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The analysis of time intervals for establishing types of users

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Abstract. *Depending on the time of solving a received task the users are categorized in many categories. In the paper structures of time intervals are determined for establishing types of users and models to determinate the users' collectivities according to the time needed for solving the users' tasks.*

Keywords: user, type, collectivity, interval, mobile.

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REL Classification: 10J.

1. Establishing the types of users

Determining types of users is very important for the optimization of mobile applications. Developers identify common usage patterns in the attempt to optimize various aspects of their applications (Pocatilu, 2012). Identifying the correct types of users for an application and improving the involved use cases improves dramatically the quality of the application (Ivan et al., 2006).

Let NT be the number of users depending on the speed of completing a given task. The set TP of the types is given by:

$$TP = \{TP^1, TP^2, ..., TP^{NT}\}$$

where

TP^i represents type i, with $i = \overline{1 \div NT}$.

The type of a user is established depending on the time interval in which it completes a given task. Let I_{TP^i} be the time interval for the type i of users with $i = \overline{1 \div NT}$. The time intervals are:

$$I_{TP^i} = (M^i_{start}, M^i_{end}), i = \overline{1 \div NT}$$

where:

M^i_{start} - the start moment of the interval for type i;

M^i_{end} - the stop moment of the interval for type i;

The time intervals for each type are disjunctive and orthogonal. So:

$$I_{TP^i} \cap I_{TP^i} = 0$$

To establish the intervals let $S = \{S_1, S_2, ..., S_{NS}\}$ be a set of specialists, where NS is their number. They give values for each element from set TP of types of users.

For all specialists the sum of the provided values for all types of users is 100, so:

$$\sum_{j=1}^{4} P_i^j = 100, i = \overline{1 \div NS}.$$

The sum of the values obtained by the type j users from all specialists, SV^j, is given by the formula:

$$SV^j = \sum_{i=1}^{NS} P_i^j, j = \overline{1 \div NT}$$

The weight W^j of the time interval for the type j users is determined through the formula:

$$W^j = \frac{SV^j}{\sum_{i=1}^{NT} SV^i}$$

On the basis of the data supplied by the specialists the minimum and maximum values are determined for each type of user.

The minimum value, MIN^j obtained by j user type is determined by the formula:

$$MIN^j = \min_{1 \le i \le NS} \{P_i^j\}, j = \overline{1 \div NT}$$

The maximum value MAX^j obtained by j user type is determined by the formula:

$$MAX^j = \max_{1 \le i \le NS} \{P_i^j\}, j = \overline{1 \div NT}$$

On the basis of the questionnaire structures of distribution of the users' collectivities are determined and the extremities of the time intervals for each type of user are established

$$Lim_0 = 0$$

$$Lim_i = \frac{x_i}{100} * TT, \ i = \overline{1 \div NT - 1}$$

$$Lim_{NT} = TT$$

where:
TT – total time allocated to the solving of the problem;
Lim_0 – the inferior extremity of the interval for the first type of users
Lim_i – the superior extremity of the interval for the i type of users and the inferior extremity for i+1 type of users;
Lim_4 – the superior extremity of the time interval for the last type of users;
x_i – the accumulated percent up to type i, calculated by the formula: $x_i = \sum_{h=1}^{i} P^h, i = \overline{1 \div NT}$.

So, for determining the collectivities of users the following function is used:

$$\Omega^j(UA_i)=\begin{cases}1, & if \quad MU_i^{problema}\in[Lim_{j-1},Lim_j)\cup\Phi_j, \quad j=\overline{1-NT}\\ 0, otherwise\end{cases}$$

where

$$\Phi_j=\begin{cases}Lim_{NT}, & if \quad j=NT\\ 0, & if \quad j<NT\end{cases}$$

The number of users from j collectivity, NUC^j is determined by the formula:

$$NUC^j=\sum_{i=1}^{nru}\Omega^j(UA_i), j=\overline{1-NT}$$

where:
nru – number of users from the analyzed set;
UA_i – application's i^{th} user.

In (Ivan et al., 2013) the authors propose a series of metrics for quantifying the quality of mobile applications.

