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Declaration of Authorship

I, Amine Saoudi declare that this thesis titled “Investment Planning Model for Cloud Computing in small- and medium sized Companies” and the work presented in it are my own and that for all work of others the sources have been given respectively.

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Abstract

The use of Cloud Computing in enterprises have increased constantly during the past decade as the application of Cloud Computing solutions allows businesses for increased efficiency in their IT infrastructure usage while providing them better scalability and thus the opportunity of sinking their operational costs. These benefits are however often bounded with some drawbacks. Besides the privacy related concerns the necessity of changes in businesses operations for adaptation into Cloud Computing environment is the biggest obstacle holding enterprises back from taking advantage of Cloud Computing solutions.

The objective of this thesis is to develop a decision support tool which can be deployed to evaluate different types of Cloud Computing solutions regarding enterprises specifications and to suggest the most suitable investment planning model. The capability of this decision support tool is not to be limited with the assessment of Cloud Computing solutions impact on the company's performance, but it is also able to show which type of Cloud Computing model serves best the enterprises interest and how the adaptation to Cloud Computing environment should be undertaken to minimize a performance decline during the transition phase and to prevent a prolonged implementation time of the necessary changes in enterprises operations.

This thesis provides an algorithm which uses attributes of businesses designated as most significant in correspondence with Cloud Computing solutions and has the capability to allocate a given business with a Cloud Computing solution and an appropriate Investment Planning Model.

Abstract

Der Einsatz von Cloud Computing in Unternehmen hat sich während der letzten zehn Jahre ständig erhöht, da die Anwendung von Cloud Computing-Lösungen die Unternehmen höhere Effizienz in der Nutzung ihrer IT-Infrastruktur ermöglicht, während sie auch eine bessere Skalierbarkeit und dadurch eine Möglichkeit um ihre Betriebskosten zu senken anbietet. Diese Vorteile sind jedoch oft mit einigen Nachteilen verbunden. Neben die Sorgen um Datenschutz stellt die Notwendigkeit von Veränderungen in Unternehmens Operationen für die Anpassung an die Cloud Computing-Umgebung das größte Hindernis, welches die Unternehmen zurückhält Cloud Computing Lösungen einzusetzen.

Das Ziel dieser Arbeit ist die Entwicklung eines Entscheidungsunterstützungswerkzeug, das eingesetzt werden kann, um verschiedene Arten von Cloud-Computing-Lösungen für Unternehmen zu bewerten und die am besten geeignete Investitionsplanungs Modell vorzuschlagen. Die Fähigkeit dieses Instruments zur Entscheidungsunterstützung ist nicht mit der Bewertung der Cloud-Computing-Lösungs Auswirkung auf die Leistung des Unternehmens beschränkt, es ist auch in der Lage zu zeigen, welche Art von Cloud-Computing-Modell am besten Interesse der Unternehmen dient und wie die Anpassung an die Cloud Computing Umgebung unternommen werden soll, um einen Leistungsabfall während der Übergangsphase zu minimieren und eine verlängerte Einführungszeit von notwendigen Veränderungen in Unternehmen Operationen zu verhindern.

Diese Masterarbeit stellt einen Algorithmus vor, der Attribute von Unternehmen, die für Cloud Computing-Lösungen signifikant sind, verwendet und die Fähigkeit hat, eine gegebenes Unternehmen mit einer Cloud Computing-Lösung und einer entsprechenden Investitionsplanung zuzuordnen.

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List of Abbreviations and Symbols

ANN	Artificial Neural Network
API	Application Programming Interface
CCO	Chief Cloud Officer
CIO	Chief Information Officer
DSPL	Dataset Publishing Language
EU	European Union
ICT	Information and Communication Technology
IMAP	Internet Message Access Protocol
IT	Information Technologies
ITIM	Information Technology Investment Management
IaaS	Infrastructure-as-a-Service
PDF	Portable Document Format
PaaS	Platform-as-a-Service
ROI	Return of Investment
SLA	Service Level Agreement
SaaS	Software-as-a-Service
TAN	Transaction Number
TCO	Total Cost of Ownership
USA	United States of America
USB	Universal Serial Bus
WACC	Weighted Average Cost of Capital
kNN	k Nearest Neighborhood

1 Introduction

Cloud Computing is a terminology describing the offering and utilization of remote services. Thus the simple access to a web page or using an email application through e.g. IMAP is an example for Cloud Computing utilization [23].
The Cloud Computing mentioned in scope of this thesis however limits this definition strictly to the strategy of gaining financial advantage or improving services of an enterprise by outsourcing its IT operations into Cloud Computing Environment.
This chapter presents the motivation, the problem statement and the aim of this thesis.

1.1 Motivation

The use of Cloud Computing in enterprises has increased constantly from 2013 to 2015 at an average rate of 28% [25] as the application of Cloud Computing solutions allows businesses to increase the efficiency of their IT infrastructure usage while at the same time providing them with better scalability and thus with the opportunity of sinking their operational costs.
Through the advantages brought by Cloud Computing, enterprises can not only offer a wider variety of services to their customers but also gain the ability to cope [29] with larger enterprises who dominate the market due to their immense investments into own IT infrastructure which made them de-facto monopoles in their respective markets. Besides the usage of Cloud Computing as a substitute for traditional IT infrastructure, this technology is also appealing to an increasing number of enterprises working with Big Data as they do require high computing power for Data Analysis [30].

1.2 Problem Statement

The benefits of Cloud Computing are bounded with a number of trade-offs. Companies do generally have the tendency to be mobilized faster when facing a crises, they do however get stifled when facing slower trends eating up their resources. The lack of knowledge about Cloud Computing's advantages, the existence of security and privacy related concerns and the necessity of changes in businesses operations for adaptation to Cloud Computing environment are some of the biggest obstacles holding enterprises back from implementing Cloud Computing solutions.

It would be a mistake to see Cloud Computing as a silver bullet, a resolution for all IT infrastructure problems. The concerns regarding Cloud Computing should not be ignored as they might have dramatic consequences. It would however be equally wrong to make false assumptions regarding whether these concerns apply for the company in question or are as critical as they are thought to be.
Due to different size, industry and location of companies, it is often challenging to make an assessment regarding the feasibility of implementing Cloud Computing solutions in companies and to asses full scale advantages which they could offer [24].

1.3 Aim of this Thesis

The main objective of this thesis is the development of a decision support algorithm which can be deployed to evaluate different of Cloud Computing solutions regarding enterprises specifications. The algorithm is implemented as a prototypical tool.
The capability of this decision support tool is not to be subject to heavy abstraction of Cloud Computing solutions' and the company's attributes. It rather should be able to make its computation by taking as many attributes as possible into consideration to compute which type of Cloud Computing model serves the enterprises interest best.

1.4 Expected Outcomes of this Thesis

The major expected outcome of this thesis is the development of an algorithm to calculate the suitability of Cloud Computing usage in an enterprise. The algorithm should allocate the given enterprise data to a company model and calculate the most suitable Cloud Computing model. After this calculation the algorithm should also suggest options of Cloud Computing solutions from the available Cloud Computing service providers.
Finally a program should run the algorithm and return the results of computation in a PDF-file.

1.5 Structure of this Thesis

The structure of the thesis can be divided into 4 major parts. The first part is chapter 2, which discusses an IT investment framework in the context of Cloud Computing. The second part consists of chapters 2 and 3, which describes the Cloud Computing usage of enterprises. The third part contains chapters 4, 5 and 6, which present company and

Cloud Computing models based on the knowledge retrieved in chapters 2 and 3. The fourth part consists of the remaining chapters and contains the development and evaluation of the algorithm and the expected results of this thesis.

2 The State of the Art in Investment Planning Models for IT Projects

This chapter describes Information Technology (IT) investment planning models taken into account to be associated with the implementation of Cloud Computing solutions. The development of the investment planning model in this study is based on the framework ITIM [8] published by the US Department of Commerce.

The main argument of selecting ITIM Framework for examination of investment planning models is its fitness in regard of being used as a reference book and its structure for categorization of the maturity steps *[Fig. 1]* for IT investments, which belongs to the foundation of all investment models.

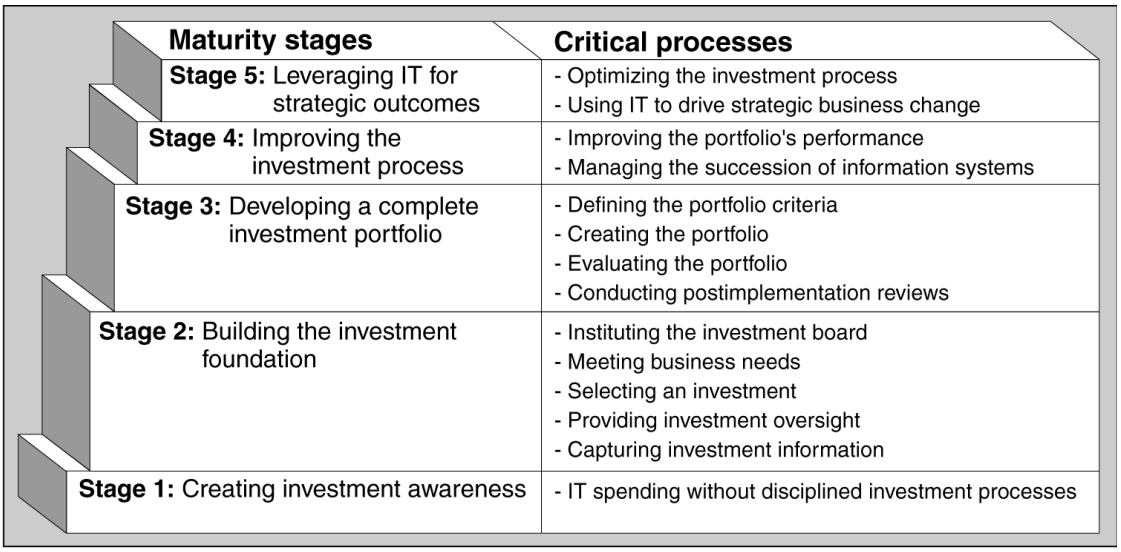


Fig. 1: *Maturity stages for IT Investment [8]*

All stages of the ITIM Framework are addressed in this study in context of Investment for Cloud Computing Technology. While the stage 1 is addressed through the chapter on “Data Collection and Integration” in an attempt to create investment awareness by reasoning such an action with action trends of similar companies in the market, the

stages; stage 2 and stage 3 are addressed in the chapter on “Resource Planning” and the remaining stages 4 and 5 in the chapter on “Investment Control”.

2.1 Resource Planning

“Building the Investment Foundation” and “Developing a Complete Investment Portfolio” are the two vital steps of Resource Planning.

For building the investment foundation, it is required to establish an investment management process, which serves the organization's objectives and the requirements of the business with the appropriate support processes to determine areas in businesses operations qualifying for investment. It is also essential that this investment management process relies on a respective governance inside the organizations hierarchical structure.

