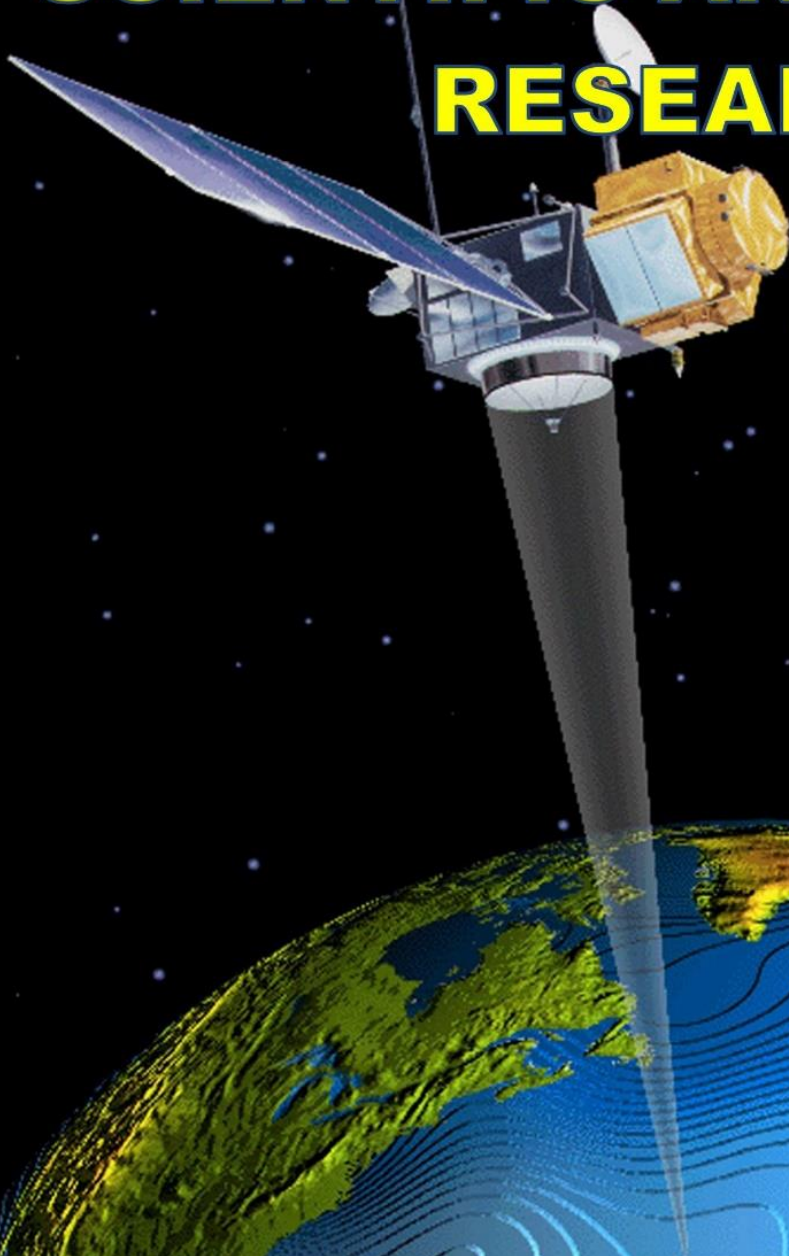


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EFFICIENCY OF A SYSTEM FOR PRIMARY PROCESSING OF SIGNALS IN AN OPTO-ELECTRONIC DEVICE¹

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ABSTRACT: *The energy efficiency of systems for primary processing of signals in optoelectronic devices is analyzed for the case of identification and study of remote objects against a bright background and under low-contrast conditions. A criterion is determined for evaluating the energy efficiency of the major unit of the system for primary signal processing - the optic system, and some expressions are derived, relating the value of the signal-to-noise ratio at the device's input with these criteria (amplification factor) and other "ideal" or "real" optic systems' parameters. The specific thing here is the operation of the system for primary processing of signals when the value of recorded contrast equals 1 percent or less. As an evaluation criterion for the energy efficiency of this system, the signal-to-noise ratio is used.*

Comparative evaluation of various systems for primary processing of signals operating under low-contrast conditions and specific values of the signal-to-noise ratio is performed.

The operation analysis for the system for primary processing of information (signals) under low-contrast conditions is performed accounting for the impact of the optic system.

KEY WORDS: *efficiency, opto-electronic device*

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The evaluation criterion for the energy efficiency of the major unit of the system for primary processing of information (the optic system) is the amplification factor, which determines the limit value for the signal-to-noise ratio at the output of the optic-electronic device.

The assumption is made that the flow, which determines the circle's area, is uniformly distributed, which does not cause significant errors in evaluating the energy efficiency of the optic- electronic system.

The system for primary processing of information is the major module of the opto-electronic device. This system consists of an optic block, an image analyzer, and an emission receiver. The operation of the system for primary processing of signals is quite specific when the registered contrast values equal one or even less than one. This is a matter of interest for space device construction and therefore, a subject of numerous studies [2, 4, 5, 7].

In this study, the signal-to-noise ratio shall be used as an evaluation criterion for the energy efficiency of the system for primary processing of information. Accounting for the fact that the observed (studied) object emits during a certain time interval Δt monochromatic flow of N_1 photons, while the background emits N_2 photons ($N_2 \gg N_1$), and accounting as well for the fact that the emission receiver features generalized quantum efficiency Y_λ [1] based on the well-known expression [3]. we can write for signal power and quantum fluctuations $\Delta N \frac{2}{\lambda}$:

$$(1) \quad N \frac{2}{\lambda} = N_1^2 \Delta t^2 Y_\lambda^2,$$

and

$$(2) \quad \Delta N_\lambda^2 = (N_1 + N_2) \Delta t \cdot Y_\lambda .$$

Then, the signal-to-noise ratio y at the output of the system for primary processing of information under low contrast conditions will be:

$$(3) \quad \psi = \frac{N_1}{\sqrt{N_2}} \sqrt{Y_\lambda} \Delta t,$$

consequently depending on the generalized quantum efficiency of the emission receiver and observation time. From the viewpoint of these two parameters we shall make the following analysis. As already known, quantum efficiency under external photoeffect is much smaller than one, amounting theoretically to $Y \leq 0,5$. The quantum efficiency of receivers with internal photoeffect is close to one. Therefore, from the viewpoint of the first parameter, it is expedient, in view of restricting photon fluctuations in the system for primary processing of

information, to use emission receivers (single-component or multi-component) whose operation is based on internal photoeffect.

Concerning the optimization of the second parameter from expression (3), observation time Δt , it is most expedient to use accumulation receivers, such as mosaic receivers and the multi-component structures that have been used more and more often recently, each of whose components accumulates during the observation period.

Here, we shall make a comparative evaluation of various systems for primary processing of information operating under low-contrast conditions, depending on the specific value of the signal-to-noise ratio.

In the case of a system for primary processing of information with single-component emission receiver operating in object accompanying mode during time interval T , under conditions where the receiver's size is synchronized with the dissipation contour of the optic system, based on formula (3), we obtain:

$$(4) \quad \Psi_1 = \frac{N_1}{\sqrt{N_2}} \sqrt{TY_\lambda}.$$

In detection mode using image analyzer, the signal value is determined not over time T , but over the time during which the object is registered by the receiver, i.e. over time:

$$\tau = \frac{T}{n},$$

where n - the number of elements within the view field.

In this case, the signal-to-noise ratio is:

$$(5) \quad \Psi_2 = \frac{N_1 \frac{T}{n} Y_\lambda}{\sqrt{N_2 T Y_\lambda}} = \frac{N_1}{n \sqrt{N_2}} \sqrt{TY_\lambda}.$$

In the same mode, in a system for primary processing of information with image analyzer of the "uniform grid" type, accounting for the fact that the signal over a time interval of one modulator revolution is accumulated over a time interval of half a period $T/2$ only, it may be written:

$$(6) \quad \Psi_3 = \frac{N_1 \frac{T}{2} Y_\lambda}{\sqrt{\frac{n N_2 T Y_\lambda}{2}}} = \frac{N_1}{\sqrt{2n N_2}} \sqrt{TY_\lambda}.$$

If the system for primary processing of information uses mosaic receiver as image analyzer, the signal from the object is actually registered by the receiver over the whole time interval T . The fluctuation noises are accumulated over the

whole area of the mosaic receiver:

$$(7) \quad \Psi_4 = \frac{N_1 T Y_\lambda}{\sqrt{n N_2 T Y_\lambda}} = \frac{N_1}{\sqrt{2n N_2}} \sqrt{T Y_\lambda}.$$

If the system for primary processing of information uses a receiver of the “electronic-optic convertor with accumulation” type or a set of microchannel plates, from each of the elements for which the signal and noise accumulated over the frame time T_k are downloaded, accounting for the background fluctuation noises of each area, it may be written:

$$(8) \quad \Psi_5 = \frac{N_1}{\kappa \sqrt{N_2}} \sqrt{T_k Y_\lambda},$$

where κ is the reserve factor accounting for the number of times the signal-to-noise ratio of the components of the electronic-optic convertor must be increased, so that the influence of background fluctuations be eliminated.

The operation analysis of the system for primary processing of information under the conditions of low contrast is made not taking into account the influence of the optic system. But, this influence on the energy efficiency of the system for primary processing of information is also of interest.

Therefore, we shall determine the value of the signal-to-noise ratio at the output of the optic system, before the image analyzer and the emission receiver.

The area within which the radiation flow from a remote dot-like source is collected defines on the focal plane of the optic system a dissipation circular contour of diameter d_j . The exposure to radiation E' created by the dot-like source on the focal plane of the optic system is determined by the expression:

$$(9) \quad E' = \frac{\frac{1}{4} \pi D^2 \zeta E}{\frac{1}{4} n d_1^2} = \frac{\zeta D^2}{d^2} E,$$

where D - diameter of the lens' inlet;

ζ - effective admission factor of the optic system;

E - exposure to radiation created by dot-like source on the inlet plane.

The effective admission factor of the optic system q is equal to

$$\zeta = \zeta_1 + \zeta_2,$$

where: ζ_1 - admission factor of the lens;

ζ_2 - factor of energy concentration within the dissipation circular contour.

The amplification factor β of the optic system is determined by:

$$(10) \quad \beta = \zeta \frac{D}{d_1}.$$

The average number of photons N_n emitted by the dot-like source, which determines the area of the dissipation circle follows the normal distribution law and, for a certain observation time T is expressed by:

$$(11) \quad N_n = a \frac{n}{4} \zeta D^2 ET,$$

where a is the quantum number for 1 s.

The average number of photons emitted from a uniform background determined on the focal plane over observation time T is determined by the formula [4]:

$$(12) \quad N' = aB\zeta d_1 \left(\frac{n}{4} \frac{D}{f'} \right)^2 T,$$

where: B - brightness of the uniform background;

f - focal distance of the optic system lens.

In practice, when the view field of the system has n elements, the average number of photons is calculated by the formula:

$$(13) \quad N'' = naB\zeta d_1 \left(\frac{n}{4} \frac{D}{f'} \right)^2 T.$$

Based on expressions (11), (12), and (13), replacing the value of amplification factor β from (10), the value of the signal-to-noise ratio at the output of the optic system is obtained. For a single-element system with momentary view field:

$$(14) \quad \varphi_1 = \frac{N_n}{\sqrt{N'}} = \frac{E}{\sqrt{B}} \sqrt{\beta a T f'} ,$$

while for a system of n elements

$$(15) \quad \varphi_2 = \frac{N_n}{\sqrt{nN'}} = \frac{E}{\sqrt{nB}} \sqrt{\beta a T f'} .$$

In this form, with focal distances and view field unchanged, and with equal observation time, the value of the signal-to-noise ratio at the output of the optic

system (not accounting for the losses in the image analyzer and the emission receiver) depends solely on the amplification factor p of the optic system.

The major conclusions from this study are:

- the energy efficiency of a system for primary processing of information in opto-electronic devices while detecting and studying remote objects against bright background under the conditions of low contrast has been analyzed; a criterion has been specified for evaluation of energy efficiency, and expressions have been derived, relating the signal-to-noise ratio with some specific parameters of the opto-electronic device.
- the evaluation criterion for the energy efficiency of the major module of the system for primary processing of information, the optic system, operating under the conditions of low contrast appears to be the amplification factor p determining the boundary value of the signal-to-noise ratio at the output of the opto-electronic device.

The results from this analysis have been used in developing systems for primary processing of information for the opto-electronic devices designed at the Space Research Institute - Bulgarian Academy of Sciences.

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A COMPARISON OF QUASI MONTE CARLO METHODS BASED ON FAURE AND SOBOL SEQUENCES FOR COMPUTATION OF MULTIDIMENSIONAL INTEGRALS

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ABSTRACT: *In this paper we implement and analyze the performance of Faure quasi-random sequence. We compare the results with the Sobol quasi-random sequence which is the most widely used quasi-Monte Carlo method. Also some experiments between Faure sequence and the plain (Crude) Monte Carlo method are given. We consider a case study with a non-smooth integrand function. We show that the Sobol sequence has some advantageous over the Faure sequence.*

KEYWORDS: *Quasi-Monte Carlo algorithms, multidimensional integrals, Faure sequence, Sobol sequence, Crude Monte Carlo algorithm, applications.*

Introduction

High dimensional integrals are usually solved with Monte Carlo algorithms and quasi Monte Carlo algorithms. Monte Carlo method is the only viable method for high-dimensional problems since its convergence is independent of the dimension. Monte Carlo methods give statistical estimates for the functional of the solution by performing random sampling of a certain random variable whose mathematical expectation is the desired functional. Monte Carlo methods are methods of approximation of the solution to problems of computational mathematics, by using random processes for each such problem, with the parameters of the process equal to the solution of the problem. The method can guarantee that the error of Monte Carlo approximation is smaller than a given value with a certain probability [5]. The most important advantage

of the Monte Carlo methods is that they are suitable for solving multi-dimensional problems, since the computational complexity increases linearly and not exponentially with the dimensionality [5,14]. The MC method is a widely used tool in many fields of science.

In the last few years new approaches have been developed that outperform standard Monte Carlo in terms of numerical efficiency. It has been found that there can be efficiency gains in using deterministic sequences rather than the random sequences which are a feature of standard Monte Carlo. These deterministic sequences are carefully selected so that they are well dispersed throughout the region of integration. Sequences with this property are known as low discrepancy sequences. These sequences are often more efficient than standard Monte Carlo in evaluating high dimensional integrals if the integrand is sufficiently regular and for many finance applications this is the case. However it is interesting to consider multidimensional integrals of non-smooth function. Such integrals can be used to describe problems in ecology (Genz test functions) or stochastic tomography, where multidimensional integrals are used for statistical measures such as the highest posterior density regions and migration areas.

As we already mention the multidimensional numerical quadratures are of great importance in many practical areas. The Monte Carlo method is known to be only accurate with a tremendous amount of scenarios since its rate of convergence is $O(N^{-1/2})$. Quasi Monte Carlo methods use deterministic sequences that have better uniform properties measured by discrepancy. They are usually superior to the Monte Carlo method as they have a convergence rate of $(\log N)^d/N$, where N is the number of samples and d is the dimensionality of the problem under consideration.

Quasi Monte Carlo algorithms for numerical integration

Consider the problem of approximate integration of the multiple integral:

$$\int_{[0,1]^d} f(x)dx = \int_0^1 dx^{(1)} \int_0^1 dx^{(2)} \dots \int_0^1 dx^{(d)} f(x^{(1)}, x^{(2)}, \dots, x^{(d)}),$$

where $x = (x^{(1)}, \dots, x^{(d)}) \in [0, 1]^d$.

For small values of d , numerical integration methods such as Simpson's rule or the trapezoidal rule can be used to approximate the integral. These methods, however, suffer from the so-called curse of dimensionality and become impractical as d increases.

The crude Monte Carlo method has rate of convergence $O(N^{-1/2})$ which is independent of the dimension of the integral, and that is why Monte Carlo integration is the only practical method for many high-dimensional problems.

Much of the efforts to improve Monte Carlo are in construction of variance reduction methods which speed up the computation or to use quasi-random sequences [1]. A quasi-random or low discrepancy sequence, such as the Faure, Halton, Hammersley, Niederreiter or Sobol sequences, is "less random" than a pseudorandom number sequence, but more useful for such tasks as approximation of integrals in higher dimensions, and in global optimization. This is because low discrepancy sequences tend to sample space "more uniformly" than random numbers. It is a question of interest to know which sequence outperforms the other. In this study we implement the Faure sequence and make a comparison with the Sobol sequence. The Faure sequences [8] are a digital $(0, s)$ -sequence over F_b with b denoting a prime (original case) or a prime power (general case) greater or equal to s . The s infinite generator matrices $C^{(1)}, \dots, C^{(s)}$ over F_b are defined by $C^{(i)} = (c_{jr}^{(i)})_{j,r \geq 0}$ with

$$c_{jr}^{(i)} = \binom{r}{j} \alpha_i^{r-j},$$

where $\alpha_1, \dots, \alpha_s$ denote s distinct elements from F_b and the conventions $\alpha^0 = 1$ for all $\alpha \in F_b$ and $\binom{r}{j} = 0, j > r$.

