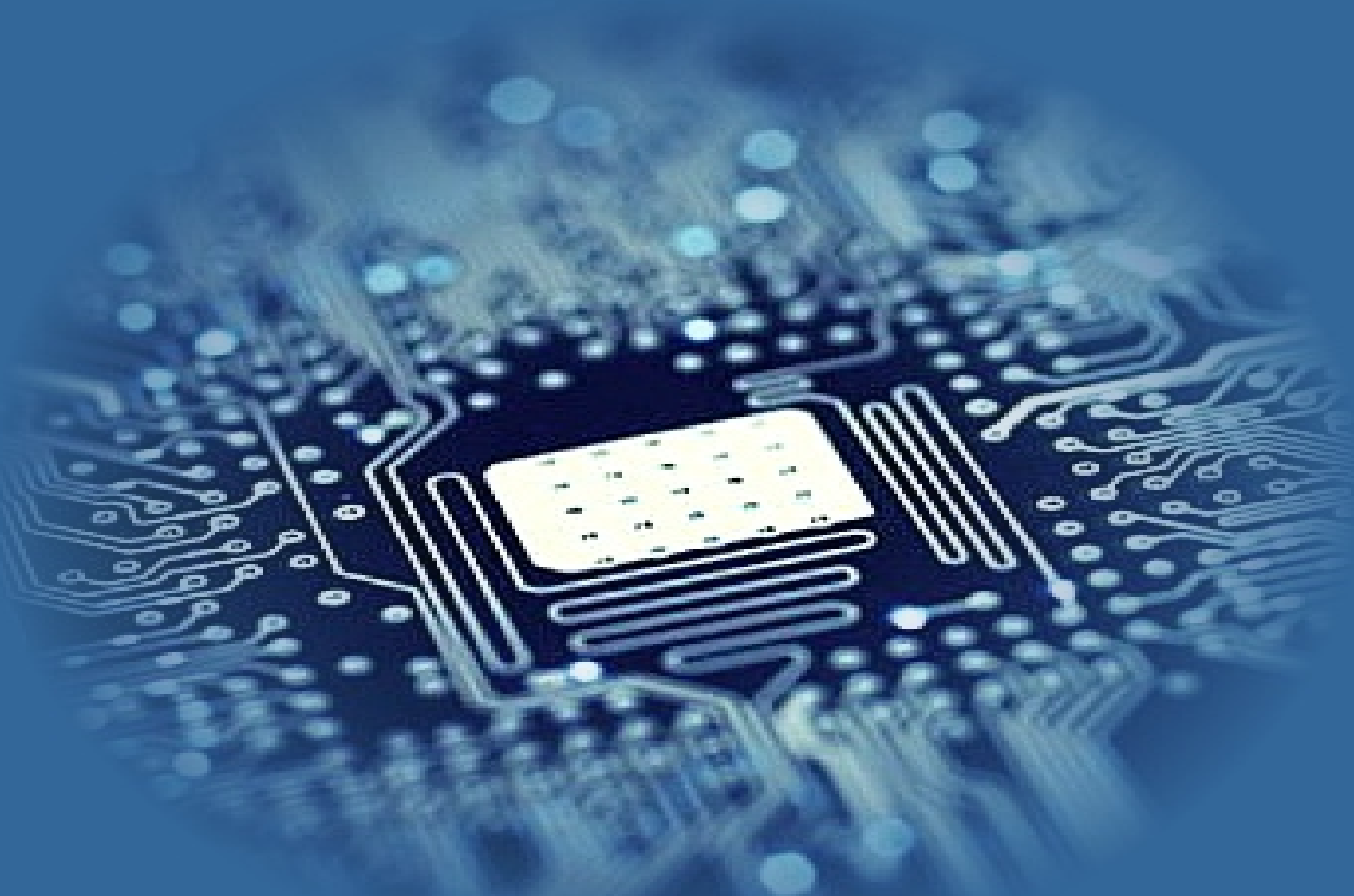

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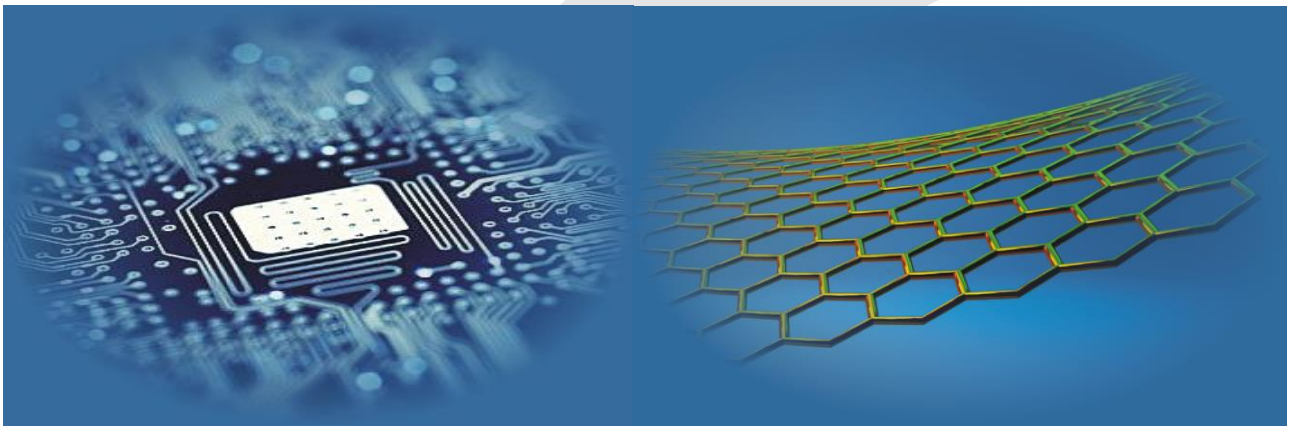

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Editors' Remarks

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Distant Time

by Rabindranath Tagore

I know not from what distant time
thou art ever coming nearer to meet me.
Thy sun and stars can never keep thee
hidden from me for aye.
In many a morning and eve thy footsteps
have been heard
and thy messenger has come within my
heart and called me in secret.

I know not only why today my life is all
astir,
and a feeling of tremulous joy is passing
through my heart.
It is as if the time were come to wind up my
work,
and I feel in the air a faint smell of thy
sweet presence.

Rabindranath Tagore (1861-1941)♠

****

This 21th volume No.3 includes research papers on **Mathematical and Computer Modelling**.
Our journal policy is directed to fundamental and applied scientific researches, innovative technologies and industry, which is the fundamentals of the full-scale multi-disciplinary modelling and simulation. This edition is the continuation of our publishing activities. We hope our journal will be of interest for research community and professionals. We are open for collaboration both in the research field and publishing. We hope that the journal's contributors will consider collaboration with the Editorial Board as useful and constructive.

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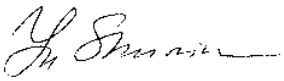

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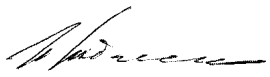
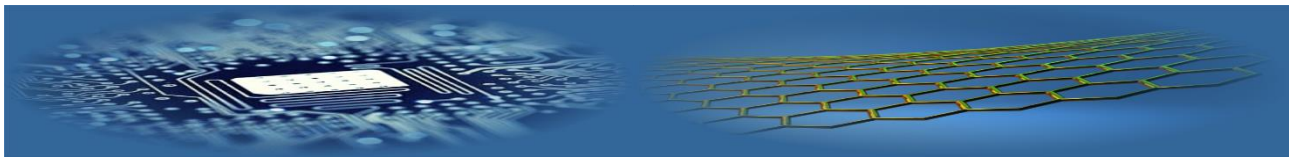


Igor Kabashkin

♠ **Rabindranath Tagore (7 May 1861 – 7 August 1941),** was a Bengali poet, novelist, musician, painter and playwright who reshaped Bengali literature and music. As author of Gitanjali with its "profoundly sensitive, fresh and beautiful verse", he was the first non-European and the only Indian to be awarded the Nobel Prize for Literature in 1913. His poetry in translation was viewed as spiritual, and this together with his mesmerizing persona gave him a prophet-like aura in the west. His "elegant prose and magical poetry" still remain largely unknown outside the confines of Bengal.

CONTENT



Factors and data for RES evaluation

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Abstract

Usage of renewable energy sources (RES) – is a modern powerful trend in energy development. "Green energy" technologies (technologies of gathering energy from renewable sources) are actively developed and will allow in the future significantly to reduce use of non-renewable resources (oil, gas, coal, peat), reduce the ecological impact of energy plants, improve the ecology around populated areas, reduce the cost of obtaining energy in some cases, increase the autonomy of life support systems and energy security of the country. RES are spatially distributed resources that depend on various factors. Thus, heterogeneous data and correctly defined factors are needed to evaluation of renewable resources. Paper considers the processes of RES potential evaluation, factors and data sources available for researchers. We discuss stages of RES potential evaluation, factors that can contribute to or hinder using RES and some data sources which can be used during the process. The Kazakhstan problems are briefly discussed.

Keywords:

Renewable energy resources, data sources, information systems, multiple-criteria decision making

1 Introduction

According the expert calculations the potential of the renewable energy sources in the Republic of Kazakhstan exceeds one trillion kWth yearly [1, 2], of which less than 0.1% are used (as mentioned below). The use of RES is associated with a certain complexity due to the dependence of the systems performance from random natural factors. Wind speed, solar radiation, hydropower resources can't be predicted exactly. Due to the depletion of the fossil fuel and ecological problems, the role of RES and of the more intellectual systems of energy distribution is going to increase. To solve the problem of RES evaluation we need collect several kind of data. Information system should collect weather, geographical, technical and social data. After analysing gathered data the system can support decision making process.

Despite large potential of renewable energy sources (RES) in Kazakhstan it might be economically indefensible to harness them in full. Consequently it is necessary to select the locations in the territory of the Republic where use of RES would be most useful. Although such a work has been performed in a range of projects mentioned above, purely engineering considerations are not sufficient for detailed analysis of the specified territories, as deployment of such facilities is influenced by a variety of different factors, which should be evaluated and consolidated in a generalized estimate.

Such factors encompass geographical (environmental, geomorphologic, location [3], ecological, technical, economical, social factors. Particularly, recent research show that there should be taken into account the problem of generator recycling [4] landscape and aesthetic limiting criteria, emerging in recreational area locations [5], etc.

This review discusses the evaluation of RES potential. We consider the factors and data affecting the evaluation process. The sources of such data and problems related to the conditions of Kazakhstan are briefly analyzed.

2 Evaluation of RES potential

RES potential evaluation approaches are considered in different research papers. The paper [6] defines basic stages of that process (Figure 1).

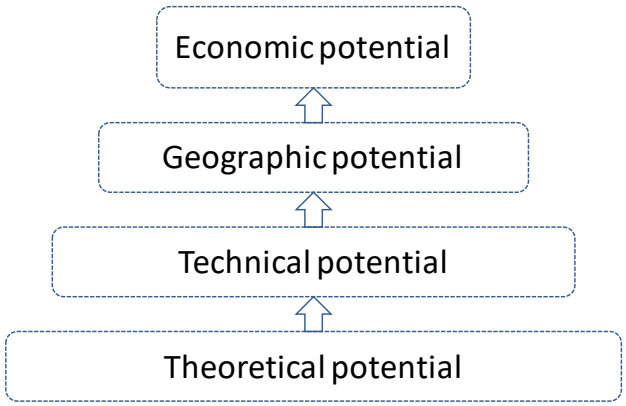

FIGURE 1 Stages of RES potential evaluation

It shows that the total scope of existing potential of a certain renewable (theoretical RES potential) is evaluated at the first stage. Technological potential, depending on parameters of the environment, generator effectiveness, service lines, etc., is evaluated at the second stage. Economic strength is evaluated at the third stage, based on greatest possible number of factors. As soon as RES depend mostly on geographic conditions, the paper [7] suggests an additional step – evaluation of geographic RES potential. Geographic potential is determined as a part of technological potential, being geographically available and necessary in a certain region.

Different methods are used for evaluation of theoretical

RES potential. For instance, the atlas describes techniques and results of potential estimates for natural resources and solar and wind energy, minor streams, peat, agricultural waste biomass, forestry and wood industry waste in the territory of Russia [8]. The detailed calculation of RES potential for one of Spanish regions is described in the paper [9].

Forest biomass potential of Italy was studied in detail in the paper [10]. The paper [11] represents an example of RES (solar and wind) potential estimation for rural regions. A technically related approach was applied in the thesis paper [12], where combination of factors, impacting deployment of power generators was classified by their significance for decision-making. Certain techniques of RES potential estimation in a range of papers were summarized with regard to establish information systems, supporting decision-making processes. The paper [13] describes the approach of information system establishment based on GIS and MCDM combination (abbrev. multiple-criteria decision making). MCDM method is also used in the work [14] where it helps in the selection of a suitable wind power plant project.

The mentioned papers use some non complicated mathematical models to evaluate energy volume that can be collected using RES. Examples of such mathematical models of energy systems are considered in the review [15]. Almost all papers discuss the factor and criteria that can contribute to or hinder the use of RES.

For example, in the above-mentioned work [14], the following 4 categories were considered: Benefits, Opportunities, Costs, Risks. Categories including criteria and sub-criteria are listed below.

Benefits

a. Wind availability
   - (a1) Geographical distribution of wind speed frequency
   - (a2) Mean wind power density
   - (a3) Annual mean wind speed

b. Site advantage
   - (b1) Influence of selected height of installation
   - (b2) Effect of wind gusting
   - (b3) Micro-siting of WEGs

c. (WEG functions
   - (c1) Real and technical availability
   - (c2) Affordable, reliable, and maintenance free
   - (c3) Power factor, capacity factor

Opportunities

d. Financial schemes
   - (d1) Switchable tariff
   - (d2) Discount of tax rate and duty rate
   - (d3) Other investment and production incentives

e. Policy support
   - (e1) Wind power concession program
   - (e2) Clean development mechanisms program
   - (e3) Other policy supports

f. Advanced technologies
   - (f1) Computerized supervisory
   - (f2) Variable speed wind power generation
   - (f3) Swept area of a turbine rotor
   - (f4) Static reactive power compensator, etc.

Costs

g. Wind turbine
   - (g1) Design and development
   - (g2) Manufacturing
   - (g3) Installation, maintenance

h. Connection
   - (h1) Electric connection
   - (h2) Grid connection

i. Foundation
   - (i1) Main construction
   - (i2) Peripheral construction

Risks

- Concept conflict Entrepreneurs, policy makers, residents
- Technical risks Technical complexity and difficulties
- Uncertainty of land Loyalty or lease agreement, geology suitability, etc.

Paper [13] considers the hierarchical set of factors including following elements:

(a) Environmental
   - Agrological capacity

(b) Geomorphological
   - Slope
   - Orientation
   - Area

(c) Location
   - Distance to road
   - Distance to power lines
   - Distance to villages
   - Distance to Substantions

(d) Climatic
   - Solar irradiation potential
   - Average temperature

In the work [12], the factors affecting the installation of RES are divided into natural, environmental, technical, economical and social. Here we propose taxonomy consist of six groups (Figure 2).

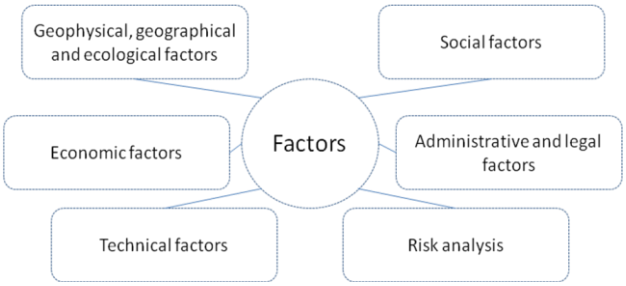

FIGURE 2 Groups of factor affecting the installation of power generators

Each of categories contains approximately 5-10 factors; the overall number of factors currently taken into account is 65.

Depending on type of RES generator, each parameter can be either an inhibitor or catalyzer. Some of inhibitors absolutely prohibit installation of generators in the area and are called hard inhibitors – they are not taken into account in further ranking of factors, and if hard inhibitor is present in the area, further calculations are terminated. The example of such hard inhibitor is national park.

Thus, to evaluate the theoretical potential of RES, it is necessary to determine the energy density for the territory, which depends on geophysical, geographical and weather characteristics of the terrain.

To assess the technological potential, it is necessary to know parameters of energy converters and factors that can limit the use of respective types of generators. We should mention that technologies development changes these parameters and influence of factors.

To gain assess to economical potential the information

about factors are needed which contribute to or hinder the deployment of energy generators.

There are several methods used to heterogeneous factors estimation. AHP is method of factor weights calculation based on pair wise comparison process. AHP was proposed by T. Saaty [16]. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is considered in [13]. The paper [17] discusses integrated method based on fuzzy logic and AHP.

Categories of factors with possible methods of their evaluation are shown in table 1.

TABLE 1 Categories of factors

Group ID	Name	Possible method of evaluation
G	Geophysical, geographical and ecological factors	Computed evaluation
GN	Natural potential	Computed evaluation
GC	Consistency of energy source	Part is hard-threshold inhibitor, the rest – AHP
GG	Geographical and geophysical factors	Statistical evaluation
GGE	Unfavorable geotechnical conditions	Computed, hard-threshold inhibitors
GGW	Abnormal weather conditions	Statistical evaluation
GGN	Abnormal natural phenomena and disasters	Statistical evaluation
E	Economic factors	AHP
T	Technical factors	AHP
S	Social factors	AHP
A	Administrative and legal factors	AHP
F	Risk analysis	Statistical evaluation

The estimations obtained using these techniques are applied in decision-making support systems [13, 14, 18]. Geo-information systems visualize the results [8, 11, 12, 13, 19].

The accuracy of estimates and recommendations directly depends on quality of collected data.

3 Data sources

Energy resources evaluating tasks imply collecting data from different sources. Weather stations, autonomous sensors, remote sensing data, surface images from satellites, results of mathematical modelling can serve as the data sources for the parameters of the environment. Besides crowd source data-mining gradually becomes of more importance [20]. SETI@home, Galaxy Zoo, Citizen Weather Observer Program (CWOP) serve as the examples of such projects [21]. The latter is intended to collect meteorological data by the community of users, providing the data to the weather forecast services and to the security services, providing the feedback to the users in order to improve the quality of the collected data. The data received by the project is used in the universities, research centres, weather forecast services etc. The data collection in this systems is performed by the weather stations owned by the enthusiasts, by measuring the temperature of the mobile devices' batteries [22] etc. E.g. OpenWeatherMap [23] project uses the data from private weather stations in order to improve the accuracy of the weather forecasts as the number of measuring points is more important in predicting than the accuracy of the measurements.

For European researchers, several databases are available. For example, some databases present data for solar radiation of varying levels (global, continental). The Meteonorm [24] database is based on the 3D interpolation of solar radiation measured by meteorological stations. It includes data on global solar radiation, as well as direct and diffuse fractions.

The PVGIS database [25] includes month averaged values of solar radiation and ambient temperatures for Europe. It processes climatologically data that is available within the European Solar Radiation Atlas using interpolation methods and the r.sun model [26]. This model is implemented in GRASS GIS, an open source environment. Data is freely available at [27].

The HelioClim 2/3 databases contain long-term solar radiation data series for Europe and Africa. Satellite images of Meteosat are used to form global radiation maps on a horizontal surface [28]. The estimates are based on the Heliosat2 method [26, 29], who's software at the time of this writing was available at www.helioclim.net, but currently at [30].

Many researchers also use local data sources available in selected areas [9, 11, 13]. For example, in [11] the local data sources of the county of Vermont, the state of Poltney, were used. This approach allows a more balanced assessment of resources, especially for mountainous and remote areas.

The list of the main sources of the meteorological data consists of:

- NASA SSE (Surface meteorology and Solar Energy) [31]
- ECMWF (European Centre for Medium-Range Weather Forecasts) [32] archived sets of data
- NASA GSOD (Global Surface Summary of Day) [33]
- Some sets of publicly available data from NOAA (National Oceanic and Atmospheric Administration), NCEP (National Centers for Environmental Prediction) [34].

Currently, the data provided by numerous subsidiaries of NASA and NOAA are of the highest interest. This data is mostly results of remote sensing of earth's surface. NCDC (National Climatic Data Center) [35] should be noted out of these organisations also as the data can be ordered in a certified printed form and the authenticity is guaranteed [36].

In addition to the text and numerical information, spatial data may be stored in the form of maps (layers of maps). There is a significant amount of map sources on different subjects. Lately, online map suppliers such as OpenStreetMap (OSM) [36], OpenWeatherMap (OWM) mentioned above, Google Maps etc. become popular. E.g. OWM provides the maps of cloud coverage, air pressure, temperature, precipitation all over the world. Typically, the map suppliers have a well-documented API (which often is free of charge) using which it is possible to create own web-GIS with maps consisting of different layers, available from the map suppliers. However, the most of the spatial information is stored in the form of the map's files and satellite images. The most popular formats of map storage are Shape, GeoJSON for vector information and TIFF,

JPEG for raster maps.

The problem of collecting data for the territory of the Republic of Kazakhstan is quite actual as data itself is not sufficient for full-scale analysis. E.g. in order to assess the energy potential of wind and solar energy it is necessary to get the data about the weather conditions on the territory of the whole country with the best possible resolution in the first place. This data should also contain information about time. The force of wind, illumination and temperature affect the performance of energy plants of the given type directly. In order to assess the parameters the weather stations are placed on the territory of interest.

But according to the NASA Global Surface Summary of Day (GSOD) [37] data for the year 2015 the territories of the Republic of Kazakhstan covered by the World Meteorological Organization (WMO) are about 1 for 7590 km2. This cannot be compared with the coverage in Europe and USA and does not allow assessing the weather conditions accurately enough.

Despite the fact that the number of automatic weather stations is gradually increasing, but this number still is very small for such a large territory (Figure 3).

The presence of a large number of the weather stations should allow improving the weather forecasting models assessing the energy potential more precisely. Currently, these models are mostly based on the data of the remote sensing and interpolation taking into account this data. The errors of the given models are assessed in ref. [8].

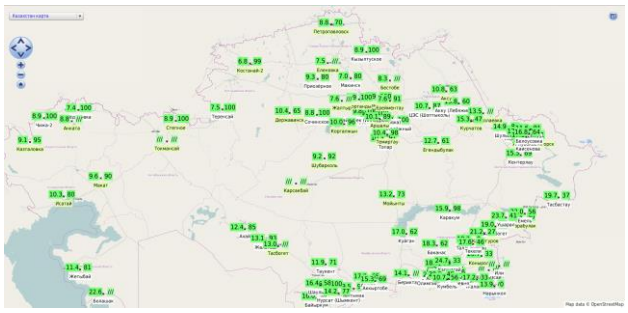

FIGURE 3 Automatic weather stations on Kazakhstan territory [38]

E.g. it is about 10% to 30% for the solar energy in comparison with the data observed on the surface, significantly increasing during the winter. Thus, the basis of assessment of renewable energy potential in Kazakhstan should become remote sensing data and ground-based meteorological data.

4 Conclusion

There are four stages of RES evaluation process:

1. To assess the theoretical potential of renewable energy it is necessary to determine density of energy for territory, which depends on geophysical, geographical, weather and other characteristics of terrain.
2. To assess the technological potential it is necessary to know parameters of energy converters, which change related to technology development.
3. To assess the economic potential the information about the factors is needed contributing or hindering generators installation.
4. At the end of evaluation process the possible location of generators is selected using some kind of decision support system.

The work lists the sources of information needed to perform three stages of assessing the potential of RES.

One of the main problems that apply to the conditions of the Republic of Kazakhstan is the low quantity of the data sources, especially the local one. Nevertheless, it is possible to use the remote sensing and global meteorological data for initial assessment of the resources.

For decisions on the use of various mechanisms of state regulation in the transition to renewable energy sources and the use of other useful resources a decision support system at national and regional levels is necessary.

It is expedient to develop a special information system to solve problems of estimating the potential of renewable energy sources and choosing the location of generators (power plants), such a system can greatly facilitate decision-making process on the use of renewable energy sources.

For the implementation of the system it is necessary to solve some important problems related to the detailed system architecture, services, data collection, integration and processing, functionality provided to users, aggregation of heterogeneous data and methods of their storing.

Acknowledgments

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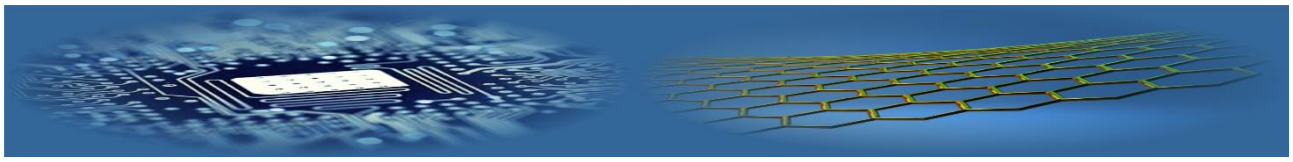

Proposition of web services composition approach basing of model-driven approach and multi-agent systems

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Abstract

Web services composition is an emerging paradigm for application integration within and across organizations and enterprises. For this reason, various approaches and formalism have been proposed and used for web services composition. Among these approaches we have the Models Driven Approach (MDA), which concentrates on the realization of abstract models. Thus, the phase of specification represents an important part of the cycle of development of composite web service. To proceed to this cycle of development, a developer has to elaborate a specification which allows the modelling of the global behaviour of the system, to verify formally this model for assuring his quality, then pass to the implementation of the composed service. In the paper we present a summary of our proposed approach of web services composition based on MDA, thus it is separated into three tasks: specification using BPMN notation and Multi-agent reactive decisional (MARDS) model, formal verification using LOTOS language and implementation using BPEL language. Then we present a case study to prove the feasibility and reliability of our proposed approach.

Keywords:

Web services composition
MDA; Specification
MARDS
Formal verification

1 Introduction

Nowadays Web Services are defined as software components, which can be invoked by application programs through a stack of Internet standards. Once deployed, web services provided by various organizations can be inter-connected in order to implement business collaborations, leading to composite web services. In the literature several approaches are proposed in order to compose web services, these approaches can be grouped into four classes: workflow-based approaches [1], approaches based on artificial intelligence planning techniques [2], approaches based on dependence graphs [3], and model-driven approaches.

Model-driven approach (MDA) concentrate on the realization of abstract models rather than on computer or algorithmic concepts. The specification phase is therefore particularly important in an MDA approach and represents a significant part of the development cycle. This allows developers to focus on the desired behaviour of the system, regardless of how to implement it. The partial generation of low level, code from the specification also reduces the time and therefore the development costs. For these reasons, we present a solution of web services composition faithful to the principles of Model-driven approach.

The layout of this paper is as follows. In the second section, we present a summary of our proposed approach of web services composition, the third section is devoted to the case study, we present a web services scenario that is used to apply and explain the different steps of our proposed development process. The conclusion and future work are presented in section IV.

2 Proposed approach

In this section, we present a summary of our proposed approach based on MDA and we explain the process of development of composite service. The figure 1 shows the steps involved in the proposed development process (specification, formal verification and implementation) to better understand how to proceed.

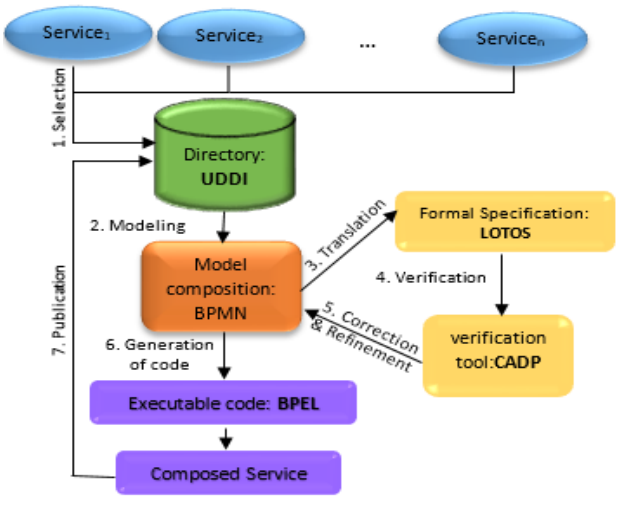

FIGURE 1 Process of development of composite service

2.1 PHASE OF SPECIFICATION

The specification phase is very important because it allows to detach from the implementation to realize clear abstract models, helping to the overall understanding of the system.

Furthermore, this specification is generally sufficiently expressive to serve as a basis for the implementation and even possibly to enable the generation of code in an automated manner.

In the process presented in figure 1, once the requested services are selected by the directory we pass to the specification stage. At this level we propose a modelling based on MARDS (Multi-Agent Reactive Decisional System) model [4], and using the BPMN notation (Business Process Model and Notation) [5]. The MARDS model, constitutes an approach among the newest and most useful ones for the composing and modeling of complex system such as the automated systems of production, the mobile systems [6] and organizational system [4]. We have used this system in our approach because it allows to model the composition of services in a simple and powerful way, and in well-structured architecture. The BPMN notation, is a modeling language, it is more adapted to the domain of the Web services, legible and sufficiently precise and expressive to allow the generation of executable code from it. We have used this notation for modeling the processes generated from the composed web services on orchestration mode. This modeling phase is described in detail in [7].

2.2 PHASE OF VERIFICATION AND IMPLEMENTATION

Our approach considers not only the specification of compound services but also their verification. The verification step is essential for any software development approach, it ensures the reliability and quality of the system and also helps to reduce costs since the discovery of design errors after putting into production of a system can entail significant costs. As it is better to detect errors as early as possible in the cycle of development, from the specification stage, the next step is the qualitative formal verification of our proposed model. This type of verification consist of the description of the expected behavior of the program, measured at a certain level of abstraction. The model of the system and behavioral properties described by the developer must be represented by a formal language so that they can be interpreted by formal verification tools which gives the result of verification. Our specification is described by the BPMN notation, but this language is often criticized for its lack of formality. One proposed solution is to transform the BPMN model in formal specification. Any formal specification language is susceptible to agree, but we propose the use of the process algebra LOTOS [8] which has the advantage of being supported by free formal verification tools such as CADP [9] toolbox. Due to CADP, it is possible to validate automatically the behavioral properties. In case where errors are detected, the developer is responsible for correct and refine its model to arrive at a model proven correct. The formal verification step is the object of [10] where there is more detail and description.