2. The mode of building the time intervals

For NT=4 the types of users are defined:

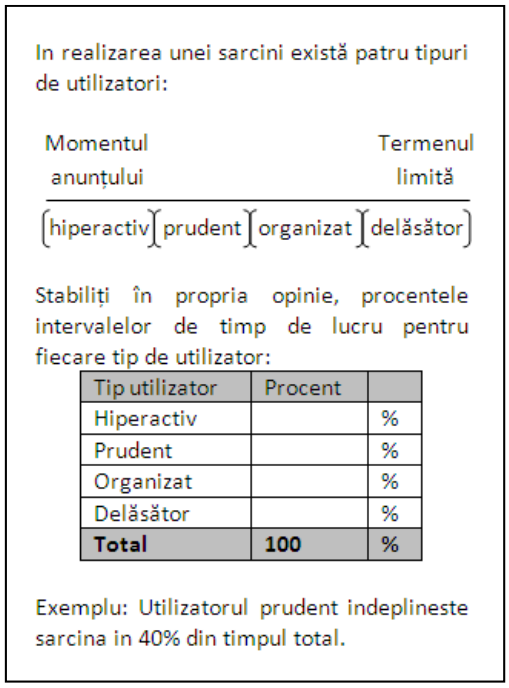
- *Hyperactive* is the user that completes the received task in the first moments from the statement that describes the task; he is built to solve a problem from the first moment in order to set himself free and solve other problems; the short time allocated for solving doesn't allow a deepening of the domain and thus he gets solutions from intuition, characterized by simplicity and immaturity; he is not comfortable with delaying the problems and he prefers immediate solutions.
- *Cautious* is the user that waits for a short period and then completes the activity; the waiting is caused by the fact that the cautious user documents himself regarding the received task, deepens into the domain of the problem and the supplied solutions are detailed, based on experience and a well based theory.
- *Organized* is the user that realizes the activities by following well defined steps of documentation and deepening of the domain; when he is documented well enough he completes the task with the experience gained in the documenting and deepening process; for him it is important to go through the steps necessary for the self-building of the solution, without additional effort; giving importance to the steps, the moment of starting the completion of the task

depends on how many problems he had to solve before the current problem; if he's got more problems to solve, he solves the ones he began and after that starts the new one;

- *Sloppy* is the user that delays the completion of the task for the last moments; this type of users is oriented towards critical moments, and will finalize the task very close to the deadline; as the deadline is close, the solutions are not detailed as he starts very late and the pressing time makes him hurry and propose simple solutions, based on intuition, similar to the hyperactive user.

According to (Zamfiroiu et al., 2012) all users must fall into one of the defined users collectivities.

A set of 56 persons was build out of a lot of 76. They were given the questionnaire from Figure 1. The questionnaire was realized in order to highlight the structure on time intervals of the four types of users.



In realizarea unei sarcini există patru tipuri de utilizatori:

Momentul anunțului — Termenul limită

[hiperactiv][prudent][organizat][delăsător]

Stabiliți în propria opinie, procentele intervalelor de timp de lucru pentru fiecare tip de utilizator:

Tip utilizator	Procent	
Hiperactiv		%
Prudent		%
Organizat		%
Delăsător		%
Total	**100**	%

Exemplu: Utilizatorul prudent indeplineste sarcina in 40% din timpul total.

Figure 1. *The questionnaire given to specialists*

Through the supplied questionnaire the specialists split the available time for completing a task for each type of users.

Each specialist supplied his own structure of time for the NT = 4 types of users respecting the format: $\{P_i^1, P_i^2, P_i^3, P_i^4\}, i = \overline{1 \div NS}$. The obtained results are presented in Table 1.

Table 1. *Obtained results*

Specialist (S_i)	Hyperactive (P_i^1)	Cautious (P_i^2)	Organized (P_i^3)	Sloppy (P_i^4)
S1	20	30	30	20
S2	35	30	20	15
S3	30	30	30	10
....	...	...	...	...
S55	15	35	40	10
S56	15	30	50	5

After processing the data from Table 1 the weights from Table 2 were obtained.

Table 2. *Weights of the time intervals for the types of users*

Type of user	Hyperactive	Cautious	Organized	Sloppy
Weight (W^j)	0,24	0,30	0,28	0,18

So the hyperactive user completes the received task in 24% of the allocated time for completion. The cautious user uses 30% of the total time. The time allocated for the cautious user is allocated after the time allocated for the hyperactive user. So the cautious user completes the task in the interval 24%-54% of the total time allocated for the completion of the task. The organized user completes the task in the interval 54%-82% of the total time, the duration of the interval being of 28% of the total time allocated for the completion of the task.

The sloppy user completes the task in the period close to the deadline with a duration of 18% of the total time allocated for the completion of the task.

