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Issues affecting the evaluation of the beneficial effect of new technologies and ways to solve these issues

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Issues affecting the evaluation of the beneficial effect of new technologies and ways to solve these issues.

Nowadays Information and Communication technologies (ICTs) are defined by the shortest implementation and obsolescence periods. In such cases, the two most important tasks are the evaluation of the new technological advantages and comparing them with deployment and utilization costs. The creation of a uniform numerical assessment toolkit is necessary for all of the interested parties listed below:

- Communication administrations that distribute finite resources (private sector, for example) and funds.
- Persons that estimate advisability of spending on machinery replacement, staff training, getting licenses and permissions and all other matters related to the transition to the new technology.
- Experts and members of the public who participate in regulating the public engineering policy process. They have to decide whether the benefits from the new technology use outweigh the cost. In addition they have to consider the ecological aftermath of deploying such technology.

According to the Declaration of Principles “Building the Information Society: a Global Challenge in the New Millennium” that was adopted in Geneva [1]: “The usage and deployment of ICTs should seek to create benefits in all aspects of our daily life”. But taking control of achieving these benefits is a complicated task for the following reasons. First of all, it is necessary to define relevant factors for determining both the quality of life and ICT development. Furthermore, once these factors have been identified then the dynamics can be monitored, but this will only provide correlation information about them. It is recognised that two variables can be related to each other in one of three ways: the first variable is dictated by the second; the second variable is dictated by the first; or both variables are dictated by some other [2]. However, for the tasks specified above, we need to identify the nature of such relationship and this always involves additional research and measurement.

This is the reason why all the papers, standards and recommendations from various organizations including the International Telecommunication Unit (ITU) are considering a wide set of metrics to allow evaluation of ICT features. These metrics can be grouped in three layers depending on the number of man-machine systems being considered simultaneously.

The first layer: network element metrics

The network element is the hardware used to provide telecommunication services. A single network element can be presented by one or several devices. In this layer, different types of network elements have their own metrics:

- Communicating channel – bitrate, time delay;
- Data-center – amount of stored data, number of connected clients;
- Telephone switch – the number of clients being serviced, time delay.

The value of almost all metrics in this layer can be measured directly; for the rest of the metrics there are some methods that work well in practice. Therefore we can confirm that the metrics in this layer are objective factors.

The second layer: quality of service (QoS) metrics

The process of service provision is measured by the metrics in this layer. There are some particular metrics for specific services, as well as the common metrics:

- For voice communications – time delay, jitter;
- For data transfer – bitrate;

Common metrics for all services:

- Mean service provision time;
- Mean time between failures due to faults, ordinary maintenance, etc.;
- Mean recovery time of service in the case of various faults.

One can see that some network elements metrics are called the same as some QoS metrics (time delay, for example). The difference between them is that the first ones describe the work of the singular object responsible for providing the service, and the second ones present the service as the result of interaction between all of these objects in total, hence they define the quality of service.

The objectiveness of the QoS metrics is not as unequivocal as for the network elements metrics. First of all one should define the information-communication (IC) service provided. This definition is determined by the technical properties, the service goal and by the degree to which this goal is achieved. In practice an accord called the Service Level Agreement (SLA) can be framed that contains all required conditions between the service provider and the end user. Since all necessary definitions are determined, it is possible to obtain the values of QoS metrics from, for example, Operations Support Systems (OSS). When the metrics of this second layer can be measured directly, they can be obtained based on the values of network elements metrics; in such cases a model is required that describes the single network element influence on the process of providing the IC service.

The third layer: high-level metrics

These metrics represent factors of those social development aspects that are connected with ICTs. There is a wide set of metrics connected directly with ICTs, as well as metrics for measuring technology's benefits in our daily life.

1. Degree of Social development, considered by ITU and being part of the ICT Development Index (IDI): number of Internet users, telephone lines-to-population ratio, number of households having a computer, etc. [3]
2. Extent of reaching the millennium goals set by United Nations (UN): child mortality rate, literacy rate, men-to-women in the government ratio, etc.[4]
3. Monetary indicators of economic development: Gross Domestic Product (GDP), Net National Income (NNI), personal income and so on.
4. Various metrics of subjective well-being, based on daily experience sampling (random mood descriptions throughout the day) and day reconstruction (summary of mood during the day), physiological measures (hormone concentration, skin sensitivity), neurological measures (cerebral activity) and behavior observations (smile...) [5].

