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## USAGE OF A CONCEPTUAL FRAMEWORK FOR MODELING SELF-FINANCING RESEARCH AND EDUCATION NETWORKS

*Розглянуто питання, пов'язані з керуванням науково-освітньою роботою інтернет-мереж. Описано проблеми у сфері фінансової самодостатності науково-освітніх інтернет-мереж. Фінансове самозабезпечення відбувається в умовах відсутності централізованого фінансування та періодичних витрат, що покриваються за рахунок оплати користувачів.*

*Рассмотрены вопросы, связанные с управлением научно-образовательной работой интернет-сетей. Описаны проблемы в сфере финансовой самодостаточности научно-образовательных интернет-сетей. Финансовое самообеспечение происходит в условиях отсутствия централизованного финансирования и периодических расходов, покрываемых за счет взимания оплаты с пользователей.*

*This paper addresses some issues related to the management of research and education networks. A conceptual framework based on applying entity-relationship approach to the management paradigm is introduced. Entities, their properties and instances together with relationships among entities are shortly*

*described. A problem area comprising issues of financial self-sustainability of research and education networks is described. The problem area is considered in case of URAN (Ukrainian Research and Academic Network). Financial self-sustainability is considered in conditions of the lack of central funding and all the periodic expenses covered by charging users. The conceptual framework is then used for the specification of the problem area and for the formulation of research questions. The paper ends with an outline of a possible approach to finding a solution to the specified research questions.*

**Formulation of the problem in general.** The great need for and importance of computer networks for science and education can hardly be disputed nowadays. In the modern computerized and "Internetized" world networks is an indispensable tool for science and education rather than a luxury.

**Analysis of recent research and publications.** To catch up with the developed research and education networks (RENs), developing RENs should progress at a faster pace, moving revolutionary rather than evolutionary. However, the development process needs proper management. The trial-and-error way of management may lead to waste of scarce and vital resources (funds, labour) and waste of time. It is important to avoid such wastes by getting preliminary advises about the way of using scarce resources in an effective and efficient manner. This implies also effective usage of external financial help and donations.

**The aims and objectives of the article.** The knowledge about the management of RENs is usually presented by various approaches that often have form of a simple description of particular experiences and existing practices. A doctorate research project, aimed to investigate RENs and their management and to build such knowledge was started at Delft University of Technology in March 1998. The title of the research project is "Modeling Management of Research and Education Networks Current paper represents a part of this doctorate research project.

**The main material of research.** The paper is structured as follows. In the beginning a conceptual framework, based on applying entity-relationship approach to the management paradigm is presented. The next covers the problem area, comprising issues related to financial self-sustainability and bandwidth management of a national REN (URAN). In this part the problem area is not described yet in terms of the conceptual framework but rather from the practical point of view. The next paragraph on the contrary, gives the specification of the problem area in terms of the introduced conceptual framework. And the last section presents an outline of a possible approach to finding a solution for the specified problems. The paper ends with the summary and conclusions.

This section presents the conceptual framework that forms the main theoretical achievement of the present doctorate research project. The management paradigm used as a basis for the framework is introduced and briefly described. Subsections presents the content of the conceptual framework, by means of a brief description of entities, properties, instances and relationships introduced to model the management of RENs.

Let us first give some useful definitions that are often used in the text of the paper and are important to know for further understanding of the presented material.

Research and education network (REN) is a computer communication network that primarily connects research and education organizations among themselves, with other networks and with the Internet. The fact that an organization is connected to a REN implies that the communication link/links between a (backbone of) REN and the campus/local network of an organization is established and can be utilized. It is also implied that an organization can utilize network services that are an integral part of such connectivity.

Institution is (primarily) a research and/or educational organization that is connected to a REN.

REN geographical area is an area where institutions are located - city/municipality, region/province, country or group of countries (continent). Consequently metropolitan (MAN), regional, national and international networks are considered. National RENs (NRENs) receive particular attention.

The objectives of the conceptual framework are the following: to capture and classify existing practice and experience (knowledge of practitioners) in a strict and classified scientific way, bringing different aspects playing key roles in the management of RENs to a common picture. To help in the understanding of the nature and complexity of RENs and their management; to create awareness and insight into various aspects of RENs and their management.

To serve as a basis for communication among the various bodies having a part in RENs and their management (end-users, managers, government authorities, R&E institutions, network operators, hardware and software suppliers, service providers, donors, etc.).

Management paradigm is the basis of the framework.

