DEVELOPMENT OF RANKING SYSTEM FOR HIGHER EDUCATION OF UKRAINE[*]

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A system of determination of university ranking in Ukraine was developed based on the creation of the corresponding methods adequate to the structure, peculiarities and conditions of the Ukrainian universities functioning. A complex of organizational and program-technical means was proposed for collection of the necessary data and determination of university rankings. For specialists in the field of higher education management, those seeking for higher education and employers.

The society and labor market in Ukraine require distinct and objective information on the quality and professional competence of graduates from different universities. For some years this work has been carried out by a number of non-governmental institutions and the Ministry of Education and Science of Ukraine. While positively assessing these first steps, at the same time one can see some weak points in techniques and approaches being used. These are, first of all, insufficient application of scientifically grounded methods of expert estimation, unjustified comparison of different groups of universities which are difficult to compare, non-systematic approach to the formation of independent, professional groups of experts for carrying out such type of ranking estimation, and others.

In this connection it is very important for Ukraine to join the international activities in the above mentioned field [1]. That is why the UNESCO Chair «Higher technical education, applied system analysis and informatics» at National Technical University of Ukraine «KPI» in collaboration with UNESCO-CEPES has set the objective to work out a scientifically grounded methodology both for internal and external ranking of Ukrainian universities.

The network of higher education institutions covers the total territory of Ukraine and comprises 951 universities of all types and accreditation levels.

Today the number of students in the system of higher education is about 2 ml. 704 thou. During the years of independence the number of students per 10000 of the population has increased from 310 to 578 persons. The dynamics of the number of students at higher education institutions during these years is shown in fig. 1.
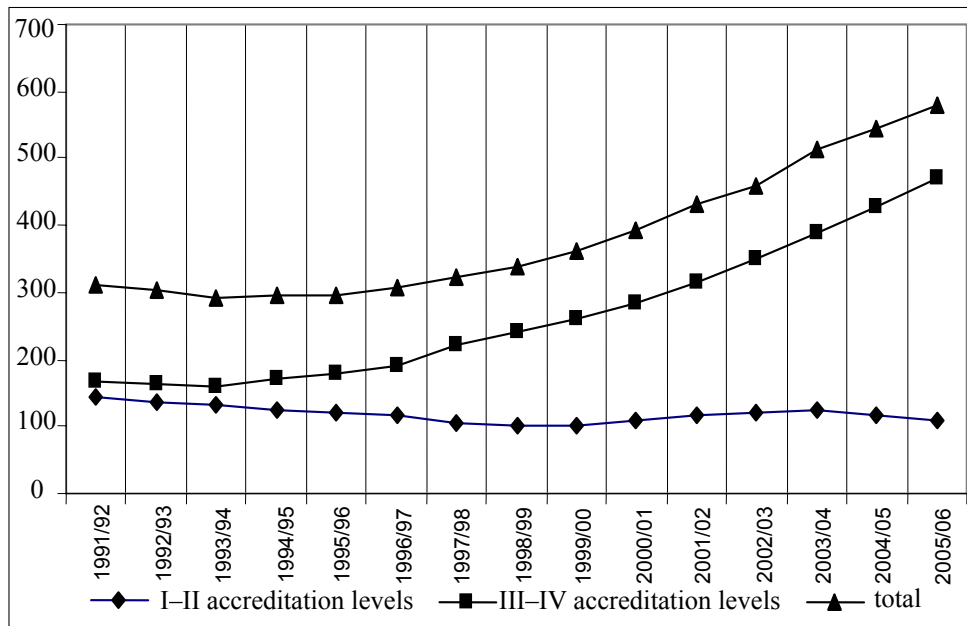
Fig.1. The dynamics of the students number at higher education Institution per 10 000 of the population (by the beginning of 2005–2006 academic year)

The methodology of university ranking in Ukraine is based on two main principles:

1. Comparison of universities by groups and accreditation levels, but not by the places.

2. Criterial determination of university rankings.

Proceeding from the national classification of higher education institutions all universities in Ukraine are divided in accordance with two groups of accreditation levels and in eight groups in terms of types of universities. These types are: classical; technological; technical; pedagogical; medical; agrarian; art and military. Comparison is carried out for each type of universities within the two groups of accreditation levels. So, theoretically such comparison can be made for 16 sub-groups of universities, though not all of these sub-groups exist. For example, there is no sub-group of classical universities of I-II accreditation levels.

