\int_0^\infty \sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left[1+(m-l+1+j)\left(\left(\frac{x_l}{\widehat{\beta}}\right)^{\widehat{\delta}w_2} - \left(\frac{x_k}{\widehat{\beta}}\right)^{\widehat{\delta}w_2}\right)\left(\sum_{i=1}^{k} z_i^{w_2} + (m-k)z_k^{w_2}\right)^{-1}\right]^{-k}$$

$$\times f(w_2 \mid \mathbf{z}^{(k)})dw_2. \tag{47}$$

**Proof.** We reduce (8) to

$$P_\theta\{X_l \le x_l \mid X_k = x_k\}$$

$$= 1 - \frac{(m-k)!}{(l-k-1)!(m-l)!}\sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left[\exp\left(-\left[\frac{\hat{\beta}}{\beta}\right]^{\delta}\left[\left(\frac{x_l}{\hat{\beta}}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)} - \left(\frac{x_k}{\hat{\beta}}\right)^{\hat{\delta}\left(\frac{\delta}{\hat{\delta}}\right)}\right]\right)\right]^{m-l+1+j}$$

$$= 1 - \frac{(m-k)!}{(l-k-1)!(m-l)!}\sum_{j=0}^{l-k-1}\binom{l-k-1}{j}\frac{(-1)^j}{m-l+1+j}\left[\exp\left(-w_1\left[\left(\frac{x_l}{\hat{\beta}}\right)^{\hat{\delta}\,w_2} - \left(\frac{x_k}{\hat{\beta}}\right)^{\hat{\delta}\,w_2}\right]\right)\right]^{m-l+1+j}. \quad (48)$$

Now, we eliminate the unknown parameters $\beta$ and $\delta$ from the problem and find (47) as

$$P\left\{X_l \le x_l \mid X_k = x_k; \mathbf{z}^{(k)}\right\} = \int_0^\infty\int_0^\infty P_\theta\{X_l \le x_l \mid X_k = x_k\} f(w_1, w_2 \mid \mathbf{z}^{(k)})\, dw_1 dw_2$$

$$= \int_0^\infty\int_0^\infty P_\theta\{X_l \le x_l \mid X_k = x_k\} f(w_1 \mid w_2, \mathbf{z}^{(k)}) f(w_2 \mid \mathbf{z}^{(k)}) dw_1 dw_2. \quad (49)$$

This ends the proof.

Under conditions of Theorem 7, the lower prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ is given by

$$L_{\text{lower}} = l_{\max} - k, \quad (50)$$

where

$$l_{\max} = \max_{k<l\le m} \arg\left(P\{X_l > t_w \mid X_k = x_k; \mathbf{z}^{(k)}\} \le \alpha\right), \quad (51)$$

The upper prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ is given by

$$L_{\text{upper}} = l_{\min} - k - 1, \quad (52)$$

where

$$l_{\min} = \min_{k<l\le m} \arg\left(P\{X_l > t_w \mid X_k = x_k; \mathbf{z}^{(k)}\} \ge 1-\alpha\right). \quad (53)$$

In the above case, when both parameters $\beta$ and $\delta$ are unknown, the prediction limits (lower and upper) for the number of units that will fail in the time interval $[t_c, t_w]$ are based on $(\hat{\beta}, \hat{\delta})$ and conditional on fixed $\mathbf{z}^{(k)}$.

If $l$, which satisfies (51), does not exist then $l_{\max} = k$ and the lower prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ is given by $L_{\text{lower}} = 0$. If $l$, which satisfies (53), does not exist then $l_{\min} = m + 1$ and upper prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ is given by $L_{\text{upper}} = m - k$.

## 5. Numerical Example

For the sake of simplicity, but without loss of generality, we consider (for illustration) the special case of Theorem 2 where $m = 40$ items simultaneously tested have life times, which follow the Weibull distribution with $\delta = 1$. In other words, we deal with the exponential distribution. Two items have failed by the inspection at times, $X_1 = 45$ and $X_2 = 100$ hours. Let us assume that the situation takes place when $t_c = X_k = 100$ hours, where $k = 2$. Suppose, say, $t_w = 450$ hours. Taking into account (15), we find the lower prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ as

$$L_{\text{lower}} = l_{\max} - k = 3 - 2 = 1, \tag{54}$$

where

$$l_{\max} = \max_{k<l\le m} \arg\left(P\{X_l > t_w\} \le \alpha\right) = 3, \quad \alpha = 0.05, \tag{55}$$

$$P\{X_l > t_w\} = \frac{m!}{(l-k-1)!(m-l)!} \sum_{j=0}^{l-k-1} \binom{l-k-1}{j} \frac{(-1)^j}{m-l+1+j} \left( \prod_{s=0}^{k-1} \left[ \left( \frac{t_w}{x_k} - 1 \right) (m-l+1+j) + (m-k+1+s) \right] \right)^{-1}, \tag{56}$$

the upper prediction limit for the number of units that will fail in the time interval $[t_c, t_w]$ is given by

$$L_{\text{upper}} = l_{\min} - k - 1 = 17 - 2 - 1 = 14, \tag{57}$$

where

$$l_{\min} = \min_{k<l\le m} \arg\left(P\{X_l > t_w\} \ge 1 - \alpha\right) = 17. \tag{58}$$

It will be noted that when both parameters $\beta$ and $\delta$ are unknown, the lower and upper prediction limits for the number of units that will fail in the time interval $[t_c, t_w]$ can be found either from (29) and (31), which are based on $(x_k, \hat{\delta})$, or from (50) and (52), which are based on $(\hat{\beta}, \hat{\delta})$.

## 6. Conclusion and Future Work

The methodology described here can be extended in several different directions to handle various problems that arise in practice.

We have illustrated the prediction method for log-location-scale distributions (such as the Weibull or exponential distributions). Application to other distributions could follow directly.

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## References

1. Nelson, W. (2000). Weibull Prediction of a Future Number of Failures. *Quality Reliability Engineering International*, 16, 23–26.
2. Hahn, G. J. & Nelson, W. (1973). A Survey of Prediction Intervals and Their Applications. *Journal of Quality Technology*, 5, 178–188.
3. Patel, J. K. (1989). Prediction Intervals–a Review. *Communications in Statistics. Theory and Methods*, 18, 2393–2465.
4. Hahn, G. J. & Meeker, W. Q. (1991). *Statistical Intervals: A Guide for Practitioners*. New York: Wiley.
5. Nordman, D. J. & Meeker, W. Q. (2002). Weibull Prediction for a Future Number of Failures. *Technometrics*, 44, 15–23.
6. Nechval, N. A., Nechval, K. N. & Vasermanis, E. K. (2003). Effective State Estimation of Stochastic Systems. *Kybernetes* (*An International Journal of Systems & Cybernetics*), 32, 666–678.

7. Nechval, N. A., Purgailis, M., Berzins, G., Cikste, K., Krasts, J. & Nechval, K. N. (2010). Invariant Embedding Technique and Its Applications for Improvement or Optimization of Statistical Decisions. In K. Al-Begain, D. Fiems and W. Knottenbelt (Eds.), *Analytical and Stochastic Modeling Techniques and Applications*. LNCS, vol. 6148 (pp. 306–320). Berlin, Heidelberg: Springer-Verlag.
8. Nechval, N. A., Nechval, K. N. & Purgailis, M. (2011). Prediction of Future Values of Random Quantities Based on Previously Observed Data. *Engineering Letters*, 9, 346–359.
9. Nechval, N. A. & Purgailis, M. (2010). Improved State Estimation of Stochastic Systems via a New Technique of Invariant Embedding. In Chris Myers (Ed.), *Stochastic Control* (pp. 167–193). Croatia, India: Sciyo.
10. Nechval, N. A., Nechval, K. N., Purgailis, M. & Strelchonok, V. F. (2011). Planning Inspections in the Case of Damage Tolerance Approach to Service of Fatigued Aircraft Structures. *International Journal of Performability Engineering*, 7, 279–290.
11. Nechval, N. A., Purgailis, M., Nechval, K. N. & Strelchonok, V. F. (2012). Optimal Predictive Inferences for Future Order Statistics via a Specific Loss Function. *IAENG International Journal of Applied Mathematics*, 42, 40–51.
12. Nechval, N. A., Purgailis, M., Nechval, K. N. & Bruna, I. (2012). Optimal Inventory Control under Parametric Uncertainty via Cumulative Customer Demand. In Lecture Notes in Engineering and Computer Science: Proceedings of the World Congress on Engineering, WCE 2012, 4–6 July, 2012, vol. I (pp. 6–11). London, UK.
13. Nechval, N. A., Purgailis, M., Nechval, K. N. and Bruna, I. (2012). Optimal Prediction Intervals for Future Order Statistics from Extreme Value Distributions. In Lecture Notes in Engineering and Computer Science: Proceedings of The World Congress on Engineering, WCE 2012, 4–6 July, 2012, vol. III (pp. 1340–1345). London, UK.
14. Nechval, N.A. & Purgailis M. (2012). Stochastic Control and Improvement of Statistical Decisions in Revenue Optimization Systems. In Ivan Ganchev Ivanov (Ed.), Stochastic Control (pp. 151–176). Croatia, India: Sciyo.
15. Paramonov, Yu. M. (1992). *Methods of Mathematical Statistics in Problems on the Estimation and Maintenance of Fatigue Life of Aircraft Structures.* Riga: RIIGA. (In Russian)

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# KINETICS OF ONE-DIMENSIONAL INSTANTANEOUS FOREST FIRE MODEL

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Forest tree kinetics is investigated by the computer simulation in one-dimensional instantaneous model. A universal index which characterizes tree cluster distribution is found. The index is independent from the model parameters in the wide range of its values.

**Keywords:** forest fire one-dimensional models, self-organized critical properties

## 1. Introduction

A number of forest fire one-dimensional models were investigated theoretically and by computer simulation [1–5]. The main aim of these papers was the investigation of self-organized critical properties of the model, where it is usually assumed that:

1) a burning tree becomes an empty site;
2) a tree becomes a burning tree, if at least one of its nearest neighbours is burning;
3) a tree becomes a burning tree with probability f << 1, if no neighbour is burning;
4) at an empty site a tree grows with probability p.

Here we will consider instantaneous forest-fire model, and investigate the tree kinetics under the fire. Let us consider one-dimensional discreet forest fire model. In this model, the forest is depicted as a line segment of length $L$, which has trees placed on it. In the discreet model, every tree has a separate place of a concrete size. Thus all the considered forest territory would consist of line segments with trees on them and of empty line segments (places where no tree has been planted or it has been burned). The periodic boundary conditions on the ends of $L$ are used.

At a separate time steps a new tree is planted on the line segment $L$ randomly, unless another tree has already been planted there. Lightening strokes occur with the probability $f$. Any separate tree or overlapping tree clusters are burned instantaneously if the fire hit them. Initial clusters of trees are allowed. But using another probability, from the forest territory a fire ignition is thrown onto this line segment by drawing a random number. If there is a tree on this line segment, the fire burns it down.

After the trees on line segments are burnt down, the fire disappears. The same takes place if the ignition has fallen on the line segment, which has no tree on it.

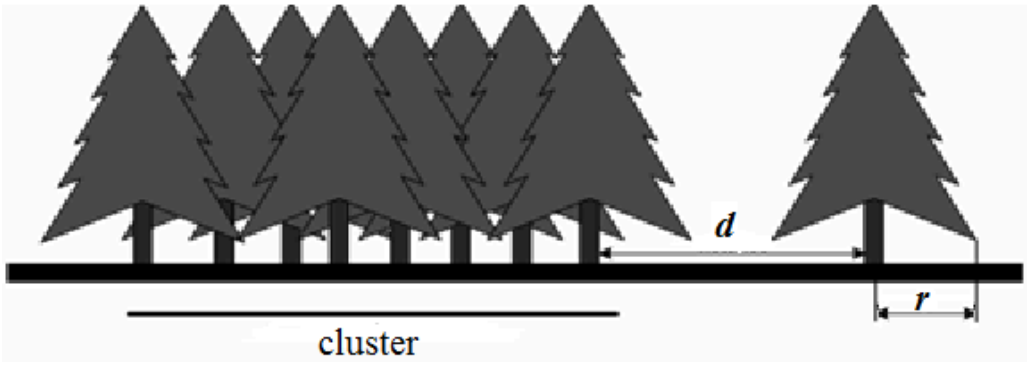


*Figure 1.* Tree cluster, $r$ – tree crown radius, $d$ – distance between trees

In the next time step, instead of the burnt-down tree a new tree appears, with a set probability. This process is continued – in each time step of the model, identifying the number of trees in the whole forest that have survived the fire (have not been burnt down).

## 2. Model

The given parameters of the model are the following: length $L$ of the forest region, $r$ – radius of the tree crown, (we assume that all growing trees have the same crown radius); $d$ permitted minimal distance between proximal growing trees; $p$ – tree appearance probability (further it is chosen 1), $f$ – probability of the lightening stroke.

If the tree occupies only isolated cells of size $2r+1$, tree number $N$ accumulation kinetics is simple:

$$\frac{dN}{dt} = p(N_{\max} - N) - fbN, \tag{1}$$

where $N_{\max}$ is the number of allowed places for trees, $b = 2r+1$ and $N_{\max} = L$.
In the stationary state $N = N_{st}$ where, we have from (1)

$$N_{st} = \frac{pN_{\max}}{fb+p}. \tag{2}$$

Eq. (2) simply follows from the equilibrium considerations in the stationary state:

$$p(N_{\max} - N_{st})\tau = fbN_{st}\tau, \tag{3}$$

where the number of created trees during a time interval $\tau$ in the stationary state is equal to the number of burned trees during $\tau$.

Kinetics of tree accumulation follows from (1) if $N(t=0) = N_0$:

$$N(t) = \frac{pN_{\max}}{fb+p}\left(1 - e^{-(fb+p)t}\right) + N_0 e^{-(fb+p)t}, \tag{4}$$

(stationary concentration does not depend on initial conditions).

If the fire strokes are absent, instead of (1) we have

$$\frac{dN}{dt} = p(N_{\max} - N). \tag{5}$$

This equation is only approximate even in the discrete case if the size crown is larger than one discrete cell and it is not permitted the overlapping of them. In order to show this we presented on Figure 2 tree cluster distribution function $N(s)$ (number of clusters with the length $s$) in double logarithmic scale for the case $L$ = 1000, $r$ = 5, for different time steps from 50 to 700.

The graphs on Figure 2 were obtained by the averaging of cluster distribution over 10000 samples and length of one history $t$ = 1000 steps. The cluster distribution function significantly changes as the saturation is approached. Further we will compare the results on Figure 2 with the results obtained in the model with fire ignition.

In general case instead of Eq. (1), when overlapping of trees is permitted, we can write

$$\frac{dN}{dt} = p(N_{\max} - N) - f\alpha(N), \tag{6}$$

where $\alpha$ depends on the covered by trees part of $L$ and number of clusters and their density. Really, $\alpha$ accumulates all the cluster distribution in an averaged manner and in order to calculate it many-tree distribution function is needed. Tree accumulation kinetics is complicated.

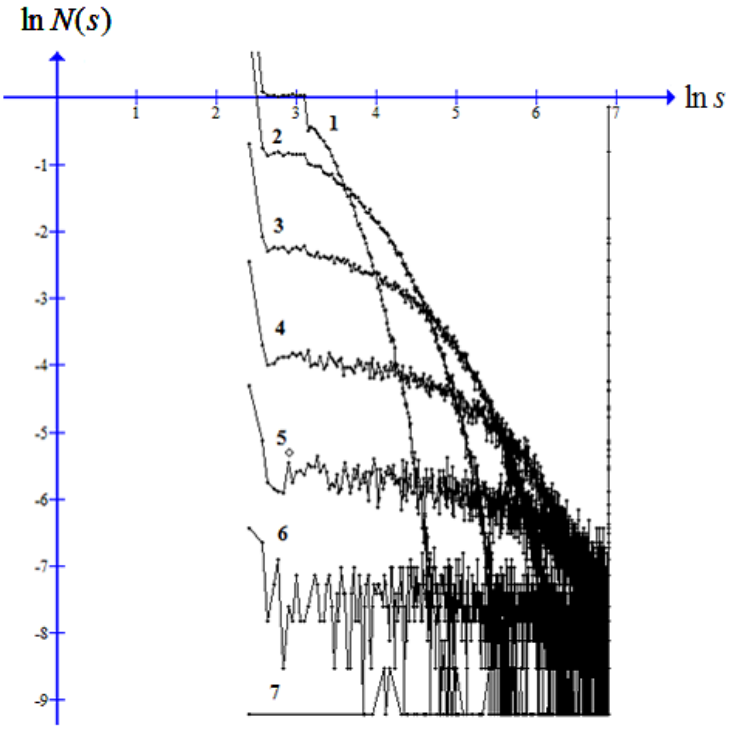


*Figure 2.* Cluster distribution function $N(s)$, 1) $t = 100$, 2) $t = 200$, 3) $t = 300$; 4) $t = 400$, 5) $t = 500$, 6) $t = 600$, 7) $t = 700$, $r = 5$

A tree accumulation kinetics averaged over $2 \cdot 10^4$ histories for $L = 2000$, $f = 0.005$ and $r = 5$ is shown on Figure 3.

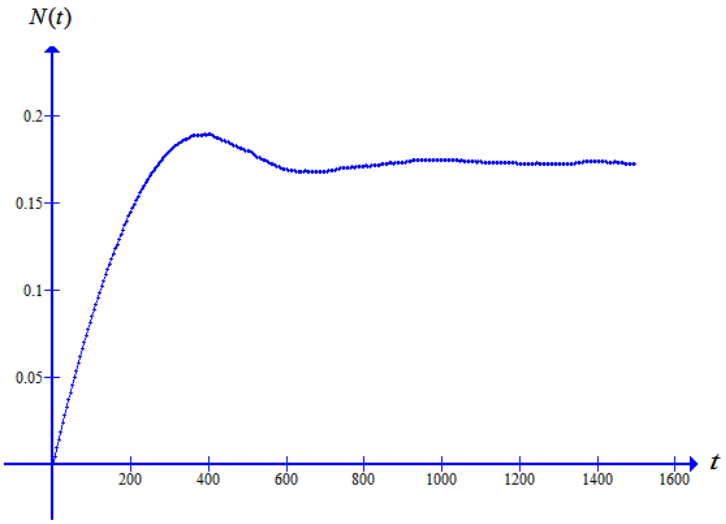


*Figure 3.* Tree accumulation kinetics: $L = 1000$, $r_0 = 5$, $N_p = 10000$, $T = 1500$

After a transition period a stationary state is reached. In comparison with the cellular automata one-dimensional and two-dimensional models, only two or three distinguished peaks are usually observed. If $fr < 0.05$ transition peak does not appear.

The corresponding distribution curves if the fire is taken into account ($f = 0.003$) for four different times are shown on Figure 4. The parameters were chosen $L = 2000$, $r_0 = 5$, $p = 1$.

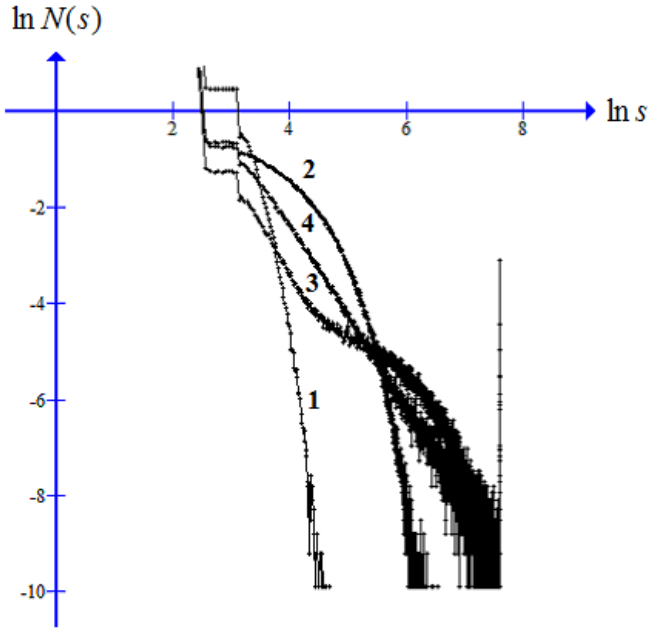


*Figure 4.* Cluster distribution in the model with $f = 0.003$: 1) $t = 100$; 2) $t = 500$; 3) $t = 1000$; 4) $t = 3000$

In the stationary state cluster distribution curve becomes a straight line for a sufficiently low $f$ values, which denotes that

$$N(s) \propto s^{-\gamma} \tag{6}$$

and $\gamma$ is model characterizing index. Transition to the stationary straight line is also very complicated. Our simulation shows that $\gamma$ for the described model is a universal index. It does not depend on the parameters $L$, $r_{0,}$ and $f < f_{crit}$ in a wide range of values, Figure 5. We have found that $f_{crit} \leq 0.01$.

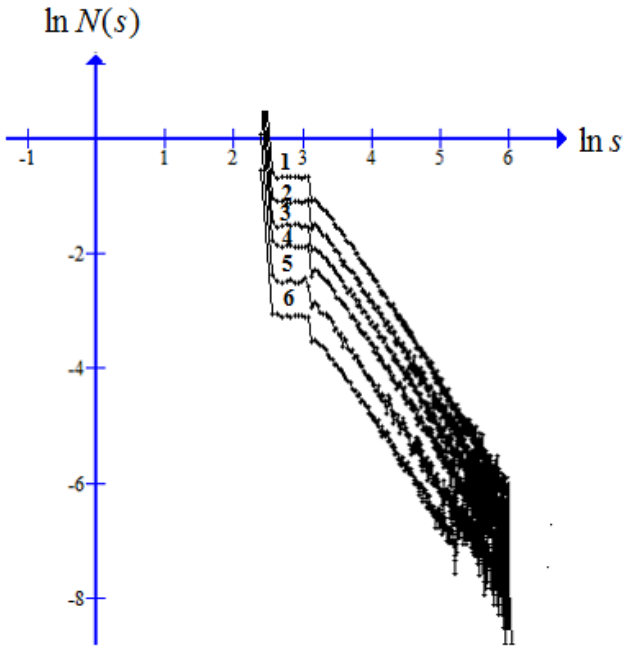


*Figure 5.* Cluster distribution for a various parameters:
1) $L = 2000, f = 0.003$; 2) $L = 100, f = 0.001$; 3) $L = 1000, f = 0.003$; 4) $L = 750, f = 0.003$; 5) $L = 500, f = 0.003$; 6) $L = 500, f = 0.001$

Determined universal index is $1.85 \pm 0.05$ and differs from the law $\gamma = 2$ [3].
In order to test the universality of $\gamma$ we simulate model where the growth of new trees was forbidden in the just burned region for the certain time steps (100–500). The values of obtained index do not change.

We also simulated model with the different allowed distances between trees in the case $r_0 = 5$. In this case the straight line in the stationary state is approached only in the case of close trees (beginning from distance between trees 4 cells, straight line is deformed).

## 3. Conclusions

Simulation of the tree kinetics on the instantaneous forest-fire model shows that model has a universal cluster distribution index, evaluated as $1.85 \pm 0.05$. It is shown that straight line cluster distribution appears at low forest fire ignition frequencies.

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## References

1. Honecker, A., Peschel, I. (1996). Critical Properties of the One-Dimensional Forest-Fire Model. *Physica A*, 229, 478.
2. Drossel, B., Clar, S., Schwabl, F. (1993). Exact Results for the One-Dimensional Self-Organized Critical Forest-Fire Model. *Phys.Rev.Lett.* 71, 3739.
3. Schenk, K., Drossel, B., Schwabl, F. (2002). The self-organized critical forest-fire model on large scales. *Phys. Rev. E,* 65, 026135.
4. Lichtenegger, K., Schappacher, W. (2009). Phase transition in a stochastic forest fire model and effects of the definition of neighborhood. *International Journal of Modern Physics C – IJMPC,* 20(8).
5. Bressaud, X. & Fournier, N. (2010). Asymptotic of one-dimensional forest fire processes. *The Annals of Probability,* 38(5), 1783.

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# COMMON SCIENTIFIC AND TECHNOLOGICAL SPACE AS THE BASIS FOR CONSTRUCTION INNOVATIVE SYSTEM

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The Construction industry in any country is the major part of its economy. Construction materials production (hereinafter – CMP) expenses in average exceed 50% [7] of the construction finished products net price. Forming a major material and technical basis for construction it significantly impacts the other economy sectors growth and social status of the society in general.

The Construction industry is considered to be the most conservative and inactive with regards to new materials and technologies introduction. This is caused by the fact that major criteria for construction materials and technologies assessment is the compliance with the requirements of technical regulations, and other applicable regulatory instruments before the first ones are adopted. Incomplete regulatory base in the Republic of Kazakhstan monitoring the construction, production and application of construction materials holds the industry back from transitioning to a whole new level.

Exchange and interaction infrastructure is developing in modern economic processes. This intensifies the exchange processes between enterprises, regions, states not only in a form of goods and finances movement, but also in a form of delivery of new technologies, intellectual property objects, and integration of various knowledge and skills.

**Keywords:** construction, construction materials production (CMP), economy, regulatory documents, scientific and technological space, innovations, innovative infrastructure

## 1. Introduction

### Construction Industry and its Impact on Economy

This study is focused on methodological justification of necessity of common scientific and technological space establishment in CMP industry, which would ensure systematic innovations implementation within the industry enterprises supported by achievement of modern scientific and technical progress and its resource potential. This will serve the basis for formation of the construction innovative system, covering such elements as scientific research and development system integrated with the higher education, malleable towards the demands of construction complex, engineering business, innovative infrastructure, intellectual property market institutions, innovation incentive mechanisms and others.

The construction industry in any country is the major part of its economy. Construction as the economy industry creates the main funds for all the industries of the national economy. More than 70 [7] industries of the national economy such as construction material industry, metallurgy, engineering, chemical, transport, fuel-power industries and many others take direct or indirect part in creation of such funds.

The construction industry is the most raw materials intensive one; it consumes the enormous quantity of construction materials and items. Construction uses more than 50% of products of the construction material industry, about 18% of rolled metal products, 40% of timbers, more than 10% of products of the engineering industry. In the cost of manufacturing of final construction products, expenditures for products of the construction material are in average more than 50% [7]. The construction material industry, being the main material and technical base of construction, has the great impact on growth dynamics in other industries of the economy and social situation of the society as a whole.

## 2. Innovation Development of CMP: Restrictions and Problems

The dynamical social and economic development of many world countries is based on innovations of the strategic important nature. At present time, the level of the innovation development in Kazakhstan is low. There are a number of serious restrictions and problems having the negative impact on the innovation development of the country and industry of the CMP such as:

a) the structural decline of the economy is continued toward the production industry, and namely oil-gas and mining industries (Figure 1). For the period from 1991 to 2010 in question, the share of the mining industry is increased by 6 times, and the share of the processing industry is decreased by more than 2.5 times.