For $\alpha = 1$, the resulting matrix is the infinite Pascal matrix modulo the characteristic of F_b ; for $\alpha = 0$, it is the infinite identity matrix. If $s = 1$ and $\alpha_1 = 0$, the resulting $(0, 1)$ -sequence is identical to the van der Corput sequence in the same base [17]. The algorithm for the Faure sequence follows the method of Henri Faure in [8] for computing quasi-random numbers. It is a merging and adaptation of the routines INFAUR and GOFAUR from ACM TOMS 647. We use of persistent variables to improve the MATLAB implementation. The parameters of the Faure algorithm are described below. The input is an integer DIM_NUM, the spatial dimension, which should be at least 2. The other parameter is integer SEED, which is the seed, that indicates the index of the element of the sequence to be calculated. If SEED is negative, it is effectively replaced by a more suitable value. The output is a real QUASI(DIM_NUM), the next quasi-random vector. For the output the appropriate value of SEED have to be used on the next call, if the next element of the sequence is desired. For the Sobol sequence we use an implementation that is an adaptation of the INSOBL and GOSOBL routines in ACM TOMS Algorithm 647 [9] and ACM TOMS Algorithm [1,2,3,4]. The original code can only compute the "next" element of the sequence [11]. The revised code allows the user to specify the index of the desired element. The algorithm has a maximum spatial dimension of 40 since MATLAB doesn't support 64 bit integers. A remark by Joe and Kuo [10] shows how to extend the algorithm from the original maximum spatial dimension of 40 up to a maximum spatial dimension of 1111. The FORTRAN90 and C++ versions of the code has been updated in this way [12,15], but updating the

MATLAB code has not been simple, since MATLAB doesn't support 64 bit integers. We use algorithm that generates a new quasi-random Sobol vector with each call. The routine adapts the ideas of Antonov and Saleev [1,13] . The parameters of the algorithm are an integer *DIMNUM* , the number of spatial dimensions. The algorithm starts with integer *SEED*, the "seed" for the sequence. This is essentially the index in the sequence of the quasi-random value to be generated. On output, *SEED* has been set to the appropriate next value, usually simply *SEED* + 1. If *SEED* is less than 0 on input, it is treated as though it were 0. An input value of 0 requests the first (0-th) element of the sequence. Output is the real *QUASI(DIMNUM)*, the next quasi-random vector [5].

Numerical example and results

Table 1: The relative error for 4 dimensional integral of a non-smooth function with Faure and Sobol QMC

N	Faure	Time,s	Sobol	Time,s
100	5.05e-2	0.03	5.67e-3	0.02
1000	8.84e-3	0.43	8.91e-4	0.21
10000	2.10e-3	3.93	5.51e-4	1.78
100000	4.97e-4	42.3	5.79e-5	18.6
1000000	1.09e-4	200	7.70e-6	119

Table 2: The relative error for 4 dimensional integral of a non-smooth function with Faure QMC and Crude MC

N	Faure	Time,s	Crude	Time,s
100	5.05e-2	0.03	2.82e-2	0.003
1000	8.84e-3	0.43	1.47e-2	0.01
10000	2.10e-3	3.93	8.12e-3	0.11
100000	4.97e-4	42.3	1.30e-3	1.36
1000000	1.09e-4	200	7.35e-4	13.08

Table 3: The computational time for 4 dimensional integral of a non-smooth function with the three methods

time in seconds	Faure	Sobol	Crude
0.1	1.82e-2	1.86e-3	8.12e-3
1	5.26e-3	7.15e-4	2.31e-3
5	1.86e-3	2.03e-4	9.81e-4
10	8.22e-4	9.75e-5	7.67e-4
60	3.90e-4	8.91e-6	5.11e-4

We will test Faure and Sobol sequence for evaluating the following multidimensional integral of non-smooth integrand function, taken from the paper of Ivan Dimov and Rayna Georgieva [6]:

$$f_1(x_1, x_2, x_3, x_4) = \sum_{i=1}^4 |(x_i - 0.8)^{-1/3}|,$$

where the integration is over the unit 4-dimensional hypercube. The referent value of the integral is 7.22261 [6,7].

As can be seen from the table for 4 dimensional integral, the low discrepancy sequence of Sobol produces more rapid convergence, and lower errors, than the Faure sequence and the pseudorandom sequence. This is as anticipated since the pseudo randomly obtained averages converge at the rate $O(N^{-1/2})$, while the quasi randomly obtained averages converge at a rate closer to $O(N^{-1})$. As expected the Sobol sequence gives better results than the Faure sequence. It is interesting to see that for a given number of samples the Faure sequence gives better relative error than the Crude Monte Carlo algorithm – see Table 2, but the latter is between 10 and 20 times faster. It is interesting that for a preliminary given time up to 10s the Crude MC gives a little bit better results than the Faure sequence – see Table 3, but for 60s the Faure sequence starts producing better results. This means that Faure sequence has advantage over Crude MC only or large number of samples and for higher computational time. For a preliminary given time of only 1s Sobol sequence gives relative error of $7.15e-4$ and Faure sequence gives relative error of $5.26e-3$ which is already a sufficient accuracy. Definitely for larger number of points and for a preliminary given time, the advantage of Sobol quasi-random sequence in place of both Crude MC and Faure QMC should become even more pronounced – see Table 1 and Table 3. For this example of non-smooth integrand function even the first derivative does not exist. Such kind of applications appears also in some important problems in financial mathematics and stochastic tomography. It should be mentioned that in the case of a smooth integrand functions the results with the methods under consideration are even more precise. In the future a comparison with other sequences like Halton sequence will be done.

Conclusion

In this paper we analyze the performance of plain Monte Carlo algorithm and two quasi Monte Carlo methods for multidimensional integrals. The Sobol quasi-random sequence is compared with the Faure sequence and the results are very precise for the multidimensional integrals under consideration, which shows the strength of the presented algorithm for relatively low dimensions. We consider an example of non-smooth integrand function which is the more complicated case compared to examples of smooth integrand functions.

For this particular example the stochastic algorithms under consideration produce reliable results. While Sobol sequence is a lot better than the pseudorandom sequence, the Faure sequence gives similar results to the Crude Monte Carlo algorithm. The experiments show that for a preliminary given time the Crude Monte Carlo algorithm outperform the Faure sequence, but for a given number of samples the Faure sequence gives better results than the pseudorandom sequence. The multidimensional integral under consideration is with non-smooth integrand which is more difficult case than the smooth integrand function. This multidimensional integral can be applied to various problems where data is taken in randomized way like stochastic tomography connected with people migration. International migration is a topic that is attracting a significant level of interest in current political debate and is high on the agenda for policy makers in central and local government [16]. One area of debate is the impact of student migration, for example, on net migration. Stochastic methods under consideration are an efficient way to solve problems like the mentioned above that are described with multidimensional integrals of both smooth and non-smooth functions. It will be interesting to compare Faure sequence with Halton and Niederreiter sequences, but this will be an object of a future study.

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A NUMERICAL STUDY ON HAMMERSLEY SEQUENCE AND FIBONACCI BASED LATTICE RULE FOR COMPUTATION OF MULTIDIMENSIONAL INTEGRALS

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ABSTRACT: *In this paper we make a numerical study between Hammersley quasi-random sequence and Fibonacci based lattice rule for computing multidimensional integrals. The two methods have not been compared before and both are recommended in case of smooth integrands. The two quasi-Monte Carlo approaches are completely different thus it is a question of interest which one of them outperforms the other. We consider a case study with smooth integrand functions of different dimensions. A comparison with Sobol sequence for a fixed computational time is given.*

KEYWORDS: *Quasi-Monte Carlo sequences, multidimensional integrals, Hammersley sequence, Fibonacci lattice rule, Sobol sequence, applications.*

Introduction

High dimensional integrals are usually solved with Monte Carlo algorithms and quasi-Monte Carlo algorithms. The crude Monte Carlo method has rate of convergence $O(N^{-1/2})$ which is independent of the dimension of the integral, and that is why Monte Carlo integration is the only practical method for many high-dimensional problems. Much of the efforts to improve Monte Carlo are in construction of variance reduction methods which speed up the computation or to use quasi-random sequences [4]. Quasi-Monte Carlo methods use deterministic sequences that have better uniform properties measured by discrepancy [12]. They are usually superior to the Monte Carlo method as they have a convergence rate of $((\log N)^s/N)$, where N is the number of

samples and s is the dimensionality of the problem under consideration.

A low-discrepancy sequence is a sequence with the property that for all values of N , its subsequence x_1, \dots, x_N has a low discrepancy. The discrepancy of a sequence is low if the proportion of points in the sequence falling into an arbitrary set B is close to proportional to the measure of B , as would happen on average (but not for particular samples. Specific definitions of discrepancy differ regarding the choice of B (hyperspheres, hypercubes, etc.) and how the discrepancy for every B is computed (usually normalized) and combined (usually by taking the worst value). Low-discrepancy sequences are also called quasi-random or sub-random sequences, due to their common use as a replacement of uniformly distributed random numbers [11]. The "quasi" modifier is used to denote more clearly that the values of a low-discrepancy sequence are neither random nor pseudorandom, but such sequences share some properties of random variables and in certain applications such as the quasi-Monte Carlo method their lower discrepancy is an important advantage.

A low discrepancy sequence, such as the Faure, Halton, Hammersley, Niederreiter or Sobol sequences, is "less random" than a pseudorandom number sequence, but more useful for such tasks as approximation of integrals in higher. This is because low discrepancy sequences tend to sample space "more uniformly" than random numbers. It is a question of interest to know which sequence outperforms the other [10].

Lattice rules are based on the use of deterministic sequences rather than random sequences. They are a special type of so-called low discrepancy sequences. It is known that as long as the integrand is sufficiently regular, lattice rules outperform the basic Monte Carlo method and most of the other types of low discrepancy sequences [1].

Quasi Monte Carlo algorithms for numerical integration

Because any distribution of random numbers can be mapped onto a uniform distribution, and subrandom numbers are mapped in the same way, this article only concerns generation of subrandom numbers on a multidimensional uniform distribution. There are constructions of sequences known such that for their discrepancy:

$$D_N^*(x_1, \dots, x_N) \leq C \frac{(\ln N)^s}{N}.$$

Here C is a certain constant, depending on the sequence. These sequences are believed to have the best possible order of convergence.

The standard M -dimensional Hammersley sequence [6] based on a number of samples N is simply composed of a first component of successive fractions $0/N, 1/N, \dots, N/N$, paired with $M-1$ 1-dimensional van der Corput sequences [19], using as bases the first $M-1$ primes. The van der Corput sequence generates a

sequence of points in $[0,1]$ which never repeats. For positive index I , the elements of the van der Corput sequence are strictly between 0 and 1. In particular, the I -th element of the van der Corput sequence is computed by writing I in the base B (usually 2) and then reflecting its digits about the decimal point. Let b_1, \dots, b_{s-1} be coprime positive integers greater than 1. For given s and N , the s -dimensional Hammersley set of size N is defined by [7]

$$x(n) = (g_{b_1}(n), \dots, g_{b_{s-1}}(n), \frac{n}{N})$$

for $n = 1, \dots, N$. Then the discrepancy of the set is obtained in [10]:

$$D_N^*(x(1), \dots, x(N)) \leq C \frac{(\log N)^{s-1}}{N}$$

where C is a constant depending only on b_1, \dots, b_{s-1} . The above estimation for the discrepancy of the Hammersley sequence means that this is a low discrepancy sequence. The parameters of the algorithm are input: the integer I , the index of the element of the sequence $0 \leq I \leq N$; integer M , the spatial dimension, $1 \leq M \leq 100$ and integer N , the "base" for the first component $1 \leq N \leq 1000$. Output is real $R(M)$, the element of the sequence with index I .

The monographs of Sloan and Kachoyan [15], Niederreiter [13], Hua and Wang [10], Wang and Hickernell [20] and Sloan and Joe [14] provide comprehensive expositions of the theory of integration lattices. We implemented a specific lattice rule and compared its performance with an implementation of Hammersley sequence over integrals of smooth functions.

Let n be an integer, and $a = (a_1, \dots, a_s)$ be an integer vector modulo n . A set of the form [19]

$$P_n = \left\{ \left\{ \frac{ak}{n} \right\} = \left(\left\{ \frac{a_1 k}{n} \right\}, \dots, \left\{ \frac{a_s k}{n} \right\} \right) \mid k = 1, \dots, n \right\}$$

is called a lattice point set, where $\{x\}$ denotes the fractional part of x . The vector a is called a lattice point or generator of the set. As one can see, the formula for the lattice point set is simple to program. The difficulty lies in finding a good value of a , such that the points in the set are evenly spread over the unit cube. The choice of good generating vector, which leads to small errors, is not trivial [8]. Complicated methods from theory of numbers are widely used, for example Zaremba's index or error of the worst function. We consider the following generating vector based on generalized Fibonacci numbers of corresponding dimensionality:

$$a = (1, F_{l+1}^{(s)}, \dots, F_{l+s-1}^{(s)}), \quad n_l = F_l^{(s)},$$

where

$$F_{l+s}^{(s)} = F_l^{(s)} + F_{l+1}^{(s)} + \dots + F_{l+s-1}^{(s)}, \quad l = 0, 1, \dots$$

with initial conditions

$$F_0^{(s)} = F_1^{(s)} = \dots = F_{s-2}^{(s)} = 0, F_{s-1}^{(s)} = 1,$$

for $l=0,1,\dots$

The discrepancy of the set obtained by using the vector described above is asymptotically estimated in [9].

The number of calculation required to obtain the generating vector is $O(\ln n_i)$. The generation of a new point requires constant number of operations, thus to obtain a lattice set of the described kind consisting of n_i points, $O(\ln n_i)$ number of operations are necessary. However the discrepancies of the lattice point sets obtained by these two methods have larger upper bounds than those obtained by Korobov's method [1].

In experiments in the next section we use the well known quasi-random sequence of Sobol which is given as reference. They were first introduced by the Russian mathematician Ilya M. Sobol in 1967 [15] and later described in [16]. We use an adaptation of the INSOBL and GOSOBL routines in ACM TOMS Algorithm 647 [3] and ACM TOMS Algorithm 659 [2]. The original code can only compute the "next" element of the sequence. The revised code allows the user to specify the index of the desired element [18].

Numerical example and results

We will test the performance of the Hammersley sequence (HAM) and a particular lattice rule with generating vector, based on the generalized Fibonacci numbers of the corresponding dimensionality (FIBO) on multidimensional integrals of smooth functions of different dimensions. A comparison with Sobol quasi-random sequence (SOBOL) for a preliminary given computational time will be given. We will be interested which of the methods gives lowest relative errors for 1 minute. We consider examples of 4, 10 and 25 dimensional integrals.