In each sub-group universities are to be arranged not according to the place, but be referred to one of four classes: **high, average, low** and **lower than qualification** (fig. 2).

Similar to the German system [2] such comparison is based on the thesis that universities can be comparable not by all indices. For example, a university leading in research may be not strong enough in teaching pedagogical or management disciplines.

To determine the qualitative and quantitative characteristics of the university activities it is expedient to use **the integral index of university ranking (Iur).** This index is synthetic and is defined by the group of seven criteria. Each of the criteria is formed by means of the corresponding groups of indicators. The list of criteria is:

1. **Reputation of the university in the labor market (Rlm)**, which is estimated by a group of experts. Each expert determines the estimate of the university

reputation by the 10-point scale. Then the arithmetic average Rul is found for the group of experts, which is in the interval from 0 to 10.
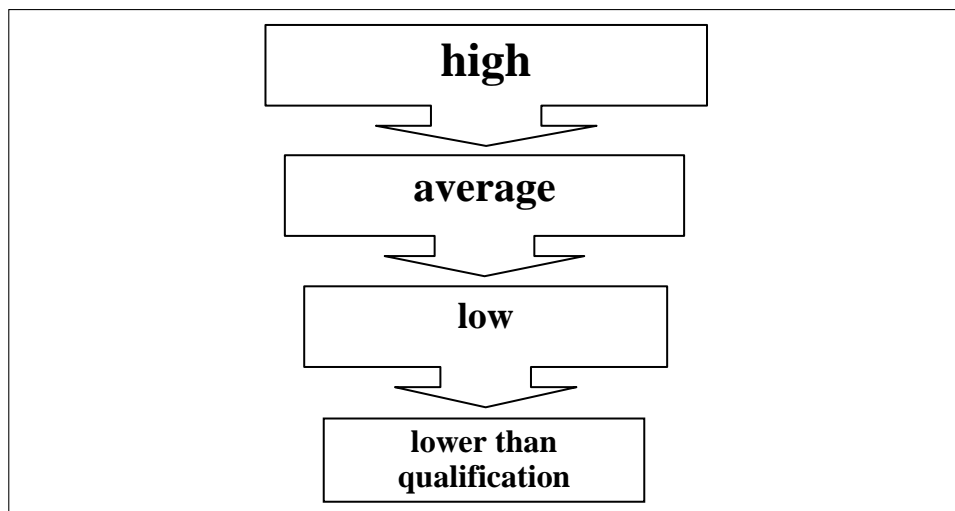

Fig 2. Ranking classes of universities

2. **The university estimation by students (Se),** which is done by questioning of the undergraduate students of the corresponding university regarding the following indicators: correspondence of the acquired knowledge to the requirements of the society, the averaged estimate of the teaching quality, the level of corruption students faced during their studies, estimation of the competitiveness level of the acquired knowledge and skills, the level of equipment of laboratories and libraries with computer and other teaching facilities. Each indicator is estimated by the 10-point scale. Then the average arithmetic of Se is found for the group of indicators, which is in the interval from 0 to 10.

3. **The quality of the first year students contingent (Qsc)** which is estimated by 20-point scale. This criterion is determined quantitatively by using the following indicators: the competition level by results of examinations, the competition level by the given applications for admittance, the percentage of medal school leavers admitted to the first course, the percentage of winners of national and international Olympiads in the specialties which are profile for the university.