When the composition model is validated, the next step is the implementation of the system by generating BPEL [11] executable code from the BPMN specification. Finally, once the composed service is implemented, the last step is usually to publish it in the directory to facilitate its future use. More details and descriptions of this step of implementation are gives in [12].

We will provide in the next section a case study that allow to develop a composite service end-to-end using our development approach described previously.

3 Case study: E-health

Our proposed approach is based on standardized and powerful languages, templates and technologies; therefore it can solve problems of web services composition in different application domains and at all levels of complexity. We choose the health sector in view of his importance in the daily life of the citizens and for improving the quality of its services particularly to minimize the time of patient receptions and avoid blocking.

3.1 COMPOSITION SCENARIO

The following describes a typical scenario of patient journey in a hospital, in each stage of this scenario different web services can be used to inform gradually and continuously the patient's administrative and medical record.

The process is triggered by the appointment request from the patient. Once the patient is admitted, the hospital takes charge of the patient. A medical secretary reveals the patient's administrative record (if it exists, if not it creates it) and leads the patient in consultation with the doctor with whom he made an appointment and becomes the physician in charge. In order to carry out its consultation, the physician may need to access other services, such as medical record service, in order to consult and update the patient's data, status, antecedents and its history, the pharmacy service to help him to prescribe his prescription, radiology and laboratory services to request analyses and radios and receive the results. If it is necessary other services and processes can be triggered after this consultation as the hospitalization and operating block service depending on the case and the need of the patient. In all cases and at each stage the billing service is necessary to automatically appreciate the benefits and consumptions of the patient. The edition of the invoices can intervene other services like that of the insurance and the bank.

The scenario presented will be dealt throughout this document and in all stages of development.

3.2 MODELLING PHASE

3.2.1 Structure of the service composition modelling

Applying the rules and methods described in [7] and [12] to the "Online hospital" scenario, we obtain the MARDS structure shown in figure 2.

In this model of service composition, the basic components are: "Administrative Record" (AR); "Medical staff " (MS); "Appointment"; "Insurance"; "Bank"; "Medical Record" (MR); "Radiology"; "Laboratory"; "Pharmacy"; "Bed" and "Operating Block" (OB). The intermediate components are: "Home"; "Billing"; "Consultation"; "Hospitalization"; "Technical Service"(TS); "Administrative Service"(AS) and "Medical Service"(MS). The main composite component is "E-hospital".

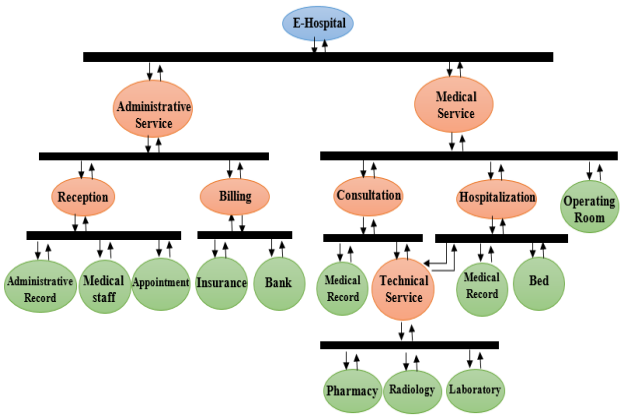

FIGURE 2 Web service composition model based on MARDS

3.2.2 Structure of the service composition modelling

Figures 3 and 4 show the business model presented in the BPMN diagram of the composition of web services.

The "A_OnlineHospital" action received by the main component (orchestrator) "E-hospital" generates two decisions {D1_ManageAdministration; D2_ManageMedicalUnit}. Each decision corresponds to a sub-action received by one of the services of the low level in the MARDS hierarchy. The first decision "D1_ManageAdministration" generates the sub-action "A_ManageAdministration". The second decision "D2_ManageMedicalUnit" generates the sub-action "A_ManageMedicalUnit".

The action "A_ManageAdministration" received by the component "AdministrativeService" generates two decisions {D1_ManagePatientInput; D2_ManagePatientOutput}. Each decision corresponds to a sub-action received by one of the services of the low level in the hierarchy. The first decision "D1_ManagePatientInput" generates the sub-action "A_ManageHome". The second decision "D2_ManagePatientOutput" generates the sub-action "A_Innvoice".

The action "A_ManageMedicalUnit" received by the "MedicalService" component generates the decision "D_ManageMedicalUnit". This decision generates three parallel sub-actions "A_ManageConsultation"; "A_ManageHospitalization" and "A_ManageOperatingBlock" received respectively by the services "Consultation"; "Hospitalization" and "OperatingBlock".

The sub-action "A_ManageHome" received by the "Home" component generates a sub-decision "D_ManageHome". On his part, this sub-decision generates three parallel sub-actions {A_IdentifyPatient; A_consultMS; A_PlanAppointment} for the components "AdministrativeRecord"; "MedicalStaff" and "Appointment". The three sub-actions correspond to the subprocess of the sub-action "A_ManageHome".

The sub-action "A_Invoice" received by the "Billing" component generates a sub-decision "D_Invoice". On his part, this sub-decision generates two parallel sub-actions {A_ConsultInsurance; A_consultBank} for the components "Insurance" and "Bank". The two sub-actions correspond to the sub-process of the "A_Invoice" sub-action.

The sub-action "A_ManageConsultation" received by the "Consultation" component generates a sub-decision "D_AchieveConsultation". On his part, this sub-decision generates two parallel sub-actions {A_ ConsultAR; A_ConsultTS} for the "MedicalRecord" and "TechnicalService" components. The two sub actions correspond to the sub-process of sub-action "A_Manage Consultation".

The "A_ManageHospitalization" sub-action received by the "Hospitalization" component generates a sub-decision "D_AchieveHospitalization". From its role this sub-decision generates three parallel sub-actions {A_AffectBed; A_ConsultMR; A_ConsultTS} for the components "Bed"; "MedicalRecord" and "TechnicalService". The three sub-actions correspond to the sub-process of sub-action "A_ManageHospitalization".

The sub-action "A_ConsultTS" received by the "TechnicalService" component generates a sub-decision "D_ConsultTS". From its role this sub-decision generates three parallel sub-actions {A_ConsultPharmacy; A_ConsultRadio; A_ConsultLabo} for "Pharmacy" components; "Radiology" and "Laboratory". The three sub-actions correspond to the sub-process of the "A_ConsultTS" sub-action.

The sub-actions {A_ManageOperatingBlock; A_ConsultPharmacy; A_ConsultRadio; A_ConsultLabo; A_AffectBed; A_ConsultMR; A_ConsultInsurance; A_consultBank; A_IdentifyPatient, A_consultMS, A_PlanAppointment} received respectively by the basic components "OperatingBlock"; "Pharmacy"; "Radiology"; "Laboratory"; "Bed"; "AdministrativeRecord"; "MedicalRecord"; "Insurance"; "Bank"; "MedicalRecord"; "MedicalStaff" and "Appointment" generate the external states {XS_OperatingBlockPlanified; XS_PharmacyResults; XS_RadioResults; XS_LaboResults; XS_BedAffected; XS_MRConsulted; XS_InsuranceResult; XS_ExpensesPaid; XS_ARcreated; XS_MSAgenda; AppointmentPlanified}.

The sub process "ManagePatientInput"; "ManagePatientOutput"; "AchieveConsultation" "AchieveHospitalization" and "ConsultTS" generate respectively the external states "HomeSet"; "InvoicePaid"; "XS_ConsAchieved"; "XS_HospAchieved" and "XS_TSConsulted".

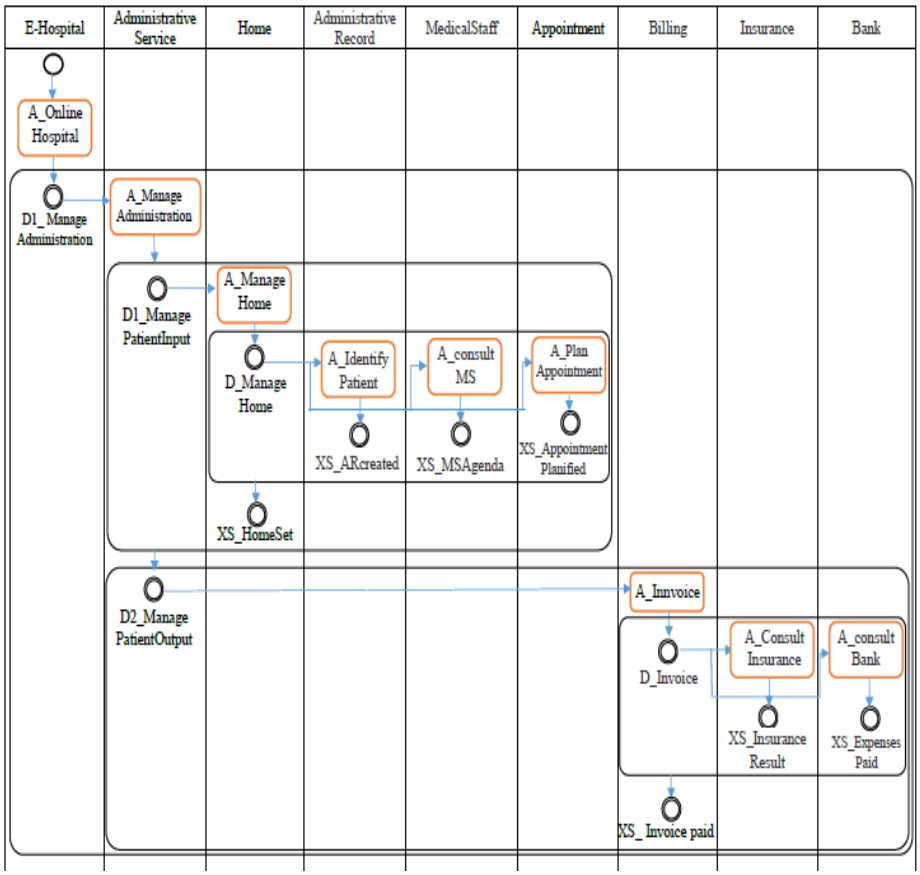

FIGURE 3 BPMN Diagram of "E-Health" Composition Scenario (Part 1)

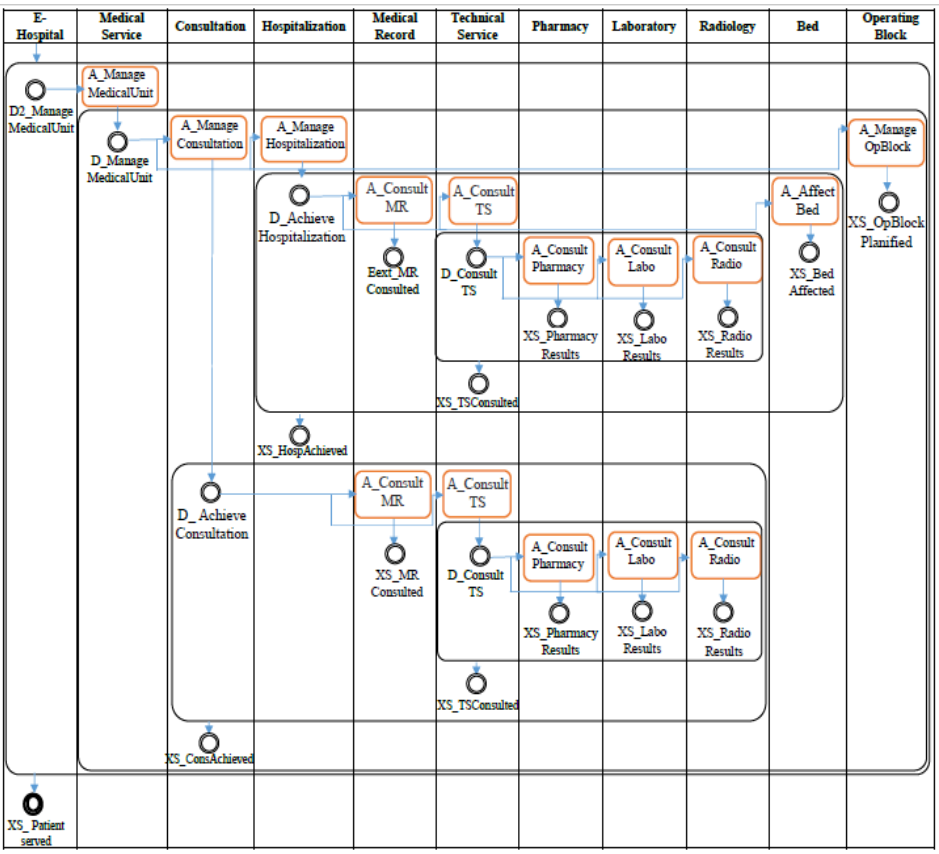

FIGURE 4 BPMN Diagram of "E-Health" Composition Scenario (Part 2)

3.3 VERIFICATION PHASE

As part of our model driven approach, service composition is expressed as a workflow or business process. This composition model can then be transformed into a formal specification described with LOTOS [14]. The goal of this transformation is to obtain a specification that can be verified formally and automatically using a tool that supports LOTOS input. CADP [15] is the most popular and successful tool for verifying models expressed with LOTOS. Indeed, the verification phase consists of two essential steps, the translation of the BPMN business model into a LOTOS specification and then the use of the CADP tool to verify the properties of the system and validate the model before embarking on the implementation phase.

3.3.1 Translation of BPMN modelling to LOTOS formal specification

To translate the BPMN notation depicted in figures 3 and 4 into LOTOS we are going to follow these steps:

- Define a process for each step of the activity (including initial and final nodes). Each process is defined by a set of behaviors.
- Assign an identifier (integer) to each of process.
- Define the gates, which are the channels of communication between processes. The peculiarity of our modeling with the SMARD model is that communication between services is done via the communication interfaces that receive and send actions and decisions, so we can consider these interfaces as processes (INTRF0, INTRF1 ... INTRFn). The actions and decisions sent and received by the services and communication interfaces are considered LOTOS gates (INPUTi, OUTPUTi) when i between 0 and n. Indeed services processes can communicate with each other through these gates, thanks to INTRF0…INTRFn processes.
- Define the operations between processes, in our example all service processes are executed concurrently using the ||| operator, which means that they are independent and they do not communicate directly with each other, but they use INTRFi process. Note however that the |[INPUTi,OUTPUTi]| operator is used to synchronize the service processes with the INTRFi process through the gates INPUTi and OUTPUTi, when i between 0 and n.
- Identify the control-flow patterns in the workflow in order to provide a definition (implementation) for each process.

The instantiation of the processes in LOTOS is provided as follow.

```
Specification Online_Hospital[INPUT,OUTPUT,
INPUT0,OUTPUT0,INPUT1,OUTPUT1,INPUT2,OUTPUT2,INPUT3,
OUTPUT3,INPUT4,OUTPUT4,INPUT5,OUTPUT5,INPUT6,OUTPU
T6,INPUT7,OUTPUT7]:noexit
behaviour
Init [INPUT, OUTPUT](0)|[INPUT,OUTPUT]| Ehospital[INPUT,
OUTPUT,INPUT0,OUTPUT0] (1)
|||
(Ehospital [INPUT, OUTPUT,INPUT0,OUTPUT0](1)
|||
AdministrativeService[INPUT0,OUTPUT0,INPUT1, OUTPUT1](2)
|||
MedicalService[INPUT0,OUTPUT0,INPUT2,OUTPUT2](3)
|||
final[INPUT0,OUTPUT0](4))|[ENV0,REC0]|
INTERF0 [INPUT0,OUTPUT0]
|||
(AdministrativeService[INPUT0,OUTPUT0,INPUT1, OUTPUT1](2)
|||
Home[INPUT1,OUTPUT1,INPUT3,OUTPUT3] (5)
|||
Billing[INPUT1,OUTPUT1,INPUT4,OUTPUT4](6))
|[INPUT1,OUTPUT1]|INTERF1 [INPUT1,OUTPUT1]
|||
(MedicalService[INPUT0,OUTPUT0,INPUT2, OUTPUT2](3)
|||
Consultation [INPUT2,OUTPUT2,INPUT5,OUTPUT5] (7)
|||
Hospitalization [INPUT2,OUTPUT2,INPUT6,OUTPUT6](8)
|||
OperatingBlock[INPUT2,OUTPUT2](9))
|[INPUT2,OUTPUT2]|
INTERF2 [INPUT2,OUTPUT2]
|||                    (Accueil
[INPUT1,OUTPUT1,INPUT3,OUTPUT3](5)
|||
AdministrativeRecord[INPUT3,OUTPUT3] (10)
|||
PersonnelMedical [ENV3, REC3](11)
|||
RendezVous [ENV3, REC3](12))          |[INPUT3,
OUTPUT3]|INTRF3 [INPUT3, OUTPUT3]          |||
(Billing [INPUT1,OUTPUT1,INPUT4,OUTPUT4](6)
|||
Insurance [INPUT4,OUTPUT4](13)
|||
Bank [INPUT4,OUTPUT4](14))
|[INPUT4,OUTPUT4]|INTRF4 [INPUT4,OUTPUT4]
|||
(Consultation[INPUT2,OUTPUT2,INPUT5,OUTPUT5](7)
|||
MedicalRecord [INPUT5,OUTPUT5,INPUT6, OUTPUT6] (15)
|||
TechnicalService [INPUT5,OUTPUT5,INPUT6, OUTPUT6,
INPUT7,OUTPUT7](16))
|[INPUT5,OUTPUT5]|INTRF5 [INPUT5,OUTPUT5]
|||
(Hospitalization [INPUT2,OUTPUT2,INPUT6, OUTPUT6](8)
|||
MedicalRecord [INPUT5,OUTPUT5,INPUT6, OUTPUT6] (15)
|||
TechnicalService [INPUT5,OUTPUT5,INPUT6,
OUTPUT6,INPUT7,OUTPUT7](16)
|||
Bed [INPUT6, OUTPUT6](17))          |[INPUT6,
OUTPUT6,]|INTERF6[INPUT6,OUTPUT6,]
|||
(TechnicalService [INPUT5,OUTPUT5,INPUT6, OUTPUT6,INPUT7,
OUTPUT7](16)          |||
Pharmacy [INPUT7,OUTPUT7] (18)
|||
Radiology [INPUT7,OUTPUT7](19)
|||
Laboratory [INPUT7,OUTPUT7](20))
|[INPUT7, OUTPUT7]|INTRF7 [INPUT7, OUTPUT7]
where
(*Definition of process*)
endspec
```

To complete the implementation of the above specification. We go on to define the processes declared in the behaviour section. In our specification we have to define several processes, we choose some to define it in this work.

- "Init" process

The "Init" process (*Id:0*) merely starts the "Ehospital"

process (*Id:1*). As a consequence, it uses the sequence pattern before exiting.

In Sequence process, an activity identified by dst_id should be executed after the completion of the activity identified by Emt_id in the workflow, we say that both activities are then executed sequentially.

```
process Init [INPUT, OUTPUT](Id:Int): exit:=
Sequence [INPUT, OUTPUT] (Id, 1)                    >> exit
where                                   process Sequence
[INPUT, OUTPUT] (Emt_Id:Int, dst_Id:Int): exit :=          ENV
!dst_Id !Emt_Id !RUN !void; exit                    endproc
endproc
```

- "Ehospital" process

The "Ehospital" process waits for a RUN message from "Init" before starting. After that, it realizes an sequence between "AdministrativeService" (*Id:2*) and "MedicalService" process (*Id:3*).

```
process Ehospital[INPUT, OUTPUT, INPUT0, OUTPUT0] (Id:Int):
exit:=          OUTPUT ! Id ! 0 of Int ! RUN ! Void;
Sequence [INPUT0, OUTPUT0] (Id,2 of Int)
>> Sequence [INPUT0, OUTPUT0] (Id,3 of Int)
>>exit                                   where
(*Definition of Sequence process*)
endproc
```

- "AdministrativeService" Process

The "AdministrativeService" process waits for a RUN message from the "Ehospital" process before starting sequentially the "Home" (*Id:5*), "Billing" (*Id:6*) processes.

```
process AdministrativeService
[INPUT0,OUTPUT0,INPUT1,OUTPUT1] (Id:Int) : exit:=
OUTPUT0 ! Id ! 1 of Int ! RUN ! Void;                Sequence
[INPUT1,OUTPUT1] (Id,5 of Int)                  >> Sequence
[INPUT1,OUTPUT1] (Id,6 of Int)                  >>exit
where
(*Definition of Sequence process*)
endproc
```

- "Consultation" process

The "Consultation" process waits for a RUN message from the "MedicalService" process before starting concurrently the Reservation_Hairfare (*Id:4*) and "MedicalRecord" (*Id:15*) and "TechnicalService" (*Id:16*) processes, thus realizing a parallel split pattern.

In ParallelSplit process, the identifiers of the activities (*dsts_Id*) are passed in parameters to the process as a set of integers (*IntSet*). The process needs to iterate over this set and send a RUN message to each activity identified in the set. However, recursion is the only way to realize cyclical behavior in LOTOS. As a consequence, the ParallelSplit process is calling itself recursively and removing already processed *dst* from the set in order to iterate over it.

```
process Consultation [INPUT2,OUTPUT2,INPUT5, OUTPUT5]
(Id:Int) : exit:=          OUTPUT2 ! Id ! 3 of Int ! RUN ! Void;
ParallelSplit[INPUT5,OUTPUT5](Id,insert(15, insert(16, emptyset))
where                           process ParallelSplit [INPUT5,
OUTPUT5]   (Emt_Id:Int, dsts_id:IntSet) : exit :=  [empty(dsts_id)] ->
exit                                    []
[not(empty(dsts_id))] ->                        (let
dst:Int=pick(dsts_id) in                        INPUT5 !dst !
Emt_Id !RUN !void;                  BranchementMultiple [INPUT5,
OUTPUT5] (Emt_Id, remove(dst, dsts_id))     ) endproc
endproc
```

- "OperatingBlock" process

The "OperatingBlock", Like all atomic process, waits for a RUN message from other process in Upper layer before exiting.

```
Process OperatingBlock [INPUT2,OUTPUT2] (Id:Int) : noexit:=
OUTPUT2 ! Id ! 3! RUN ! Void;                   stop
endproc
```

3.3.2 Formal verification with CADP

In the second step of verification, and after the LOTOS specification is developed, we use the CADP toolkit [9] and especially the Caesar compiler in order to transform the description of the LOTOS composition into a mathematical representation in the form of a labeled transitions system (LTS) [13] on which it will be possible to verify certain behavioral properties. The developer's task is to define behavioral properties using μ-calculus [14] and verify them using the EVALUATOR compiler in CADP.

3.3.2.1 Using of Caesar compiler

Caesar is a compiler that can be used to transform a LOTOS specification into a mathematical representation. The mathematical representation used is LTS. Caesar takes the LOTOS program to check, as well as an implementation in C for the abstract types it contains (either written by hand or generated automatically by Caesar.adt). Output Caesar produces a LTS. The information contained in this LTS can be used by various tools like automation reducers, temporal or computational logic evaluators and diagnostic tools.

The LTS graph illustrated in figure 5 present the result of compilation of LOTOS specification described previously using Caesar Compiler.

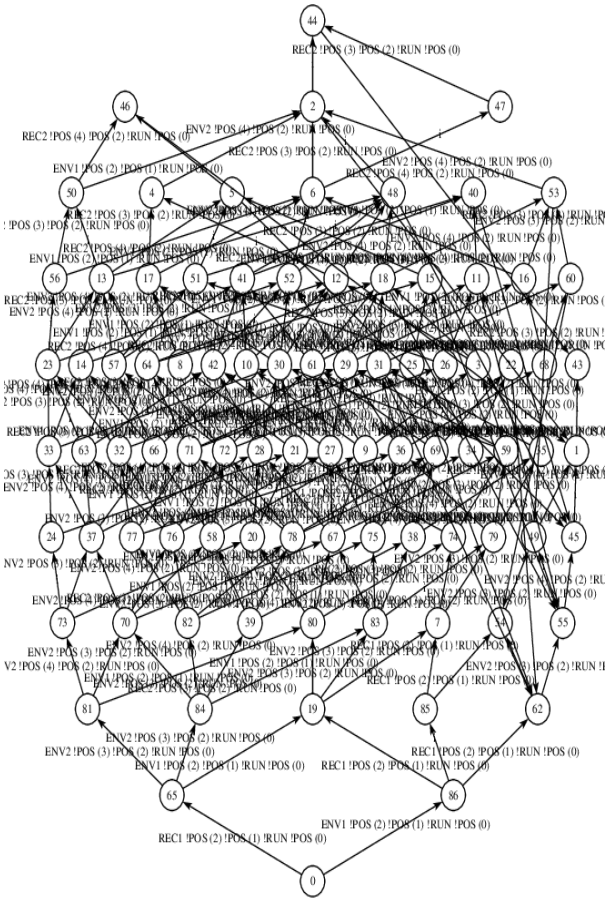

FIGURE 5 LTS generated and reduced by CADP

3.3.2.2 Using of EVALUATOR

EVALUATOR is a tool for on-the-fly verification of models integrated into CADP environment. The tool operates by taking two inputs. The first entry corresponds to the model in the form of an LTS, on which the verification is to be performed. The second input is a temporal property to be verified, expressed in the form of a formula with μ-calculus [14]. EVALUATOR will mathematically explore all possible execution branches on the generated LTS in order to prove that the property is verified (or not). The temporal property, defined by the developer and supplied to EVALUATOR, characterizes a behavior within the model. As part of our case study, we define a set of properties that would be useful to check in our example.

Property 1: We want to prove that a user can always execute the action to plan an appointment when the patient is identified and the practitioner's agenda is consulted. The property is translated to regular expression μ-calculus here as follows.

macro Lead (A, B) =[true_.(A)]mu X.(<true> true and [**not** (B)] X)
end_macro
macro IdentifierPatient() = 'ENV3!POS(10)!POS(5)!**RUN**.*'
end_macro
macro ConsulterAgenda() = 'ENV3!POS(11)!POS(5)!**RUN**.*'
end_macro
macro PlanifierRDV() = 'ENV3!POS(12)!POS(5)!**RUN**.*'
end_macro
Mener (IdentifierPatient and ConsulterAgenda, PlanifierRDV)

Property 2: We now want to show that a user can not plan an appointment without identifying the patient and consulting the practitioner's agenda. This is to verify that the inverse operation of property 1. The property is translated here as follows.

macro Lead (A, B) =[true_.(A)]mu X.(<true> true and [**not** (B)] X)
end_macro
macro IdentifierPatient() = 'ENV3!POS(10)!POS(5)!**RUN**.*'
end_macro
macro ConsulterAgenda() = 'ENV3!POS(11)!POS(5)!**RUN**.*'
end_macro
macro PlanifierRDV() = 'ENV3!POS(12)!POS(5)!**RUN**.*'
end_macro
Mener (not[PlanifierRDV], [ConsulterAgenda]false And [PlanifierRDV]false)

The formal verification step can be repeated iteratively until a correct and refined composition model is obtained. The model can then be used as the basis for the implementation. More precisely, this is directly transformable into executable code.

3.4 IMPLEMENTATION PHASE

The implementation phase includes the generation of BPEL4WS [11] executable code from the BPMN model. Our BPMN model is based on SMARD system, therefore a description of the behaviour of a SMARD system under BPEL4WS is necessary. This description is the object of [12].

A complete BPEL description of the proposed business model should include the WSDL interfaces of the different services involved in the composition and the BPEL codes of the main process "E-hospital", the sub-processes for composite agents, and the web services performed by simple agents. As follow, we present the BPEL implementation of main process "E-hospital".

<!—Definition of main process of composition-->
<process name="Ehopital ">
<!-- Declaration of partnerLinks -->
<PartnerLinks>
<PartnerLink name = "Ehospital.A_OnlineHospital"
partnerLinkType = " Ehospital.A_OnlineHospital_LT"
myRole = " A_OnlineHospital_Role"
partnerRole = "A_OnlineHospital Callback_Role" />
<PartnerLink name =
"AdministrativeService.A_ManageAdministration"
partnerLinkType = "
AdministrativeService.A_ManageAdministration_LT"
myRole = " A_ ManageAdministration_Role"
partnerRole = " A_ ManageAdministrationCallabck_Role" />
<PartnerLink name = "MedicalService.A_ManageMedicalUnit"
partnerLinkType = "MedicalService.A_ManageMedicalUnit_LT"
myRole = "A_ManageMedicalUnit_Role"
partnerRole = " A_ManageMedicalUnitCallback_Role" />
</PartnerLinks>
<!-- Declaration of variables -->
<variables>
<!—Input/output for Ehospital process -->
<variable name="Action_Ehospital" messageType=" StartState"/>
<variable name="ExternalState_Ehospital" messageType=" EndState"/>
<!— Input/output for MedicalService process -->
<variable name="Action_MedicalService" messageType="
StartState"/>
<variable name=" ExternalState_MedicalService" messageType =
"EndState"/>
<!— Input/output for AdministrativeService process -->
<variable name="Action_AdministrativeService" messageType="
StartState "/>
<variable name=" ExternalState_AdministrativeService "
messageType="EndState"/>
</variables>
<!-- Definition of process main body-->
<sequence>
<receive partnerLink=" Ehospital.A_OnlineHospital"
portType=" Ehospital.A_OnlineHospital_PT"
operation="A_OnlineHospital "
Variable="Action_Ehospital"
CreateInstance="Yes" />
<!-- Decision Name = D1_ManageAdministration -->
<Flow>
<!-- Action = "A_ManageAdministration ", Action = AdministrativeService -->
<sequence>
<assign>
<copy>
<from expression="A_MangeAdministration"/>
<to variable="Action_AdministrativeService" part="Message"/>
</copy>
</assign>
<invoke partnerLink=" AdministratifService.A_ManageAdministration"
portType=" AdministratifService.A_ManageAdministration_PT"
operation=" A_ManageAdministration"
inputVariable="Action_AdministrativeService" />
<receive partnerLink=
"AdministrativeService.A_ManageAdministration"
portType= "AdministrativeService.A_GererAdministrationCallBack"
operation="A_ManageAdministrationCallBack"
Variable="EtatExterne_AdministrativeService" />
</sequence>
</Flow>
<!-- Decision Name = D2_ManageMedicalUnit-->
<Flow>
<!-- Action = "A_ManageMedicalUnit", Action = MedicalService -->
<sequence>
<assign>
<copy>
<from expression="A_GererUniteSoin"/>
<to variable="Action_ServiceMedical" part="Message"/>
</copy>
</assign>

```
<invoke partnerLink="MedicalService.A_ ManageMedicalUnit"
portType=" MedicalService.A_ManageMedicalUnit_PT"
operation=" A_ManageMedicalUnit"
inputVariable="Action_MedicalService" />
<receive partnerLink=" MedicalService.A_ManageMedicalUnit"
portType=" MedicalService.A_ManageMedicalUnit CallBackPT"
operation=" A_ManageMedicalUnitCallBack"
Variable="EtatExterne_MedicalService" />
</sequence>
</Flow>
<invoke partnerLink=" Ehospital.A_OnlineHospital"
portType=" Ehospital.A_OnlineHospitalCallBack_PT"
operation=" A_OnlineHospitalCallBack"
outputVariable=" EtatExterne_Ehospital" />
</sequence>
</process>
```

5 Conclusions

In this work, an approach for the specification, formal verification and implementation of composite Web services is proposed. It is a model-driven approach faithful to the MDA principles.