The determination of investment areas and their funding are based on ROI calculations which consists of TCO and the expected financial gain in a given time interval. The ROI is then compared to WACC. The WACC is the cost of raising the required funds to finance an investment, which may be generated as a result of loss of interest rate the company would receive in case the enterprise is using its own funds or the amount of interest it will need to pay to the institution from which the amount is borrowed. If the ROI is greater then WACC the investment can be called as justified. Thus it is of great importance to select the attributes for the calculation of ROI correctly. The funding and further management related tasks are to be executed by a governance body, which should specialize itself in the field of the investment [9].

There are 3 major categories of cloud delivery models based on SLAs;

SaaS, PaaS and IaaS.

The SaaS is a delivery model where the service provider enables its client the use of a software over the Internet for the time interval agreed on, where the software runs on service providers infrastructure. The main advantage of SaaS is that the client is relieved from software and platform maintenance. This type of model limits however the client to use only the features made available through the software and does not allow to add new features or make The PaaS model allows the client the use development tools. In this model the client has the ability to create and deploy new software without dealing with the maintenance of the platform. The IaaS model gives the client

access to the operating system and firewalls, thus it allows the client more flexibility while at the same time increasing its maintenance responsibilities.

Regardless its model the cloud delivery provided by a third party is called as public cloud. In this case the client does not necessarily know where its data is geographically stored and what security measures have been undertaken for data protection.

Depending on the size of the enterprise, the volume of its IT operations and the level of sensitivity of data it deals with, it is possible that the organization might decide to use a private cloud. In this case all of the IT infrastructure used for cloud service delivery is located in enterprises premises and the enterprise itself is responsible for all maintenance related task. Private clouds are primarily suitable for enterprises handling sensitive data, which have multiple subsidiaries to increase the efficiency of its IT infrastructure usage by leveraging Cloud Computing technology.

Cloud Computing is about leveraging dynamic resource usage just like other utilities such as electricity, which clients do not buy in specific quantities but rather during a time interval as much as they require. Assessing the requirements of the business and managing the operations regarding Cloud Computing requires a specialized governance body as the enterprises need the capability to deal with this emerging technology.

In [10] it has been suggested that the cloud governance should be in technical, business and service levels.

The technical level governance deals with determination of specifications for the cloud services planned to be taken in-use, while the business level governance relates to the consumption of the cloud services. The domain of service level governance contains the relationship with cloud service provider and the monitoring of cloud services. Fig. 2 presents a governance structure proposal for Cloud Computing services.

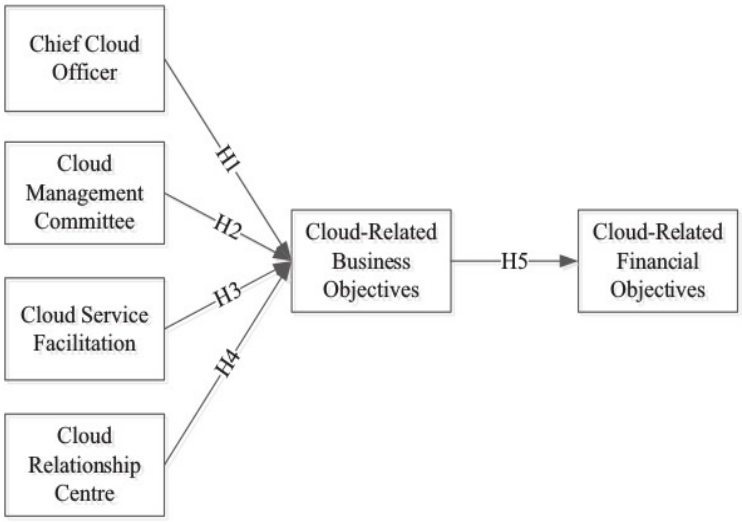


Fig. 2: *A design approach for Cloud Computing governance structures according the 5 hypothesis described in [10]*

The notations regarding hypothesis 1 to 5 express that each respective suggestion is expected to improve enterprises Cloud Computing performance positively. According to this governance model, a CCO is responsible to make the decisions regarding Cloud Computing operations, which are to be overseen by a Cloud Management Committee. The Cloud Service Facilitation deals with daily Cloud Computing operations and acts as the single contact point for Cloud Computing related tasks for all the departments of the enterprise. The Cloud Relationship Centre stands between the enterprise and the cloud service provider and communicates the Cloud Computing specifications determined by the CCO and the Cloud Computing service requirements of the Cloud Service Facilitation to the cloud service provider.

Establishment of Cloud Computing governance and creation of models for ROI are vital for resource planning, where the costs regarding Cloud Computing governance should be regarded as part of the TCO.

Once the resource planning is complete, the next stage to create a complete investment portfolio can be initiated. This step contains the creation and assessment of ROI models and the respective TCO calculation.

For the suitability calculation a formula has been suggested in the research paper [9], which consists of TCO calculations of designated attributes, such as size of IT resources, utilization pattern, sensitivity of data and level of operations criticality.

The results of these TCO calculations are then put into a formula which is used to calculate the level of enterprises suitability for Cloud Computing.

This proposed formula should be extended with the expected financial and operational impact calculation of the planned investment as suggested in the research paper [12]. In order to take future financial risks caused by external factors also into account a sensitivity analysis should be conducted to assure an effective resource planning. Also important to notice is that none of these calculations take the organizational costs for governance of Cloud Computing services into account, which is critical for the enterprise to leverage the most of Cloud Computing technology.

Once the TCO calculation is complete the ROI analysis can be conducted. The calculation for ROI in context of Cloud Computing as suggested in the research paper [9] consists of the division of the difference from costs saved and cost of the investment to the cost of the investment.

If the enterprise possesses a traditional IT environment a partial migration into the cloud might be considered. Such a scenario would require a ROI calculation by taking only a limited number of benefits from Cloud Computing services into account which would be achieved respective the usage expectation as illustrated in Fig. 3.

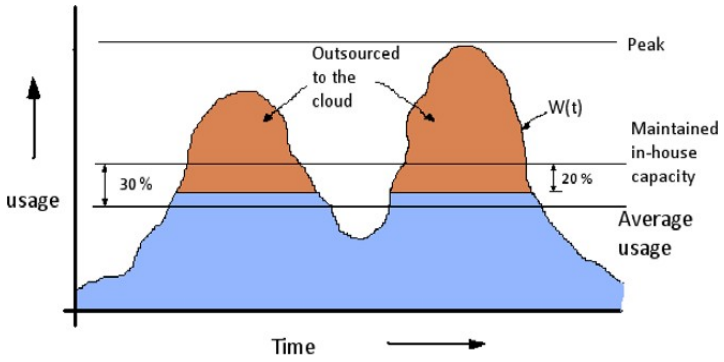


Fig. 3: *Workload during a time interval with partial migration to the Cloud Computing environment [9]*

2.2 Investment Control

There are two steps related to investment control; “Improving the Investment Process” and “Leveraging Information Technology for Strategic Outcomes”.

Once the investment portfolio has been created the organization should attempt to improve the newly introduced investment processes with the aim to increase their effi-

ciency. This way the enterprise will have the possibility to reach the outcome targeted through the investment portfolio with the best financial plan sinking the TCO wherever possible. This will require to introduce new processes for evaluation such as the re-evaluation process shown in Fig. 4.

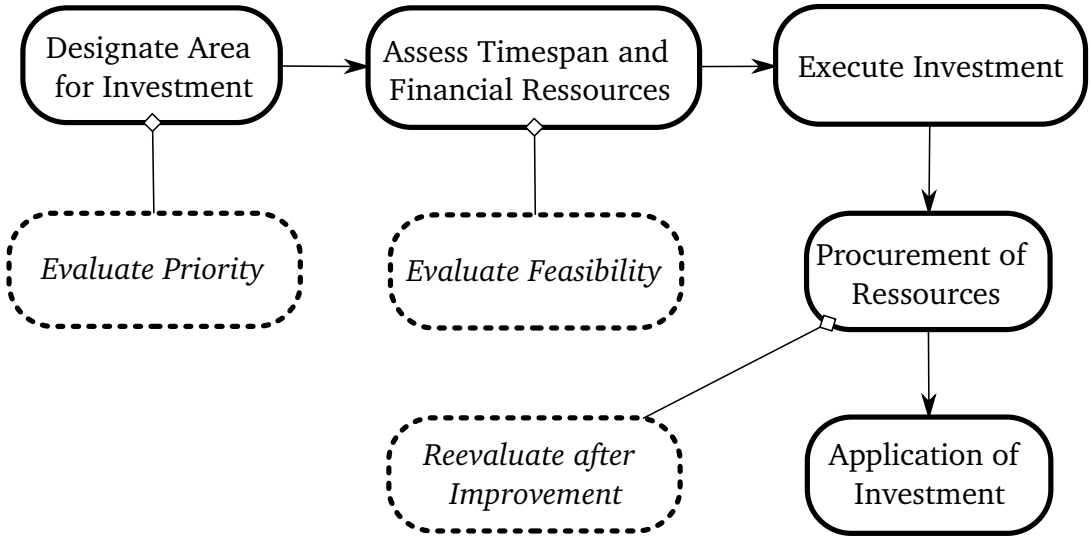


Fig. 4: *Overview of Investment Processes at a high abstraction level*

As suggested in the research paper [14] following assumptions may be considered;

- Taking advantage of the existing infrastructure which is required to conduct daily IT operations regardless whether these operations are executed on traditional IT infrastructure or on a Cloud Computing environment. It can be assumed that the employees already possess a mobile computer, a smart phone and Internet connection. This existing infrastructure should not be included in the TCO calculation unless there are specifications not satisfied with the existing infrastructure, e.g. bandwidth of the Internet connection.
- There is no necessity of a server infrastructure in enterprises facilities if it is planned to use Cloud Computing services for all IT operations. The concerned inefficiency e.g. regarding large data transmissions inside the enterprises premisses can be overcome by the Cloud Computing applications providing direct data streaming between users in the same network.
- The change of Cloud Computing service provider should be accounted as a new service deployment since the steps to be undertaken are same in both situ-

ations. As stated in the research paper [9] the Cloud Computing service providers have the tendency not to allow users to download their virtualized systems due to potential violation of licensing agreements.

- The existing IT personnel of the enterprise can be assumed to posses the required know-how for the migration from traditional IT infrastructure to Cloud Computing environment, thus there is no factor generating costs for acquiring external support.

The step regarding leveraging IT for strategic outcomes deals with benchmarking of IT investment processes. This step attempts to compare enterprises IT investment decisions and processes with other enterprises operating in same industries. Through know-how from external consultants cloud life cycles can be designed suiting the enterprises needs regarding the deployment of different types of cloud operations.

3 Significant Factors affecting Cloud Computing Solutions

This chapter discusses significant attributes effecting Cloud Computing solutions based on the expected benefits from Cloud Computing services. It also presents the effects of the designated attributes in ROI calculations.