4. **The quality of teaching staff (Qts),** which is estimated by the 20-point scale and is determined by application of such indicators as the percentage of full-staff teachers with the degree of Doctor of sciences , the percentage of full-staff teachers with the degree of Candidate of sciences, the percentage of full-staff teachers under the retirement age, the average salary of a university teacher, the total expenditures for one teacher in the university (including social, bonuses and others), the ratio of the number of teachers per one student, the ratio of the total international projects and grants per one student.

5. **Participation of the university in research (Ur),** which is estimated by the 20-point scale and is determined by application of the following indicators: the ratio of the total fund allocated for research to the total fund of the university, the ratio of the articles published by teachers and researchers in international and national (according to the list of the Higher Attestation Commission of Ukraine) scientific magazines to the number of teachers and researchers, the ratio of the

number of articles published by students to the total number of students, the number of defended doctor thesis to the total number of teachers and researchers, the ratio of defended candidate thesis to the total number of teachers and students.

6. **Universities International cooperation (Uic),** which is estimated by the 10 point scale and determined by the following indicators: the ratio of the number of foreign students to the number of Ukrainian students, the ratio of funding coming from the foreign research and educational contracts and grants to the funding received from all sources in Ukraine, the ratio of the number of international organizations in which the university is an official member to the number of 100.

7. **The level of the university provision (Lp),** which is estimated by the 10-point scale is determined by the following indicators: the volume of total expenditures per one student, the quantity of issues of the university library fund per one student, the number of accommodation places in the university hostels per one student, the ratio of the university classrooms fund to the conditional fund required for organization of one-shift studies, the number of places with free Internet access per one student.

30 indicators form the 7 criteria. Some of them have a qualitative character, another are quantitative. The qualitative indicators are determined by the expert analysis method. The quantitative — are measured by university monitoring process.

Naturally, all indicators are measured in different units and have different interpretations. That is why they are reduced to the normalized form in such a way that their variations are in the range from 0 to the upper boundary of the corresponding criteria variation. Thus, the worst meanings of the mentioned indicators will correspond to the numerical values close to 0, and the best meanings approach these values to the upper boundary of the range of this or that criterion variation. Such normalization allow to calculate each of the each criteria as the arithmetic average of the indicators influencing it, and integral index Iur as a sum of these criteria.

The university ranking system in Ukraine is based on the application of the given methodology and a complex of organizational and program-technical means used for collection of necessary data and determination of universities ranking.

In the given methodology for combining the quantitative and qualitative estimations of the main indicators (criteria) the following ratio is used:

• expert estimation of qualitative characteristics (estimation of criteria 1, 2) is performing in the volume of 20 %;

• direct indicators measurement (quantitative estimation of criteria 3…7) takes up 80 %.

The expert estimation of qualitative characteristics of universities is carried out by means of the expert analysis methods. It is connected with the fact that outputs of these methods are conclusions made by experts involved in this work.

To solve such types of problems it is very important to select a group of most highly qualified experts, as well as to use the mathematical support and appropriate information technologies. It is to ensure high accuracy and credibility of the obtained estimates.

Let us give the mathematical statement of the problem. Let the system under investigation consist of a finite set O_0 of objects O_n, $O_0 = \left\{ O_n \mid n = \overline{1, N} \right\}$. Each

object $O_n \in O_0$ is characterized by a finite set Q_0 of indicators Q_j, $Q_0 = \left\{ Q_j \middle| j = \overline{1, J} \right\}$. A group E_0 of experts E_k is formed, $E_0 = \left\{ E_k \middle| k = \overline{1, K} \right\}$. Each expert $E_k \in E_0$ performs expertise in the on-line mode on the basis of the information submitted to him in the form of a scale of qualitative and quantitative estimation of indicators (see table). An expert is carrying out the expertise independently and has no information about other experts' estimates. The estimate of j-th indicator of n-th object k-th expert determines for each level $s \in S_0$ $S_0 = [1, S]$ in the form of fuzzy variable $\widetilde{Q}_{njs}^k = \left\langle Q_{njs}^k, \mu_{njs}^k \right\rangle$. The estimate of j-th indicator for all $s = \overline{1, S}$ is formed by the computer system of expert questioning in the following form:

$$\widetilde{Q}_{nj}^k = \left\{ \left\langle Q_{njs}^k, \mu_{njs}^k \right\rangle \middle| n \in N_0; \; j \in J_0; \; s = \overline{1, S} \right\}, \tag{1}$$

$$N_0 = [1, N], \; J_0 = [1, J],$$

where μ_{njs}^k determines the results of estimation by k-th expert the degree of possibility of realization of the estimate Q_{njs}^k for $s = \overline{1, S}$ (see table).

№	Qualitative characteristics of *s*-th level	Quantitative characteristics of *s*-th level	Expert's estimation of realization possibility of *s*-th level
1	Extremely low	[0 – 0,1]	0,05
2	Very low	[0,1 – 0,25]	0,15
3	Low	[0,25 – 0,4]	0,35
4	Average	[0,4 – 0,6]	0,9
5	High	[0,6 – 0,75]	0,45
6	Very high	[0,75 – 0,9]	0,05
7	Extremely high	[0,9 – 1]	0,01

Estimation of μ_{njs}^k for each value $s \in S_0$ $S_0 = [1, S]$ is done independently. Each estimate is chosen from the total interval [0;1]. The final estimate of each j-th indicator is found by normalization of all estimates for $s = \overline{1, S}$.

The estimate by k-th expert of n-th object in general is formed by the system of expert questioning as an array:

$$\widetilde{Q}_n^k = \left\{ \widetilde{Q}_{nj}^k \middle| n \in N_0; \; j = \overline{1, J}; \; k \in K_0 \right\}; \; K_0 = [1, K]. \tag{2}$$

The results of expertise for n-th object by all experts is formed by the system of expert questioning as an array:

$$\widetilde{Q}_n = \left\{ \widetilde{Q}_n^k \middle| n \in N_0; \; k = \overline{1, K} \right\}. \tag{3}$$

It is required to determine estimates for all objects O_n, $n = \overline{1, N}$, of a set O_0 by all $k = \overline{1, K}$ experts.

It should be noted that the number of gradations S of the expert estimation scale (see table) is expedient to form in accordance with the Miller number which is equal 7 ± 2.

The solving procedure of the expert estimation problem. To carry out real expert estimation it is important rationally choose a metrics and criteria based on which it is necessary to compare indicators of the objects under consideration. It should be taken into account that the quality indicators of universities are usually additive values. In such cases it is expedient to use the Chebyshev criterion and metrics. Then the measure of difference of any pair of expert estimates for j-th indicator of n-th object will be defined by the relationship:

$$\widetilde{\rho}s_{njs} = \left\{\left|\left|\widetilde{Q}_{njs}^{p} - \widetilde{Q}_{njs}^{q}\right|\right|\right\}, \quad p, q \in K_0, \quad p \neq q; \quad s \in S_0; \quad n \in N_0.$$

Taking into consideration that according to the input information (see table) the quantitative characteristics of s-th level of j-th quality indicator, for example, competitiveness, for n-th type of product depends only on $j \in J_0$, $s \in S_0$. That if why for all $n \in N_0$, $p, q \in K_0$ the condition $Q_{njs}^{p} = Q_{njs}^{q}$ is fulfilled, where p and q determine the order number of experts in the group K_0. Thus, the difference of any pair of expert estimates (1) is determined only by the difference of estimates of experts and is characterized by the relationship:

$$\widetilde{\rho}_{njs} = \left|\mu_{njs}^{p} - \mu_{njs}^{q}\right|.$$

Based on the Chebyshev criterion and metrics the problem solving can be reduced to a sequence of the following procedures [3]:

1. To form the general estimate of j-th indicator of n-th object on the basis of the results of expert estimation by all $k = \overline{1, K}$ experts.