The sum of percentages is 100%, the total time allocated for the completion of the task. The minimum and maximum values supplied by the specialists are presented in Table 3.

Table 3. *Minimum and maximum values*

User type	Hyperactive	Cautious	Organized	Sloppy
Minimum value MIN^j	0	5	5	0
Maximum value MAX^j	50	70	50	75

With these values of minimum and maximum an ideal structure of user types is built. As the collectivities are of very large dimensions, the normal law of distribution works in orienting choices:

- hyperactive – minimum; choosing the minimum time for determining the category;
- cautious – maximum; choosing the maximum time for determining the category;

- organized – maximum; choosing the maximum time for determining the category;
- sloppy – minimum; choosing the minimum time for determining the category.

The ideal membership structure of the types of users is $\{0,70,50,0\}$. Because for the hyperactive and sloppy users the minimum values are 0, the next values different than 0 are used (5). So the ideal structure is $\{5,70,50,5\}$. As their sum is 130, the values are normalized to obtain the total of 100.

For normalization the following formula is used:

$$WN^j = \frac{W^j}{\sum_{i=1}^{NT} W^i} * 100$$

where

W^j - non-normalized weight;

WN^j - normalized weight.

So the ideal membership structure of types of users is: $\{4,54,38,4\}$.

Using the same principle the not-ideal structure is built: $\{50,5,5,75\}$.

By normalizing using the above formula we get: $\{37,4,4,55\}$.

The structure obtained from the minimum values is determined. Because the hyperactive and sloppy users' minimum values are 0 the next available ones will be used, 5. The structure is $\{5,5,5,5\}$. After the normalization the structure is: $\{25,25,25,25\}$.

The structure obtained from the maximum values is: $\{50,70,50,75\}$. After the normalization the structure of maximum values is: $\{20,29,20,31\}$.

On the basis of the average values obtained after the analysis of the data supplied by the specialists the average structure is obtained: $\{24,30,28,18\}$.

Table 4. *The structures of types of users*

Structure	Hyperactive (H)	Cautious (C)	Organized (O)	Sloppy (S)
Ideal	4	54	38	4
Not-ideal	37	4	4	55
Minimum	25	25	25	25
Maximum	20	29	20	31
Average	24	30	28	18

Depending on the determined intervals and the users' membership to a certain type the structure of the collectivity is determined:

- collectivity with a normal structure in which few users are at extremities and many users are in the groups from the center;
- collectivity with heterogeneous structure in which the users are equilibrated between the four groups;
- collectivity with structure oriented towards critical moments in which most of the users are at the right extremity (very close to the superior limit);
- collectivity with hyperactive structure in which most of the users are at the left extremity (very close to the inferior limit);
- collectivity with cautious structure if the majority of users are cautious.

For determining the extremities of the intervals of types of users' collectivities the following intervals are used:

- Lim_0, the inferior extremity of the interval for the fist type of users;
- Lim_1, the superior extremity of the interval for the first type of users and the inferior extremity for the second type of users;
- Lim_2, the superior extremity of the interval for the second type of users and the inferior extremity for the third type of users;
- Lim_3, the superior extremity of the interval for the third type of users and the inferior extremity for the fourth type of users;
- Lim_4, the superior extremity of the interval for the fourth type of users.

So the collectivity of the hyperactive users CSH, is determined by the model:

$$CSH = \left\{ UA_i \mid \Omega^H(UA_i) = 1, i = \overline{1-nru} \right\}$$

where:

$$\Omega^{hiperactiv}(UA_i) = \begin{cases} 1, & if \quad MU_i^{problema} \in [Lim_0, Lim_1) \\ 0 & otherwise \end{cases}$$

And the number of users from this collectivity is given by the formula:

$$NUC^H = \sum_{i=1}^{nru} \Omega^H(UA_i)$$

In a similar manner is determined the collectivity of cautious users CSP:

$$CSP = \left\{ UA_i \mid \Omega^P(UA_i) = 1, i = \overline{1-nru} \right\}$$

where:

$$\Omega^P(UA_i)=\begin{cases}1, & if \quad MU_i^{problema}\in[Lim_1,Lim_2)\\ 0 & otherwise\end{cases}$$