The consistency of the measure of well-being or certain aspects of social development described by these metrics is the subject of major argument. In particular, ITU reexamines the IDI factor every year. Also, there are many ways of obtaining the values of such metrics: questionnaire surveys, statistical calculations, and indirect indicator analysis. However, none of these methods use the results from the QoS metrics or the network elements metrics, so there is disconnection between metric layers (see fig.1)

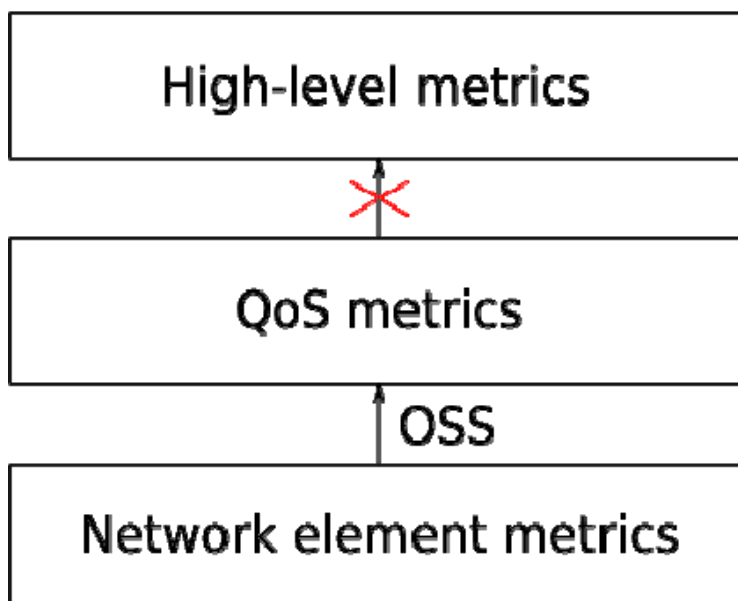


Figure 1. Relations between the layers of ICT metrics.

Considering the above, it is possible to formulate the task of estimating the useful effects of ICT: there are no methods for estimating the degree of reaching the ICT goals that are based on a known set of objective factors for providing IC services. This causes a problem with evaluating

the effect of the deployed ICT on the quality of life. The main reason for this problem is the lack of any IC services models for describing ICT as part of economic and social processes. Since QoS metrics are being carefully collected by the operators and providers, these metrics are marked as private for their organizations and this factor complicates the problem of evaluating the useful effect of ICT. As a result neither state regulatory nor research organizations have access to the values of these metrics. This not only makes the design of service models difficult, but makes even simple empirical checks of the effect of ICT on social daily life impossible.

Hence on the one hand it is necessary to design models to describe the place of certain IC services in human life. In order to produce high-level metrics relating to the deployment of new technology, new models need to be designed. These will involve not only mathematicians, but will require cross-disciplinary consultation with a range of experts including sociologists, economists and psychologists. On the other hand it is necessary to design a common QoS metrics system based on these models. After that it will be necessary to get the metric values from the operators and providers. It is necessary to make the process of providing such information profitable for organizations too. The Supply Chain Object Reference (SCOR) system from the field of supply chain which is currently accepted by most product companies, can be regarded as a good example. This system works as follows: a business company provides the Supply Chain Council with the values of the major business-processes metrics for their supply chains and in return it receives the potential to analyze the weaknesses of its supply chains taking into account the experience of other companies, by itself or with the help of consulting companies. To use the experience of SCOR in the information-communication field it is necessary to define standard high-level metrics which should be intelligible and unambiguously understandable by every operator and provider. The most important thing is that such metrics should provide the possibility of automatic value procurement by a basic usable system like OSS or Business Support System (BSS).

The first step of this task is the hardest. Models for IC services such as discussed above can be designed by allowing some a-priori assumptions about consumers' preferences and behaviors. In any case, verification for such models and assumptions is required, through experimentation. This verification needs a representative sample of the IC services that are provided for people. But this sample cannot be obtained until measurement standards are designed. Because even if one gets the service metric values from operators, it will not be possible to have an opportunity to compare them since the same metrics in different companies can be understood in different ways. It creates a vicious circle: the lack of data prevents the researchers from designing and analyzing models and the lack of models prevents them from formulating the requirements for necessary data.

In discussing these problems, we consider here that the solution lies not in designing an independent model for each IC service but in designing a common theory for the provision and consumption of IC services which combines all the independent models within it. The key factor in our common theory is the conception of typical processes (TP). A typical process is a process that is regularly and repeatedly reproduced by an entity and is associated with maintaining the stable existence and evolution of said entity. A large number of processes in engineering and society can be described by TP. The entities that produce TP can be represented by an

engineering system, a single person, an organization, a social group, the whole of society and so on. Hereafter we will talk about TP being produced by people, but all of the conclusions can be equally applied to all of the other cases.