The expected benefits, the most influential attributes of enterprises and the evaluation process has been compiled from 5 research papers [9,10,11,12,13]. The soundness of the most influential attributes of enterprises could be partially verified through the chapter “Data Collection and Integration”.

3.1 Expected Benefits from Cloud Computing

The main objective of Cloud Computing is to turn the traditional IT into a commodity and as a result to boost the efficiency of enterprises IT infrastructure. The easiest use-case to observe Cloud Computing benefits is a company, where no IT infrastructure has been set up and upfront capital investment is an issue for the enterprise. In such a scenario the enterprise would be relieved from purchasing IT hardware, software licences and premises to store and run its IT system. It is also important to mention that dealing with one provider regarding various technical issues is more convenient then dealing with multiple software, hardware and service providers. The foremost benefit however is the sinking of initial costs caused by establishment of IT infrastructure. The enterprise still have the possibility to increase its IT resources later when and if re-

quired without the necessity of an expensive adjustment such as discarding and replacing IT components. The utilization of IT turns fixed costs into variable costs and is especially for enterprise with a limited budget a financially healthier option to invest into IT.

Assessing the benefits of Cloud Computing becomes more challenging if the enterprise in question has already an IT infrastructure set up. Thus it is of utmost necessity to develop methods to detect and asses also the benefits which are intangible.

According to the research paper [11] the expected benefits from Cloud Computing can be listed as below;

- Cost reduction

The utilization of computing as a commodity sinks the initial IT costs which are generated through hardware purchase and facility costs. It also allows companies to use software with smaller licence fees. According to the study in [11] the IT costs can be sunk up to 70% by using e.g. Amazon Cloud Services.

- Ease of use and convenience

Cloud Computing eases access to data practically from anywhere, which provides improved support for employees working outside of office. Financial processes on cloud not only allows access to data from remote locations and save administrative overhead caused by monitoring operations, it also makes hardware changes and software upgrade convenient, as such changes can be made overnight causing no interruption of daily operations. Increasing number of online transactions can be managed through Cloud Computing with automatized processes.

- Reliability

As Cloud Computing service providers specialize in IT services, they provide technical support round the clock, which is in most cases for small and medium sized companies a service more expensive to exercise with in-house IT staff. With almost 100% up times and data redundancy feature Cloud Computing services offer a cheaper alternative for building an in-house IT system with same capabilities.

- Sharing and collaboration

Cloud services provide additional sharing and collaboration features then classical IT technologies offer. Users can share large files in a secure way with time limits and password protection and can view/edit documents together with other users in different locations in real time or communicate through instant messaging or video conference.

Virtualization allows users also simple way to replicate their IT systems or configure new machines with automatized processes in the Cloud Computing environment.

- Security and privacy

Although security and privacy are known as biggest concerns of Cloud Computing services, with introduction of data encryption, authentication with transaction authentication number (TAN) and activity monitoring features Cloud Computing can be accounted as secure. In fact according to the study in [11] although 75% of CIO's are concerned with Cloud Computing security, 66% of USB drives are lost, which makes cloud storage a safer alternative for physical data sharing methods.
As Cloud Computing has built-in monitoring tools, it becomes for enterprises easier to measure the cost of its IT infrastructure cost and level of efficiency.
Leveraging the Cloud Computing services requires its successful integration into appropriate business processes which is vital for the enterprise to fulfil its financial commitments and provide better results regarding their ROI [10].

3.2 Most Influential Characteristics

Most influential attributes used to indicate the companies suitability have been stated in the research paper [9] as;

- Size of the IT resources

The size of existing IT resources of the enterprise have two effects on their interest for adoption of Cloud Computing services. First of these effects is based on decommissioning existing IT infrastructure. The transition phase is expected to drop work capacity of the enterprise thus costing them less revenue for the time period of transition. The previously purchased software licences become obsolete as the Cloud Computing service providers include the licensing price in the fee of their solution packages.

The second effect of an existing IT infrastructure is that the larger infrastructure of the enterprise is, the lower will be the per capita cost. This effect is the principle reason which allows Cloud Computing service providers to offer their services for lower prices then it would cost to the client in case of building their own IT infrastructure. If the enterprise in question has already a large IT infrastructure, it would have a similar performance as the IT infrastructure of Cloud Computing service providers. This fact is also the reason why Cloud Computing services are more suitable for small- and medium sized enterprises.

The research paper in [9] mentions the attributes related to the size of the IT resources as number of servers, size of customer base, annual revenue and number of countries IT has spread across. E.g. the high number of countries enterprises IT spreads would increase the benefit from Cloud Computing since could computing services would provide increased accessibility and features for sharing data and collaboration. All these attributes are contained in the attributes investigated in the chapter “Data Integration”. Although the decision support tool created for data integration does not have the exact attributes, it allows the user to enter values which would logically create same effect as entering a value for the attributes mentioned in the research paper [9]. Thus through the decision support tool it can be confirmed that values of these attributes correlate with changes regarding the enterprise's suitability for adoption Cloud Computing solutions and the specification of the Cloud Computing services the enterprise might take into consideration.

- The utilization pattern of the resources

The utilization pattern of resources is about the main reason which makes the traditional IT infrastructure inefficient. According to the research paper [9] is the global average for server usage is around 5%-10% only. Through scalability offered by Cloud Computing services it is possible to build efficient IT systems by increasing the resources of client dynamically and only when required. The pay-as-you-go subscription model offered by Cloud Computing service providers would also allow the enterprise to calculate its IT costs effectively.

The scalability feature of Cloud Computing can only be leveraged, if the enterprise has an actual need for such a service, such as the case where there are significant changes in computation usage in short time intervals. E.g. the *Fig. 5* shows a hypothetical graph of server usage with three pikes in the graph, where the workload has exceeded well over the average usage. It would be beneficial for the enterprise to outsource the task of this server to a cloud computer service provider.

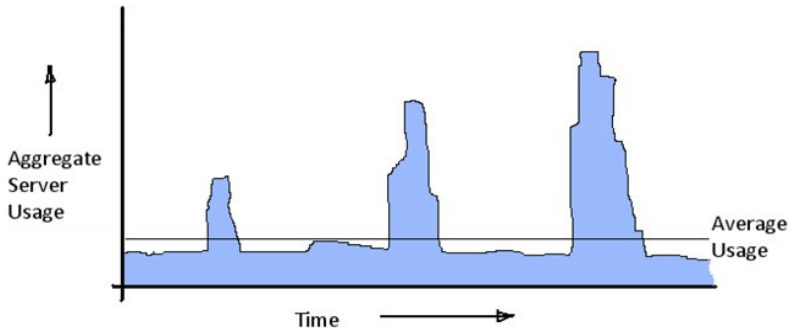


Fig. 5: *Changes in workload of servers over time [9]*

- Sensitivity of the data they are handling

Sensitivity of data is the biggest obstacle that prevents Cloud Computing from being instantiated as a universal IT infrastructure. The higher sensitivity of data handled is the more unlikely are the enterprises to adopt public Cloud Computing services. Although through introduction of data encryption and authentication with transmission authentication numbers the cloud storages have been well secured, the concerns in the industry still exists. Some enterprises have to comply with regulations regarding the geographic location of their data stored. These regulations create also obstacles preventing widespread adoption of Cloud Computing services.

- Criticality of work done by the company

Highly critical work might be not suitable to be performed by cloud computation services. Cloud computation service providers define in the SLA the specifications of their Cloud Computing services. These specifications include uptime and quality assurance. It is possible that the requirements of highly critical work might be higher then the specifications stated in the standard SLA.

There is the possibility that the clients with higher requirements might ask for a individualized SLA but depending on the size of outsourcing the service provider may reject the proposed SLA due to lack of profitability.

3.3 Evaluation Process of Cloud Computing Effects

The challenge in a holistic evaluation of Cloud Computing effects lies primarily in the difficulty of converting improvements provided by Cloud Computing into numeric data [12]. Another challenge is the difficulty in detecting the intangible benefits of Cloud Computing. The evaluation process is visualised in Fig. 6.

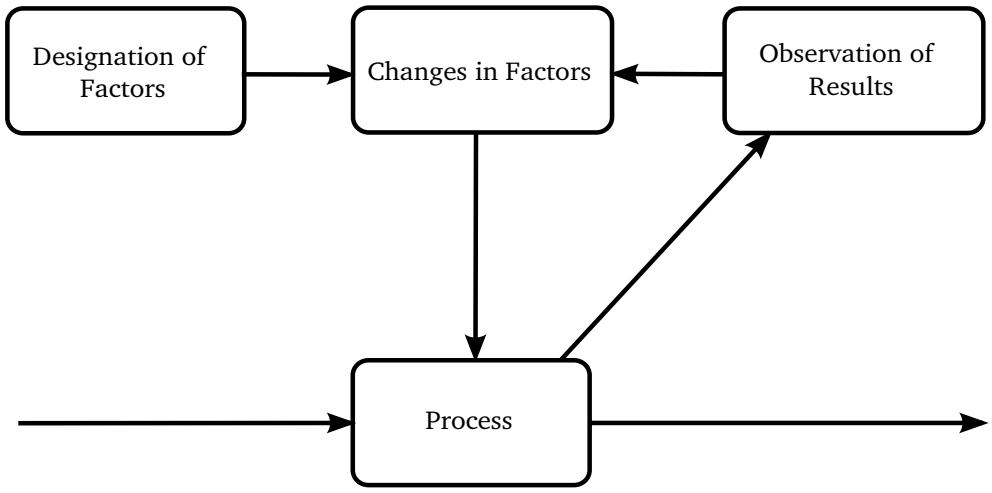


Fig. 6: *Basic structure of an Evaluation Process for Cloud Computing Decisions*

The effects of Cloud Computing have been designated in the research paper [12] as follows; Diagram of the Process

- Reduction and lower risk of server down time

  A comparison of servers up-time for a given time interval by using traditional IT infrastructure versus by using Cloud Computing services. Also a comparison of uptime percentage stated in the SLA and the uptime percentage established with traditional IT infrastructure.

- Scalability

  Measuring the savings gained through Cloud Computing by calculating the initial capital cost for setting up the necessary IT infrastructure and its operation costs including the salaries of IT staff required for maintenance and the cost of Cloud Computing services. The time interval should be selected as the maximum amount of time the IT infrastructure is planned to be used, e.g. duration of warranty.

- Improving service scalability

  Measuring the savings gained through the cost of extending hardware resources of Cloud Computing environment (aka. making changes in Cloud Computing subscription) and the cost of the same improvement in traditional IT infrastructure.

- Simplify and streamline IT management

  The amount of salaries saved by outsourcing the support for IT management and monitoring tasks.
- Greater customer satisfaction and number of new customers

  Measuring the improvement of customer satisfaction through feedbacks regarding products and services which rely on the consume of Cloud Computing services. Measuring the changes in customer numbers of products and services which rely on the consume of Cloud Computing services.
- Automation of tasks and collaboration

  Measuring the work hours saved through automation of e.g. software update or maintenance tasks. Also measuring the work hours saved through improved collaboration between employees, e.g. the time saved from administrative overhead.