Example 1.

$$\int_{[0,1]^4} x_1 x_2^2 e^{x_1 x_2} \sin(x_3) \cos(x_4) \approx 0.1089748630.$$

Exampe 2.

$$\int_{[0,1]^{10}} \frac{4x_1 x_3^2 e^{2x_1 x_3}}{(1 + x_2 + x_4)^2} e^{x_5 + \dots + x_{10}} \approx 14.808435.$$

Example 3.

$$\int_{[0,1]^{25}} \frac{4x_1x_3^2e^{2x_1x_3}}{(1+x_2+x_4)^2} e^{x_5+\dots+x_{20}} x_{21} \dots x_{25} \approx 103.808.$$

Table 1: The relative error for 4 dimensional integral

N	FIBO	Time,S	HAM	Time,S
100	1.39e-1	0.001	2.44e-2	0.01
1000	9.27e-3	0.01	4.91e-3	0.17
10000	7.90e-4	0.09	7.84e-4	1.61
100000	3.40e-4	1.10	7.17e-5	12.4
1000000	2.68e-5	5.79	1.66e-6	74.7

Table 2: The computational time for 4 dimensional integral

time in seconds	FIBO	SOBOL	HAM
0.1	9.27e-3	5.17e-3	2.44e-2
1	3.26e-4	5.37e-5	1.22e-3
10	7.21e-6	1.43e-5	9.18e-5
60	9.10e-8	2.68e-7	3.61e-6

Table 3: The relative error for 10 dimensional integral

N	FIBO	Time,S	HAM	Time,S
100	8.35e-1	0.001	2.30e-1	0.01
1000	1.47e-1	0.08	1.55e-2	0.25
10000	4.21e-2	0.12	2.34e-3	0.98
100000	1.02e-2	0.91	7.55e-4	12.08
1000000	1.08e-3	6.27	1.56e-5	124.6

Table 4: The computational time for 10 dimensional integral

time in seconds	FIBO	SOBOL	HAM
0.1	9.82e-2	1.06e-2	5.94e-2
1	4.58e-2	9.15e-2	1.24e-3
10	1.37e-2	9.93e-4	9.46e-4
60	1.28e-3	1.38e-4	6.65e-5

Table 5: The relative error for 25 dimensional integral

N	FIBO	Time,S	HAM	Time,S
1000	9.84e-1	0.03	4.49e-1	0.17
10000	7.10e-1	0.11	1.53e-1	2.27
100000	1.97e-1	0.81	1.65e-4	12.55
1000000	9.09e-2	6.40	9.16e-5	147.1

Table 6: The computational time for 25 dimensional integral

time in seconds	FIBO	SOBOL	HAM
0.1	7.10e-1	2.50e-1	4.22e-1
1	1.21e-1	1.09e-1	1.13e-1
10	8.86e-2	1.85e-2	2.43e-2
60	7.13e-2	9.21e-3	2.78e-3

In the Table 1,3 and 5 are presented the relative error for the 4,10 and 25 dimensional integrals with Fibonacci lattice sequence (FIBO) and Hammersley quasi-random sequence (HAM) for a fixed number of points. In table 2,4,6 are presented the relative errors for 4,10 and 25 dimensional integrals with Sobol quasi-random sequence (SOBOL), FIBO and HAM for a fixed computational time which is a measure of the computational complexity. Obviously FIBO has the lowest computational complexity and is the fastest algorithm, while HAM and SOBOL are slower, because they need an additional time for generating the corresponding low discrepancy sequences. As can be seen from the results for 4 dimensional integral, the low discrepancy sequence of Hammersley produces more rapid convergence, and lower errors, than the Fibonacci lattice sequence for a given number of realizations of the random variable-see Table 1, but for a fixed computational time- Fibonacci sequence gives better results- see Table 2. In Table 2 Fibonacci gives better results than Hammersley sequence for a fixed computational time and better results than Sobol sequence with increasing the preliminary given time. Therefore Fibonacci lattice rule is the best choice for low dimensional integrals- for one minute it gives relative error of $9.10e-8$ which is better than Sobol and Hammersley sequences. For the 10-dimensional integral Hammersley gives lower relative errors than the Fibonacci algorithm- see Table 3. For a preliminary given time in seconds Sobol and Hammersley gives better results than Fibonacci-see Table 4. It is interesting that for 1 minute Hammersley gives $6.65e-5$, which is better than Sobol- $1.38e-4$ and far better than FIBO- $1.28e-3$. This means that for mid and high dimensions Hammersley sequence gives more reliable results than FIBO and it

can be successfully compete with one of the best quasi-random sequences of Sobol. For 25- dimensional integral as expected FIBO produces the worst results, while Hammersley sequence is more appropriate for higher dimensions- see Table 5. For a fixed computational time Hammersley again gives lower relative errors than Sobol- for 1 minute Hammersley gives $2.78e-3$ which is better than Sobol with 1 order and better than FIBO with 2 orders- see Table 6. For higher dimensions the errors can not be small. However, Hammersley and Sobol sequences gives sufficient accuracy.

Conclusion

In this paper we analyze the performance of different quasi-Monte Carlo methods for multidimensional integrals. The Hammersley quasi-random sequence is compared with the Sobol sequence and the results are very precise for the multidimensional integrals under consideration, which shows the strength of the presented algorithm for low, mid and high dimensions.

Stochastic methods under consideration are an efficient way to solve problems that are described with multidimensional integrals. For example, stochastic methods have been successfully applied for sensitivity studies of large air pollution model in [5]. Such multidimensional integrals of smooth functions can be used to describe problems in quantum mechanics for Wigner kernel evaluation; in computational finance for evaluation of option pricing; for quick choice of frequent range for objects with plasma cover; for determining the type of dynamic objects with low effective reflecting surface or for increasing the efficiency of radiolocation systems with application of artificial intelligence.

This is the first time a particular 1-rank lattice rule based on Fibonacci lattice sequence is compared with Hammersley quasi-random sequence. There are several papers from authors in which Fibonacci lattice sequences is compared with Sobol sequence for different multidimensional integrals. Numerical experiments in this paper shows that Fibonacci sequence is the best choice for lower dimensions, as it was previously established. It is well known that as long as the integrand is sufficiently regular Fibonacci lattice rule outperforms other low discrepancy sequences for lower dimensions because of its lowest computational complexity and higher accuracy.

It is interesting that Hammersley sequence gives better results than Sobol with increasing the dimensionality of the integral. In the case of mid and high dimensional integrals it can be seen that Hammersley sequence produces lower relative errors for a fixed computational time. Tables show that for dimensional integral Sobol sequence gives better results than Hammersley, but for 10 and 25 dimensional integrals Hammersley sequence produces lower relative errors than Sobol sequences. In the future a scrambled version of Sobol sequence will be

presented and a comparison with the Hammersley sequence will be given. It will be interesting to compare Hammersley sequence with Halton and Niederreiter sequences, but this will be an object of a future study.

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RELIABILITY TECHNIQUES FOR RFID

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ABSTRACT: *Radio Frequency Identification (RFID) technology has the potential to dramatically improve numerous industrial practices. However, it still faces many challenges, including security and reliability, which may limit its use in many application scenarios. While security has received considerable attention, reliability has escaped much of the research scrutiny. Radio Frequency Identification (RFID) technology is growing rapidly across many different industries. Developers apply the technology not only in traditional applications such as asset or inventory tracking, but also in security services such as electronic passports and RFID-embedded credit cards. However, RFID technology also raises a number of concerns regarding privacy and security.*

KEY WORDS: *Radio Frequency Identification (RFID) technology.*

1. Introduction

Radio Frequency Identification (RFID) technology is a wireless, automatic identification technology that uses radio signals to identify, track, sort and detect a variety of objects including people, vehicles and assets without the need for direct contact (magnetic stripe technology) or line of sight contact (bar code technology). RFID technology can track the movements of objects through a network of radio-enabled scanning devices over a distance of several meters.

2. Overview

The application of RFID technology requires RFID tags attached to objects and an infrastructure for reading the tags and processing tag information. The infrastructure typically consists of antennas, readers (each typically controlling 1 to 4 antennas), and a back-end system with edge servers, application servers, and databases. An antenna employs RF signal to activate the tag, which then responds

with its data, typically a unique 96-bit identification code and some asset related data. The reader collects the data and forwards it to the back-end system. The back-end system implements the logic and actions for when a tag is identified. The logic can be as simple as opening a door, setting off an alarm, updating a database, or complicated, such as an integrated management and monitoring for shipment tracking.

2.1 Reliability: Definitions and Challenges

We define the read reliability as the probability that an RFID reader successfully detects and identifies an RFID tag when it is in the read range of one of the reader's antennas. Similarly, we define the tracking reliability of an RFID system as the probability that the system successfully detects and identifies an object when it is present in a designated area. Note that the system-level definition of tracking reliability obviates a one-to-one mapping between a tag and an object. For example, an object may carry multiple tags or a human may be identified indirectly based on tagged objects in his possession. In this paper, we will only consider the reliability of detection and identification of tags and/or objects, not the reliability of the individual system components or the actions taken by the system logic.

There are many factors that can impact read reliability, including the type of material surrounding a tag (e.g., metals or liquids), the inter-tag distance, the orientation of the tags with respect to the antenna, the tag-antenna distance, the number of tags in the read range of the antenna, and the speed of the tagged objects. Materials such as metals and liquids not only block the signal when the material is placed between the antenna and the tag, but may act as a grounding plate if the tag is too close to the material even if the material is not between the tag and the antenna. Tags placed too close to one another also interfere with each other's operation. The orientation of the tags, specifically, the orientation of the tag's antenna with regard to the reader antenna has a large impact on how much of the reader signal the tag is able to absorb. The number of tags in the read range of an antenna affects reliability because only one tag can be read concurrently but multiple tags may respond in a given read slot, causing collisions. State of the art RFID systems use sophisticated collision control mechanisms to reduce collisions. Finally, higher object speeds limit the time when tags are visible to an antenna.

RFID measurements are particularly prone to false negative reads, where a tag present in the read range of an antenna is not detected. In some cases, it is also possible to get false positive reads, where RFID tags might be read from outside the region normally associated with the antenna, leading to a misbelief that the object is near the antenna [3]. We focus on false negatives since false positives

can typically be eliminated by increasing the distance between antennas and/or by decreasing the power output of the readers.

Note that we do not consider intentional destruction of tags (e.g., removal of tag antenna [8] or removal of the whole tag), hiding of tags by shielding them, or interfering with the read protocol [7]. Furthermore, we do not consider modifications to the RFID protocol itself such as better collision control algorithms that can significantly improve reliability in multiple tag situations [9, 18].

2.2 Related work

Several recent pilot studies have evaluated the reliability aspects of RFID technology. A pilot study of a pharmaceutical supply-chain tracking system [1] observed read reliabilities ranging from under 10% to 100% for item-level and case-level tags in different stages of the shipping process. A performance benchmark [12] presented the results from number of experiments including read speed for a population of stationary tags and read reliability for different tagged materials on a conveyer belt. However, neither work attempted to develop techniques to improve reliability.

Other research efforts have proposed techniques to improve the reliability of RFID systems. In [10], the authors propose a cascaded tagging approach, where in addition to normal item level tags, the cases, pallets, and truckloads are tagged with ‘macro tags’. A macro tag provides information about the tags contained in the macro tagged collection. The macro tags are typically different from the item-level tags to make them easier to detect, for example, they may have larger antennas or be active tags. In this paper, we only consider techniques that use identical tags. In [17], the authors propose redundancy and diversity of antennas, readers, and tags, as methods to increase system reliability. Neither of these two efforts evaluates the effectiveness of their proposed techniques. Finally, in [6], the authors propose to use real-world constraints to correct missed reads for tracking mobile objects. Specifically, they consider constraints related to possible physical movement paths of objects (‘route constraint’) and known groupings of tagged objects (‘accompany constraint’).

3. RFID Reliability Experiments and Results

To highlight the reliability challenge in current state of the art EPC Gen 2 RFID systems, we have conducted numerous experiments that reproduce various realworld situations in our lab using COTS components. We used single-dipole Gen 2 tags from Symbol Technologies, which had an antenna patch size of 2.5 cm by 10 cm. We used the Matrix AR400 reader along with a single area antenna. We used the default settings on the reader, which included a maximum power

output of 30 dB (1 watt). While our experiments consider only one type of tags, readers, and antennas, our results offer insights to (1) a number of important parameters impacting RFID system reliability, and (2) the effectiveness of system-level reliability techniques. We developed software in Java to interface with the reader. Our software sends commands to the reader over its HTTP interface and the reader responds with a list of tags in XML format. For all but the read range experiment, the readers were operated in a buffered (continuous) read mode and our tracking results were independent of the application level polling speed.

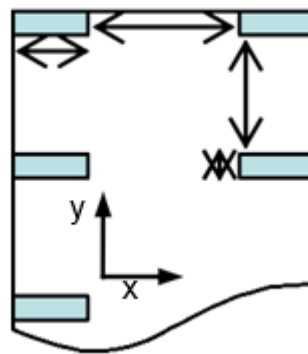


Fig. 1. Tag placement for read range exp

Read Range: The read range of RFID systems depends a lot on their operating frequencies. For the UHF systems we used, it is generally a few meters. To characterize the impact of the tag-antenna distance on read reliability, we placed 20 tags in a single plane, parallel to the antenna. The tag placement is shown in Figure 1. Inter-tag distances were 12.5 cm and 20 cm along the x and y axes, respectively. Our experiments showed that this distance is more than sufficient to eliminate direct interference between tags. The tags were fixed in position facing a single antenna, and a single read was performed each time. We repeated the read 40 times for each distance. Figure 2 shows the average number of tags read, and the upper and lower quartiles. Our results show a 100% read reliability at a distance of 1 m. However, reliability gradually dropped between 2 m and 9 m.

Inter-Tag Distance and Tag Orientation: In many practical scenarios, tags may be placed close to one other, in parallel, and/or in different orientations with regard to the antennas. To characterize the impacts of inter-tag distances and tag orientation with respect to the antenna, we performed multiple experiments using 10 tags in parallel to each other. We mounted the tags on a cardboard box, and used a cart to pass them in front of a single antenna with a speed of about 1 m/s and antenna-tag distance of 1 m. This represents a situation where items are carried by a conveyor belt through a gate.

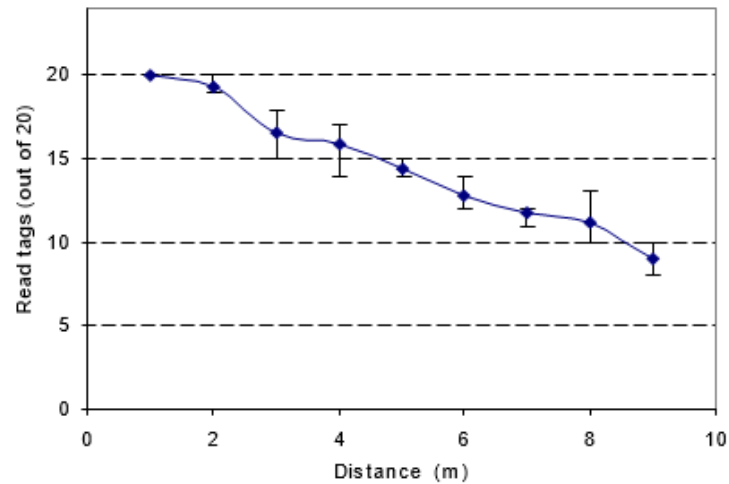


Fig. 2. Read reliability vs. antenna distance

We tested the combination of five different inter-tag distances: 0.3 mm, 4 mm, 10 mm, 20 mm, and 40 mm, and six different tag orientations (Figure 3). We repeated each experiment at least 10 times. Figure 4 shows the average number of tags read, and the upper and lower quartiles for each experiment. We are interested in finding the minimum ‘safe’ distance between tags where they will not interfere with each other. Our results show that, depending on orientation, tags require at least 20 to 40 mm spacing between them to operate in a reliable fashion. We can also see the effect of tag orientation. It is not surprising that tag reads are least reliable when the tags are perpendicular to the antenna (cases 1 and 5). Our results clearly indicate that current UHF tags would not work well for scenarios where tags are placed very close to each other and are perpendicular to the antenna, such as on book covers in a bookshelf.

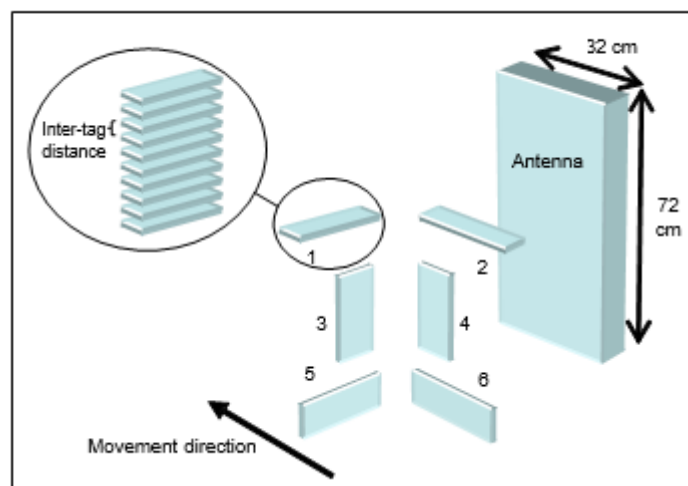


Fig. 3. Tag orientation and antenna

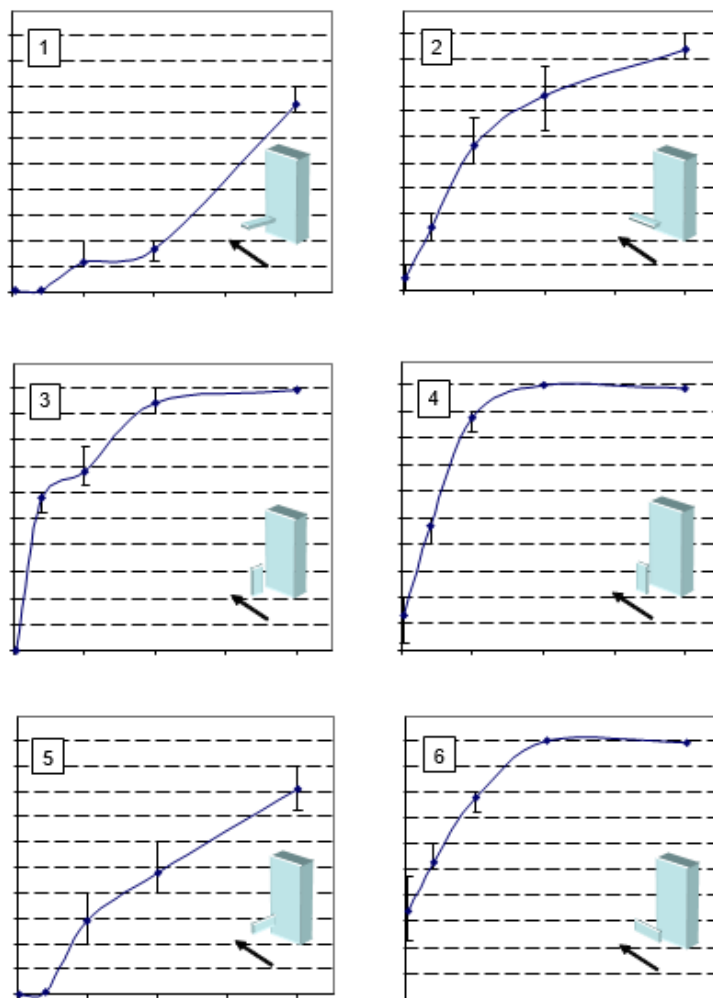


Fig. 4. Tag orientation and inter-tag distance

Object Tracking: In the previous experiments, the tags were not attached to any objects. However, in real world situations, tags are placed on objects that may interfere with RF signals. To measure RFID performance for realistic case level and item level tagging, we individually tagged 12 identical boxes, each containing a network router and accessories in original packaging. The metal casing and relatively large size of the routers compared to their packaging material would make them a challenging scenario for an RFID system. We placed the boxes on a cart as three rows of 2x2 boxes, and passed the cart in front of the antenna with a speed of 1 m/s at a distance of 1 m. We performed this experiment for different tag locations, namely top, front, side closer to antenna, and side farther from antenna. The experiments were repeated 12 times. Our results in Table 1 demonstrate that the location of a tag on an object has a dramatic impact on the tag read reliability. Assuming that tag read reliabilities are equal between the front and back of the box, and between the top and bottom of the box, the average read reliability for all locations is 63%. While guaranteeing the exact location of tags

upon passing in front of a reader is impractical for many scenarios, it is often practical to avoid the worst locations (in this case, the top of the box). Our measurements show determining and avoiding the worst case locations can greatly improve average reliability. This is similar to the orientation tests, where two out of six orientations had considerably worse reliability.