Since the entity repeatedly produces TP, a fairly fixed action sequence is obtained which is repeated in every iteration of TP. Whereby the time T_0 that is needed for executing this sequence can be estimated. This time can be differentiated from the TP period (the period of one iteration) because the entity can take part directly only in some TP iterations, so the value of T_0 may be less than the TP period. The goal of using various services (including an IC service) is to reduce T_0 by means of shifting some functions to the service operator. New ICT deployment allows the creation of new IC services or reduction of the time for providing services that already exist. From this point, we can consider the time δt , that the entity saves through new ICT deployment as the main metric of the useful effect from such deployment. Notice that the end user may not know about the deployment of the new technology or may not even use it at all, but may still benefit from it.

Here is an example. One of the major TP produced by an individual is eating. For a rural population the need to buy products in the town can include a significant waste of time. The deployment of ICT which provides remote product ordering will reduce such loss on the assumption that the necessary infrastructure is built. This is not only about providing society with the necessary customer equipment and communication channels, but the creation of a manufacturing system, storage and transport for regular delivery of the ordered products to the inhabited locations. On the other hand the deployment of ICT in trade business organizations can reduce the waiting in queue and hence bring advantages even for those who do not use ICT directly.

If we generalize from one entity to the total sum being investigated (from a single person to the whole society, for example) we should take into account the number of entities that will receive advantages from the new technology deployment. Also we should take note of the following fact. For every entity there is a set of base TP, production of which is necessary for entity existence. The entity will try to produce such TP even when there are no acceptable conditions. Examples of such TP are feeding, security and relations with governmental authorities. Another TP connected with education or leisure will be produced by the entity only if it has enough resources for them. New technology deployment can reduce the amount of resources (time, for example) needed for the production process. Due to this, the number of people having access to this process is increased.

But it is possible that profits from the new technology are received only by those who own specific resources, social rights, skills or other specific advantages. Such technology will not bring any profitable results for the typical processes of the rest of the people. That is why the time metric δt should be complemented with the coverage metric μ . This metric value can be equal to the number of users of an IC service that involves some new technology or can be equal to the number of people that have the potential to produce the TPs with which these services are connected. The existence of the dual definition of a single metric corresponds to the dual

economic approach to the evaluation of society well-being: via functions and via possibilities [5]. The advantage of the first approach is that it can be implemented without any expert views about some TP availability connected with social factors. On the other hand – many experts follow the second approach because it takes into account the considerations about freedom of choice and requires an individual's personal responsibility for their lifestyle [5].

No matter what approach we are selecting, the set of metrics μ and σ determined in relation to the different TP will significantly help to evaluate the quality of life. One can make an objection that quality of life is not only defined by access to the TP. However discussion in some economic publications [6] shows that, for that moment, none of the designed quality of life factors can be considered to be generally accepted or can be measured without some assumptions about human preferences, behavior patterns and so on. But use of the typical processes concept allows reduction of the number of such assumptions and makes the evaluation of high-level metrics based on the first and the second layer metrics possible. So this concept makes it possible to evaluate high-level metrics based on objective factors.

To implement the suggested idea in practice we should design models of the production of various TPs as well as models of the participation of different IC services in producing such TPs. This is a cross-disciplinary task which requires simultaneous work from specialists in different branches of knowledge. And this is the main objective of our investigations for now. As described above, the model design and verification need actual information about provided IC services. Also, to improve the quality, models require the complete (as far as possible) sample collections of actual IC services and populations of investigated region. Otherwise it would be impossible to analyze the casual relationships between the different models being evaluated.

From this point of view information control networks (ICN) have unique possibilities. These networks utilise television broadcast networks and that is why they have a centralised environment (see fig.2). All information threads in ICN go through a central node. Besides, the service administration is centralized too, because all IC services are provided by a single operator to the end user. This allows evaluation of various parameters of IC services, loading them into a common database, and exposing them to complex analysis.