2. To find the boundaries of the interval for j-th indicator of n-th object by using the relationships:

$$\widetilde{\rho}_{nj}^{+} = \max_{p, q \in K_0} \left\{\max_{s=\overline{1, S}} \left|\mu_{njs}^{p} - \mu_{njs}^{q}\right|, \quad n \in N_0\right\},$$

$$\widetilde{\rho}_{nj}^{-} = \min_{p, q \in K_0} \left\{\min_{s=\overline{1, S}} \left|\mu_{njs}^{p} - \mu_{njs}^{q}\right|, \quad n \in N_0\right\}.$$

3. To find the center of the interval for j-th indicator of n-th object in the form of a half sum of the interval limiting values:

$$\widehat{\widetilde{\rho}}_{nj} = \frac{\widetilde{\rho}_{nj}^{+} + \widetilde{\rho}_{nj}^{-}}{2}.$$

4. To find the boundaries regarding the interval center for j-th indicator of n-th type of an object by the relationships:

$$\rho_{nj}^{+} = \max_{p \in K_0} \left\{\max_{s=\overline{1, S}} \left|\widehat{\widetilde{\rho}}_{nj} - \mu_{njs}^{p}\right|, \quad n \in N_0\right\},$$

$$\rho_{nj}^{-} = \min_{p \in K_0} \left\{ \min_{s=\overline{1,\,S}} \left| \hat{\tilde{\rho}}_{nj} - \mu_{njs}^{p} \right|, \quad n \in N_0 \right\}.$$

5. To carry out procedures $1-4$ for all other indicators $j \in J_0$ for n-th object.

6. To form the general estimate $\widetilde{Q}_n$ in the form of the relationship (3) for n-th object based on the results of its estimation (2) by all $k = \overline{1, K}$ experts.

7. To carry out procedures 1–6 for all other objects $n \in N_0$.

The direct measurement of quantitative indicators of criteria 3–7 is performed by the so-called information-administrative system, named OSVITA. This system has a widely distributed hierarchy infrastructure which covers all regions of Ukraine and educational institutions (fig. 3).
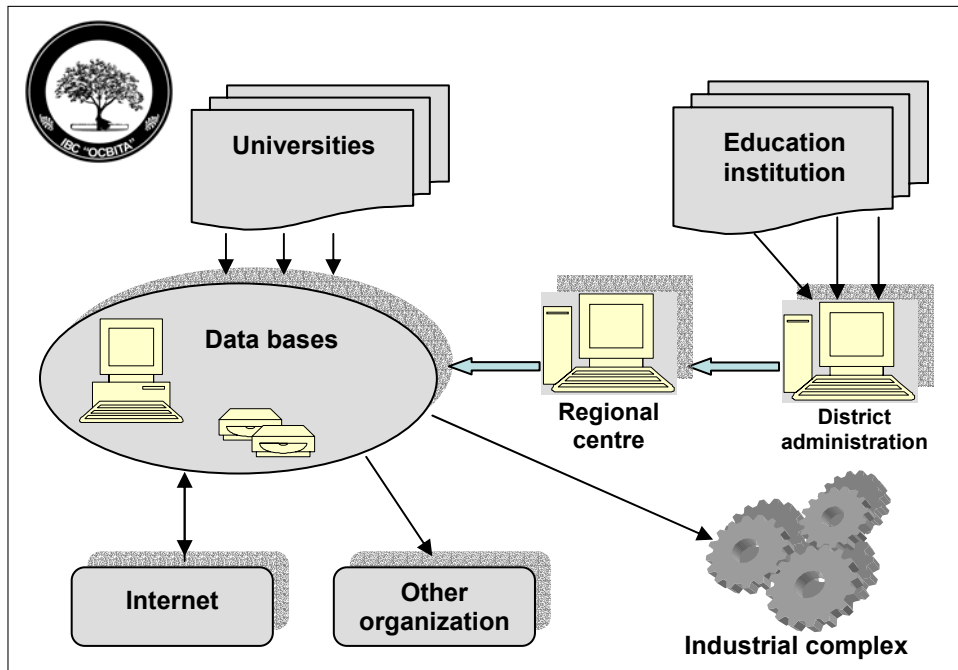

Рис. 3. Administrative and Educational system OSVITA

The infrastructure of this system includes more than 5500 nodes of collection of the initial information from all 951 universities.