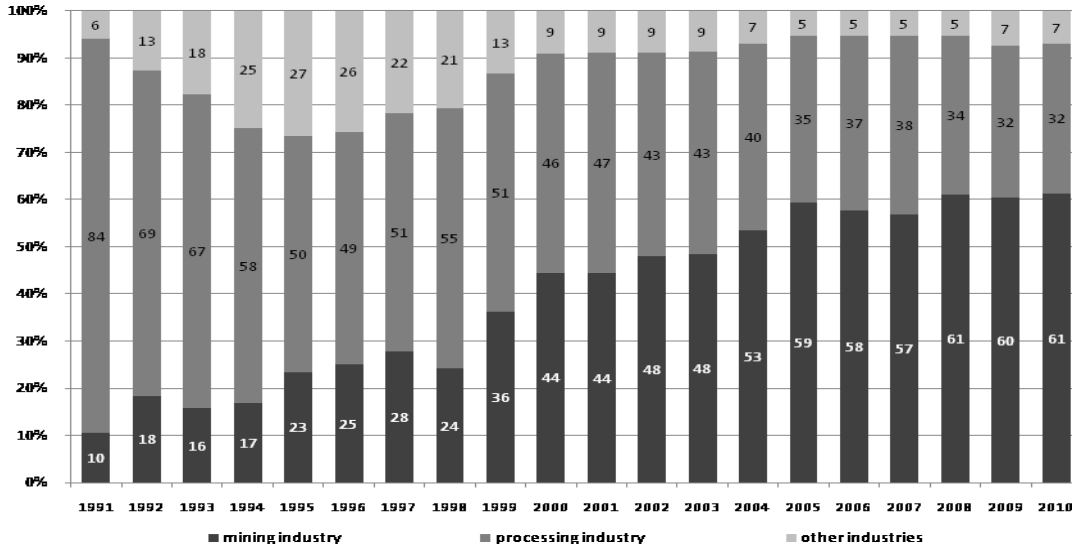


*Figure 1.* Dynamics of change in industry structure of the Republic of Kazakhstan [2]

b) Kazakhstan has rich raw material stocks for manufacturing of construction materials; however, today only a half of the existing fields are developed. For example, there are stocks of high-quality raw materials for manufacturing of ceramic sanitary-technical items; quartz sand for manufacturing of sheet glass, raw materials for manufacturing of heat-insulation and fireproof materials, but their manufacturing is not adjusted.

c) Low-added value products are mainly manufactured. Manufacturing of modern construction materials, items and structures, as well as engineering equipment systems providing the long service life, architectural expression and high economical efficiency of operated buildings and structures is not practical in relation to a lack of new enterprises in the industry. The existing production capacities in the industry experience the impetuous moral and physical obsolescence (for various sub-industries from 50% to 85%) [6].

d) Kazakhstan remains short of the industrially developed countries as per the level of the GDP research intensity. In 2010, in Kazakhstan, this index is only 0.15% of GDP, while in the USA – 2.9%, in the EU countries – 2.06%, in Russia – 1.16%. [3] In such situation, the Kazakhstan science is decided to retardation, in its turn, causing increase in technological dependence on the developed countries. In addition, as shown by the world experience, if the index of the GDP research intensity is less than 0.4%, the science may perform only the social and cultural function in the country. Only with the index of higher than 0.9%, it is possible to reckon on any influence of the science on the economical development of the country. In the European Union, the limit value of the technological safety is deemed as the GDP research intensity at the rate of 2% [5].

e) At this date, in Kazakhstan, so-called process innovations dominate. The concept of such innovations is that they consist of developments and introduction of new technologies for output of "old" products. The structure and composition of the national economy will mainly require such innovations. The results of such innovations are directly observed not in products, but are represented only in qualitative indices (Figure 2) [1].

f) The Construction industry is considered to be the most conservative and inactive with regards to new materials and technologies introduction. At this stage of the construction industry development, the main criterion for estimation of construction materials or technologies becomes their conformity with the requirements of the technical regulations and other current regulatory documents such as SNiPs, GOSTs, standards, etc., which are to be developed in eighties of the last century. Their use restricts the possibilities of innovation use both in construction and in the construction material industry.

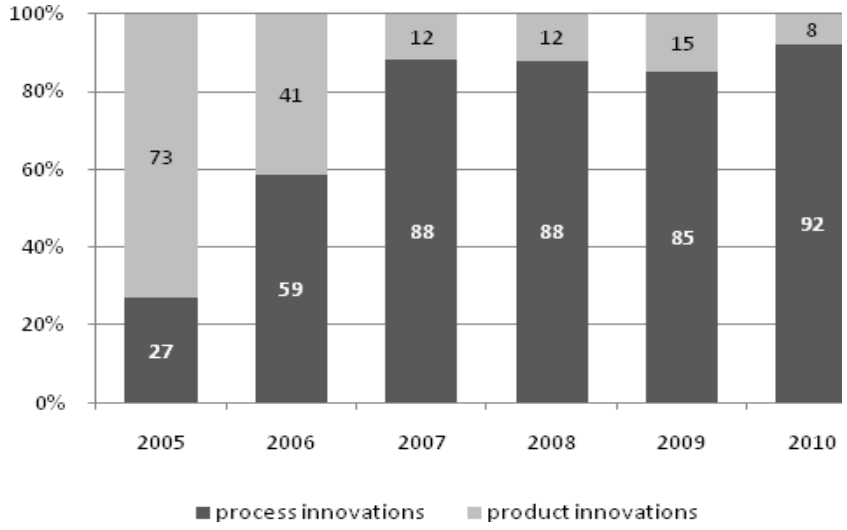


*Figure 2.* Structure of innovations in the Republic of Kazakhstan [4]

g) The Construction industry is considered to be the most conservative and inactive with regards to new materials and technologies introduction. At this stage of the construction industry development, the main criterion for estimation of construction materials or technologies becomes their conformity with the requirements of the technical regulations and other current regulatory documents such as SNiPs, GOSTs, standards, etc., which are to be developed in eighties of the last century. Their use restricts the possibilities of innovation use both in construction and in the construction material industry.

h) There are not regulatory documents on stimulation of developments and assimilation of manufacturing of scientific-intensive high-quality products, increase in labour efficiency, resource and power supply, rational use of local raw materials and wastes of the industry, in the industry of construction material production.

Thus, the educational, scientific and manufacturing complex of the industry does not provide its necessary innovation development. Lack of the notified authorities, imperfection of the existing accreditation systems and regulatory base in the Republic of Kazakhstan for regulation of construction, manufacturing and use of construction materials; lack of engineering-technical staff detains the development and introduction of innovations having the strategic important nature, thus, not allowing the industry to be transferred to the wholly new level.

**Common Scientific and Technological Space**

Exchange and interaction infrastructure is developing in modern economic processes. This intensifies the exchange processes between enterprises, regions, states not only in a form of goods and finances movement, but also in a form of delivery of new technologies, intellectual property objects, and integration of various knowledge and skills. The information exchange assists in activation of innovation developments. The important element of the industry development shall be formation of the common scientific and technological space.

The common scientific and technological space supposes joining and development of scientific and technical potentials of scientific and research, design, construction, commercial organizations, enterprises of the construction industry and adjacent industries, and namely:

a) formation of the single information system in the scientific and technological sphere by creation and support of the single base of scientific surveys and experimental and industrial testing of perspective developments and manufacturing of research and testing equipment and instruments;

b) unification of the international scientific and innovation infrastructure components such as standards, certification systems, mechanisms for protection of intellectual property rights;

c) coordination of scientific surveys and developments based on the agreed scientific and technical and innovation policies of the state;

d) determination of forms and mechanisms for cooperation in domain of commercialization of the results of scientific and research and experimental development works and transfer of technologies;
e) creation of the relation system between the state, investment funds, venture companies and enterprises of the construction industry for funding of scientific and technical and innovation surveys and developments.

Creation of common scientific and technological space will provide the members of scientific and research, design, construction and commercial organizations, construction and allied industries enterprises with the opportunity to obtain the complete information on modern high-quality materials and products, its production technologies, equipment, instruments and tools produced both in Kazakhstan and abroad, and will contribute to arrangement of conditions in Kazakhstan, which set new grounds in the sphere of development of XXI century construction materials, equipment and technologies based on the existing scientific achievements. Cooperation of the construction science, industry, business and the state in domain of creation and commercialization of innovation construction materials and technologies will assist in their introduction in the commercial serial manufacturing and in ensuring of sales and demand at the market. For that achievement, it is possible to use either economical mechanisms such as tax preferences, grants, subsidies and others or market tools such as licenses, franchising, option, leasing, auction and others.

## 3. Conclusions

Modern conditions of the construction complex development impose the requirements for the construction material industry and construction industry based on change in the structure of residential construction, transfer to new architectural and construction systems, types of buildings and technologies of their erection, necessity of decrease in resource intensity. As well as power and labour costs during construction and operation of housing, decrease in duration of the investment cycle, solving of tasks for increase in scopes of residential construction, satisfaction of demands of capital construction and operation needs in high-quality products. The common scientific and technological space will allow meeting all the requirements of the modern conditions of the construction complex development, as well as will be the foundation not only for formation of the construction innovation systems, but including the national innovation system.

## References

1. Alshanov, R. (2012). Economy of Kazakhstan for 20 years: innovations and diversification. *Kazakhstanskaya Pravda*, 112–113.
2. Industry of Kazakhstan and its regions for 2006–2010. (2011). *Statistic collection*. Statistic Agency of the Republic of Kazakhstan, Astana, 217.
3. OECD. (2012). Main Science and Technology Indicators Retrieved on (20.10.2011.), from http://stats.oecd.org/index.aspx#
4. Science and innovation activity of Kazakhstan for 2006–2010. (2011). *Statistic collection*. Statistic Agency of the Republic of Kazakhstan, Astana, 66.
5. Semashko, V. I. (2009). Innovation development of the Republic of Belarus: condition and prospects. In Proceedings of the Conference 'Training of high-qualification scientific staff under conditions of public innovation development', 288. Minsk: BelISA (Bel. Inst. of System Analysis International Scientific Practical Conference "Training of scientific staff of high qualification in conditions of innovative development of a society" (Minsk, 24–25 September 2009)
6. *State program on rapid industrial-innovation development of the Republic of Kazakhstan for 2010– 2014.* Approved by the Order of the President of the Republic of Kazakhstan dated March 19, 2010, № 958. (2010) Astana. Ch. 1, 39.
7. Stepanov, I. S. (2007). *Construction economy*. Ch. 1 (pp. 24–25). Moscow: Uwrite-Izdat.

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# SMART TARGET SELECTION IMPLEMENTATION BASED ON FUZZY SETS AND LOGIC

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This paper aims to emphasize the effectiveness of an application of fuzzy sets and logic in the implementation of target selection (TS). TS is an important data mining problem that aims to identify profiles of customers who are likely to respond to the offer for a particular product or service. Very often TS of information have very blurred conditions. Fuzzy classification can be extremely efficient there, because it is much closer to the way that humans express and use their knowledge. One of the advantages of the proposed method is that it is consistent with relational databases. But the main advantage is – the query to the system is done in a natural language, such as show the list of not very young married clients with average or more-or-less high income, which is impossible using a standard query mechanism.

**Keywords:** target selection, fuzzy sets, fuzzy logic, fuzzy mathematics, natural query

## 1. Introduction

Nowadays, computers take control of more and more of the activities of human everyday life. No doubt, they have brought a lot of ease to our life. But the striking difference between human and computer system is that human performs wide range of mental tasks without any measurements and any computations. This particular ability of humankind can be explained by the fact that we can manipulate perceptions of size, taste, weight, speed, distance, etc. [8]. So, humans *perceive,* whereas computers *measure* (compute). We need to highlight one fundamental distinction between perceptions and measurements – the former are imprecise (fuzzy), whereas the latter are crisp.

Concerning target selection, it is a usual case when the experts can only give qualitative (e.g. *not young*), but not quantitative characteristics (e.g. *age* > 30). This is where fuzzy queries can help us, because they are natural and are much closer to the way human express their knowledge.

This paper is composed of five sections. Section 1 is this introduction. Section 2 introduces the target selection problem and its critical importance in advertising. Furthermore, in Section 3 we describe the querying model based on fuzzy sets and logic intended to make the process of target selection more efficient. The next section provides descriptive examples of different types of queries and their result sets produced by our application. Finally, the last section provides the concluding remarks of this research.

## 2. Target Selection Problem

Target selection (TS) is an important data mining problem that aims to identify profiles of customers who are likely to respond to the offer for a particular product or service. The target auditory is selected from a database given different types of information, like profession, age, purchase history, etc. [1].

Almost all companies operating with a database of 100 or more clients use email-mailing in their business for advertising. Careful selection of recipients is critical for them. Poor TS strategy introduces problems for companies and their clients as well. Particularly, organizations try to avoid wasting money on communicating with customers not interested in their products. However, they don't want to lose potential buyers. Clients, in turn, try to avoid spam, but want to be informed about the new products or services that might be interesting for them. Therefore, email-mailing is a very delicate instrument, since the line between a useful message and spam is very thin. So, TS need to be neither too liberal nor too strict. Instead, it needs to be based on user's perception – linguistic description, which is usually less specific than a numerical one.

Many techniques have been applied to select the targets in commercial applications, such as decision tree methods, statistical regression, neural computing and fuzzy clustering [3]. As it was already mentioned, very often TS of information have very blurred conditions which can be easily expressed via

natural language. That is why fuzzy models are interesting in this respect, since they can be used to obtain numerically consistent models, while providing a linguistic description as well.

## 3. Adding Fuzziness to Target Selection

It is well-known fact that most of the data processed in information systems has a precise nature. Nevertheless, natural queries produces by people in their everyday life often have some degree of fuzziness. For example, a person seeking a car might express the description of it like "*low fuel consumption car that is not very expensive, preferably Audi or BMW*". Statements like "not very expensive", "low consumption" is vague, imprecise, despite of the fact that the price and consumption can be completely determined. The reason for that is that in real life, we operate and argue using imprecise categories [5], [6].

Fuzzy sets and logic play a major role in this research. Particularly, the job of the fuzzy set in the model is to represent linguistic expressions, while fuzzy logic is used for reasoning. In a nutshell, if something is fuzzy, (e.g. old, tall, and expensive) it can be partially true and partially false. Fuzzy mathematics enables us to represent linguistic variables and use imprecision in a positive way.

### 3.1. Linguistic Variables and Modifiers

The main advantage of using linguistic variables rather than numbers is that a linguistic description is usually less specific than a numerical one [5], [6]. Moreover, it is closer to human cognitive processes, and that can be used successfully in decision making involving uncertain or ill-defined phenomena.

By a linguistic variable we mean a variable whose values are not numbers but words or sentences in a natural or artificial language [6]. For example, *price* is a linguistic variable if its values are expressed via words (*low, average, high)* rather than numerical (190 000 tg., 600 tg.…). To clarify, *high* is considered as a linguistic value of the variable *price*, it plays the same role as some certain numerical values. However, it is less precise and conveys less information.

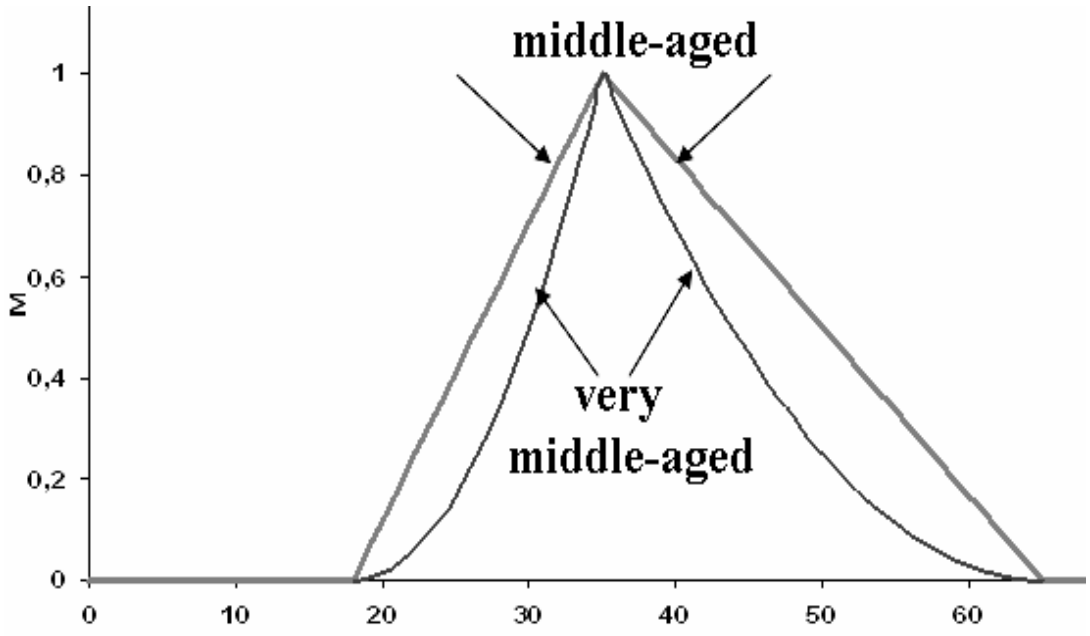


*Figure 1.* Visualizing the hedge ***very***

Linguistic variables may also involve connectives such as *and, or, not* and hedges such as *very, quite extremely, more or less*, completely, fairly, that can change the statement in various ways – intensify, weaken, complement [8]. This is useful for constructing various semantic structures –composite words – from atomic words (i.e. young) that reinforce or weaken the statements [7] such as very low price, more-or-less old, etc.

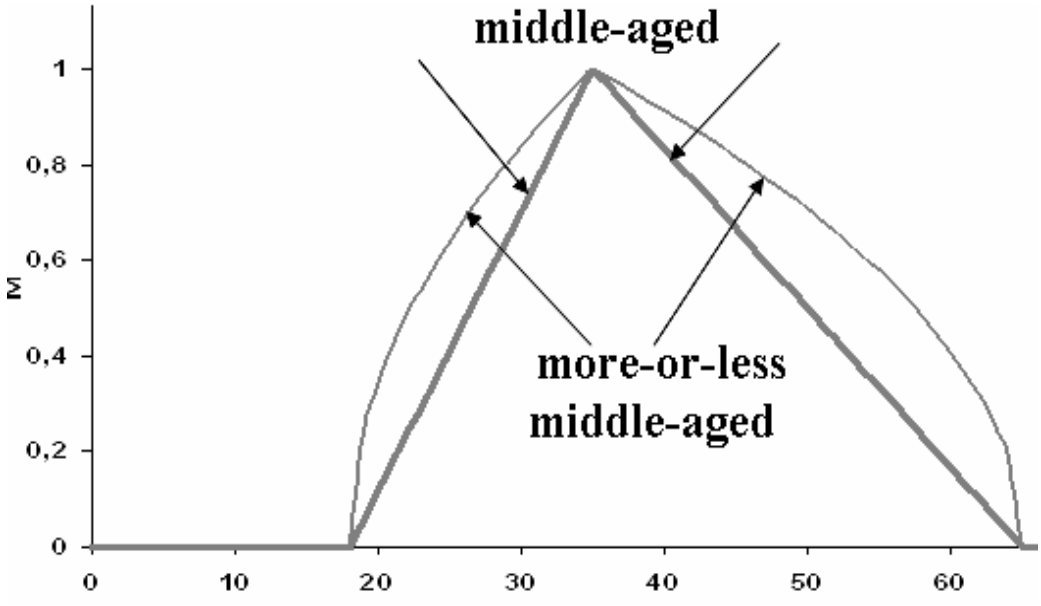


*Figure 2.* Visualizing the hedge ***more-or-less***

For reinforcing the modifiers – very, to weaken, more-or-less, almost, approximately – exist. For example, let's suppose that the meaning of X (middle-aged) is defined by some membership function. Then the meaning of very X (i.e. very middle-aged) could be obtained by squaring this function [8]:

$$\mu F_{VERY}(X) = (\mu F(X))^2 .$$

Weakening modifier *more-or-less X* (i.e. more-or-less middle-aged) would be given as a square root of the initial function [8]:

$$\mu F_{MORE-OR-LESS}(X) = \sqrt{\mu F(X)} .$$

Finally, *not X* (i.e. not young) which is a complement fuzzy set, can be expressed by subtracting the membership function of *X (middle-aged)* from 1:

$$\mu F_{NOT}(X) = 1 - \mu F(X) .$$

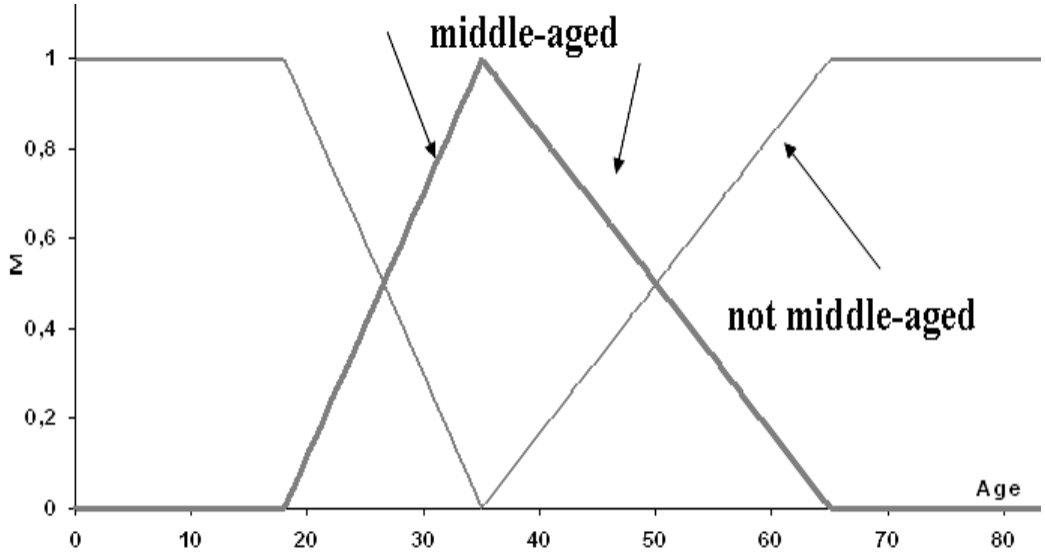


*Figure 3.* Visualizing the modifier ***not***

From the figures below we can see that *very* hedge steepens the curve, whereas *more*- The main flexibility modifiers provide is that they can make a fuzzy natural query even more natural.

To sum up, in situations where information is not precise (which are very common in our real life), linguistic variables can be a powerful tool that takes the human knowledge as model [2].

### 3.2. Fuzzification

In order to simplify the model we present just some of the possible criteria – clients' features that will play the role of explanatory variables in the model. They are gender, age, status, income.

Suppose we have a table "Clients", consisting of 7 rows: id (primary key), name, gender ('Male','Female'), age, status ('Married', 'Not_married'), email, income. By the way, in practice, a certain threshold of membership value is given in excess of which records are included in the result of a fuzzy query. So, an expert can tune it to make the query more or less strict.

Fuzzy variables mentioned will be described by triangular membership functions, which are good enough to catch the ambiguity of the linguistic assessments [2]. The parametric representation is achieved by the 3-tuple (a; b; c) for each fuzzy variable, it is enough, since we apply a fuzzy partition.

Now let's try to formalize the fuzzy concept of the client's age. We define it for the domain X = [0, 90], so, the universal set U = {0 ,1, 2, …..,89, 90}. The term set consists of 3 fuzzy sets – {"Young", "Middle-aged", "Old"}. We define the membership functions for the young, middle-aged, and old fuzzy sets with the following parameters [a, b, c] = [18, 35, 65]. The fuzzy sets and corresponding membership functions can be seen in figures provided below.

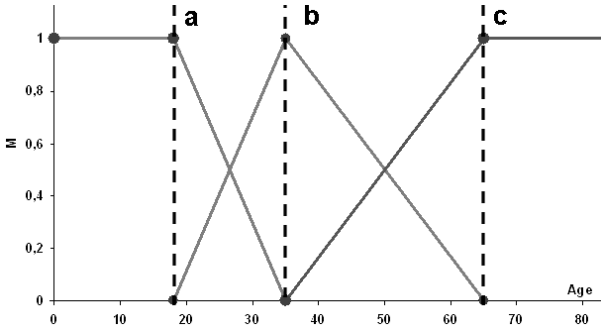


*Figure 4.* Fuzzy sets for young, middle-aged, and old

$$\text{"Young"} = \begin{cases} 1, & x \le a \\ 1 - (x - a) / (b - a), & a \le x \le b \\ 0, & \text{otherwise} \end{cases}$$

$$\text{"Middle-aged"} = \begin{cases} 1 - (b - x) / (b - a), & a \le x \le b \\ 1 - (x - b) / (c - b), & b \le x \le c \\ 0, & \text{otherwise} \end{cases}$$

$$\text{"Old"} = \begin{cases} 0, & x \le b \\ 1 - (c - x) / (c - b), & b \le x \le c \\ 0, & \text{otherwise} \end{cases}$$

*Figure 5.* Membership functions

Another fuzzy variable in the system is client's income. It has 3 fuzzy sets – {"Low", "Average", "High"}. The parameters for the membership functions are [a, b, c] = [40 000, 100 000, 200 000].

### 3.3. Fuzzy Model

Now it's time to develop a methodology to process natural queries for TS.

In linguistic features of variables, words play the role of the values of variables and serve as fuzzy constraints at the same time [7]. For example, the fuzzy set *young* plays the role of a fuzzy constraint on the *age* of clients. Our aim is to make explicit the implicit fuzzy constraints, which are resident in a query. In general, a query q in a natural language can be considered as a set of fuzzy constraints. Once we have processed it we get a number of overall fuzzy constraints, which can be represented in the form ***X is R, Y is S…,*** where ***X*** is a constrained criterion variable (e.g. age) which is not explicit in q, and ***R*** is a constraint on that criterion (e.g. young).

For instance, let's consider the simple query: ***not very young males with more-or-less high income***. Notice that some of the variables in a query are crisp, while some have fuzzy constraints as well. Let's assume that the user chose the threshold value specified as a sufficient level of precision. So, we obtain:

$$\textbf{YOUNG[Age; not, very; } \mu_{\text{Total}} \textbf{]} \cap \textbf{ HIGH[Income; more-or-less; } \mu_{\text{Total}} \textbf{]} \cap \textbf{ MALE[Gender; ; } \mu_{\text{Total}} \textbf{ = 1].}$$

One cannot deny that *not very young* and *very not young* are different queries and thus must produce different results. This means that the order is important. Another issue to note is that $\mu_{\text{Total}}$ is a membership value that indicates the degree of membership to *not very young* and *more-or-less high*, not to *young* and *high*. However, in order to obtain the answer we need the membership value that corresponds to *young* and *high*. Due to this fact the process is reversed: before we presented the formulas

to shift to *very young* from *young*. But now, instead, we want to define *young* using *very young*. So, if we squared the value for *young* to get the threshold for *very young*, now we apply the inverse operation – *square root*. Going back to our example, we get:

**YOUNG[Age; very; 1–** $\mu_{\text{Total}}$**]** $\cap$ **HIGH[Income; ;** $\mu_{\text{Total}}^2$**]** $\cap$ **MALE[Gender; ;** $\mu_{\text{Total}}$ **= 1] = YOUNG[Age; ;** $\sqrt{1-\mu_{\text{Total}}}$ **]** $\cap$ **HIGH[Income; ;** $\mu_{\text{Total}}^2$**]** $\cap$ **MALE[Gender; ;** $\mu_{\text{Total}}$ **= 1].**

As regards set operations, if *A* and *B* is fuzzy relations, then disjunction – *or* (union) and conjunction – *and, but* (intersection) are defined, respectively, as max and min [7]:

$$\mu A(x) \cup B(x) = \max\left[\mu A(x), \mu B(x)\right], \quad \mu A(x) \cap B(x) = \min\left[\mu A(x), \mu B(x)\right].$$

Users can express the intersection in 3 ways distinguished by the connective type – *and, but*, or no connective at all, while union is represented only by *or* connective.