Theoretical basis for the conceptual framework is the management paradigm introduced in [1]. In case of RENs the main blocks of the paradigm are Network Management (NM), Network System (NS) and Real System (RS), connected by relationships. Further there are various external influences such as marketing, technical, financial, regulatory and others.

Real System (RS) is a composition of *institutions* located within the *REN Geographical area*. Their *business processes* (teaching/education, research and administration) and the *needs of the people* belonging to these institutions (students, teachers, researches, etc.) require support by means of connecting institutions among themselves, with other networks/organizations and with the Internet.

Network System (NS) is a structured composition of *hardware*, *software* and *services* utilized by people that belong to institutions in order to satisfy their needs and support business processes of a RS. User *requirements* are also included in a NS - such as availability, performance, security, etc.

Network Management (NM) is the operation, control and maintenance of a NS in accordance with: user requirements; characteristics of hardware, software and services; characteristics of a RS.

Usage of entity-relationship approach to model the management paradigm. The entity-relationship approach, widely used in relational databases, is now used to model each block of the management paradigm together with the relationships within and between blocks. Each block is represented by entities. Each entity has a set of properties gives also instances of each entity.

Internal relationships (relationships within a NM, NS or RS) and drawn with thin lines, while relationships between blocks – with thick lines. Whether a relationship is one-to-one, one-to-many or many-to-many has not been considered yet, though in most cases it might be obvious from the context of a relationship.

External influences can be applied to entities and relationships. When an external influence is applied to the entity, it may change properties of this entity. When an external influence is applied to the relationship, it may change the existence of this relationship and its qualities.

Examples of financial influences are donor and government subsidies, prices/tariffs for hardware/ software, infrastructure and ISP services. Subsidies are important for RENs since RENs are often subsidized by domestic government or by external donors. Donor subsidies are specifically important for developing countries, which do not have their own financial resources to finance R&E networking. Examples of technical influences are availability of communication infrastructure; growth of processing power, storage capacity and transport capacity; developments of Internet services, applications and content; standardization.

Short information about URAN.

URAN (Ukrainian Research and Academic Network) project was launched by the group of leading ukrainian universities in 1997 as a national

scope networking project aimed at the creation of a national REN. Association of Users was established. Membership in the Association is opened to any research and education organization in Ukraine. The startup of the project was financed by NATO. The national network operating center (NOC) was established in Kiev and six regional NOCs were established in Kharkiv, Lviv, Dnepropetrovsk, Donetsk, Rivno and Odessa. The star-shaped backbone of URAN is based on 64/128K digital channels leased from UkrTelecom. There are also several external channels to the Internet with the total capacity of 384K and some peering channels to other ISPs. URAN has now about 25 users (various R&E institutions) connected to 6 regional centers.

Being a project, initiated by universities - from "the bottom" rather than from "the top" (government) - URAN till so far has not received any financial support from the state. Nevertheless, it is foreseen to get such a support in the nearest future.

However, taking into account the difficult economic situation in Ukraine and scarce funding of science and education, it is not likely that either donor or government subsidies can cover all the expenses of the national network. Therefore, management of URAN attempts to use a self-sustainable mode of operation, when all the recurrent expenses are covered by the users - connected institutions. Recurrent expenses (particularly payments for communication channels - especially external Internet links) are usually more significant comparing to procurement/upgrade expenses. The last are more likely to be covered by donor and/or government subsidies.

#### Problem area.

Management of URAN is constantly looking for an improvement of the current management model and finding answers to the questions such as: How investments/subsidies coming from donors/government can be best used in an efficient and effective way? How subsidies should be distributed among the following directions. Network development/innovation (procurements/upgrades of hardware and software). Network operation (recurrent payments for channels, depreciation, salary). Personnel training/education. User support (equipment subsidies, helpdesk) and attraction of new users (marketing activities). New services/applications/content development. What tariffs for transmission (connectivity) services should be used? Should the tariffs be dependent on the traffic volume (usage-based scheme) or not (flat-rate scheme)? For usage-based scheme: should the incoming or the outgoing traffic be charged or both and in which way? What topology should the network (URAN) have? In which nodes (regional centers, national center) external channels

should be established and what capacities they must have (incoming and outgoing)? How and when upgrade capacities? How to monitor and "fairly" distribute scarce bandwidth among users? How to encourage economical usage of limited transport capacities (how to decrease utilization)?