Although for all of these effects listed above a suggestion for evaluation has already been made, it is important to mention that there are in general two steps to be undertaken for evaluation of effects; conversion of the effect into numeric data and conduction of a sensitivity analysis as suggested in the research paper [13].

The conversion of the effects into numeric data is vital for determination of whether the effect delivers any profitability. The conversion can be made with or without consideration of the time factor.

A method suggested as a universal proceeding for generating numeric data derived from intangible benefits in the research paper [12] is the Cost Benefit Analysis (CBO). In CBO analysis the values such as licence and hardware costs are subtracted from the sum of benefits, which may consist from savings through efficiency increase and product improvement.

The overall evaluation of Cloud Computing is conducted by calculating the ROI, TCO and employee productivity. The selection of indicators such as formulas to be used can be determined by the enterprises themselves.

The next step is the conduction of a universal sensitivity analysis. This analysis is indicates the sensitive of the results to various changes in the given inputs, thus allowing to determine the effect of inputs on the result. These inputs to be analysed might belong to a wide range of values such as tax rates, energy prices and exchange rates. E.g. if the Cloud Computing services provider resides in a country which has a currency

with a tendency to increase its value against the currency of clients country, it needs to be calculated how much this change will effect the financial benefits of Cloud Computing for the client.

The steps for this analysis have been described in the research paper [13] as follows:

- Designation of the factors expected to make significant changes in profitability calculations
- Change of each factor by a constant level and observation of the changes in result

4 Data Collection and Integration

This chapter includes the description of procedures followed for analysis of the cost advantage Cloud Computing might provide for businesses, the limitations of Cloud Computing and the proceeding for creation of models for investment plans.

For this purpose data on Cloud Computing usage of companies have been collected and integrated in a program to investigate cases which also may not be included in the data used. The result have been evaluated through the implemented program and common knowledge on the comparative economic states of countries and operations of enterprises regarding their industry.

4.1 Data Collection

To create an overview of companies from various industries and to make assumptions on their ICT costs open data sources available to public domain have been taken into consideration.

The collected data was not only made to classify industries with largest number of companies, but also to collect information about the operations in these industries e.g. supply chains and to create an overview of their respective market. This proceeding was used to establish a better understanding of the environmental changes and the usage of Cloud Computing solutions in enterprises. The information on environmental changes combined with news about similar businesses was used to create the means for analysis and cross-referencing from which the effects of Cloud Computing implementations could be studied.

While most of the data have been formatted as spreadsheets, some of the data was not directly accessible and had to be visualised through the website of its respective source.

4.1.1 OpenData500

OpenData500 is an initiative with the goal of providing a basis for assessing the economic value of government data. Although the OpenData500 does not provide any sort of statistical analysis or ranking of companies, the interactive diagram they provide on their website summarizes usage of government data by organizations from various industries. The diagram [1] provided on the website of OpenData500 is helpful for understanding the usage of open data by companies. The diagram provides information in regard of origin of the data and its amount used by companies. This information helps to create a better understanding of the potential for Cloud Computing Solutions for various industries; e.g. not only to increase their capability in analysing Big Data but also to generate more data regarding their operations by taking advantage of more sophisticated analysis tools.

4.1.2 Forbes

Forbes is an American business magazine published by the Forbes, Inc. featuring articles on market, industry, investment and finances [2]. There are various articles published by Forbes regarding trends in Cloud Computing market. These articles include also statistical analysis based on data from 3rd party corporations and discusses Cloud Computing from different perspectives such as the providers, the overall performance in stock exchange and consumer trends.

Articles on the expectations of companies about future Cloud Computing models, the overall impact of Cloud Computing adoption in enterprises on the market and Cloud Computing Application development trends provide a deeper insight on the Cloud Computing market and the possibility of analysing the patterns in advancement of this field.

4.1.3 Google Public Data Explorer

Google Public Data Explorer is a service of the American technology company Google, Inc. offering public data from a number of organizations through its web interface and for download in Data Set Publishing Language (DSPL) format.

Although the Google Public Data Explorer has a high number of sources, it is currently (2015) lacking of data which could be useful in analysing the Cloud Computing usage in different countries or throughout enterprises from various industries.
The most relevant data set available which could be helpful for making assessments on Cloud Computing is the “Connected Consumer” data provided by the company “TNS Infratest Germany”, which gives an overview on device and internet usage trends in a number of countries [3].

4.1.4 Eurostat

Eurostat is the Directorate-General of the European Commission which has the responsibility of providing statistical information to the institutions of the EU [4]. The open-data initiative of Eurostat makes data and statistical analysis conducted in member countries of the EU available to the public domain.
The figures provided by Eurostat is available for download in multiple formats. The data on Eurostat website includes Cloud Computing usage in different countries by different industries, consumer data, sizes of enterprises and data on limitations of Cloud Computing usage associated with enterprises industry and location.
There were 9 spreadsheets of importance for analysing the relation between Cloud Computer usage and enterprises. 7 of these spreadsheets were acquired from the file “Data_for_SE_article_on_Cloud_computing.xlsx” and the other two from files “Obstacles that limit prevent the use of Cloud Computing services isoc_cicce_obs.xls” and “Use of Cloud Computing services isoc_cicce_use.xls”.
Additionally the Eurostat includes files providing information about Cloud Computer usage of individuals similar to the “Connected Consumer” data of Google Public Data Explorer.

4.2 Data Integration

The Data Integration was conducted on spreadsheets downloaded from Eurostat institutes website as they were directly relevant to the study of this Master Thesis. The main approach was to detect patterns from different spreadsheets and to combine them in a way so that data for different case studies could be generated even if the new case study would consist of a situation which is not identical to the one provided by these spreadsheets.

The first proceeding in Data Integration was to conduct an analysis by using descriptive statistics and combine the interpretation of the outcome. This proceeding had also the advantage that for some of the spreadsheets such an analysis was already provided on Eurostat website. The problem with such a proceeding was however that the combination of different data in an algorithm to make assumptions would become more challenging and could potentially include a higher error rate. A cluster analysis was also ruled out as depending the start conditions the clusters had the possibility to be arranged differently thus leading the user to diverse conclusions.

The second -and final- proceeding was using ANNs to learn patterns in data. The advantage of this method is that artificial networks provide high flexibility in regard of allowing to be trained further when e.g. new data sets are available.

To make the ANN learn the pattern in spreadsheets from chapter 4.1.4, the data had to be translated first into a format, which consists of inputs and outputs. Each line in these spreadsheets starts with a textual mark indicating an attribute for which the data in the right fields on the same row are associated. This means that if the textual input for that attribute is given, values for this attribute are to be read on the same row of the spreadsheets' respective table. For the required transition a program “DataSetGenerator” [Appendix I] has been written, which not only changes the format of the data accordingly (separation with comma) but also adds prefix for each column indicating the input (aka. selection of the line in spreadsheet), thus translating the textually written attribute into a form which is accepted as an input by the ANN training program.

Table 1 illustrates an example transition of the columns. Please note that the attributes represented by letters A, B and C are textual information written in the cells of the table just like the numeric data following up.

A	23	24
B	41	56
C	18	37

A	B	C		
1	0	0	23	24
0	1	0	41	56
0	0	1	18	37

Table 1: Columns on the spreadsheet (left), Columns of the same spreadsheet with prefix (right)

After the transition the non-numeric attributes are replaced with binary numbers. The amount of these binary numbers is equal to the number of rows of that table as each

binary number in the prefix indicates whether the row in the same order has been selected or not. The generated data set for each spreadsheet is at this point ready to be used for training of ANNs.

There have been 9 data sets generated in total from following spreadsheets;

- Data_for_SE_article_on_Cloud_computing.xlsx
  - Table 1: Use of Cloud Computing services in enterprises, 2014
  - Figure 2: Use of Cloud Computing services, by economic activity, EU-28, 2014 (% of enterprises)
  - Figure 3: Enterprises with high level of dependence on Cloud Computing services, 2014 (% of enterprises)
  - Figure 4: Degree of dependence on Cloud Computing, by economic activity, EU-28, 2014 (% of enterprises using the cloud)
  - Figure 5: Use of Cloud Computing services
  - Figure 6: Factors limiting enterprises from using Cloud Computing services, by size class, EU-28, 2014 (% enterprises using the cloud)
  - Figure 7: Factors preventing enterprises from using Cloud Computing services, highest factor by economic activity, EU-28*, 2014 (% of enterprises)
- Obstacles that limit prevent the use of Cloud Computing services isoc_cicce_obs.xls
  - Data: Obstacles that limit/prevent the use of Cloud Computing services
- Use of Cloud Computing services isoc_cicce_use.xls
  - Data: Use of Cloud Computing services

Due to the high number of spreadsheets, the diversity of data they contain and the high number of input and output neurons on generated data sets it has been decided to train a separate neural network -for the content of- each spreadsheet. The results of calculations made by these ANNs would still be able to be combined later in the decision support tool.

Before starting the training of ANNs it needed to be decided what type of algorithm the neural network is going to use and which ANN API should be selected for the training task.

As the aim of this study lies primarily on making assessments based on patterns in the data, the most suitable algorithm picked for this task is using Multilayer Perceptrons with Back-propagation.

As suggested in the study [5] on behaviour analysis of Multilayer Perceptrons the number of hidden layer has been set as 1 and the number of hidden neurons has been set no more then double size of the input neurons. It has been decided that the max. error rate should be set as low as possible, so the rate of 0.0001 has been designated as the appropriate max. error rate. The momentum has been set to 0 and the learning rate to 0.0001.

For training of the ANNs there have been two open source artificial intelligence frameworks considered: Encog[6] and Neuroph[7]. Both of these frameworks support various algorithms for machine learning and both of them provide API's for multiple programming languages as well as a workbench. The main difference between these frameworks can be roughly summarized as that Encog is superior to Neuroph in training speed and can take advantage of multi-core processor architecture. It offers also a bigger spectrum of machine learning algorithms. Neuroph on the other hand is very focused on ANNs and has better expressionism. The fact that the to be trained ANN in this study consists of multiple networks and the lack of necessity for a fast training led to the decision of using the Neuroph framework for training of the ANNs.

The training has been realized through the program “DataTrainer” [Appendix: II] and took on 2.4Ghz processor 115917476 ms (~1.34164 days). Each trained network has been saved under its respective name to be used by the decision support program.

The program “DataAnalyser” [Appendix: III] has been implemented as a primitive version of the decision support tool. The aim of this program is only to conduct analysis for a given setting without combining the networks or interpreting the results. This version gives only the outputs of ANNs in the analysis report.

After launching the program the user is asked to answer 3 questions about the enterprise to be evaluated; the countries where it operates, the relevant industries and the company size.