Table 1. Read reliability for tags on objects

Tag location	Reliability
Front	87%
Side (closer)	83%
Side (farther)	63%
Top	29%
Average	63%

Human Tracking: One application of RFID systems is tracking humans. Active tags have been employed for human location sensing and tracking [11]. Passive RFID tags are currently in use for identification purposes in access cards and credit cards. We set out to evaluate the performance of passive RFID systems for human identification and tracking.

We experimented with multiple tag locations, and found that for best performance, tags and antennas should be at the same height, and tags should not touch the body. Therefore, we placed the tags at waist level, hanging from the belt or pocket, as often seen with ID cards, to achieve best performance. We placed a tag on one or two volunteers and they walked in front of an antenna at a distance of 1 meter. The volunteers tried to walk in parallel for the two person tests to maximize blocking. This could resemble a typical case for people with a RFID tagged ID card passing through a gate or doorway. It can also be used for human tracking with room-level accuracy. We tested with multiple tag locations. Each test was repeated 20 times. From the results in Table 2, the read reliability averaged 63% for one subject. Blocking by the closer subject caused the two subject read reliability to average 56%. Interestingly, read reliabilities for the closer subject in the two subject case was higher than those for a single subject. Further tests showed the reason was not the slightly closer distance. We attribute the higher read reliabilities to signal reflections off the farther subject. The low reliability in all of these cases motivates us to apply simple fault-tolerance techniques.

Table 2. Read reliability for tags on humans

Tag location	One subject	Two subjects		
		Closer	Farther	Average
Front / Back	75%	90%	50%	70%
Side (closer)	90%	90%	50%	70%
Side (farther)	10%	30%	0%	15%
Average	63%	75%	38%	56%

4. Improving RFID Reliability

We investigated the use of redundancy to improve the reliability of RFID systems and evaluated its effectiveness through both analytical analysis and experimental measurements. Redundancy in the form of replication is a widely used fault-tolerance technique for improving reliability. It can be applied to RFID systems in a number of ways: multiple antennas per portal, multiple readers per portal, or multiple tags per object.

Multiple antennas mounted per portal is a widely used technique and virtually all readers have built-in support for assigning two or more antennas to a single zone or portal. Even though readers employ measures such as TDMA to prevent interference between two or more of their antennas, our initial observations showed a slight decrease in performance when blocking was not an issue. Nonetheless, in realistic cases, there was a distinctive gain using multiple antennas. For multiple antenna tests, we used two area antennas placed at a distance of 2 meters from each other and connected to the same reader. While one might expect to see similar improvements for multiple readers per portal, our measurement clearly showed the opposite: read reliability was severely reduced in our experiments. The reason is reader-to-reader RF interference. While Gen 2 has standard measures to combat this problem, called dense-reader mode, it is optional for readers. Our readers did not support dense-reader mode, and neither do most older Gen 2 readers.

While using multiple tags for each object seems straightforward, to the best of our knowledge it has not been evaluated before in scientific literature. Multiple tags on different sides of an object and/or with different orientations increases the probability that at least one of the tags is successfully read by a reader. However, if the tags are too close, they may interfere with one another and actually reduce the read reliability. Furthermore, if the number of tags in the antenna read area gets large, it can take considerably longer to read the tags.

We now use a simple analytical model for multiple tag and/or antenna scenarios. We define every combination of tag and antenna in the same area as a

read opportunity. Assuming read opportunities are independent, if the reliabilities for read opportunities leading to an object identification are P1, P2, Pn, the expected object tracking reliability RC is:

$$RC = 1 - ((1 - P1)(1 - P2)...(1 - Pn))$$

We will next present our experimental results, and compare their performance with the analysis. All measurements and conclusions in this section are dependent on not exceeding the minimum safe tag distances measured in Section 3.3, and allowing adequate time for all tags to be read, which is around .02 sec per tag.

4.1 Reliable Object Tracking

To characterize the effect of reliability techniques for object tracking, we repeated the same experiment as in Section 3, while employing redundancy at different levels. We will present both the measured reliability RM and the expected reliability RC, where RC is calculated based on the read reliabilities measured in Section 3. We have investigated the following cases: two antennas per portal instead of one, two tags per object instead of one, and two tags per object and two antennas per portal. The results for all cases are shown in Table 3 and Figure 5. Our measurements show the performance of multiple tags per object is better than multiple antennas per portal, and very similar to the analytical model. Using two tags instead of one, we increased the average object tracking reliability from 80% to 97%.

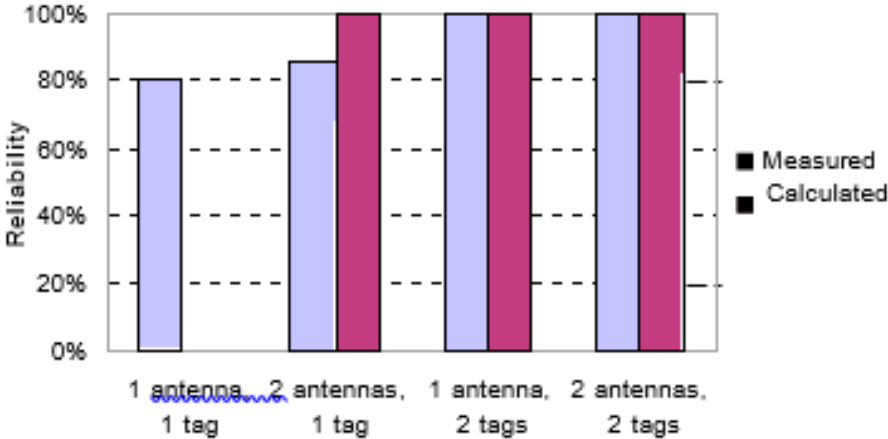


Fig. 5. Object tracking with redundancy

Table 3. Redundancy for multiple objects

Antennas	tags/ object	Tag location	Avg reliability	
			RM	RC
2	1	Front	92%	98%
2	1	Side	79%	94%
		Average	86%	96%
1	2	Front + side (good)	97%	98%
1	2	Front + side (bad)	96%	95%
		Average	97%	97%
2	2	Front + side	100%	99.9%

4.2 Reliable Human Tracking

To characterize the effect of reliability techniques for human tracking, we repeated the same experiment as in Section 3, while employing redundancy at different levels. We present both experimental results and expected tracking reliability for the combination of two antennas per portal, and two or four tags per person. The results for 1-antenna and 2-antenna cases are presented in Table 4 and Table 5 respectively. The average performances for one-subject and two-subject cases are shown in Figure 6 and Figure 7, respectively.

Similar to object tracking, the performance of multiple tags per person is better than multiple antennas per portal. Using two tags instead of one, increases average reliability from 63% to 96% for 1-person cases, and from 56% to 83% in 2-person cases. Reliability virtually reaches 100% using four tags per person or a combination of two tags per person and two antennas per portal.

We can clearly see that simple reliability techniques, especially using multiple tags per object, can significantly improve RFID system reliability to near 100%, even for applications that previously seemed out of the domain of passive RFID systems.

Table 5. Human tracking, 2 antennas

Tags per subject	Location	One subject		Two Subjects	
		RM	RC	RM	RC
1	Front/Back	80%	94%	90%	95%
1	Side	90%	91%	80%	78%
2	Front/Back	100%	99.6%	100%	99.8%
2	Sides	100%	99.2%	95%	97%
4	F/B/Sides	100%	100%	100%	99.9%

Table 4. Human tracking reliability, 1 antenna

Tags per subject	Location	One subject		Two Subjects					
		RM	RC	RM			RC		
				Closer	Farther	Avg	Closer	Farther	Avg
2	Front/Back	100%	94%	100%	90%	95%	99%	75%	88%
2	Sides	93%	91%	90%	50%	70%	93%	50%	72%
4	F/ B/Sides	100%	99.5%	100%	100%	100%	99%	88%	94%

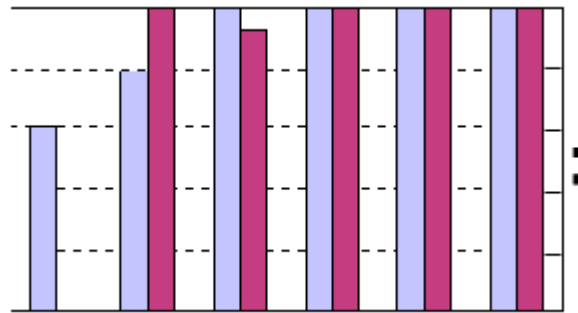


Fig. 6. Tracking of one subject

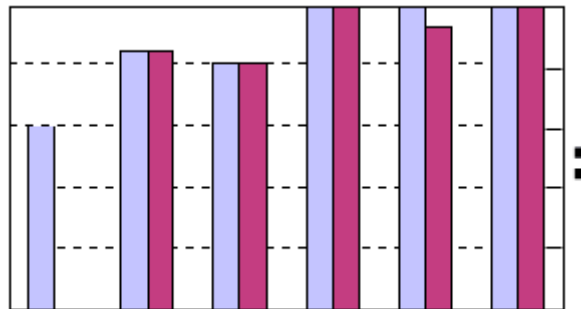


Fig. 7. Tracking of 2 subjects

5. Conclusion

In this work, we conducted extensive controlled measurements to characterize the reliability of passive RFID tags for tracking mobile objects and humans. Our measurements revealed critical insights into how reliability depends on various practical factors, such as inter-tag distances, location of the tag on an object, and tag orientation. To improve reliability, we explored simple and cost-effective reliability techniques, namely redundancy at the tag level, the antenna level, and the reader level. Our measurement clearly showed the high effectiveness of tag-level redundancy, followed by antenna-level redundancy, in increasing system reliability. Because our readers did not support dense-reader mode, reader-level redundancy severely reduced reliability in our experiments, due to reader-reader interference. To the best of our knowledge, our work is the first that

systematically characterizes the reliability of RFID systems and its dependence on various practical factors. Our results provide important guidelines for real-world deployment of RFID-based tracking applications as well as simple yet effective solutions to guarantee reliability. Future extensions of this work involve experimenting with active tags, and tag reliability for different tag designs.

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TYOLOGY OF RISKS IN RFID

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ABSTRACT: *Radio Frequency Identification (RFID) is still evolving technology. It is technology with many possible applications. There are also many different possible frequencies, different physical forms of RFID tags, different possible use cases for RFID readers. There are also many standards related to RFID. In this paper state of RFID standards is presented. Typology of RFID systems according to six different criteria was proposed. This overview can serve for engineers, managers and decision makers, when doing first insights into technology.*

KEY WORDS: *Radio Frequency Identification (RFID)*

1. Introduction

Radio frequency identification technology, known as RFID, has been described as “tech’s official Next Big Thing.” RFID is not actually a new technology, but it is being applied in new ways, spurred by technological advances and decreased costs. Once used during World War II to identify friendly aircraft, RFID is now being used in a variety of public and private sector settings, from hospitals to the highway.

In RFID systems, an item is tagged with a tiny silicon chip and an antenna; the chip plus antenna (together called a “tag”) can then be scanned by mobile or stationary readers, using radio waves (the “RF”). The chip can be encoded with a unique identifier, allowing tagged items to be individually identified by a reader (the “ID”). Thus, for example, in a clothing store, each particular suit jacket, including its style, color, and size, can be identified electronically. In a pharmacy, a druggist can fill a prescription from a bottle bearing an RFID- chipped label

confirming the authenticity of its contents. On the highway, cars with RFID tags on their windshields can move swiftly through highway tollbooths, saving time and reducing traffic congestion. At home, pets can be implanted with chips so that lost animals can be identified and returned to their owners more readily. In each case, a reader must scan the tag for the data it contains and then send that information to a database, which interprets the data stored on the tag. The tag, reader, and database are the key components of an RFID system.

2. What is RFID?

Understanding what RFID devices are and how they work is critical to an analysis of the policy issues surrounding this technology. Generic references to “RFID technology” may be applied incorrectly to a wide range of devices or capabilities. For example, RFID by itself is not a location-tracking technology. At sites where readers are installed, RFID may be used to track tagged objects, but this static readability differs from technology such as global positioning systems, or GPS, which uses a network of satellites to pinpoint the location of a receiver. And RFID technology itself can be used for a variety of applications, from contactless identification cards that can be scanned no farther than inches away from a reader, to highway systems utilizing “active” RFID tags that can initiate communication with a scanner 30m away.

2.1 Primary Components of RFID Devices

RFID devices have three primary elements: a chip, an antenna, and a reader. A fourth important part of any RFID system is the database where information about tagged objects is stored.

- The chip, usually made of silicon, contains information about the item to which it is attached. Chips used by retailers and manufacturers to identify consumer goods may contain an Electronic Product Code (“EPC”).¹¹ The EPC is the RFID equivalent of the familiar universal product code (“UPC”), or bar code, currently imprinted on many products. Bar codes must be optically scanned, and contain only generic product information. By contrast, EPC chips are encrypted with a unique product code that identifies the individual product to which it is attached, and can be read using radio frequency. These codes contain the type of data that product manufacturers and retailers will use to track the authenticity and location of goods throughout the supply chain. An RFID chip may also contain information other than an EPC, such as biometric data (a digitized image of a fingerprint or photograph, for example). In addition, some

chips may not be loaded with information uniquely identifying the tagged object at all; so-called “electronic article surveillance systems” (“EAS”) may utilize radio frequency communication to combat shoplifting, but not to uniquely identify individual items.

– The antenna attached to the chip is responsible for transmitting information from the chip to the reader, using radio waves. Generally, the bigger the antenna, the longer the read range. The chip and antenna combination is referred to as a transponder or, more commonly, as a tag. Participants at the workshop brought samples of tags currently in use. The pictures below show a common EPC tag that can be affixed to an object (Figure 1) and a paper hang-tag that can be attached to individual articles of clothing (Figure 2).

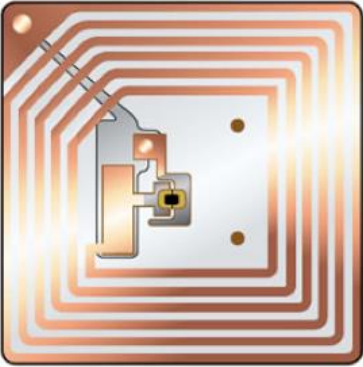


Fig. 1. EPC tag



Fig. 2. RFID hang-tag

– The reader, or scanning device, also has its own antenna, which it uses to communicate with the tag. Readers vary in size, weight, and power, and may be mobile or stationary. Although anyone with access to the proper reader can scan an RFID tag, RFID systems can employ authentication and encryption to prevent

unauthorized reading of data. “Reading” tags refers to the communication between the tag and reader via radio waves operating at a certain frequency. In contrast to bar codes, one of RFID’s principal distinctions is tags and readers can communicate with each other without being in each other’s line-of-sight. Therefore, a reader can scan a tag without physically “seeing” it. Further, RFID readers can process multiple items at one time, resulting in a much-increased (again as compared to UPC codes) “speed of read.”

– The database, or other back-end logistics system, stores information about RFID- tagged objects. Access to both a reader and its corresponding database are necessary before information stored on an RFID tag can be obtained and understood. In order to interpret such data, RFID readers must be able to communicate with a database or other computer program.