It is of interest to note that the threshold used in the system serves as α-cut, which is a crisp set that includes all the members of the given fuzzy subset *f* whose values are not less than α for $0 < \alpha \leq 1$:

$$f_\alpha = \{x : \mu_f(x) \geq \alpha\}.$$

We also know how to connect α-cuts and set operations (let *A* and *B* be fuzzy sets):

$$(A \cup B)_\alpha = A_\alpha \cup B_\alpha, \quad (A \cap B)_\alpha = A_\alpha \cap B_\alpha.$$

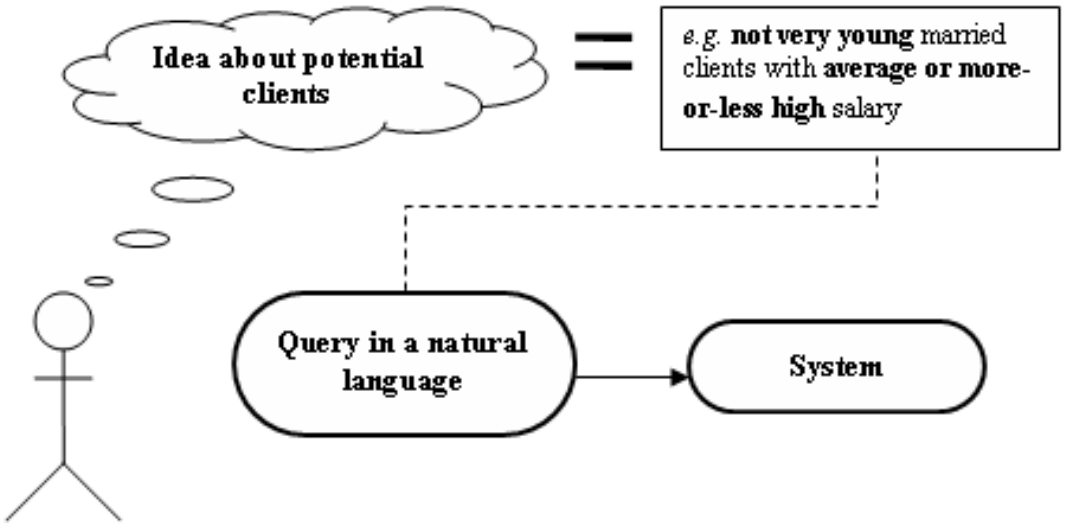


*Figure 6.* The conceptual representation of the model

So, using the formulas provided above, to find the result of a query with a certain threshold – α, containing *or* or *and* operations, we first find the α-cuts and then take the crisp or / and operation

The conceptual representation of the model is illustrated at the left, in figure 6. So, expert forms the idea about potential clients, not a crisp query. The motivation for that is that usually we don't wish to define the clear bounds of acceptance or rejection for a condition, that is, we want to be allowed some imprecision. That is what makes our query natural – imprecision.

## 4. Experiments

In the previous section we've described the fuzzy querying model aimed for target selection. This method can handle various types of queries given in a natural language. So, the main advantage of our system is that the query is done in a natural language. That is very convenient for users, who don't wish to define the clear bounds of acceptance or rejection for a condition, that is, they want to be allowed some imprecision in the query [4]. Another advantage is that existing clients databases do not have to be modified and developers do not have to learn a new query language. Basically, we just have a fuzzy

interface that is used as a top layer, on an existing relational database, so, no modifications on its DBMS were done. Now let's look at the application itself.

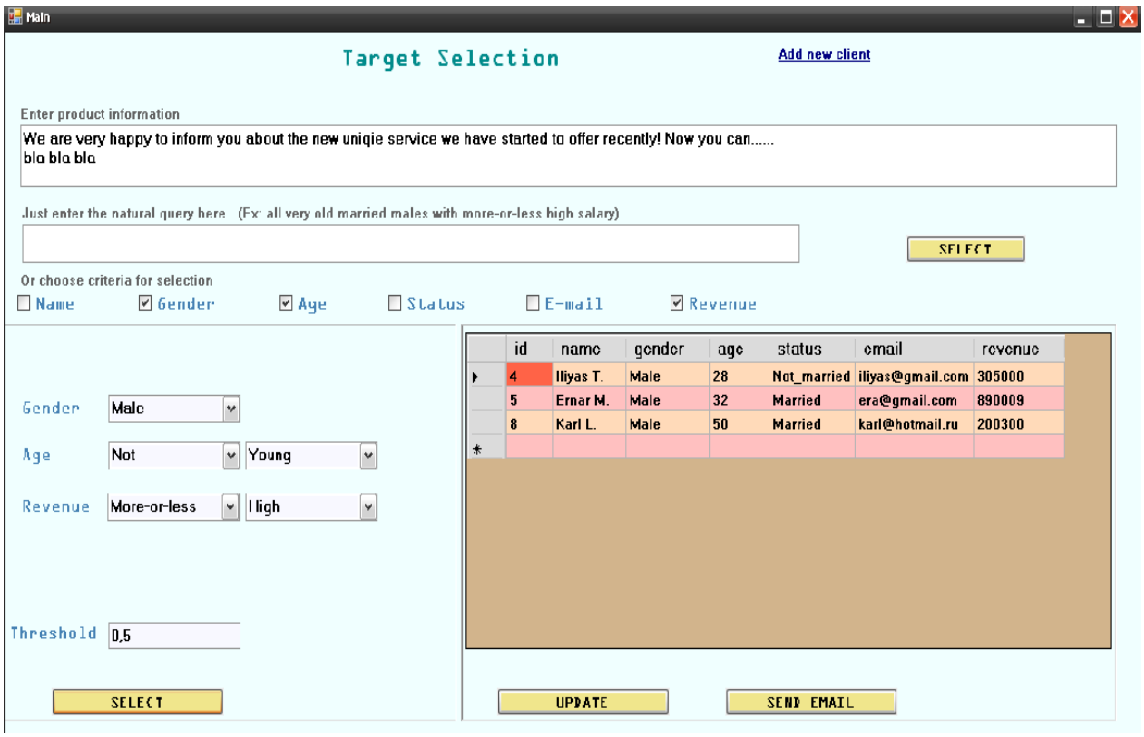


*Figure 7.* The application interface

So, our application enables users to express questions in a natural language, by just entering the query body to the text area. The user then needs to press "select" button in order to see the result set. Our user-interface is very friendly. In case of experiencing some problems while forming a natural query, user can use another menu provided (at the left bottom part). In it the criteria are listed on the screen, and user can just pick and choose which ones he wants. Furthermore, the parameters he chooses appear and he needs to choose needed values (salary: "*very high*", age: "*not old*", etc.) on the respective pull-down menu.

This interface can be used in direct mail – the text of the message is to be inputted to the top text box and then, and then, after pressing the "Send email" button, they will receive the advertising message.

**Table 1**. Sample table for the application

| id | name | gender | age | status | email | revenue |
|---|---|---|---|---|---|---|
| 1 | Pakita S. | Female | 22 | Married | pakita883@... | 105 000 |
| 2 | Tom M. | Male | 23 | Married | tom@gmail... | 120 500 |
| 3 | Akbota S. | Female | 25 | Not_married | akbota@gm... | 70 000 |
| 4 | Iliyas T. | Male | 28 | Not_married | iliyas@gma... | 305 000 |
| 5 | Ernar M. | Male | 32 | Married | era@gmail.... | 890 009 |
| 6 | Kaminari S. | Female | 40 | Married | kaminari@... | 55 000 |
| 7 | Rus K. | Male | 24 | Not_married | rus_kamun... | 200 000 |
| 8 | Karl L. | Male | 50 | Married | karl@hotm... | 200 300 |
| 9 | Amina L. | Female | 74 | Married | amina@ya... | 120 000 |
| 10 | Alan D. | Male | 18 | Not_married | alan@gmai... | 35 000 |
| 11 | Madina D. | Female | 34 | Not_married | madina_@... | 30 000 |
| 12 | Adam S. | Male | 58 | Married | adam@gm... | 42 000 |
| 13 | Alfi A. | Male | 67 | Married | alfi@gmail... | 88 000 |
| 14 | Farida D. | Female | 53 | Not_married | far@mail.c... | 164 000 |
| 15 | Meir A. | Male | 23 | Not_married | meir@g..... | 133 000 |

Now it's time to demonstrate how our application can process natural queries. The sample data table for testing can be seen at the left. The threshold value for 1st and 3rd examples is 0.5, for the 2nd one – 0.7.

**1) *not old* married males with *very high* income.**

As it can be seen, there are two crisp criteria – status is married, gender is male. Besides, there are two fuzzy criteria – age is *not old* and income is *very high.* So, we have:

**OLD[Age; not; $\mu_{Total}$=0.5] ∩ HIGH[Income; very; $\mu_{Total}$=0.5] ∩ MALE[Gender; $\mu_{Total}$ = 1] ∩ MARRIED[Status; $\mu_{Total}$ = 1] = OLD[Age; $\mu_{Total}$=0.5] ∩ HIGH[Income; very; $\mu_{Total} \approx 0.7$] ∩ MALE[Gender; ; $\mu_{Total}$ = 1] ∩ MARRIED[Status;; $\mu_{Total}$ = 1]**.

Next our system finds the constraining values with respect to the thresholds obtained. For the age, it will be "$\leq 50$", for the income - "$\geq$ **170 710** tg.". There are 2 clients satisfying this query:

| id | name | gender | age | status | email | income |
|---|---|---|---|---|---|---|
| 5 | Ernar M. | Male | 32 | Married | era@gmail.com | 890 009 |
| 8 | Karl L. | Male | 50 | Married | karl@hotmail.ru | 200 300 |

**2) *not very young* married clients with *average* or *more-or-less high* salary**

**YOUNG[Age; not, very; $\mu_{Total}$=0.7] ∩ MARRIED[STATUS; ; $\mu_{Total}$=1] ∩ (AVERAGE[Income; ; $\mu_{Total}$=0.7] ∪ HIGH[Income; more-or-less ; $\mu_{Total}$=0.7]) = YOUNG[Age; ; $\mu_{Total} \approx$0.55] ∩ MARRIED[STATUS; ; $\mu_{Total}$=1] ∩ (AVERAGE[Income; ; $\mu_{Total}$=0.7] ∪ HIGH[Income; ; $\mu_{Total}$=0.49])**

| id | name | gender | age | status | email | income |
|---|---|---|---|---|---|---|
| 5 | Ernar M. | Male | 32 | Married | era@gmail.com | 890 009 |
| 8 | Karl L. | Male | 50 | Married | karl@hotmail.ru | 200 300 |
| 9 | Amina L. | Female | 74 | Married | amina@yahoo.com | 120 000 |
| 13 | Alfi A. | Male | 67 | Married | alfi@gmail.com | 88 000 |

One more issue to note, the modifiers can be applied infinitely in any order. Let's demonstrate this by the following example:

**3) *very very very* old or *very very very* young**

| id | name | gender | age | status | email | income |
|---|---|---|---|---|---|---|
| 9 | Amina L. | Female | 74 | Married | amina@yahoo.com | 120 000 |
| 10 | Alan D. | Male | 18 | Not_mar | alan@gmail.com | 35 000 |
| 13 | Alfi A. | Male | 67 | Married | alfi@gmail.com | 88 000 |

No doubts, such type of human oriented interfaces can be very useful for all companies facing the problem of poor target selection.

## 5. Conclusions

The main objective of this research was to show the effectiveness of fuzzy mathematics in natural query processing. Our method allows forming queries in natural language, which is impossible using a standard query mechanism.

In certain areas TS of information from databases has very vague and blurred conditions. Fuzzy natural queries can be very efficient there. Similarly, fuzzy queries can be used in the variety of other fields, namely, in selecting tourist services, real estates, etc. Take for example a person, who is searching for "housing that is *not very expensive* and is *close* to downtown".

There are some plans regarding future improvements, like adding more modifiers, improving a parser in order to handle more complex queries, taking into account the previous sells, etc.

To conclude, the use of natural language in decision problems is highly beneficial when the values cannot be expressed by means of numerical values. Particularly, in situations where information for TS is not precise (which are very common in our real life), fuzzy classification can be a powerful tool that takes the human knowledge as model.

## References

1. Bilgiç, Taner, De Baets, Bernard, Kaynak, Okyay. (2003). Fuzzy Sets and Systems. In Proceedings of the10th International Fuzzy Systems Association World Congress, June 30–July 2, 2003, Istanbul, Turkey: Springer-Verlag Berlin Heidelberg. 736 p.
2. Herrera, F., Herrera-Viedma, E. (2000). Linguistic decision analysis: steps for solving decision problems under linguistic information. Fuzzy Sets and Systems, 115:1, 67–82.
3. Maderia, S., Sousa, M. (2002). Comparison of Target Selection Methods in Direct Marketing. Eunite. Technical University of Lisbon, Instituto Superior T´ecnico, Lisbon.
4. Ribeiro, R. A., Moreira, Ana M. (2003). Fuzzy Query Interface for a Business Database. International Journal of Human-Computer Studies, 58, 363–391.
5. Zadeh, L. A. (1965). Fuzzy sets. Information and Control, 8, 338–353.
6. Zadeh, L. A. (1975). The concept of a linguistic variable and its application to approximate reasoning. Part I. Information Sciences, 8(3), 199–249, 197.
7. Zadeh, L. A. (1996). Fuzzy Logic = Computing with Words. Life Fellow. IEEE Transactions on Fuzzy Systems, 4, 103–111.
8. Zadeh, L. A. (2002). From Computing with Numbers to Computing with Words – from Manipulation of Measurements to Manipulation of Perceptions. Int. J. Appl. Math. Comput. Sci., 12, (307–324).

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# SYNCHRONIZATION BETWEEN DESKTOP APPLICATION AND WEB CLIENTS PROVIDED BY *NODE.JS* SOFTWARE SYSTEM

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IT-market is a very rapidly developing sector in most of the developing and developed countries and in Kazakhstan in particular. According to the statistics, the number of active KazNet users has increased more than twice since 2010, forming 2,150,000 users. Users can more and more often come upon various internet-shops, which are now selling not only software products, but also such products as fruit and vegetables and even more exotic things.

**Keywords:** IT-market, web clients, Node.js, web sockets, TCP, JavaScript, synchronization

## 1. Introduction

Let's have a deeper look at the level of Internet commerce in Kazakhstan and decide what this market is and how it is developing. According to the official data, the market of e-commerce in Kazakhstan formed about $240 million in 2010. Moreover, this market is growing by at least 10% annually. The main factors influencing Internet sales in Kazakhstan are as follows:

- Growth of the amount of active users – Internet is becoming faster and more affordable, resulting in the increase of internet audience;
- Increase of the number and variety of internet-shops – Internet market seeks for new forms, new products and new influence geography;
- Increase of the number of Charge Cards – in accordance with the National Bank of Kazakhstan, the number of Charge Cards is 8.5 million owned by 7.8 million clients;
- Improvement of the legal system for Internet sales.

Despite the big, from the first sight, amount of $240 million, Kazakhstan Internet-market is only at the beginning of its development, placed far from such countries as USA ($150 billion) and even Russia ($5 billion). Nowadays many businesses that are using local information systems would like to expand their businesses to World Wide Web in order to increase the number of potential clients. The businesses like shops do not meet any problems, as the number of Internet-customers is never comparable with the number of physical clients, and the information about the products left in the stock can be updated only once a day. The other businesses must have full synchronization between the procurements made via Internet and the procurements made at a local shop. In order to implement such architecture, an event-driven software system designed for developing scalable applications must be used, and in this paper the author will describe such synchronization on the example of Node.js Software System used for interconnecting a number of desktop applications and web-clients.

## 2. Problem Statement

Let's take the businesses that sell tickets bound to particular places as an example of the ones, which would benefit from the synchronization between their local information system and web clients. The main obstacle for expanding such businesses to World Wide Web is in supplying full synchronization between what is done by the cashbox working inside the institution and web-clients. Before such businesses can provide the service of buying tickets online, they must at avoid many false scenarios, such as buying multiple tickets for the same place in the same event, and others.

From technical point of view, the solution to the problem described above is in using an event-driven software system, which will serve as an intermediate layer between desktop clients (cashboxes inside institutions) and web-clients. There are a number of alternatives for such software systems: Twisted for Python, Perl Object Environment for Perl, libevent for C, EventMachine for Ruby and, finally, Node.js written with Google's V8 JavaScript engine. For the project the author decided to use Node.js system.

*Node.js* is a software system for writing scalable internet applications, notably web servers. In order to minimize overhead and maximize scalability, the system is written with Google's V8 JavaScript engine, using event-driven, asynchronous I/O. The system proves to be stable in more than one hundred Internet projects, being able to broadcast data to 32000 connections in less than 10 seconds. It is not a web-server, but rather a tool for writing web-servers.

## 3. Results and Discussion

An abstract architecture of the system that will solve the problem of synchronization of actions between desktop clients and web clients is described like this:

1. The server located in the institution will be the heart of the system. It will have Node.js-based server running on it. It will process requests from both desktop clients (physically located in the institution) and web clients, and, if required, will broadcast messages to either all or limited number of clients (no matter web or desktop).
2. Data integrity will be provided by limited access to the database: all the operations with database are performed by Node.js. The clients (both desktop clients and web clients) can only send requests with different content to Node.js, while Node.js will process the requests and based on the processing of the request, will either do nothing, or retrieve data from database or write data to database.
3. The communication of desktop clients with the local server is provided by Transmission Control Protocol (TCP).
4. Web clients, in turn, will communicate with the server via WebSocket API.
5. The non-relational database – MongoDB – is used in this project.

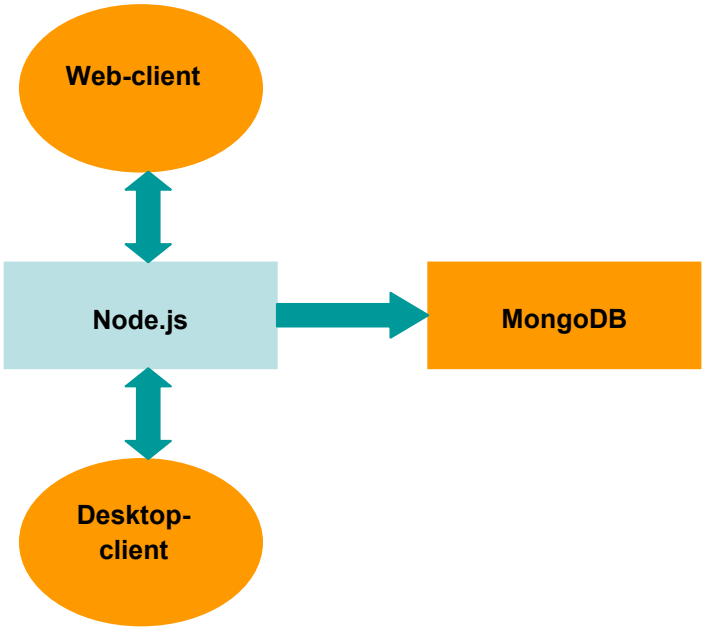


*Figure 1.* Architecture of the system for synchronizing desktop and web clients

WebSocket technology, used in this project for communication of web clients with Node.js, is a relatively new technology that can provide bi-directional channels for communication over TCP socket. It is now being standardized by the World Wide Web Consortium (W3C), and it has already been standardized by a number of other organizations, such as Internet Engineering Task Force (IETF) and

RFC 6455. The API is accessed via Socket.IO library, and it allows communicating with Node.js server using JSON format.

When implementing the system for synchronization of desktop and web clients, choosing right efficient database is a very important issue, and in this case the author has decided to use MongoDB, which is a NoSQL database. The reasons for such an option are the following:

- MongoDB is written with C++, being thread safe and deployable to most of the platforms, such as Window, Mac OS X and Linux;
- Considering the speed issue, key'd updates are comparable with SQL-like databases, while inserting and updating on MongoDB are significantly faster. For ticket-selling systems, a single client can perform up to 3–4 selection and deselection requests per second, and MongoDB copes with this easily;
- It's much easier to distribute the database between multiple servers, as the memory usage is fraction of, for instance, MySQL;
- All the data is stored in BSON ("Binary JSON") format, which is actually native for JavaScript. Moreover, all the communications between Node.js and its clients are in JSON format. So, if some data is requested by clients, the objects can be retrieved from the database and sent to the client instantly, as there is no need to parse data into JSON format.

One of the drawbacks of TCP is that it is not possible to detect connectivity problems without trying to send some data. In order to know exactly, whether the connection between Node.js and a desktop client is alive, the desktop client and the server must send "connection verification" packets to each other. On the other hand, desktop client must be able to send request data to the server and wait until the response data comes. Combining both "connection verification" and request-response communication is impossible for a single TCP connection, as there might be collision of response data from the server. In order to solve this problem, there must be two TCP connections open. The first connection will be responsible for request-response communication, while the second will be responsible for sharing "connection verification" packets as well as for broadcasting messages to all clients – such messages might come at any time and must be processed by the desktop application within a separate thread.

Let's consider the most frequently used operation for a ticket-buying system: selecting a free place, making it unavailable for other clients. This operation can be performed both by web clients and by cashbox clients. When a client clicks on a free place, a request is sent to the server in JSON format. The client does not mark the place as selected until it receives the success response. The server performs required validation, and returns a response with a corresponding status and after this sends a broadcast message to all connected clients, avoiding the client that is trying to select the place. The message is broadcasted in order to informing that the place is now unavailable. In the case when multiple clients click on the same seat simultaneously, the selection will be successful only for the client whose request is received first, while the response for the request that was received later will be with unsuccessful status, as it is not allowed to select unavailable seats.

The core principle for implementing a system that can synchronize desktop and web clients is to provide common interfaces of communication between the server and the clients. Depending on the needs of the system, there can be limitless types of requests processed by Node.js-based server.

## 4. Conclusions

In the process of implementation of the system, the author has tried to make it as scalable as possible, thus it could be used for different businesses with ticket system. The combination of Node.js with fast NoSQL MongoDB database can produce a very stable system, which will be able to process a big number of requests quickly and reliably. The approach described in this paper can be used in a number of businesses, and businesses that sell tickets bound to particular places, in particular. If, for instance, buying tickets is available online, both clients and service providers will benefit from this: businesses will expand their sales by means of the increased audience. Moreover, as all the actions are centralized, it would be possible to provide additional tools based on stored data about all purchases, such as analytics. Speaking of the ordinary users, they might be able to buy tickets for events without wasting much time, as they don't need to leave their homes or working places.

The only drawback of implementing such a system is that it cannot be integrated into existing information system (it can, only if the developers of the system write the implementation of the interfaces

responsible for communication with the local Node.js-based server). Nevertheless, most of the businesses that could use synchronization between desktop and web clients do not have any information system at all. Anyway, it is always possible to implement custom desktop applications for the cashboxes, which will implement all the required interfaces.

## References

1. HicksonI. (2010). *The WebSocket protocol*. Google, Inc.
2. Comer, D. E. (2006). *Interworking with TCP/IP: Principles, Protocols, and Architecture.* (5th edition). New-Jersey: Prentice Hall.
3. Pedro Teixeria. *Hands-on NODE.JS*. Retrieved on May 2, 2011, from http://www.goodreads.com/book/show/12111488-hands-on-node-js
4. Chodorow, Kristina. (May 2011). *50 Tips and Tricks for MongoDB Developers*. USA Sebastopol: O'Reilly Media Inc. 52 p.
5. Thompson, Mick. (August 2011). *Getting Started with GEO, CouchDB and Node.js*. USA Sebastopol CA: O'Reilly Media Inc . 66 p.
6. Banker, Kyle. (December 2011). *MongoDB in Action*. Shelter Island NY, Manning Publications Co. 155 p.

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# DEVELOPMENT OF SOFTWARE FOR PROJECT MANAGEMENT BASED ON *PMBoK*

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Nowadays effective project management leads to success of the project as a whole. Therefore it is very important to know how to manage them in most effective and accurate way. Numerous guides and applications are considered to solve this problem. However variety of software for managing documents electronically and based on specific guide is pure. The purpose of this article is to introduce the developed web application based on PMBoK guide, which simplify project documentation management. The article provides general information about PMBoK guide, methods used in web application development and shows its class diagrams.

**Keywords:** project management, PMBoK, MVC

## 1. Introduction

Today project management in information technologies sphere is the most rapidly developed knowledge area. Therefore wide range of standards, books and guides are published. It is very difficult for beginner project managers to get success in this sphere due to variety of termins and rules. As a rule, it is followed by huge proportion of unfinished projects towards success ones. The solution of this problem is development of conceptually new software for project management based on specific methodology.

First, let me briefly determine termins of project management. According to the PMBoK, a widespread guide among project managers, project is a temporary endeavour undertaken to create a unique product or a service. The fundamental base of every project is the “triangle of the project”. The main purpose of project managers is to do everything to hold the project inside this triangle. The sides of triangle are price, structure of works and time. The project, which was inside of this triangle during the whole its lifecycle, considered as successful project [1, 2].

Unfortunately, it is very difficult to watch after software projects. Therefore it is reasonable to separate them into stages and to provide every step with documentation, because the documentation is one of the most important indicators of the project.

However, project management have experienced project separation into the stages during its history. Thus, these works have been done for us. Our aim is to choose the best one. After examining different guides, the authors have decided that PMBoK guide is the most suitable on this case, because in this guide processes are divided into knowledge areas and groups of processes, which can be successfully applied as a base of web application.

## 2. Project Overview

The main purpose of the tool is development of unified web application which helps to manage projects by simplifying the organization of documents in effective way. The programming language is PHP. Also to provide the extension and integration with other projects the MVC pattern will be used. So its' view and business logic will be separated.

As it was mentioned before, document management providing by application will be based on knowledge areas and process groups in the PMBoK guide. That is, processes will be located in the cells of these concepts intersection. User will allow uploading necessary document into this cell. If user do not know what he should include into the document he will able to download a sample or, in special cases, fill provided forms.


*Figure 1.* The main page of web application

Generally, tool will provide the following functions:

- Authentication;
- Creation of new project;
- Uploading/downloading documents;
- Creation of some specific documents by filling forms;
- Report generation from forms.

## 3. The MVC Pattern Implementation

As it was mentioned before the MVC pattern would be used to build the web application. Let us to briefly introduce this concept.

The MVC (Model-View-Controller) architecture is a way of decomposing an application into three parts: the model, the view and the controller. It was originally applied in the graphical user interaction model of input, processing and output.

A model represents an application's data and contains the logic for accessing and manipulating that data. Any data that is part of the persistent state of the application should reside in the model objects. The services that a model exposes must be generic enough to support a variety of clients. By glancing at the model's public method list, it should be easy to understand how to control the model's behaviour. A model groups related data and operations for providing a specific service; these group of operations wrap and abstract the functionality of the business process being modelled. A model's interface exposes methods for accessing and updating the state of the model and for executing complex processes encapsulated inside the model. Model services are accessed by the controller for either querying or effecting a change in the model state. The model notifies the view when a state change occurs in the model.

The view is responsible for rendering the state of the model. The presentation semantics are encapsulated within the view; therefore model data can be adapted for several different kinds of clients. The view modifies itself when a change in the model is communicated to the view. A view forwards user input to the controller.

The controller is responsible for intercepting and translating user input into actions to be performed by the model. The controller is responsible for selecting the next view based on user input and the outcome of model operations.

The figure below shows the implementation of this concept in the main part of application.