Using the conceptual framework for the specification of the problem area. In this section the problem area outlined in the previous section is specified using the conceptual framework presented in the section 2. The concepts of the framework (entities, instances, properties, relationships and external influences) are used for the specification of the problem area. The specification is built by selecting entities, properties, instances, relationships and external influences that are vital for further consideration.

Why is it important to have a conceptual framework?

The description of the problem area in terms of a conceptual framework is the beginning vital step in analyzing the problem and approaching its solution. Conceptual approach allows setting out in broad terms the definition of the problem. Once a conceptual model of the problem has been formed, an applied model can be formed and a solution, if one is possible, can be derived. Conceptual approach ensures that no important aspects will be left out of the consideration and forgotten. It provides an implementation-independent representation of the problem area and supplies language for discussions and negotiations between solution consumers and solution providers. We (authors) see ourselves as the solution providers, while managers of a REN (URAN) as the solution consumers.

Selection of entities, properties, relationships and external influences.

The conceptual framework described in the section 2 was presented to the management of URAN. It has allowed selecting and emphasizing aspects that are of interest for finding a solution to already mentioned problem of financial self-sustainability of URAN. Usage of the conceptual approach ensures that no important aspects were left out of the consideration. Entities, their instances and properties together with relationships were selected to be in the focus of the following consideration (analysis).

The following external influences have been identified to be vital for further consideration. Financial influences: donor (sponsor) subsidies, government subsidies, prices/tariffs (HW/SW, infrastructure services, ISP services) Technical influences: availability of communication infrastructure; growth of processing power, storage capacity and transport capacity.

Formulation of the research questions.

On the basis of the description of the problem area and its specification given in the previous subsection, the following two research

questions have been formulated: how can the management be supported with regard to capacity (bandwidth) planning and management under the conditions of growing user population and increasing utilization (traffic volume)? How can the management be supported with regard to ensuring financial self-sustainability of the network backbone under the conditions of the lack of central funding and all the recurrent (periodic) expenses covered by charging users?

Mentioned research questions form the basis for the further investigation and development of a solution that will allow to answer given research questions as well as to answer more specific practical questions formulated in.

Outline of a possible approach to finding a solution

This section gives only preliminary ideas and should not be considered as a completed methodology.

The possible direction to further investigation of the problem area relates to the usage of control theory's approach. The dynamic system is under consideration. In our case such a system might be called "Financial system of National REN". The mathematical model of the system has to be created. The system generates some outputs in response to some input stimuli. In order to achieve a desired output, input stimuli have to be regulated, in other words the system has to be controlled. The system can also be affected by uncontrolled, external or more or less unpredictable inputs, known also as exogenous inputs. Input (control) variables: capacity, topology, investments/subsidies, tariffs, charging scheme. Output (controlled) variables: financial sustainability/profitability of an operator (national, regional), quality/performance parameters (availability, latency times, packet loss %, throughputs of data transfers). Exogenous variables: utilization/traffic volumes, availability of telco infrastructure, prices/tariffs for telecommunication services (primarily terrestrial channels), tariffs and charging schemes for Internet access service, hardware/software prices.

According to the described approach, the specification of input and output variables should be done in the first place. Then the (mathematical) model of the system has to be created and investigated, functional dependencies among variables should be analyzed. Mathematical methods of dynamic programming and simulation are likely to be used in further investigation.

**Summary and conclusions.** The paper has presented the conceptual framework of REN management and its usage for the specification of the problem area. It is important to emphasize the value of a scientific approach to the analysis of a problem area as opposed to purely practical approaches. The importance and necessity of the conceptual framework was demonstrated. The framework has allowed to specify the problem area

(financial self-sustainability of URAN and capacity planning and management) in terms of a language created by the conceptual framework: entities, properties, instances, relationships and external influences.

Although the answers to the research questions formulated in 4.3 have not been found yet, the authors hope that by the time of presenting current paper at the IES2000 conference, some results can already be achieved and presented to the audience.

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### **SOME ASPECTS OF TIME MANAGEMENT IN ONLINE EDUCATION**

*Розглянуто деякі з аспектів підготовки дистанційного інтернет-курсу з опрацюванням рекомендацій щодо практичного застосування викладачами для розподілу свого часу на різні види робіт зі студентами в онлайн- і офлайн-режимах.*

*Рассмотрены некоторые аспекты подготовки дистанционного интернет-курса с выработкой рекомендаций по практическому использованию преподавателями при распределении своего времени на различные виды работы со студентами в онлайн- и офлайн-режимах.*