Our approach of composition of web services is based on standardized and powerful languages, templates and technologies (MARDS model, BPMN Notation, BPEL language, LOTOS language, CADP tool), therefore it can solve problems of the web services composition in different application domains and at all levels of complexity. As part of a case study, we chose the health sector and we have detailed each step of our proposed approach, to better explain, illustrate and help to understand this approach.

For the prospects, we are currently working on the automatic transformation of BPMN models into LOTOS models and BPEL code. This work is important to facilitate the task of the developer and to make the steps of formal verification and implementation simple, rapid and completely automatic.

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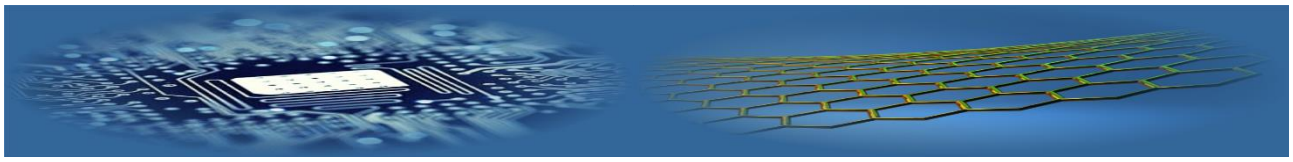

Security challenges of vehicular cloud computing applications: from software architecture viewpoint

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Abstract

The use of vehicular ad-hoc network is considered by researchers in recent years. Although these networks have been deployed in real world offering appropriate services to their users, researches show that their current architecture have different development and management problems. It seems that cloud computing due to its scalability and other features is an appropriate technology to compensate the shortcomings. By moving the vehicular ad-hoc network to the cloud, we have the new technology of vehicular cloud network. Considering quality attribute is the best approach to improve the vehicular cloud network applications' software architecture. Among the quality attributes, security is so important and the lack of security in the system causes the rejection of these technologies by users. This paper studies vehicular cloud networking security. In order to achieve the security in vehicular cloud network applications, first of all a list of applications is prepared. Then applications are categorized to identify various security threats. To confront the existing threats, various security tactics are provided. Finally an approach to increase the security in vehicular cloud applications is proposed.

Keywords:

Vehicular cloud computing,
VANET,
Security,
Software Architecture

1 Introduction

In recent years due to the vast number of vehicles on the roads, researchers concentrate on the vehicular cloud network applications. Using tiny embedded sensors in vehicles, wireless communication models and computing and storage capabilities, the future generation of vehicles are moving toward more intelligence [1]. The sensors collect various information from their surroundings and share them with their neighbourhood vehicles through the vehicle to vehicle or vehicle to infrastructure connections [2]. To support the variety of such network applications, some of which require a lot of computing power and bandwidth, vehicles and road side units work together to share resources that make the temporary cloud. The combination of temporary cloud spaces with the common cloud results in network performance. This creates vehicular cloud networking [2].

Cloud networks faced different security challenges [4]. With the increase in the number of vehicles, regard to the use of thousands of different sensors in the vehicle, the security aspects are more important. Hostile attacks to the cloud infrastructure to prevent the vehicle from accessing the cloud or intercepting transmitted data are among the threats that affect these networks [5]. With the advent of ever-increasing applications in these networks, using software architecture tactics to design a secure software to transmit data among vehicles is a good strategy. Before using software architecture tactics, application classification and extracting their common features can help us to provide a security model for the applications.

We covered the following objectives in this paper:

- Vehicular cloud network applications classification.
- Reviewing the key features of applications in terms of security.
- Proposing new approaches in these networks to increase efficiency and improve security.

The remainder of the paper is organized as follows. In section 2 we describe an overview of related work. Section 3 presents the definitions and basic concepts of vehicular cloud networks. Section 4 offers the categorization of applications and some of their features related to the security. In section 5 different software architecture tactics to solve security problems are applied. Section 6 provides fog computing case study and finally section 7 concludes the article and presents future works.

2 Related work

In 2012 the first idea of an ad-hoc cloud network architecture was presented [6]. This study focuses on the architecture of vehicular ad-hoc network to develop a running cloud model. Authors of [1] investigate that how the vehicular ad-hoc network expanded with vehicular cloud and data-driven networks. Vehicular cloud combines the mobile cloud model with vehicular networks and then changes the network services delivery modes. On the other hand, data-driven networks change the method of data routing and its propagation. According to this, a new network system is created for vehicles that are behind each of these concepts. In fact this article examines the architecture and functionality of this phenomenon and the design principles is discussed. Recent studies have not considered the role of software architecture and quality attribute. In [7] Authors detects and analyses some of security challenges and potential threats for privacy in vehicular cloud. This study pointing out some of security

threats and providing a security plan, presents appropriate security architecture. This studies future work is about establishing a systematic way to implement intelligent transportation systems. The authors of [2] introduce the vehicular cloud network with the combination of three kinds of clouds which are 1) vehicular cloud 2) infrastructure cloud 3) Back-End cloud. In addition the importance of security, privacy and trust in the systems which are used in vehicular cloud networks is discussed. So the paper which describes the security in vehicular cloud network, Investigated various threats relates to every layer of vehicular cloud network. No attention is paid to the security needs in available vehicular cloud network applications.

This study provides a list of vehicular cloud network applications and their potential threats and uses the software architecture to realize the security quality attribute in vehicular cloud networks.

3 Vehicular cloud networks

Vehicular ad-hoc network is responsible for communication between vehicles. A vehicle can communicate and exchange information with its peer (V2V - Vehicle to vehicle communication) or with the infrastructure like RSU - Road Side Unit (V2I - Vehicle to Infrastructure) [1]. With the advent of cloud computing concepts, computing, communication and data storage resources are provided as services. Vehicular cloud network is formed with the combination of cloud computing and vehicular ad-hoc networks. According to various applications of vehicular ad-hoc networks and cloud computing, there will be so many applications to develop with the combination of these two technologies [2].

Software architecture has a great affect in designing and developing vehicular cloud network applications. In software architecture in addition to the functionality, quality attribute like performance, availability, security, usability and etc. must be taken to the account. One of the most important quality attribute of the vehicular cloud networks is security. In this part, first we introduce architecture of the vehicular cloud networks and various applications and then security threats associated with these networks are discussed.

3.1 VEHICULAR CLOUD NETWORK ARCHITECTURE

Vehicles and sensors in an area produce different content and data. These data is stored and searched in cloud and is processed and used by the neighbours in the lifetime [8]. Figure 1 shows the architecture of vehicular cloud networks. According to figure 1, three main concepts of the vehicular cloud networks are vehicles, communication and the cloud.

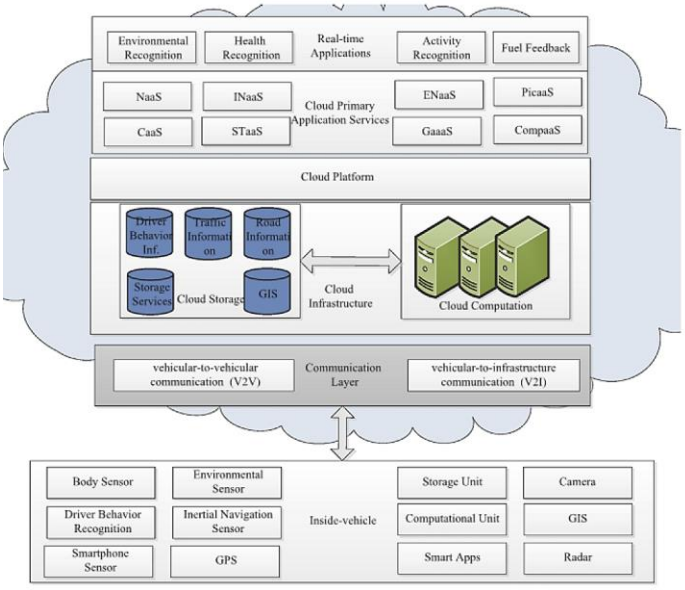

FIGURE 1 Vehicular cloud network architecture [8]

3.2 VEHICULAR CLOUD NETWORK APPLICATIONS

Since different vehicles and RSUs share their resources thorough common cloud, vehicular cloud networks offer a wide range of applications. Some of these applications include [3, 5]:

- Vehicle maintenance: Vehicles can get their software updates from the cloud whenever the developer releases a new version.
- Traffic management: Drivers can get the traffic reports from the vehicular cloud.
- Sharing road condition: You can share road condition such as floods or icy road in the vehicular cloud. According to this drivers will be warned about dangerous conditions in their chosen routes.
- Accident warnings at intersections: In certain driving conditions such as fog, severe storms, snow and etc. drivers can use this service if they want to be alerted about potential accidents. A high-rise building with radars that should cover all intersections at specified intervals can be used as an infrastructure for this service. To predict the likelihood of accidents, using an intelligent algorithm is inevitable.
- Security applications: Applications related to critical scenarios in life like collision avoidance need strong security protection.
- Intelligent parking management: Vehicles using vehicular cloud networks will be able to reserve a

place in parking lots for themselves. All parking's information will be accessible in the cloud without central control.

- Planned evacuation of residents: In some natural disasters such as hurricanes and tsunamis, clouds vehicles can be used as a tool to organize evacuation.

3.3 VEHICULAR CLOUD NETWORK APPLICATION SECURITY THREATS

Vehicular cloud networks security threats according to the classification in [9] are:

- Spoofing User Identity: Attackers pretend to be another user to obtain illegal information and benefits. A classic example of this attack "man in the middle" in which attackers pretend to be Alice when communicating with Bob and vice versa. As a result, both Bob and Alice send decrypted messages to their attackers.
- Tampering: In this type of attack, the attacker modifies data or creates his/her own data.
- Repudiation: Attacker try to impersonate new data or manipulate data, activity and operation.
- Information Disclosure: In this threat, attackers try to discover and disclosure of identifying information such as identity, legal, finance, politics, accommodation and biological traits and racial and geographic data records involved.
- Denial of service attack: The invaders poured out their attacks as a large number of questions toward the running system. As a result, the system resources for the users will be inaccessible.
- Elevation of Privilege: in this threat, attackers exploit a defect in the system, system leaks, design flaw or error in the configuration of the operating system or software application to illegally raise the privileges and accessibilities to the protected resources and data.

According to the security triangle [10] confidentiality, integrity and availability, a classification for existing threats is presented in figure 2.

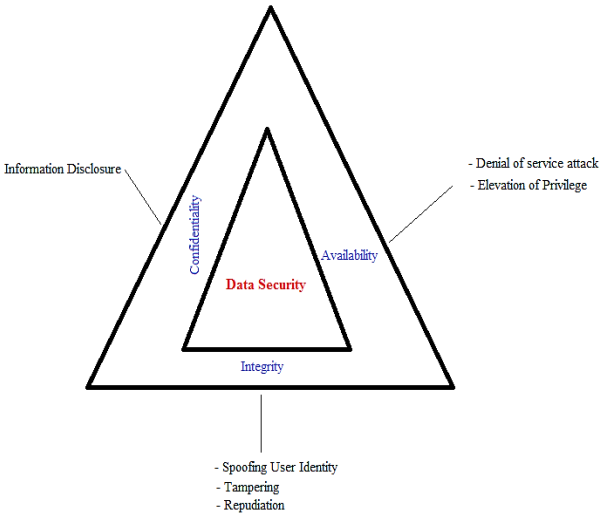

FIGURE 2 Vehicular cloud networks security threats

4 Vehicular cloud networks application security

Due to the advances of the vehicular cloud networks, the number of applications in this field will grow. Investigating the existing software and applications, determines the role of the software architecture to meet the expectations of quality attributes. Therefore noticing applications and their security threats is necessary to provide the appropriate tactics for security in software architecture [11]. In this study, vehicular cloud network applications are classified according to their type of usage. This categorization is presented in Table 1. Some other columns like data importance, related units in the application, delay sensitivity and propagation type are added to better introduce the applications. In Table 2 Each group of applications are related to the threats type and suggested tactics using Table 1.

TABLE 1 Characteristics of vehicular cloud applications

Application type	Application	Associated units	Data importance	Delay sensitivity	Casting type
Safety	Accident alert	V2I V2V	Public	Delay-sensitive	Broadcast
	Security threat alert	V2I	Public	Delay-sensitive	Geocast
	danger on the road alert	V2I V2V	Public	Delay-sensitive	Broadcast
	scope of work and repair alert	V2I V2V	Public	Delay-sensitive	Broadcast
Management	Bandwidth Management	V2BEC*	Public	Insensitive to delay	Multicast
	Remote traffic management	V2I	Public	Delay-sensitive	Broadcast
	Intelligent Parking Management	V2I	Public	Insensitive to delay	Unicast
Controlling	Visual control of urban areas	V2I	Public	Insensitive to delay	Geocast
	Control of drains in times of crisis and natural disasters	V2I	Public	Delay-sensitive	Geocast
	Congestion Control	V2I	Public	Delay-sensitive	Broadcast
Business	commercials	V2I	Public	Insensitive to delay	Broadcast
Infotainment	Multimedia file sharing	V2V	Private	Delay-sensitive	Unicast
Public Services	Highway information	V2I	Public	Insensitive to delay	Broadcast
	Emergency passing vehicles alert	V2V	Public	Delay-sensitive	Broadcast
	Road condition sharing	V2V V2I	Public	Delay-sensitive	Broadcast
	Vehicle maintenance	V2I	Public	Insensitive to delay	Multicast
	Vehicle and traffic real time tracking	V2I	Private	Delay-sensitive	Unicast

*Back-End Cloud

5 Proposed approach

In all the considered applications in Table 1 delay sensitivity factor is studied. Looking to the values of this column, we can understand that some of vehicular cloud network applications are time sensitive and this means that if they do not be effective in a certain time, they won't be effective any more. Considering the relationship between vehicular cloud network and human life and health, the concept of time sensitivity becomes clearer. It seems offering an approach to solve the delay problem in this technology is essential. Vehicular cloud networks application as a security tool in this technology is one of the most important benefits of vehicular cloud networks. It is obvious that most of these applications are delay sensitive. In scheduling security attacks, malicious vehicle receives messages but before sending the message to the others, adds an amount of time to the original message to cause a delay. Of course, the way of eliminating the possibility of time adding in the messages is maintaining data integrity. However, if the delay is due to infrastructural issues, the possibility of this should be minimized. Fog computing is a new technology that provides delay sensitive services to meet the needs of delay-sensitive scenarios. Fog computing called distributed computing concepts that expands the services that are provided by the cloud to the network edge. In addition, fog computing supports mobility of the computing resources, communication protocols, cloud integration and distributed data analysis, which is associated with lower delay. Due to the characteristic of the fog computing, it seems that using it in the vehicular cloud network systems to reduce delay and increase security would be an appropriate approach.

6 Case study: intelligent traffic lights and connected vehicles

Cameras at intersections seeing ambulance lights can change traffic lights automatically and open the road for ambulance. Using the common cloud, information is expected to be transferred to the central cloud infrastructure and then the result of changing the colour of traffic light would be applied [12]. On the other hand if a cyclist or pedestrian is detected by sensors in intersections or near the traffic lights, it is possible to measure the speed and distance of approaching vehicles and changes the colour of smart light. In this case, time is an important factor. Transferring all of this information to the cloud (as well as information on neighbourhood traffic lights) will cause delay. This distance may create vulnerability so the hostile person can cause traffic lights inappropriate performance by adding a small delay. On the other hand if information transmission is multi hop and with the help of other vehicles, the risk of delay would be more, because of the hostile vehicle. In this scenario, fog computing can greatly reduce the vulnerability and minimize the additional delays on the path. Fog can extend the services provided by the cloud to the edge of the network. Hence, we can reduce transmission delays and even moderate multi hop transmission by using fog computing. The important difference between cloud and fog that causes delay reduction and limits the hostile access are summarized in Table 3 [13].

TABLE 2 Threats and tactics to solve vehicular cloud application Security

Application type	Threats	Security dimension	Solution (Tactics)
Safety	- Tampering - Repudiation	- Integrity	- Maintain integrity - Authenticate users
Management	- Tampering - Repudiation - Denial of service attack - Elevation of Privilege - Spoofing User Identity	- Integrity -Availability	- Maintain integrity - Authenticate users - Authorize users - Limit exposure - Limit access
Controlling	- Denial of service attack - Elevation of Privilege - Spoofing User Identity - Information Disclosure	- Integrity - Availability - Confidentiality	- Maintain integrity - Authenticate users - Authorize users - Limit exposure - Limit access - Maintain data confidentiality
Business	- Tampering - Repudiation - Elevation of Privilege - Spoofing User Identity	- Integrity -Availability	- Maintain integrity - Authenticate users - Authorize users - Limit exposure - Limit access
Infotainment	- Tampering - Repudiation - Denial of service attack - Information Disclosure - Spoofing User Identity	- Integrity - Availability - Confidentiality	- Maintain integrity - Authenticate users - Authorize users - Limit exposure - Limit access - Maintain data confidentiality
Public Services	- Tampering - Repudiation - Denial of service attack - Information Disclosure	- Integrity - Availability - Confidentiality	- Maintain integrity - Authenticate users - Authorize users - Limit exposure

TABLE 3 Difference between cloud and fog computing [13]

Requirement	Cloud Computing	Fog Computing
Latency	High	Low
Delay Jitter	High	Very low
Location of server nodes	Within the internet	At the edge of the local network
Distance between the client and the server	Multiple hops	One hop
Security	Undefined	Can be defined

7 Conclusions

The importance of the security quality attribute in vehicular cloud network due to important applications is clear. In this article we examined the security quality attribute in vehicular cloud networks, from the perspective of software architecture. Security requirement of each application with their features is extracted. By providing different categorization for application and threats, a mapping between threats and usable software architecture tactics is achieved. Finally an approach to improve security in vehicular cloud networks is proposed.

As a future work, Table 1 and Table 2 provide an overview to offer a security model or framework for vehicular cloud networks. This model can be developed by studying information and data security reference model and customizing it for vehicular cloud networks.

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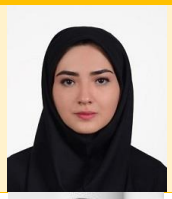

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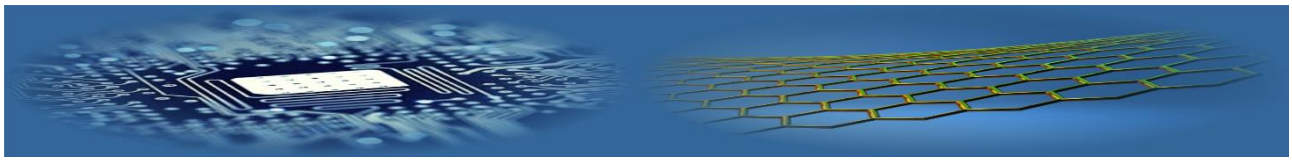

Fuzzy logic based job scheduling algorithm in cloud environment

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Abstract

Cloud computing is a technology which is growing faster day by day and applied in various fields such as in industry, commerce, and research. Handling resources and the task according to the need of user is the current major issue. In cloud environment when users submit their task, it selects the best virtual machine on which the task can execute. Considering the commercialization and virtualization aspect of the Cloud Environment, this paper proposes an algorithm for Job scheduling which ensures fairness of the resource allocation according to the Quality of service. It mainly focuses on two problems. One is the selection of virtual machine(s) which are eligible to execute the task. Another problem is justification of the task according to the quality of service. Our approach simplifies the complexity of the algorithm and reduces the overhead associated with selecting appropriate and justified virtual machine for a given task. It ensures the fairness of the resource allocation for each classified task and also justifies the overall system allocation. Further, it uses fuzzy logic to adjust the general expectation vector of the task based on the fairness of the allocation of resource.

Keywords:

Cloud Computing,
QoS,
Fairness,
Job scheduling,
Resource allocation

1 Introduction

Cloud computing is a subscription based service like pay-as-you-go model which delivers software, infrastructure and the platform kind of services. These services are called as the Infrastructure as a service (IaaS), Platform as a service (PaaS), and Software as a service (SaaS) in the industry as shown in figure 1. Cloud computing is introduced to reduce the cost of the hardware and software. It also aims to make the next generation data center more powerful so that it will provide dynamic and flexible services to the consumer. Deployment of cloud computation makes the industry stronger and also gives the time to focus on innovation and creativity. This will lead the IT services to the different level and will help in developing the world [3].

Cloud computing is an evolution of the parallel computing, grid computing, and distributed computing. It deals with trading the resources in an efficient way according to the need of the user. Also, it is a large scale of heterogeneous resources that resides in the datacenter. The virtualization ability of the cloud computing hides the heterogeneity of the resources which makes it different from other computing introduced previously. The other feature such as user-oriented approach which gives the services as per need of the user and virtualization technology which is used to pack the resources makes it scalable and flexible.

The working of the cloud computing is to dispatch the tasks to the pool of resources which consists of several computers. It provides various services including storage, power, and several software services according to the need of the task [1, 2]. The business and virtualization technology used by the cloud computing has taken the technology to the new heights. As an example, it leaves the responsibility of resource allocation to the virtualization of virtual machine layer. Further, it pays more attention to the fairness of the resource allocation, likewise, various new features are introduced in cloud computing.

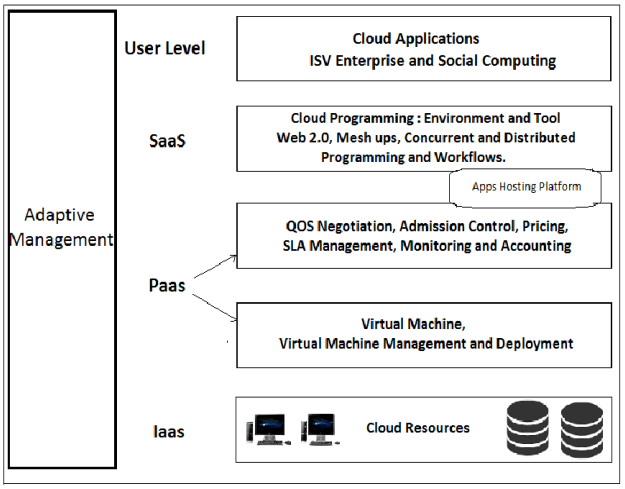

FIGURE 1 Architecture of cloud computing

This paper is organized into various parts. Section II is related work. Section III gives the description of the job scheduling algorithm based on fuzzy logic. Section IV describes the performance and result analysis. Section V provides the future work and conclusion.

2 Related work

Resource allocation of tasks has been core research topic hence there are plenty of papers published in this area. To use the technology of virtualization and allocation of resource efficiently, job scheduling algorithm plays an important role. There are various algorithms, strategies, and techniques proposed in past decade. Berger model [4] is

introduced for the first time which discussed the fairness of the allocation of the task. This Algorithm based on Berger Model is taken from the Social theory of distributive justice. It established the dual constraint in which the tasks are classified according to the Quality of service parameters and define the justice evaluation function to judge the fairness in an allocation of the resource.

Bag of Tasks [5] schedules multiple applications which are a set of identical and independent tasks that runs on a heterogeneous master-slave platform. The goal of this algorithm is to minimize the ratio between the actual time taken by the task to execute in a system and the time taken to the task if executed alone. Next, workflow based scheduling algorithm [6] is introduced to find the solution that considers the user Quality of service of the task according to the preference of the user. Work provides the scheduling of the workflows that shows the significant improvement in the utilization of the CPU. This algorithm shows improvement in efficiency along with the fairness in the allocation of the task.

Previously papers have covered the efficiency of the resource allocation schemes but the fairness is missed out in most of the approaches. Those approaches who have considered the fairness of these resource allocation schemes suffer from the performance issues. Hence, this paper has proposed job scheduling algorithm which mainly resolves the problem of fairness while allocating jobs efficiently. Allocation of the jobs according to the Quality of service requirement of the user is one of the major issues in cloud computing, tasks are submitted to the virtual machine according to the availability of the resource. This paper introduces an algorithm which is used to evaluate the justification of the allocation of the task and adjusts the general expectation vector of the task. This paper uses fuzzy logic which helps in adjusting the general expectation vector of the task. It evaluates the fairness of the individual task as well as for classified task. Judging the fairness involves the justice evaluation function (JEF) which calculates the fairness of the allocation of the task [4, 7, 8].

Cloud computing is a pool of resources which consist of several virtual machine in the datacenter. Selecting an appropriate virtual machine is typical because there are thousands of virtual machines in a particular datacenter. To reduce the overhead of selecting it we have proposed a formula to deduce a set of the virtual machine(s) eligible to execute the task. It reduces the complexity of the algorithm and helps in getting better completion time and response time of the task which results in a better performance of the system that improves efficiency.

3 Proposed approach

In this paper, fairness constraint of the allocation of resource is served by the general expectation vector of the task. Task's general expectation vector is defined according to the classification of the task. The classification of the task is performed according to the quality of service *(QoS)* parameter of the task. These QoS parameters are Completion time *(CT)* and Bandwidth *(BW)*.

The general expectation vector of class type task I is: $e_i = [e_{i1}, e_{i2}, e_{i3}]$ and,

$$\sum_{j=1}^{3} e_{ij} = 1, \qquad [4]$$

where e_{i1} = Weight of Number of CPU, E_{i2} = Weight of Memory, E_{i3}= Weight of Bandwidth.

Justice evaluation function of the task is calculated by the ratio of the actual reward to expected reward. If the result is more than one that means the task is executed gets more resource than it needed. If the value is less than one, it represents resource allocated is less than needed for the task. The resource is justified when the value of the justification evaluation function is one.

Justice evaluation function J_i for the task i:

$$J_i = \Theta \ln AR/ER, \qquad \text{eq(1) [8]}$$

where *AR* is an actual resource allocated to the task and *ER* is an expected resource by the user.

The algorithm starts with the classification of the task according to the need of the user. Later, Actual execution time (AET) of the task is calculated using the file length of the task (FL) and the Million of Instruction per second of the Virtual Machines (MIPS). Now to select the machine(s) eligible for the execution of the task we compare it to the Actual execution time (AET) with the expected execution time (EET) along with this we need to compare the memory required by the task (MRT) and the memory size of the virtual machine (MVM). Similarly, the bandwidth required by the task is also compared with the bandwidth of each virtual machine. The number of tasks requirement of completion time is denoted as *k* and the number of tasks user requirement Bandwidth is *l*. Now justification of each class type is calculated using JCT_i and JBW_i. The Justification bandwidth of the completion time requirement of the task and the completion time of the bandwidth requirement of the task is assumed as 0.9. Now, to get the better mathematical association we have fuzzified JCT_i and JBW_i parameters using Mamdani Fuzzy inference system. It is passed with the rules base which is in the form of *if..else* rule shown in table 1and 2. Table 1 is a rule base for the task whose user requirement is completion time and table 2 is the rule base for the task whose user requirement is bandwidth. Defuzzification is performed using centroid method which is used to give the result in the range [0,1]. Now, Output after the defuzzification denoted with F_out is used to adjust the General expectation vector of classified tasks. The value used for adjusting the vectors are $\alpha_0 = 0.2$, a = 0.1 and b=0.2.