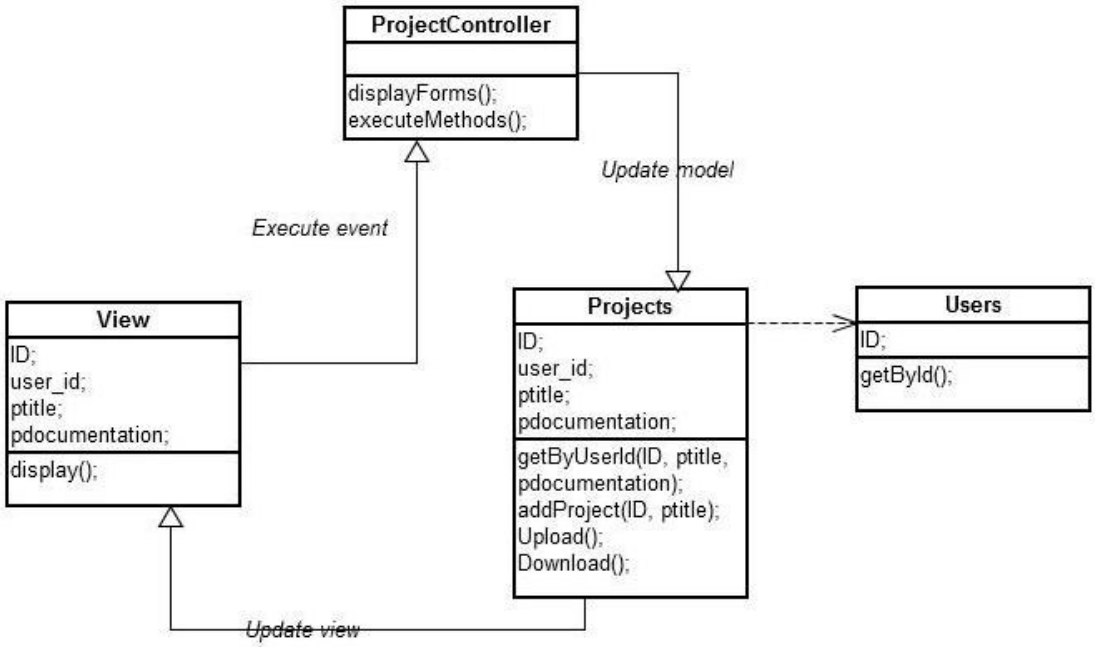


*Figure 2.* The MVC concept in the applications' class diagram

It can be clearly seen from the Figure 2, that the View part of the application only displays data, neither operate with them. It is the part, which interacts with users. All data entered in the view will be passed to Controller class. Controllers connect Model and View. Models are core of the system; its domain logic.

For example, let's see how the list of particular user projects is displayed in our application by using this concept. Firstly, we should define in the model class the method, which gets projects titles of users, by their id.

```
public function getByUserId($user_id)
    {
      $select = $this->select()->where('user_id='.$user_id)->order('id DESC');
      $row = $this->fetchAll($select);
      return $row;
}
```

Then we should implement this method in controller and push results into the view.

```
public function indexAction()
    {
      $projects = new Application_Model_DbTable_Projects();
      $auth = Zend_Auth::getInstance();
      $user_id = $auth->getIdentity()->id;
      $this->view->projects = $projects->getByUserId($user_id);
    }
```

And finally display results in view.


*Figure 3.* The displayed view

```
<?php $auth = Zend_Auth::getInstance();
      if ($auth->hasIdentity()): ?>
  <div id="sidebar">
<ul>
  <li>
  <h3 class = "toggle">My projects</h3>
        <ul>
        <?php if (count($this->projects) < 1) : ?>

                                        <li>No projects</li>
                                <?php else : foreach ($this->projects as $project) : ?>
                                        <li>
                                    <a href="<?php echo $this->url(array('controller' =>
                                'index', 'action' => 'project', 'id' => $project->id)) ?>">
                        <?php echo $this->escape($project->ptitle) ?></a>
                </li>
<?php endforeach; endif;  ?>
```

Benefits of the MVC concepts are the following:

1. Code reuse – Separation of concern principle will provide code reusability as the design will have proper domain model and business logic in its logical unit.
2. Adaptable design – A good design is close for changes and open for additions. Isolated code in presenter/controller, domain model, view and data access provide a freedom of choosing a number of views and data sources.
3. Layering – MVC/MVP forces to separate data access login for the other layers and various other patterns would be opted to implement data access layer.
4. Test driven approach – Isolated implementation allows testing each component separately. Especially in MVP pattern that uses interface for a view, it is a true test driven approach.

## 4. Conclusions

The Republic of Kazakhstan is one of the most rapidly developed countries in information technology. However, most of companies, government structures use software, which has been developed in the foreign countries. This application will be one of the first domestic applications for project management. Despite its simplicity, it covers all complex PMBoK concepts. The application helps to manage projects documentation as well, so as helps to understand PMBoK.

In conclusion, software for project management is universal instrument of effective project management, The MVC pattern, which is used to develop this application, provides possibility to extension of tool. In future it can be upgraded by adding such functionalities as risk analysis, planning, cost estimation, etc. The user of the application takes such benefits, as a hard disk memory economy and an accurate document management.

## References

1. PMI Standard Committee. (2008). *A guide to the project management body of knowledges*. PMBoK Guide, 4th.ed. Ch. 1, 5. Project Management Institute, Inc. http://en.wikipedia.org/wiki/A_Guide_to_the_Project_Management_Body_of_Knowledge, 22.04.2012). A Guide to the Project Management Body of Knowledge Project Management Institute (Corporate Author). USA, Pennsylvania Project Management Institute. 2008
2. Selihovkin, I. (2010). *IT-project management. Effective way from the scratch* (pp. 8–9). St. Petersburg: Books.Ru.Ltdr.
3. Governance Institute. (2008). Aligning CobiT 4.1, ITIL V3 and ISO/IEC 27002 for Business Benefit (pp. 90–128). Rolling Meadows, IL 60008 USA: IT Governance Institute http://www.isaca.org/Knowledge-Center/Research/Documents/Aligning-COBIT,ITILV3,ISO27002-Bus-Benefit-12Nov08-Research.pdf (22.04.2012).

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# RESEARCH OF RELIABILITY OF DISTRIBUTED COMPUTER SYSTEM

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Development and improvement of distributed computer systems (DCS) is one of the general trends in nowadays' computer science and information processing. The core of such systems is a set of processor's modules (PM), carrying out a parallel processing of the information and cooperating by means of any subsystem of communication.

**Keywords:** distributed computer systems (DCS), processor's modules (PM)

## 1. Introduction

As a rule, modern information and operating systems concern distributed computer systems (DCS).

Today they became the integral component of responsible technical complexes:

it's impossible to operate without such a system, its subitaneous trapping leads to a full stop of operated object at the best (frequently at the big material losses), and to failures with catastrophic consequences at worst.

The requirement of extremely high reliability of distributed computer systems that is a part of such technical complexes as technological installations, power supply systems, communication systems and transport, aerospace systems, etc., is obvious but not easily achievable.

The chain of severe accidents proceeds, despite of continuous improvement of quality and reliability of components of distributed computer systems (DCS), even at their careful selection for applications.

It means that as a result of extremely rapid growth of complexity of DCS, an increase of reliability of the integrated circuit can't solve completely a problem of their reliability if the structure of RVS is that a unique element is detected all system does not operate.

So, it is supposed that attempts to "close" a reliability problem, based on a technological progress, is not possible. It is obvious that to solve a problem of reliability of the real difficult systems without mentioning their structure and the organization of operations is impossible.

The decision of this problem lies on a way of creation of failure-safe systems, i.e. the systems are capable to carry out the functions, and it is possible with admissible loss of quality, at refusals of certain number of elements.

In this direction (certainly, at the account of achievements of technology system of large information systems), all basic researches and elaborating in the field of creation of highly reliable systems are conducted.

It is important to notice that the leading foreign companies that create responsible operating and information systems pay a paramount attention to a fault tolerance problem

Certainly, there are traditional methods of construction failure-safe (distributed or not distributed) computing systems in practice.

These methods take an important and strong place both in practice and in the new advanced projects which have emerged and developed for all time of existence of computer facilities and programming.

Among traditional methods there are the following:

- Various kinds of reservation.
- *N*-modular redundancy with voting.
- Duplication of processor modules with comparison of results, etc.

These methods are improved and developed at present. However, in the pure state they don't take into account distribution of structure of the modern DCS that contain a "natural" hardware and a time redundancy which can be used for fault tolerance maintenance.

In consequence of at high requirements to reliability of DCS an application of these methods leads to excessive redundancy and the big additional expenses, and often doesn't allow to reach the requirements of reliability at a set of cost, hardware, weight -dimensional, technological and other restrictions.

This circumstance stimulates development of such approaches to construction failure-safe of DCS which consider their structural and functional distribution and allow using the natural superfluous resources which are a consequence of a distribution.

It is reached by flexible change of a structure of DCS at its processor modulus cut-off. The purpose of this structure is to block of the refused processor modules and redistribution of objectives between not refused processor modules.

An admissibility of functioning of DCS with the indicators of quality worsened in the prescribed limits ("gradual degradation") is taking into account.

Sufficiently large quantity of researches is executed and a number of practical workings out are created in this direction.

However, the integral concept of failure-safe of DCS on the basis of these properties has started only last years. Models and methods of rational (i.e. optimized) redistributions of problems at processor modulus cut-off occupy an important place.

In the given work the followings are done:

- The basic categories of the fault tolerance of DCS are systematized.
- Fundamentals of the concept of construction failure-safe of DCS on the basis of rational redistribution of problems and reconfiguration of system structures at the account of an admissibility of its gradual degradation are considered.
- A number of the methods developed within the limits of given concepts of construction failure-safe of DCS.
- Possible variants of an estimation of reliability are resulted by a method of imitating modelling and their comparison.
- The choice of the most perspective variants for realization is stipulated.

## 2. Reliability Evaluation of Distributed Computer Systems Using Simulation Modelling

Simulation modelling is used intensively in DCS design stage for the following tasks:

- prediction the performance of the system followed by analysis of its structure;
- the development and debugging of distributed programs on a detailed model of the equipment;
- verification of logical properties of parallel algorithms on the basis of the same description of the system;
- optimization of the DCS structure on a given criterion.

Since, as seen at the design stage model is created that takes into account the structure of developed DCS, as well as hardware and software components of the system, then there is the idea of using this simulation model to assess the reliability of the DCS.

The main stages of a simulation experiment:

- A description of the model;
- Run the model (simulation);
- Analysis and interpretation of experimental results;
- We estimate the necessary changes to the scheme of simulation experiments to assess the reliability at each stage.

For further consideration we should distinguish between two possible options of initial data on the reliability of the system components:

- Absence of reliability characteristics of some components;
- Full availability of DCS components' reliability characteristics.

It should be noted that at the stage of designing the first situation occurs quite often. This happens because the hardware components of DCS at the design stage may not yet exist.

If at the second case we can develop the existing methods for assessing the reliability, at the first it is necessary to use an entirely new methods. The possible approaches are shown at Figure 1 and described below.

### 2.1. Fault Injection Methods

As one of the methods of solving the problem of reliability evaluation in case of absence of certain components' characteristics it is proposed to adapt a method of Fault Injection. The point of fault injection methods is to conduct a special test of software and hardware part of the DCS. This testing is performed by faults injection in the software or hardware parts of the system, followed by consideration of the ability or inability of the system to detect and eliminate this failure. In fact, in this way we test the effectiveness of fault tolerance mechanisms used in the system. This approach was used to study the reliability of Ericsson's telephone networks.

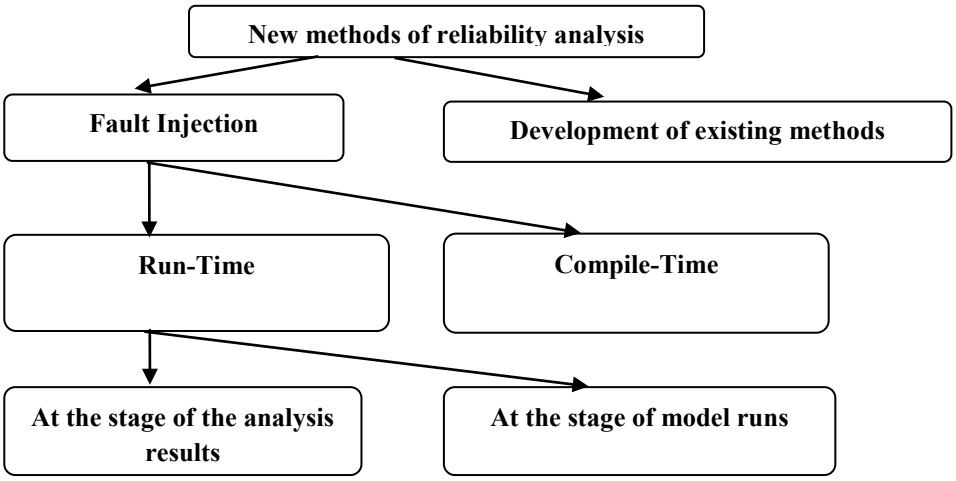


*Figure 1.* Suggested approaches for reliability analysis

Fault injection methods can be divided into the two groups of Run-time and Compile – time. In the methods of compile-time failure is injected directly into the description of the system, and at the methods of run-time in the system during its operation. These methods are actually used to assess the reliability of full-scale software and hardware, let's consider the possibility of using these methods for models of software and hardware. Adapted methods of failure injection must meet the following requirements. First, the initial model to assess the reliability must change minimally, and secondly, the reliability characteristics obtained in the simulation, should give a smaller error compared to the actual values than in existing methods.

In applying compile – time method for the problem of assessing DCS reliability there will be need to inject changes to the model at the stage of model description. These changes depending on the type of failure should be entered either into the description of the equipment in the simulation model, or in a description of applied load. This method is labour intensive in terms of writing code and the subsequent compilations and model runs. Also, while using this method when you change the structure of the model you have to rewrite that part, which models the system reliability.

In applying run-time method for the problem of assessing DCS reliability there will be need to inject changes either on the stage of model running or on the stage of simulation results analysis.

In applying changes on the stage of models running there will be need to significantly change of that part of the simulation environment, which is responsible for the simulation of described models. The main drawback of this method is that in case of necessity to test the stability of the system to a new type of failures you will have to remake "heart" of simulation modelling environment. The apparent advantage of this approach is that models that do not require evaluation of reliability, the availability of certain features in a simulation environment related to the assessment of reliability will not be noticeable and in the case of rewriting the model, in contrast to the method of compile-time, will not need to rewrite the code associated with the assessment of reliability.

DCS failures injection on the stage of the analysis of simulation results in the first place means the implementation of changes to the route obtained after running the model. The method of analysis of simulation results is the least labour-intensive than other approaches discussed, but in such approach there is no feedback from the simulation, in the other words it is impossible to simulate the operation of the system during working of fault-tolerant algorithms.

Comparing these methods it can be seen that the method of compile – time is more accurate than the other two. This is due to the fact that in the method of introducing changes on the route analysis stage, as shown above, possibility of fault-tolerant algorithms using is not supported, and at the method of introducing changes at the models running stage known to the author the simulation environment does not support dynamic reconfiguration of the system being modelled.

### 2.2. Development of the Existing Methods

In the case when at least one of the common characteristics of the reliability of all hardware components is known, it is possible to evaluate not only the effectiveness of fault tolerance mechanisms, but also quantitatively calculate the reliability of the DCS.

Let's consider the possibility of using simulation in conjunction with the method calculating the reliability by the structural graph of the system hardware. In this case, the simulation allows you to collect data on the utilization of hardware components that are used to determine the weight with which to consider this or any other hardware in the calculation of reliability, and failure injection method refines the data load.

That is, initially allocated system resources, which are known for reliability characteristics. Then, a run of the model is performed, where the route is gathered. From the route information about utilization of resources is gathered. This information is used to calculate the reliability of a structural graph of the system.

Such a hybrid method for estimating reliability is more accurate than existing methods for estimating reliability. At the same time, a priori, it is rather difficult to compare it with proposed failure injunction methods.

## 3. Comparison of the Proposed Methods with Existing

Reliability of DCS depends on the reliability of its individual components, as well as on those taken in the design decisions.

These decisions include:

- the possible reservation of one or more devices;
- the ability to dynamically reconfigure the system;
- diagnostic testing during system operation;
- the use of fault-tolerant algorithms.

The last three types of design decisions require consideration of software's dynamics.

Despite a number of advantages, none of the existing evaluating reliability methods does support all possible design decisions for improving reliability. Thus it is supposed to use one of above methods for reliability research instead of traditional methods. Also one of the advantages of the proposed methods is to use a single mechanism for describing a computer system, as for the problem of reliability assessment, so for the tasks of evaluation the performance and logical analysis.

## 4. Conclusions and Prospects

This paper presents the possible modern approaches to assessing the reliability of the DCS. The possible options for adapting of these approaches to assess the reliability of the DCS in the case of simulation of researched system are given. Advantages and disadvantages of proposed approaches are shown. In the course of the research there are identified possible methods for implementation (the method of compile-time, the methods of failures injection, and run-time and hybrid methods for assessing the reliability).

The author has partially implemented a hybrid method, which develops a method for calculating the reliability by system's structural graph and possible applicability of a distributed computing system to the problem of estimating the reliability is shown.

The following areas can be pointed as immediate prospects of development:

- mathematical formalization and rigorous justification of the correctness of the selected methods to assess reliability;
- software implementation of the selected methods within a framework of unified approach, at that, at first it is necessary to implement a hybrid method and the method of faults injection on the stage of results analysis, due to their lower laboriousness;
- comparison of results of evaluating the reliability regarding the proposed approaches with the results of existing methods and the real got results.

## References

1. Bolognesi, T., Brinksma, E. (1987). Introduction to the ISO specification language LOTOS. *Computer Networks,* 14(1), 25–59.
2. Haupt, T., Pierce, M. E. (2003). Distributed object-based Grid computing environments. In *Grid Computing: Making the Global Infrastructure a Reality* (pp. 713–728). New York: Wiley & Sons.
3. Bonner, A., Kifer, M. (1998). A logic for programming database transactions. In *Logics for Databases and Information Systems* (pp. 117–166). Amsterdam: Kluwer Academic Publishers.

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# CALCULATION OF COMPOSITE PLATES OF VARIABLE THICKNESS AND FOLD IN ACTION RADIAL FORCE

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The problem of the symmetric deformation of an elastic composite circular plate, a radially variable thickness, which is generally subjected to a transverse load, the radial forces experienced uneven heating.

**Keywords:** bending, composite plate, boundary value problem, bending moment

## 1. Introduction

The problem of the symmetric deformation of an elastic composite circular plate, a radially variable thickness, which is generally subjected to a transverse load, the radial forces experienced uneven heating. The system of resolving equations describing this problem, we make based on the theory of symmetric-deformed shallow shells of revolution with respect to two unknown meridian efforts and angular displacement. This choice of the unknown provides a relatively simple form of the resolving equations.

## 2. Model

The differential equation is quasi-static form:

$$\frac{d^2\vartheta_1}{dr^2}+\left(\frac{1}{r}+\frac{1}{D_{1M}}\frac{dD_{1M}}{dr}\right)\frac{d\vartheta_1}{dr}+\left(\frac{\nu}{rD_{1M}}\frac{dD_{1M}}{dr}-\frac{1}{r^2}\right)\vartheta_1+\frac{1}{rD_{1M}}\left(\int q_1 r dr - C\right)-$$
$$-\frac{1+\nu}{D_{1M}}\frac{d}{dr}\left(\chi_{1T}D_{2M}\right)=0, \qquad (1)$$
$$\frac{d^2\vartheta_2}{dr^2}+\left(\frac{1}{r}+\frac{1}{D_{2M}}\frac{dD_{2M}}{dr}\right)\frac{d\vartheta_2}{dr}+\left(\frac{\nu}{rD_{2M}}\frac{dD_{2M}}{dr}-\frac{1}{r^2}\right)\vartheta_2+\frac{1}{rD_{2M}}\left(\int q_2 r dr - C\right)-$$
$$-\frac{1+\nu}{D_{2M}}\frac{d}{dr}\left(\chi_{2T}D_{2M}\right)=0.$$

We obtain the following solution by taking into account the conditions $q_z = q; q_1 = q_2 = \ldots = 0$.

$$\vartheta_2 = B_2 - \frac{A_2}{3r^3}+\frac{1}{3r^3}\left\{\nu\sum\left[\ln\frac{D(r_k)}{D_0}r_{k-1}^3\vartheta(r_{k-1})H(r-r_{k-1})-\ln\frac{D(r_k)}{D_0}r_k^3\vartheta(r_k)H(r-r_k)\right]+\right.$$
$$\left.+\sum\left[\left(\frac{1}{r_k}\right)r_{k-1}^4\vartheta(r_{k-1})H(r-r_{k-1})-\left(\frac{1}{r_k}\right)r_k^4\vartheta(r_k)H(r-r_k)\right]\right\}-\frac{q_0 r_0^2}{2D_0}\left[\frac{r_0^3}{2r^2}+\frac{1}{3}\ln\frac{r}{r_0}\right]-\frac{Qr_0^4}{2D_0 r^2}, \qquad (2)$$

$$\vartheta_1 = B_1 + A_1 r_0 \left[ \ln \frac{r}{r_0\left(1-\frac{r}{r_0}\right)} + \frac{1}{\left(1-\frac{r}{r_0}\right)} + \frac{1}{2\left(1-\frac{r}{r_0}\right)^2} \right] + \frac{q_0 r_0^3}{6D_0}\left[ \frac{r_0^2}{(r_0-r)^2} + \frac{2r_0}{r_0-r} + \ln\left(1-\frac{r}{r_0}\right) \right] + \frac{Qr_0^4}{(r_0-r)^3} -$$

$$-J_1(r)\left\{ v\sum\left[ \ln \frac{D(r_k)}{D_0}\frac{\vartheta(r_{k-1})}{r_0}\left(1-\frac{r_{k-1}}{r_0}\right)^3 H(r-r_{k-1}) - \ln \frac{D(r_k)}{D_0}\frac{\vartheta(r_k)}{r_0}\left(1-\frac{r_k}{r_0}\right)^3 H(r-r_0) \right] + \right.$$

$$\left. + \sum\left[ \left(\frac{1}{r_k}\right)\frac{r_{k-1}}{r_0}\left(1-\frac{r_{k-1}}{r_0}\right)^3 \vartheta(r_{k-1}) H(r-r_{k-1}) - \left(\frac{1}{r_k}\right)\frac{r_k}{r_0}\left(1-\frac{r_k}{r_0}\right)^3 \vartheta(r_{k1}) H(r-r_k) \right] \right\}, \quad (3)$$

where A1, B1 and A2, B2 – integration constants determined from boundary conditions.

Expressions (2)–(3) represent the general solution of the problem in the sense that the A1, B1 and A, are not yet defined, and that the deformation temperature heating loads defined in general terms.

Here we consider the specific laws of change of external influences; secondly, bending of non-uniform composite plates with variable thickness with a hole in a non-uniform temperature field. Allowing the differential equation of the problem is (1).

The boundary condition we assume in the form:

$$\left.\begin{array}{ll} M_1(r_1) = M_2(r_1) & \vartheta_1(0{,}1r_0) = 0 \\ \vartheta_1(r_1) = \vartheta_1(r_1) & M(r_2) = 0 \end{array}\right\}. \quad (4)$$

Consider the solution of (2)–(4), a composite circular plate with a radially variable thickness rigidly clamped inner loop, loaded evenly distributed over its surface, the intensity of the transverse forces and uniformly distributed on its outer contour of the transverse force Q. The impact of symmetrically distributed in the median plane of the shear force intensity is given by the expression:

$$q_z = \sum q_j r^j = q_0 + q_1 r + q_2 r^2 + \ldots\ldots, \; C = 0{,}5 q_0 r_0^2 + Q r_0.$$

Then

$$\vartheta_1(r) = -0{,}512\frac{q_0 r_0^3}{D_0} - 0{,}7957\frac{Qr_0^2}{D_0} - \left(0{,}1583\frac{q_0 r_0^2}{D_0} + 0{,}3805\frac{Qr_0}{D_0}\right) r_0 \left[ \ln\frac{r}{r_0-r} + \frac{r}{r_0-r} + \frac{2_0^2}{2(r_0-r)^2} \right] -$$

$$-I_1(r)\left\{ \sum\left[ \left(\frac{1}{r_k}\right)\frac{r_{k-1}}{r_0}\left(1-\frac{r_{k-1}}{r_0}\right)\vartheta(r_{k-1}) H(r-r_{k-1}) - \left(\frac{1}{r_k}\right)\frac{r_k}{r_0}\left(1-\frac{r_k}{r_0}\right)^3 \vartheta(r_k) H(r-r_k) \right] + \right.$$

$$\left. + \sum\left[ \ln\frac{D(r_k)}{D_0}\frac{\vartheta(r_{k+1})}{r_0}\left(1-\frac{1_{k-1}}{r_0}\right)^3 H(r-r_{k-1}) - \ln\frac{D(r_k)}{D_0}\frac{\vartheta(r_k)}{r_0}\left(1-\frac{1_k}{r_0}\right)^3 H(r-r_k) \right] \right\} +$$

$$+ \frac{q_0 r_0^3}{6D_0}\left[ \frac{r_0^2}{(r_0-r)^2} + \frac{2r_{0r^2}}{r_0-r} + \partial m\left(1-\frac{\kappa}{\kappa_0}\right) + \frac{Qr_0^4}{2B_0(r_0-r)_m^2} \right], \quad (5)$$

$$\vartheta_2 = -0{,}512\frac{q_0 r_0^3}{D_0} - 1{,}7562\frac{Qr_0^2}{D_0} + \frac{1}{3r^3}\left(-0{,}2\frac{q_0 r_0^2}{D_0} - 0{,}3805\frac{Qr_0^2}{D_0}\right) +$$
$$+ \frac{1}{3r^3}\left\{\nu\sum\left[\ln\frac{D(r_k)}{D_0} r_{k-1}^3 \vartheta(r_{k-1}) H(r-r_{k-1}) - \ln\frac{D(r_k)}{D_0} r_k^3 \vartheta(r_k) H(r-r_k)\right] +\right.$$
$$\left. + \sum\left[\left(\frac{1}{r_k}\right) r_{k-1}^4 \vartheta(r_{k-1}) H(r-r_{k-1}) - \left(\frac{1}{r_k}\right) r_k^4 \vartheta(r_k) H(r-r_k)\right]\right\} + \frac{q_0 r_0^3}{2D_{02}}\left(\frac{r_0^2}{2r^2} + \frac{1}{3}\ln\frac{r}{r_0}\right) - \frac{Qr_0^4}{2D_0 r^2}. \qquad (6)$$

For bending moments will be as follows:

$$M_{1r} = D\left\{-\frac{r_0^4}{r(r_0-r)^3}\left(0{,}1583\frac{q_0 r_0^2}{D_0} + 0{,}3805\frac{Qr_0}{D_0}\right) -\right.$$
$$- \frac{r_0^4}{r(r_0-r)^3}\left(\nu\sum\left[\ln\frac{D(r_k)}{D_0}\frac{\vartheta(r_{k-1})}{r_0}\left(1-\frac{r_{h-1}}{r_0}\right)^3 H(r-r_{k-1}) - \ln\frac{D(r_k)}{D_0}\frac{\vartheta(r_k)}{r_0}\left(1-\frac{r_h}{r_0}\right)^3 H(r-r_k)\right]\right) +$$
$$+ \sum\left[\left(\frac{1}{r_k}\right)\frac{r_{k-1}}{r_0}\left(1-\frac{r_{h-1}}{r_0}\right)^3 \vartheta(r_{k-1}) H(r-r_{k-1}) - \left(\frac{1}{r_k}\right)\frac{r_k}{r_0}\left(1-\frac{r_h}{r_0}\right)^3 \vartheta(r_k) H(r-r_k)\right]\Bigg)$$
$$\frac{\nu}{r}\left[-0{,}63278\frac{q_0 r_0^3}{D_0} - 0{,}7957\frac{Qr_0^2}{D_0} - \left(-0{,}1583\frac{q_0 r_0^2}{D_0} - 0{,}3805\frac{Qr_0^2}{D_0}\right) I_1(r)\right] +$$
$$+ \frac{\nu}{r}\left(\frac{q_0 r_0^3}{6D_0}\left[\frac{r_0^2}{(r_0-r)^2} + \frac{r_0}{r_0-r} + \ln\left(1-\frac{r}{r_0}\right)\right] + \frac{Qr_0^4}{2(r_0-r)D_0}\right) -$$
$$\left. - \frac{\nu}{r} I_1(r)\left(\nu\sum\left[\ln\frac{D(r_k)}{D_0}\frac{\vartheta(r_{k-1})}{r_0}\left(1-\frac{r_{h-1}}{r_0}\right)^3 H(r-r_{k-1}) - \ln\frac{D(r_k)}{D_0}\frac{\vartheta(r_k)}{r_0}\left(1-\frac{r_k}{r_0}\right)^3 H(r-r_k)\right]\right)\right\} +$$
$$+ \sum\left[\left(\frac{1}{r_k}\right)\frac{r_{k-1}}{r_0}\left(1-\frac{r_{h-1}}{r_0}\right)^3 \vartheta(r_{k-1}) H(r-r_{k-1}) - \left(\frac{1}{r_k}\right)\frac{r_k}{r_0}\left(1-\frac{r_h}{r_0}\right)^3 \vartheta(r_k) H(r-r_k)\right], \qquad (7)$$

$$M_{2r} = D\left\{-\frac{1}{r^4}\left(0{,}2\frac{q_0 r_0^2}{D_0} + 0{,}3805\frac{Qr_0}{D_0}\right)\right\} + \frac{q_0 r_0^2}{2D_0}\left(\frac{r_0^3}{r^3} - \frac{r_0}{3r}\right) + \frac{Qr_0^4}{D_0 r^3} -$$
$$- \frac{1}{r^4}\left(\nu\sum\left[\ln\frac{D(r_k)}{D_0} r_{k-1}^3 \vartheta(r_{k-1}) H(r-r_{k-1}) - \ln\frac{D(r_k)}{D_0} r_k^3 \vartheta(r_k) H(r-r_k)\right]\right) +$$
$$+ \sum\left[\left(\frac{1}{r_k}\right) r_{k-1}^4 \vartheta(r_{k-1}) H(r-r_{k-1}) - \left(\frac{1}{r_k}\right) r_k^4 \vartheta(r_k) H(r-r_k)\right]\Bigg) +$$
$$+ \frac{\nu}{r}\left[-0{,}512\frac{q_0 r_0^3}{D_0} - 1{,}756\frac{Qr_0^2}{D_0} + \frac{1}{3r^3}\left(0{,}2\frac{q_0 r_0^2}{D_0} + 0{,}3805\frac{Qr_0}{D_0}\right)\right] +$$
$$+ \frac{\nu}{3r^4}\left(\nu\sum\left[\ln\frac{D(r_k)}{D_0} r_{k-1}^3 \vartheta(r_{k-1}) H(r-r_{k-1}) - \ln\frac{D(r_k)}{D_0} r_0^3 \vartheta(r_k) H(r-r_k)\right]\right) +$$
$$+ \sum\left[\left(\frac{1}{r_k}\right) r_{k-1}^4 \vartheta(r_{k-1}) H(r-r_{k-1}) - \left(\frac{1}{r_k}\right) r_k^4 \vartheta(r_k) H(r-r_k)\right]\Bigg) -$$
$$- \frac{\nu}{r}\left[\frac{q_0 r_0^3}{2D_0}\left(\frac{r_0^2}{2r^2} + \frac{1}{3}\ln\frac{r}{r_0}\right) - \frac{Qr_0^4}{2D_0 r^2}\right]. \qquad (8)$$

The results of specific calculations represent graphically bending moments under the action of shear force and transverse force of intensity $Q$.