The user input is then forwarded to each ANN and the output is shown on the terminal. To offer a better understanding of the outcome a report is generated, where the output of each neural networks is associated with one of the three groups, each reflecting the result from its own perspective.

There are three categories of data distilled from the spreadsheets elected in Chapter 4.1.4. These categories provide different in-depth view on enterprises Cloud Computing usage trends based on the user input entered beforehand;

A. Inquiry on necessity of Cloud Computing usage

- Data_for_SE_article_on_Cloud_computing.xlsx
  - Figure 2: Use of Cloud Computing services, by economic activity, EU-28, 2014 (% of enterprises)
  - Figure 3: Enterprises with high level of dependence on Cloud Computing services, 2014 (% of enterprises)

B. Inquiry on the type of Cloud Computing solutions

- Data_for_SE_article_on_Cloud_computing.xlsx
  - Table 1: Use of Cloud Computing services in enterprises, 2014
  - Figure 4: Degree of dependence on Cloud Computing, by economic activity, EU-28, 2014 (% of enterprises using the cloud)
  - Figure 5: Use of Cloud Computing services
- Use of Cloud Computing services isoc_cicce_use.xls
  - Data: Use of Cloud Computing services

C. Inquiry on limitations of Cloud Computing usage

- Data_for_SE_article_on_Cloud_computing.xlsx
  - Figure 6: Factors limiting enterprises from using Cloud Computing services, by size class, EU-28, 2014 (% enterprises using the cloud)
  - Figure 7: Factors preventing enterprises from using Cloud Computing services, highest factor by economic activity, EU-28*, 2014 (% of enterprises)
- Obstacles that limit prevent the use of Cloud Computing services isoc_cicce_obs.xls
  - Data: Obstacles that limit/prevent the use of Cloud Computing services

In an attempt to prove the consistency of the results provided by the “DataAnalyser” program, two test-cases have been formulated and given as input to the program. The outcome of the conducted analysis was fitting the expected results.

Test Case #1:

"We have a medium sized company developing entertainment and productivity software with customers in Finland, Iceland, Sweden, Denmark and the Netherlands. We also offer other companies project-based software development services. Lately we are taking part at some research projects in Italy and Ireland, so that we are planning to extend our operations also to these countries in near future. "

The user input & outcome of the case study 1 is as follows;

```
+-----------------------+
| Decision Support Tool |
+-----------------------+

Please ANSWER following questions..
NOTE: Invalid input will be regarded as 0(zero).

Please select one or more countries matching your companies operations [e.g.
2 5 6]:
1.  BE      2.  BG      3.  CZ      4.  DK      5.  DE
6.  EE      7.  IE      8.  EL      9.  ES      10. FR
11. HR      12. IT      13. CY      14. LV      15. LT
16. LU      17. HU      18. MT      19. NL      20. AT
21. PL      22. PT      23. RO      24. SI      25. SK
26. FI      27. SE      28. UK      29. IS      30. NO
31. MK
ANSWER> 26 29 12 27 4 30 19 7

Please select one or more industries matching your companies operations [e.g.
2 5 6]:
1.  Construction
2.  Transport and storage
3.  Manufacturing
4.  Wholesale and retail trade; repair of motor vehicles and motorcycles
5.  Accommodation
6.  Electricity, gas, steam and air conditioning; water supply, sewerage,
waste management and remediation activities
7.  Administrative and support service activities
8.  Real estate activities
9.  Professional, scientific and technical activities
10. Information and communication
ANSWER> 10 9

Please select size of your company [e.g. 2]:
1.  large
2.  medium
3.  small
4.  no specification regarding company size (aka. average)
5.  small and medium
ANSWER> 2

A. Inquiry on necessity of Cloud Computing usage

Result: There is a 51.18% probability that the company may use for its
business activities Cloud Computing Solutions.
Result: The given company may use Cloud Computing Solutions with 99.0%
probability in its medium level activities and for 97.1% probability in its
high level activities.

B. Inquiry on the type of CC solutions

Result: The 64.98% of CC solutions are expected to be used in medium level
activities and 30.72% in high level activities.
```

Result: The use of Cloud Computing Services (est. as 23.76%) is expected to consist of
15.89% Delivered from shared servers of service providers (public cloud) and 9.65% Delivered from servers of service providers exclusively reserved for the enterprise (private cloud).
Result: The given company is expected to use following Cloud Computing Solutions with respective percentages as below;

E-mail	63.13
Storage of files	88.78
Hosting the enterprise's database(s)	82.96
Office software	52.19
Financial or accounting software applications	75.61
CRM software applications	65.26
Computing power for enterprise's own software	16.18

Result: The given company is expected to buy following Cloud Computing Solutions with respective percentages as below;

Buy E-mail	88.29
Buy Storage of files	82.31
Buy Hosting the enterprise's database(s)	91.14
Buy Office software	90.17
Buy Financial or accounting software applications	92.04
Buy CRM software applications	80.12
Buy Computing power for enterprise's own software	57.7

C. Inquiry on limitations of Cloud Computing usage

Result: The limitations and their respective percentages for holding companies back is as follows;

Risk of a security breach	38.01
Uncertainty about applicable law, jurisdiction, dispute resolution mechanism	30.93
Uncertainty about the location of data	29.07
Problems accessing data or software	27.02
Difficulties in unsubscribing or changing service provider	27.01
High cost of buying Cloud Computing services	31.87
Insufficient knowledge of Cloud Computing	31.66

Result: The factors preventing companies from using CC services based on your industry and their respective percentage of importance are as follows;

Risk of a security breach	51.55%
Uncertainty about the location of data	41.34%
Uncertainty about applicable law, jurisdiction, dispute resolution mechanism	41.79%
High cost of buying Cloud Computing services	24.45%
Insufficient knowledge of Cloud Computing	17.37%

Result: The factors preventing companies from using CC services based on your location and their respective percentage of importance are as follows;

Risk of a security breach	70.93%
Problems accessing data or software	66.39%
Difficulties in unsubscribing or changing service provider	59.77%
Uncertainty about the location of data	72.27%
Uncertainty about applicable law, jurisdiction, dispute resolution mechanism	65.13%
High cost of buying Cloud Computing services	79.37%
Insufficient knowledge of Cloud Computing	83.7%

Test Case #2:

"We have a medium sized construction company which is active in Romania, Latvia and Poland. After receiving the order from customers our company takes over also supplier related tasks -if not stated otherwise in the contract-, so that we are responsible also for transportation and storage of construction material. "

The user input & outcome of the case study 2 is as follows;

```
+-----------------------+
| Decision Support Tool |
+-----------------------+

Please ANSWER following questions..
NOTE: Invalid input will be regarded as 0(zero).

Please select one or more countries matching your companies operations [e.g.
2 5 6]:
1.  BE      2.  BG      3.  CZ      4.  DK      5.  DE
6.  EE      7.  IE      8.  EL      9.  ES      10. FR
11. HR      12. IT      13. CY      14. LV      15. LT
16. LU      17. HU      18. MT      19. NL      20. AT
21. PL      22. PT      23. RO      24. SI      25. SK
26. FI      27. SE      28. UK      29. IS      30. NO
31. MK
ANSWER> 23 14 21

Please select one or more industries matching your companies operations [e.g.
2 5 6]:
1.  Construction
2.  Transport and storage
3.  Manufacturing
4.  Wholesale and retail trade; repair of motor vehicles and motorcycles
5.  Accommodation
6.  Electricity, gas, steam and air conditioning; water supply, sewerage,
waste management and remediation activities
7.  Administrative and support service activities
8.  Real estate activities
9.  Professional, scientific and technical activities
10. Information and communication
ANSWER> 1 2

Please select size of your company [e.g. 2]:
1.  large
2.  medium
3.  small
4.  no specification regarding company size (aka. average)
5.  small and medium
ANSWER> 2

A. Inquiry on necessity of Cloud Computing usage

Result: There is a 11.05% probability that the company may use for its
business activities Cloud Computing Solutions.
Result: The given company may use Cloud Computing Solutions with 0.63%
probability in its medium level activities and for 0.34% probability in its
high level activities.

B. Inquiry on the type of CC solutions

Result: The 29.58% of CC solutions are expected to be used in medium level
activities and 67.9% in high level activities.
```

Result: The use of Cloud Computing Services (est. as 23.76%) is expected to consist of
15.89% Delivered from shared servers of service providers (public cloud) and 9.65% Delivered from servers of service providers exclusively reserved for the enterprise (private cloud).
Result: The given company is expected to use following Cloud Computing Solutions with respective percentages as below;

E-mail	71.75
Storage of files	38.09
Hosting the enterprise's database(s)	46.78
Office software	34.1
Financial or accounting software applications	33.48
CRM software applications	2.47
Computing power for enterprise's own software	21.85

Result: The given company is expected to buy following Cloud Computing Solutions with respective percentages as below;

Buy E-mail	0.57
Buy Storage of files	0.34
Buy Hosting the enterprise's database(s)	0.29
Buy Office software	0.29
Buy Financial or accounting software applications	0.33
Buy CRM software applications	0.08
Buy Computing power for enterprise's own software	0.14

C. Inquiry on limitations of Cloud Computing usage

Result: The limitations and their respective percentages for holding companies back is as follows;

Risk of a security breach	38.01
Uncertainty about applicable law, jurisdiction, dispute resolution mechanism	30.93
Uncertainty about the location of data	29.07
Problems accessing data or software	27.02
Difficulties in unsubscribing or changing service provider	27.01
High cost of buying Cloud Computing services	31.87
Insufficient knowledge of Cloud Computing	31.66

Result: The factors preventing companies from using CC services based on your industry and their respective percentage of importance are as follows;

Risk of a security breach	28.96%
Uncertainty about the location of data	27.52%
Uncertainty about applicable law, jurisdiction, dispute resolution mechanism	26.22%
High cost of buying Cloud Computing services	31.16%
Insufficient knowledge of Cloud Computing	48.72%

Result: The factors preventing companies from using CC services based on your location and their respective percentage of importance are as follows;

Risk of a security breach	0.18%
Problems accessing data or software	0.1%
Difficulties in unsubscribing or changing service provider	0.09%
Uncertainty about the location of data	0.11%
Uncertainty about applicable law, jurisdiction, dispute resolution mechanism	0.19%
High cost of buying Cloud Computing services	0.27%
Insufficient knowledge of Cloud Computing	0.15%

The outcome of both case studies differ in regard to Cloud Computing usage expectations and obstacles the enterprises face which prevent them from implementing Cloud Computing solutions.

The enterprise in case study 1 operates in economically stronger countries and has high IT activities, so the expectation for this enterprise using Cloud Computing solutions was very high. Due to the nature of its activities, it was also expected that the biggest concern of this enterprise when using Cloud Computing products would be information security. The outcome of the program has pointed out the same conclusions.