Although all RFID systems have these essential components, other variables affect the use or set of applications for which a particular tag is appropriate. As discussed further below, key factors include whether the tag used is “active” or “passive”; what radio frequency is used; the size of the antennas attached to the chip and to the reader; what and how much information can be stored on a tag; and whether the tag is “read/write” or “read-only.” These factors affect the read ranges of the systems as well as the kind of object that can usefully be tagged. They also impact the cost, which is an especially important commercial consideration when tagging a large volume of items.

2.2 Passive v. Active Tags

There are three types of RFID tags, differentiated by how they communicate and how that communication is initiated:

– **Passive tags** have no onboard power source – meaning no battery – and do not initiate communication. A reader must first query a passive tag, sending electromagnetic waves that form a magnetic field when they “couple” with the antenna on the RFID tag.” Consistent with any applicable authorization, authentication, and encryption, the tag will then respond to the reader, sending via radio waves the data stored on it. Currently, depending on the size of the antenna and the frequency, passive tags can be read, at least theoretically, from up to 10 meters away. However, real-world environmental factors, such as wind and interference from substances like water or metal, can reduce the actual read range for passive tags to 3 meters or less. Passive tags are already used for a wide array of applications, including building-access cards, mass transit tickets, and,

increasingly, tracking consumer products through the supply chain. Depending on the sophistication of the chip, such as how much memory it has or its encryption capability, a passive tag currently costs between 20 cents and several dollars.

– **Semi-passive tags**, like passive tags, do not initiate communication with readers, but they do have batteries. This onboard power is used to operate the circuitry on the chip, storing information such as ambient temperature. Semi-passive tags can be combined, for example, with sensors to create “smart dust” – tiny wireless sensors that can monitor environmental factors. A grocery chain might use smart dust to track energy use, or a vineyard to measure incremental weather changes that could critically affect grapes. Devices using smart dust, also known as “motes,” currently cost about \$100 each, but, in a few years, reportedly could drop to less than \$10 apiece.

– **Active tags** can initiate communication and typically have onboard power. They can communicate the longest distances – 30 or more meters. Currently, active tags typically cost \$20 or more. A familiar application of active tags is for automatic toll payment systems, like the Northeast’s “E-ZPass,” that allow cars bearing active tags to use express lanes that don’t require drivers to stop and pay.

2.3 Radio Frequency

Communication between RFID tags and readers is also affected by the radio frequency used, which determines the speed of communications as well as the distance from which tags can be read. Higher frequency typically means longer read range. Low-frequency (“LF”) tags, which operate at less than 135 kilohertz (KHz), are thus appropriate for short-range uses, like animal identification and anti-theft systems, such as RFID-embedded automobile keys. Systems that operate at 13.56 megahertz (MHz) are characterized as high frequency (“HF”). Both low-frequency and high-frequency tags can be passive. Scanners can read multiple HF tags at once and at a faster rate than LF tags. A key use of HF tags is in contactless “smart cards,” such as mass transit cards or building-access badges.

The third frequency, Ultra-High Frequency (“UHF”), is contemplated for widespread use by some major retailers, who are working with their suppliers to apply UHF tags to cases and pallets of goods. These tags, which operate at around 900 MHz, can be read at longer distances, which outside the laboratory environment range between three and possibly fifteen feet.³⁶ However, UHF

tags are more sensitive to environmental factors like water, which absorb the tag's energy and thus block its ability to communicate with a reader.

2.4 Read/Write Capacity

Finally, another important feature of RFID tags is their “read/write” capacity, or “read-only” status. These terms refer to a tag's ability to have data added to it during its lifetime. The information stored on a “read-only” tag cannot be altered, but a writable tag (with read/write capacity) can receive and store additional information. Read/write applications are most prevalent when tags are re-used. They are usually more sophisticated and costly than read-only applications. In addition, read/write applications have shorter read ranges. Read-only tags are well-suited to applications like item-level tagging of retail goods, since they are less expensive and, as part of a networked system, can provide a great deal of information by directing the reader to the associated database(s) where information about the tagged item is maintained.

3. RFID Today and Tomorrow

3.1 Current Uses of RFID

Workshop participants described a number of RFID applications that consumers may already be using. For example, some consumers are familiar with employee identification cards that authenticate the pass-holder before permitting access. A related use of RFID is for event access – to amusement parks, ski areas, and concerts, where tagged bracelets or tickets are used. Panelists also explained how RFID is being used in a variety of transportation-related contexts. Many automobile models already use RFID tags in keys to authenticate the user, adding another layer of security to starting a car. Another example, the “Speedpass,” allows drivers to purchase gas and convenience store goods from ExxonMobil stations. RFID is also transforming highway travel, with the advent of E-ZPass in Northeastern and Mid-Atlantic states and similar programs in other regions of the country that allow drivers to pass through tolls without stopping to pay. An active tag on the vehicle's windshield lets a reader installed at the tollbooth know that a tagged vehicle is passing through; information flows from the tag, to the reader, and then to a centralized database, where the prepaid or checking account associated with that vehicle is charged.

3.2 RFID in the Supply Chain

To the extent that the much-touted “RFID revolution” is underway, it is occurring somewhat out of public sight – in warehouses, distribution centers, and other stages of the supply chain. Workshop participants discussed how RFID's

impact on the flow of goods through distribution channels has implications not just for manufacturers, suppliers, and retailers, but also for consumers. Many panelists reported that as a result of more efficient distribution practices generated by RFID use, consumers may find what they want on the store shelves, when they want it, and perhaps at lower prices.

Participants discussed how RFID may help prevent these lapses by improving visibility at multiple stages of the supply chain. RFID readers can gather information about the location of tagged goods as they make their way from the manufacturer, to a warehouse or series of distribution centers, and to the final destination, their store. Also, as one workshop participant explained, RFID enhances the accuracy of information currently obtained through bar code scanning, which is more vulnerable to human error. According to this panelist, access to more – and more accurate – information about where products are in the distribution chain enables retailers to keep what they need in stock and what they do not need off the shelf.

Workshop participants also touted the discipline that RFID imposes on the supply chain by, for example, reducing “shrinkage,” or theft. One panelist explained how RFID may lower costs by keeping shipping volumes leaner and more accurate. Other panelists described how RFID tags can be read much faster than bar codes, citing tests indicating that RFID’s scanning capability can result in goods moving through the supply chain ten times faster than they do when bar codes are used. According to another participant, RFID will facilitate quicker, more accurate recalls by enabling the tracking of a product’s origin and its location in the distribution chain. Further, this panelist asserted, RFID will enhance product freshness by monitoring expiration dates of consumer goods, so retailers know when not to offer items for sale.

3.3 RFID Use in the Public Sector

Panelists also discussed how RFID is being used or contemplated for use by government entities to meet objectives similar to those their private-sector counterparts hope to achieve. Workshop participants discussed a variety of ongoing and proposed government RFID applications.

3.4 Emerging RFID Applications

The Workshop also addressed emerging RFID applications and when such uses are expected to be implemented. According to panelists, one sector that is the focus of extensive RFID research is health care, where RFID devices can be used to track equipment and people within a medical facility. Other proposed applications contemplate using RFID in different ways. For example, one

ongoing study discussed at the Workshop is exploring how RFID can enhance the quality of elder care. By tagging key objects in a senior’s home – such as prescription drug bottles, food items, and appliances – and embedding small RFID readers in gloves that can be worn by that individual, that person’s daily habits can be monitored remotely by a caregiver. This system would develop more accurate record-keeping for medical treatment purposes and could facilitate independent living for senior citizens.

3.5 Typology of risks

Risks result from threats posed by vulnerabilities or weaknesses that can be exploited and cause adverse effects. There are many ways to describe risks to RFID systems.

3.5.1 Typology of risks for Standards and Technology:

- Business process risks - Direct attacks on RFID system components potentially could undermine the business processes the RFID system was designed to enable.
- Business intelligence risks - An adversary or competitor potentially could gain unauthorized access to RFID-generated information and use it to harm the interests of the organization implementing the RFID system.
- Privacy risks - Personal privacy rights or expectations may be compromised if an RFID system uses what is considered personally identifiable information for a purpose other than originally intended or understood. The personal possession of functioning tags also is a privacy risk because it could enable tracking of those holding tagged items.
- Externality risks - RFID technology potentially could represent a threat to non-RFID networked or collocated systems, assets and people.

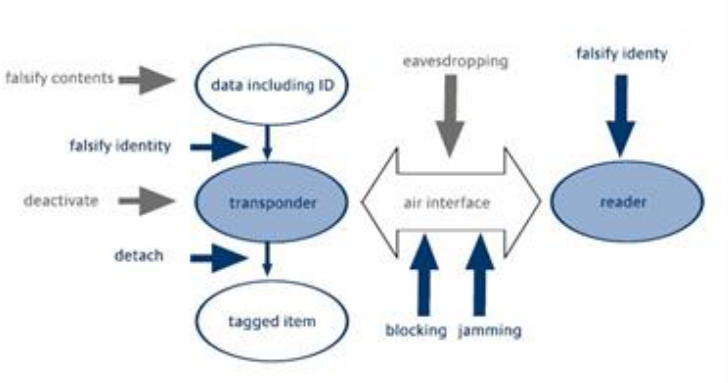


Fig. 3. Basic types of attacks relating to data/tag relationship, tag/tagged item relationship and tag/reader relationship

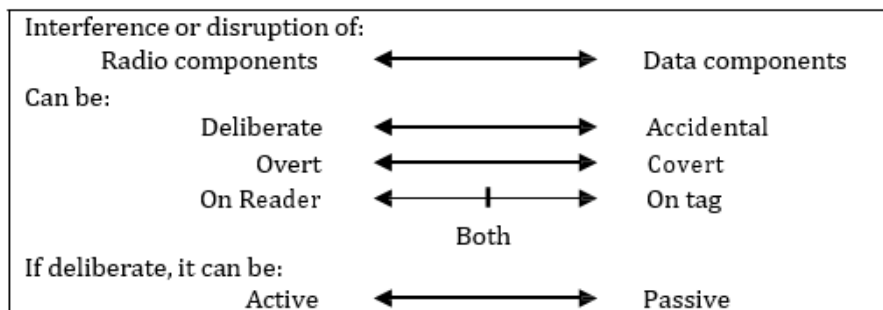
Table 1. Types of attacks according to their purpose: spying, deception, denial of service, protection of privacy

	Spying	Deception	Denial of Service	Protection of privacy
Falsifying content		+		
Falsifying tag identity		+		
Deactivating		+	+	+
Detaching		+		+
Eavesdropping	+			
Blocking		+	+	+
Jamming		+	+	+
Falsifying reader	+			

Security challenges raised by RFID can also be structured according to the traditional dimensions of information security: loss of availability, integrity and confidentiality.

3.5.2 Risks related to tags and readers

Many events can disrupt a RFID system. They can be categorized as interference or disruption of either the hardware, or the radio, or the data components of the system. Interference or disruption to the physical components of readers and tags can be deliberate or accidental, overt or covert. Accidental or deliberate disruption of the radio components can be of the reader or tag or both. Deliberate attacks can be active or passive. Interference or disruption on the data components can be of the tag or reader data or both.



RFID systems, as any information system, include software and hardware components. However, their main specificity lies in the hardware components,

namely the tags and readers as well as the methods of energy exchange they use to communicate.

Availability is the assurance of timely and reliable access to data services for authorized users. It ensures that information or resources are available when required. For instance, Denial of Service (DoS) attacks target the availability of a system. Consequences of disruption of availability of typical RFID systems could be, for example, delays in processing identity documents (*e.g.* disabled RFID passports) thus possibly disturbing airport border control processes, preventing individuals to access public transportation systems (*e.g.* subway access card) or work premises (*e.g.* access control cards), preventing an owner to access his/her vehicle (*e.g.* RFID car keys), preventing automatic processing of medicine information in a health context leading to dangerous errors for patients (*e.g.* medicine tagging).

Threats to the availability of the physical components of a RFID system can be overt or covert. Overt attacks on tags include cutting the electrical circuit on the tag, detaching the tag from the tagged item, discharging the battery of an active tag, or masking the antenna (shielding) with a conductive material or paint. Such strategies could be pursued to evade anti-theft RFID systems in stores. They could also be used for privacy protection purposes: companies have developed RFID blocking wallets (for RFID credit cards) and passport cases that are presented as privacy protective apparel.

Covert attacks can be conducted by overloading receiving components to stop them from functioning or to destroy them, for example by subjecting a passive tag to a high energy field in close proximity. Hackers have demonstrated that a strong energy field generated by an inexpensive, modified, single-use camera flash light can produce this result.

Integrity is the underlying assurance that data has not been altered during a transmission from the point of origin to the point of reception. Consequences of loss of integrity in common RFID systems could include, for example, delays and misdirection in the supply chain or confusion in retail operations due to corrupt or erroneous information. In some cases, loss of integrity generates loss of availability. For example, corrupt access cards would not enable individuals to access the transportation system. If car ignition key information is altered, then it is likely that access to the car will be impossible.

A man-made unwanted signal can also be used to inject a false signal, compromising the system's integrity. Reader identity could be falsified to access, modify or kill a tag. For example, a "kill" command could be sent before the tag is read by the legitimate reader and lead to fraud in a retail context, or disrupt supply chain information. Tag cloning and emulation could be used to falsify the identity of goods, and, for example, replace them with cheaper item identifiers. Automobile thieves could clone car keys. Cloned credentials could enable individuals' identity to be stolen to enable access to restricted areas in the work environment. Cloning could lead to identity theft if the cloned credential can be used as a proof of identity.

Confidentiality is the assurance that information is accessible only to those who are authorized to have access. When the data relates to an individual, loss of confidentiality results in data protection violations. Consequences of loss of confidentiality in typical RFID systems could include, for example, stealing competitor information in the supply chain or in the retail environment, stealing a vehicle by gaining access to electronic key information and cloning the chip. According to a Japanese newspaper, data about passengers' latest entry and exit stations stored in a Japanese public transport access card (Suica card) can be read by basic RFID readers, such as the one embedded in Sony Clié PDA. A journalist claimed that the possibility to read such information at a distance could potentially facilitate stalking. The vulnerability of passport information (including biometric data) has been pointed out as a possible source of fraud or crimes involving identity theft (see Annex III). Unauthorized remote access to data is sometimes also called "skimming".

Any system based on radio technology is susceptible to eavesdropping of the radio signal between transmitter and receiver, thus raising confidentiality challenges (as well as integrity challenges if the data can be reinjected). RFID systems based on magnetic induction also generate radio waves that an attacker equipped with the appropriate radio equipment could, in theory, intercept. However, although theoretically possible, it is practically improbable because the energy levels would be relatively low and would be covered by noise, forcing the attacker to operate at short distance of the tags and reader (likely, in an overt manner).

RFID eavesdropping can be both passive and active. The attacker (or "interceptor") may actively send a signal to the tag to get a response, or simply

passively listen to the response prompted by a reader activating the tag. Some tags can only reply with data (*e.g.* an identification number). More “intelligent” tags can send back a processed response akin to being actively interrogated with the objective of exploiting a vulnerability.

3.5.3 Risks related to other components

Other components of RFID systems present security risks too. In particular, database security has been identified as a serious and sometimes underestimated concern, since databases containing information associated to tags are likely to be accessed by different enterprises and, sometimes, will be maintained by third parties.

Academic research has also demonstrated that classic Structured Query Language (SQL) and script injection attacks are capable of significantly damaging an RFID system through the use of just one infected RFID tag. RFID tags’ data could include unexpected code or instructions designed, for example, to damage the back-end database of an RFID system, compromise the whole system and/or self-replicate inside the system. In such scenarios, the exploits are not inherently linked to the RFID technology but rather to the quality of the design and coding of the middleware software components, which interact with the RFID devices. Researchers highlighted that RFID applications are potential candidates for exploitation by malware: they involve complex applications with a large amount of source code, rely on generic protocols and facilities as well as back-end databases, they process and store high-value data and, since nobody expects RFID malware yet, they convey a false sense of security.

4. Conclusion

RFID technologies are often presented by their advocates as the “next big IT revolution” and are subject to a considerable amount of communication and publicity, sometimes drifting to technology and marketing “hype” or sensationalism. This phenomenon may increase the visibility of a technology with significant potential benefits to business and individuals. But it may also be counterproductive. The complexity of RFID technologies, their technical variety, and the very large range of possible applications they enable make them prone to being misunderstood. Like any information technology, if RFID were implemented without appropriate consideration of how to address privacy and security risks, it might damage the organization that has deployed it, and cause harm to the individuals involved. Should significant risks be detected in existing

or planned sensitive (e.g. passports, credit cards), large-scale (e.g. transportation systems) or striking (e.g. RFID implants) RFID systems, there would be a risk that RFID “hype” becomes RFID fear, damaging the perception of the technology by the general public and handicap its promising future.