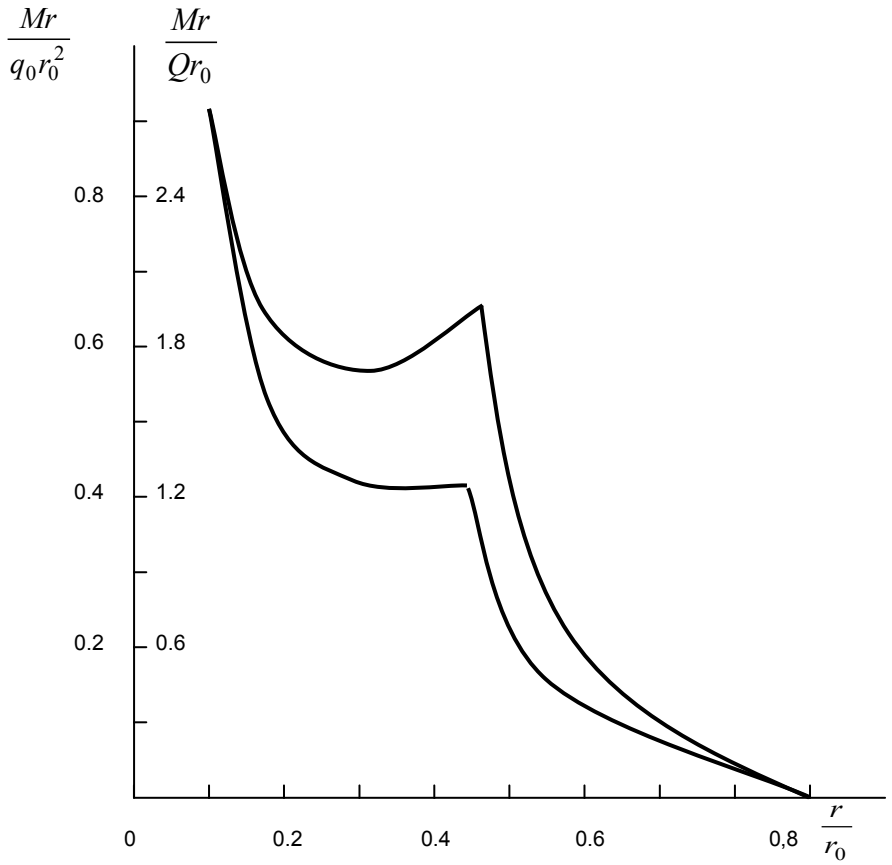


*Figure 1.* Bending moments under the action of shear force and transverse force of intensity $Q$

## 3. Conclusions

Figure 1 shows the curves for the variation of the radial moments for composite plates during loading and the intensity of the transverse forces are uniformly distributed over its outer contour of the transverse force Q. On the curves clearly stand out kinks in the curves interface.

## References

1. Tyurehodzhaev, A. N., Kasabekov, S. I. (1997). Method of investigating heterogeneous thermoelastic stresses, round plates, solid and full cylinders, shells of revolution. In Abstracts of International Scientific Conference "Modern Problems of Rock Mechanics", (pp. 127–128). Almaty: Modern Problems of Rock Mechanics (20–22 May 1997, Almaty, Kazakhstan, Karaganda State Technical University, 1997).
2. Kovalenko, A. D. (1959). *Circular plates of variable thickness*. Moscow: Moscow Publishing House, Physical and Mathematical Literature.
3. Mikeladze, M. (1953). Elastic-plastic deformations in rapidly rotating disk of variable thickness. *Ing. Sat*, USSR Academy of Sciences, XV, 1, 21–24.
4. Colin, K. (1996). *The course in computer science education: present state and prospects of development / systems / tools, and computer science,* No. 8. Moscow: Nauka.
5. Bazhenov, I. (2003). *YU Delphi 7 tutorial programmer.* Moscow: KUDITS-WAY.

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# SUSTAINABLE ENERGY USE: *PROSPECTS OF BIOFUEL*

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This paper aims to examine benefits and threats of first-generation biofuels and discuss the potential of advanced, more sustainable next generation biofuels to offer promising potential to address energy security issues.

**Keywords:** biofuel, first-generation ligno-cellulosic biofuels, second generation biofuels, third generation algae-based biofuels

## 1. Introduction

Recent concern over depleting petroleum reserves and anthropogenic climate change has increased effort to develop new technologies and focus on the renewable energy sector. Assuming the rapidly rising energy demand, which is expected to double by 2050, biofuels can play an important role in the global energy market [1]. Biofuels are produced from photosynthetic material converted into solid (biochar), liquid (bioethanol, vegetable oil and biodiesel) and gaseous (biogas, biosyngas and biohydrogen) fuels.

Currently, biofuel represents 14% of primary energy consumption in the world and is the largest contributor amongst renewable energy sources [2]. The biofuels industry has significantly expanded over the last decade and received high attention in both developed and developing countries (Fig. 1).

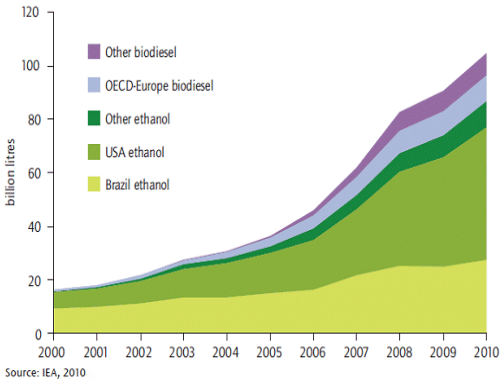


*Figure 1.* Global biofuel production (IEA, 2010)

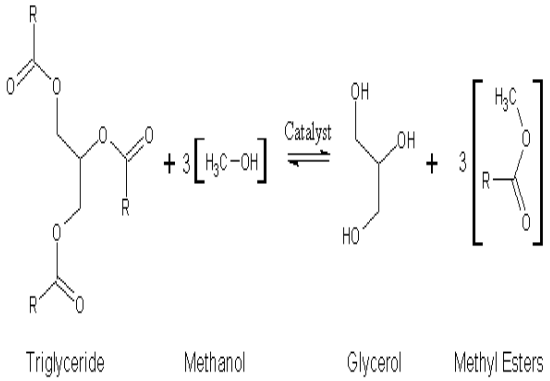


*Figure 2.* Generic trans-esterification reaction between vegetable oil (triglyceride) and alcohol

Although biofuels have the potential to reduce reliance on fossil fuels and cut $CO_2$ emission, not all biofuel types are equally efficient and secure [1]. For instance, first generation biofuels produced from food crops and vegetable oils can provide carbon benefits, but their sustainability is questioned over concerns relating to nitrous oxide emissions released upon combustion, the competition for land with the agricultural sector and the biodiversity threats due to land use change [3]. Thus, first-generation biofuels cannot be part of a cost-efficient emission abatement strategy and require novel, sustainable alternatives.

The current energy research is focused on advanced, so-called next generation biofuels, mainly produced from lignocellulosic non-food materials, e.g. cellulosic ethanol, Fischer-Tropsch fuels and algae-based biofuels [3]. Their production appears to be more sustainable, as it does not interfere with food supplies and can make use of abandoned lands to avoid land clearing. In addition, they may consume agricultural residue feedstock and contribute to bio-waste reduction. Although, next generation biofuels are not yet available on a commercial scale, pilot projects have proved their cost-efficiency and comparability to high quality conventional fossil fuels, such as petrol and diesel [4].

This paper aims to examine benefits and threats of first-generation biofuels and discuss the potential of advanced, more sustainable next generation biofuels to offer promising potential to address energy security issues.

## 2. Benefits and Threats of First Generation Biofuels

First generation biofuels have been considered for a long time as prominent alternatives to conventional fossil fuels which have the potential to provide energy security, carbon savings, reduced reliance on crude oil imports and rural development opportunities [4].

The most important and competitive liquid transport biofuels are biodiesel with a potential to replace petroleum diesel and bioethanol as a gasoline substitute. Biodiesel is produced through trans-esterification of vegetable oils, e.g. rapeseed, jatropha and palm oil, animal fats or waste cooking oil, in the presence of a catalyst (Fig. 2). The reaction also produces a valuable co-product glycerol which is used in food industry and medicine [5].

Biodiesel can be used directly as a car fuel with some engine modifications, or blended with petroleum diesel. To date, the cost of biodiesel production remains fairly high, but it can be reduced by developing more advanced innovative technologies, using co-solvents to facilitate the processing of the reaction and increasing feedstock yields [6]. The market for biodiesel can create numerous socioeconomic benefits associated with income in the local and regional economy, increased employment, rural growth and poverty reduction. Given that biodiesel is produced from common biomass material, many developing countries such as Argentina, India and Malaysia could play a large role in biodiesel exports and increase their international competitiveness [7].

However, alongside obvious benefits, biodiesel production may also cause certain problems. For instance, biodiesel made from classic food crops requires high-quality agricultural land for growth which inevitably imposes pressure on farming and food production. This may lead to socio-economic conflicts and serious environmental issues, such as land clearing and biodiversity loss. For instance, Brazil and the United States, being the world's largest biodiesel producers, tend to increase yields by converting rainforests, peatlands, savannas and grasslands into oil palm plantations and soybean fields, causing indirect $CO_2$ emissions as a result of burning and microbial decomposition of organic carbon stored in plant biomass and soils [8]. Land conversion may produce up to 420 times more $CO_2$ than the amount of carbon savings achieved through displacement of fossil fuels by biofuels. These indirect emissions create a so-called biofuel carbon debt which can be repaid only if the future biofuels production and combustion is completely offset by carbon sequestration of the crops used as a feedstock. Otherwise, biofuels can contribute to even higher greenhouse gas emissions than the fossil fuels which they intended to displace (Fig. 3). The 2009 EU Renewable Energy Directive [9] has set stringent targets for biofuels to deliver a 35% carbon saving compared to fossil fuels by 2013, increasing to 50% by 2017 (Fig. 3). However, in the context of the carbon debt as a result of indirect emissions, it is questionable whether the EU objectives will be met on time and to the specified conditions.

Another problem is associated with the release of nitrous oxide ($NO_x$) upon combustion of the biofuels made from the crops fed with nitrogen-based fertilizers. Nitrous oxide is a strong greenhouse gas, which has a global warming potential 298 times higher than that of carbon dioxide [10]. In addition, $NO_x$ is a short-lived tropospheric ozone precursor, which drives the chemistry of the OH radical and influences the distribution of tropospheric ozone, one of the major radiatively-active trace gases [11]. Overall, $N_2O$ emissions derived from biofuels can contribute to climate change as much as conventional fossil fuels [12].

Bioethanol is another type of liquid biofuels, which is usually made from sugar-containing or starch-containing biomass via anaerobic fermentation conducted by microorganisms [3]. The production cost of ethanol still remains high in relation to gasoline, with the exception for Brazil, where bioethanol is manufactured from relatively cheap and abundant sugar cane feedstock [5]. Cost-efficiency can be increased by producing ethanol through enzymatic hydrolysis of non-food lignocellulosic biomass of herbaceous and woody plants, agricultural and forestry residues, and municipal solid waste. Although the processing cost of cellulose will be higher compared to starch or sugar-based materials, the cost of the feedstock itself would be substantially reduced [5].

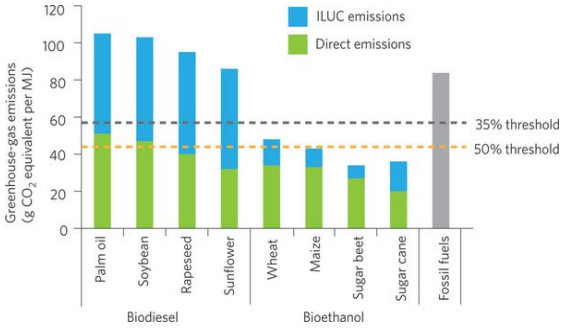


*Figure 3.* Direct and ILUC (indirect land use change) $CO_2$ emissions of biofuels

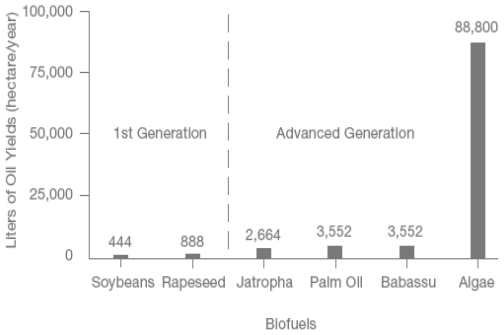


*Figure 4.* Relative oil yields of the next generation biofuel

Main environmental benefits of using bioethanol are associated with its ready availability, renewability and biodegradability [13]. Bioethanol has also high evaporation heat, octane number and flammability, so when it is added to unleaded gasoline it improves engine performance, increases combustibility and reduces exhaust emissions [14]. Although, there is currently no global market for ethanol, it is projected that the production of ethanol from sugar cane in developing countries could provide a profound displacement of petroleum worldwide over the next 20 years [15, 16]. Although, ethanol is much cleaner than biodiesel, compared to conventional energy sources, it saves only 50–60% of carbon emissions and cannot be regarded as carbon-neutral [17].

Overall, biofuel projections in the developing world are uncertain due to small production rates in recent years and high processing cost [4]. Therefore, the controversy surrounding biofuels has attracted attention to advanced second and third generation biofuels which can be produced in a more sustainable fashion with a zero or even negative net $CO_2$ impact.

## 3. Sustainability of Next Generation Biofuels

Next generation biofuels are regarded as sustainable and secure energy alternatives to first-generation biofuels and can be produced from a variety of various feedstocks, such as lignocellulosic biomass and microalgae. According to the IEA assessment, next generation biofuels will account for 90% of all biofuels in 2050 [18].

The potential of lignocellulosic material to provide valuable feedstock for biofuels production has not been fully realised [3]. However, such feedstock forms a readily available biomass source from harvesting activities and does not require any additional land management activities [4]. Lignocellulosic biomass primarily contains cellulose and polymeric hemicelluloses which are subjected to special biochemical or thermochemical pre-treatment. Biochemical treatment involves breaking down cellulose into simple sugars via enzymatic hydrolysis followed by fermentation and distillation into ethanol. Thermochemical route implies gasification of the feedstock into a syngas ($CO_2$ + $H_2$) which is then transformed into Fischer-Tropsch fuels, e.g. BTL-diesel. Compared to their first generation alternatives, lignocellulosic fuels offer energy of better quality and produce 15% less $CO_2$ emissions. However, to achieve cost-efficient production on a large-scale, they require technological advances and infrastructure development for biomass harvesting, transporting and refining [19].

Lignocellulosic ethanol and BTL-diesel (biodiesel-to-liquid) are referred to the so-called second generation biofuels and mainly produced from woody crops (e.g. willow, eucalyptus, poplar and bamboo), perennial grasses (e.g. miscanthus, rye and switchgrass) and agricultural and forestry residues. They can be grown on marginal and degraded land and therefore do not compromise agricultural production and access to food. Field trials in Australia showed that eucalyptus energy crops are ideal for increasingly saline soils, as they not only exhibit environmental tolerance, but also create favourable conditions for cereal crops in adjacent areas through the control of the water table and surface salt depositions [20].

Although lignocellulosic biofuels have a positive environmental and economic impact in terms of increasing energy efficiency, reducing net carbon emissions and creating job opportunities, deployment of high-quality second-generation biofuels is not yet commercialised and not regarded as priority in many developing countries (except Brazil) due to high associated costs and lack of technologies [4]. Thus, to

achieve successful production, it is essential to invest into research and development activities on regional markets to overcome technological constraints and ensure that land-use requirements comply with minimum lifecycle greenhouse gas reductions and social standards.

Another type of next generation biofuels comprises microalgae which are sometimes referred to the third generation biofuels. Microalgae cover unicellular and multicellular microorganisms (e.g. cyanobacteria, green algae, red algae and diatoms) capable of all year round photosynthetic production [21]. They also have a short harvesting cycle (1–10 days), which allows continuous harvests with substantial energy yields. Oil content of algae accounts for 80% of their dry mass which reflects in 25–200 times higher oil yields compared to crop-based biofuels [22].

In addition to high energy efficiency, algae may also provide a positive environmental impact. For instance, some heterotrophic microalgae (i.e. non-photosynthetic species feeding on exogenous organic nutrients) can be grown in brackish water on marginal or non-arable land and therefore minimise land use change and provide potential for bio-treatment of nutrient-rich water. Furthermore, algae do not require heavy fertilizers to grow. In fact, they can produce proteins and other valuable co-products which can themselves be used as livestock feed and fertilizers [21].

Commercial algae production can be based either on the use of natural resources required for their growth, i.e. sunlight, water and nutrients, or artificially replicated conditions. Under artificial conditions, algae are subjected to fluorescent lighting compatible with the absorption spectra of algal photosynthetic pigments and constantly supplied with minerals and $CO_2$ fed into the algae media in the form of carbonates or from external sources. Overall, algae are able to assimilate up to 150,000 ppmv $CO_2$ and potentially make use of carbon emissions released by power plants [23].

The most cost-efficient large-scale production technology is to grow algae in open ponds and bioreactors. Cultivation in ponds is less efficient due to diurnal and seasonal temperature and light variations, evaporation losses, $CO_2$ diffusion into the atmosphere and slow mixing, whereas a closed bioreactor permits manipulation of growth conditions with lower risk of contamination [21]. The newly produced algae biomass is harvested and processed to recover oil, proteins and sugars which are then converted into biofuels and other valuable co-products.

The main algae-based biofuels include biodiesel, bioethanol and biohydrogen. While the first two can be produced by all algae species, the biohydrogen production is restricted to selected groups of microalgae which can use sunlight to convert water to hydrogen (as protons and electrons) and oxygen. The advantage of biohydrogen is that it is carbon-free and can be easily released into the gas phase and used as a clean energy source. In addition, combustion of hydrogen and oxygen extracted by marine algae from sea water can be used as desalination strategy. Given that there is a direct relationship between water and hydrogen yields, a 1 million L of water medium containing algae culture can annually produce 610,000 L of fresh water [24]. Further technological development and investment into bioengineering will optimise the algae production and improve efficiency of biomass-to-biofuels conversion.

## 4. Conclusions

The expanding biofuel industry has been recently critically questioned over important concerns associated with food safety, efficiency of net lifecycle greenhouse gas emission reductions and high processing costs. It is realised that most first-generation biofuels cannot be regarded as socially and environmentally sustainable and therefore have a weak potential to displace petroleum-derived transport fuel. Therefore, the current research is focused on the development of more advanced, next generation biofuels which can provide high energy efficiency and substantial carbon reductions without compromising the competition with food market. Second generation lignocellulosic fuels can make use of abandoned land and help to enhance local economy through job creation and rural development, while third generation algae-based biofuels offer the potential to completely displace conventional energy sources due to unique biological properties translating to high biomass yields and production of clean, carbon-free fuel. Proper energy analysis, investment into R & D activities and adoption of special legislation will help to overcome technological constraints and increase competitiveness of next generation biofuels in the global energy market.

## References

1. World Energy Council. (2010). Biofuels: Policies, Standards and Technologies. London: WEC.
2. Balat, M., Balat, H. (2009). Recent trends in global production and utilization of bio-ethanol fuel. *Applied Ecology,* 86, 2273–2282.
3. Naik, S. N., Goud, V. V., Rout, P. K. & Dalai, A. K. (2010). Production of first and second generation biofuels: A comprehensive review. *Renewable and Sustainable Energy Reviews,* 14(2), 578–597.

4. IEA. (2010). *Sustainable Production of second-generation biofuels: Potential and perspectives in major economies and developing countries*. Paris: IEA.
5. Demirbas, A. (2009). Political, economic and environmental impacts of biofuels: A review. *Applied Energy,* 86, 108–117.
6. Demirbas, A. (2008). Economic and environmental impacts of the liquid biofuels. *Energy, Education, Science and Technology,* 22, 37–58.
7. OECD/FAO. (2011). Biofuels. In *OECD-FAO Agricultural Outlook 2011–2020*. Retrieved February 10, 2012, from http://www.agri-outlook.org/dataoecd/23/56/48178823.pdf
8. Fargione, J., Hill, J., Tilman, D., Polasky, S. & P. Hawthorne. (20080. Land Clearing and the Biofuel Carbon Debt. *Science,* 319, 1235–1238.
9. Directive 2009/28/28/EC of the European Parliament and of the Council of 24 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. *Official Journal of European Union*, L 140.
10. IPCC. (2007). Changes in Atmospheric Constituents and in Radiative Forcing. In *IPCC Fourth Assessment Report*: *Climate Change 2007 – The Physical Science Basis*. Cambridge: Cambridge University Press.
11. Crutzen, P. J. (1974). Photochemical Reactions Initiated by and Influencing Ozone in the Unpolluted Troposphere. *Tellus,* 26, 47–57.
12. Crutzen, P. J., A. R. Mosier, K. A. Smith & W. Winiwarter. (2007). $N_2O$ release from agro-biofuel production negates global warming reduction by replacing fossil fuels. *Atmospheric Chemistry and Physics Discussions,* 7, 11191–11205.
13. Demirbas, A. (2006). Theoretical heating values and impacts of pure compounds and fuels. *Energy Sources,* 28, 459–467.
14. Najafi, G, B. Ghobadian, T. Tavakoli, D. R. Buttsworth, T. F. Yusaf, M. Faizollahnejad. (2009). Performance and exhaust emissions of a gasoline engine with ethanol blended gasoline fuels using artificial neural network. *Applied Energy,* 86, 630–639.
15. Grassi, G. (1999). Modern bioenergy in the European Union. *Renewable Energy,* 16, 985–990.
16. Antizar-Ladislao, B. & J. L. Juan, L. Turrion-Gomez. (2008). Review: Second-generation biofuels and local bioenergy systems. *Biofuels, Bioproducts and Biorefining,* 2(5), 455–469.
17. Bothast, R. J. (2005). *New technologies in biofuel production*. United States Department for Agriculture: Agricultural Outlook Forum.
18. Renssen, S. (2011). A biofuel conundrum. *Nature Climate Change,* 1, 389–390.
19. IEA. (2008). *Energy Technology Perspectives 2008: Scenarios and Strategies to 2050*. Paris: OECD/IEA.
20. Wu, H., Q. Fu, R. Giles & J. Bartle. (2008). Production of Mallee Biomass in Western Australia: Energy Balance Analysis. *Energy and Fuels,* 22(1), 190–198.
21. Brennan, L. & P. Owende. (2010). Biofuels from algae – A review of technologies for production, processing, and extractions of biofuels and co-products. *Renewable and Sustainable Energy Reviews,* 14, 557–577.
22. Boeing. (2008). 2008 Environment Report. *Relative energy yields from next generation biofuels* [Image]. Retrieved February, 10, 2012, from http://www.boeing.com/aboutus/environment/environmental_report_08/boeing-2008-environment-report.pdf
23. Chisti, Y. (2007). Biodiesel from microalgae. *Biotechnology Advances,* 25, 294–306.
24. Schenk, P. M., S. R. Thomas–Hall, E. Stephens, U. C. Marx, J. H. Mussgnug, C. Posten, O. Kruse & B. Hankamer. (2008). Second Generation Biofuels: High–Efficiency Microalgae for Biodiesel Production. *Bioenergy Resources,* 1, 20–43.


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# COGNITIVE RADIO NETWORKS IS THE NEXT STEP IN COMMUNICATION TECHNOLOGY

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Wireless computing and communications are growing rapidly. The expansion of wireless applications usage creates an increasing demand for developing of an effective access to radio spectrum. The problem of spectrum usage could be solved with deployment of cognitive radio (CR) which is a breakthrough in technological innovations.

CR makes it possible to use existed spectrum bands effectively and finds solution to the "congestion" problem in information systems. Apart from having positive characteristics in terms of spectrum efficiency, its application performance is configurable, upgradable and flexible. Therefore for the future several decades CR provides opportunity of scaling wireless systems.