The enterprise from the second case study operates in a smaller geographic area with more fragile economies and its core activities do not include a high volume of IT processes. This makes the necessity of using Cloud Computing solutions practically irrelevant for the enterprise as also pointed out by the outcome of the program.

5 Development of Models

This chapter includes a proposal for company and Cloud Computing models which could be associated in different variations with changing suitability. The models described in this chapter should not be perceived as IT service models as they are more conventional and abstract.

The aim of this chapter is to create models for both enterprises and Cloud Computing services to enable assessing the impact of their combinations on the enterprise.

5.1 Company Models

The company models described in the context of Cloud Computing are categories of enterprises based on their significant attributes regarding Cloud Computing. The aim of creating of company models is to designate groups of enterprises to analyse their behaviour patterns regarding their Cloud Computing decisions. In this way a common ground can be established to link enterprises from different continents and more data regarding Cloud Computing trends can be generated, which applies to all enterprises regardless their market. This procedure would eventually help to improve the understanding of enterprises Cloud Computing needs.

The company models designated through the “Data Integration” conducted in Chapter 2 and the research papers [9, 12] have been created by analysing the attributes of enterprises in groups according to their industry. The values have been retrieved from the “Data Analyser” program and were interpreted according to the 6 designated

attributes mentioned in the research paper [9]; “Size of IT resources, Utilization Pattern, Sensitivity of Data, Criticality of Work, Countries of Activity and Reliance on IT”. Table 2 represents the association of attributes to the respective parts of the report generated by the “DataAnalyser” Program.

Attribute Name	***Associated Output***
Size of IT resources	`A. Inquiry on necessity of Cloud Computing usage ..probability that the company may use for its business activities Cloud Computing Solutions.`
Utilization Pattern	`B. Inquiry on the type of CC solutions ..use of Cloud Computing Services (est. as ..)..`
Sensitivity of Data	`C. Inquiry on limitations of CC usage Risk of a security breach..`
Criticality of Work	`C. Inquiry on limitations of CC usage Problems accessing data or software..`
Countries of Activity	`B. Inquiry on the type of CC solutions Financial or accounting software applications..`
Reliance on IT	`B. Inquiry on the type of CC solutions CRM software applications..`

Table 2: *Association of designated attributes to outputs of “DataAnalyser” Program.*

The interpretation was executed as each percentage value from the report was linearly transformed into the model except for the interpretation of the attribute “Countries of Activity”. Here the higher percentage value is interpreted as lower number of countries the company might be operating in. When modelling the values of “Countries of Activity” are written in ascending order from Model A to C. The reason for this interpretation is that an automation in finances and accounting is only possible if all branches of the company are subject to the same regulations in terms of taxation and financial products. Thus the higher number of countries the company operates in would result in a lower usage of Cloud Computing for financial and accounting tasks.

For the creation of the 3 Models input from Table 3 was given into the “DataAnalyser” Program and the generated report was interpreted respective to the association given in Table 1.

Countries	***Industry***	***Size***
1-10	10-8	M
11-20	7-4	S

Countries	Industry	Size
21-31	3-1	No Spec.

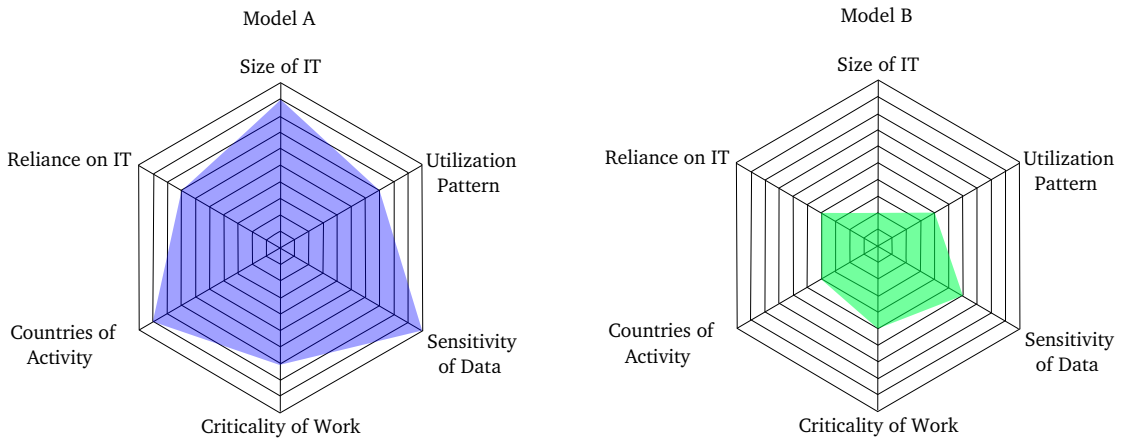
Table 3: *Inputs given into the "DataAnalyser" Program for creating of the 3 Models.*

The results of the interpretation are presented in Table 4 where for each model the percentage has been scaled and transformed into a number for sake of simplicity by modelling.

Attribute Name	Model A		Model B		Model C	
Size of IT resources	49.72%	9	13.23%	2	9.02%	2
Utilization Pattern	35.23%	7	23.76%	4	16.96%	3
Sensitivity of Data	53.79%	10	30.08%	6	30.77%	6
Criticality of Work	34.97%	7	27.02%	5	27.02%	5
Countries of Activity	18.80%	3	21.21%	4	47.57%	9
Reliance on IT	40.33%	7	23.66%	4	1.30%	0

Table 4: *Values from the "DataAnalyser" Program for the 3 Models.*

According to these results, as illustrated on Fig. 7, Model A represents enterprises working in an industry dealing with high information generation and consume.



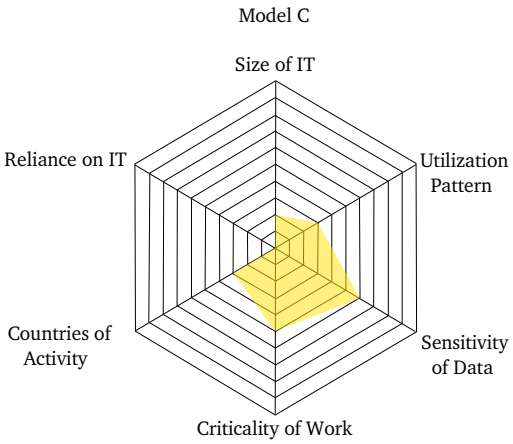


Fig. 7: *The company models according their most significant attributes regarding their Cloud Computing usage potential*

Model B represents enterprises using information mainly to support their medium level operations. Model C represents enterprises which do not rely on IT to conduct their daily operation but use it for supporting their high level operations.

5.2 Cloud Computing Models

Cloud Computing services can be delivered in different ways each providing different advantages for different trade-offs.

A well-defined model has been proposed by author in [15] based on the Cloud Cube Model proposed by The Jerico Forum (JF) categorizing Cloud Computing services regarding the 4 specifications;

- External and Internal (aka. Public and Private)
- Proprietary and Open (aka. Free API and Paid API)
- Perimetrised (Per) and De-Perimeterised (aka. IaaS/PaaS and SaaS)
- In- and Outsourced (aka. Cloud Development in- and outside the company)

Although the proposed model expresses the most important attributes of Cloud Computing environments, it does not address the following specifications which are essential for enterprises to consider Cloud Computing implementation;

- Standard and Individualised SLA
- Interoperability enabled/disabled
- Encryption enabled/disabled

The standard and individualised SLA is about the QoS (Quality of Service) requirements the clients might request due to the level of criticality of their operations.
Interoperability between the cloud environment and clients infrastructures is not an issue unless client decides to change its service provider. In this case the client is required to redeploy the whole cloud environment instead of a simpler migration to the new service provider which would be less time consuming [20].
Encryption is a feature which is about data's state of storage on the cloud. Unencrypted storage concerns clients due to the security risk which could result in criminals accessing their sensitive data. Another concern is due to the lack of confidence in cloud storage provider regarding their access to this sensitive information. This study suggests that the Cloud Computing Model is to be extended to address the three above mentioned attributes which according to published research [10, 12, 15, 20] are significant for enterprises decision making on Cloud Computing solutions implementation.

6 Mapping between use of Models and their Impact

This chapter provides a detailed description of the proposed company and Cloud Computing models introduced in chapter 5. It describes the proposed extended model for Cloud Computing solutions by discussing strengths and weaknesses of each model when applied to a specific company model and provides suggestions regarding the transition of the enterprises processes during adoption of the selected Cloud Computing solution.
Through the comparative analysis of each combination it is aimed to develop a methodology which can be utilized as a part of the decision support algorithm to evaluate the fitness of the considered Cloud Computing model for the enterprise in question. The suggestions regarding transition phase are aimed to enable a swift adoption while causing minimal performance lost.

6.1 Combinations

As this study is aimed at providing a decision support algorithm which should take the impact of selected Cloud Computing solution on companies performance in long and short term into consideration, the 3 company models have been combined with the respective Cloud Computing models that are expected to be most suitable for the company. Although the maximum number of combinations is greater then the number of

combinations discussed in this study, all combinations which are not expected to please requirements of small- and medium sized enterprises and offer less sustainability have been disregarded.

An analysis has been conducted on the models to examine the advantages and trade-offs of the proposed combination by discussing the ideal specifications and the specifications of Cloud Computing solutions offered by service providers on the market [17, 18].

As the attributes of Cloud Computing models consists of tuples with two specifications and are of type boolean the radar diagram has been drawn where the value '0' indicates that the first specification is in use and the value '1' indicates that the second specification is in use.

6.1.1 Combinations for Company Model A

Enterprises represented by the company model A have data intense processes and do rely highly on the IT for their daily operations. In Fig. 8 are the two proposed Cloud Computing models most suitable for the Company Model A illustrated.

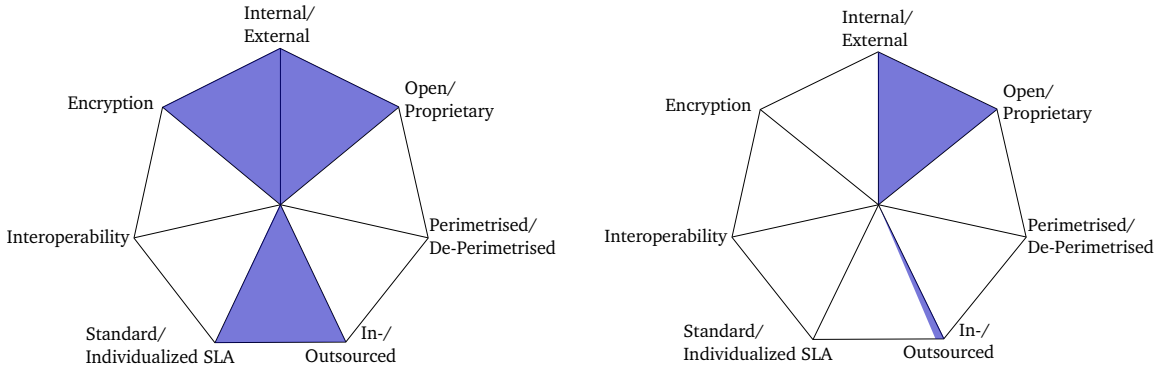


Fig. 8: *The Cloud Computing models providing best fit for companies of Model A.*

The model on Fig. 8 (left) represents the optimal specifications of Cloud Computing solution. These specifications suggest that the Cloud Computing solution to be utilized is a public cloud provided through servers residing outside the enterprises premises. While the public cloud allows the enterprise to benefit from the cost advantage of Cloud Computing, the security requirements for handling sensitive data by the Cloud Service Provider is to be satisfied through encrypted data storage. The individualised SLA and Cloud Computing by IaaS/PaaS do not only guarantee the compliance of provided Cloud Computing service with enterprises computing requirements, they

also provide flexibility regarding the deployment of specific applications. The interoperability is assumed as not a critical feature as frequent switch between providers is not expected for enterprises with high IT usage.