And the number of users from this collectivity is given by the formula:

$$NUC^P=\sum_{i=1}^{nru}\Omega^P(UA_i)$$

The collectivity of organized users CSO, is given by:

$$CSO=\left\{UA_i\mid\Omega^O(UA_i)=1,i=\overline{1-nru}\right\}$$

where:

$$\Omega^O(UA_i)=\begin{cases}1, & if \quad MU_i^{problema}\in[Lim_2,Lim_3)\\ 0 & otherwise\end{cases}$$

And the number of users from this collectivity is given by the formula:

$$NUC^O=\sum_{i=1}^{nru}\Omega^O(UA_i)$$

The collectivity of sloppy users CSD, is given by:

$$CSD=\left\{UA_i\mid\Omega^D(UA_i)=1,i=\overline{1-nru}\right\}$$

where:

$$\Omega^D(UA_i)=\begin{cases}1, & if \quad MU_i^{problema}\in[Lim_3,Lim_4)\cup\Phi_4\\ 0 & otherwise\end{cases}$$

Knowing that $\Phi_4=Lim_4$ the equality becomes:

$$\Omega^D(UA_i)=\begin{cases}1, & if \quad MU_i^{problema}\in[Lim_3,Lim_4]\\ 0 & otherwise\end{cases}$$

And the number of users from this collectivity is given by the formula:

$$NUC^D=\sum_{i=1}^{nru}\Omega^D(UA_i)$$

Through the established formulas the users collectivities are determined.

3. The analysis of the data supplied by specialists

Let SLF be the set of the specialists that awarded the same value for all the four types, built accordingly to the relation:

$$SLF = \{S_i \mid S_i \in S, P_i^j = P_i^k, i = \overline{1 \div NT}, k = \overline{1 \div NT}\}$$

The set of the users that is the result of filtering accordingly to the above relation is: $SLF = \{S5, S52\}$. The two specialists awarded for all the four types of users the same value – 25. Eight specialists attributed the same interval for three types of users and for the fourth type of users a value different than the first three. The specialists that attributed three identical values are presented in Table 5.

Table 5. *Identical value for three types of users*

Specialist	Hyperactive (H)	Cautious (C)	Organized (O)	Sloppy (S)
S3	30	30	30	10
S12	30	30	30	10
S21	20	20	40	20
S31	30	30	30	10
S38	20	20	20	40
S41	20	20	20	40
S42	20	40	20	20
S43	40	20	20	20

The identical value attributed to the three types is 20 or 30, and the rest of 40 or ten is attributed to the fourth type of users.

There are users that gave identical values to two types of users. For the rest of the values they attributed either identical values, Table 6, either different values Table 7.

Table 6. *Two identical values for two types of users*

Specialist	Hyperactive	Cautious	Organized	Sloppy
S1	20	30	30	20
S9	20	30	30	20
S14	20	30	30	20
S26	10	40	40	10
S28	10	40	40	10
S29	15	35	35	15
S30	20	30	30	20

Table 7. *Identical values for two types of users*

Specialist	Hyperactive	Cautious	Organized	Sloppy
S10	15	30	15	40
S17	20	35	35	10
S20	50	20	20	10
S22	25	25	40	10
S23	20	20	50	10
S36	20	40	40	0
S39	25	35	35	5
S47	40	30	15	15
S48	25	30	15	30

The values attributed by specialists to the four types of users and their frequencies are presented in Table 8.

Table 8. *The frequencies of the values*

Value	0	5	10	15	20	25	30	35	40	45	50	70	75	Total
Frequency	3	12	32	15	47	19	39	9	33	2	11	1	1	224
Frequency (per cent)	1,34	5,36	14,29	6,7	20,98	8,48	17,41	4,02	14,73	0,89	4,91	0,45	0,45	100
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	

By sorting the per cent frequencies the following order is obtained: F5, F7, F9, F3, F6, F4, F2, F11, F8, F1, F10, F12, F13.

The sum of the first nine per cent frequencies: F5, F7, F9, F3, F6, F4, F2, F11, F8 is 96.88%. This shows that the nine values cover 96.88% of the total values the specialists attributed. So, the representative values are: 20, 30, 40, 10, 25, 15, 5, 50, 35.

4. The study of the stability of time intervals

For the analysis we consider a collectivity of users that interact with the MCSAM application to take a test.

The test was available for seven days or 185 hours. So, TT=185. The moment a user takes the test, MU_i^{st1}, is represented in Table 9.