ALGORITHM

BEGIN
STEP 1: Let the set of virtual machine in the environment of cloud computing is
$VM = VM_1 \ldots\ldots VM_m$
STEP 2: Classify the task according to the Quality of service parameters of the user.
STEP 3: Calculate the Actual Execution time (AET) of the task i.
$AET = \frac{FL}{MIPS}$
STEP 4: Produce the set of Virtual Machine which is eligible to execute the task i.
If QoS = CT.
{
If MRT<MVM && AET<=EET
{

Add VM to the VM_i list
}
}
If QoS = BW
{
If (BW_i<BW_{vm})
{
Add VM to the VM_i list
}
}
VM_i={$VM_1 \ldots\ldots VM_t$}
Where, t<m

STEP 5: Normalize the virtual machine using the equation (2) to map it with the initial general vector of the task.
STEP 6: Calculate the Euclidean Distance of the virtual Machine.
STEP 7: Repeat from STEP 4 and STEP 5 for each task.
STEP 8: Evaluate the Justification Evaluation Function of task i using eq (1) for type 1 of the task.

$$JCT = \sum_{i=1}^{k} \frac{Actual_{CT}}{Expected_{CT}}$$

Similarly, for the type 2 of task,

$$JBW = \sum_{i=1}^{l} \frac{Actual_{BW}}{Expected_{BW}}$$

STEP 9: The parameter JCT_i and JBW_i are taken as the input. For implementing parameters in fuzzy inference system, we are using following steps.
Define a rule base which is a set of if...else rules.
$R = \{R_1, R_2, R_3, \ldots, R_s\}$.
Fuzzify the input parameters using triangular membership function $\mu(v)$.
$\mu(v) \rightarrow [0,1]$

$$\mu(x) = \begin{cases} 0, & v \le p \\ \dfrac{v-p}{r-p}, & p \le v \le r \\ \dfrac{q-v}{r-q}, & r \le v \le q \\ 0, & q \le v \end{cases}$$

Where,

$$x = \{CT, BW\}$$

Apply the inference on rule base based on the values of fuzzified input parameters.
R_i:
$if(L,M,H)\ AND\ if(L,M,H)\ AND\ if(L,M,H) \rightarrow T\_out(L,M,H)$.

$$L \rightarrow Low, M \rightarrow Medium, H \rightarrow High$$

Generate $F\_out(L,M,H) \rightarrow [0,1]$.
Defuzzify the produced F_out by FIS using centroid method,
$F\_out \rightarrow [F_{min}, F_{max}]$
STEP 9: Adjust the General Expectation Vector of the task by using the output of the fuzzy inference system for each classified task.

$$\propto = \propto_0 - \ a(F\_out - b)$$

END

TABLE 1 Rule base for the task which requires Completion time as QoS parameter

S. no.	Justification Completion time	Justification Bandwidth	Output (F_out)
1	LOW	HIGH	MEDIUM
2	MEDIUM	HIGH	MEDIUM
3	HIGH	HIGH	HIGH

TABLE 2 Rule base for the task which requires Bandwidth as QoS parameter

S. no.	Justification Completion time	Justification Bandwidth	Output
1	HIGH	LOW	MEDIUM
2	HIGH	MEDIUM	MEDIUM
3	HIGH	HIGH	HIGH

4 Performance analysis

The performance of this algorithm is simulated on CloudSim Platform [9]. CloudSim is simulation software which is introduced by University of Melbourne in 2009. There are four levels in this framework that includes GridSim, CloudSim, SimJava, and UserCode. The implementation of the proposed algorithm is performed in CloudSim layer and simulation program in UserCode layer. The proposed algorithm is added in CloudSim by overloading *bindCloudletToVM()* method of the DatacenterBroker class. Cloudlet class is also extended by adding two variables such as expectation completion time and expectation bandwidth and four methods are used to get and set the value of these variable. The fuzzy logic is applied using MATLAB. It has the Fuzzy inference engine which is used to fuzzify and defuzzify the parameters.

The value of the expectation vector of the class 1 type of task is initially taken as e_1 = [0.7, 0.1, 0.2] and the expectation vector of the class 2 type task is e_2 = [0.3, 0.2, 0.5]. e_1 and e_2 are empirical value and are determined in the same experimental environment. To create a cloud computing scenario we have taken data which is listed in table 3 and 4. In table 3, 0 to 3 tasks are class 1 type of task and 4 to 7 are class 2 type of task. Table 3 is the set of the virtual machine which has different preference and performance, data is listed in the table.

Figure 2 and figure 4 is a rule base for the class 1 and 2 type of task in MATLAB, respectively. Similarly, Figure 3 and figure 5 shows the surface view in MATLAB for class 1 and class 2 type of task.

Algorithm 1 is Fuzzy based job scheduling algorithm. Algorithm 2 is job scheduling algorithm based on Berger model. Execution time of task attained by the comparative analysis of result after simulation is demonstrated is figure 6. Overall, after execution, it is noted that efficiency of the algorithm 1 is better than algorithm 2. Task 0-3 prefers high computing power. Also, the completion time of Algorithm 1 is better than algorithm 2.

TABLE 3 Virtual machine parameters

VMid	CPU	Memory	Bandwidth
0	4	2048	1200
1	2	1024	3000
2	2	1024	1000
3	1	512	1200

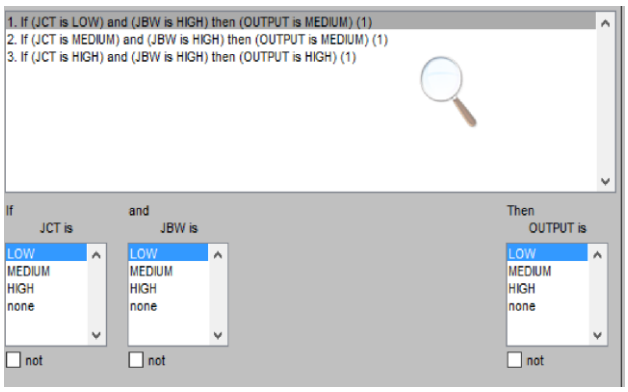

FIGURE 2 Rule base for the class 1 type of task in MATLAB

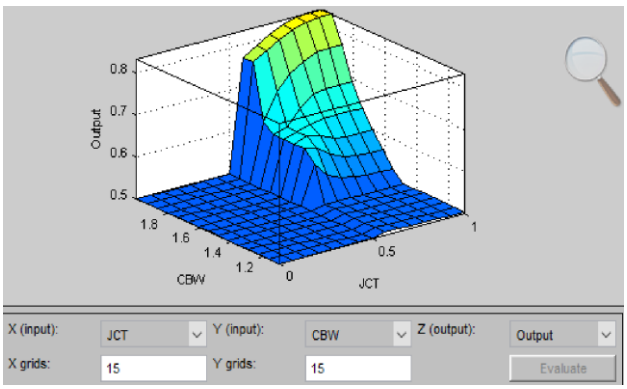

FIGURE 3 Surface View of the parameters in MATLAB for class 1 type of Task

TABLE 4 Task Parameters

CloudletId	Classtype	Length	File_size	Output_size	Expectationtime	ExpectationBW
0	1	4000	2500	500	400	–
1	1	3000	2000	400	200	–
2	1	2000	800	300	150	–
3	1	5000	5000	2000	500	–
4	2	2000	800	300	–	2000
5	2	3000	2000	400	–	3000
6	2	800	300	300	–	1200
7	2	2500	1000	500	–	2000

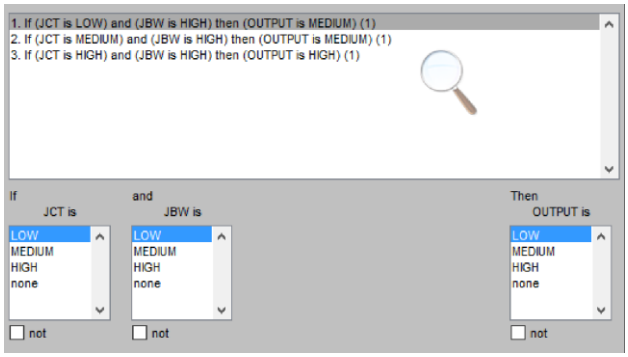

FIGURE 4 Rule base for the class 2 type of task in MATLAB

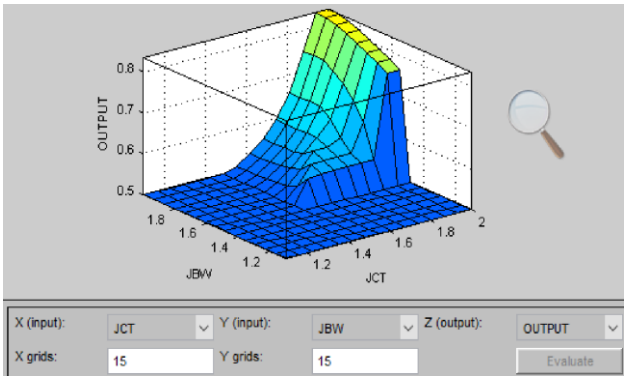

FIGURE 5 Surface View of the parameters in MATLAB for class 2 type Task

Figure 7 presents the comparison of the Justification of user task (J value). J value 0 means the allocation of the resource achieved by the user task are stable with their expectation. J >0 refers that the user achieved resources are higher than its expectation. J<0 refers that the user doesn't meet its expectation. Clearly, Algorithm 1 provides more satisfaction than Algorithm 2.

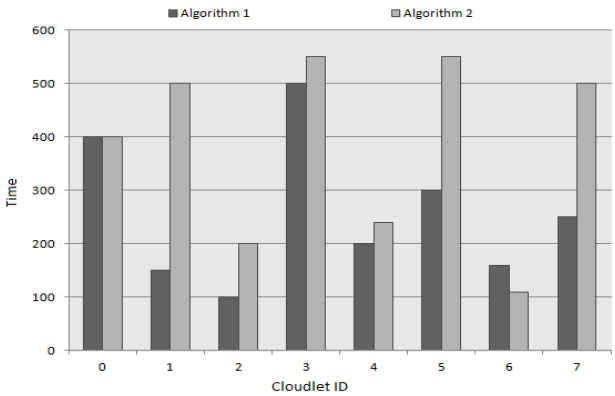

FIGURE 6 Task Execution time comparison

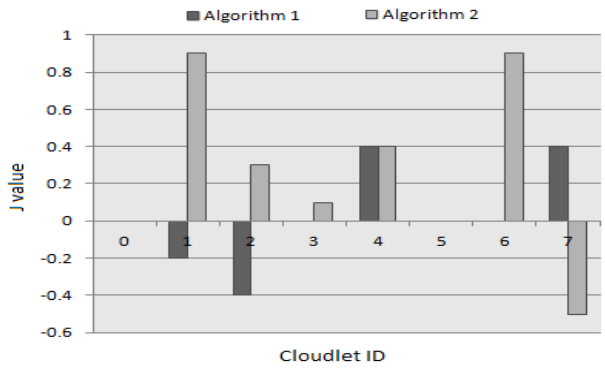

FIGURE 7 User Satisfaction

Class 1 type of task is for the high computing power hence, demands earliest completion time. Figure 7 shows the comparison of the CPU number of the allocated virtual machine for the first type of task. Overall, First algorithm ensures better high performance computation to the task which meets task preference with fairness.

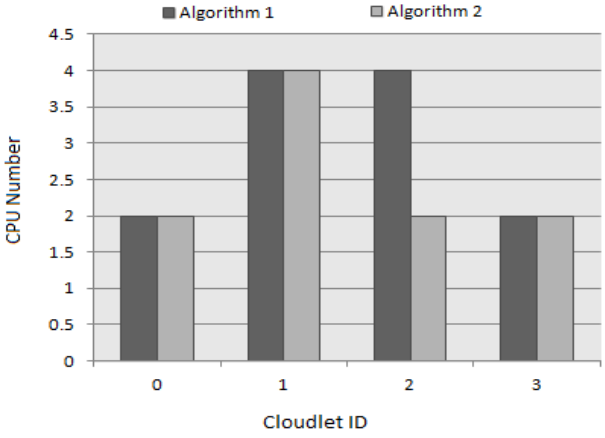

FIGURE 8 Comparison of the first type of task

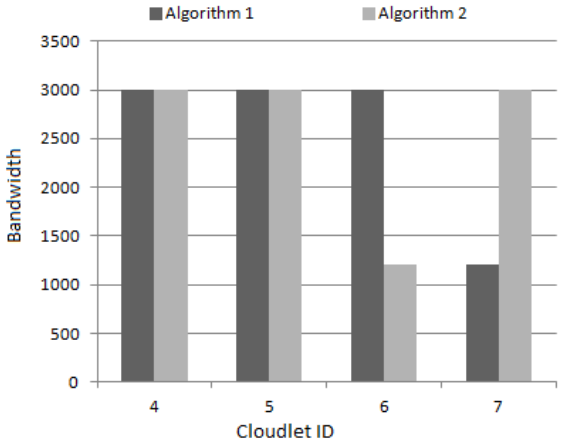

FIGURE 9 Comparison of the Second type of task

Class 2 type of class prefers high bandwidth, which includes task 4-7. Figure 8 shows the comparison of the allocated bandwidth of the virtual machine for the second type of task. Evidently, Algorithm 1 meets better preferences of task with better fairness.

5 Conclusion and future work

In this paper, expectation vector of the task is adjusted using fuzzy logic so that that the fairness in the allocation of the task can be performed. Scheduling algorithm is implemented and verified using extension of CloudSim. The results are compared with the Berger model which shows that the proposed algorithm performs better. It also shows better mathematical association between the parameters to adjust the expectation vector of the classified task. Proposed approach also performed modification in selection of supported virtual machine for a particular task that increased the efficiency of the system.

Further, for accurate results we can use the neural network for quality of service vector of the task to adjust the expectation vector. This will give a better mapping between the task and resources and fairer value of the general vector of the task.

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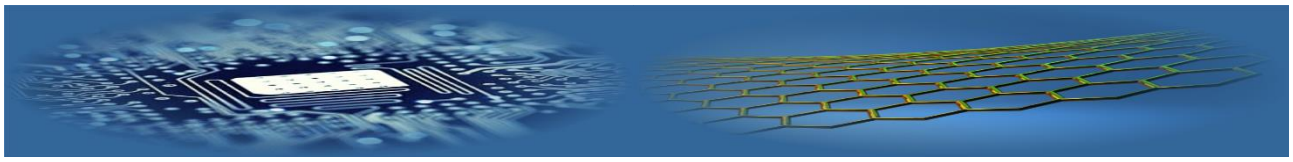

Cognitive evolution in software development life cycle through design thinking

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Abstract

Software engineering is methodical, well-organized and proven approach to the advancement, operation and maintenance of the software. Agility moves toward compact set of process activity. Design thinking is an organized, intellectual process in which designers ideate and validate notion for solving the given problem whose outcome and function fulfills clients' objectives or users' needs under specified set of constraints. This paper describes cognitive impact of design engineering process on software development life cycle (SDLC) in agile development community. The paper also depicts correlation between various design engineering canvases and phases within software development lifecycle in agile models.

Keywords:

Mind Mapping,
Design Thinking,
Agile Methodology,
Storytelling,
Prototyping

1 Agile practices

Software engineering deals with the systematic and qualitative approaches for software development [1]. Traditional process models focus on carefully defined practices, in detail documentation, comprehensive planning and management. Agile practices focus on effectual informal communication among all stakeholders, and iterative enhancement of implementations. Agile practices have introduced prototype move in software development [2]. Agile methods center on quick development of software along with the concerns to flexibility, quality and speed. These methods incorporate valuable increase in responsiveness to the customers. The agile development requires backbone knowledge and skills of developers as well as changes in requirements as well as developing and targeted environment. The agile practices include various models such as Extreme Programming, SCRUM, DSDM, Adaptive Software Development, Crystal, Feature-Driven Development, pragmatic Programming [3]. Extreme Programming (XP) proposed by Kent Beck in 2004 [4]. XP is a way of software development based on the values of communication, feedback, simplicity, courage, and respect. SCRUM is a software development method initially planned by Schwaber and Beedle in 1990 [5]. SCRUM development method divides the whole set of changing requirement in terms of packets. The current work unit is defined as sprints, which is a stable set of requirement. Sprints are derived from Backlog. Backlog is a set of an existing but changing set of requirement.

Dynamic Systems Development method (DSDM) is introduced by UK based Consortium of organizations [6]. DSDM is an agile software development approach that provides a structure for software development and maintenance for time critical high quality business requirements.

Adaptive Software Development (ASD) projected by Jim Highsmith (2000) [7]. ASD introduced complex software development through three phases- speculation, collaborations and learning.

Crystal is a family of process models proposed by Cockburn and Highsmith [8, 9]. Crystal process models allow frequent delivery, close communication and reflective improvement [9].

Feature-Driven Development (FDD) proposed by Peter Coad et al [8]. FDD is an object-oriented software engineering process model. FDD defines various client valued functions as features to be implemented in short span of time.

2 Design thinking for social needs

"Design is a process especially suited to divergent thinking-exploration of new choice and alternative solutions"- Tim Brown, President and CEO of IDEO.

The core of Design Thinking is innovating through the perception of the end user. It invigorates in-the-field research that builds empathy for people.

It is the requirement of the hour to observe what the people need, what technology can do (through agile development) and what is profitable.

To come up with an innovative solution that really matters to the mass, we ought to change our mindset of exploring the pain points of the user in the society. It would be unethical to hypothesize (like traditional software development strategies) the people's problems and try to fit in solutions that do not really matter.

Hence, Design Thinking is one methodology that is paving a way towards this endeavor.

The five-step framework for Design Thinking is:

1. **Empathize** – Empathy is the foundation of a human-centred design process [10]. It is to be noted that the problems that you are trying to solve are rarely your own- they are those of particular users.
2. **Define** – The define mode is the unpacking and coalescence of empathy findings into conclusive needs and perception. It deals with defining clear and meaningful challenge to be met. What it aims is focus on the user and the context of the user and then come

up with practical and applicable problem definition.

3. **Ideate** – The purpose of ideation is to focus on the exploration of solutions for the problem identified for the users.
4. **Prototype** – The main aim of developing a prototype is to get ideas and explorations out of the head into the physical world. The most fruitful and successful prototype constructed is the one that when people can experience and interact i.e working prototype.
5. **Test** – The refinement of solutions and to learn further about the users can be carried out in the form of feedback. Testing is the chance to get feedback on the solutions for its betterment.

3 Design thinking canvases

AEIOU Design Thinking Worksheets developed by Mark Baskinger and Bruce Hanington [11] is an interrelated framework that guides designers in thinking through a problem or scenario from a variety of perspectives: activities, environments, interactions, objects and users. They are useful in organizing thoughts, observations and ideas into distinct categories.

Empathy Mapping is the means by which one can extract what the client is thinking. It is a highly collaborative exercise that involves all the stakeholders who hold concern. A product or service without users is worthless. Unless the entire team is crystal clear as to how and why the users might want to use the product and service, it would not get much propulsion among the audience.

The empathy mapping is carried out by observing the following four traits of the end-user as you review your notes, audio and video from the fieldwork [11]:

SAY: What are some quotes and defining words your user said?

DO: What actions and behaviours did you notice?

THINK: What might your user be thinking? What does this tell you about his or her belief?

FEEL: What emotions might your subject be feeling?

Ideation

3.1 PRODUCT DEVELOPMENT CANVAS

The product canvas describes the big picture and the product details [12]. It encompasses user interaction, the functionality, the design, and operational qualities such as performance, robustness, interoperability and security. This canvas is designed to work in tandem with Scrum, Lean and Startup. It depicts and captures the UX, and supports a user-centered design approach.

4 Agile models and design thinking

Ken Schwaber in [13] introduced SCRUM, which produces prototype, which is responsive in current and additional requirement revealed during the constant development. SCRUM has sprint phases where analysis, design, and development of current customer requirements are performed with flexibility at concern. This leads to the development of prototype of current requirement.

Broderick Crawford et al., in [14] introduced creative thinking in extreme programming. Extreme programming embraces the change at any phase in agile mode. The agile mode allows the direct interaction of development team with customers that is a user centered approach. User centre approach causes implementing creativity required for customers requirement satisfaction.

Design Thinking is an innovation process with a fundamentally human-centered approach. However, it is not simply about doing what the customer tells you, but watching and observing what the customer is facing and solving that problem [15].

Its value is not only how well an individual develops the problem solving skills to create "products" but also how he/she can begin to develop higher-order thinking skills to solve some of society's greatest system challenges [15].

Inquire, Ideate and Rapid prototyping are the main stages of Design Thinking. Identify and define a problem or challenge and reframe it into an opportunity which can then be used as the basis for a design project. Ponder on these questions to obtain a clue - What Is? What If? What Wows? What Works? [16]. Through a range of ideation design strategies come up with potential solutions to the identified challenge. Get the feedback for the ideas and based on these feedbacks choose and select one idea to begin the prototyping of the potential solution. Rapid prototyping is used as a tool for testing and redefining ideas. The prototype has to be constructed within a limited timeframe to propel to action rather than thinking [16].

"Design Thinking is a critical mix of Storytelling and prototyping"- Mark Zeh, former IDEO design leader [17]. Communication of knowledge is not through raw data but through data in context that construct a story. Knowledge is captured in stories. Building narratives is how communication is carried of customer's problem to others in the product team. Storytelling is used throughout the Design Thinking activities. Prototypes are the props. A prototype is something that you can engage with physically. It is a tool to help us communicate and test ideas. Putting the prototype into the hands of the customers actually causes them to think differently than simply talking about the concept. By iterating through prototypes with customers, designers can learn what product features are needed and what design constraints exist [16].

5 Discussion

Requirement Gathering is always a challenging phase in software development. The traditional requirement gathering techniques are too stringent and involves a handful of people. It does not focus on collaborative exercise of all the stakeholder involved in the interest of the product or service. This leads to a product or service that may not satiate the needs of the end-user.

Today innovation is the need of the hour for many organizations to survive in the competitive race. Innovation deals with discovering solutions that are novel and at the same time resolves the pain areas of the end-user.

To achieve this we need a methodology that empathizes and not only understands the end-user's pragmatic requirement.

Visualizing ideas is the most influential way to communicate to others. Therefore, *mind mapping* is one such strategy that facilitates in drawing our ideas on paper and connects the dots. This is a highly effective technique that accelerates the requirement gathering in agile software

development. It is a highly collaborative task that may involve business experts, end users, programmers, product owners, business analyst, testers, database experts, system administrators. It is an effective tool for seeing the whole story on a high-level**.** Mind mapping helps the agile development to extract the most imperative requirements cognitively.

Designing a more fruitful shopping experience for a value seeking customer: - The design is influenced by observation of the purchasing process of someone that goes to the shopping mall(offline shopping) on a "need to go" basis. The key insight learn is that -consumers are busier and have less free time to shop in stores; smart phones, tablets, conference calls, email, social network and video streaming all help provide efficient communication and more; and consumer preferences are shifting toward what can be done quickly and efficiently.

These insights drove the creation of prototypes using the Agile Story Mapping mechanism.

Story Mapping is an engaging activity where all participants are involved in the process of building a product backlog on a wall versus writing a dull 100-page requirement document. It is a top-down approach of requirement gathering and is represented as a tree. It starts from an overarching vision which is achieved via goals. Goals are reached by completing activities. To complete activities user needs to perform tasks. These tasks can be transformed into user stories for software development [19].

Goal > Activities > Tasks > Stories

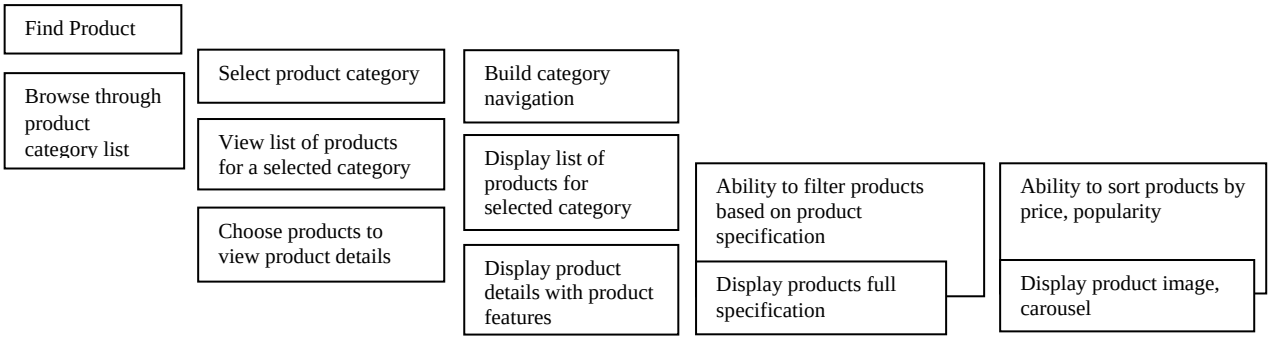

FIGURE 1 Story mapping

Goal- As shown in figure 1 "Find a Product"
Activities -

1. Browse through the product categories
2. Free text search
3. Promoted products

For Activity 1, following are the tasks

1. Select product category
2. View list of products for a selected category
3. Choose product to view product details

TABLE 1 Design thinking to agile methodology- a roadmap

Design Thinking	Agile Methodology
It is a human-centered approach to defining and solving problems.	It involves the end-users from initial to completion stage of the product development.
It is suitable in situations where the problem itself is not clear.	It embraces uncertainty and is suitable for projects where requirements are subject to change (Extreme Programming).
Ad hoc conversations to discuss particular ideas and solutions.	Conversations are the engine room of shared understanding where breakthrough moments can occur.(SCRUM)
A critical mix of Storytelling and Prototyping.	Story telling leads to feature specification and implementation(SCRUM)
A limited time frame for rapid prototyping to propel action rather than thinking.	Content is more important than representation (AM model)
It encourages a multitude of possibilities.	Focuses on a model of purpose and permits multiple models (AM model)
Divergent thinking to form creative ideas	Convergent thinking to come up with a product from a prototype
Rapid prototyping	Rapid implementation
Uses mind mapping technique for requirement gathering to identify and define problems and challenges.	Stories with priorities

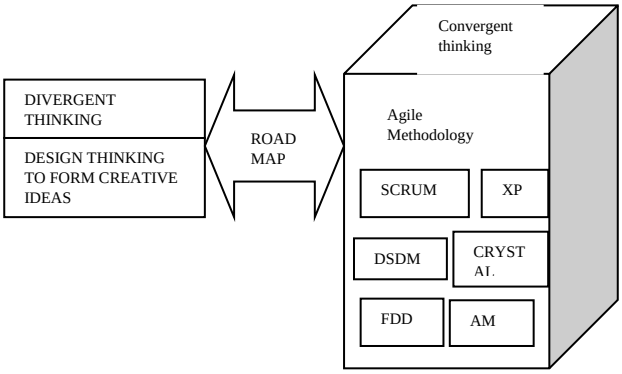

FIGURE 2 A Road map from DT to agile methodology

Table 1 and Figure 2 show the roadmap that connects design thinking and agile methodology cognitively. Human-centred approach in design thinking leads divergent thinking that is formation of creative ideas for defining and solving user problems which enriches end user involvement in agile methodology intellectually. Design thinking has ideas to deal situations where problem itself is not clear. This can lead to a continuous change in requirement. This change as well as uncertainty in requirement is embraced by Extreme Programming technique of agile development model. Design thinking and agile methods such as SCRUM are always welcoming the informal, face-to-face, ad hoc conversation between various stakeholders of the project. Story telling in

design thinking clears the problem statement which guides to feature specification (user stories) in agile development (SCRUM). A limited time frame for rapid prototyping in design thinking results to proper action which cognitively leads to Agile modeling where content (immediate end product) is more important than representation. Design thinking has rationale of rapid prototype and this rapid prototype can be implemented rapidly by agile methodology. Moreover, mind mapping techniques for requirement gathering in design thinking can be converted to user stories with priorities of agile methodology.

6 Conclusion

Agile development culture can be enhanced using Design thinking mindset/tactics cognitively. Design Thinking helps us to understand our customers- getting to the 'why' behind what they do and then exploring crazy ideas that might lead to a unique offering that our customer will love. Design thinking serves to understand a need and generate a creative solution which can be implemented and deployed with software engineering lite that is agile methodology. Thus the agile culture overlaps perfectly with the prototyping stage of design thinking.

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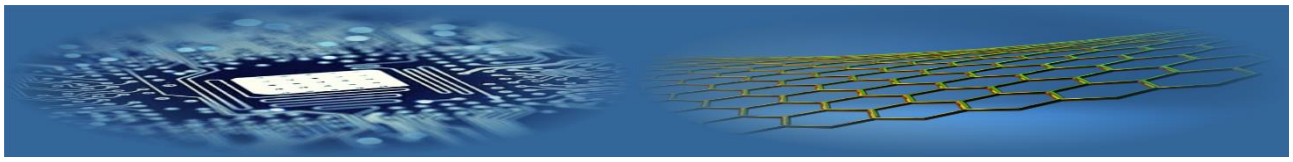

Optimal implementation of critical peak pricing in cloud computing

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Abstract

Cloud computing offers a variety of services and hence the opportunity to make profit by using a suitable pricing strategy by selling these services. Yet, the instability of the dynamic price, create a risk for cloud tenants so as to effectively implement a pricing strategy which is beneficial for both tenants and end user. To overcome the dynamic price risk for tenant, method of dynamic pricing scheme between tenants and end user is employed. This paper proposes a model of dynamic pricing scheme, i.e. Critical Peak Pricing based on demand response program for profit of cloud tenants as well as end user satisfaction. The proposed model used the price responsiveness model of end user and the parameters of Critical Peak Pricing that simultaneously affects the benefit of cloud tenants and end user.

Keywords:

Cloud computing,
critical peak pricing (CPP),
demand response,
critical days,
cloud tenant,
end user

1 Introduction

Cloud computing offers a variety of computing services to the end user. There are several companies such as IBM, Google, Amazon are making huge investment in cloud computing. Therefore, the emergence of cloud computing in the market will change the IT sectors into IT industry. In a simple way, cloud resources like CPU, storage, network domain, memory etc are quoted as the utility in cloud computing which is rented by the cloud service provider to user as per demand [1]. Cloud Service provider (CSP) like Amazon EC2, Google, and Microsoft Azure etc. offers resources in the form of virtual machine (VMs) using various pricing scheme such as pay per use, on demand etc. As per the end user perspective, honesty is a major concern in resource pricing and allocation [2]. As far as economics is concerned, fairness is major concern in cloud computing. If pricing is unfair, users get disappointed and as a result CSP fail to gain the loyalty of users. Additionally, the loyalty of users also affects the utilization of the services of the datacenters.

Mostly, the user would pay on the basis of amount of resources they used. This pricing scheme termed as pay as you go model or pay per use [3]. User's demand of computing resources are either scaled up or scaled down based on their needs. But they used to pay according to price fixed by cloud service provider. Consider the example, Billing period of Amazon EC2 on demand instance is 1hour.if user want to use virtual machine for 10 minutes or 1hour they have to pay the same price. Therefore, it leads to serious problem for users whose demands are not consistent in nature. Moreover, as increase in demand of users cloud computing become worldwide that creates more heterogeneous infrastructure. Result in user's challenges for selecting the appropriate CSP for their increasing as well as time varying demand. To reduce this problem at some extent, cloud tenant are introduced in cloud environment. Cloud tenants are worked as agent between the cloud service provider and end user. Users are requested their demand to the cloud tenants. And the cloud tenant's rents virtual machines from CSP to service the users demand. They charge the end user based on the utilization of VMs is used to service their request. Since these tenants are not only developing the new technologies related to migration, virtualization etc. but they are also addressing the new provisioning and pricing scheme to provide the resources to the end users efficiently [4]. Therefore, the tenants invested in cloud market to maximize their profit and end user satisfaction. In existing scenario, the tenants can have made a profit by matching the end users demand with provider's s. They used the various methods to get optimal prices between these providers and end users.