Conclusion

RFID is still evolving, but nowadays many standards already exist. There are many possible use cases, applications etc. There are also many variants of technology. It is always a question about environment, when deciding on RFID application. There are many possible criteria to classify RFID systems. For example different frequencies may be used depending on needs and situation of particular organization. RFID is enabling technology, that enables creation of solutions delivering new values and enables error-prone, automatically collected data in real time.

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THE HEURISTIC ALGORITHMS IN LOGISTICS

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ABSTRACT: *The paper deals with algorithms for solving logistics problems. It describes types of heuristic algorithms focusing on their strengths and weaknesses. Incorporating the advantages and disadvantages of heuristic algorithms, it offers feasible solutions*

KEY WORDS: *logistics, heuristic algorithms, traveling salesman problem.*

I. Introduction

Many logistic problems are combinatorial by nature. Combinatorial optimization problems could be solved by exact or by heuristic algorithms. The exact algorithms always find the optimal solutions. The wide usage of the exact algorithms is limited by the computer time needed to discover the optimal solutions. In some cases, this computer time is enormously large [1].

Heuristic algorithm could be described as a combination of science, invention, and problem solving skills. In essence, a heuristic algorithm represents procedure invented and used by the analysts in order to “travel” through the space of feasible solutions. Good heuristics algorithm should generate quality solutions in an acceptable computer time. Complex logistic problems of big dimensions are usually solved with the help of various heuristic algorithms [2]. Good heuristic algorithms are capable of discovering optimal solutions for some problem instances, but heuristic algorithms do not guarantee optimal solution discovery.

The trade-off criteria for deciding whether to use a heuristic for solving a given problem include the following:

Optimality: When several solutions exist for a given problem, does the heuristic guarantee that the best solution will be found. Is it actually necessary to find the best solution?

Accuracy and precision: Can the heuristic provide a confidence interval for the purported solution? Is the error bar on the solution unreasonably large?

II. Exposition

An example of approximation is described by Jon Bentley [3] for solving the traveling salesman problem (TSP) so as to select the order to draw using a pen plotter. TSP is known to be NP-Complete (Nondeterministic Polynomial time) so an optimal solution for even a moderate size problem is intractable. Instead, the greedy algorithm can be used to give a good but not optimal solution (it is an approximation to the optimal answer) in a reasonably short amount of time.

The problem can be defined as follows: Find the shortest itinerary, which starts in a specific node, goes through all other nodes exactly once, and finishes in the starting node. In different traffic, transportation, and logistic problems, the traveling salesman can represent airplanes, boats, trucks, buses, crews, etc. Vehicles visiting nodes can deliver or pick up goods, or simultaneously perform pick-up and delivery.

“Greedy” heuristic algorithms build the solution of the studied problem in a step-by-step procedure [4]. In every step of the procedure the value is assigned to one of the variables in order to maximally improve the objective function value. In every step, the greedy algorithm is looking for the best current solution with no look upon future cost or consequences. Greedy algorithms use local information available in every step. The fundamental concept of greedy algorithms is similar to the “Hill-climbing” technique.

In case of “Hill-climbing” technique the current solution is continuously replaced by the new solution until it is not possible to produce further improvements in the objective function value. “Greedy” algorithms and the “Hill-climbing” technique are similar to the hiker who is trying to come to the mountaintop by never going downwards (Fig. 1).

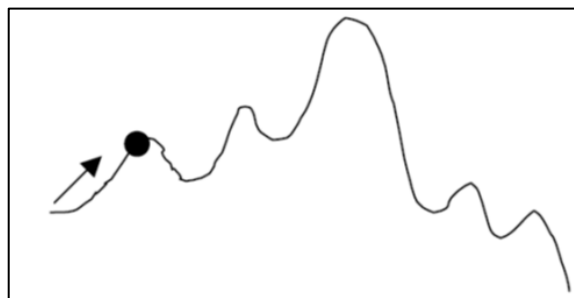


Fig. 1. Hiker who is trying to come to the mountaintop by going up exclusively

As it can be seen from Figure 1, hiker’s wish to never move down while climbing, can trap him or her at some of the local peaks (local maximums), and

prevent him or her from reaching the mountaintop (global maximum). “Greedy” algorithms and the “Hill-climbing” technique consider only local improvements.

The Nearest Neighbor (NN) heuristic algorithm is a typical representative of “Greedy” algorithms. This algorithm, which is used to generate the traveling salesman tour, is composed of the following algorithmic steps:

Step 1: Arbitrarily (or randomly) choose a starting node in the traveling salesman tour.

Step 2: Find the nearest neighbor of the last node that was included in the tour. Include this nearest neighbor in the tour.

Step 3: Repeat Step 2 until all nodes are not included in the traveling salesman tour. Connect the first and the last node of the tour.

The NN algorithm finds better solutions than the algorithm based on random choice, as it uses the information related to the distances between nodes.

Let us find the traveling salesman tour starting and finishing in node 1, using NN heuristic algorithm (Figure 2). The distances between all pairs of nodes are given in the Table 1.

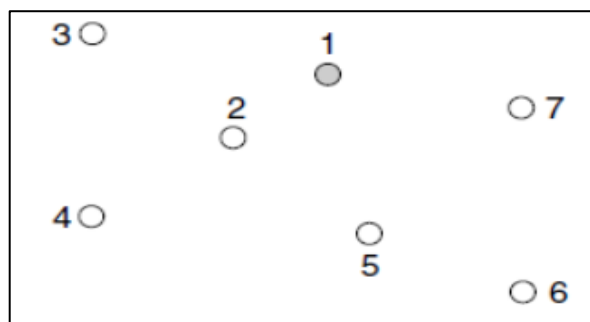


Fig. 2. Network in which a traveling salesman tour should be created using NN heuristic algorithm

Table 1. The Distances between All Pairs of Nodes

	1	2	3	4	5	6	7
1	0	75	135	165	135	180	90
2	75	0	90	105	135	210	150
3	135	90	0	150	210	300	210
4	165	105	150	0	135	210	210
5	135	135	210	135	0	90	105
6	180	210	300	210	90	0	120
7	90	130	210	210	105	120	0

The route must start in node 1. The node 2 is the NN of node 1. We include this NN in the tour. The current tour reads: (1, 2). Node 3 is the NN of node 2. We include this NN in the tour. The updated tour reads: (1, 2, 3). Continuing in this way, we obtain the final tour that reads: (1, 2, 3, 4, 5, 6, 7, 1). The final tour is shown in Figure 3.

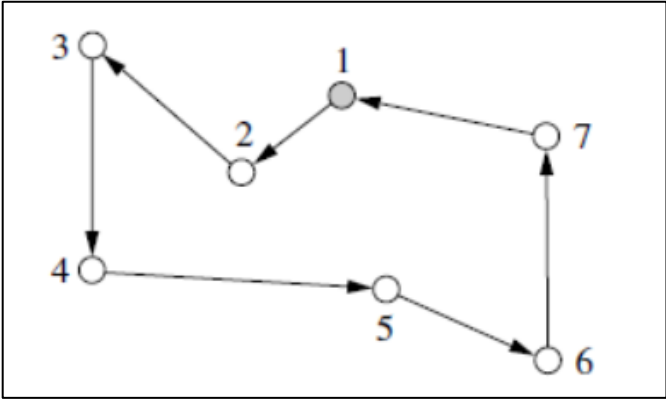


Fig. 3. Traveling salesman tour obtained by the NN heuristic algorithm

When applying “greedy” approach, the analyst is forced, after a certain number of steps, to start to connect the nodes (in case of TSP) quite away from each other. Connecting the nodes distant from each other is forced by previous connections that significantly decrease the number of possible connections left.

Exchange heuristic algorithms are based on the idea of interchange and they are widely used. The idea of interchange is the idea to start with the existing solution and check if this solution could be improved.

Exchange heuristic algorithm first creates or selects an initial feasible solution in some arbitrary way (randomly or using any other heuristic algorithm), and then tries to improve the current solution by specific exchanges within the solution.

The good illustration of this concept is two-optimal tour (2-OPT) heuristic algorithms for the TSP [3-OPT and k-optimal tour (k-OPT) algorithms are based on the same idea]. Within the first step of the 2-OPT algorithm, an initial tour is created in some arbitrary way (randomly or using any other heuristic algorithm). The two links are then broken (Fig. 4).

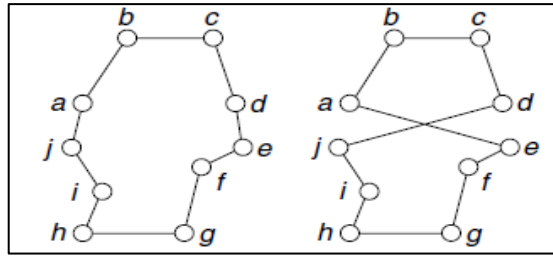


Fig. 4. Interchange of two links during 2-OPT algorithm

The paths that are left are joined so as to form a new tour. The length of the new tour is compared with the length of the old tour. If the new tour length is less than the old tour length, the new tour is retained. In a systematic way, two links are broken at a time, paths are joined, and comparison is made. Eventually, a tour is found whose total length cannot be decreased by the interchange of any two links. Such a tour is known as two-optimal tour (2-OPT).

By using the 2-OPT algorithm, we will try to create the traveling salesman tour for the network shown in Figure 2. The distances between nodes are given in Table 1. The traveling salesman should start his trip from node 1. The initial tour shown in Figure 3 is generated by the NN algorithm. It was not possible to decrease the total length of the initial tour by interchanging of any two links. Our initial tour is 2-OPT

In some cases it is desirable to decompose the problem considered into smaller problems (sub problems). In the following step every sub problem is solved separately. Final solution of the original problem is then obtained by “assembling” the sub problem solutions. We illustrate this solution approach in case of the standard vehicle routing problem (VRP).

The Sweep algorithm is one of the classical heuristic algorithms for the VRP [5]. This algorithm is applied to polar coordinates, and the depot is considered to be the origin of the coordinate system. Then the depot is joined with an arbitrarily chosen point that is called the seed point. All other points are joined to the depot and then aligned by increasing angles that are formed by the segments that connect the points to the depot and the segment that connects the depot to the seed point. The route starts with the seed point, and then the points aligned by increasing angles are included, respecting given constraints. When a point cannot be included in the route as this would violate a certain constraint, this point becomes the seed point of a new route, and so on. The process is completed when all points are included in the routes (Fig. 5).

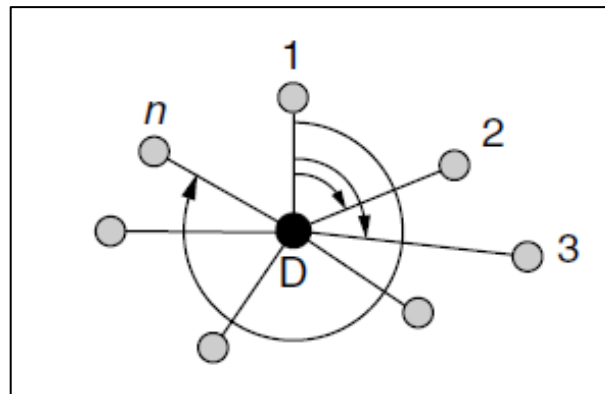


Fig. 5. Sweep algorithm

In case when a large number of nodes need to be served, the Sweep algorithm should be used within the “clustering-routing” approach. In this case, considering clockwise direction, the ratio of cumulative demand and vehicle capacity should be checked (including all other constraints).

The rotating calipers technique for designing geometric algorithms may also be interpreted as a form of plane sweep, in the projective dual of the input plane. A form of projective duality transforms the slope of a line in one plane into the x-coordinate of a point in the dual plane, so the progression through lines in sorted order by their slope as performed by a rotating calipers algorithm is dual to the progression through points sorted by their x-coordinates in a plane sweep algorithm.

In case when a large number of nodes need to be served, the Sweep algorithm should be used within the “clustering-routing” approach. In this case, considering clockwise direction, the ratio of cumulative demand and vehicle capacity should be checked (including all other constraints). The node that cannot be included because of the violation of vehicle capacity or other constraints becomes the first node in another cluster. In this way, the whole region is divided into clusters (zones). In the following step, VRP is solved within each cluster separately. Clustering is completed when all nodes are assigned to clusters (Fig. 6). It is certain that one vehicle can serve all nodes within one cluster. In this way, the VRP is transformed into few TSP.

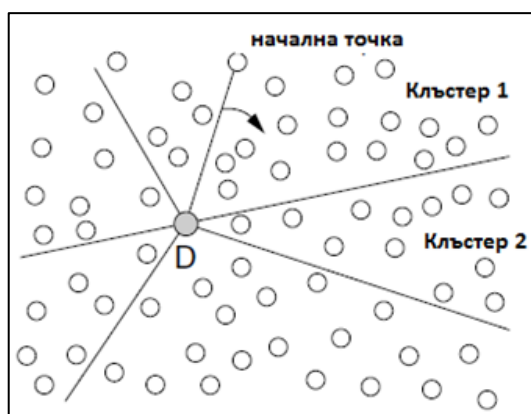


Fig. 6 Clustering by Sweep algorithm

The final solution depends on a choice of the seed point. By changing locations of the seed point it is possible to generate various sets of vehicle routes. For the final solution the set of routes with minimal total length should be chosen.

III. Conclusion

The objective of a heuristic is to produce a solution in a reasonable time frame that is good enough for solving the problem at hand. This solution may not be the best of all the actual solutions to this problem, or it may simply approximate the exact solution. But it is still valuable because finding it does not require a prohibitively long time.

The final solution depends on a choice of the seed point. By changing locations of the seed point it is possible to generate various sets of vehicle routes. For the final solution the set of routes with minimal total length should be chosen.

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EDUCATION IN THE DOCTORAL PROGRAM IN INFORMATICS THROUGH THE PRISM OF THE PHD STUDENTS¹

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ABSTRACT: *The following article is based on an empirical study completed at the Faculty of Mathematics and Informatics focusing on the evaluation which the PhD students of Informatics within the period 2012-2017 give to the doctoral program they have been enrolled in. This evaluation concerns the quality of education provided by the Shumen University. The study aims to investigate the attitude of PhD students towards enrolling in programs at the Shumen University and to determine the level of their satisfaction with the quality of the process of education.*

KEY WORDS: *quality of higher education; the education of PhD students*

In the present world of ever growing global economical, informational, technological, educational and cultural cooperation the problems of the quality of education have particular priority and importance. Education is at the basis of the growing role of the human capital and social cohesion. [1]

The quality of education at Shumen University is the responsibility of all members of the academic community - the academic staff, the administration, the students, the PhD students - towards the aspects of the process of education which their professional profile entails. In this sense, it is defined not as a work obligation and the responsibility of a particular organizational institution, but rather as a common responsibility of the academic management body, the academic staff, the university administration and the structures of student autonomy. [2]

With their personal qualities, motivation and efforts, the PhD student is part of the system which creates the quality of the product of education. This is the reason for studying the opinion of part of the PhD students at Shumen University, namely those enrolled in the doctoral program in Informatics, regarding the education process within the program.

¹ The study is financed by project № RD-08-95/6.02.2017 "Monitoring of the realization of Shumen University alumni"

The survey includes the PhD students enrolled in the doctoral program in Informatics during the entire period of accreditation between 2012 and 2017. Eight PhD students were surveyed. The majority of the surveyed are male, accounting for 63% of the total number, whereas females account for 37%. For the most part the surveyed are of mature age. 63% of the surveyed are between the ages of 36 and 45, while 37% are aged 26 to 35. The age structure of the PhD students presupposes a more mature attitude towards education, whereby it is approached not only as another challenge, but rather as a conscious need for professional and personal growth.

Among the surveyed there are no PhD students enrolled in the full-time form of the doctoral program. Each of the forms has its advantages. Full-time PhD students can dedicate their time entirely to research, they can concentrate their efforts on the problems of their study and in case they work diligently, they can prepare and defend their thesis more quickly. Within the studied doctoral program, 13% have chosen the individual form, an 87% - the part-time form of doctoral program. These two categories of persons are in more difficult circumstances. They need to combine their study and research work with their professional duties. This can be explained by the fact that the students work within the field of their research and would like to combine the practical realization with academic prominence and professional growth. This proposition is supported also by the age structure. The majority of the PhD students are middle-aged individuals who have families and the money provided by the scholarship for full-time PhD students is entirely insufficient. The fact should not be neglected that more than a third of the surveyed are women whose main social role is the raising and upbringing of children, as well as providing care for the family as a whole. It must be taken into consideration that this is an additional burden for the students. The need for combining multiple functions sometimes slows down, holds back or even discontinues their PhD studies.

The surveyed are at different stages of their doctoral education. 50% have completed their doctoral education successfully and the defense of their thesis is pending, 25% are second-year PhD students, another 25% - third year. They all have experience as PhD students for at least a year and their impressions reflected in the survey are objective.

The PhD students' motives for choosing a particular topic for their dissertation are various and are often a combination of several different ones. Thus on the basis of the most preferred reasons a rating scale of incentives is formed. The leading incentive, chosen by 11 participants in the survey, is "my personal interests". In second place, with an equal relative share of 38% are "the interests of my supervisor" and "the need for specialists in the respective field". The aforementioned data show that in their choice of topic for their thesis PhD students are led by intrinsic rather than by instrumental values.