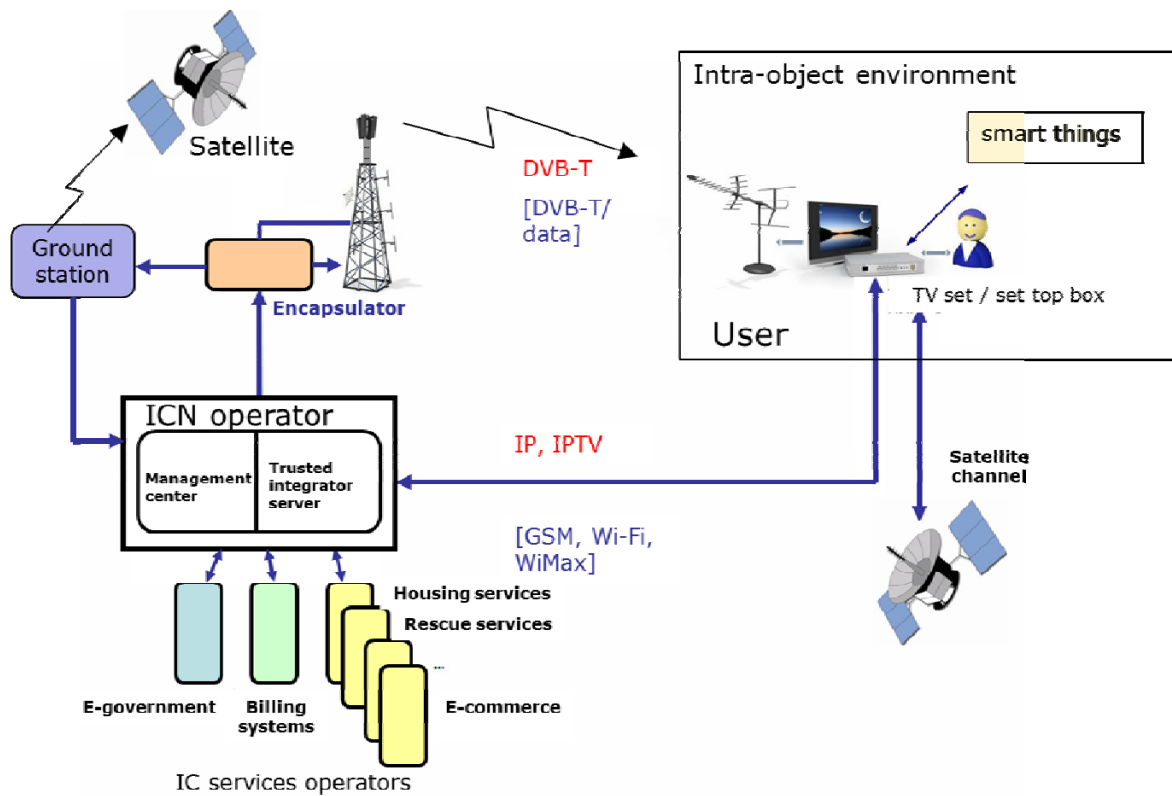


Figure 2. Information-management network structure

FSUE NIIR are currently implementing the ICN deployment project in Tomsk region, which is why we will soon be provided with a large quantity of information about the actual IC services usage of this region's population. It is possible to frame the hypothesis of any aspects of IC service consumption using this data.

This can be the basis for creating models of typical processes and IC services. We presume that the number of researchers from the different countries taking part in this work would be as high as possible. This would attract not only IC experts, but economists, sociologists, psychologists and other specialists, too. The main goal of this work would be to obtain some standards that include the technical principles of building the IC infrastructure, as well as social consequences and methods of evaluation of such consequences. We offer to call such standards "hybrid". The idea of hybrid standards was first suggested by us during the innovation focus-group in ITU [7] (V. Sarian, one of the authors of this paper is the vice-chairman there). This idea found wide approval there, especially by the representatives of developing countries. This is unsurprising because the new technology deployment can cause the biggest useful effect on the actual population of such countries. On the other hand, there are massive social and economic risks in making the wrong decisions in such countries. The design of the mechanism that provides the evaluation of the useful effect from the deployment of specific technology can steer the efforts of state controls and investors in the right direction and, just as important, involve the emerging nations in designing the international standards.

In conclusion let us consider the prospects of this work from the viewpoint of social technology assessment (STA), the new scientific discipline, dedicated to the extremely practical tasks of

predicting the ecological, social and economic aftermath of new technology application and managing the stable development of engineering [8].

First of all, compared to other fields ICT has the strongest possibility of receiving data that can be utilized for social analysis of STA: many operations that utilize ICT also collect much statistical information which is very useful for billing, analytics, and malfunction analysis. Secondly, ICTs produce a valuable impact on the development of other technologies: transport, industrial, financial, etc.; also we cannot neglect the effect of ICTs on the environment. Thirdly, nowadays ICTs are defined by the shortest deployment and obsolescence periods, so this means that time for hypothesis checking for them would be minimal. Because of that ICTs can be considered like fruit flies (*drosophila*) that are the model objects of genetic researches due to their short life cycle and simplicity of growth. Various theories and practices can receive practical approval through testing on IC before they are applied for social engineering evaluation. These circumstances enhance the need for working on the task that is being considered in this paper.

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