The spot pricing is started by Amazon web services in 2009 for selling unused capacity of resources. The spot pricing is known as real time price or market price or dynamic price which is change over based on demand and supply [5]. The real-time price is far below than on demand and reserve price of services [6].

So, real time price is more efficient for tenants to purchase the resources than on demand pricing but the issues are that how to effectively implement the pricing scheme that tenants also increased their profit and provides benefit to the end user.

In cloud, DR is the action to change the cloud services demand with response to changes in prices. So, Demand response can be considered as the instantaneously demand controlling. It is often more expensive to build new datacenters. Therefore, it is better and efficient solution for balancing the demand and supply is to cut or shift the demand.

The proposed model deal with the Virtual machine pricing design of Cloud tenants whose end users engaged in price sensitive demand response. Our approach modeling the optimal Critical Peak Pricing implementation strategy for

incrementing in profit of cloud tenants via reducing their purchasing cost of Virtual Machine (VMs) and taken in to account for end user satisfaction in term of reducing their Virtual Machine cost. Most of the research work has been done earlier for profit maximization of cloud provider or datacenters using DR which is implemented between cloud service provider and tenants. Therefore, cloud service provider profit depends on tenant's demand, and tenants demand depends on the end user satisfaction. If the end user is not participating conveniently during peak load of service then, tenant's demands directly effects on data center profit during peak load of service. So, the proposed model aims to balance the satisfaction between tenants and end user especially in term of benefit. This approach is used for multi-party win.

2 Motivation

In electricity market, Load Serving Entities (LSEs) are suppliers who supplies electricity to the retail customers [7]. In the Deregulation of electricity market, DR program is implemented that make capable market participants to take responsibilities as well as action [9]. Accordingly, the demand response programs make customer enable to adjust their consumption pattern of power which enhances the efficiency of power system by reducing the peak demand [8]. As mentioned in [10], Demand response programs can be classified into two classes: Time based program and Incentive based program. Time based Program includes Time of Use (TOU) Program, Real time Pricing (RTP) Program, Critical peak Pricing (CPP) which are used to determine the price for different periods as per supply e.g. high price for peak load period, low prices for low load period. While Incentive based program includes Direct Load Control (DLC), Capacity Market program (CAP), Interruptible Curtailable Service, Demand Bidding Buy Back, Emergency Demand Response program (EDRP), Ancillary Service Market. These programs provide incentive if the consumption of power is reduced by the customer, and if they do not reduce load then penalty is applicable in various forms.

In cloud computing in order to attract the users, tenants should offer the service that reduces the service charge of users. That is why the cloud tenant's aim is to reduce their service purchasing cost and provides benefits to end user by reducing their selling cost of service.

Cloud tenants can earn profit by purchasing the service from cloud provider at dynamic price and reselling to users its own retail price. If demand response program would be used in cloud, user will also be able to participate to increase the efficiency of cloud by adjusting their demand pattern at peak demand of cloud services i.e. DR program implementation will make users able to take appropriate action or responsibility.

3 Related works

Demand response (DR) is one of the program which recently identified a method for profitable operation of data centers [11]. DR is motivated by the power system that has used to balance the electricity demand and supply at all level of power grid [12]. In electricity market environment, different types of DR program are used for decision making of pricing of electricity [13].This section listed the research work related to our proposed model.

[14] Provide a framework for DR program in cloud. The DR based on dynamic pricing scheme used for geo distributed data center (DCs) to maximize its profit. In this work [14] decision making of DCs is difficult because of dependency on each utility. Utilities set their price when they know the total demand also DCs demand. It is possible only when the price is available. [15], [16] the two works presented pricing strategies for maximizing the profit of cloud brokers. To serve the demand at each time slots based on the reserve instance or on demand instance pricing scheme. If the demand is remaining continuously for a long time then it has used the Reserve instance scheme. If users demand falls instantly it used on demand instance. [17] Proposed a pricing framework based on leader-follower game with the aim of maximize the cloud's profit. These frameworks recoup the energy cost with its tenants for profitability. Energy cost is big contributor in overall cost of cloud provider. In [17], DR program is carrying out between tenants and service provider. Tenants are price sensitive so the VMs procure by the tenants in response of prices set via provider. They perform empirical and analytical evaluation using myopic control with short term prediction of price and workloads.

Most of the research work mentioned above, does not considered the tenants profit with respective of end user satisfaction with demand response program.

4 Proposed model

In presented work, we proposed the DR program based Critical Peak pricing that improve the relationship between cloud tenants and end user. Critical Peak Pricing is a dynamic pricing model that is designed to reward the participating user that shift or reduce their demand during on peak hour to off peak hours. Basically, critical peak pricing is a tariff plan which is applied to the end user in electricity market. When the end users have massive demand of services refers to on peak hour and less demand refers to the off-peak hours. CPP includes four schemes [18]: Variable-Period CPP (CPP-V), Variable Peak Pricing (VPP), critical peak rebates and Fixed-Period CPP (CPP-F). This work analysis on CPP-F scheme to offers the services to user and then optimally implements the CPP scheme between them. The proposed pricing scheme categorizes the days in critical days and non-critical days. Therefore, during critical day cloud tenants charge high price from end users. Typically, this scheme has predefined the number of critical days, starting and ending time of critical periods. Critical Peak Period is limited in a month (16-18hr in month) that is invoked by tenants. So, users are informed by the cloud tenants about the critical days of services in day-ahead, and thus end user can change their strategy for utilization of services.

Critical days and non-critical days are recognized by the days with and without critical periods. In CPP-F scheme, there are only limited critical days are present; it is significant for tenants to implement the optimal CPP scheme strategies to increase its profit [19]. So, tenants must choose the proper critical days to increase their profit and return benefit to end user in non-critical days. Thisproposed pricing scheme aim to realize multiparty win.

4.1 NEED OF CPP

There is very hard for cloud tenants to exist in competitive market of cloud as they are bound to offer the services to the user at low price as possible. However, if the tenants could not fulfill the expectation of end user they can never exists in this competitive market. So, the tenant's requirement is to fulfill user's expectations also their own expectations. How it is possible for tenants to fulfill their requirements as well as user's expectation simultaneously. Since, service provider also always wants to maximize their profit. So, it provides the services in such a way that it always gets profit. If tenants purchase the services in real time price and reselling the service to end users at fixed prices, it does not allow the tenant to adjust their price of service with regardsto time and demand. End user also gets affected if the services are underutilized mainly when the service prices are high. So, it is better opportunity to provide the services by tenant to user in dynamic way.

As the tenants work in the cloud computing market as a retailer, so it procures the services in time varying prices and to attract the end user, they use own pricing model to provide the benefit to end users. CPP scheme is one of the dynamic mechanisms used for developing a pricing model which is efficiently works between tenants and enduser.

4.2 SYSTEM MODEL

In cloud computing, the cloud tenants receive the resources from different kind of cloud provider and construct virtualized resources for the end user. The cloud tenants buy the various kinds of resources from the cloud e.g., Virtual Machine (VM), Software Services and Storage, etc. with a range of pricing scheme e.g. on-demand pricing, spot pricing and reserve based pricing etc. Generally, tenants try to buy the resources at minimum prices from the service providers.

We consider a simple system in which single type of instances i.e. VM is procured by tenants from the Cloud Service provider and resell to end user. Since, cloud tenants cannot be considered as cloud service provider because tenants only purchase the services and resell them. Instead, the tenant's deal with cloud service provide for services. However, the service provider provides the resources and the capabilities in the form of services. Hence, tenants procure the services from the provider at real time price and resells to user based on the demands using its own pricing scheme. Numerous enterprise and business are moving towards the cloud computing to grow their business using cloud service and this tendency also maintained in future [20]. The cloud tenants are increases their investment into cloud computing, because the price responsive of users will help to increase their profit e.g. the video steaming giant Netflix acquires its computational resource from the Amazon's EC2 cloud [21]. Figure.1 illustrates the model of general cloud ecosystem and highlights the elements which are used in the model [22].

- Cloud-Tenants

The Cloud service provider (CSP) sold the services at real time price to the tenants. The service demand of tenants depends on the service demands of end users. So, Tenants need to predict the future demand of end users. Therefore, tenant's purchase the services from the CSP equal to selling of services to the users. In order to decide the critical day, Tenants used the price forecasting model to predict the price of services in day ahead before the delivery of services. Accordingly, tenants set their own price of services based on the decision of critical day. The realizations of purposed model will base on CPP-F pricing scheme policy.

- Tenants-Users

The cloud tenant's charges its users based on CPP pricing scheme. The tenant would choose the optimal price of services that increase their revenue and also return benefit to the end user. Tenants are the entities that must maintain the trust of end-users. So, in trade of exchange services with price is transparent to end users. So, Users would inform of critical day one day ahead so, they are effectively participated in Demand Response program; e.g., a Netflix play the crucial role informs of manages and control in responses, in the different variations of capacity of resources of Amazon EC2 VMs [20]. If end users are not well participated in Demand Response Program they suffered by loss. In developing the model, user's responses to CPP are explained via User price responsive model of demand.

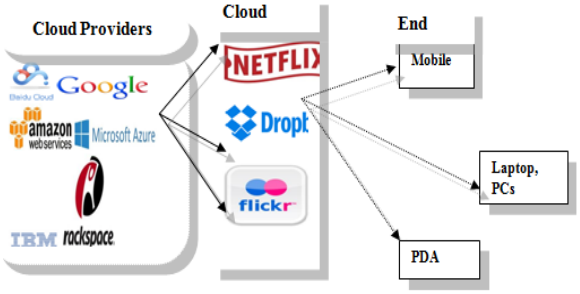

FIGURE 1 Illustrative Model of general cloud ecosystem and its elements [22]

4.3 CPP IMPLEMENTATION SCHEME

End Users plays a key role in implementation of CPP scheme in cloud computing. In order to allow end user, participate conveniently, includes the price structure of Services in CPP scheme during non-critical days and critical days [23]. Table 1 show the hour of the day pattern price structure in CPP scheme. End users shifts or reduce the workloads of services during critical days. In non-critical day, end user obtains a price discount during non-critical days of on peak periods. So, they will encourage to actively participating in CPP.

TABLE 1 Hour of the day's pattern and price structure in CPP

CPP days	Off peak periods	On peak periods	Critical peak periods
Critical day	p_{off}	p_{on}	p_{peak}
Non-critical days	p_{off}	p_{base}	–

The critical days are separated in to critical peak periods, on peak periods, off peak periods. While non-critical days are categorizing in to on-peak periods and off-peak period. In proposed approach tenants also offers the service based on critical day and non-critical days. In off-peak period the tenants sell the services to user in same price they purchased because in this time period service provider offers the services in low price. While in on- peak period service

providers offer the services in high cost to tenants because at this period time real time price is high. So, this particular time periods, tenants offer the services to the end users in discount price referred to p_{base} which is less than the real-time price ($p_{base} < p_{RTP}$). The price during critical peak periods is very expensive because of real time price is extremely high. So, tenant charge the users during this period is very high to the users refer to p_{peak} which is greater than the real-time price ($p_{peak} >> p_{RTP}$). At critical time periods, users either shift or cut the demand of services. It is because tenants provide the notification of critical day in day ahead after prediction of next day price. Actually, the users respond to extremely high price not the usage of services. Only those users are willing to pay for services that have great need of services.

4.4 USER PRICE RESPONSIVE MODEL

In proposed model, real time price change in each hour, so tenants expected revenue depend on the end user demands of services as well as cost of services. As assumption, tenants purchased the services from the CSP in RTP that would change in specified time period (1hour). So, the price elasticity of demand can measure the performance of dynamic pricing scheme that represents the customer sensitivity of demand corresponding to price. Therefore, Price elasticity of demand plays a key role for tenants in designing the rational service price scheme. To maximize the expected revenue, tenants use the demand price elasticity intended for receiving the response of users.

Price elasticity of demand can measure the change in demand in response to change in price [25]. This is formulate as-

$$E = \frac{\Delta d/d}{\Delta p/p}. \quad (1)$$

Since, the Δd and Δp represents the change in demand and price and p and q signify that initial demand and price. Usually, any commodity does not cover linear price – demand curve [18]. So, elasticity E could be linear by balancing the initial demand and price (d_0, p_0). So, one equilibrium point is necessary for each period because prices and demands decrease if the prices are above the equilibrium points (d_0, p_0) [18]. In cloud, users demand response to price could not justify by the price of particular period only, but also depends on the price of services in adjacent periods. Because users can be described into two categories, 1) short range users 2) long range users. Long ranges users can decide their demand by concerning the price in all periods to maximize the long-term benefit. Where short range users set, their demand based on price of current period. To identify the demand response of users in corresponding of price can be determined by using the coefficient of self elasticity and cross elasticity. Self elasticity measure the demand reduction in particular time interval corresponding to price of that interval. Cross elasticity measure the demand of certain interval in respect of price of another interval [26]. So, it would describe the user demand response of price in single period as well as in multi period. These two coefficients are integrated together to express overall demand price elasticity of service of the users.

$$\begin{bmatrix} \Delta d_1/d_1 \\ \Delta d_2/d_2 \\ \Delta d_3/d_3 \\ \vdots \\ \Delta d_l/d_l \end{bmatrix} = E \begin{bmatrix} \Delta p_1/p_1 \\ \Delta p_2/p_2 \\ \Delta p_3/p_3 \\ \vdots \\ \Delta p_l/p_l \end{bmatrix}. \quad (2)$$

So, E can be obtained as;

$$E = \begin{bmatrix} e_{11} & e_{12} & \dots & e_{1l} \\ e_{21} & e_{22} & \dots & e_{2l} \\ \vdots & \vdots & \vdots & \vdots \\ e_{n1} & e_{n2} & \dots & e_{nl} \end{bmatrix}, \quad (3)$$

$$e_{ii=} (\Delta d_i/d_i)/(\Delta p_i/p_i). \quad (4)$$

The above equation signifies that users demand of service in particular period on behalf of price at that period.

$$e_{ij} = (\Delta d_i/d_i)/(\Delta p_j/p_j). \quad (5)$$

The above equation (3) demonstrate that price of services of adjacent period can also affect the demand of users in another period. So, the tenants receive meaningful demand of users in each period. Create the matrix of price elasticity of demand for l=24 hour. The 24-rank matrix of price elasticity E can be obtained via statistical regression analysis of historical data.

Tenant predicts the price of services by using historical data of day ahead price, real time price of actual day of each hour and informs about the critical days when the predicted prices is extremely high. If the end user participated in CPP scheme they change their demand of services or shift their demands when service price is extremely high. So, their response toward the price of service could reflect by the change in demand pattern of services.

The time interval of critical peak period is 1h. So, the users demand corresponding to critical peak period can be changed, it can formulate as;

$$d_{cpp} = d_0 \left\{1 + \frac{E_p(p-p_0)}{p_0}\right\}. \quad (6)$$

This equation (6) implies that users have demand price elasticity E_p, change their demand since d_0 to d_{cpp}. d_{cpp} represents the demand of users change with respect to price when the critical day informed to user. p_0 represents the initial price or nominal prices of services. d_0 represents the demand of users which is forecasted before critical day information. P is the forecasted price of next 24 hr. This demand price elasticity E_p can be obtained from the demand price elasticity matrix which is created through historical data.

5 Methodology

The assumption of the model is; 1) The cloud tenants receive the cloud services from cloud provider in real time price and provide the services using CPP pricing schemes; 2) Cloud tenant procure the services equal to selling of services; 3) Critical peak period are defined with the time period of 1hr and matrix of demand price elasticity would be formed for l = 24; 4) Billing period is n= 30 days; These certain assumptions simplify the diversity of model.

When the CPP scheme implements between tenants and end users, tenants have responsibility to acknowledge the critical days when the predicted price is extremely high that

service provider offered. So, after acknowledgement of critical days, users would reduce their service rent by adjusting their demand of service at critical days which can be realized through user price responsive model. While the users get benefit of price discount of service during non-critical days of on peak periods. The benefit function of end users can be estimated by considering both the critical day and non-critical days as:

$$K(u) = \sum_{i=i_s}^{i_e} u_i \sum_{j=1}^{24}\left(d_o(i,j) * p_o(i,j) - d_{cpp}(i,j) * p_{peak}(i,j)\right) + \sum_{i=i_s}^{i_e}(1-u_i)(d_{0n}(i) * p_{base}(i)), \quad (7)$$

where $u = \{u_i i = i_s, i_s + 1, \ldots\ldots, i_e = 30\}$ and $d_{cpp}(i,j)$ is obtain from the equation (6) it represents the demand during critical peak periods. $d_o(i,j)$ and $p_o(i,j)$ represents the demand of end user and price of service that tenant charged before implementation of CPP scheme in i^{th} days of j^{th} hour. $d_{0n}(i)$ represents the users demands during non-critical days of on peak periods. u_i represents the binary decision variable of critical days and non-critical days ($u_i = 1$ represents critical days and $u_i = 0$ represents non-critical days). $p_{peak}(i,j)$ and $p_{base}(i,j)$ represents the critical peak price and on peak period price that tenants charge the services to the end users. The first part of above mentioned equation (7) represents the service charge reductions in critical days due to reduction in demand of service. The second part represents the service charge reduction due to price discount during non-critical days.

Tenants can reduce their purchasing cost of services from service provider after CPP scheme implementation so, the benefit function of tenants can be formulated as;

$$C(u) = \sum_{i=i_s}^{i_e} u_i \sum_{j=1}^{24}\left(p_{RTP}(i,j) * \left(d_o(i,j) - d_{cpp}(i,j)\right)\right), \quad (8)$$

where $p_{RTP}(i,j)$ represents the purchasing price of services by tenants from service providers in jth hour of ith day. Now, the profit of tenants would be changed after the CPP implementation. It can be determined by the difference between benefit function of tenants and users. To increase the activity of cloud tenants in CPP implementation, cloud tenant must be ensured that increase their profit growth with CPP accomplishment, i.e.

$$C(u) - K(u) \geq 0. \quad (9)$$

The benefit of implementing CPP scheme that provides the benefit in services charge saving for end users and the purchasing cost saving for cloud tenants. CPP implementation strategies can conclude that how to decide and utilize the limited critical days that increased the entire benefits. Thus, the objective function is:

$$\max A(u) = \max\left(K(u) + C(u)\right). \quad (10)$$

Constraints are:

$$C(u) \geq 0, \quad (11)$$

$$K(u) \geq 0, \quad (12)$$

$$C(u) - K(u) \geq 0, \quad (13)$$

$$\sum_{i=i_s}^{i_e} u_i \leq N_{CPP}. \quad (14)$$

$$t_y - t_{y-1} = \Delta t_{min}\left(2 \leq y \leq N_{cpp}\right). \quad (15)$$

(10) is objective function, (11) it ensure that tenants would reduce the purchasing cost and increase the selling price during critical peak periods of all critical days;(12) ensure that users would save service charges by contribution and the responses to CPP; (13) ensure that cloud tenants would increase their profit after implementation of CPP scheme between the tenants and end users ; (14) implies the constraint of maximum permitted number of critical days that tenants offer the services to the users in higher price; (15) implies the constraint that describe the least time interval between the two adjacent critical days.

The abovementioned model is solved through 0-1 integer programming function in Matlab to implement the optimal critical peak pricing in cloud computing. In CPP, cloud tenants generally decide that the next day would be noted as critical day according the price prediction of next day prices of service in advance (i.e., informed to end user in advance). Therefore, the continuous approach, i.e., everyday re-calculating the decision model composing of residual study period, could be used to advance the rationality of decision conclusion. In such a way, next day predicting price in residual study period would be combined efficiently in model solving process.

5.1 PERFORMANCE EVALUATION

To perform the study of model in cloud computing required a real cloud environment. For the study in real cloud environment is more time consuming and expensive because it required a different configuration and real data of price and demand which is not available of 24hr.To evaluate the proposed model using the simulation tool of a mat lab that a better alternative to perform experiment without much paying.

5.2 EXPERIMENT EVALUATION OF OPTIMAL IMPLEMENTATION OF CPP IN CLOUD COMPUTING

To illustrate the study performance of proposed model, using the simulation tools of Mat lab. In cloud computing, virtual machines are defined by CPU in MIPs, Storage in Gigabyte or Megabytes and RAM in Gigabytes or Megabytes. Price of a virtual machine considers the CPU as attributes. To consider the base case, demand request per hour is generated through Poisson distribution with parameter (λ). To evaluate the performance that represents the proposed scenario, one month data of price that being offered by the service provider and demand of VMs per hour (one month) by end user is required. Therefore, the parameters required for study the model as shown in Table 1.

Table 1 Parameter Required to study the model

Parameters	Descriptions
Types of Virtual Machine	1 (single)
CPU (processor)	2x
Memory	1 GB
Storage	2.5 GB
Price range	$ [0.027, 0.2625]
VM request per hour range	[6,20]

To illustrate the behaviour of model used the single service provider, single tenant and the aggregate demand of end users request per hour range between [6, 20]. The price of Virtual machine is dynamically changed per hour within range [0.027, 0.2625].

Decision of critical day taken by the tenants based on price of VMs when it is extremely high. According to the model it is decided by the forecasting of price by the tenants that service provider offers the VMs in next day. Instead of focus on forecasting of price and demand, decision of critical day is taken on the price of VMs that being generated through the normal distribution. In CPP scheme, tenant is informed to the end users in advance to change the pattern of demand of VM.To estimate the actual demand of end user by using price responsive model as given in equation (6).Whenever the critical days are triggered. Since, i_s=1 and i_e=31 it represents that the study periods will span for 31 days, $N_{cpp} = 4$ and $\Delta t_{min} = 24h$. The time period of CPP is classify in to critical peak periods, on peak periods and off peak periods. Therefore, the time duration is on peak period is between 12:00-18:00, critical peak period between the 12:00-16:00 and the remaining time period considered as the off-peak periods. For optimal implementation of CPP select the day as 5th, 17th, 19th, and 26th as the critical days in generated data therefore, $u_5 = u_{17} = u_{19} = u_{26} = 1$.To implement the CPP, end user shift or reduce their demand of VMs from critical peak periods and tenants offer discounted price in non-critical days which ensure that end users obtain the benefit of saving purchasing cost. It is because end users are price sensitive and participated in CPP demand response program. So, the benefit (saving purchasing cost) of end user is calculated as given in equation (7) is 1.107×10^4.The purchasing cost saving for tenant is estimated using the equation (8) is 2.996×10^4. Entire profit increment of tenant estimating from equation (9) is 1.889×10^4. The entire profit of tenants depends on the decision of critical days that how to efficiently utilize the limited critical days. Tenant selling price during critical peak periods is higher than the service provider price of Virtual machine. Due to relatively high price, tenant can effectively stimulate the end users to reduce or shift their demand in critical peak periods by increasing the critical peak price (p_{peak}). As shown in fig.1 effect of CPP implementation that reduce theVMs demand in a critical peak periods of four hour interval. End user also get benefit during non-critical days because the tenant offer the VMs in discounted price (p_{base}) which is lower than service provider price.

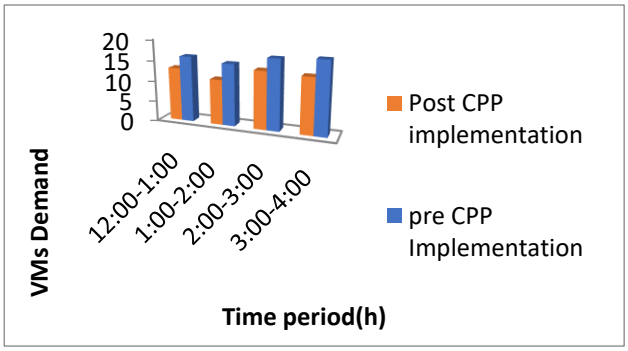

FIGure 1 Illustrate the Role of CPP in reduction of VMs demand

It is clear that reduction in VMs demand during critical periods can also lower the purchasing cost of tenants that ensure the balancing the purchasing cost and selling income, which increased the reliability of tenant to exist in cloud market and relief in shortage of VMs in critical peak hours of the whole system. While combining the tenant selling price during critical peak periods after shifting or reducing the demands of VMs with service provider selling price as shown in fig 2 it illustrates that the selling cost of tenants during critical peak periods is lower than the actual VMs cost of service provider.

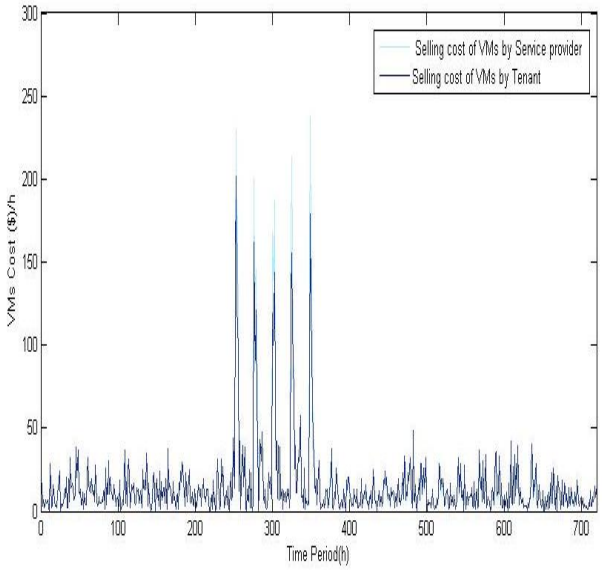

FIGURE 2 Selling cost of tenants during critical peak periods is lower than the actual VMs cost of service provider

Consider the situation in which the N_{cpp} increases while the other parameters are remains same as show in Table 2. Therefore, the actual critical days are increased then profits of tenants increased because users adjust their demand pattern and tenants increased their selling cost in critical days. Because in equation (9) combined the both purchasing cost reduction and selling cost increment. The end user has decreased the saving of purchasing cost because in equation (8) combining the purchasing cost reduction in critical day due to demand adjustment and purchasing charge saving in non-critical day due to reduced selling cost of services by tenants in on peak hours of non-critical days. If N_{cpp} increased to certain degree, for example $N_{cpp} = 5$ then the decision result would not change which is equal to the result of $N_{cpp} = 4$. This is because the actual four critical days are executing, therefore, tenants and users profit would get stable. But in this situation when the N_{cpp} keeps increases, then tenants profit will increase and the end users profit will jeopardize. Hence, the total benefit will be affected. It is also indicated that if $N_{cpp} = 5$ then optimal entire profit will obtain because of same decision result when only actual critical days are executing ($N_{cpp} = 4$).

TABLE 2 Impact of N_{cpp} in Benefit of tenant and end user

N_{CPP}	Benefit of end user ($)	Benefit of tenant ($)	Total Profit increment ($)
5,17	1.637 X 10^4 (4.27%)	2.216 X 10^4 (6.56%)	0.573x10^4 (14.88%)
5,17,19	1.495X10^4 (3.95%)	2.367 X 10^4 (7.06%)	0.872 X 10^4 (17.5%)
5,17,19,26	1.347 X 10^4 (3.58%)	2.496 X 10^4 (7.39%)	1.149 X 10^4 (19.63%)
5,17,19,26	.347 X 10^4 (3.58%)	2.496 X 10^4 (7.39%)	1.149 X 10^4 (19.63%)

6 Comparative study

Real time price increased the efficiency of utilization of services and revenue maximization of service provider because its allow service providers to sell spare or additional capacity in lower price which is less than fixed price (i.e. on demand or reserve price) [5]. Real time price is also claim that it increased the user's satisfaction on overall cloud performance. Real time price is also introduced to encourage the users shift load from peak hour to off peak hour [6]. But the interesting fact is that a user does not shift their work load in real time price they save their purchase cost only by switching to real time price. The additional cost saving is challenging task this can be achieved through the workload shifting. This concludes that the real time pricing does not effectively work to motivate the users to shift their load. Because cloud provider does not provide enough monetary incentive to the users that they shift their workload. To save the additional cost of users only they shift their work load. It is possible only when the users are getting more incentive in monetary. So, to reduce the complexity of heterogeneous environment and save the additional purchasing cost of users, tenants work better between the cloud provider and end users. Since, the tenants efficiently manage the resource and fulfil the expectation of end users. In comparative study, show that if end users rent the virtual machine directly from the service provider how much they pay to them. Secondly, end users rent the virtual machine directly from the tenants, how much they obtain benefit either in renting virtual machines from the service providers or from tenants. Suppose that Single user have 1 month demand of Virtual machine of each hour in each day. Using the Poisson distribution and generate the demand of single users of 1 month. Assume that 4 days are critical days in which 12:00 - 4:00 p.m. are critical peak periods and remaining days are non-critical day and fixed the duration of 12:00 - 6:00 p.m. is on peak periods. Demand of VMs by single users is shown in fig 3. Price of Virtual machine that service provider is being used to offer the services to users are change hourly as per demand of users [5].

Using normal distributions used to generate the cost of single virtual machine cost per hour of one month [6]. Now, there is no early notification of critical day so the user does not shift their demands of Virtual machine they pay the same price of VMs that the service provider charged. This can be shown in Fig 4 that VMs cost pay by users to service provider. While the user purchased the VMs from the tenants they have to pay less cost to tenants then service provider because the early notification of critical day by the tenants make easier to take decision by users to shift their work load as shown in Fig 5. Therefore, the users shift their work load to save their purchasing cost.