Most of the surveyed evaluate the curriculum of their doctoral program as well balanced - 87%. There is a relatively small portion who are undecided - 13%. It is a positive fact that there are no negative opinions. None of the surveyed believes the curriculum is “unnecessarily overloaded” or “easy and lacking in depth”.

The assessment the PhD students give regarding their participation in the academic life of the department with which they are enrolled is also interesting. More than a half - 63% - believe that it is “active and fruitful”. A group of 25% claim that they are “engaged in activities which are unrelated to their PhD studies”. It is a concerning fact that 12% admit to a lack of such participation. It is advisable that the efforts of the Faculty management body be directed towards improving the level of awareness and the inclusion of PhD students in all activities of the department which administers their education. It is also advisable that the opinion of the department be considered regarding the degree to which the doctoral students are actively and fruitfully involved in the life of the department. Regardless of what an opinion is, it needs to be supported with proof - with what, when and in what way.

At the moment of the survey all of the surveyed have passed their doctoral exams. More or less they all believe that their knowledge was assessed objectively. 75% answer they “strongly agree”, and 25% “moderately agree”. Similar is the opinion regarding the grade they received from their PhD student attestation. 87% strongly agree that it was objective and 13% evasively claim they “moderately agree” with the objectivity of the grade. It should be noted that there are no negative attitudes among the PhD students.

This is not the case with the evaluation of the introductory information for the newly-enrolled PhD students received at University level from the staff member responsible for the scientific development of the academic staff. Opinions on this matter vary. Although the majority (63%) consider the introductory information to be sufficiently full and have given a positive grade, there is a number of surveyed of a different opinion. 12% are undecided. About a quarter, however, give a negative grade - 12% answer “strongly disagree”, 12% “moderately disagree”. This variation in the opinions can be explained with the fact that the PhD students have high expectations and demands towards the administrative staff. It is advisable that an instructional seminar be organized where information is given regarding the extent of the responsibilities of the staff member, to what extent she is responsible for the administrative support of the students and to what extent - the department is. Otherwise the responsibilities become fuzzy and shifting and as a result hamper the process of education in the doctoral program.

It is obvious that the introductory information is received mainly from the respective department. 88% of the surveyed support this claim. 63% agree, 25% moderately agree. Regarding this indicator there is a category of unsatisfied,

who make up 12% of the surveyed and moderately disagree. The conclusion can be drawn that the feedback in the process of communication is ineffective and needs work.

The surveyed demonstrate optimism and confidence in their abilities. The majority claim that they are able to complete on their own tasks related to the doctorate - 50% agree, 35% moderately agree. This determination and conviction that the tasks correspond to their abilities is important for the systematic laying of quite a bit of effort, the diligent pursuit of goals, for good concentration and maximum mobilization, which determine the successful defense of the dissertation. It is a worrying fact that 13% are undecided regarding this question. The lack of opinion has to do not only with the PhD student being disoriented, but also with an inability to judge their own actions, or to invest systematic effort and pursue their goals, which could influence negatively the quality of the research and scientific work and eventually, the successful defense of the doctoral dissertation.

The difficulties which the surveyed encountered during their work on writing the dissertation are various. In first place with 75% they point out "being excessively busy with activities not related to the dissertation". In second and third place with parity in their percentage are "lack of sufficient materials" or "lack of time". 13% of the surveyed gave no answer. This question correlates with a previous one regarding the active and productive participation in the academic life of the department. Could this participation be so large and all-consuming that it exhausts the young people? More likely not. A tendency can be observed for PhD students wanting to be ensured working comfort and not being required to do anything else. This way the consumerist attitude towards the process of education becomes visible, whereby students demand rights without fulfilling their share of responsibilities.

The intensity of the contact between the PhD students and their doctoral advisors varies. Under the guidance of their doctoral advisor, half of the surveyed have participated in 2 scientific projects, 12% in 3 and 26% - in 4 or more projects, It is worrying that 12% of the surveyed have not participated in a single project. Similar variation can be observed in the participation in scientific research under the guidance of the doctoral advisor. 12% have participated in one, 50% in 2, 12% in 3 and 26% in 4 or more. The data from the final two indicators are commensurable and show that the percentage of PhD students in projects and research under the guidance of their doctoral advisor is the same. It should however be treated not only as the responsibility of the advisor, but also as an initiative and responsibility for the PhD student during the process of education.

It should be noted that most of the surveyed do their best to fulfill their obligations successfully. From the moment of their enrollment up to the time the survey was made, half of the PhD students have 4 or more published articles.

26% have 3, 12% have 2 and another 12% have one. There are no students who have not published an article, but some thought could be given to whether a single published article is enough during the second year in the doctoral program.

When publishing, most of the surveyed have used the University and Faculty editions (75%). A quarter have not taken advantage of this opportunity.

In general, the surveyed are supported financially in their research work. 87% claim that they receive support with the processing and publishing of the results of their research. The percentage of those who received support for participation in scientific forums is much lower - 63%. It is advisable to inquire into the reasons why 37% of the surveyed have not received at least partial financial support.

The majority are of the opinion that the PhD students receive competent scientific and methodological guidance from their doctoral advisors. 50% strongly agree and 37% moderately agree. Here, too, 13% are undecided.

The doctoral advisor's help is various. The largest percentage of 87% is formed by the statement "critical notes on the work". Second place with 75% take the answers "in structuring and composing the dissertation". Third place with 63% take the items "sharing personal experience and original ideas" and "ensuring opportunities for testing the results".

The overall administrative service is evaluated positively by the PhD students. 76% give a very good grade, 12% - a good grade and 12% a satisfactory grade. Although the predominant evaluation is positive, it is worrying that there are "satisfactory" grades. This is a signal that there is a problem which needs to become the object of clarification and resolving. There is also a need that the reasons for the grade in question to be found and analyzed.

Less positive is the evaluation of the available book-stock of the University library. Although 38% give a very good grade, and 25% a good grade, another 25% give claim it is unsatisfactory. Combined with the 12% of the representative sample who give a satisfactory grade, there forms a group of 37% of the surveyed who are not especially satisfied with the available library resources. This is debatable. In evaluating the available library resources within a specific professional field there must be considered not only the paper-based resources, but also the possibilities made available by the library through the use of the shared inter-library borrowing service and the licensed access to international databases, such as www.ebscohost.com; www.sciencedirect.com; www.scopus.com; www.isiknowledge.com; <http://incites.isiknowledge.com>. There are detailed instructions regarding the use of these databases on the Library website. In addition, the University library is part of two library consortia: the Bulgarian Information Consortium (BIC) and the National Academic Library Information System (NALIS). The ambiguous evaluation of

the library resources given by the PhD students could suggest that they might not be well informed about the possibilities which the Library offers. For that purpose there could be created a separate module as part of the School for PhD students at the university.

There is more to be desired in terms of the participation by the PhD students in collective forms of education. As few as 50% of the surveyed have taken part in such. Those usually concern foreign-language education and courses on the methodology of scientific research.

The analysis of the data shows that in their majority, the PhD students work productively and with commitment. However, there can be observed a worrying phenomenon which needs to be reduced and eliminated. According to the presented information, 12% of the PhD students do not participate actively in the academic life of the department. An equal number have not participated in a single research project. The situation is made worse by the fact that an equal number of the surveyed cannot evaluate the curriculum of the PhD program they are enrolled in. The same is the number of surveyed who have no opinion on the question if the introductory information for the newly-enrolled PhD students is sufficient or not. The same percentage corresponds to those who do not know whether they are able to fulfill tasks related to the PhD program on their own. The same number cannot determine if they have difficulties preparing their dissertation and what kind. The same number yet have no opinion if they are receiving competent scientific and methodical guidance by their doctoral advisor. If all these five categories correspond to the same surveyed individuals, ought there be an answer to the question of their place within the doctoral program?

The data show that the opinion of the PhD students must be analyzed. It should be compared to the point of view of the doctoral advisors and the academic staff. The discussion should make it clear if the surveyed's statements are well grounded. Before this has been done, it can be said that there is a need for improving the communication within the department, enhancing the level of informedness of the PhD students, so that there is a uniform understanding of the rights and obligations within the PhD program. The management of the department needs to direct their efforts towards changing the attitude of the surveyed regarding their responsibilities, as well as towards enhancing their sense of commitment to the academic life of the Faculty in general. Otherwise, instead of being a constructive force leading to success, the high self-esteem of the young people would turn into indiscriminating presumptuousness.

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THE EDUCATION IN ECONOMICS AT SHUMEN UNIVERSITY AT THE INTERSECTION BETWEEN EMPLOYERS AND STUDENTS¹

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ABSTRACT: *The article is based on the idea that an improvement in the quality of education at Shumen University can be achieved only after surveying the opinions and evaluations of all concerned parties. The present study correlates the standpoints of students and employers regarding the quality of education within the Economics major at Shumen University. This way one of the main European principles for quality of education is observed - its self-evaluation.*

KEY WORDS: *the quality of higher education*

During the 2016/2017 academic year an empirical sociological survey was conducted at Shumen University's Faculty of Mathematics and Informatics. 136 people participated. It is part of the University's policy regarding the quality of education which includes the constant monitoring of different target groups having relation to the process of education.

The purpose of the survey is to juxtapose the evaluations of students and employers regarding the quality of education within the Economics major and to identify problematic points which need to be addressed.

The analysis of the survey data provides the university's management body with information regarding:

- the attitudes, expectations and priorities of the applying students regarding their choice of Shumen University;
- the level of satisfaction of university graduates regarding the quality of education in different sections;
- the attitudes, opinions and evaluations of users of staff regarding the professional capacity of Shumen University graduates who work for them.

¹ The study is financed by project № RD-08-95/6.02.2017 "Monitoring of the realization of Shumen University alumni"

The survey uses 3 survey forms - for employers, for newly admitted students and for graduating students. The first form was used to survey 56 people, the second - 37 first-year Bachelor students of Economics, and the third one - 43 students from the same major.

The process of education is the shared responsibility of students, academic body and employers. Each one must fulfill their share of the work. Without the motivation and hard work of the young people, only with the dedication of the academic body and the administrative personnel it is impossible to achieve a competitive quality of the educational service. This is the reason for inter-relating the quality of education with the attitudes, ideas and expectations of the newly admitted students. This is also the purpose of surveying this category of persons, which is done at the end of the winter semester so that there is accumulated sufficient experience regarding the process of education.

The motives for doing the survey at Shumen University are related to instrumental rather than terminal values. They are various and form different combinations. Within the formed rating scale, the first place is held by the reason "acquiring higher education" with 36,67%. In second place is "proximity to the place of living" with 20%. Only in third place is the idea of "acquiring good quality education" with 18,33%. In fourth place is "affordable education" with 15%. The conclusion from the data is that the student chose the University mainly because of the convenience and comfort of their family. They are at this particular university in order to have a degree in higher education at an affordable price and close to their home.

Unlike their motives for choosing a university, the choice of a major among the young people is guided by terminal values. In first place is the motive "it corresponds to my personal interests and abilities" - chosen by 32,14% of the surveyed first-year students. In second place is the option "it provides an opportunity for realization" with 25%, and in third place - "it provides an opportunity for a good income" with 21,43%. Motives such as "influenced by my parents" or "by accident" have a symbolic share of 5,36% and 1,79% respectively.

The data shows that the surveyed students are well motivated to study the selected major, which is a prerequisite for a good quality of education. This is supported by the fact that during the application process 87,10% placed it as their first choice and 9,68% as their second choice. It is clear that the young people were not admitted in this major by chance but rather made a conscious choice.

Most of the surveyed are optimistic regarding finding a job - 70,97%. A portion evaluate these chances as good - 41,94%, another - as very good - 29,03%. Only a few do not expect to find a job which corresponds to their major - 6,45%.

The overall evaluation of the first impressions of the students at Shumen University is not uniform. A little over a half of the surveyed have given a positive evaluation: good (32,26%) and very good (19,35%). Approximately a fifth give the condescending satisfactory evaluation and 6,45% - unsatisfactory. The share of those without an opinion is large - approximately one fifth. This points to an immature attitude towards the process of education. The registered varying opinions can be explained with the fact that the students have great expectations and high demands for the University. Perhaps their adaptation towards the institution is still not completed.

The students gave a better assessment for the administrative service at the Students' Office. More than a half give a good grade (51,61%), 19,35% - very good, and 12,90% - satisfactory. Here there is also a relatively large group of people who do not have an opinion. These account for 16,13% of the surveyed.

The fact that so many young people do not have an opinion is worrying. The lack of opinion has to do not only with the student being disoriented, but also with an inability to judge their own actions, or to invest systematic effort and pursue their goals, which could influence negatively the quality of the process of education.

This is not so at the final surveying of the graduating students. The opinion of these students is important since they have the ability to compare their fresh impressions from their education at Shumen University and the requirements of the actual practice. At the moment of conducting the survey, almost half of the students are employed - 48,84%. Almost one quarter work in the field of their major.

The surveyed are satisfied with the fact that they will have a degree from Shumen University. 83,72% are entirely satisfied, 16,28% - partially satisfied. According to them this satisfaction has to do with three reasons, selected with an equal share of 28,07%: a good theoretical basis; an optimal balance between theory and practice; good theoretical basis, high quality practical preparation and a balance between them. Although there are no surveyed who are not satisfied, the students point out that the practical training programs and apprenticeships are insufficient - 28,07%.

The satisfaction is supported by the fact that if they decide to pursue a higher degree, most of the surveyed would choose to do it at Shumen University - 72,73%. Those who have a negative opinion are 15,91%. There is a further 11,36% who hesitate and cannot decide.

The students evaluate highly the quality of education at the University. The generalized answers about the overall evaluation of the teaching process form up a rating scale where the leading position is given to the option "interesting and very useful knowledge is given" (46,58%). This is followed by "conditions are created for an active and creative participation in the process of education"

(34,25%) and “a passive behaviour and the acquisition of pre-selected knowledge is provoked” (13,70%).

In their large part, the surveyed evaluate the academic ethics and the atmosphere within the major as very good (53,49%) and good (34,88%).

The graduating students evaluate their behaviour during the process of education as responsible. According to them, more than half attended the classes regularly (55,81%) and another 41,86% - partially.

Within the acquired rating of motives for attending classes the most preferred one with 35,48% states “due to personal practical use and importance for the future work”. In second place is the motive stating “in order to prepare myself better for the exams” - 27,96%. In third place is the reason stating “due to an interest in the particular subject” with 16,13%, and in fourth - “the lecturer provides interesting information on the subject” with 15,05%. The data shows that terminal values prevail, which is a precondition for an effective process of education.

The surveyed are of the opinion that the subjects they studied correspond to the major they chose - 95,35%. Only a few have a negative opinion - 4,65%.

In spite of the positive evaluation, if they had the opportunity the students would change different elements of their education. Despite the rich diversity, the scale of propositions is led by the idea selected by one third of the surveyed - “more discussions and disputes should be held”. This is followed by “alternative methods of education should be used”(27,27%). There are also a few who believe no changes are necessary - 13,64%.

The attitude towards current assessment is positive. More than half of the surveyed believe that it “stimulates systematic preparation” - 55,81%. 34,88% believe that it helps “more objective assessment”. The negative opinions are relatively few - 9,30% believe that it “unnecessarily burdens the student”. The aforementioned data points to the fact that the students have a mature attitude towards the current assessment, and thus towards the process of education, which is a prerequisite for a better quality education.

The positive evaluation students give the education at Shumen University is confirmed in another cross-cut. Almost half claim that the education prepares the for their future job “to a certain degree” - 46,51%. Another 39,53% believe it is “to a large degree”.

In this sense the circumstance is logical that most of them expect as a result from the acquired education to find quick and effective realization - 69,77%. The pessimists (to a different extent) are 16,28%. There are also those who are confused and do not have an opinion - 13,95%.

The graduating students evaluate positively their opportunity to participate in academic research work. 27,91% evaluate it as vary good; 27,91% as good and 23,26% as satisfactory. There are also critical attitudes. 9,30% define this opportunity as unsatisfactory and 6,98% are unaware of the existence of such an

opportunity. The latter statement should be challenged since the connection between the academic staff of the department, as well as the special efforts of the lecturer, who is also the course leader, are very active. The students are informed about the opportunity for participating in academic research work as early as their first meeting in their first year and are constantly invited during their classes.

Also positive is the evaluation of the administrative service at the Students' Office. More than half - 51,16% give it a very good grade and 34,88% - a good grade. Here, too, there are negative opinions, but those are only a few - 6,98%.

Not so uniform is the evaluation of the library services. Although 39,53% evaluate it as very good, and 32,56% as good, there are some who are not that satisfied. 16,28% claim it is satisfactory, and 11,63% - unsatisfactory.

Very significant is the students' answer that if they were to apply right now, in their majority they would choose the same major once again - 83,72%. Those who have a negative attitude are 16,28%.