However, creation of cognitive networks requires definition of many technical challenges from dynamic spectrum allocation methods and sensing to network security. It the presented paper important details about high-level cognitive radio opportunities and challenges will be shown.

**Keywords:** Cognitive Radio CR, Cognitive Radio Network CRN, Spectral Policy, Dynamic Spectrum Access DSA

## 1. Introduction. Overview of Cognitive Radio

Wireless communications is not a new paradigm in today's technological world. Its purpose is to convey information by air from one point to another, from transmitter to receiver. The evolutionary future of the wireless communication will be based on usage of computer-based devices. Development in this sphere brings further deployment of software-defined and cognitive radios. On the Figure 1 differences between the traditional radio, software-defined radio (SDR) and cognitive radio (CR) are showed.

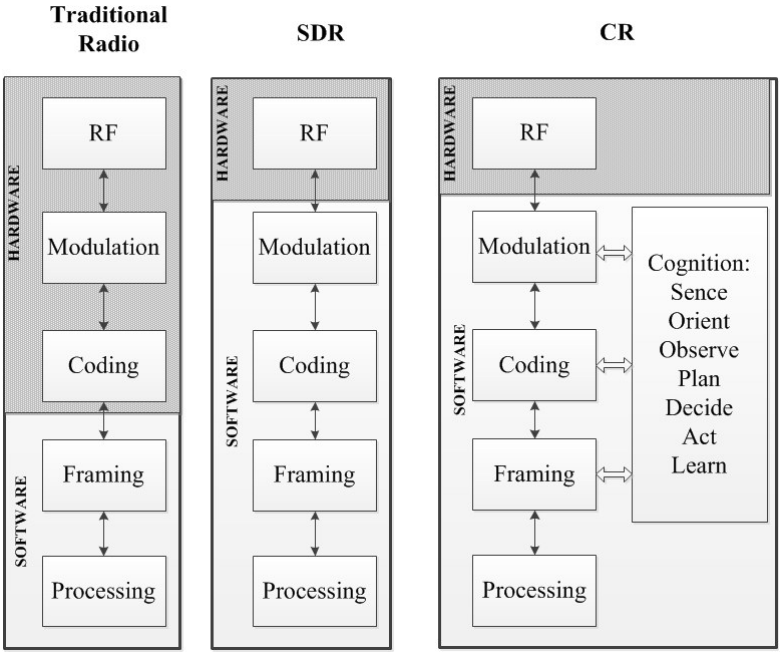


*Figure 1.* Evolution of radio (Traditional Radio, Software-Defined radio, Cognitive Radio)

It is illustrated that in SDR many signal processing functions such as modulation and coding are done in software. From picture it is obvious that CR is an extension of the SDR. Cognitive radio adds interfaces, applications, and other cognition functions such as behaviour and sense. There are several definitions and concepts, which are involved in CR. CR is a radio that can change its transmission parameters based on the interaction with the environment in which it operates [1]. This definition makes emphasis on the environment which includes the interference levels in a frequency band and data traffic of communication sets in the same time and geographic region. D. Cabric defines CR as "a network of radios that co-exists with higher priority PU, by sensing their presence and modifying its own transmission characteristics in such a way that they do not yield any harmful interference." [2] In this definition spectrum awareness is related to the physical and network layers.

## 2. White Space and Dynamic Spectrum Access

The Commission on Radio Frequency Spectrum, as well as similar representatives in other countries, oversees spectrum management and allocation in Kazakhstan. The frequency spectrum is assigned to the particular licensed primary users (PU). Therefore, in realization of CR, it faces the problem of using a frequency spectrum without interfering with PU. For this reason white spaces or spectrum holes are used by CR users. The description of that conception is shown on the Figure 2.

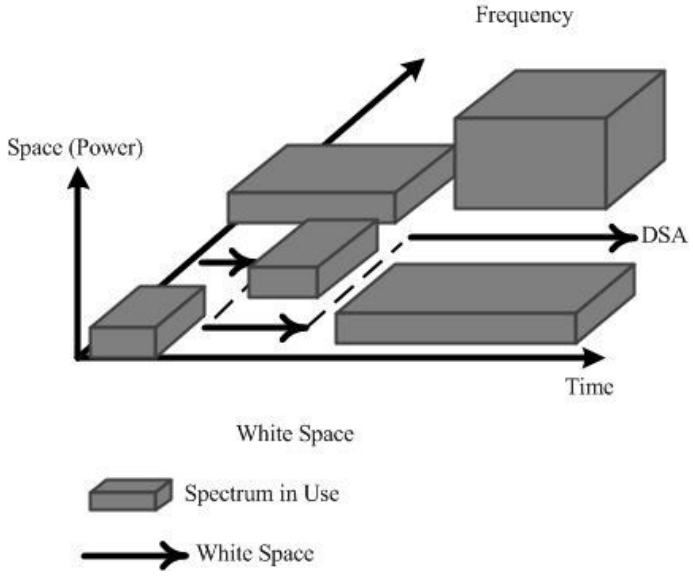


*Figure 2.* Spectrum Holes

White spaces are the frequencies assigned to the PU, but at a particular time and specific geographic location the band is not used by them [3]. In this realization CR must finish transmission on that band if the PU starts to utilize the frequency which it has been assigned. It is a requirement to the CR in order not to create interference with the PU. To continue signal transmission the CR changing its characteristics such as power level and modulation scheme. The concept of dynamic spectrum access (DSA) is used to identify spectrum holes or white spaces and use them for communication.

## 3. Cognitive Radio Operations

The idea of CR extends the concepts of SDR from a simple, single function device to a radio that senses and reacts to its operating environment [4]. The CR operation could be modelled through a cognitive cycle (CC). It has several phases which are named as *observe*, *orient*, *plan*, *learn*, *decide* and *act* [5]. From the Figure 3 it is clear that these phases do not have a particular order. The CR tailors **(***orient***)** its operating conditions based on information about *outside environment*. To *observe* conditions and establish its priorities an application does calculations of all previous transmission characteristics. Then the CR *plans* its options based on the observations. To *decide* which frequency should be used the CR uses plans and then transmit signal (*act***).** To complete the CC the operating environment is observed again. Based on these stages CR radio *learns* for better signal transmissions. Therefore cognition is the main characteristic of intelligent CR.

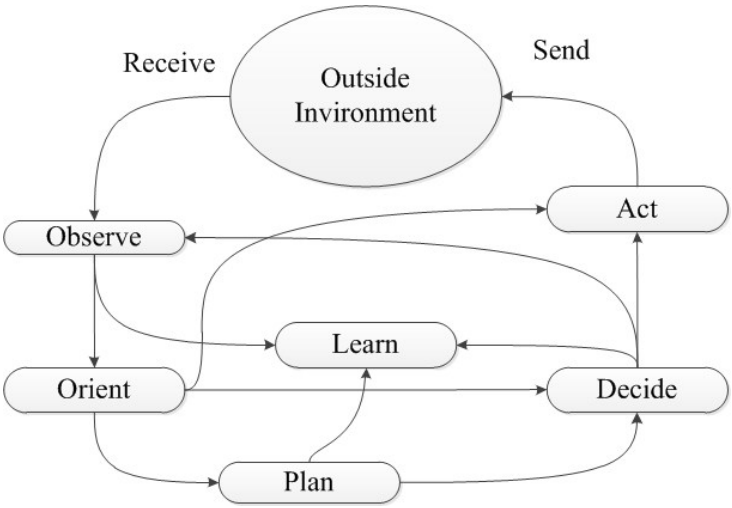


*Figure 3.* Cognitive Cycle

To make the CC well-ordered we improved its representation. On the Figure 4 it is shown that a modified CC consists of three tasks: Sensing analysis, Spectrum identification, and Dynamic spectrum management.

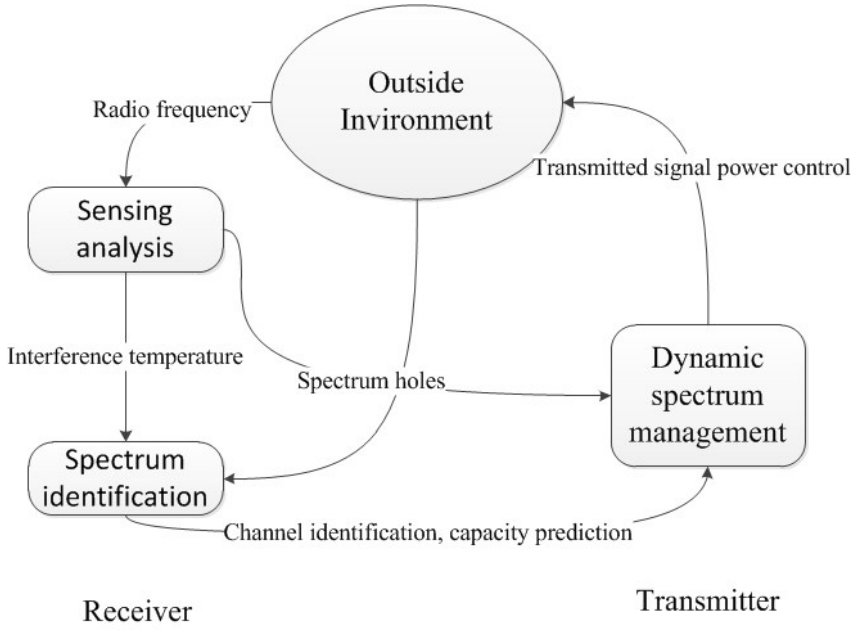


*Figure 4.* Modified Cognitive Cycle

The first task in the CC consists of two sub-tasks: estimation of interference temperature and detection of spectrum holes. The first sub-task represents the temperature of a radio frequency power available at an aerial (per unit bandwidth). The interference temperature is needed to estimate and manage interference among different PU's services in a radio environment. The maximum acceptable level of interference temperature is the worst characteristic of the radio frequency environment in a particular spectrum band, time and location. In this case the receiver could be not expected to operate satisfactory. Spectrum holes are available frequencies for particular time and in particular geographical location. There are three spaces: black, grey and white. They can be identified by exploring the power spectrum of an incoming radio frequency signal. The frequency bands with high power currently occupied by PU and they are called black spaces. They could become spectrum holes when the PU are switched off. Grey and white spaces are low-power and free of interferences bands. Therefore they are candidates to be occupied by secondary users (CR).

The second task in the CC consists of two sub-tasks: identification of channel and its capacity prediction. After finishing the first two tasks of the CC, the Dynamic spectrum management and the power control is performed at the transmitter CR.

## 4. Cognitive Transmitter and Receiver

According to the modified CC presented above we can implement Cognitive Receiver and Transmitter. Explanations of building concepts and flow charts are given below.

In the transmitter detection and transmission of CR is presented in parallel. A power detector first senses several channels during the given period and then detects white spaces. The results about which channels are used or opened are passed to the transmitter. Then it decides to transmit signal through one of the free channels. Depending on the hardware, there is a time between the results of the detection and the actual start of the transmission. If the transmitter is active, the detector discards samples. When the transmitter stops signal transmission, the detector starts sensing again, then the cycle repeats. One antenna is used to detect and transmit. The power detector provides information about the channels state (free or in use) and the transmitter chooses where to transmit. Transmitter will continue send signal on the same channel N if it is still free. If the previous channel is not open and the next one is available (N++), transmitter uses it. Otherwise, if the next channel is occupied transmitter cycles through the channels until it finds free. On the Figure 5 the flow chart identifies explained above information.

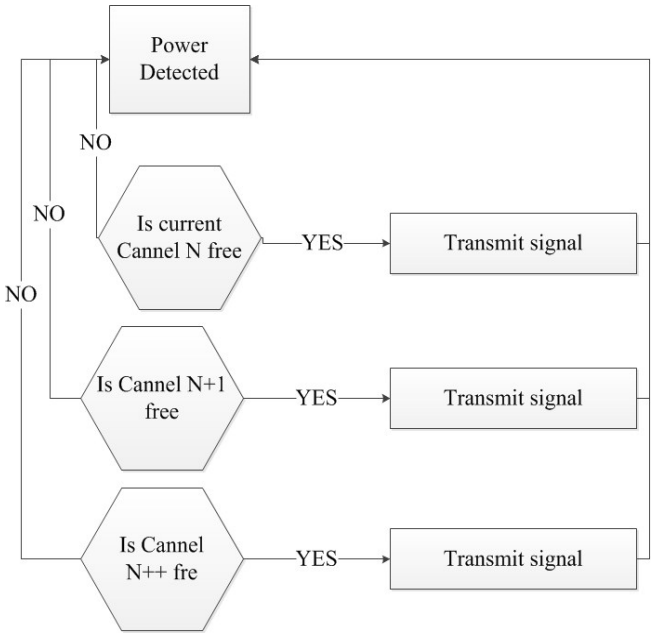


*Figure 5.* Flow Chart for Cognitive Transmitter

The cognitive receiver works depending on the information send by transmitter, Figure 5. Therefore, it knows the set of frequencies used by the transmitter. The receiver stops on each of the channels to find the transmitter. Firstly, it stops on channel N for a particular period. If it has not received any packet during that time, it switches to the next channel N++. If it received at least one packet from the transmitter during that time, it stays on the channel for another cycle.

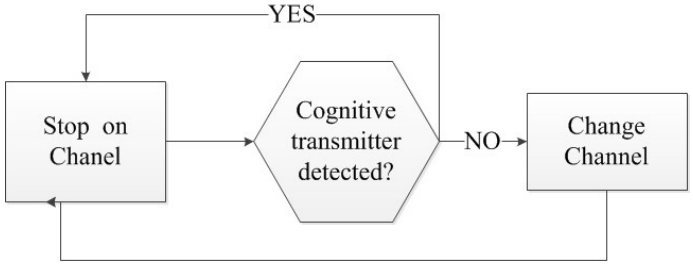


*Figure 6.* Flow Chart for Cognitive Receiver

## 5. Conclusions

Many conventional frequency bands are underutilized. On the other hand, that spectrum models have many space-time holes, particularly in urban areas where buildings cause blind spots. These spaces can be used for CR signal transmission that does not cause interference to the primary spectrum users [6]. CR is a technology which changes the way of radio spectrum access and management. As a result implementation of CR networks could reduce spectrum overhead and improve integration within existing telecommunication system. The CR integration is an issue which connects different fields of computing and communications. In the paper information about basics of CR, modified CC and implementation concepts of cognitive transmitters and receivers are presented. These data and models could serve as a basis for the future deployment of CR network.

## References

1. Federal Communications Commission. (2003). *Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies*. Federal Communications Commission, No. 03–322.
2. Cabric, D. (2007). *Cognitive Radios: System Design Perspective*. Technical Report No. UCB/EECS-2007-156, http://www.eecs.berkeley.edu/Pubs/TechRpts/2007/EECS-2007-156.html USA, Berkeley: University of California at Berkeley http://www.eecs.berkeley.edu/Pubs/TechRpts/2007/EECS-2007-156.pdf (20.04.2012)
3. Linda, E. D. (2009). *Essentials Of Cognitive Radio*. UK: Cambridge University Press.
4. Fette, B.A. (2006). *Cognitive Radio Technology*. Ch. 2 (pp. 29–69). UK: Elsevier Inc.
5. Arslam, H. (2001). *Cognitive, Software-defined radio and adaptive wireless systems.* Heidelberg: SpringerVerlag, 75.
6. Medeisis, A., Delaere, S. (2011). *High-Level Scenarios for the Future of Cognitive Radio Business.* PIMRC Workshop. In: Kaveh Pahlavan, Shahrokh Valaee, Elvino Silveira Sousa (Eds.): IEEE 22nd International. Symposium on Personal, Indoor and Mobile Radio Communications, PIMRC 2011, Toronto, ON, Canada, September 11–14, 2011. IEEE 2011 ISBN 978-1-4577-1346-0. Toronto: IEEE, 2330–2334.

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# ARCHITECTURAL PATTERN SUITE OPTIMIZATION FOR LOGISTICS AND TRANSPORT SYSTEMS

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Software architecture design plays the key role for logistics and transport software engineering. One of the design approaches is to reuse the architectural patterns, which express a fundamental structural organization of software systems and its behaviour. The usage of the proven and tested solutions allows us to increase the software quality and reduce potential risks.

To choose the optimal architectural patterns suite it is necessary to use a technique that contains a number of steps. The technique proposed in this paper allows us to consistently evaluate the impact of specific patterns to overall software development effort with a given functionality. In addition, it takes into account the interference between patterns. Effectiveness and efficiency of the described method is confirmed by a case study.

**Keywords:** architecture, pattern, functional points, metrics, logistics and transport software, integer programming, objective function, restriction, bounded, optimization, decision

## 1. Introduction

Architectural and detailed design of a modern logistics and transportation software have a huge impact on a quality as well as a cost of development, so it is necessary to put reasonable attention when making architectural and design decisions.

Architectural design provides an understanding of the system organization. Also it creates a framework for the proper representation of a system. The creation of architecture is the first and fundamental step in the software designing. It creates software system representation base that satisfies to the full range of detailed requirements [1, 2, 3].

As long as there is no effective method for the architecture building we should rely on used techniques as well as past experience in that area. One of the common approaches is to use architectural patterns for creation of the software architecture.

Architectural patterns organize the essence of architecture which was used in various software systems. Today the patterns are widely used during the software development process. They help to reuse knowledge and the best practice [4, 5, 7].

Architectural patterns can be seen as a generalized description of best practice. The patterns were tested and proven in a variety of systems and environments, as a result of that, the architectural pattern describe the system organization which has been successful in previous systems.

It's obvious what we need to have some technique that allows selecting the optimal suite of patterns from a number of patterns, also such selection should take into account the specific requirements for the logistics and transport system.

## 2. Selection of an Optimal Patterns Suite

Let's assume that there is a set of patterns which can be separated into groups according to their corresponded functionality. Also we know numerical values of system characteristics which depend on used patterns for the given system. So we need to develop a model which helps us to determine the optimal suite of patterns for logistic and transport system with a given functionality.

Suppose that there is a set of input pattern groups – $\{P_i | i = 1,..., g\}$.

Each group can have different number of patterns, so we can define it as follows:

$$\{P_{ij} | i = 1,..., g; j = 1,..., m_j\},$$

where $P_{ij}$ – *i-th* pattern from group *j*, $m_j$ – number of pattern in group *j* which is a variable number.

Let's assume that from some groups we aren't obligated to select a pattern (this is due to the fact that the selection of some patterns can exclude a whole group of patterns). On the other hand, we can select several patterns from some of the groups.

Thus the input data for our model makes a complete set of patterns for each group, and such set can be represented as a multiset.

For simplicity, we reduce the multiset to a uniform set of patterns $\{P_1,...,P_n\}$ where we use special restrictions for partitioning to the groups.

At the output, the model with the specified constrains should select the optimal combination of patterns which should be used for software development.

The produced restrictions should exclude those combinations of patterns that are logically inconsistent or interchangeable. In addition, some restriction should allow selection of multiple patterns from specified group of patterns.

The objective function for finding the optimal suite of pattern defined as follows:

$$W = f(P_1) \times x_1 + f(P_2) \times x_2 + \ldots + f\left(P_n\right) \times x_n \to min\,,$$

where $f(P_i)$ – function, which reflects numerical changes of the system characteristics depending on used pattern $P_i$;

$x_i$ – variable, which indicates the usage of the *i-th* pattern.

It's obviously that the integrality constrain should be applied for a given variable $x_i$:

$$x_i = \{0,\ 1 \big| i = 1,2,...,n\},$$

where $n$ – number of patterns in the one dimensional set, which were transformed from the original multiset of patterns.

To indicate the fact that we can select only one pattern from the group, let's introduce the following restriction:

$$\sum_{i=start}^{i=end} x_i = 1,$$

where *start, end* – the start and end indices of patterns in a group.

To take in to account that the selection of the *j-th* pattern excludes patterns from a different group, we use the following restrictions:

$$x_j + \sum_{i=start}^{i=end} x_i = 1.$$

If we can select any number of patterns from the group we specify the following constrains:

$$\sum_{i=start}^{i=end} x_i \le (end - start + 1).$$

On the base of the mentioned definitions and assumptions, we obtain the classical integer programming problem where we need to find the optimal solution.

We should pay special attention for choosing the function $f(P_i)$. Such selection should be based on the requirements for a software system.

## 3. The Choice of Patterns

According to the statistics on architecture types used for transportation and logistics systems, which are represented in the global ISBSG database, most of these systems are based on client-server architecture model [6]. Nowadays the most used subtype of such architecture is N-tier architecture. Therefore, for our case study we select a set of patterns used for transportation and logistics systems' N-tier architectures.

There are patterns that can be divided into the following groups:

- **Domain Logic Patterns**. *Transaction Script*, *Domain Model*, *Table Module*, *Service Layer*.
- **Data Source Architectural Patterns**. *Table Data Gateway*, *Row Data Gateway*, *Active Record*, *Data Mapper*.
- **Object-Relational Behavioural Patterns**. *Unit of Work*, *Identity Map, Lazy Load*.
- **Web Presentation Patterns**. *Model View Controller*, *Page Controller*, *Front Controller*, *Template View*, *Transform View*, *Two-Step View*, *Application Controller*.
- **Distribution Patterns**. *Remote Facade*, *Data Transfer Object*.
- **Offline Concurrency Patterns**. *Optimistic Offline Lock*, *Pessimistic Offline Lock*, *Coarse Grained Lock*, *Implicit Lock*.

Fowler in [7] indicates the steps how to select a pattern from multiple groups taking into account the requirements for the software. The problem of his approach is that it isn't formalized enough. Also he indicates the relationship between groups of patterns, for example, it's allowed to choice only one pattern from multiple groups, etc. This selection technique can be represented as follows:

1. Initially we have to select the base pattern for *Domain Layer* implementation; such pattern should be selected from *Domain Logic Patterns* group.
2. Next, we need to select a pattern for *Data Source Layer* implementation (it should be selected from Data *Source Architectural Patterns* group). This choice also depends on the first step (for example, when we select *Domain Model* on the first step we can choose only *Data Mapper* on this step). Together with patterns from *Data Source Layer* we can use *Object-Relational Behavioural Patterns*, *Concurrency Patterns* and some other groups of the patterns.
3. In the final step we do select a pattern from *Presentation Layer* (from *Web Presentation Patterns* group).
4. Furthermore, in addition to the selected patterns, we select other patterns from the remaining groups.

As a result of this technique ap plication, we have obtained the following list of patterns that we use in our case study:

| Group of patterns | Pattern | Pattern's notation |
|---|---|---|
| Domain Logic Patterns | Transaction Script | $P_{11}$ |
| | Domain Model | $P_{12}$ |
| | Table Module | $P_{13}$ |
| | Service Layer | $P_{14}$ |
| Data Source Architectural Patterns | Table Data Gateway | $P_{21}$ |
| | Row Data Gateway | $P_{22}$ |
| | Active Record | $P_{23}$ |
| | Data Mapper | $P_{24}$ |
| Web Presentation Patterns | Model View Controller | $P_{31}$ |
| | Page Controller | $P_{32}$ |
| | Template View | $P_{33}$ |
| | Application Controller | $P_{34}$ |
| Distribution Patterns | Remote Facade | $P_{41}$ |
| | Data Transfer Object | $P_{42}$ |
| Offline Concurrency Patterns | Optimistic Offline Lock | $P_{51}$ |
| | Pessimistic Offline Lock | $P_{52}$ |
| | Coarse Grained Lock | $P_{53}$ |
| | Implicit Lock | $P_{54}$ |

## 4. Selecting a Function $f(P_i)$

Using the above listed patterns we need to build a model for selecting the optimal suite of patterns; where the requirement for the software should be considered. For doing so we must determine the patterns impact on specific system characteristics. This means that we need to define the function $f(P_i)$.

During the architecture design stage we can operate the system requirements as well as make indirect measures of some system characteristics, so one of the most suitable metric for consideration is functional point (*FP*) metric, which indirectly measures software and the effort of its development. The value of this metric reflects the functional complexity of the product [1].

The selection of a pattern affects the overall system characteristics. Therefore, it is necessary that the metric for such system also reflects this influence. In our case the metric should reflect a change of FP metric when we use a specific pattern. Due to these considerations, we define our function which reflects such behaviour as follows:

$$f\left(P_i\right)=\frac{FP'_{P_i}}{FP},$$

where $FP$ – the original value of functional points;

$FP'_{Pi}$ – the value of functional points if pattern $P_i$ is used for software development.

This metric is a modification of the original FP and is calculated as follows:

$$FP'=UFP\times\left(0,65+0,01\times\sum_{i=1}^{14}CF_i\right),$$

where

$$CF_i=\begin{cases}5, & if\ c_i\times F_i>5;\\ round(c_i\times F_i), & otherwise,\end{cases}$$

$CF_i$ – adjusted degree of influence coefficient which corresponds to $F_i$ used in original FP;

$c_i$ – pattern influence on *i-th* system's characteristic. The value of this coefficient can be equal to the following scales:

- ½ – use of a pattern reduces the significance of a system characteristic,
- 1 – no influence,
- 2 – use of a pattern actualizes a system characteristic (i.e. we must pay more attention to this characteristic when applying this pattern).

## 5. Obtaining Values of Pattern Influence Coefficients $c_i$

The following table represents the patterns influence coefficients $c_i$ with the given requirements. These figures are empirical and intended to demonstrate the proposed technique, so these values might be not optimal. To obtain more precise values of the coefficients, the values should be calibrated on a number of projects. These values also might be different for the software of the other domains, i.e. not transportation or logistics. In addition, the values might vary for systems with other requirements.

| Group of patterns | Pattern | Pattern's notation | $c_1$ | $c_2$ | $c_3$ | $c_5$ | $c_9$ | $c_{10}$ | $c_{14}$ |
|---|---|---|---|---|---|---|---|---|---|
| Domain Logic Patterns | Transaction Script | $P_{11}$ | 1 | 2 | ½ | ½ | 2 | 2 | 2 |
| | Domain Model | $P_{12}$ | 1 | ½ | 1 | 1 | ½ | ½ | ½ |
| | Table Module | $P_{13}$ | ½ | 1 | ½ | ½ | 1 | 1 | 1 |
| | Service Layer | $P_{14}$ | 1 | ½ | 1 | 1 | 1 | ½ | ½ |
| Data Source Architectural Patterns | Table Data Gateway | $P_{21}$ | 1 | 1 | ½ | 1 | 1 | 2 | 1 |
| | Row Data Gateway | $P_{22}$ | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| | Active Record | $P_{23}$ | 1 | 1 | 1 | 1 | 1 | ½ | ½ |
| | Data Mapper | $P_{24}$ | ½ | 1 | 1 | 1 | 1 | ½ | ½ |
| Web Presentation Patterns | Model View Controller | $P_{31}$ | 1 | 1 | 1 | 1 | 1 | ½ | ½ |
| | Page Controller | $P_{32}$ | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| | Template View | $P_{33}$ | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| | Application Controller | $P_{34}$ | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| Distribution Patterns | Remote Facade | $P_{41}$ | 2 | 1 | 1 | ½ | 1 | 1 | 1 |
| | Data Transfer Object | $P_{42}$ | 2 | ½ | 1 | 1 | 1 | ½ | ½ |
| Offline Concurrency Patterns | Optimistic Offline Lock | $P_{51}$ | 1 | ½ | ½ | 1 | 2 | 1 | 1 |
| | Pessimistic Offline Lock | $P_{52}$ | 1 | 1 | 2 | 1 | 2 | 1 | 1 |
| | Coarse Grained Lock | $P_{53}$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Implicit Lock | $P_{54}$ | ½ | 1 | 2 | 1 | 1 | 1 | 1 |

The coefficients $c_i$ listed in the table have the following meanings:

- $c_1$ – pattern influence coefficient on system characteristic "Data Communications";
- $c_2$ – pattern influence coefficient on system characteristic "Distributed Data Processing";
- $c_3$ – pattern influence coefficient on system characteristic "Performance";
- $c_5$ – pattern influence coefficient on system characteristic "Transaction Rate";
- $c_9$ – pattern influence coefficient on system characteristic "Complex Processing";
- $c_{10}$ – pattern influence coefficient on system characteristic "Reusability";
- $c_{14}$ – pattern influence coefficient on system characteristic "Facilitate Change".