The main purpose of OSVITA system is collection and analysis of information about educational programs and progress of every student of the university, including assessment of his/her level of knowledge in all subjects, about the material and technical facilities of universities, its research activities and others. The scheme of operation of this segment of OSVITA system is given in fig. 4.

The presented results of the universities monitoring in a complex with the opinion of independent experts will allow ranking university in the educational space. The integral scheme of the universities ranking on the base on OSVITA system is given in fig. 5.
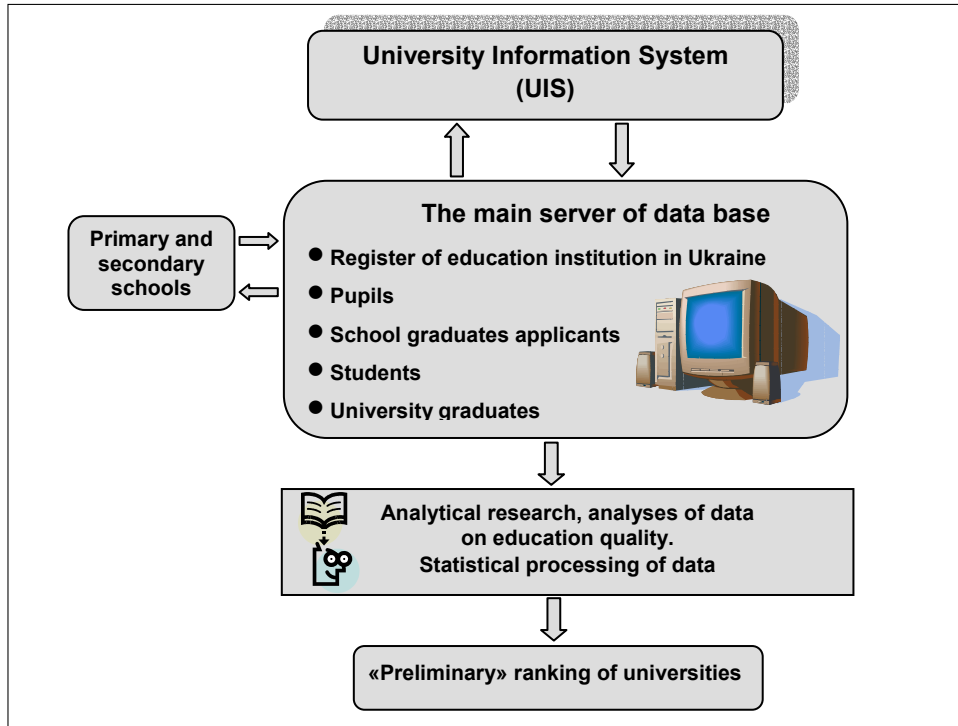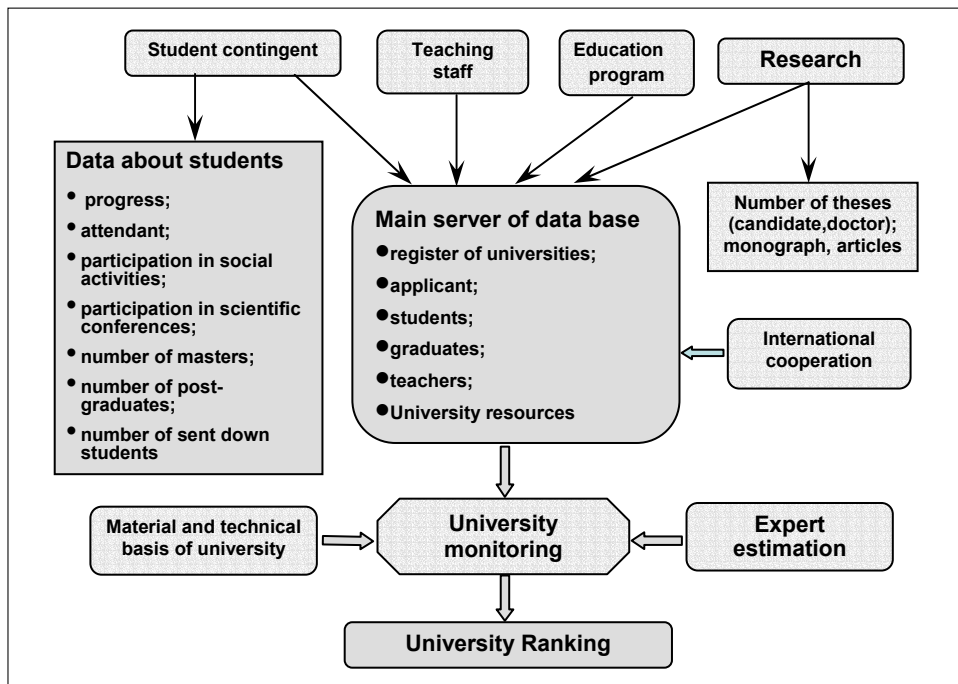
Fig. 4. Structural scheme of UIS