Table 9. *Moments of taking the test*

User	MU_i^{st1} (hours)
UA1	98,33
UA2	120,46
…	…..
UA69	174,51
UA70	180,56

To determine students collectivities the following intervals are used:

$$Lim_0 = 0$$

$$Lim_1 = \frac{24}{100} * 185 = 44$$

$$Lim_2 = \frac{54}{100} * 185 = 100$$

$$Lim_3 = \frac{82}{100} * 185 = 152$$

$Lim_4 = 185$

So the formulas for determining the users collectivities that interacted with the application are:

$$\Omega^H(UA_i) = \begin{cases} 1, & if \quad MU_i^{problema} \in [0,44) \\ 0 & otherwise \end{cases}$$

$$\Omega^P(UA_i) = \begin{cases} 1, & if \quad MU_i^{problema} \in [44,100) \\ 0 & otherwise \end{cases}$$

$$\Omega^O(UA_i) = \begin{cases} 1, & if \quad MU_i^{problema} \in [100,152) \\ 0 & otherwise \end{cases}$$

$$\Omega^D(UA_i) = \begin{cases} 1, & if \quad MU_i^{problema} \in [152,185] \\ 0 & otherwise \end{cases}$$

The collectivity of hyperactive students CSH is:

CSH={UA30, UA31, UA37, UA39, UA49, UA63}

The number of students from the hyperactive collectivity is:

$$NUC^H = \sum_{i=1}^{70} \Omega^H(UA_i) = 6$$

The collectivity of cautious students CSP is:

CSP={UA1, UA6, UA8, UA25, UA28, UA32, UA33, UA54, UA60}

The number of students in the cautious collectivity is:

$$NUC^P = \sum_{i=1}^{70} \Omega^P(UA_i) = 9$$

The collectivity of organized students CSO is:

CSO={UA2, UA3, UA7, UA10, UA12, UA16, UA17, UA18, UA19, UA21, UA23, UA24, UA26, UA29, UA40, UA42, UA44, UA45, UA46, UA48, UA51, UA52, UA53, UA56, UA57, UA58, UA59, UA61 }

The number of students from the organized collectivity is:

$$NUC^O = \sum_{i=1}^{70} \Omega^O(UA_i) = 28$$

The collectivity of sloppy students CSD is:

CSD={UA4, UA5, UA9, UA11, UA13, UA14, UA15, UA20, UA22, UA27, UA34, UA35, UA36, UA38, UA41, UA43, UA47, UA50, UA55, UA62, UA64, UA65, UA66, UA67, UA68, UA69, UA70 }

The number of students in the sloppy collectivity is:

$$NUC^D = \sum_{i=1}^{70} \Omega^D(UA_i) = 27$$

Because $CSH \cap CSP \cap CSO \cap CSD = 0$ the sum of the numbers of students in all collectivities is equal to the total number of students:

$$NUC^H + NUC^P + NUC^O + NUC^D = nru$$

The number of students in each collectivity is presented in Table 10.

Table 10. *Number of students per collectivity*

Type	Hyperactive	Cautious	Organized	Sloppy	Total
Number of students	6	9	28	27	70
Percentage (%)	9	13	**40**	**38**	100

If another structure is used, the limits of the intervals change. So, for the ideal structure the intervals are:

$$Lim_0 = 0$$

$$Lim_1 = \frac{4}{100} * 185 = 7.4$$

$$Lim_2 = \frac{58}{100} * 185 = 107.3$$

$$Lim_3 = \frac{96}{100} * 185 = 177.6$$

$$Lim_4 = 185$$

So, the formulas for determining the students collectivities are:

$$\Omega^H(UA_i) = \begin{cases} 1, & if \quad MU_i^{st1} \in [0,7.4) \\ 0 & otherwise \end{cases}$$

$$\Omega^{P}(UA_i)=\begin{cases}1, & if \quad MU_i^{st1}\in[7.4,107.3)\\ 0 & otherwise\end{cases}$$

$$\Omega^{O}(UA_i)=\begin{cases}1, & if \quad MU_i^{st1}\in[107.3,177.6)\\ 0 & otherwise\end{cases}$$

$$\Omega^{D}(UA_i)=\begin{cases}1, & if \quad MU_i^{st1}\in[177.6,185]\\ 0 & otherwise\end{cases}$$

The collectivity of hyperactive students CSH is:

CSH={UA30, UA31, UA49}

The number of students in the hyperactive collectivity is:

$$NUC^{H}=\sum_{i=1}^{70}\Omega^{H}(UA_i)=3$$

The cautious students collectivity CSP is:

CSP={UA1, UA6, UA8, UA19, UA25, UA28, UA29, UA32, UA33, UA37, UA39, UA46, UA54, UA60, UA63}

The number of students in the cautious collectivity is:

$$NUC^{P}=\sum_{i=1}^{70}\Omega^{P}(UA_i)=15$$

The collectivity of the organized students CSO is:

CSO={UA2, UA3, UA4, UA5, UA7, UA9, UA10, UA11, UA12, UA13, UA14, UA15, UA16, UA17, UA18, UA20, UA21, UA22, UA23, UA24, UA26, UA34, UA35, UA36, UA38, UA40, UA41, UA42, UA44, UA45, UA47, UA48, UA50, UA51, UA52, UA53, UA55, UA56, UA57, UA58, UA59, UA61, UA62, UA64, UA67, UA68, UA69}

The number of students in the organized collectivity is:

$$NUC^{O}=\sum_{i=1}^{70}\Omega^{O}(UA_i)=47$$

The collectivity of sloppy students CSD is:

CSD={ UA27, UA43, UA65, UA66, UA70 }

The number of students in the sloppy collectivity is:

$$NUC^D = \sum_{i=1}^{70} \Omega^D(UA_i) = 5$$

The number of students in each collectivity is presented in Table 11. The numbers are determined by using the application *CountUserTypes* made in C# and available at *http://alinzamfiroiu.ro/Applications/CountUsersTypes.rar* .

Table 11. *Number of students in collectivities for the ideal structure*

Type	Hyperactive	Cautious	Organized	Sloppy	Total
Number of students	3	15	47	5	70
Percentage (%)	4	22	**67**	7	100

The MCSAM application is developed for the Android running mobile devices and is aimed at the students of the Master of Economic Informatics Study, second year. The application records statistical data about the behavior of users (Zamfiroiu and Sbora, 2013).

To determine the stability of the ideal structure the number of distance learners that uploaded the homework on the platform was determined using the application CountUserTypes. These numbers are represented in Table 12.

Table 12. *Number of students for different collectivities on the ideal structure*

Collectivity	Hyperactive	Cautious	Organized	Sloppy
I	0	0	8	20
II	0	4	14	2
III	1	4	19	21
IV	0	5	18	17
V	0	0	2	27
VI	0	1	4	19
VII	0	0	5	27

The values in Table 12 are graphical represented in Figure 2.

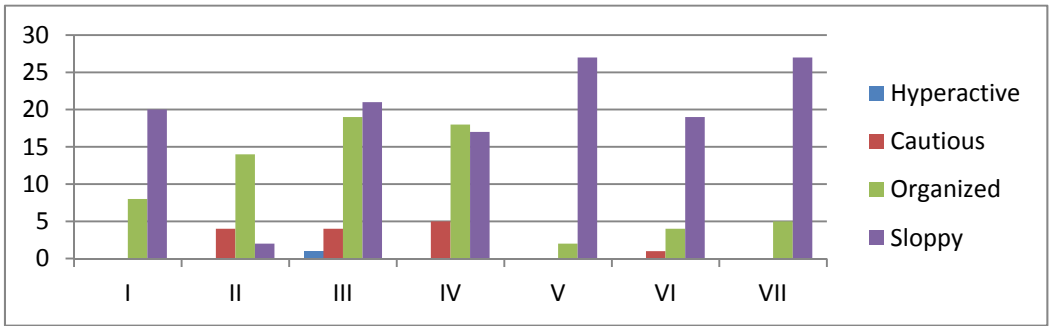


Figure 2. *Graphical representation of the distribution of students on types by the ideal structure*

According to (Ciurea, 2011) the graphical representation of data creates a greater impression on the viewer and also the time the actual data is retained in memory increases.

One can see the orientation of the students towards the critical points, most of them being in the sloppy collectivity.

5. Conclusions

Structures of limits of intervals are determined for determining the types of users depending on the time they complete a received task.

Ideal structures and average structures are determined on the basis of the results obtained from specialists in the domain of work time management.

For the study of the stability of the intervals of the structures and the choosing of the optimum structure for the determination of the groups of users new users collectivities are analyzed taking into consideration the four types of users and the five determined structures: ideal, non-ideal, minimum, maximum, average.

Data acquisitions are pretty easy to do and cover all interaction between client and operator and are organized in very large databases. The aim is to adequately use this information on the basis of statistical methods in order to obtain distinct durations for developing applications in which simulations are efficient aiming to optimize the flux to increase the users satisfaction degree.

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