We consider only these system characteristics, since the described patterns do not affect other characteristics of the system, i.e. the pattern influence for them is 1.

## 6. The Patterns Usage Restrictions

When we build the model we should take into account the following corresponding constraints:

- restrictions which are applied on pattern groups;
- restrictions applied on patterns compatibility.

For the considered patterns we have the following limitations:

1. We can choose only one pattern from the first three groups as well as from *Offline Concurrency Patterns*;
2. We can choose any patterns from the remaining groups (each pattern can be selected only one time);

3. If *Transaction Script* is selected from the first group we can choose *Table Data Gateway* or *Row Data Gateway* from the second group;
4. If *Table Module* is selected from the first group we are allowed to choose only *Table Data Gateway* from the second one;
5. If *Domain Model* is selected from the first group we can choose *Active Record* or *Data Mapper* from the second group.

## 7. Requirements for a Software System

For our case study we consider a system which provides information regarding safety cameras. Later we use it as an input for our pattern suite optimization technique. Architecture of the software should be based on *N-tier* architectural pattern.

The software system must provide the following requirements:

1. Loading an xml file as an input data.
2. Data modification (add, delete, edit).
3. Retrieving a list of result depending on the following search condition:
   a. full list of data;
   b. results depending on address;
   c. results, which depends on location (Lat+Long).
4. For data editing and searching both, the graphical user interface (web interface) and service API might be used.
5. For every safety camera we need to store the following information:
   a. safety camera type;
   b. location (Lat+Long);
   c. address;
   d. direction.

## 8. *FP* Calculation for the Considered System

Let's obtain the value of *FP* for the considered system. For doing that we need to evaluate the complexity of the function types as Internal Logical Files, External Logical Files, External Inputs, External Outputs and External Inquiry. The requirements for the system lead to the following characteristics:

| Function type | Features | Functional complexity |
|---|---|---|
| **Internal Logical Files** | Table with safety cameras | Low |
| **External Logical Files** | XML input | Low |
| | Search result | Low |
| **External Inputs** | Xml file loading | Average |
| | Add | Low |
| | Delete | Low |
| | Update | Low |
| | Add API | Low |
| | Delete API | Low |
| | Update API | Low |
| **External Outputs** | - | - |
| **External Inquiry** | Search | Average |
| | Search API | Low |

Initial data for *FP* calculation are summarized in the following table:

| Function type | Low | Average | High | Total |
|---|---|---|---|---|
| **Internal Logical Files** | 7×1 | 0 | 0 | 7 |
| **External Logical Files** | 5×2 | 0 | 0 | 10 |
| **External Inputs** | 3×6 | 4×1 | 0 | 22 |
| **External Outputs** | 0 | 0 | 0 | 0 |
| **External Inquiry** | 3×1 | 4×1 | 0 | 7 |
| | | | **Total:** | **46** |

To calculate *FP* we also need to determine a degree of influence for every system characteristics of the considered software. The following table reflects the degree of influence of the characteristic for our software system:

| Nr | System characteristic | Value |
|---|---|---|
| 1 | Data Communications | 4 |
| 2 | Distributed Data Processing | 2 |
| 3 | Performance | 3 |
| 4 | Heavily Used Configuration | 1 |
| 5 | Transaction Rate | 5 |
| 6 | Online Data Entry | 1 |
| 7 | End-User Efficiency | 1 |
| 8 | Online Update | 1 |
| 9 | Complex Processing | 1 |
| 10 | Reusability | 1 |
| 11 | Installation Ease | 0 |
| 12 | Operational Ease | 3 |
| 13 | Multiple Sites | 1 |
| 14 | Facilitate Change | 2 |
| | **Total:** | **26** |

After we got the total degree of influence for system characteristics as well as unadjusted functional point count we can get the final value of *FP*:

$$FP = 46 \times (0.65 + 0.26) = 41.86.$$

## 9. *FP* Value Changes Depending on Used Pattern

Once the values of pattern influence coefficient $c_i$ and original *FP* value for the considered system are obtained, we can evaluate $FP'_{Pi}$ values for each pattern. First, we need to get $CF_i$ values for every determined pattern. Note that values $c_4$, $c_6$, $c_7$, $c_8$, $c_{11}$, $c_{12}$, $c_{13}$ are equal to one, so for such case $CF_i = F_i$. Next, we can calculate values of $FP'_{Pi}$. The obtained values are presented in the following table.

| Pattern | Variable | $CF_1$ | $CF_2$ | $CF_3$ | $CF_5$ | $CF_9$ | $CF_{10}$ | $CF_{14}$ | $\sum_{i=1}^{14} CF_i$ | $FP'_{Pi}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $P_{11}$ | $x_1$ | 4 | 4 | 2 | 2 | 2 | 2 | 4 | 28 | 42.78 |
| $P_{12}$ | $x_2$ | 4 | 1 | 3 | 5 | 0 | 0 | 1 | 22 | 40.02 |
| $P_{13}$ | $x_3$ | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 20 | 39.10 |
| $P_{14}$ | $x_4$ | 4 | 1 | 3 | 5 | 1 | 0 | 1 | 23 | 40.48 |
| $P_{21}$ | $x_5$ | 4 | 2 | 2 | 5 | 1 | 2 | 2 | 26 | 41.86 |
| $P_{22}$ | $x_6$ | 4 | 2 | 3 | 5 | 1 | 2 | 2 | 27 | 42.32 |
| $P_{23}$ | $x_7$ | 4 | 2 | 3 | 5 | 1 | 0 | 1 | 24 | 40.94 |
| $P_{24}$ | $x_8$ | 2 | 2 | 3 | 5 | 1 | 0 | 1 | 22 | 40.02 |
| $P_{31}$ | $x_9$ | 4 | 2 | 3 | 5 | 1 | 0 | 1 | 24 | 40.94 |
| $P_{32}$ | $x_{10}$ | 4 | 2 | 3 | 5 | 1 | 1 | 4 | 28 | 42.78 |
| $P_{33}$ | $x_{11}$ | 4 | 2 | 3 | 5 | 1 | 2 | 2 | 27 | 42.32 |
| $P_{34}$ | $x_{12}$ | 4 | 2 | 3 | 5 | 1 | 2 | 4 | 29 | 43.24 |
| $P_{41}$ | $x_{13}$ | 5 | 2 | 3 | 2 | 1 | 1 | 2 | 24 | 40.94 |
| $P_{42}$ | $x_{14}$ | 5 | 1 | 3 | 5 | 1 | 0 | 1 | 24 | 40.94 |
| $P_{51}$ | $x_{15}$ | 4 | 1 | 2 | 5 | 2 | 1 | 2 | 25 | 41.40 |
| $P_{52}$ | $x_{16}$ | 4 | 2 | 5 | 5 | 2 | 1 | 2 | 29 | 43.24 |
| $P_{53}$ | $x_{17}$ | 4 | 2 | 3 | 5 | 1 | 1 | 2 | 26 | 41.86 |
| $P_{54}$ | $x_{18}$ | 2 | 2 | 5 | 5 | 1 | 1 | 2 | 26 | 41.86 |

For a model building we need to enter the number of variables $x_i$ which is reflecting the application of *i-th* pattern.

## 10. Mathematical Model Building

Applying the above results we obtain the following objective function:

$$1.022x_1 + 0.956x_2 + 0.934x_3 + 0.967x_4 + x_5 + 1.01x_6 + 0.978x_7 + 0.956x_8 + 0.978x_9 + 1.021x_{10} +$$
$$+1.01x_{11} + 1.033x_{12} + 0.978x_{13} + 0.978x_{14} + 0.989x_{15} + 1.033x_{16} + x_{17} + x_{18} \to min$$

with the following restrictions which came from the patterns usage limitations:

a) We can choose only one pattern from the first three groups:

$$x_1 + x_2 + x_3 + x_4 = 1,$$
$$x_5 + x_6 + x_7 + x_8 = 1,$$
$$x_9 + x_{10} + x_{11} + x_{12} = 1,$$
$$x_{15} + x_{16} + x_{17} + x_{18} = 1.$$

b) We can choose any patterns from the remaining groups (or not to choose a pattern at all):

$$x_{13} \le 1,$$
$$x_{14} \le 1,$$
$$x_{13} + x_{14} \le 2.$$

c) If *Transaction Script* is selected from the first group we can choose *Table Data Gateway* or *Row Data Gateway* from the second group:

$$x_1 + x_7 + x_8 \le 1.$$

d) If *Table Module* is selected from the first group we are allowed to choose only *Table Data Gateway* from the second one:

$$x_3 + x_6 + x_7 + x_8 \le 1.$$

e) If *Domain Model* is selected from the first group we can choose *Active Record* or *Data Mapper* from the second group:

$$x_2 + x_5 + x_6 \le 1.$$

### 10.1. The Solution of Integer Programming Problem

Once the objective function is defined as well as all restrictions, we can find the optimal solution for this integer programming problem. The optimal solution for the considered problem is formed by the following values of the variables: $x_2 = x_8 = x_9 = x_{13} = x_{14} = x_{15} = 1$. Thus, the optimal pattern suite for our system consists of the following patterns: $P_{12}$, $P_{24}$, $P_{31}$, $P_{41}$, $P_{42}$, $P_{51}$.

### 10.2. Optimal Pattern Suite's Influence on *FP*

When we determined the optimal pattern suite we can obtain the new value of *FP* which considers such selection — *FP′*. For doing that we need to find the average values of $CF_i$.

| Pattern | $CF_1$ | $CF_2$ | $CF_3$ | $CF_5$ | $CF_9$ | $CF_{10}$ | $CF_{14}$ |
|---|---|---|---|---|---|---|---|
| $P_{12}$ | 4 | 1 | 3 | 5 | 0 | 0 | 1 |
| $P_{24}$ | 2 | 2 | 3 | 5 | 1 | 0 | 1 |
| $P_{31}$ | 4 | 2 | 3 | 5 | 1 | 0 | 1 |
| $P_{41}$ | 5 | 2 | 3 | 2 | 1 | 1 | 2 |
| $P_{42}$ | 5 | 1 | 3 | 5 | 1 | 0 | 1 |
| $P_{51}$ | 4 | 1 | 2 | 5 | 2 | 1 | 2 |
| **Average** | 4 | 2 | 3 | 4 | 1 | 0 | 1 |

If take that $\overline{CF_i} = F_i$ we get the following degree of influence of the characteristic for our software system:

| Nr | System characteristic | Value |
|---|---|---|
| **1** | Data Communications | 4 |
| **2** | Distributed Data Processing | 2 |
| **3** | Performance | 3 |
| **4** | Heavily Used Configuration | 1 |
| **5** | Transaction Rate | 4 |
| **6** | Online Data Entry | 1 |
| **7** | End-User Efficiency | 1 |
| **8** | Online Update | 1 |
| **9** | Complex Processing | 1 |
| **10** | Reusability | 0 |
| **11** | Installation Ease | 0 |
| **12** | Operational Ease | 3 |
| **13** | Multiple Sites | 1 |
| **14** | Facilitate Change | 1 |
| | **Total:** | **23** |

Taking into the consideration the obtained values, the resulting *FP'* will have the following definition:

$$FP' = 46 \times (0.65 + 0.23) = 40.48.$$

Therefore, the difference between the original and the modified value of FP defined as:

$$FP - FP' = 41.86 - 40.48 = 1.38.$$

In a summary, if we apply the optimal pattern suite the value of *FP* is reduced by 1.38, i.e. the overall development effort of the considered software system with the same functionality will be lower.

## 11. Conclusions

In this paper the technique that allows selecting the optimal suite of architectural patterns for logistics and transportation software is proposed. This selection technique is reduced to the classical problem of integer programming where the optimal solution should be found.

As long as the most of the modern logistics and transportation systems are based on N-tier architecture, we've considered a set of patterns that are suitable for its creation. The proposed technique is applied for this set of architectural patterns.

Functional point (*FP*) metric is used as a base metric that measures patterns' numerical impact on system characteristics. It indirectly measures the functional complexity of software, which is directly proportional to the effort of its development.

The objective function is defined for the case study as well as constrains on the use of specific architectural patterns. The resulting solution reflects the optimal suite of architectural patterns that are suitable for the development of the system with the specified requirements. In addition, the quantitative study is given to reduce the development effort by applying the selected suite of architectural patterns.

According to that, the results indicate that the proposed technique is applicable for solving problems of optimal architectural pattern's suite selection when we construct architecture for logistics and transportation systems.

## References

1. Orlov, S., Tsilker, B. **(**2012). *Software Engineering: A Textbook for Universities,* 4th ed. St Petersburg: Piter. 608 p. (In Russian)
2. Bass, L., Clements, P., Kazman, R. (2003). *Software Architecture in Practice*, 2nd Edition. Addison Wesley. 560 p.
3. Pressman, R. S. (2010). *Software Engineering: A Practioner's Approach*. 7th ed. McGraw-Hill. 895 p.
4. Buschmann, F., Meunier, R., Rohnert, H., Sommerlad, P., Stal, M. (1996). *Pattern-Oriented Software Architecture Volume 1: A System of Patterns*. Willey. 476 p.
5. Martin, R. C. (2003). *Agile Software Development: Principles, Patterns and Practices*. Prentice Hall. 552 p.
6. Sergeev, V. Grigoriev, M. Uvarov, S. (2008). *Logistics. Information systems and technology.* Moscow: Alpha-Press. 608 p. (In Russian)
7. Fowler, M. (2002). *Patterns of Enterprise Application Architecture.* Addison Wesley. 560 p.

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# AN INTRODUCTION TO CLOUD COMPUTING

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The future of Internet is cloud computing. All researches, development activities, resources, usability and network infrastructure are working by clouds. For example, Google, Gmail, Dropbox, Yahoo and etc. has clouds. We are using clouds for sending and receiving messages, to get some information, downloading and uploading photos, videos, music and others. This paper reports about an introduction to cloud computing. Firstly, describes the clouds and types of cloud, secondly continue to specific characteristics / capabilities of clouds, where will be shown schemas and table of non-functional aspects, economic aspects, technological aspects.

**Keywords:** Cloud computing, types of cloud, Non-functional aspects, Technological aspects, Economic aspects

## 1. Introduction

Cloud systems are not to be misunderstood as just another form of resource provisioning infrastructure and in fact, as this report shows, multiple opportunities arise from the principles for cloud infrastructures that will enable further types of applications, reduced development and provisioning time of different services. Cloud computing has particular characteristics that distinguish it from classical resource and service provisioning environments.

***Open Research Issues.*** Cloud technologies and models have not yet reached their full potential and many of the capabilities associated with clouds are not yet developed and researched to a degree that allows their exploitation to the full degree, respectively meeting all requirements under all potential circumstances of usage.

***Clouds in the Future Internet.*** Cloud computing is becoming an integral part of computing life, but experts are beginning to wonder whether the future of cloud computing technology beyond the corporate computer services. Some experts believe that cloud solutions will be popular in the commercial, financial and many other areas, and other analysts do not see any of these decisions outside the IT-sector.

Cloud computing – computing infrastructure, carried out in the final you have access through the network. The infrastructure may consist of thousands, hundreds of thousands of computing nodes, storage arrays. All this is connected in a network and operates as one large computer. All set up and is available from the “box”.

***Types of Clouds.*** Cloud providers typically centre on one type of cloud functionality provisioning: Infrastructure, Platform or Software / Application, though there is potentially no restriction to offer multiple types at the same time, which can often be observed in PaaS (Platform as a Service) providers which offer specific applications too, such as Google App Engine in combination with Google Docs. Due this combinatorial capability, these types are also often referred to as “components” deployment types (cloud usage)

***Private Clouds*** are typically owned by the respective enterprise and/or leased. Functionalities are not directly exposed to the customer, though in some cases services with cloud enhanced features may be offered – this is similar to (Cloud) Software as a Service from the customer point of view.

*Example: eBay.*

***Public Clouds.*** Enterprises may use cloud functionality from others, respectively offer their own services to users outside of the company. Providing the user with the actual capability to exploit the cloud features for his/her own purposes also allows other enterprises to outsource their services to such cloud providers, thus reducing costs and effort to build up their own infrastructure.

***Hybrid Clouds.*** Though public clouds allow enterprises to outsource parts of their infrastructure to cloud providers, they at the same time would lose control over the resources and the distribution /management of code and data. In some cases, this is not desired by the respective enterprise.

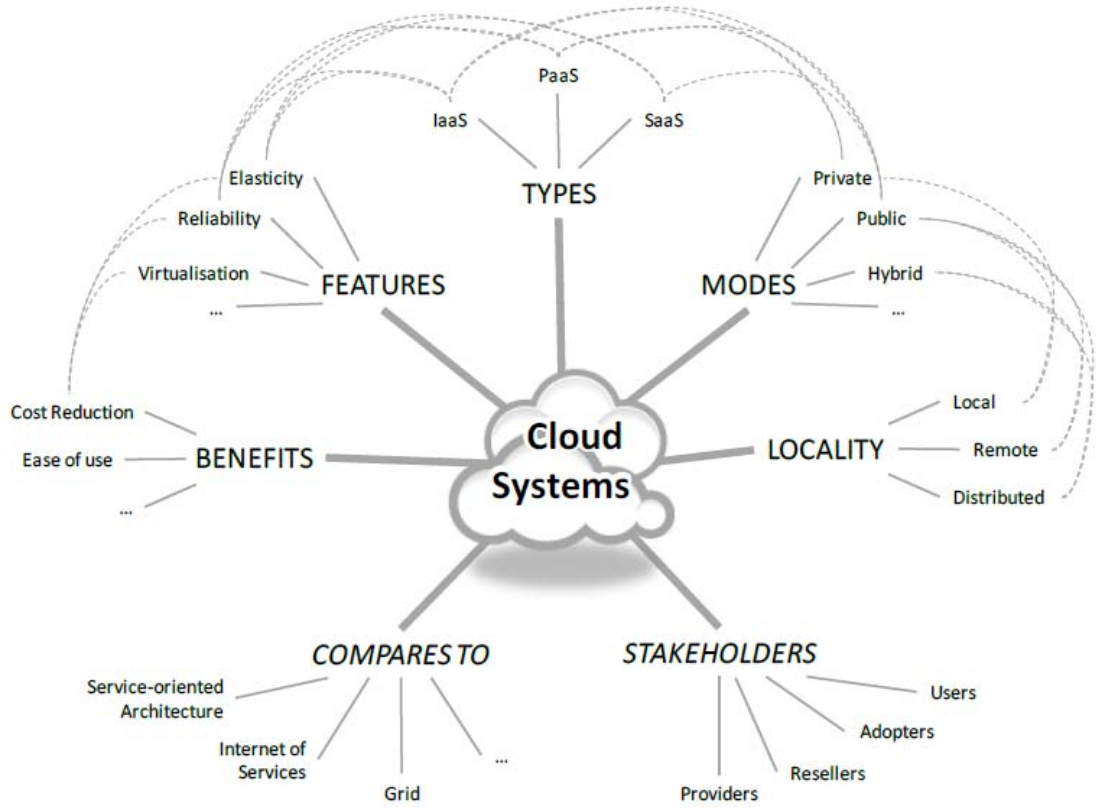


*Figure 1.* Non-exhaustive view on the main aspects forming a cloud system

## 2. Specific Characteristics of Clouds

Capabilities of clouds – includes this three elements are called: **Non-functional, economic considerations, technological challenges.**

### 2.1. Non-Functional Aspects

**Elasticity** – is an essential core feature of cloud systems and circumscribes the capability of the underlying infrastructure to adapt to changing, potentially non-functional requirements, for example amount and size of data supported by an application, number of concurrent users.

**Reliability** – is essential for all cloud systems – in order to support today's data centre-type applications in a cloud, reliability is considered one of the main features to exploit cloud capabilities.

**Quality of Service** – support is a relevant capability that is essential in many use cases where specific requirements have to be met by the outsourced services and / or resources.

**Agility and adaptability** – are essential features of cloud systems that strongly relate to the elastic capabilities.

1. NON-FUNCTIONAL ASPECTS OVERVIEW

| | General | Examples | (IaaS) | (PaaS) | (SaaS) | (Users) |
|---|---|---|---|---|---|---|
| Elasticity | ☑ horizontal scale-out<br>☐ vertical scalability<br>☐ efficient scale-down | horizontal: Amazon EC2 ; Amazon S3; Google Docs; eBay, MS Azure<br>vertical: Xen; Amazon S3 (to a degree) | ☑ horizontal scale<br>☐ vertical scale<br>☐ scale-down | ☑ horizontal scale | ☑ horizontal scale | ☑ scalability<br>☐ potentially too high resource consumption |
| Reliability | ☑ reliable data storage<br>- no code execution | Xen Server Virtualisation, VMWare | ☑ reliable data storage<br>☐ no code execution | ☑ reliable app execution | ☑ reliable data storage<br>☐ no code execution | ☑ data replication |
| Quality of Service | ☑ resource level QoS solved<br>☐ little usage in clouds<br>☐ no higher level representation | Cisco, Amazon S3, Amazon EC2 | ☑ resource level QoS<br>☐ no abstraction | ☐ no SLA | ☐ hardly any SLA | ☑ basic quality guarantees |
| Agility and adaptability | ☑ see elasticity<br>☐ little adaptability to use cases<br>☐ little adaptability to technology | RightScale, FlexNet | ☑ adapt to resource (virtualisation)<br>☐ only on image level | ☑ elasticity<br>☐ static APIs | ☑ elasticity<br>☐ depends fully on service' capabilities | ☐ has to adapt code to system not vice versa |
| Availability | ☑ high availability<br>☐ basically only through replication<br>☐ requires large infrastructure | MS Azure, Amazon S3 | ☑ high data availability<br>☐ little resource availability | ☑ high data availability<br>☑ fair applet availability | ☑ high data availability<br>Note: service availability depends on complexity | ☑ data availability<br>☐ service availability<br>☐ resource availability |

TABLE 1: NON-FUNCTIONAL ASPECTS ADDRESSED BY CURRENT COMMERCIAL EFFORTS
(☑ SUPPORTED; ☐ DEFICIENCY)

*Figure 2.* Non-functional aspects

## 2.2. Economic Aspects

***Cost reduction*** is one of the first concerns to build up a cloud system that can adapt to changing consumer behaviour and reduce cost for infrastructure maintenance and acquisition.

***Pay per use.*** The capability to build up cost according to the actual consumption of resources is a relevant feature of cloud systems.

2. ECONOMIC ASPECTS OVERVIEW

| | General | Examples | (IaaS) | (PaaS) | (SaaS) | (Users) |
|---|---|---|---|---|---|---|
| Cost reduction | ☑ simplified service provisioning<br>☑ simplified resource management<br>☐ proprietary structures<br>☐ no general recommendations<br>(cf. "improved time to market") | Google Apps Engine (through scaling) | ☑ resource management<br>☐ no general rules | ☑ resource mgmt<br>☑ scale management<br>☐ recommendations | ☑ resource & scaling management<br>☐ no general policies | ☑ outsourcing<br>☑ reduced mgmt overhead<br>☑ scalability<br>☐ change vs. gain<br>☐ too high resource consumption |
| | | | all providers have the full costs of providing and maintaining the resources - cost reduction is mostly on user's side. | | | |
| Pay per use | ☑ static billing<br>☑ dynamicity e.g. in DSL<br>☐ use case specific<br>☐ not related to resource availability | PayPal, HP PPU | ☑ basic billing support<br>☐ little resource specific support<br>☐ no relationship to QoS management | ☑ basic billing support<br>☐ little service specific support | ☑ basic billing support<br>☐ little service specific support | ☑ automatic billing<br>☐ little negotiation support<br>☐ little QoS related support |
| Improved time to market | ☑ simplified service provisioning<br>☑ simplified resource management<br>☐ proprietary structures | Animoto | n/a | n/a | n/a | ☑ simplified resource & service lifecycle<br>☑ simple (use case specific) APIs<br>☐ use case specific<br>☐ vendor lock-in |
| | | | applies only to aggregators,resellers or consumers | | | |
| Return of investment (ROI) | ☑ outsourcing & work offloading<br>☐ difficult to assess<br>☐ no general guidelines | | ☐ no general recommendations | ☐ no general recommendations | ☐ no general recommendations | ☑ outsourcing & work offloading<br>☐ general guidelines |
| | | | applies mostly to cloud uptakers | | | |
| Turning CAPEX into OPEX<br>"Going Green" | *General issue* | | No dedicated tool support | | | |
| | ☑ addressed by data centres<br>☑ EC code of conduct [21]<br>☐ little support "in the cloud" | EfficientServers | ☑ measurement mechanisms<br>☑ EC code of conduct<br>☑ greener hardware (e.g. Intel Atom)<br>☐ needs to be implemented manually | ☑ EC code of conduct<br>☐ needs to be implemented manually | ☑ EC code of conduct<br>☐ needs to be implemented manually | ☑ outsourcing<br>☑ dynamic scalability<br>☐ effectively manually |

TABLE 2: ECONOMICAL ASPECTS ADDRESSED BY CURRENT COMMERCIAL EFFORTS
(☑ SUPPORTED; ☐ DEFICIENCY)

*Figure 3.* Economical aspects

***Improved time to market*** is essential in particular for small to medium enterprises that want to sell their services quickly and easily with little delays caused by acquiring and setting up the infrastructure, in particular in a scope compatible and competitive with larger industries.

***Return of investment* (*ROI*)** is essential for all investors and cannot always be guaranteed – in fact some cloud systems currently fail this aspect.

***Turning CAPEX into OPEX*** is an implicit, and much argued characteristic of cloud systems, as the actual cost benefit (cf. ROI) is not always clear (see e.g. [9]).

***"Going Green"*** is relevant not only to reduce additional costs of energy consumption, but also to reduce the carbon footprint.

### 2.3. Technological Aspects

***Virtualization*** is an essential technological characteristic of clouds which hides the technological complexity from the user and enables enhanced flexibility (through aggregation, routing and translation).

***Multi-tenancy*** is a highly essential issue in cloud systems, where the location of code and / or data is principally unknown and the same resource may be assigned to multiple users (potentially at the same time).

***Security, Privacy and Compliance*** is obviously essential in all systems dealing with potentially sensitive data and code.

***Data Management*** is an essential aspect in particular for storage clouds, where data is flexibly distributed across multiple resources.

***APIs and/or Programming Enhancements*** are essential to exploit the cloud features: common programming models require that the developer takes care of the scalability and autonomic capabilities him- / herself, whilst a cloud environment provides the features in a fashion that allows the user to leave such management to the system.