The model on Fig. 8 (right) represents the features offered by 11 of 14 of the Cloud Computing providers listed in [17, 18] for cloud storage services. It is to be mentioned that Cloud Providers which are specialized in Cloud Storages offer De-perimeterised Cloud Computing only, while other Cloud Providers also offer Perimeterised Cloud Computing [19].

The advantage of this model is it provides a transition platform for medium size enterprises with high IT activity to expand their computing power without decreasing their liquidity or binding their finances to investments which may not be as profitable as planned due to unexpected changes in their respective market.

6.1.2 Combinations for Company Model B

Enterprises represented by the company model B have limited number of data intense processes and a moderate reliance on the IT for their daily operations. In Fig. 9 are the two proposed Cloud Computing Models designated fit for satisfaction of the requirements of model B companies illustrated.

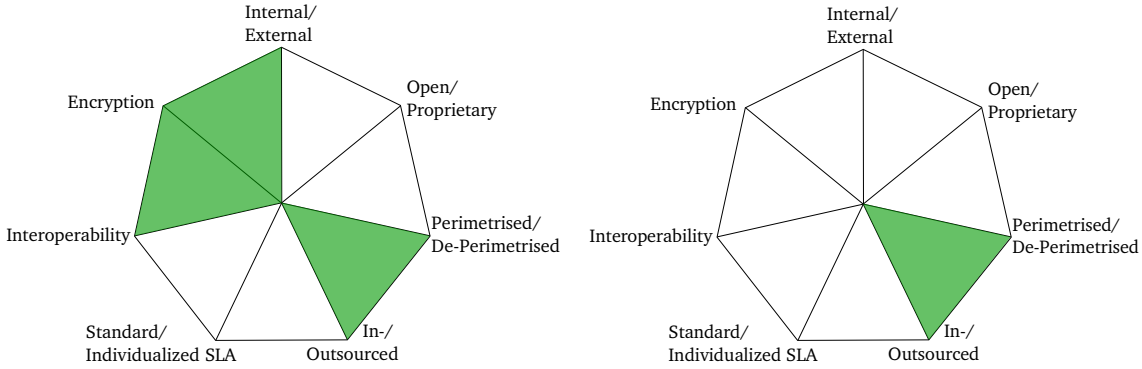


Fig. 9: *The Cloud Computing models providing best fit for companies of Model B.*

The model on Fig. 9 (left) represents the optimal specifications of the Cloud Computing solution which may be utilized by enterprises of this category. Although these enterprises have moderate reliance on IT which in many cases is expected to fairly distributed on their medium and high level operations, data security is still of great im-

portance. This is why a public cloud with encryption feature is part of the specifications for the Cloud Computing solution. As far as laws and regulations which do apply on the enterprise permit, the data storage outside of the enterprises premisses would allow to leverage the cost advantage of Cloud Computing at a greater level. As the companies of model B do not have a high Cloud Computing consume they might not profit from the cost advantage as model A companies which comparatively act as whole-buyer would. The less Cloud Computing consume of these companies indicates however at the same time to smaller Cloud Deployments which enables companies to switch their service provider without the worry of a complicated migration.

The model on Fig. 9 (right) represents the common specifications based on the offerings of service providers on the market [17, 18, 19]. These specifications differ from the ideal specifications by lacking in encryption and interoperability features. Although the encryption feature may be partially substituted through encryption forced by clients, the interoperability is harder to realized especially in cases where 3rd party commercial software is offered by the service provider through a business-to-business licence agreement with its publisher.

The main advantage of this model is its ability to provide a scalable computing platform which is critical for sustainability while minimizing IT related costs through outsourcing all maintenance tasks to 3rd parties.

6.1.3 Combinations for Company Model C

Enterprises represented by the company model C do not have data intense processes and they do rely on the IT only in their high level operations. In Fig. 10 is the model representing the ideal specifications for enterprises of company model C illustrated which can be realized through the Cloud Computing solutions offered on the market [17, 18, 19].

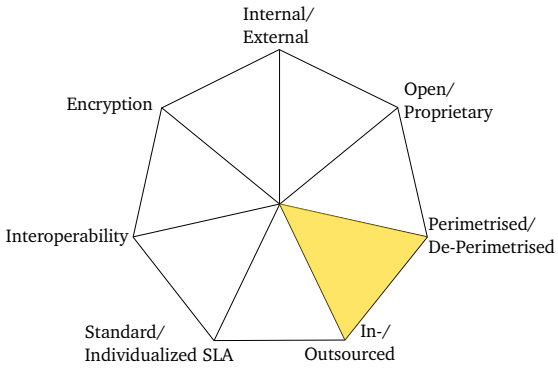


Fig. 10: *The Cloud Computing models providing best fit for companies of Model C.*

Due to the nature of scarce IT usage of these enterprises external Cloud Computing solutions in public clouds maintained outside the enterprises premises are among the specifications of the optimal Cloud Computing model. Although these companies utilize cloud solutions in high level operations the required security measures to be undertaken are limited to authentication. In most of the cases there is no necessity for application of a system-wide encryption and if such a demand should emerge the client-side encryption can be considered as sufficient.

6.2 Transition

The transition of traditional IT infrastructures to Cloud Environments is challenging not only due to the necessity of designing a new architecture but also due to the necessity of correct estimation of capacity usage, designation of specifications of the Cloud Computing service the enterprise requires and training of employees for adapting them into the new platform quickly to prevent operational problems caused by lack of employee know-how or lack of collaboration capability.

The greatest challenge is the estimation of required computation power for enterprises operations. The difficulty hereby lies in the architecture of desktop computers utilized in traditional IT applications and servers utilized in Cloud Computing. The workload of a server can be easily monitored to optimized resources reserved to make processes work smooth. However the calculation of workload on desktop computers is not as straightforward as on servers due to desktop applications being additionally to the main work to be executed also responsible for providing a convenient user inter-

face that requires extra computing resources, which would be performed in case of Cloud Computing by the so called “thin clients” and not on the server. Fig. 11 represents the 8 steps undertaken during the transition from traditional IT to Cloud Computing environment as mentioned in the research paper [21].

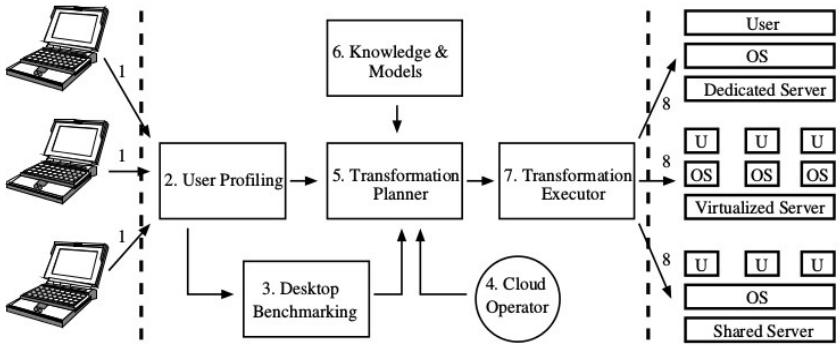


Fig. 11: *“Overview of Transformation Planning [21]”.*

The first step starts with the introduction of desktop applications to execute respective operations of the enterprises.

In the second step, Data on the interaction created during these operations is gathered in an attempt to conclude the overall workload estimation generated by these operations.

This step can be compared to the concept of automated creation of “Use-Case Diagrams” by analysing the runtime behaviour of the target software. The second step consists from the application of this concept on an extended basis including the human interaction so that also the frequency of operations can be monitored for a healthy estimation of the overall workload.

Once the workload for each operation has been calculated the “Desktop Benchmarking” is executed as step 3. In this step user interaction creating the workload recorded in step 2 is artificially generated on different desktop environments to estimate the resources required for the completion of tasks belonging to respective operations.

This step can be compared to the utilization of automation software e.g. “Selenium” in software testing to regenerate the same or variations of user behaviour to check the response of a software system.

After the estimation of the necessary computing power to handle the enterprises operations workload the “Cloud Operator” designates the Cloud Computing solutions fitting the requirements best as part of step 4 and the transition can be organized as part of step 5 to determine the selection of the appropriate Cloud Computing plan, to orchestrate the change of respective processes and to enable the adoption of the new technology by employees.

The mentioned “Knowledge & Models” in step 6 are utilized as a tool for counselling the planned transition such as selection of the Cloud Computing model and services based on previously conducted analysis and use-cases which are taken under consideration during the execution of step 5.

Once the “Transformation Planner” has been executed the in step 7 mentioned “Transformation Execution” is conducted, which results on enterprise specific set of instructions to complete the transition phase, so that the migration of the IT into the Cloud Environment can be completed as step 8.

The decision support algorithm aimed to be created in this study addresses all of these steps mentioned in the research paper [20] with the exception of step 7 and step 8 as these steps strongly depends on the enterprises specifications.

7 Development of a Decision Support Algorithm

This chapter describes design and development of the Decision Support Algorithm which can be used by enterprises to asses their need to take Cloud Computing solutions into consideration and to decide on the type of Cloud Computing model they should be considering and the transition process.

In Fig. 12 illustrated are the type of data sources taken as input by the decision support algorithm.