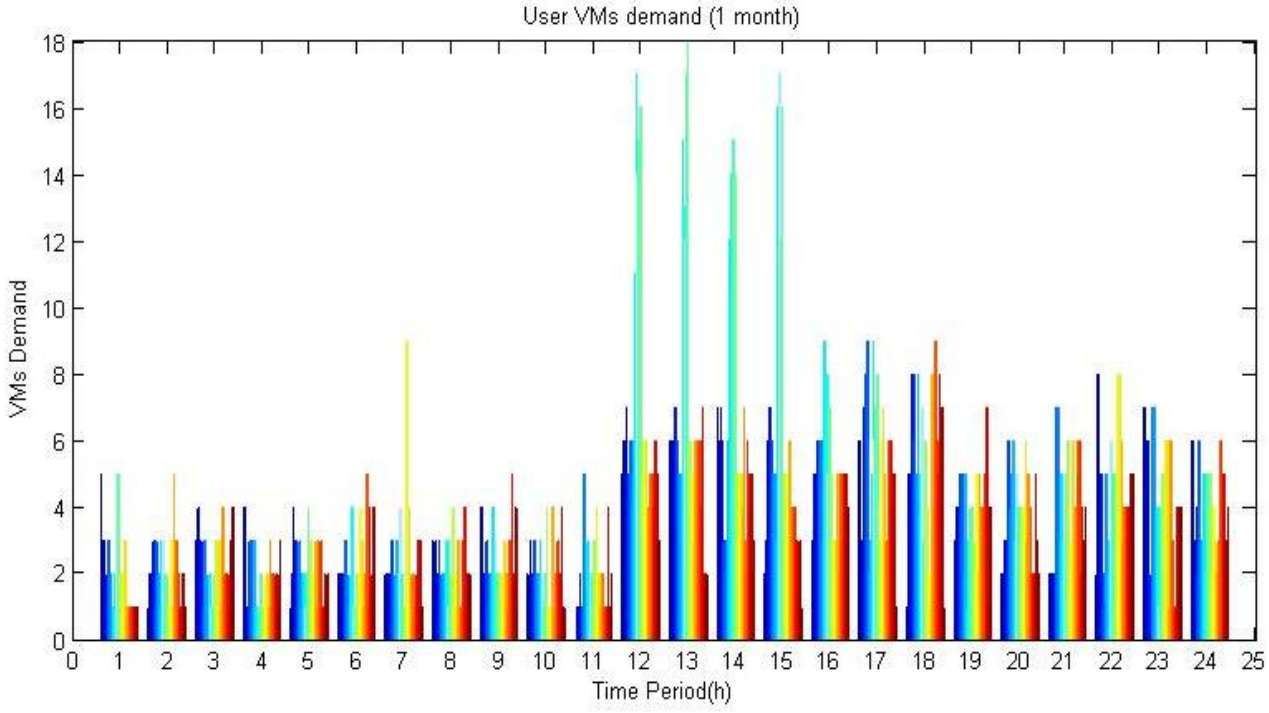

FIGURE 3 User VMs demand to Service Provider

This can be shown in Fig 6 purchasing cost of VMs pay by users to tenants. Critical peak pricing scheme is more efficiently work in cloud computing environment because this enables the user to shift their workload and allow the end users to save their purchasing cost. In addition, demand of same users is shift in CPP scheme that normalized the peak load of critical peak periods and shifted in non-critical days. Therefore, it improves the balance of demand and supply. It is also ensuring the tenants profit because if users shift their demand in critical peak hours then tenants purchasing costs also reduced in critical days. Table 3 shows the comparison of purchasing cost of users from tenants and service provider. Table 4 shows the profit of tenants and users in CPP Scheme.

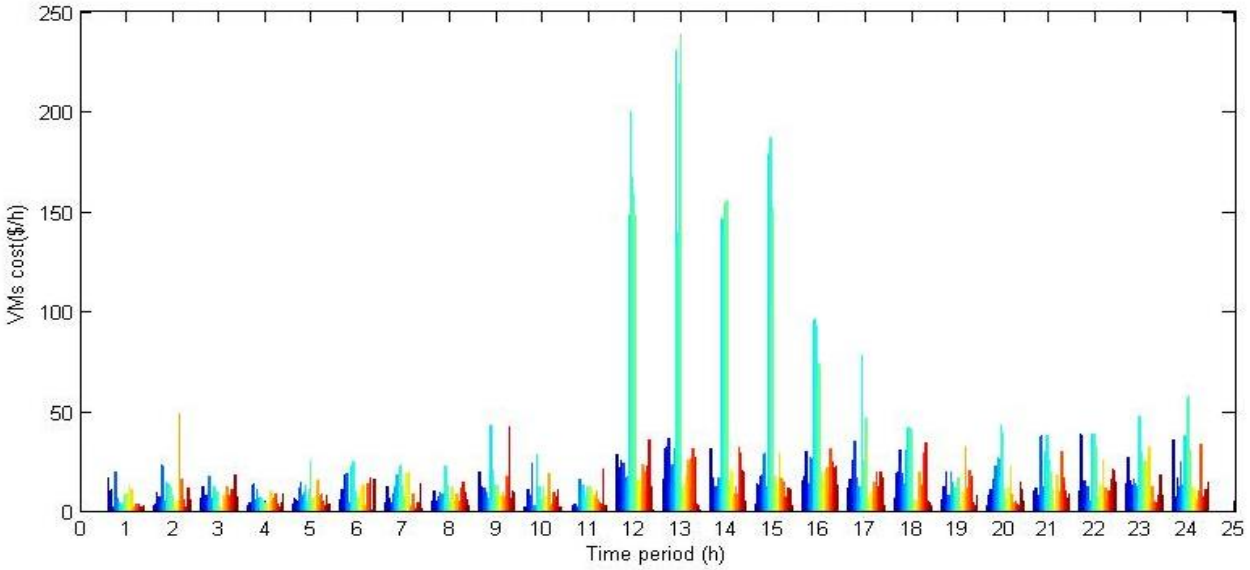

FIGURE 4 User VMs cost pay to Service Provider

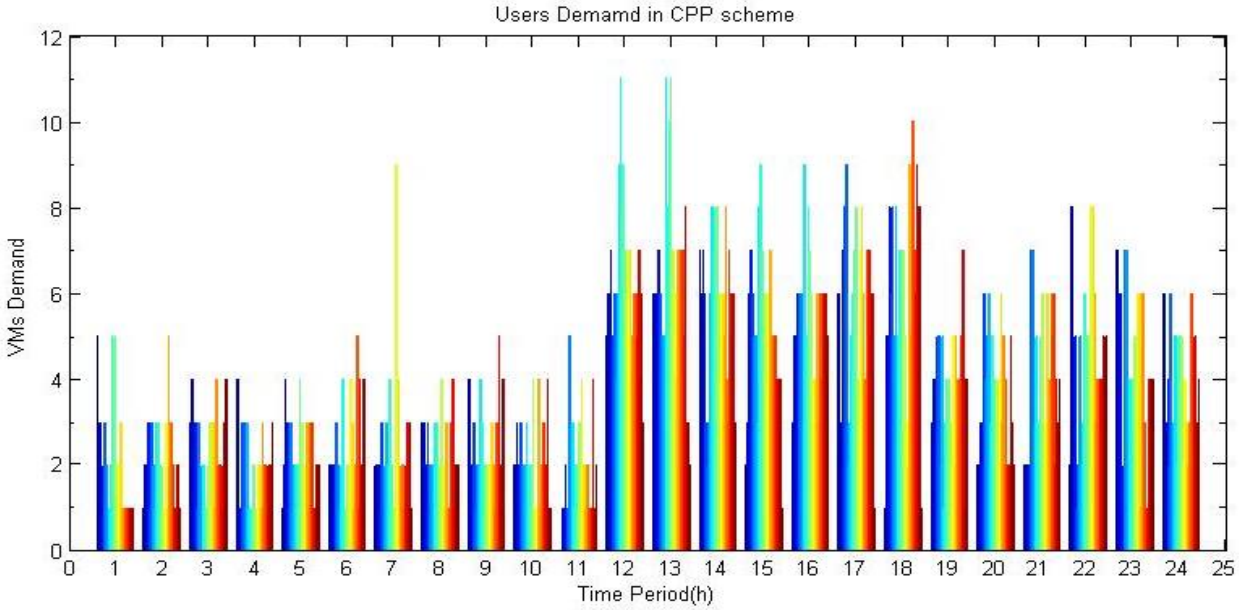

FIGURE 5 User VMs demand to Tenants

Comparison of tenants and service provider cost illustrate that users have less pay to tenants and getting approximate 4.11% profit in purchasing VMs. Additionally, due to incentive monetary users are shifting their demand of VMs in critical day to non-critical. This is profitable for tenants and service provider both because reduced in demand of VMs decreased the purchasing cost and also decreased the peak load of services in critical peak hour.

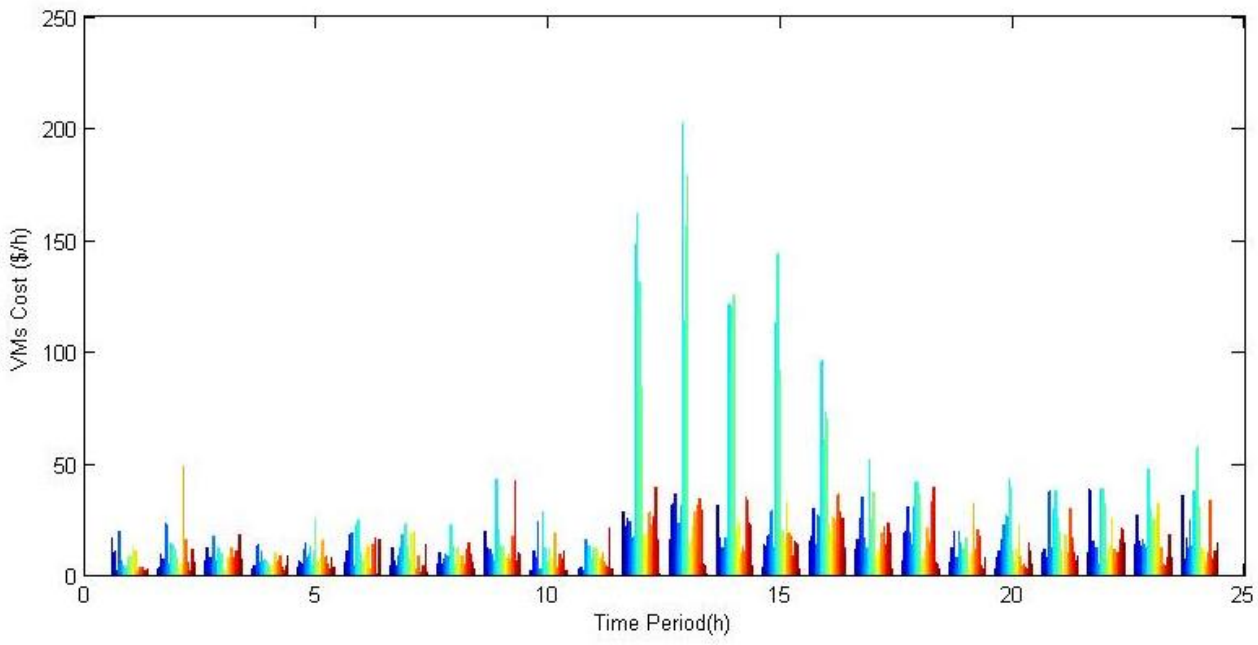

FIGURE 6 Reduced VMs cost pay to tenants

Tenants profit must be higher than the profit of users to exist in cloud market environment. Therefore, the existence of tenants must be possible if users are conveniently participating in cloud computing.

TABLE 3 Profit of an End User (When purchased through tenant)

Purchasing cost from Service Provider (1 month)	Purchasing Cost from Tenant (1 month)	Profit of Users (%)
1.1492×10^4	1.0994×10^4	0.0498×10^4 4.11%

TABLE 4 Profit of Tenant

Purchasing Cost Of tenant ($)	Selling Cost Of tenants($)	Total Profit of tenants ($)
1.0292×10^4	1.0994×10^4	0.0702×10^4 (14.14 %)

7 Discussion and conclusion

This work deal with the implementation of critical peak pricing scheme in cloud computing which works between the tenants and end user. This scheme is based on the user's response through price responsive model which incorporate the sensitiveness of user toward the price of services. The problem faced by the tenants in cloud computing is that they purchase the resources from service provider at dynamic price but how to further sell that they get profit with end users satisfaction. To resolve this problem, dynamic pricing scheme is implemented between the tenants and end user. It is designed for satisfactory benefit to both of tenants and users. So, firstly we designed the hour of the day pattern in which the services provided to the user are based on the particular structure. Therefore, by using forecasting method, the demand and price of services were predicted. If the next day price is extremely high then tenants notify the end-user. So, this can be realized through user price responsive model. The DR program, CPP scheme is used by the cloud tenants that work in a cloud environment; it should be appropriately designed to meet the objective such as profit increment of tenant with workload reduction and return benefit to the end users in reducing services cost of user. From table 6.4 and 6.5 it is evident that both tenant and end user are making 14% and 5% using the said scheme as compared to the traditional way of purchasing the services on cloud.

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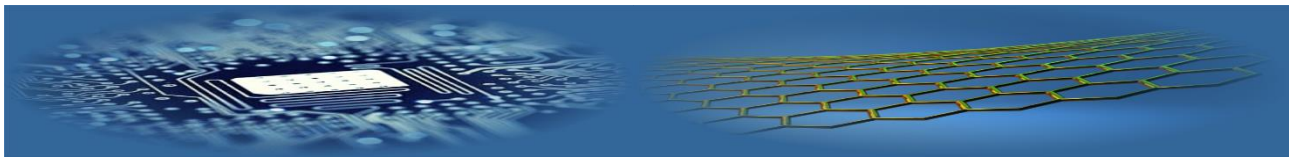

Computer modelling in the physics course for IT students

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Abstract

Since today's students have a great interest in information and communication technologies (ICT), we must recognize that it contains a significant potential for development innovative approaches to learning and teaching. Organization of students' learning activities using ICT and the problem-project method can significantly enhance the feasibility of additional forms of educational processes. The author use ICT to organize the IT students' integrated problem-project activities to computer modelling of physical processes. Second-year IT students of the Technical University implement individual virtual projects. The problem-project method generates students' interest to the process of creating program products and to models of physical processes and phenomena. This complex activity stimulates processes of learning and skills development for multiple subject areas such as physics, mathematics, and programming. Usually the IT students' virtual projects are created using high-level languages C ++ or C#, and 3D editors. The students' virtual projects ultimately are software products that can be used in the e-learning environment complementing existing traditional didactic means with virtual computer experiments. The programs make it possible to do virtual experiments, observe and analyse behaviours of simulated systems and features of physical processes. In this article some virtual labs designed by our second year IT students are demonstrated. Some of virtual labs have real prototypes in laboratories and some are unique.

Keywords

learning and teaching physics, information and communication technologies, problem-project activities, computer modelling, virtual labs

1 Introduction

Recent years we have seen a significant decrease of students' interest in learning physics. And in contrast a clear shift of their interest to information and communication technologies (ICT) is a fairly obvious fact [1]. Of course students' experiences with ICT provide them computer thinking and increases their future chance for choice of specialty and career growth [1]. But declining interest in physics has far-reaching consequences. Physics is a unique academic discipline that allows learning to work with model representations of reality and learn the scientific method of cognition [2]. The study of physics provides a methodological basis for students' future activities in the process of studying many other disciplines and lays the foundation for analytical thinking. Increasing of students' interest in physics is an important task of modern education.

Since today's students have a great interest in ICT, we must recognize that it contains a significant potential for developing innovative approaches to learning and teaching. The organization of students' learning activities using various opportunities of ICT and the problem-project method can significantly enhance effectiveness of additional forms of the educational process.

We use ICT to organize the students' integrated problem-project activities to computer modelling of physical processes. The second-year IT students of the Technical University plan, design and carry out individual virtual projects. The problem-project method generates the students' interest to the computer modelling of physical processes and to creation software products. This complex activity stimulates processes of learning and skills development for multiple subject areas such as physics, mathematics, and programming. Usually the IT students' virtual projects are created using high-level languages C ++ or C #, open graphics library OpenGL and 3D editors.

The IT students' virtual projects ultimately are software products that can be used in the e-learning environment complementing existing traditional didactic means. The students' programs make it possible to do virtual experiments, observe and analyze behaviors of simulated systems and features of physical processes. So, the IT students can be designers and creators of educational resources [3]. In this article some virtual labs designed by our IT students are demonstrated.

2 Computer modelling as a means for motivation in teaching and learning

Of course, the greatest effect is achieved in teaching and learning when students are directly motivated to study disciplines. But the indirect motivation can also play a significant role in transferring motives to organized training activities for the required discipline [4]. One of these motives that able to transfer students' interest to study physics is associated with a great popularity of ICT. Students' activities in the computer modelling of physical processes may be a contributing factor to the awakening of interest in physics and beyond.

For the cognition of the world we have to use simplified mathematical models of real physical phenomena. We understand any physical phenomenon if we are able to build the adequate mathematical model. Sometimes, in the framework of the adopted model it is possible to obtain an

exact or approximate analytical solution of the problem. But for the most practical problems we use numerical methods.

Numerical computations are finding their way into the curricula of more and more introductory physics courses [5-11]. A model-based view of physics provides a framework within which the computational activities may be structured so as to present to students an authentic representation of physics as a science discipline [11]. The computer modelling is a multidisciplinary field of study that encourages students to understand physics along with the computer science and applied mathematics [8].

The computer modelling includes the development of a conceptual physical model, mathematical formalization, choice of adequate methods for solving equations, software implementation of the model with the creation an interactive interface and visualization of simulated systems and processes [11, 12]. Computer models allow us to carry out various numerical experiments, which are the basis of virtual labs that can be used in training with real labs [13-15]. Modern students show a great interest both to virtual labs and to their designing.

Many undergraduate IT students of the Novosibirsk State Technical University (NSTU) already know some programming languages including even high-level languages such as C ++ or C #. This allows us to attract our IT students to the learning activities of the computer modelling of physical processes and phenomena.

3 Organization of the IT students' problem-project activity to computer modelling

What is the better way for organization of students' computer modelling activity?

The modern society's dynamics demands to use new technologies practically in all spheres of the human existence. Education is not an exception to the general trend. The modern Universities' graduates have to study the whole life, constantly adapting to new technologies and information flows. In the last decades the idea of switching from the paradigm of knowledge to the paradigm of activity is widespread. In this paradigm the main focus is shifting from the problem of mastering a particular knowledge toward the problem of development activities for extraction, processing and practical application of knowledge. The new paradigm has caused the emergence of new approaches and technologies for teaching and learning. The approach, known as Active Learning in Physics [16, 17], has been adopted in most developed countries in the physics education programs. Three methods of Active Learning are of the considerable interest in teaching and learning physics – the Research-Based Learning, the Problem Based Learning and the Project Based Learning.

The author use combination of all the three technologies for organization of the IT students' activity of the computer modelling of physical processes [14, 18, 19]. The students' activity is organized in the form of projects. The second-year IT students having programming skills design and perform virtual projects. All the students who express a desire to participate in the project activity are divided into groups of 2-4 people. The every group is given a problem for computer simulation. Some general requirements for the virtual projects are formulated and reported to the students. All the groups perform the projects independently. The teacher only plays the role of a consultant for the students.

The process of the project activity requires decision a number of problems:

1. Selection and mathematical formalization of a model of the physical process.
2. Selection the methods for solving the model's equations (analytical or numerical).
3. Development of the flowchart of the algorithm.
4. Development of the Graphical user interface.
5. Programming
6. Virtual experiments.
7. Analysis of the virtual experiments' results.
8. Reflection.
9. Reporting.
10. Presentation.

In the process of their project activity our IT students solve a number of problems related to different subject areas - physics, mathematics, programming, design. The students use their software products for testing virtual experiments to verify the computer model performance.

One of the results of this activity is the software product - the virtual laboratory, making it possible to carry out interactive computer experiments.

4 The IT students' software products - virtual labs

As characteristic examples we demonstrate some virtual labs designed by the second-year IT students of the Faculty of Applied Mathematics and Computer Science of the NSTU. Some of the virtual labs have the real prototypes in the NSTU physical laboratories and some students' virtual labs are unique. The virtual labs are presented for different parts (not for all) of the introductory physics course of the Technical University.

4.1 VIRTUAL LAB "OBERBECK PENDULUM"

The Oberbeck pendulum is used for study the rotational laws of a rigid body. The Oberbeck pendulum is a cross-piece consisting of four rods strengthened on a cylinder under direct angle to one another. The pendulum can rotate around its horizontal axis of symmetry. The inertia moment of the Oberbeck pendulum can be changed by moving its four identical weights along the rods.

A force moment causing rotation of the pendulum is created by a tension of the thread that is winded on the sheave. The weight is attached to the free end of the thread. The moment of force can be changed by the weights of various mass or by changing the sheave of a different diameter.

The students' program simulates the Oberbeck pendulum rotation under the external force moment. The computer model is based on the dynamics laws of the mechanical motion.

The main window of the virtual lab's interface is shown on Figure 1. The Oberbeck pendulum 3D image is reproduced in the window. The interface allows changing the weights' position on the pendulum and the mass of the weight suspended on the thread. You can observe the pendulum's rotation in real time.

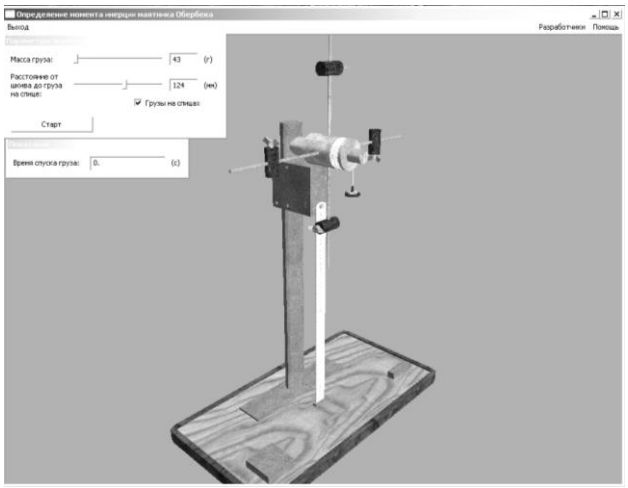

FIGURE 1 Interface of the virtual lab "Oberbeck pendulum"

Then you can measure the time and calculate a value of the moment of inertia. In addition this program simulates random measurement errors.

There are similar real labs in the NSTU laboratories. Using of the virtual lab enables our students to carry out the tentative virtual experiments at their home computers before doing the real experiments in the laboratories.

4.2 VIRTUAL LAB "OSCILLATIONS OF TWO COUPLED SPRING PENDULUMS"

Usually an analysis of the natural oscillations of coupled oscillators is presented in the part “Vibrations and waves” of the physics course [20]. Students learn the important idea of the superposition of normal vibrations (normal modes). The simplest is to harmonic oscillations of pendulums with a frequency depending on their relative phases. When the oscillations are in phase the connecting spring is not deformed, and the vibration frequency coincides with the natural frequency of the individual pendulum. In the case of out of phase the connecting spring is deformed, and the oscillation frequency is greater than the natural frequency of a single pendulum.

The normal oscillations occur in the system with the same initial deviations of the pendulums. If the initial deviations are of different size, the system beats are observed, representing a superposition of the two normal vibrations. During the beat a periodic transfer of energy from one pendulum to another and back is observed. The beat frequency is determined by the difference between the frequencies of the normal vibrations.

The students’ program simulates oscillation of two coupled ideal spring pendulums. The computer model is based on the system of differential equations describing the joint motion of the spring pendulums without friction.

The main window of the virtual lab’s interface is shown on Figure 2. The interface allows changing the ball's mass, the spring constant and the initial displacements of the pendulums. Depending on the initial displacements you can observe in real time the two normal modes or the beat phenomenon.

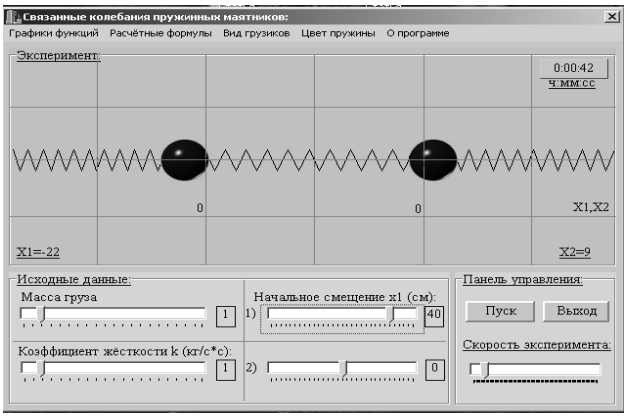

FIGURE 2 Interface of the virtual lab "Oscillations of two coupled spring pendulums"

The graphs of the pendulums’ displacements and velocities are in the additional window of the interface. The curves allow us to analyze the redistribution of energy between two coupled pendulums.

This virtual lab has no real analogues in the laboratories of the NSTU. The students’ software product is used as a lecture demonstration and a virtual lab.

4.3 VIRTUAL LAB "WAVES AT A BOUNDARY OF TWO JOINED STRINGS"

When any wave is falling on a boundary between two mediums there are two phenomena: wave's reflection to the first medium and passing to the other [20]. The both phenomena are determined by different reaction of the mediums to impacts associated with the wave process. The knowledge of the mediums’ impedances for a particular type of waves allows determining amplitudes of transmitted and reflected waves if we know amplitudes of the incident waves [20].

The students’ program simulates the wave processes at a boundary of two joined strings.

The strings are homogeneous and continuous, characterized by the same value of the tension force F, but may have different the linear density ρ. Due to various ρ the strings are characterized by two different values of the phase velocity and the impedance for the transverse harmonic waves [20]. The first leads to the different values of the wavelength on the strings, and the second - to the different reactions to the same transverse harmonic action.

The main window of the virtual lab’s interface is shown on Figure 3. The two joined strings are shown in the background of the grid. The axes’ scales are different in a thousand times, because the wave processes are modeled in the approximation of small transverse displacements. This means that the waves’ amplitudes must be many times smaller than the wavelength.

You can watch in time the wave processes on the strings, register the real time and the transverse displacements of different parts of the strings. If on the second string there is only the transmitted wave, but on the first string the wave process is the superposition of the direct and reflected waves.

The interface allows changing the string’s tension force, the linear density of the strings, the amplitude and the frequency of the incident wave.

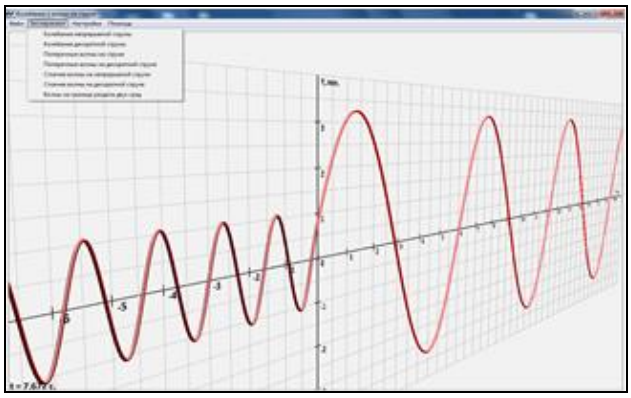

FIGURE 3 Interface of the virtual lab "Waves at a boundary of two joined strings"

The simulated processes visualization allows observing all the characteristic changes taking place due to changing the ratio of the strings densities, leading to the changes in the ratio of the impedances and the phase velocities.

This virtual lab has no real analogues in the laboratories of the NSTU. The students' software product is used as a lecture demonstration and a virtual lab.

4.4 VIRTUAL LAB "DIFFRACTION OF LIGHT"

As we know, light exhibits a dual nature! The phenomenon of diffraction evidences the wave nature of light.

All waves display the phenomena of diffraction, which arise from the superposition of waves. The waves contributing to the diffraction pattern must ultimately derive from the same single source. At each point of observation within the diffraction pattern the phase difference between component waves of the same frequency will depend on the different paths they have followed. Therefore, the resulting wave amplitude may be greater or less than that of any single component.

Diffraction is classified as Fraunhofer and Fresnel. In Fraunhofer diffraction the pattern is formed at such a distance from the diffracting system that the waves may be considered as the plane waves. A Fresnel diffraction pattern is formed so close to the diffracting system that the waves still retain their curved characteristics of the wave front [20].

One of the most interesting diffracting systems is a diffraction grating. A large number of equivalent slits forms a diffraction grating. The importance of the diffraction grating as an optical instrument lies in its ability to resolve the spectral lines of two wavelengths that are too close to be separated by the naked eye.

The students' program simulates diffraction phenomena of monochromatic light. The model is based on the Fraunhofer approximation for diffraction of plane waves on a system of parallel slits. The main window of the virtual lab's interface is shown on Figure 4.

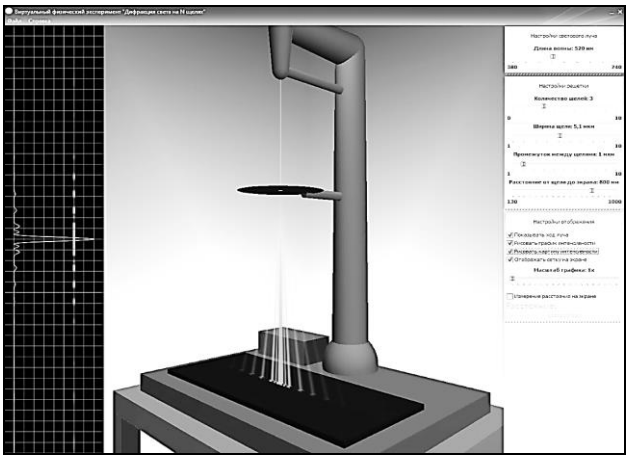

FIGURE 4 Interface of the virtual lab "Diffraction of light"

The interface allows changing the light wavelength, the width and the number of slits, the grating space, and the distance from the diffraction grating to the screen. The program allows observing and analyzing diffraction patterns.

The students realized the program tool "Interactive straightedge" using the adaptive mouse-replacement interface control functions. This tool allows measuring the characteristic distances between the maxima and minima of the diffraction pattern in the same way as in real experiments.

There are similar real labs in the laboratories of the NSTU. But in the real laboratory works we use a laser with a fixed wavelength. Only four diffraction gratings are used, and the change in distance to the screen is not provided at all. The virtual lab significantly expands possibilities of laboratory training complementing the existing real experiment "Diffraction of light" in the laboratories.

The students' software product is used as a lecture's demonstration and a virtual lab.

4.5 VIRTUAL LAB "THOMSON PARABOLA METHOD"

The charged particle motion in electric and magnetic fields is the basis of many devices and instruments of physical electronics [21]. Some of the devices are specifically designed to measure characteristics of moving charged particles. The simulation of the charged particles motion in electric and magnetic fields is an important practical task [21].