Fig.5. System of determination of universities ranking on the basis of UIS

For exchange and transfer of data in OSVITA system the Ukrainian research and educational computer network, called URAN is used (fig. 6).
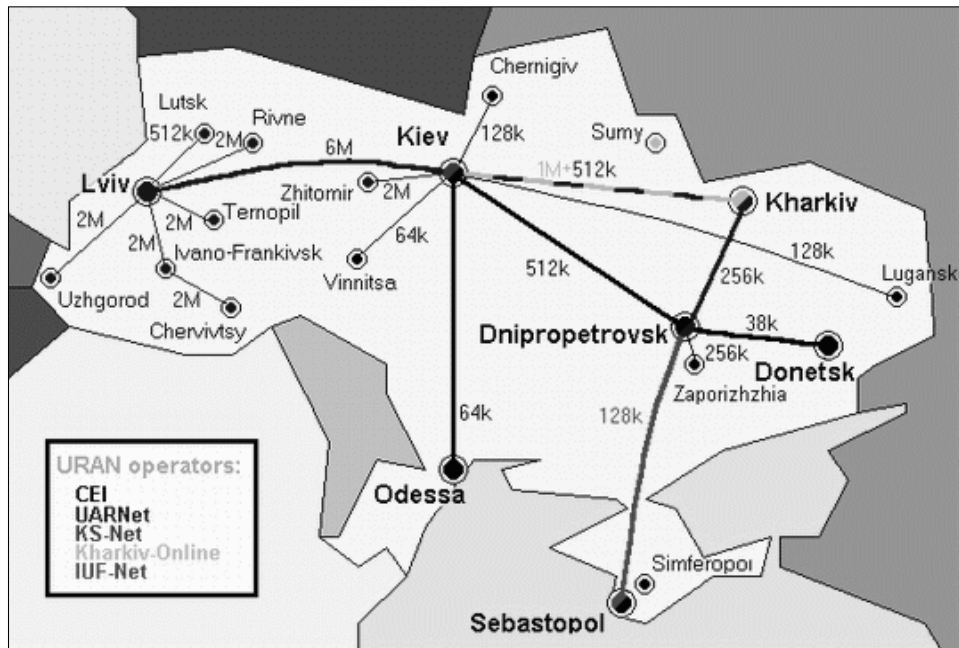
Fig. 6. URAN operators location

The usage of these network makes possible to expand the sphere of application of OSVITA system by means of its integration into international, first of all European information space in the fields of education and science, which is determined by Ukraine's participation in Bologna process. The statistical data are available on the site of OSVITA system.

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