3. TECHNOLOGICAL ASPECTS OVERVIEW

| | General | Examples | (IaaS) | (PaaS) | (SaaS) | (Users) |
|---|---|---|---|---|---|---|
| Virtualisation | ☑ some virtualisation in all clouds<br>☑ numerous technologies<br>☑ location independence<br>☐ difficult to use<br>☐ no interoperability | Xen, Virtual PC, VMWare, Virtual Box, MS HyperV | ☑ machine virtualisation<br>☑ routing, security ...<br>☑ leave images to customer<br>☐ only images | ☑ easier resource maintenance<br>☑ routing<br>☐ difficult to use | ☑ easier resource maintenance<br>☑ routing<br>☐ difficult to use | ☑ simple access<br>☐ no interoperability |
| Multi-tenancy | ☑ general data management support<br>☐ little multi-purpose solutions | MS SQL [27] | ☑ image separation<br>☐ VM support little cross resource multi-tenancy issues | ☑ general data management support<br>☑ engine re-usage<br>☐ mostly manual | ☑ data mgmt.<br>☑ instantiation support<br>☐ manual | ☑ higher availability<br>☐ data consistency manual (see data management) |
| Security and Compliance | ☑ encryption<br>☑ identification, authentication & authorization<br>☑ data rights management<br>☐ legislative regulation<br>☐ constant changes<br>☐ compliance with specific security requirements | almost all | ☑ encryption, authentication etc.<br>☑ virtual machine separation<br>☐ only valid for access portals | ☑ encryption, authentication etc. Note: manual configuration but only per engine | ☑ encryption, authentication etc.<br>☐ manual configuration per service | ☑ easily available<br>☑ mostly catered for by provider<br>☐ legislative regulations not available / not observed |
| Data Management | ☑ many basic issues addressed<br>☑ distributed data management<br>☑ versioning<br>☑ conversion<br>☐ always new challenges<br>☐ little interoperability<br>☐ consistency, scalability, growth | Mesh, Amazon Dynamo, WebSphere | ☑ general data management support<br>☐ no specific data management across virtual machines<br>☐ efficiency | ☑ general data management support<br>☐ consistency management<br>☐ concurrency<br>☐ efficiency | ☑ general data management support<br>☐ consistency management<br>☐ concurrency<br>☐ efficiency | ☑ data available anywhere<br>☐ consistency mostly manual<br>☐ little interoperability - speed vs. size |
| APIs and / or Programming Enhancements | ☑ use case specific "simple" APIs<br>☑ generic programming models<br>☑ full application development for clouds<br>☐ complexity<br>☐ control | MS Azure, Google App Engine, Hadoop | n/a | ☑ use case specific APIs (engines)<br>☐ complexity<br>☐ control | ☑ generic programming models<br>☐ complexity<br>☐ control | ☑ different programming models<br>☐ complexity mostly with the developer<br>☐ little in-depth control |

TABLE 3: TECHNOLOGICAL ASPECTS ADDRESSED BY CURRENT COMMERCIAL EFFORTS (☑ SUPPORTED; ☐ DEFICIENCY)

*Figure 4.* Technological aspects

## 3. Conclusions

Cloud computing is a way to access, dynamically scalable, to computing resources, i.e. service that is provided by the internet. At the same time from someone who makes a request, does not require any special knowledge about the structure of clouds or cloud the ability to control technology. Cloud computing is a new approach that allows you to reduce the complexity of it systems, thanks to that used a wide range of effective technologies, which are managed independently and are available on request within a virtual infrastructure, as well as the services are consumed. In the transition to private cloud, the customer gets a lot of advantages, namely, reducing the cost of it, business agility and improve the quality of service. Cloud is a completely new business model for obtaining and providing information services. In the near future, this model reduces capital and operational costs.

## References


1. Malis, A. (1993). Routing over large clouds (ROLC) charter, part of the 32nd IETF meeting, from http://www.ietf.org/proceedings/32/charters/rolc-charter.html.
2. Markoff, John. (2001). Internet Critic Takes on Microsoft. Retrieved 20.04.2012, from New York Times ( Published: April 09. 2001) http://www.nytimes.com/2001/04/09/technology/09HAIL.html?ex=1217563200&en=7c46bdefb6a8450a&ei=5070
3. Wikipedia. John McCarthy (computer scientist). (20.04.2012, Retrieved, from http://en.wikipedia.org/wiki/John_McCarthy_ (computer_scientist)
4. Barr, J. (2006). Amazon EC2 Beta. Retrieved 20.04.2012,, from http://aws.typepad.com/aws/2006/08/amazon_ec2_beta.html
5. Sutter, H. (2005). The Free Lunch Is Over: A Fundamental Turn Toward Concurrency in Software. *Dr. Dobb's Journal*, 30(3).
6. Toffler, A. (1980). The Third Wave: Pan Books
7. Wikipedia. Cloud Computing. Retrieved 20.04.2012, from http://en.wikipedia.org/wiki/Cloud_computing
8. Wikinomics. The Prosumers. Retrieved 20.04.2012, from at http://www.socialtext.net/wikinomics/index.cgi?the_prosumers
9. Golden; B. (2009). Capex vs. Opex: Most People Miss the Point About Cloud Economics' Retrieved 20.04.2012, from http://www.cio.com/article/484429/Capex_vs._Opex_Most_People_Miss_the_Point_About_Cloud_Economics


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# CUMULATIVE INDEX

## *COMPUTER MODELLING and NEW TECHNOLOGIES, volume 16, no. 3, 2012*

## *(Abstracts)*

**D. Greenberg, D. Golenko-Ginzburg.** Financial Models of Human Behaviour in Design Office. *Part II. Projects' Executors as Active Players*, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 7–11.

The developed models are a further extension of the model presented in [1]. The general idea centres on determining quasi-optimal estimates of random activity durations from the executors in order to maximize both the project's utility and the executors' personal profit. Here both the executors and the design office are active players.

**Keywords:** active systems; active players; PERT-COST projects; project activity of random duration; activity executor; estimation of p.d.f. activity duration

**K. N. Nechval, N. A. Nechval, M. Purgailis, U. Rozevskis, V. F. Strelchonok, M. Moldovan.** Prediction Limits for a Number of Future Failures under Uncertainty, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 12–23.

In this paper, we present an accurate procedure to obtain prediction limits for a number of failures that will be observed in a future inspection of a sample of units, based only on the results of the first in-service inspection of the same sample. The failure-time of such units is modelled with a two-parameter Weibull distribution indexed by scale and shape parameters $\beta$ and $\delta$, respectively. It will be noted that in literature only the case is considered when the scale parameter $\beta$ is unknown, but the shape parameter $\delta$ is known. As a rule, in practice the Weibull shape parameter $\delta$ is not known. Instead it is estimated subjectively or from relevant data. Thus its value is uncertain. This $\delta$ uncertainty may contribute greater uncertainty to the construction of prediction limits for a future number of failures. In this paper, we consider the case when both parameters $\beta$ and $\delta$ are unknown. In literature, for this situation, usually a Bayesian approach is used. Bayesian methods are not considered here. We note, however, that although subjective Bayesian prediction has a clear personal probability interpretation, it is not generally clear how this should be applied to non-personal prediction or decisions. Objective Bayesian methods, on the other hand, do not have clear probability interpretations in finite samples. The technique proposed here for constructing prediction limits emphasizes pivotal quantities relevant for obtaining ancillary statistics and represents a special case of the method of invariant embedding of sample statistics into a performance index. Two versions of prediction limits for a future number of failures are given.

**Keywords:** Weibull distribution, parametric uncertainty, future number of failures, prediction limits

**J.-R. Kalnins, I. Pakalnite.** Kinetics of One-Dimensional Instantaneous Forest Fire Model, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 24–28.

Forest tree kinetics is investigated by the computer simulation in one-dimensional instantaneous model. A universal index which characterizes tree cluster distribution is found. The index is independent from the model parameters in the wide range of its values.

**Keywords:** forest fire one-dimensional models, self-organized critical properties

**Y. Shishkina.** Common Scientific and Technological Space as the Basis for Construction Innovative System, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 29–32.

The Construction industry in any country is the major part of its economy. Construction materials production (hereinafter – CMP) expenses in average exceed 50% [7] of the construction finished products net price. Forming a major material and technical basis for construction it significantly impacts the other economy sectors growth and social status of the society in general.

The Construction industry is considered to be the most conservative and inactive with regards to new materials and technologies introduction. This is caused by the fact that major criteria for

construction materials and technologies assessment is the compliance with the requirements of technical regulations, and other applicable regulatory instruments before the first ones are adopted. Incomplete regulatory base in the Republic of Kazakhstan monitoring the construction, production and application of construction materials holds the industry back from transitioning to a whole new level.

Exchange and interaction infrastructure is developing in modern economic processes. This intensifies the exchange processes between enterprises, regions, states not only in a form of goods and finances movement, but also in a form of delivery of new technologies, intellectual property objects, and integration of various knowledge and skills.

**Keywords:** construction, construction materials production (CMP), economy, regulatory documents, scientific and technological space, innovations, innovative infrastructure

**P. Shamoi.** Smart Target Selection Implementation Based on Fuzzy Sets and Logic, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 33–40.

This paper aims to emphasize the effectiveness of an application of fuzzy sets and logic in the implementation of target selection (TS). TS is an important data mining problem that aims to identify profiles of customers who are likely to respond to the offer for a particular product or service. Very often TS of information have very blurred conditions. Fuzzy classification can be extremely efficient there, because it is much closer to the way that humans express and use their knowledge. One of the advantages of the proposed method is that it is consistent with relational databases. But the main advantage is – the query to the system is done in a natural language, such as show the list of not very young married clients with average or more-or-less high income, which is impossible using a standard query mechanism.

**Keywords:** target selection, fuzzy sets, fuzzy logic, fuzzy mathematics, natural query

**S. Makagonov.** Synchronization Between Desktop Application and Web Clients Provided by *Node.js* Software System, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 41–44.

IT-market is a very rapidly developing sector in most of the developing and developed countries and in Kazakhstan in particular. According to the statistics, the number of active KazNet users has increased more than twice since 2010, forming 2,150,000 users. Users can more and more often come upon various internet-shops, which are now selling not only software products, but also such products as fruit and vegetables and even more exotic things.

**Keywords:** IT-market, web clients, Node.js, web sockets, TCP, JavaScript, synchronization

**Zh. Madimova, L. Atymtayeva.** Development of Software for Project Management Based on *PMBoK*, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 45–48.

Nowadays effective project management leads to success of the project as a whole. Therefore it is very important to know how to manage them in most effective and accurate way. Numerous guides and applications are considered to solve this problem. However variety of software for managing documents electronically and based on specific guide is pure. The purpose of this article is to introduce the developed web application based on PMBoK guide, which simplify project documentation management. The article provides general information about PMBoK guide, methods used in web application development and shows its class diagrams.

**Keywords:** project management, PMBoK, MVC

**R. Uskenbaeva, G. Bektemyssova.** Research of Reliability of Distributed Computer System, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 49–53.

Development and improvement of distributed computer systems (DCS) is one of the general trends in nowadays' computer science and information processing. The core of such systems is a set of processor's modules (PM), carrying out a parallel processing of the information and cooperating by means of any subsystem of communication.

**Keywords:** distributed computer systems (DCS), processor's modules (PM)

**K. A. Kultasov, A. A. Rysbekova.** Calculation of Composite Plates of Variable Thickness and Fold in Action Radial Force, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 54–57.

The problem of the symmetric deformation of an elastic composite circular plate, a radially variable thickness, which is generally subjected to a transverse load, the radial forces experienced uneven heating.

**Keywords:** bending, composite plate, boundary value problem, bending moment

**G. Nurmukhanbetova, A. Suleimenova**, Sustainable Energy Use: *Prospects of Biofuel, Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 58–62.

This paper aims to examine benefits and threats of first-generation biofuels and discuss the potential of advanced, more sustainable next generation biofuels to offer promising potential to address energy security issues.

**Keywords:** biofuel, first-generation ligno-cellulosic biofuels, second generation biofuels, third generation algae-based biofuels

**A. Z. Aitmagambetov, Z. M. Jakipbayeva.** Cognitive Radio Networks is the Next Step in Communication Technology, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 63–67.

Wireless computing and communications are growing rapidly. The expansion of wireless applications usage creates an increasing demand for developing of an effective access to radio spectrum. The problem of spectrum usage could be solved with deployment of cognitive radio (CR) which is a breakthrough in technological innovations.

CR makes it possible to use existed spectrum bands effectively and finds solution to the "congestion" problem in information systems. Apart from having positive characteristics in terms of spectrum efficiency, its application performance is configurable, upgradable and flexible. Therefore for the future several decades CR provides opportunity of scaling wireless systems.

However, creation of cognitive networks requires definition of many technical challenges from dynamic spectrum allocation methods and sensing to network security. It the presented paper important details about high-level cognitive radio opportunities and challenges will be shown.

**Keywords:** Cognitive Radio CR, Cognitive Radio Network CRN, Spectral Policy, Dynamic Spectrum Access DSA

**S. Orlov, A. Vishnyakov.** Architectural Pattern Suite Optimization for Logistics and Transport Systems, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 68–75.

Software architecture design plays the key role for logistics and transport software engineering. One of the design approaches is to reuse the architectural patterns, which express a fundamental structural organization of software systems and its behaviour. The usage of the proven and tested solutions allows us to increase the software quality and reduce potential risks.

To choose the optimal architectural patterns suite it is necessary to use a technique that contains a number of steps. The technique proposed in this paper allows us to consistently evaluate the impact of specific patterns to overall software development effort with a given functionality. In addition, it takes into account the interference between patterns. Effectiveness and efficiency of the described method is confirmed by a case study.

**Keywords**: architecture, pattern, functional points, metrics, logistics and transport software, integer programming, objective function, restriction, bounded, optimization, decision

**S. B. Mukhanov, B. Ye. Amirgaliyev.** An Introduction to Cloud Computing, *Computer Modelling and New Technologies,* vol. 16, no. 3, 2012, pp. 76–80.

The future of Internet is cloud computing. All researches, development activities, resources, usability and network infrastructure are working by clouds. For example, Google, Gmail, Dropbox, Yahoo and etc. has clouds. We are using clouds for sending and receiving messages, to get some information, downloading and uploading photos, videos, music and others. This paper reports about an introduction to cloud computing. Firstly, describes the clouds and types of cloud, secondly continue to specific characteristics / capabilities of clouds, where will be shown schemas and table of non-functional aspects, economic aspects, technological aspects.

**Keywords:** cloud computing, types of cloud, non-functional aspects, technological aspects, economic aspects

## *COMPUTER MODELLING and NEW TECHNOLOGIES, 16. sējums, Nr. 3, 2012*

## *(Anotācijas)*

**D. Grīnbergs, D. Golenko-Ginzburgs.** Cilvēka uzvedības finanšu modeļi dizaina birojā. II daļa. Projektu izpildītāji kā aktīvie spēlētāji, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 7.–11. lpp.

Izstrādātie modeļi ir modeļa, kas parādīts [1], turpmāka pagarināšana. Galvenā ideja koncentrējas uz izpildītāju izlases darbības ilguma noteiktām kvazi-optimālām aplēsēm, lai palielinātu gan projekta lietderību, gan izpildītāju personīgo peļņu. Šeit aktīvi spēlētāji ir kā izpildītāji, tā arī dizaina birojs.

**Atslēgvārdi:** aktīvas sistēmas, aktīvi spēlētāji, *PERT-COST* projekti; izlases laika projekta aktivitāte; aktivitātes izpildītājs, *p.d.f.* darbības ilguma novērtējums

**K. Nečvals, N. Nečvals, M. Purgailis, U. Rozevskis, V. Strelčonoks, M. Moldovans**. Prognozēšanas ierobežojumi attiecībā uz vairākām turpmākām neveiksmēm nenoteiktības apstākļos, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 12.–23. lpp.

Šajā rakstā mēs piedāvājam precīzu procedūru, lai iegūtu prognozēšanas ierobežojumus attiecībā uz vairākām nepilnībām, kas jāievēro vienību paraugā turpmākajā pārbaudē, pamatojoties tikai uz tā paša parauga pirmajiem ekspluatācijas pārbaudes rezultātiem. Šādu vienību neveiksmes laiks ir veidots ar Veibula sadalījuma diviem parametriem, kas indeksēts ar mēroga un formas parametriem $\beta$ un $\delta$, attiecīgi. Jāatzīmē, ka literatūrā tikai gadījums tiek izskatīts, ja mēroga parametrs $\beta$ ir nezināms, bet formas parametrs $\delta$ ir zināms. Kā likums, praksē Veibula formas parametrs $\delta$ nav zināms. Tā vietā tiek aprēķināts subjektīvi vai no attiecīgajiem datiem. Tādējādi tā vērtība ir neskaidra. Šī $\delta$ nenoteiktība var veicināt lielāku nenoteiktību prognozēšanas limitu konstruēšanā turpmākam neveiksmju skaitam. Šajā rakstā autori izskata gadījumu, kad abi parametri $\beta$ un $\delta$ ir nezināmi. Literatūrā šajā situācijā parasti tiek izmantota *Bayesian* pieeja. Šeit nav aplūkotas *Bayesian* metodes. Mēs tomēr atzīmējam, ka, lai gan subjektīvām *Bayesian* prognozēm ir skaidra personīgā varbūtības interpretācija, tas parasti nav skaidrs, kā tas būtu jāpiemēro bezpersoniskām prognozēm vai lēmumiem. Objektīvi *Bayesian* metodēm, no otras puses, nav skaidras varbūtību interpretācijas ierobežotos paraugos. Paņēmiens, kas tiek ierosināts šeit, lai konstruētu prognozēšanas robežas, uzsver noteicošos daudzumus būtiskus, lai saņemtu palīg- statistiku, un pārstāv izlases statistikas invariantu iestiprināšanas metodes īpašu gadījumu darba kvalitātes rādītājā. Rakstā turpmākam neveiksmju skaitam ir dotas prognozēšanas limitu divas versijas.

**Atslēgvārdi:** Veibula sadalījums, parametriska varbūtība, turpmākais neveiksmju skaits, prognozēšanas ierobežojumi

**J.-R. Kalniņš, I. Pakalnīte.** Viendimensijas momentānā meža ugunsgrēka modeļa kinētika, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 24.–28. lpp.

Meža koku kinētiku pēta ar datoru simulāciju viendimensijas momentānā modelī. Pētījumā ir atrasts universāls indekss, kas raksturo koku kopas sadalījumu. Indekss ir neatkarīgs no modeļa parametriem tās vērtību plašā lokā.

**Atslēgvārdi:** meža ugunsgrēku viendimensijas modelis, pašorganizētas kritiskas īpašības

**J. Šiškina.** Kopīgs zinātniskais un tehnoloģiskais kosmoss kā pamats novatoriskās sistēmas veidošanai, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 29.–32. lpp.

Būvniecības industrija jebkurā valstī ir galvenā ekonomikas daļa. Celtniecības materiālu ražošanas izdevumi vidēji pārsniedz 50% [7] no būvniecības gatavās produkcijas neto cenas. Veidojot lielu materiālo un tehnisko bāzi būvniecībai, tas būtiski ietekmē citu ekonomikas nozaru izaugsmi un sociālo statusu sabiedrībā kopumā.

Mūsdienu ekonomiskajos procesos attīstās apmaiņas un mijiedarbības infrastruktūra. Tas pastiprina apmaiņas procesus starp uzņēmumiem, reģioniem, valstīm, ne tikai preču un finansu kustības veidā, bet arī jaunu tehnoloģiju piegādāšanas, intelektuālā īpašuma objektu un dažādu zināšanu un prasmju integrācijas veidā.

**Atslēgvārdi:** būvniecība, būvmateriālu ražošana, ekonomika, normatīvie dokumenti, zinātnes un tehnoloģiju telpas, inovācijas, inovatīvā infrastruktūra

**P. Šamojs.** Gudra mērķa atlase un tā ieviešana, pamatojoties uz fazi-rindu un loģiku, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 33.–40. lpp.

Šī raksta mērķis ir uzsvērt fazi rindu un loģikas pielietojuma efektivitāti mērķa atlases īstenošanā. Mērķa atlase ir svarīgs datu ieguves jautājums, kuras nolūks ir noteikt klientu profilus, kuri var atbildēt uz piedāvājumu par konkrētu produktu vai pakalpojumu. Ļoti bieži informācijas mērķa atlasei ir ļoti neskaidri apstākļi. Fazi klasifikācija var būt ļoti efektīva, jo tas ir daudz tuvāk tam, kā cilvēki izsaka un izmanto savas zināšanas.

Viena no piedāvātās metodes priekšrocībām ir tā, ka tā ir savienojama ar relāciju datu bāzēm. Bet galvenā priekšrocība ir tā, ka vaicājums sistēmai tiek veikts dabiskā valodā, piemēram, parādīt ne pārāk jaunu precētu klientu sarakstu, ar vidējiem vai ar vairāk vai mazāk augstiem ienākumiem, kas, savukārt, nav iespējams, izmantojot standarta vaicājumu mehānismu.

**Atslēgvārdi:** mērķa izvēle, fazi rindas,, fazi loģika, fazi matemātika, dabisks vaicājums

**S. Makagonovs.** Sinhronizācija starp galddatora lietojumprogrammu un interneta klientiem, ko nodrošina *Node.js* programmatūras sistēma, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 41.–44. lpp.

IT tirgus ir nozare, kas attīstās ļoti strauji lielākajā daļā jaunattīstības valstīs, attīstītajās valstīs un, jo īpaši, Kazahstānā. Saskaņā ar statistikas datiem, aktīvo KazNet lietotāju skaits ir palielinājies vairāk nekā divas reizes kopš 2010.gada, veidojot 2.150.000 lietotāju. Lietotāji var arvien biežāk nākt uz dažādiem interneta veikaliem, kas tagad pārdod ne tikai programmatūras produktus, bet arī tādus produktus, kā augļus un dārzeņus, un vēl jo eksotiskākas lietas.

**Atslēgvārdi:** IT-tirgus, interneta klienti, *Node.js*, TCP, JavaScript, sinhronizācija

**Ž. Madimova, L. Atimtajeva.** Programmatūras izstrāde projektu vadībai, pamatojoties uz *PMBoK*, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 45.–48. lpp.

Mūsdienās efektīva projektu vadība ved pie panākumiem darbā ar projektu kopumā. Tāpēc ir ļoti svarīgi zināt, kā ar tiem tikt galā visefektīvākā un pareizā veidā. Daudzas rokasgrāmatas un pielikumi tiek uzskatīti, ka var risināt šo problēmu. Tomēr programmatūras daudzveidība, lai pārvaldītu dokumentus elektroniski, pamatojoties uz konkrētu rokasgrāmatu, ir nevainojama. Šī raksta mērķis ir ieviest izstrādāto tīmekļa pielietojumu, pamatojoties uz PMBoK rokasgrāmatu, kas vienkāršo projektu dokumentācijas pārvaldību. Raksts sniedz vispārīgu informāciju par PMBoK rokasgrāmatu, metodēm, ko izmanto tīmekļa lietojumprogrammas attīstībā, un parāda tās klašu diagrammas.

**Atslēgvārdi:** projektu vadība, PMBoK, MVC

**R. Uskenbajeva, G. Bektemisova,** Sadalītās datorsistēmas drošuma izpēte, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 49.–53. lpp.

Sadalīto datorsistēmu attīstība un pilnveidošana ir viena no vispārējām tendencēm mūsdienu datorzinātnes un informācijas apstrādē. Šādu sistēmu pamatā ir procesoru moduļu rinda, veicot paralēlu informācijas apstrādi un sadarbojoties ar jebkādu komunikācijas apakšsistēmu.

**Atslēgvārdi:** sadalītās datorsistēmas, procesora moduļi

**K. Kultasovs, A. Risbekova.** Mainīga biezuma kompozīto plākšņu aprēķins un nolocīšana ar radiālu spēku, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 54.–57. lpp.

Elastīgas kompozītu apaļās plāksnes simetriskās deformācijas problēma, radiāli mainīgs biezums, kas parasti pakļauts šķērsvirziena slodzei, radiālie spēki, kas piedzīvo nevienmērīgu sasilšanu – tie ir jautājumi, kas tiek izskatīti dotajā rakstā.

**Atslēgvārdi:** locīšana, kompozītu plate, robežgadījumu problēma, locīšanas moments

**G. Nurmuhanbetova, A. Suleimenova.** Ilgtspējīgs enerģijas lietojums: *biodegvielas perspektīvas*, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 58.–62. lpp.

Šā pētījuma mērķis ir izvērtēt pirmās paaudzes biodegvielas ieguvumus un draudus un apspriest uzlabotas, ilgtspējīgākas nākamās paaudzes biodegvielas iespējas, lai piedāvātu daudzsološas iespējas risināt energoapgādes drošības jautājumus.

**Atslēgvārdi:** biodegviela, pirmās paaudzes ligno-celulozes biodegvielas, otrās paaudzes biodegvielas, trešās paaudzes *algae*-balstītas biodegvielas

**A. Aitmagambetovs, Z. Jakipbajeva.** Kognitīvā radio tīkli ir nākamais solis komunikāciju tehnoloģijās, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 63.–67. lpp.

Strauji pieaug bezvadu skaitļošanas un komunikācijas. Bezvadu lietojuma izmantošanas paplašināšanās rada pieaugošu pieprasījumu pēc efektīvas piekļuves radiofrekvenču spektram. Spektra izmantošanas problēmu var atrisināt ar kognitīvā radio izvietošanu, kas ir tehnoloģisko jauninājumu sasniegums.

Kognitīvais radio ļauj efektīvi izmantot pastāvošās spektra joslas un atrod risinājumu „pārslodzes" problēmai informācijas sistēmās. Neatkarīgi no tā pozitīvām īpašībām attiecībā uz radiofrekvenču spektra efektivitāti, tās pielietošanas sniegums ir konfigurējams, uzlabojams un elastīgs. Tāpēc nākotnē vairākus gadu desmitus kognitīvais radio sniegs iespēju bezvadu sistēmu mērogošanai.

Tomēr izziņas tīklu izveide prasa definēt daudzas dinamiskāko spektra sadalījuma metožu tehniskas problēmas, kā arī sensora izveidi tīkla drošībai. Rakstā ir parādītas svarīgas novitātes par augsta līmeņa kognitīvā radio iespējām un izaicinājumiem.

**Atslēgvārdi:** kognitīvais radio, kognitīvā radio tīkls, spektrālā politika, dinamiska spektrālā piekļuve

**S. Orlovs, A. Višņakovs.** Arhitektūras Tipa Komplekta Optimizācija Loģistikas un Transporta Sistēmām, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 68.–75. lpp.

Programmatūras arhitektūras dizainam ir galvenā loma loģistikas un transporta programmatūras inženierijā. Viena no dizaina pieejām ir atkārtoti lietot arhitektūras modeļus, kas izsaka būtisku programmatūras sistēmu un tās uzvedības strukturālo organizāciju. Pierādītu un pārbaudītu risinājumu izmantošana ļauj palielināt programmatūras kvalitāti un samazināt iespējamos riskus.

Lai izvēlētos optimālos arhitektūras modeļu komplektus, ir nepieciešams lietot tādu tehniku, kura satur veselu rindu pasākumus. Paņēmiens, kas piedāvāts šajā rakstā, ļauj pastāvīgi novērtēt īpašo modeļu ietekmi uz kopējiem programmatūras izstrādes centieniem ar konkrēto funkcionalitāti. Turklāt, tas ņem vērā traucējumus starp modeļiem. Aprakstītās metodes lietderība un efektivitāte ir apstiprināta dotajā izpētē.

**Atslēgvārdi:** arhitektūra, modelis, funkcionālie punkti, metrika, loģistikas un transporta programmatūra, nedalīta programmēšana, mērķa funkcija, ierobežošana, ierobežots, optimizācija, lēmums

**S. Muhanovs, B. Amirgalijevs.** Ievads mākoņu skaitļošanā, *Computer Modelling and New Technologies,* 16. sēj., Nr. 3, 2012, 76.–80. lpp.

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**Atslēgvārdi:** mākoņu skaitļošana, mākoņu veidi, nefunkcionālie aspekti, tehnoloģiskie aspekti, ekonomiskie aspekti

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