Thomson parabola mass-spectrometer is the well-known device used to determine a charge to mass ratio (q/m) of ions [21, 22].

The students' program simulates charged particle motion in electric and magnetic fields in the vacuum tube. The charged particles enter the area of the two parallel fields with the velocity vector perpendicular to the fields' directions. The electric and magnetic fields deflect particles in two perpendicular directions. The particles deviations along these two lines are related by the parabolic law [21]. The identical particles (with the same q/m) fall on the tube's screen to the points forming a parabola [21].

The students' computer model is based on equations of charge particles motion in electric and magnetic fields.

The main window of the virtual lab's interface is shown on Figure 5.

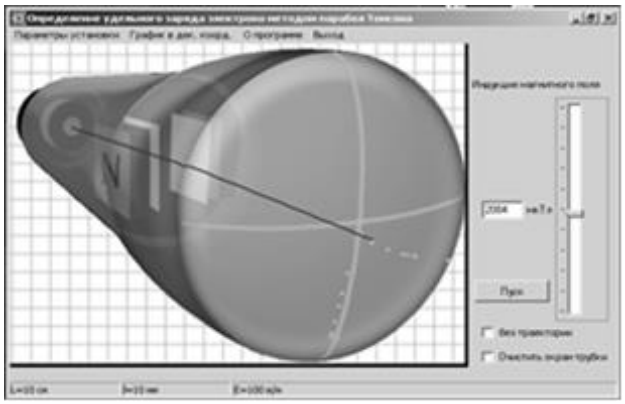

FIGURE 5 Interface of the virtual lab «Thomson Parabola Method»

In the cathode-ray tube you see stylized images of the electron gun, magnetic and electrostatic deflection systems. You can observe the charged particle's movement and see the resulting trajectory.

The program interface allows changing the value of the transverse magnetic field. The length of the tube, geometric dimensions of the fields and the magnitude of the electric field are the same values.

The «Start" button allows doing the next shot from the electron gun.

In the additional interface window all the points of the electrons' hits to the tube's screen are displayed on the background grid and Cartesian axes.

This virtual lab has no real analogues in the laboratories of the NSTU. The students' software product is used as a lecture demonstration and a virtual lab.

5 Conclusions

ICT can be used to organize the IT student's integrated problem-project activities for computer modelling of physical processes.

The problem-project activity focuses on the creation of a software product, which has a certain intellectual, social and even commercial value. It makes possible to organize teaching and learning technology with the creative direction as for the learning process and for the created software products.

The creation of their own software product brings a great emotional satisfaction and stimulates further creativity of the IT students.

At the same time, it begins to appear a significant increase of the students' interest to the studied university disciplines - physics, mathematics, numerical methods and algorithms, computer graphics and programming.

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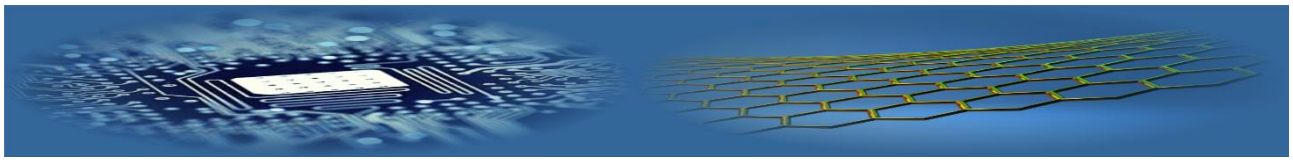

A comparative study between artificial immune system and incremental neural network for digits handwritten recognition

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Abstract

The artificial immune systems and the incremental neural networks are among novel paradigms used in artificial intelligence and pattern recognition. In this paper, we use MNIST database in order to compare these two approaches and to extract advantages and disadvantages of each one. This work is an introduction to improve the artificial immune system using principle of the incremental neural network.

Keywords:

Artificial Immune Systems,
Incremental Neural Network,
CLONCLAS,
I2GNG,
Digit Handwritten Recognition

1 Introduction

The digit handwritten recognition is an active topic in OCR applications and pattern recognition research [1- 2]. In OCR applications, digit recognition is dealt with in postal mail sorting, bank check processing, form data entry, etc. For these applications, the performance (accuracy and speed) of digit recognition is crucial to the overall performance. While in pattern classification and machine learning communities, the problem of handwritten digit recognition is a good example to test the classification performance.

Different classifiers were tested for digit handwriting recognition as linear classifiers, K-nearest neighbors, Boosted Stumps, Non-Linear Classifiers, SVM, neural nets, etc. [3]. Statistical techniques [4] and neural networks [5 - 6] have been widely used for classification due to the implementation efficiency. Structural [7] and stochastical [4] were also experimented on well-known databases so as to be compared with previous results.

The bio-inspired methods are one of the most used in artificial intelligence and pattern recognition. The artificial immune system and incremental neural network are examples of bio-inspired methods.

In this paper, we present CLONCLAS and I2GNG algorithms for digit handwritten recognition, we compare the obtained results and we give the advantages and disadvantages of each method.

2 MNIST database

To test our systems, we have carried out several experiments on the MNIST benchmark database. MNIST contains material for training and testing of handwritten digit recognition. It includes digits 0 to 9 distributed into training and test sets. The training set contains 60000 examples and the test set is composed of 10000 examples. MNIST data base is created from two bases SD-3 and SD-1. The SD-3 was collected among Census Bureau Employees and SD-1 was collected among High-School students. All pictures were normalized to images of 20X20 pixels, ready to be used in the training system.

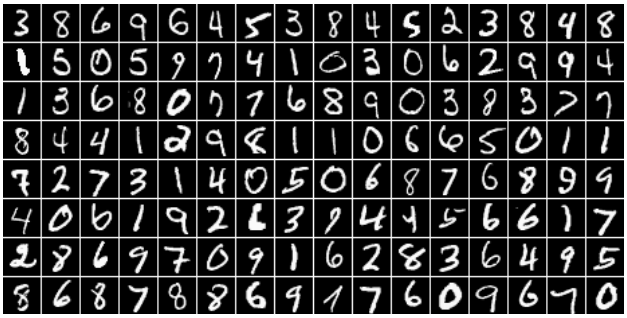

FIGURE 1 some examples of MNIST database

3 Natural immune system

As explained in [1], the immune system of vertebrates is composed of a great variety of molecules, cells, and organs spread all over the body. There is no central organ controlling the functioning of the immune system, and there are several elements in transit and in different compartments performing complementary roles. The main task of the immune system is to survey the organism in the search for malfunctioning cells from their own body (e.g., cancer and tumour cells), and foreign disease causing elements (e.g., viruses and bacteria). Every element that can be recognised by the immune system is called an antigen (Ag). The cells that originally belong to our body and are harmless to its functioning are termed self (or self antigens), while the disease causing elements are named non-self (or non-self antigens). The immune system, thus, has to be capable of distinguishing between what is self from what is non-self; a

process called self/non-self discrimination, and performed basically through pattern recognition events.

The Natural Immune System (NIS) is a distributed novel-pattern detection system with several functional components positioned in strategic locations throughout the body. Immune system regulates mechanism of the body by means of innate and adaptive immune responses (see Fig. 2).

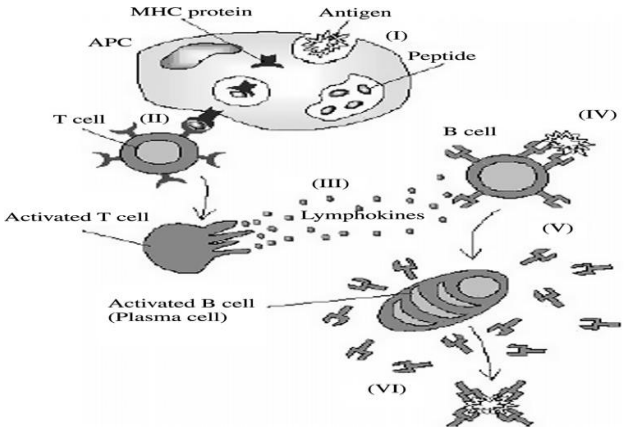

FIGURE 2 Natural Immune

The adaptive immune response is more important for us because it contains metaphors like recognition, memory acquisition, diversity, self-regulation, etc. The main architects of adaptive immune response are lymphocytes, which are of two classes as T and B lymphocytes (cells), each having its own function. Especially B cells have a great importance because of their secreted antibodies (Abs) that take very critical roles in adaptive immune response [8 - 9].

To build the Artificial Immune System, different models were proposed. B cell modeling is the most encountered representation type, among these, CLONCLAS representation. In the next section, we will briefly present the CLONCLAS algorithm and we give results of its application to digit handwritten recognition.

4 Artificial immune system for pattern recognition

As Neural Networks, the Artificial Immune System was inspired from the biological phenomenon. It simulates the Natural Immune System of the living body.

This algorithm typically exploits the features of the innate immune system in terms of learning and memorization as a method for solving problem [10].

Natural Immune Systems have several interesting properties such as the distinction between self and non-self, detection of the alteration, memorization, adaptability, and resource management [11].

In this way, the Artificial Immune System is used in several disciplines as intrusion detection in computer network [12], the illnesses diagnostic [13], handwriting recognition [14 - 18], etc.

We present below the different types of Artificial Immune Systems, their applications and we explore CLONCLAS algorithm for pattern recognition.

4.1 DIFFERENT TYPES OF ARTIFICIAL IMMUNE SYSTEM

4.1.1 Negative Selection

The Negative Selection is used for self and non-self detection. The fundamental principle is to from a set of detectors in order to identifying if a set of channels (self set) has undergone a change or no [19].

4.1.2 Clonal Selection

The Clonal Selection uses an artificial storage mechanism of immune systems. The developed algorithms are usually dedicated to the optimization or research [19- 22].

4.1.3 Artificial Immune Networks (AINET)

It is an algorithm that combines the theory of immune networks and clonal selection. This algorithm is proposed by De Castro and Von Zuben, in 2001 [23]. It uses the notion of internal image to represent groupings of data in a network. AINET can be used to data compression.

In this paper we interest to the classification problem, so we choose CLONCLAS as algorithm of clonal selection.

In the next section, we will explain the principle of this method and give the training and test steps.

4.2 CLONCLAS

In clonal selection, each antibody represents a solution to the problem. Each solution is evaluated by an affinity function. The solution opted is the one with the greatest affinity.

CLONALG is one of the clonal selection algorithms. Proposed by De Castro and Von Zuben in 2002 [20, 26]. This algorithm is designed for pattern recognition. It is very limited because it accepts just one training example per class. This limit is a disadvantage for this method.

To overcome the drawbacks of CLONALG, White and Garrett propose, in 2003 [21], a new algorithm called CLONCLAS; this algorithm is also classified in clonal selection category. It is adapted to solve the classification problem [10, 24].

4.3 CLONCLAS TRAINING AND TEST ALGORITHMS

CLONCLAS is one of the most used algorithms in artificial immune system. CLONCLAS can be used to solve several problems as optimization and pattern recognition.

In this session, we will give the CLONCLAS algorithm for pattern recognition. The objective of CLONCLAS is to train the input data in order to determine the class of the unknown forms later. The data training are named antigens, and CLONCLAS must use these antigenic forms in order to generate antibodies (named also memory cells). These antibodies are used in the classification step. Each class has one antibody, which is a solution of each class [17, 25].

In the test algorithm, each unknown form is represented to antibodies and this unknown data will be affected to the class of the nearest antibody.

We give then the training and test algorithms of CLONCLAS [10].

Algorithm 1: CLONCLAS training algorithm
Require: Training data
Ensure: set of *Abm*

1- Load the training data in Ag
2- Generate randomly the initial population of antibodies Ab, this population will be devised into two sets: memory cells Abm and a population reservoir Abr
3- Select one antigen Ag_i from Ag
4- For G generation do
4.1- For each element from Ab, calculate its affinity with the antigenic form Ag_i
4.2- Select n antibodies which have the best affinity values. Clone these antibodies and put it in the set C_i
4.3- Mutate all elements of C_i and put these clones in C_i*
4.4- Calculate the affinity between the antigenic form Agi and all the elements of C_i*
4.5- Select the candidate clone which has the best affinity value
4.6- If the affinity of this candidate clone is better than the affinity of Abm then replace Abm
4.7- Replace antibodies of Abr by the best clones of C_i*
4.8- Replace d antibodies of Abr by antibodies generated randomly.
4.9- Clear clones in C_i and C_i*
4.10- Return to 4 if G is not completed
5- Return to 3 if there are more antigenic forms.

Once the training program was finished, we will obtain the memory cells (*Abm*) of antibodies (*Ab*). These cells will be used in classification algorithm in order to classify the unknown antigenic form.

We give the classification steps as following:

Algorithm 2: CLONCLAS test algorithm
Require: Set of Abm for all classes.
The Unknown antigenic form Ag.
Ensure: Class of the Unknown Ag

1- Calculate the affinity values between all memory cells Abm and the unknown form Ag
2- Affect Ag to the same class of the memory cell which gives the best affinity value.
3- Return to step 1 if there is more antigenic form

As given in the algorithm 2, the unknown antigenic form will be assigned to the class of the nearest memory cell.

5 CLONCLAS for digit handwriting recognition

This section addresses the steps required to recognize digits using CLONCLAS.

5.1 CODING AND PREPARING DATABASE

In this section we will explain how applying CONCLAS for digit handwriting recognition. The first step is to prepare the dataset, so we binarize pictures. All pictures will be coded to 0 for white and 1 for black.

Antigens and antibodies must have the same structure. All the representative vectors have size of 400 elements. All antigens represent the training data and the antibodies were generated following the training algorithm in order to be operated for the classification.

5.2 CLONCLAS APPLICATION RESULTS ON MNIST DATABASE

In this session, we will give results of application of CLONCLAS to MNIST database.

First, we note that each digit has 6000 training samples and 1000 test samples. As given in the following table:

TABLE 1 Data Distribution

Data set	Training set (antigenic forms)	Test set (the new antigenic forms)
0	6000	1000
1	6000	1000
2	6000	1000
3	6000	1000
4	6000	1000
5	6000	1000
6	6000	1000
7	6000	1000
8	6000	1000
9	6000	1000

We run CLONCLAS training program for 10 iterations. The obtained results are 85.68% for precision rate and 84.76% for recall rate. These results can be considered important because they were obtained after only 10 iterations and using only 10 generated antibodies. Tables 2, 3 and 4 give the recall, precision and F-Measure rates (F-measure = 2 * ((precision_rate * recall_rate) / (precision_rate + recall_rate))) of MNIST database recognition using CLONCLAS algorithm:

TABLE 2 The recall rates

Data set	Recall rates
0	93.20
1	97.80
2	82.20
3	86.50
4	84.80
5	86
6	85.80
7	87.10
8	69
9	75.20

TABLE 3 The precision rates

Data set	Precision rates
0	87.26
1	71.85
2	91.43
3	90.38
4	83.13
5	79.85
6	92.15
7	79.90
8	92.12
9	88.67

TABLE 4 F-Measures rates

Data set	Precision rates
0	90,13
1	82,84
2	86,57
3	88,4
4	83,95
5	82,81
6	88,86
7	83,34
8	78,9
9	81,38

According to the recall rates, CLONCLAS can recognize better ‘0’ and ‘1’ than the other digits, but it confused the classification of the other digits with ‘0’ and ‘1’ which is confirmed by the decrease of the precision rates (87.26% and 71.85%).

We observe also that the precision rates of ‘2’, ‘3’, ‘6’ and ‘8’ are better comparing with ‘0’, ‘1’, ‘4’, ‘5’, ‘7’ and ‘9’, this can be explained that CLONCLAS misclassify

more the new antigenic forms in '0', '1', '4', '5', '7' and '9'.

We note that these results are obtained after 10 iterations only. Table 5 represents a comparison between the previous results and those obtained after 100 iterations.

TABLE 5 Influence of iteration number on recall and precision rates

Number of iterations	Recall rates	Precision rates	F-Mesure rates
10 iterations	84.76	85.68	85,21
100 iterations	87.88	90.24	89,04

According to these results, the recall, precision and F-measure rates have been respectively increased by 3.12% and 4.56% and 3,83%. Thus, the AIS give results better than the linear classifier.

We note by increasing the number of iterations the recognition rates was increased.

6 Incremental neural networks

The objective of this paper is to compare two bio-inspired systems: the artificial immune system (CLONCLAS) and the incremental neural network (IGNG, I2GNG). In this session we give the training and test algorithms of IGNG algorithm and we compare after the obtained results of session V with those obtained by Hatem in [27]

6.1 IGNG TRAINING AND TEST ALGORITHMS

GNG, IGNG and I2GNG are incremental neural networks which can start without any neuron and learn from incoming data. These dynamic neurons can add and/or remove neurons depending on the evolution of the data over the time. They have been successfully applied in incremental classification tasks as classification of images or synthetic data [27].

I2GNG is an improvement of IGNG and GNG. It gives better results than IGNG and GNG.

The training algorithm of IGNG is given as following:

Algorithm 3: IGNG training algorithm
Require: Training data
Ensure: IGNG neural network

Initialization of parameters: S, ε_b, ε_n, α_{edge}, $\alpha_{neuronmax}$.
While (a stopping criteria is not found) do
begin
Take an input signal E and find its nearest neuron n_1.
If (the network is empty or $d(E, n_1)>S$) then create a new embryon neuron $w_{new} = E$
else begin
Find the second nearest neuron n_2
if (There is only one neuron in the network
or $d(E, n_2)>S$) then
begin
create a new embryon neuron $W_{new} = E$
create a new edge between n_1 and E
end
else begin
increment the age of all edges coming from n_1.
n_1 += ε_b . d(E,n_1)
n_m += ε_n .d(E, n_m), (m are the neighbors of n_1)
if (n_1 and n_2 are connected) then $age_{n1 \to n2}$ =0
else begin create an edge between n_1 and n_2 end
Increment the age of all the neighbors neurons of n_1
for each embryon neuron do
begin
if (age(neuron)>$\alpha_{neuronmax}$) then
embryon neuron becomes mature
end
end
for each edge do
begin
if (age(edge) > α_{edge}) then remove edge
end
done
end

Once learning has finished, we obtain our neuronal network; where each class has its representative neurons. It is not necessary to have the same number of neurons in all classes, but neurons are generated according the distribution of input data. In this stage, we can apply the test algorithm to classify the unknown data.

Algorithm 4: IGNG test algorithm
Require: IGNG neural network, test data
Ensure: test data classified

for data = 1 to nb_test_data do
- Select the nearest neuron from the neural network.
- The new data will be assigned to the same class of this nearest neuron
end for

According the IGNG test algorithm, we classify the unknown data to the class of the nearest neuron.

6.2 IGNG APPLICATION RESULTS ON MNIST DATABASE

The MNIST handwritten digit database was used by multiple authors. Prudent and Ennaji [28] applied the GNG and IGNG for the recognition of these images. The images are not used in their raw state, but a four-level pyramid decomposition was performed on these images before obtaining representation vectors.

The results obtained are in the range of 91.44% to the GNG and 91.71% for IGNG. The foundation for learning and testing has been partially used for these tests (2626 examples for training and 2619 examples for testing). The obtained results are given in table 6:

TABLE 6 Recognition rates of the three networks in the portion of the NIST database [28]

Number of iterations	Cycles	Offline
LVQ	50	89.65%
GNG	50	91.44%
IGNG	10	91.71%

We observe here that IGNG gives better results than GNG and LVQ.

I2GNG is an improvement of IGNG. It has the same training steps as IGNG, the only difference is about parameter S. the threshold S is adapted to data volume.

$$S = m + \alpha\,\sigma, \quad (1)$$

where m is the average of distances between all data and neuron, and σ is the standard deviation of distances.

Hatem [27, 29] proposes to use MNIST database entire (60000 training samples gradually). In each experience, he use n*10000 samples for I2GNG training algorithm (n varies from 1 to 6). A single iteration is sufficient to apply the I2GNG. The test set is composed of 10000 samples as given in [3]. The recognition rates are given in table 7:

TABLE 7 Recognition rates obtained after applying one iteration of I2GNG to MNIST database.

Training samples	Recognition rates
10000	88.45%
20000	91.02%
30000	92.58%
40000	93.66%
50000	94.06%
60000	94.29%

The advantages of IGNG and I2GNG that they are fastest. We do not need to reiterate training for new data integrated. We need to store the only neurons in memory in order to be used next time. IGNG and I2GNG present a lot of advantages as well as the recognition rates and training time.

7 Comparison between CLONCLAS and I2GNG

In this session, we will study the advantages and disadvantages of each method and we will propose after an improvement of CLONCLAS. We can note several points as following:

- I2GNG training is faster than CLONCLAS, because it is not an obligation to reiterate training steps, a single iteration is sufficient for training.
- If there are more training data, I2GNG can continue training using the memorized neurons but for CLONCLAS we must restart training from the beginning using all the training data.
- In CLONCLAS we use only the affinity between antigens and antibodies in order to select the best antibody, but in I2GNG we use the threshold Si and the age of neurons in order to add or remove neurons. This threshold Si is in function of all data and neurons so IGNG takes account the distribution of all data on the contrary of CLONCLAS the affinity value is in function of the specific data and antibody.
- At the end of CLONCLAS training we obtain antibodies (memory cells) for each class. One representative is not sufficient for a large data training set. It is important here to think about a solution to create more antibodies for each class.

From this comparison we can optimize the CLONCLAS algorithm. These notes can open the new perspectives for next works.

8 Conclusions

In this paper, we have used two bio-inspired methods for digit handwritten recognition, so we have used the artificial immune system and the incremental neural network. We give training and test steps for each algorithm and we have compared results of each method.

We observe also that I2GNG can give satisfied results comparing with the artificial immune system. We note that, I2GNG improves the recognition rate on the rage of 6.41% comparing with CLONCLAS. We have study also the advantages and disadvantages of CLONCLAS and I2GNG; and we think in the next works to propose an amelioration of CLONCLAS using the incremental approaches.

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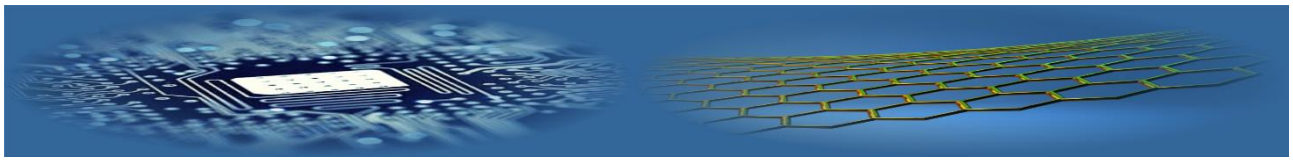

Implementation of the heteroskedasticity testing for linear regression model

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Abstract

The article discusses the problem of heteroskedasticity, which can arise in the process of calculating econometric models of large dimension and ways to overcome it. Heteroskedasticity distorts the value of the true standard deviation of the prediction errors. This can be accompanied by both an increase and a decrease in the confidence interval. We gave the principles of implementing the most common tests that are used to detect heteroskedasticity in constructing linear regression models, and compared their sensitivity. The advantage of this paper is that real empirical data are used to test for heteroskedasticity. For implementing the testing there is developed the special software with using of the algorithmic programming language MATLAB. The purpose of the article is to describe the functions implemented in the form of m-files (MATLAB environment files) to check for heteroskedasticity in multifactor regression models. To do this, modified algorithms for the tests on heteroskedasticity were used. Experimental studies of the work of the program were carried out for various linear regression models both the models of the Department of Higher Mathematics and Mathematical Methods in Economy of Simon Kuznets Kharkiv National University of Economics, and econometric models which were published recently by leading journals.

Keywords:

regression model,
homoskedasticity,
testing for heteroskedasticity,
software environment
MATLAB

1 Introduction

In econometrics, a linear regression model is often used to describe different processes and phenomena:

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_m x_{im} + \varepsilon_i,$$

or

$$\mathbf{Y} = \mathbf{XB} + \varepsilon \quad (1)$$

where y is dependant variable, $y_i \in \mathbf{Y}$; i is experiment number, $i = \overline{1, n}$; n is number of measurements (sample size); x_{ij} is the value of the independent variable $X_j \in \mathbf{X}$ in the experiment, $j = \overline{1, m}$; m is number of independent variables in the regression model; β_0 is free term of the equation; β_j are regression coefficients, $\beta_0, \beta_j \in \mathbf{B}$; ε_i are residuals (model errors).

An error term is introduced in a regression model because the model does not fully represent the actual relationship between the variables of the model. As a result of this incomplete relationship, there are differences between the observed responses (values of the variable being predicted) in the given dataset and those predicted by a linear function of a set of explanatory variables. The error term is the amount at which the equation may differ from measurements. In other words that is the 'white noise'.

As a rule, the building a linear regression model is performed using the method of ordinary least squares (OLS). This is a method for estimating the unknown parameters in a linear regression model, with the goal of minimizing the sum of the squares of the model errors. Its application requires the realization of a number of conditions [1 – 3]. Only if these conditions are met, the estimates calculated by such a model will be unbiased, efficient and well-off. These conditions are formulated in the form of a Gauss – Markov theorem. According to this theorem there are four principal assumptions which admit the using of linear regression models for purposes of research and prediction. One of them is the homoskedasticity (constant variance) of the errors in relation to any independent variable. Homoskedasticity is determined as a situation in which the random deviations in the relationship between the independent variables and the dependent variable are the same across all values of the independent variables: $\mathrm{cov}(x_j, \varepsilon) = 0$, $j = \overline{1, m}$. That is, the error term is a random variable distributed according to the normal law. Its mathematical expectation is zero, and the variance is constant: $\varepsilon \sim N(0, \sigma_\varepsilon^2)$, where $\sigma_\varepsilon^2 = const$. Failure to comply with this requirement leads to bias in the estimates obtained using such a regression model. The results of the study [4] indicate that estimation uncertainty may increase dramatically in the presence of conditional heteroskedasticity of unknown form.

The requirement of homoskedasticity with respect to empirical data also exists in the construction of the econometric model using the maximum likelihood method [5 – 7].

The violation of homoskedasticity is called heteroskedasticity. In this case, it is assumed that the model error distribution law remains normal with a mathematical expectation equal to zero, but there is a dependence of the error magnitude of the model on the values of the independent variable: $\varepsilon \sim N(0, f(\mathbf{X}))$, where $f(\mathbf{X})$ is a function that describes the change in the variance of errors

as a function of the values of the independent variables.

A similar problem arises during the building of semiparametric [8 – 10] and nonparametric [11, 12] models

Heteroskedasticity makes it difficult to gauge the true standard deviation of the forecast errors. This can be accompanied by both increasing and decreasing of the confidence interval. Thus, if the variance of the errors is increasing over time, confidence intervals for out-of-sample predictions will tend to be unrealistically narrow. In particular, the presence of heteroskedasticity makes it impossible to use the standard error formula for regression parameters S_{b_j}, which assumes a uniform dispersion of the errors. For these reasons, all the conclusions obtained on the basis of the corresponding t – statistics and F – statistics, as well as interval estimates, will be unreliable.

There is no single method for determining heteroskedasticity. To solve this problem, a large number of different tests and criteria have been developed: the Spearman rank correlation test, the Park test, the Glaser test, the Goldfeld – Quandt test, the Breusch – Pagan test, the Leven's test, the White test, and so on. The application of all the above tests is very difficult for the so-called 'manual' account, and for a large set of initial data it is completely impossible.

To solve this problem, this is a sufficiently large number of econometrics software programs with which you can identify heteroskedasticity. These are professional packages (SAS, BMDP), universal packages (STADIA, OLIMP, STATGRAPHICS, STATISTICA, SPSS) and specialized packages (DATASCOPE, BIOSTAT, MESOSAUR). However, an economist-researcher can face two main problems. Firstly, all the listed software is quite expensive and price of the product may be an insurmountable barrier for the young researcher. Secondly, company-developer never provides the source code, considering that this is not necessary for an ordinary user. This does not make it possible to change or reconfigure the built-in algorithms to detect and eliminate heteroskedasticity.

Another drawback of the above program products is the outdated conceptual approaches to econometric methods, which are constantly being improved. For example, the program products SPP and MICROSTAT calculate the coefficients of multiple correlations as the square root of the coefficient of determination, and STATGRAPHICS calculates it as the square root of the adjusted coefficient of determination [13]. While in theory the multiple correlation coefficient is calculated using elements of the correlation matrix [2]. Another important aspect that should be taken into account is the existence of different algorithms to identify heteroskedasticity and the specific problem of division by zero [14].

Ideal option would be to create your own software product that would take into account the research tasks. However, writing such a program requires the economist to have deep knowledge in the field of algorithmic programming, which often does not take place at all.

In this connection, the authors of the article carry out a comparative analysis of the tests most often used to detect heteroskedasticity [1, 2, 14] and give their source code. This is of tremendous practical value, because the use of program code allows you to modify the program in accordance with the objectives of the study.

2 Analysis of literary data and the formulation of the problem

The testing of the initial data for their correspondence to the conditions of the Gauss-Markov theorem is one of the necessary procedures for constructing regression models (both single-factor and multivariate). In the first approximation, the presence of heteroskedasticity can be detected on the graphs of the rests of the regression model (or their squares) over some variables. On these graphs, the scattering of points can vary depending on the value of the independent variables [14, 15]. However, as noted in [15 – 17], for more rigorous statistical tests are used, for example, the White test, the Goldfeld – Quandt test, the Breusch – Pagan test, the Park test, the Glazer test and/or the Spearman test.

The Spearman rank correlation test is a nonparametric statistical test that allows one to check for the heteroskedasticity of random errors in the econometric model. The test algorithm can be studied in detail in [18, 19]. However, it is still not implemented in software products which are used to build multifactor models [20 – 27]. In this paper we examined the software packages most commonly used in economic activity, which contain tests for heteroskedasticity [15, 28]. Indeed, these software products do not contain the Spearman rank correlation test.

The Park test is a statistical test used to test the heteroskedasticity of random errors in the regression model. The test algorithm is described in detail in these sources [20, 21]. However, the Park test contains the assumption that the change in the remnants of the model is described by a functional dependence of a certain type. It was noted in [24, 25] that this can lead to unreasonable conclusions. Therefore, the authors propose to consider the Park test together with other tests. The software implementation of the Park test for multifactor models also does not exist [28].