The point of view of the employers is of great importance as it evaluates the final product of the efforts of students and academic staff. Generally speaking, the attitude is positive. 85,71% of the surveyed have an employee who is a graduate of Shumen University. This means that in their majority the surveyed employers have personal experience regarding the work of graduates. It is a positive fact that those of them who do not have employees from the University are willing to hire such. Only 1,79% give a negative answer.

There are three main motives for providing employment. More than a third of the surveyed are willing to hire a graduate from Shumen University because they already have experience with the work of other students (36,21%). In second place with 29,31% is the claim "I have information about the good quality of education of students at Shumen University". In third place with 18,97% is the statement "I needed an employee with a university degree in this major". The thus formed opinion of the employers shows trust in the education at Shumen University.

According to the employers, the main competences necessary for the professional realization of the students are different. From among six suggested competences each makes their own scale of significance. After averaging out the grades, a scale of three grades emerges. With the largest importance for professional realization are selected 2 items with equal percentage: "basic knowledge in the professional field" and "ability to apply knowledge into practice". In second place in terms of importance also with equal percentage are selected two other items: "ability for using information technologies" and "communicativeness and ability for teamwork". Of the smallest importance for employers are two equal competences: "ability for individual work" and "ethics and loyalty in relations".

It is interesting to observe the opinion of the employers regarding whether the Shumen University graduates possess this competence. In their majority the surveyed claim that graduate students possess basic knowledge regarding their professional field - 85,71%. The remaining small part are evasive in their answers and have selected “partially”. There are no registered negative answers.

Similar are the numbers for evaluating the abilities for using information technologies. 83,93% of the employers believe that the students possess such skills.

Similar are the grades for communicativeness, teamwork and individual work. 80,36% of the surveyed employers think that graduate students possess those entirely, and 16,07% - partially. There are no negative evaluations, but there are 3,57% who did not answer.

The grade employers give regarding loyalty and ethics in professional relations is high. 87,5% of them are certain that the students possess such loyalty.

The situation differs partially regarding the evaluation of the graduate students` abilities for applying knowledge into practice. The share of the certain ones, although it prevails, is lower by 10 points - 76,79%. The share of evasive answers such as “partially” is larger - 21,43%. The very fact that more than a fifth have concerns regarding the application of knowledge into practice requires attention.

This claim is supported by the answer to the question “Do you think that the education at the University has provided the students with the necessary preparation for an adequate professional realization?”. In their large part - three quarters - the employers have answered “yes, entirely”. 14,29% have answered “yes, to a small extent”, and the rest cannot decide.

It can be observed that the high grade is not entirely uniform. Perhaps this is the reason why not all employers are willing to provide student apprenticeship positions. 58,93% of the surveyed are willing to accept students from Shumen University for an apprenticeship. About a quarter are hesitant, but the variation leans towards “quite agree”(23,21%). There are those who openly refuse the idea of an apprenticeship at their firm - 8,93%. When the share of the undecided (5,36%) and of those who did not answer (3,57%) is added, quite a large percentage of employers who are unwilling to provide apprenticeships to Shumen University students is formed.

Paradoxically, they are reserved regarding apprenticeship positions, but give recommendations for practices and apprenticeships. In their majority, employers have no recommendations regarding raising the quality of training of graduating students. The only recommendation, given by 33,93%, is more hands-on practice.

The employers are interested in cooperating with Shumen University but mainly with the academic staff. The largest share is formed by those who are

interested in forms of further qualification and lifelong learning - 35,16%. Those are followed by a quarter of the surveyed who are interested in educational programs at the University. Quite a few of the employers are excited about participation in common projects - 19,78% and about high-achieving students - 10,99%. Meanwhile, nobody chose the item "sponsoring university activities". The data shows that the employers are interested in the educational service in terms of consuming the educational product rather than in sharing common work.

The analysis leads to the conclusion that students of Economics at Shumen University have not been accepted in this major accidentally. Yes, they chose the University for practical reasons, but they selected a desired major which corresponds to the interests and abilities.

Towards the end of their education, the students of Economics express satisfaction and to such a degree that if they had to choose again, they would choose the same major.

The graduating students give a high grade to the quality of the process of education, especially regarding the teaching process and the academic atmosphere. They demonstrate a responsible and mature participation in this process: they attend classes, do not protest against but instead applaud current assessment, approve of the subjects they study, appreciate the opportunities for academic research work. However, for about a quarter of them the apprenticeships and practice are insufficient.

In general, towards the end of their education the students claim that it prepared them well for their future profession. And what is the employers' opinion?

The employers believe that the University education has provided the students with the necessary preparation for adequate professional realization. They are almost unanimous that Shumen University students possess the necessary basic knowledge regarding the professional field, using internet technology, communication. The University graduates possess abilities for teamwork, are ethical and loyal in their profession.

The recommendations for optimizing the education have to do with additional hands-on practice. There is also more to be desired in terms of putting knowledge to practice.

Simultaneously, not all employers are willing to provide apprenticeship positions. Less than 60% of the surveyed are willing to provide such for Shumen University students. They are quite unwilling to sponsor University activities.

Here exists a controversy. Employers give recommendations for connecting education with real-life practice, but are not willing to provide this connection themselves. They are interested in life-long learning, participation in joint projects, high-achieving students. They are willing to consume the ready product of the process of education, but unwilling to participate in the process itself.

Until employers realize that they are an important part of this process and begin to fulfill their part of the work, there will not be competitive results. They need to become an invested structure within the process of education. The quality of higher education is not the sole responsibility of the academic staff. It is the result from the “correspondence of the purpose”.

The academic management body needs to put effort in developing the quality of education as a complex activity. This can be achieved only through the active cooperation with the environment of the institution. It cannot happen, however, without reconsidering the goals and results of education on the part of employers.

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BLOOD-GROUP ABO AND RHESUS FACTOR SYSTEMS DISTRIBUTION IN INDIVIDUALS OF VIETNAMESE NATIONALITY

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ABSTRACT: *The article reports the results of a study of blood group ABO and Rhesus factor systems conducted on 423 Vietnamese citizens (104 men and 319 women) aged 19 to 77 who lived or are currently living in Bulgaria. The frequency of the individual groups of the ABO system is: 0 - 49,88%, B - 25,06%, A - 21,75%, AB - 3,31%, and the gene frequency - $r = 0,711$, $q = 0,155$, $p = 0.134$. Only subsets A1 and A1B were detected in the ABO system. There was only Rh in the studied population.*

KEY WORDS: *blood groups ABO and Rhesus factor, phenotype, genetic frequency, individuals of Vietnamese nationality*

INTRODUCTION: Determining blood group distribution is of great importance for defining anthropological characteristics of a people. Vietnam, whose nationals we have researched, is located in Indochina Peninsula, along with Cambodia, Laos, Malaysia, and Thailand. Most of Myanmar (Burma) and small parts of Bangladesh and China also belong to the peninsula (Figure 1). The peoples of these countries who belong to the mongoloid race, are characterised with a very low or completely absent negative Rhesus factor and 0 blood group prevalence - from 34.49% in Malaysia to 47.98% in China, and 48% in Cambodia [1, 2]. According to other sources, group 0 membership ranges from 21 to 55% [3,4].

Aim of the study: To research ABO blood group and rhesus factor distribution in individuals of Vietnamese nationality.

Material and methods: The study involved 423 people (104 men and 319 women) aged 19 to 77. The tests were conducted in Sofia using standard test sera. The study data were compared to those of other nationalities, calculating the phenotypic and genotypic frequencies [5].



Figure 1. Countries located wholly or partly on the territory of the Indochina Peninsula (Bangladesh is not shown)

Results and discussion:

The data of the study are presented in table 1 and 2.

Table 1. Distribution of blood groups by the AB0 and Rhesus factor systems in Vietnamese

Groups	0	B	A ₁	A ₁ B	Rh+	Rh-
Number tested	211	106	92	14	423	0
%	49,88	25,06	21,75	3,31	100,00	0

Table 2. Genotypic frequency of ABO system blood groups in Vietnamese

r	q	p
0,711	0,155	0,134

The analysis of the obtained data shows a prevalence of 0 blood group frequency (49.88%), followed by group B (25.06%) and group A (21.75%). The lowest is the frequency of group AB (3.31%) - see Table 1. The results are very similar to those obtained by Kicheva [6] - 46.94% for group 0, 29.89% for group B and 20.78% for group A. According to another source [1] the distribution in groups is: 0 - 42%, A - 22%, B - 31% and AB - 5%. The theoretical frequencies for AB0 blood group are as follows: for group 0 - $r = 0.711$, for group B - $q = 0.155$ and for group A - $p = 0.134$. Blood groups A and AB are represented only by subgroup A₁ and A₁B. The subgroup A₂ is hardly found in the indigenous people of China, East Asia (Korea, Japan) and Australia, [5]. All studied individuals have a positive Rhesus factor that fully matches Kicheva's data [6].

When comparing the obtained results with the data for the peoples living in this region, we found a greater similarity of phenotypic frequency to that of the Chinese and the Filipinos [3] was the closest, and a significant difference with Koreans and Laoists [3]. The main population of the peninsula are the Malaysians and small tribes of Negritos (Semagi), who have interbred with Chinese and Indian people (Chinese in Vietnam, and Indians in Cambodia).

The Mongoloid and Australoid populations of East Asia, Oceania and Australia differ significantly from the Euro-west population of West Asia, North Africa and Europe [7,8]. The East Asian and Central Asian distribution of AB0 was formed in the Neolithic period [9]. According to F. Berstein (1925 year), historically group B is predominant in Asia, while according to F. Sander and

M. Sander (1951 year) it is group AB [3]. The Hirschfeld hypothesis [3] accepts 0 group as the oldest predecessor to the other groups, which preserves its high frequency in the oldest population of Indochina Peninsula. This fact can correlate with the higher frequency of blood group 0 in Vietnamese, as mentioned by a number of authors [6,3]. In general, in the population of Indochina peninsula r gene is predominant, with the northern part being dominated by rqp, and the southern, by rpq [7]. Blood group 0 predominates in the local Australoid population as well, which confirms the hypothesis about the formation of the peninsula's indigenous population [3].

The frequency of the positive Rhesus factor in the Pacific ocean countries (including Oceania, Eastern and Southeast Asia) is over 80%, whereas in Africa it is 70-80%, and in Western Europe up to 60%. The very high frequency of the positive Rhesus factor is which is characteristic of most Pacific ocean countries, irrespective of the fact whether the population is of Mongoloid or Australoid origin, to the extent of forming a separate South-Eastern group including the Pacific population [3].

The study has identified some characteristic features of the blood group distribution among the studied individuals of Vietnamese origin, namely the presence of only two subgroups - A1 and A1B and a complete absence of a negative Rhesus factor. This fact makes us conclude that these people belong to the fifth group in William Boyd's classification [3,10,11].

Conclusions: Based on our studies of individuals of Vietnamese nationality, we can draw the following conclusions:

1. The distribution of AB0 system groups is: 0 - 49,88%, B - 25,06%, A - 21,75% and AB - 3,31%.
2. All persons examined are Rhesus positive.
3. Subgroups A2 and A2B are not detected.
4. In their blood-grouping characteristics, the Vietnamese can be assigned to the fifth group of peoples of William Boyd's classification.

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ИЗИСКВАНИЯ КЪМ АВТОРИТЕ

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УКАЗАНИЯ ЗА ОФОРМЯНЕ НА ТЕКСТА

ЗАГЛАВИЕ – Font: Times New Roman; Size: 14; Fontstyle: **Bold**; Effects: AllCaps; ParagraphAlignment: Centered.

ИМЕНА НА АВТОРИТЕ се печатат през 1 празен ред под заглавието в разгърнат вид - пълно собственои пълно фамилно име; Font: Times New Roman, Size: 14, Fontstyle: **Bold**, ParagraphAlignment: Left, по средата на реда – Centered.

АНОТАЦИЯТА И КЛЮЧОВИТЕ ДУМИ НА АНГЛИЙСКИ ЕЗИК се оформят така: Анотацията (**Abstract**:) в обем до 10 реда - Font: Times New Roman, Size: 12, Fontstyle: *Italic*, ParagraphAlignment: Justified; през 1 празен ред следват ключовите думи (дескриптори - **Keywords**) – Font: Times New Roman, Size: 12, Fontstyle: *Italic*; ParagraphAlignment: Justified, и двата елемента с отстъп 1 cm вляво от рамката, ограничаваща основния текст.

ОСНОВЕН ТЕКСТ – Font: Times New Roman, Size: 14; ParagraphFirstline: cm, Linespacing: Single, Alignment: Justified. Фигурите, с обяснителен текст, трябва да бъдат прецизно изработени и равномерно разположени върху страниците. Задължително е използването на международната система за мерните единици (SI). Чертежите, илюстрациите и снимките се обозначават в текста като фигури, съкратено „фиг.“. Те трябва да бъдат ясни и контрастни и да се придружават от текст. Приложените фигури и снимки да не са цветни.

Литературата в текста се означават с цифра, заградена в квадратни скоби [1] Номерацията на формулите се означават вляво от тях в малки кръгли скоби (). Литературата, посочена в края на доклада, се изписва съгласно стандарта за библиографско описание, на английски език а цитиранията в текста се означават с цифра, заградена в квадратни скоби [1].

Литературната справка трябва да съдържа не повече от 20 публикувани работи, цитирани в статията, подредени в хронологичен ред според цитирането им в текста. Името на първия автор се дава в инверсия. Следват съкратеното заглавие на списанието, том, година, книжка, страници (от - до), а при книги и монографии - заглавие, град, издателство, години, страници.

АДРЕСИ ЗА КОРЕСПОНДЕНЦИЯ се изписват през един празен ред (без абревиатури), Font: Times New Roman, Size: 12; Fontstyle: *Italic*; Effects: AllCaps, ParagraphAlignment: Justified, по средата на реда – Centered. Научни степени и звания, както и военни звания не се посочват.

Всяка статия се рецензира от двама независими анонимни рецензенти. След одобрение от рецензентите статията се приема за печат.



REQUIREMENTS FOR THE AUTHORS

The journal “Scientific and applied research” publishes reports of original scientific results in the field of mathematical, physical, chemical, biological, medical, Earth and life sciences as well as engineering, pedagogical and agrarian sciences in English. The text papers should be styled for printing. No additional redaction is planned. The papers should be sent to the following address: associationsar@abv.bg

The Fields on each page should be: left - 25 mm, right - 25 mm, top - 25 mm, bottom - 30 mm. No frame on sheet. On the first page under the title should be left 60 mm (top 25 + 35 mm), All papers shall be printed on a laser printer on standard sheets of paper format A4. The paper volume shall not exceed 8 pages. Each study should be styled as a paper in a volume of 21 to 30 pages.

Text shall be styled in the following way

TITLE - Font: Times New Roman; Size: 14; Fontstyle: **Bold**; Effects: AllCaps; Paragraph Alignment: Centered.

AUTHOR NAMES - shall be printed over empty line under the title in its complete form – complete name, initial for the surname and complete family name; Font: Times New Roman, Size: 14, Fontstyle: **Bold**, Paragraph Alignment: Left, по средата на реда – Centered.

ANNOTATION AND KEYWORDS IN ENGLISH are styled as follows: annotation (ABSTRACT) in volume up to 10 lines - Font: Times New Roman, Size: 12, Fontstyle: *Italic*, Paragraph Alignment: Justified; the keywords are next over empty line (*descriptors* - **KEY WORDS**) – Font: Times New Roman, Size: 12, Fontstyle: *Italic*; Paragraph Alignment: Justified, both elements outstand 1 cm left of the frame limiting the main text.

MAIN TEXT - Font: Times New Roman, Size: 14; Paragraph Firstline: cm, Linespacing: Single, Alignment: Justified. **Drawings** shall be precise and evenly placed on pages. The International System of Units (SI) should be used. All graphs, illustrations and photographs are referred to as Figures, abbreviated to “Fig.”. They should be clear and contrasting and should be accompanied be text. The applied figures and pictures shouldn't be color.

The literature in the text should be denoted by a number in square brackets [1]. **Numbers of formulas** are printed on their left in brackets ().

Literature, stated at the end of the paper shall be printed according to the bibliographic description standard, and citations within the text are marked with a number in square brackets [¹].

The references should contain up to 20 cited works arranged according to their order of appearance in the text. The family name precedes the initials of the first name in case of the first author. The references should include the names of the authors, followed by the standard abbreviation of the journal, the volume number, the year of publication, number of the journal and the pages cited. For books - the titles, the city of publication and the publisher followed by the year of publication and pages.

MAILING ADDRESSES printed over one more empty line (no abbreviations), Font: Times New Roman, Size: 12; Fontstyle: *Italic*; Effects: AllCaps, Paragraph Alignment: Justified, in the middle of the line – Centered.

Military and scientific degrees shall not be pointed.

All manuscripts submitted for publication must first be reviewed by two independent anonymous reviewers. After the approval of the manuscript by the reviewers the paper is submitted for publication.