Another test that the authors of the article implemented in the MATLAB environment is the Goldfeld – Quandt test. This test to check for heteroskedasticity of random errors is used when there is reason to believe that the standard deviation of errors is proportional to some variable. The test statistics has a Fisher distribution [18, 27]. The Goldfeld – Quandt test can also be used if there is an assumption of intergroup heteroskedasticity, when the variance of errors takes, for example, only two possible values. In this case, for the application of the test, there is a need for its software implementation, since applied commercial software has not taken this possibility into account [25, 28].

In scientific articles on the problem of detecting heteroskedasticity, the Breusch – Pagan test is often considered [10, 29]. We also carried out research in this direction. But they are large enough and go beyond the scope of this article.

Analysis of literature sources shows that all tests of heteroskedasticity detection are difficult for 'manual' application and require the development of special software. In turn, the software of econometric research does not contain built-in functions for heteroskedasticity testing with open source code. That is way the authors of this article attempted to implement the above tests for heteroskedasticity in the construction of multifactor econometric models in the MATLAB software environment. It should be noted that MATLAB does not contain ready-

made software implementation to verify compliance of homoskedasticity. We chose it as a programming environment. For this purpose, other programming environments can also be used, for example, a free software environment R for open source computing

3 Aims and objectives of the study

The purpose of the article is to describe the functions implemented in the form of m-files (MATLAB environment files) to check for heteroskedasticity in multifactor regression models. To do this, modified algorithms for the tests on heteroskedasticity were used. To test the program, econometric models were used in which there is or is not heteroskedasticity.

To achieve this purpose, it is necessary to solve a number of problems. Namely:

- writing the program code in the MATLAB programming environment;
- planning and execution of computer calculations;
- completion of programs;
- analysis and interpretation of results;
- comparison of the results with the calculated data and software products of leading companies.

4 Practical implementation of the criteria for the detection of heteroskedasticity in econometric models in the MATLAB environment

4.1 SPEARMAN'S RANK CORRELATION TEST FOR MULTIFACTORIAL ECONOMETRIC MODELS

The use of this test assumes that the variance of model errors will increase (or decrease) with increasing values of the independent variable X. This means that the absolute values of errors ε_i ($i=\overline{1,n}$) and the values x_{ij} of the random variable X_j will correlate with each other. To check whether heteroskedasticity is statistically significant, pairs (x_{ij}, ε_i) are ranked in order of increasing values of the independent variable X_j. Then the coefficient of rank correlation between ε_i and x_{ij} is calculated by the formula:

$$r_{x\varepsilon} = 1 - 6 \cdot \frac{\sum d_i^2}{n\left(n^2 - 1\right)}, \qquad (2)$$

where d_i is the difference between the ranks x_{ij} and ε_i.

It is known that if the correlation coefficient $\rho_{x\varepsilon}$ for the general population is zero, the statistics $t = \frac{r_{x\varepsilon}\sqrt{n-2}}{\sqrt{1-r_{x\varepsilon}^2}}$ has a Student distribution with the number of degrees of freedom $\nu = n-2$. If the value of the $t-$statistic exceeds the critical value $t_{cr.} = t_{0.5\alpha}(n-2)$, where α is the significance level, the statistical hypothesis that the correlation coefficient $\rho_{x\varepsilon}$ is zero must be fling aside. It follows that heteroskedasticity is statistically significant. In the opposite case, the hypothesis of the absence of heteroskedasticity is non-contradictory.

As an example of the implementation of this test, we can suggest the following m-file named *Spearman*:

```
% Formation of the source data array:
X = [ones(n,1) X1' X2' X3' X4' X5'...Xn'];
% Construction of a linear multifactor
% model by OLS - method:
[b,bint,r,rint,stats] = regress(Y,X,0.05);
y_p = b(1) + b(2).*X1 + b(3).*X2+
b(4).*X3+b(5).*X4+b(6).*X5+...+b(n).*Xn
sprintf('Model:')
fprintf('y_p = %f + %f *X1+%f *X2+%f *X3+%f *X4+%f
*X5'+...+%f*Xn,b)
% Calculation of model remains:
e = Y - y_p';
% Preparing an array for further work:
X = [X1' X2' X3' X4' X5'...Xn'];
[n,m] = size(X);% Determining the size of the source data
%=========================================
%% Spearman rank correlation test
% Ranking of factors:
[Xs I] = sort(X)
Dx = zeros(n,m);
for j = 1:m
   for i = 1:n
      Dx(i,j) = i;
   end
end
TMP = zeros(n,m);
% Filling an array of factors with ranks
% taking into account their sequence numbers:
for j = 1:m
   for i = 1:n
      i1 = I(i,j);
      TMP(i1,j) = Dx(i,j);
   end
end
X = [X TMP]% Output array
% Ranking of remains:
[es I] = sort(e);
es = [es ones(size(e),1)];
e = [e ones(size(Y),1)];
sprintf(' critical values t:','\n')
t_r(:,j) = (r(:,j)*sqrt(n-1))/sqrt(1 - r(:,j)^2);
end
t_r % output array t-statistics by Spearman
% Comparative analysis and conclusions:
c = 0;
for i = 1:size(e)
   es(i,2) = i;
end
% Filling an array of remains with ranks
% taking into account their sequence numbers:
for i=1:size(e)
   e(I,2) = es(:,2);
end
e% an array of remains which contains ranks
r = zeros(1,m);
d = zeros(n,m);
% Calculating the difference of ranks
for j = 1:m
   for i = 1:n
      d(i,j) = TMP(i,j) - e(i,2);
   end
end
d % difference in rank
% The square of the difference of ranks:
for j = 1:m
   d(:,j) = d(:,j).^2;
end
d
Sd = zeros(1,m);
% The sum of the difference of ranks squares
```

```
% by the corresponding columns of ranks:
for j = 1:m
   Sd(:,j) = sum(d(:,j));
end
Sd % output array
% Calculating Spearman's Statistics:
for j = 1:m
   r(:,j) = 1 - (6*Sd(:,j))/(n*(n^2-1));
end
r % Output array
t_r = zeros(1,m);
%% Testing of the significance of the Spearman coefficient:
t_t = tinv(0.975,n-2)% tabulated value t
for j = 1:m
for j = 1:m
if abs(t_r(:,j)) < abs(t_t)
   sprintf(' Heteroskedasticity is absent ')
else
   sprintf(' Heteroscedasticity is present ')
   c = c + 1;
end end
```

4.2 PARK'S TEST FOR MULTIFACTOR REGRESSION MODELS

R. Park proposed a criterion for determining heteroskedasticity, which elaborates the graphical method by some formal dependencies. Since the variance of errors $\sigma_i^2 = \sigma^2(\varepsilon_i)$ is a function of the $i-$th value x_{ij} of the explanatory variable X_j, and for its description Park proposed the this dependence: $\sigma_i^2 = \sigma^2 x_{ij}^{\beta} \varepsilon^{v_i}$. After computing its logarithms, we obtain the following relation: $\ln \sigma_i^2 = \ln \sigma^2 + \beta \ln x_{ij} + v_i$. Since the variances σ_i^2 are usually unknown, they are replaced by their estimates ε_i^2.

The calculation of Park's criterion provides for the following stages:

1) to estimate parameters of the econometric model by the OLS:

$$\hat{y}_i = b_0 + b_1 x_{i1} + b_2 x_{i2} + \ldots + b_m x_{im}; \quad (3)$$

2) to determine the value $\ln \varepsilon_i^2 = \ln(y_i - \hat{y}_i)^2$ for each observation;

3) to build regression model $\ln \varepsilon_i^2 = \alpha + \beta \ln x_{ij} + \upsilon_i$, where $\alpha = \ln \sigma^2$. For the case of multiple regressions, this dependence is constructed for each explanatory variable;

4) to check the statistical significance of the coefficient β on the basis of $t-$statistics $t = |\beta / \sigma_\beta|$. In accordance with the predetermined confidence probability p (where $\alpha = 1 - p$) the tabulated value of $t_\alpha(n-m-1)$ is found and compare empirical and tabular values. If $t > t_\alpha(n-m-1$, then at the level of significance α the coefficient β is statistically significant and there is a link between $\ln \varepsilon_i^2$ and $\ln x_i$. It means that heteroskedasticity is present in statistical data.

The M-file named *Park's* which is implementation of the Park test has the form:

```
% Formation of the source data array:
X = [ones(n,1) X1' X2' X3' X4' X5'...Xn'];
[n, m] = size(X);
% ========== Park Test Algorithm =======
%  1 stage of the Park test
% Construction of a linear multifactor
% model by OLS - method:
[b,bint,r,rint,stats] = regress(Y,X,0.05);
y_p = b(1) + b(2).*X1 + b(3).*X2+
b(4).*X3+b(5).*X4+b(6).*X5+...+b(n).*Xn
sprintf('Model:')
fprintf('y_p = %f + %f *X1+%f *X2+%f *X3+%f *X4+%f
*X5'+...+%f*Xn,b)
%   2 stage of the Park test
ln_eps = log((Y' - y_p).^2)
%   3 stage of the Park test
for j=1:m
   for i = 1:n
      X(i,j) = log(X(i,j));
   end
end
%  4 stage of the Park test
for i = 2:m
 [bet, dev,stat] = glmfit(X(:,i),ln_eps);
   t_t = tinv(0.95, n-2);
   t_r = stat.t(2);
% Comparative analysis and conclusions:
      if abs(t_r) < abs(t_t)
         sprintf(' Heteroskedasticity of %i factor is absent \n',i-1)
      else
         sprintf(' Heteroskedasticity of %i factor is present\n',i-1)
      end
end
```

The Park test's weakness is that it assumes the heteroskedasticity has a particular functional form.

4.3 GOLDFELD – QUANDT TEST FOR MULTIFACTORIAL REGRESSION MODELS

The Goldfeld – Quandt test provides that the standard deviation of errors σ_ε is proportional to the value of the independent variable in this observation: $\sigma_{\varepsilon_i}^2 = \sigma^2 x_{ij}^2$. It is also assumed that errors ε_i are distributed according to the normal law, there is no autocorrelation, and all n observations are ordered in magnitude of the independent variable X_j. Than this ordered sample is divided into three approximately equal parts k, $n-2k$, k, respectively. For each part of the sample that has a volume k, its regression equation is constructed and the sums of the squares of the deviations determine:

$$RSS_1 = \sum_{i=1}^{k} \varepsilon_i^2 \quad (4)$$

and

$$RSS_3 = \sum_{i=n-k+1}^{n} \varepsilon_i^2 . \quad (5)$$

Evidence of heteroskedasticity is based on a comparison of the residual sum of squares (*RSS*) using the $F-$statistic. Than empirical meaning of the $F-$statistic is calculated:

$$F = \frac{RSS_1 / (k-m-1)}{RSS_3 / (k-m-1)} \quad (6)$$

In accordance with the predetermined confidence probability p (where $\alpha = 1 - p$) the tabulated value of

$F_\alpha(k-m-1;k-m-1)$ is found and compare empirical and tabular values. If $F < F_\alpha(k-m-1;k-m-1)$, this means that at the level of significance α the hypothesis that there is no heteroskedasticity does not have grounds to reject. In the opposite case, the hypothesis of the absence of heteroskedasticity is rejected.

For multiple regressions, we performed tests for all factors. The M-file named *Gold_Quan* which is implementation of the Goldfeld – Quandt test has the form:

```
% Formation of the source data array:
X = [ones(n,1) X1' X2' X3' X4' X5'...Xn'];
[n, m] = size(X);
%=======================================
%% Goldfeld – Quandt test:
[Xsort Is] = sort(X);
for i=1:size(Y)
   Ysort(i,1) = Y(Is(i),1);
end
Dat = [Xsort Ysort];
c = fix(4*n/15);
k = fix((n - c)/2);
if floor(k) > 0.4
   k = k+1;
end
k
% Selective aggregate 1:
Dat1 = Dat(1:k,:);
[b1,dev1,stats1] = glmfit(Dat1(:,1),Dat1(:,2));
S1 = sum(stats1.resid.^2);
% Selective aggregate 2:
Dat2 = Dat(n-k+1:n,:);
[b2,dev2,stats2] = glmfit(Dat2(:,1),Dat2(:,2));
S2 = sum(stats2.resid.^2);
% Testing the hypothesis:
if S1 > S2
   Fp = S1/S2;
else
   Fp = S2/S1;
end
Ft = finv(0.95,k-m-1,k-m-1);
if Fp > Ft
    sprintf(Heteroscedasticity is present ')
else
   sprintf(Heteroscedasticity is absent ')
end
```

A weakness of the Goldfeld – Quandt test is that the result is dependent on the criteria chosen for separating the sample measurements into their representative groups.

5 Results of numerical experiments

The problem of detecting heteroskedasticity in various multifactor econometric models was considered. For carrying out numerical simulation experiments there were used both the models of the Department of Higher Mathematics, Economic and Mathematical Methods of Simon Kuznets Kharkiv National University of Economics [30 – 33], and econometric models which were published recently by leading journals [34 – 36]. The advantage of this paper is that real empirical data are used to test for heteroskedasticity. However, it is also possible to use data obtained by means of Monte Carlo simulations [6, 7, 37 – 39].

Numerical experiments were performed on the configuration AMD Athlon 64 3200+1.5Gb Ram, graphic accelerator – Nvidia GeForce GTX 560 2Gb with using technology NVIDIA CUDA 4.2.

Let's look at a concrete example of what happens to an eccentric model, if you do not take into account heteroskedasticity. As a model problem, the linear regression model was calculated for the cost of electronic textbooks developed by the Department Higher Mathematics and Mathematical Methods in Economy. The initial data and designations used in the process of correlation-regression analysis are shown in Figure 1, where Y is the resulting factor Y (cost of the electronic textbook).

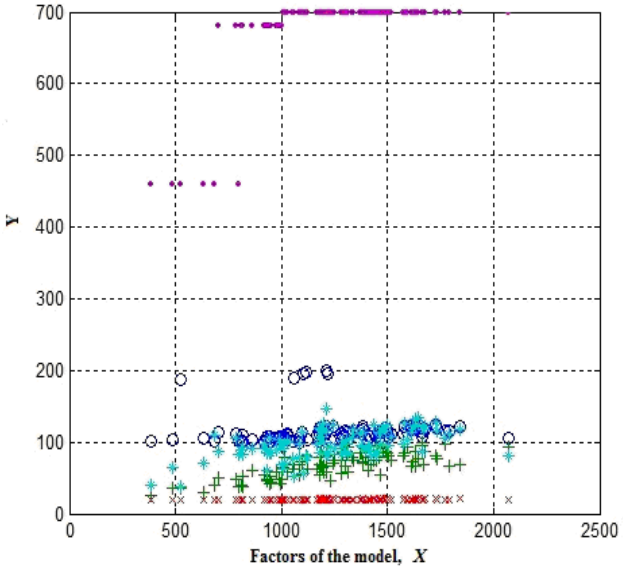

FIGURE 1 Initial data for model building: ○ - X1 (average cost of developers' wages); + - X2 (publication volume); × - X3 (average CD recording price); * - X4 (storage and distribution costs); • - X5 (cost of the use of licensed software)

The regression model was constructed using the built-in function Matlab-regress (y, X, alpha) with the code:

```
% The program for multiple regression model building, if
heteroskedasticity is not taken into account:
[b,bint,r,rint,stats] = regress(Y,X,0.05);
y_p = b(1) + b(2).*X1 + b(3).*X2+ b(4).*X3+b(5).*X4+b(6).*X5;
sprintf(' Heteroskedasticity is not taken into account:')
fprintf('y_p = %f + %f *X1+%f *X2+%f *X3+%f *X4+%f *X5',b)
```

The program for constructing multiple regressions, if you do not take into account heteroskedasticity, gives such a result:

$$\hat{y} = -1864.06 + 0.33 \cdot x_1 + 10.61 \cdot x_2 + \\ + 70.90 \cdot x_3 + 3.33 \cdot x_4 + 0.87 \cdot x_5. \quad (7)$$

By comparing empirical data and theoretical data which obtained as a result of using the model (7), the remnants of the model were found (see, Figure 2). Analysis of the remnants of the model indicates that for this model the dispersion of remnants increases with an increasing of the value of external factors, that is, heteroskedasticity can not be ignored. Using the program procedures developed by the authors to identify heteroskedasticity, the following results were obtained:

```
ans = Heteroskedasticity 1 is absent
ans = Heteroskedasticity 2 is absent
ans = Heteroskedasticity 3 is absent
ans = Heteroskedasticity 4 is absent
ans = Heteroskedasticity 5 is present
```

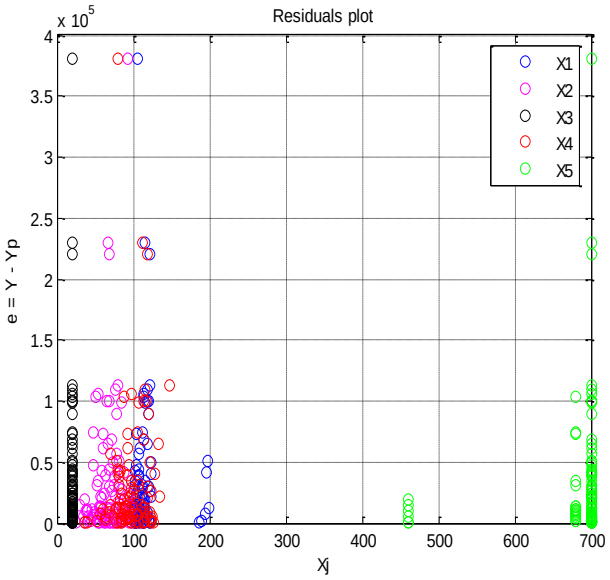

FIGURE 2 Graphic illustration of the remnants of the model

The construction of the regression model, which takes into account the heteroskedasticity, was performed using the built-in function MATLAB: robustfit(X,y,wfun, tune,const). It should be emphasized that the presence or absence of heteroskedasticity in the initial data is determined automatically by using the check box. For this we used the code:

```
if c > 0
X = [X1' X2' X3' X4' X5'];
[b,stats3] = robustfit(X,Y,'fair',0.001,'on');
y_p = b(1) + b(2).*X1 + b(3).*X2+ b(4).*X3+b(5).*X4+b(6).*X5;
sprintf('Heteroskedasticity is taken into account:')
fprintf('y_p = %f + %f *X1+%f *X2+%f *X3+%f *X4+%f *X5',b)
end
```

The program for multiple regression model building, if heteroskedasticity is taken into account yields this result:

$$\hat{y} = 27.85 + 0.94 \cdot x_1 + 10.33 \cdot x_2 - \\ - 29.16 \cdot x_3 + 4.18 \cdot x_4 + 0.80 \cdot x_5. \quad (8)$$

Thus, the above procedure allows eliminating heteroskedasticity. In this case, the resulting models will be able to adequately reflect the reality.

Table 1 shows the results of numerical experiments on testing programs on various multifactor models. According to Table 1, the software products presented in this work can be used both for constructing multifactor econometric models, and for investigating the latter for the presence of heteroskedasticity. In doing so, we used new numerical algorithms, developed on the basis of well-known tests of heteroskedasticity detection.

TABLE 1 Results of testing programs on multifactor models

Multifactor model	**Theoretical results**	**The results of the work of the authors' programs**		
		Spirmen.m	*Park.m*	*Goldfeld – Quandt.m*
Model [28]: Linear approximation	Heteroskedasticity is absent	Heteroskedasticity is absent	Heteroskedasticity is absent	Heteroskedasticity is absent
Power approximation	Heteroskedasticity is absent	Heteroskedasticity is absent	Heteroskedasticity is absent	Heteroskedasticity is absent
Hyperbolic approximation	Heteroskedasticity is present	Heteroskedasticity is present	Heteroskedasticity is present	Heteroskedasticity is present
Model [30]	Heteroskedasticity is present	Heteroskedasticity is present	Heteroskedasticity is present	Heteroskedasticity is present
Model [31]	Heteroskedasticity is present	Heteroskedasticity is present	Heteroskedasticity is present	Heteroskedasticity is present
Model [33]	Heteroskedasticity is absent	Heteroskedasticity is absent	Heteroskedasticity is absent	Heteroskedasticity is absent
Model [34]	Heteroskedasticity is absent	Heteroskedasticity is absent	Heteroskedasticity is absent	Heteroskedasticity is absent
Model [35]	Heteroskedasticity is present	Heteroskedasticity is present	Heteroskedasticity is absent*	Heteroskedasticity is present

** The conclusion is not justified, since the test uses a monotonically increasing function*

Open source code allows the researcher to use this software to solve their own problems.

6 Final remarks

The article examined one of the key problems of regression analysis, which consists in verifying the fulfillment of the requirement of homoskedasticity of the remainders of the model. To do this, we considered ways to identify it using various test statistics. Analysis of literature sources and our own studies confirm the complexity of using all existing tests for detecting heteroskedasticity in the "manual account" mode. Proceeding from this, we set ourselves the task of writing the program code in the MATLAB environment, which would allow us to implement the algorithms of the above tests. This problem was successfully solved, as shown results of numerical experiments which are presented in the article. We represent all software products we have created with open source code, which enables each researcher to tailor the program to solve their problems.

In conclusion, we want to note that these m-files are the initial stage for creating a universal software complex for studying of heteroskedasticity in regression models. And also this work in the future can be used by TheMathWorks Corporation to complement the econometric package Econometrics Toolbox.

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MATHEMATICAL AND COMPUTER MODELLING

Factors and data for RES evaluation

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Computer Modelling & New Technologies 2017 ***21****(3) 7-11*

Usage of renewable energy sources (RES) – is a modern powerful trend in energy development. “Green energy” technologies (technologies of gathering energy from renewable sources) are actively developed and will allow in the future significantly to reduce use of non-renewable resources (oil, gas, coal, peat), reduce the ecological impact of energy plants, improve the ecology around populated areas, reduce the cost of obtaining energy in some cases, increase the autonomy of life support systems and energy security of the country. RES are spatially distributed resources that depend on various factors. Thus, heterogeneous data and correctly defined factors are needed to evaluation of renewable resources. Paper considers the processes of RES potential evaluation, factors and data sources available for researchers. We discuss stages of RES potential evaluation, factors that can contribute to or hinder using RES and some data sources which can be used during the process. The Kazakhstan problems are briefly discussed.

Keywords: Renewable energy resources, data sources, information systems, multiple-criteria decision making

Proposition of web services composition approach basing of model-driven approach and multi-agent systems

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Computer Modelling & New Technologies 2017 ***21****(3) 12-19*

Web services composition is an emerging paradigm for application integration within and across organizations and enterprises. For this reason, various approaches and formalism have been proposed and used for web services composition. Among these approaches we have the Models Driven Approach (MDA), which concentrates on the realization of abstract models. Thus, the phase of specification represents an important part of the cycle of development of composite web service. To proceed to this cycle of development, a developer has to elaborate a specification which allows the modelling of the global behaviour of the system, to verify formally this model for assuring his quality, then pass to the implementation of the composed service. In the paper we present a summary of our proposed approach of web services composition based on MDA, thus it is separated into three tasks: specification using BPMN notation and Multi-agent reactive decisional (MARDS) model, formal verification using LOTOS language and implementation using BPEL language. Then we present a case study to prove the feasibility and reliability of our proposed approach.

Keywords: Web services composition MDA, Specification MARDS Formal verification

Security challenges of vehicular cloud computing applications: from software architecture viewpoint

Hanieh Kashfi, Fereidoon Shams Aliee

Computer Modelling & New Technologies 2017 ***21****(3) 20-24*

The use of vehicular ad-hoc network is considered by researchers in recent years. Although these networks have been deployed in real world offering appropriate services to their users, researches show that their current architecture have different development and management problems. It seems that cloud computing due to its scalability and other features is an appropriate technology to compensate the shortcomings. By moving the vehicular ad-hoc network to the cloud, we have the new technology of vehicular cloud network. Considering quality attribute is the best approach to improve the vehicular cloud network applications’ software architecture. Among the quality attributes, security is so important and the lack of security in the system causes the rejection of these technologies by users. This paper studies vehicular cloud networking security. In order to achieve the security in vehicular cloud network applications, first of all a list of applications is prepared. Then applications are categorized to identify various security threats. To confront the existing threats, various security tactics are provided. Finally an approach to increase the security in vehicular cloud applications is proposed.

Keywords: Vehicular cloud computing, VANET, Security, Software Architecture

Fuzzy logic based job scheduling algorithm in cloud environment

Pratibha Pandey, Sarvpal Singh

Computer Modelling & New Technologies 2017 ***21****(3) 25-30*

Cloud computing is a technology which is growing faster day by day and applied in various fields such as in industry, commerce, and research. Handling resources and the task according to the need of user is the current major issue. In cloud environment when users submit their task, it selects the best virtual machine on which the task can execute. Considering the commercialization and virtualization aspect of the Cloud Environment, this paper proposes an algorithm for Job scheduling which ensures fairness of the resource allocation according to the Quality of service. It mainly focuses on two problems. One is the selection of virtual machine(s) which are eligible to execute the task. Another problem is justification of the task according to the quality of service. Our approach simplifies the complexity of the algorithm and reduces the overhead associated with selecting appropriate and justified virtual machine for a given task. It ensures the fairness of the resource allocation for each classified task and also justifies the overall system allocation. Further, it uses fuzzy logic to adjust the general expectation vector of the task based on the fairness of the allocation of resource.

Keywords: Cloud Computing, QoS, Fairness, Job scheduling, Resource allocation

Cognitive evolution in software development life cycle through design thinking

Archana Magare, Madonna Lamin

Computer Modelling & New Technologies 2017 ***21****(3) 31-34*

Software engineering is methodical, well-organized and proven approach to the advancement, operation and maintenance of the

software. Agility moves toward compact set of process activity. Design thinking is an organized, intellectual process in which designers ideate and validate notion for solving the given problem whose outcome and function fulfills clients' objectives or users' needs under specified set of constraints. This paper describes cognitive impact of design engineering process on software development life cycle (SDLC) in agile development community. The paper also depicts correlation between various design engineering canvases and phases within software development lifecycle in agile models.

Keywords: Mind Mapping, Design Thinking, Agile Methodology, Storytelling, Prototyping

Optimal implementation of critical peak pricing in cloud computing

Aishwarya Soni, Muzammil Hasan

*Computer Modelling & New Technologies 2017 **21**(3) 35-44*

Cloud computing offers a variety of services and hence the opportunity to make profit by using a suitable pricing strategy by selling these services. Yet, the instability of the dynamic price, create a risk for cloud tenants so as to effectively implement a pricing strategy which is beneficial for both tenants and end user. To overcome the dynamic price risk for tenant, method of dynamic pricing scheme between tenants and end user is employed. This paper proposes a model of dynamic pricing scheme, i.e. Critical Peak Pricing based on demand response program for profit of cloud tenants as well as end user satisfaction. The proposed model used the price responsiveness model of end user and the parameters of Critical Peak Pricing that simultaneously affects the benefit of cloud tenants and end user.

Keywords: Cloud computing, critical peak pricing (CPP), demand response, critical days, cloud tenant, end user

Computer modelling in the physics course for IT students

A V Baranov

*Computer Modelling & New Technologies 2017 **21**(3) 45-49*

Since today's students have a great interest in information and communication technologies (ICT), we must recognize that it contains a significant potential for development innovative approaches to learning and teaching. Organization of students' learning activities using ICT and the problem-project method can significantly enhance the feasibility of additional forms of educational processes. The author use ICT to organize the IT students' integrated problem-project activities to computer modelling of physical processes. Second-year IT students of the Technical University implement individual virtual projects. The problem-project method generates students' interest to the process of creating program products and to models of physical processes and phenomena. This complex activity stimulates processes of learning and skills development for multiple subject areas such as physics, mathematics, and programming. Usually the IT students' virtual projects are created using high-level languages C ++ or C#, and 3D editors. The students' virtual projects ultimately are software products that can be used in the e-learning environment complementing existing traditional didactic means with virtual computer experiments. The programs make it possible to do virtual experiments, observe and analyse behaviours of simulated systems and features of physical processes. In this article some virtual labs designed by our second year IT students are demonstrated. Some of virtual labs have real prototypes in laboratories and some are unique.

Keywords: learning and teaching physics, information and communication technologies, problem-project activities, computer modelling, virtual labs

A comparative study between artificial immune system and incremental neural network for digits handwritten recognition

H Khelil, A Benyettou, A Kacem

*Computer Modelling & New Technologies 2017 **21**(3) 50-55*

The artificial immune systems and the incremental neural networks are among novel paradigms used in artificial intelligence and pattern recognition. In this paper, we use MNIST database in order to compare these two approaches and to extract advantages and disadvantages of each one. This work is an introduction to improve the artificial immune system using principle of the incremental neural network.

Keywords: Artificial Immune Systems, Incremental Neural Network, CLONCLAS, I2GNG, Digit Handwritten Recognition

Implementation of the heteroskedasticity testing for linear regression model

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The article discusses the problem of heteroskedasticity, which can arise in the process of calculating econometric models of large dimension and ways to overcome it. Heteroskedasticity distorts the value of the true standard deviation of the prediction errors. This can be accompanied by both an increase and a decrease in the confidence interval. We gave the principles of implementing the most common tests that are used to detect heteroskedasticity in constructing linear regression models, and compared their sensitivity. The advantage of this paper is that real empirical data are used to test for heteroskedasticity. For implementing the testing there is developed the special software with using of the algorithmic programming language MATLAB. The purpose of the article is to describe the functions implemented in the form of mfiles (MATLAB environment files) to check for heteroskedasticity in multifactor regression models. To do this, modified algorithms for the tests on heteroskedasticity were used. Experimental studies of the work of the program were carried out for various linear regression models both the models of the Department of Higher Mathematics and Mathematical Methods in Economy of Simon Kuznets Kharkiv National University of Economics, and econometric models which were published recently by leading journals.

Keywords: regression model, homoskedasticity, testing for heteroskedasticity, software environment MATLAB