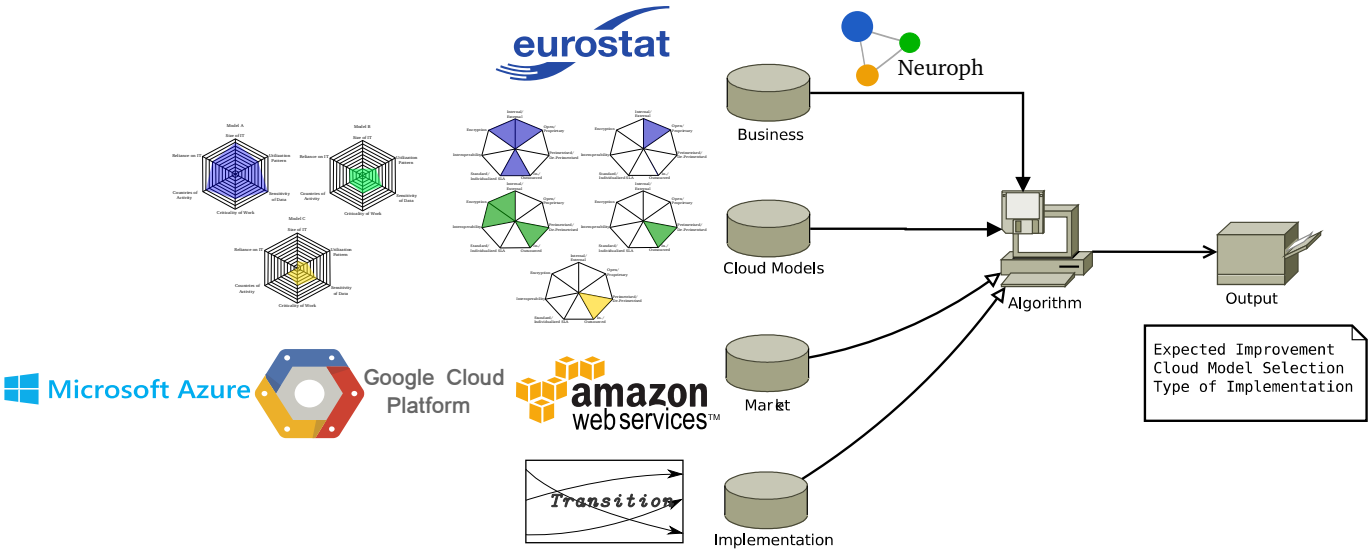


Fig. 12: *Type of data sources applied in the Decision Support Algorithm.*

Sources for “Market”and “Implementation” have been given as exemplary input and should not be thought as limited to the illustrated sources.

The data source “Business” contains information on Cloud Computing usage by enterprises based on attributes such as the industry they operate in, their country of origin and size.

The data source “Cloud Models” addresses the models suggested in Chapter 6.1 of this study. It is used to group services of different providers to help the enterprise make a better comparison of the potential Cloud Computing solution they might consider to implement.

“Market” source contains information on Cloud Computing solutions from providers offered on the market. The information on these solutions is evaluated to ease the association of each solution with a designated cloud model.

The data source “Implementation” addresses specifications regarding the transformation of enterprises IT and daily processes to Cloud Computing environment.

These specifications and the suggested proceedings are aimed to guide the enterprise for implementation of the proposed Cloud Computing solution.

7.1 Components of the Decision Support Algorithm

The Decision Support Algorithm proposed in this study consists of 4 components respective to the number of categories the utilized data is divided in. Each of the components handle the input of the predecessor component in a way that a workflow chain reaction which starts with the user input ends with the delivery of a report.

The components 1 and 2 provide an abstract decision to the question which Cloud Computing model fits the given enterprises requirements best. It is important to note that the requirements mentioned here are not based on a user input compiled from a survey by the enterprise's management but on statistics of the enterprises in the EU. Thus the data of the 1st and 3rd components are supplied before the user input for the 1st component is entered.

Components 3 and 4 provide suggestions on how the abstract decision can be realized by taking the products of the Cloud Computing Service Providers on the market available to the enterprise into consideration.

7.1.1 First Component: Selection of Company Model

The 1st component is responsible for handling the user input and designating the appropriate company type respective to the 3 company models introduced in this study. The user input consists of the industries the enterprise operates in, the countries the company has branches or conducts businesses in and the size of the company as in small- and medium-sized enterprises.

Once this input has been entered the component forwards it to the trained ANN. Similar to the fashion company models have been created the component reads and scales the related values for attributes “Size of IT resources”, “Utilization Pattern”, “Sensitivity of Data”, “Criticality of Work”, “Countries of Activity” and “Reliance on IT” as shown in Fig. 13.

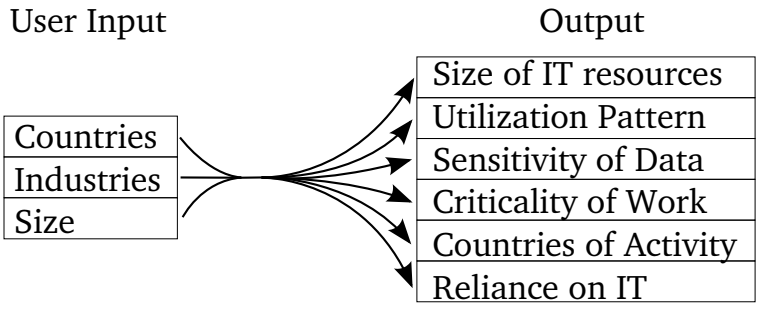


Fig. 13: *Input and Output of Component 1.*

After the user input have been interpreted to make the selection of company model possible the component compares the interpreted model with previously determined company models to designate the best-fitting company model to the interpreted model. This comparison is conducted by taking advantage of k-Nearest Neighbourhood algorithm with k set to 6 as there are 6 attributes defining the proposed company models.

To prevent runtime errors caused by dilemmas due to e.g. an interpreted model present with two fitting company models the comparison starts with the company model C which has the lowest total sum of attribute values which represents companies with lowest IT/ Cloud Computing dependency. The comparison continues then with model B and finally model A. If model B and A prove to be not better fits for the interpreted model, the model C is to be selected as default.

At this point through association with a company model the user input for company's specifications is abstracted. The data loss through abstraction is computed by calculating the average of differences at each attributes value of the interpreted model and the associated company model. The reason for measurement of the data loss is not only to give the user a complete view on how fit the designated model is, but also to utilize this data later when computing the success of the company model and Cloud Computing model association.

7.1.2 Second Component: Selection of Cloud Model

The 2nd component is responsible for associating the interpreted model it receives as an output from the first component to a Cloud Computing model. There are 128 Cloud Computing models respective the possible combination of their designated attributes, i.e. 2^7=128. For each one of the company models there is one best fitting Cloud Computing model introduced with each model tagged with a different color; blue (→ CC-A), green (→ CC-B) or yellow (→ CC-C) respective to the intensity of IT utilization in their operations in descending order.

As not all of the Cloud Computing models designated as best fit for a company model can be realized with currently (2016) existing products on the market there is a variant proposed for each Cloud Computing model subject to this problem. If a company model is associated with a Cloud Computing model for which there are two models are proposed due to the assumption that the best fit-model can not be realized both models are taken into consideration by the algorithm. In this case the best fit-model

has the priority. Thus first the best fit-model is checked whether it can be realized or not and depending on the outcome if the best fit-model has to be discarded the alternative model will be evaluated.

The outcome of the second component is not a single association but rather a list of associated Cloud Computing models which has a ranking based on the company model given as the input. As there are 3 Cloud Computing models designated as best fit for their respective company models where 2 of these models have an additional alternative model the outcome of the second component is an ordered list containing all 5 Cloud Computing models.

E.g. if the input from the component 1 is the company model A the association list would look as shown in Fig. 14.

CC-A1	CC-A2	CC-B1	CC-B2	CC-C

Fig. 14: *Output of Component 2;*
List containing suggestions for the association CC indicates that the type of the model is Cloud Computing.

The given array contains a list of the suggested associations in the order from best fit to worst fit so that if the A1 can be implemented the remaining elements of the list will be discarded, else next item is to be checked for implementation.

7.1.3 Third Component: Analysis of Cloud Computing Products

The 3rd component is responsible for associating the products of Cloud Computing Service Providers on the market accessible to the enterprise with Cloud Computing models introduced in this study. Before the association can be conducted products of Service Providers need to be evaluated respective the attributes of the Cloud Computing models. Once the evaluation is completed the result which consists of a binary array indicating the existence or lack of the attribute in question is compared to the attributes of Cloud Computing models designated as fit for the 3 company models.

The comparison is made by utilizing the k-Nearest Neighborhood algorithm -with k is set as 7- in which the proposed Cloud Computing models are represented as binary arrays. The best fitting Cloud Computing model is designated as the model for the

Cloud Computing product in question. An example for such an association is illustrated in Fig. 15.

Input

External/Internal	0
Proprietary/Open	0
Perimetrised/De-Perimeterised	0
In-/Outsourced	1
Standard/Individualised SLA	1
Interoperability	0
Encryption	0

Output

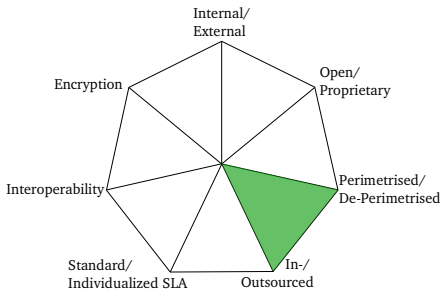


Fig. 15: *Input and Output of Component 3.*

The values given in this example will change during runtime based on the evaluated Cloud Computing products.

7.1.4 Fourth Component: Selection of Transition Type

The 4th component is responsible for providing suggestions on how the selected Cloud Computing products of the 3rd component are to be implemented. As the transition of enterprises IT system is a complex operation which needs to be well orchestrated and conducted without disrupting companies operations the 4th component makes suggestions on the transition based on the attribute “Size of IT resources” of the interpreted model.

Depending on the size and complexity of enterprises existing IT infrastructure the transition to Cloud Computing can be implemented in 3 ways;

- Service Level Transition: The Service Level Transition indicates the adoption of the new technology for one service at a time. Provided that there are no or little interoperability problems between services each service realized with classical IT infrastructure will be replaced with a service on the Cloud. This type of transition is highly fault-tolerant and allows observation of changes in the performance. The disadvantages of this transition is the high transition time compared to other two transitions and the requirement that the service architecture remains the same during transition phase. Service Level Transition is suitable for enterprises with a large existing IT infrastructure.

- Department Level Transition: The Department Level Transition is about adoption of selected Cloud Computing products at one department at a time. This type of transition has a moderate duration and as it is not limited with one service also less fault tolerant. The Department Level Transition is suitable for enterprise's with medium size IT infrastructure.
- Instant Transition: The Instant Transition indicates on replacement of enterprise's existing IT infrastructure overnight. This type is the fastest and less fault tolerant type of transition as any incompatibility or error effects directly the performance of enterprise's operations. The Instant Transition is suitable for small size enterprises with small or non-existing IT infrastructure, i.e. start-up companies.

In a similar fashion to the creation of Company models the interpreted model is clustered into 3 groups from which each value range is then associated with a transition type as shown in Table 5.

Size of IT Infrastructure	***Type of Transition***
10-8	Service Level Transition
7-4	Department Level Transition
3-1	Instant Transition

Table 5: *Association of Transition Types and Size of IT Infrastructure.*

7.2 Design of the Decision Support Algorithm

The Decision Support Algorithm is a procedure which defines how its 4 components are to interact with each other. There are two phases of the algorithm visualized in Fig. 16 and Fig. 17;

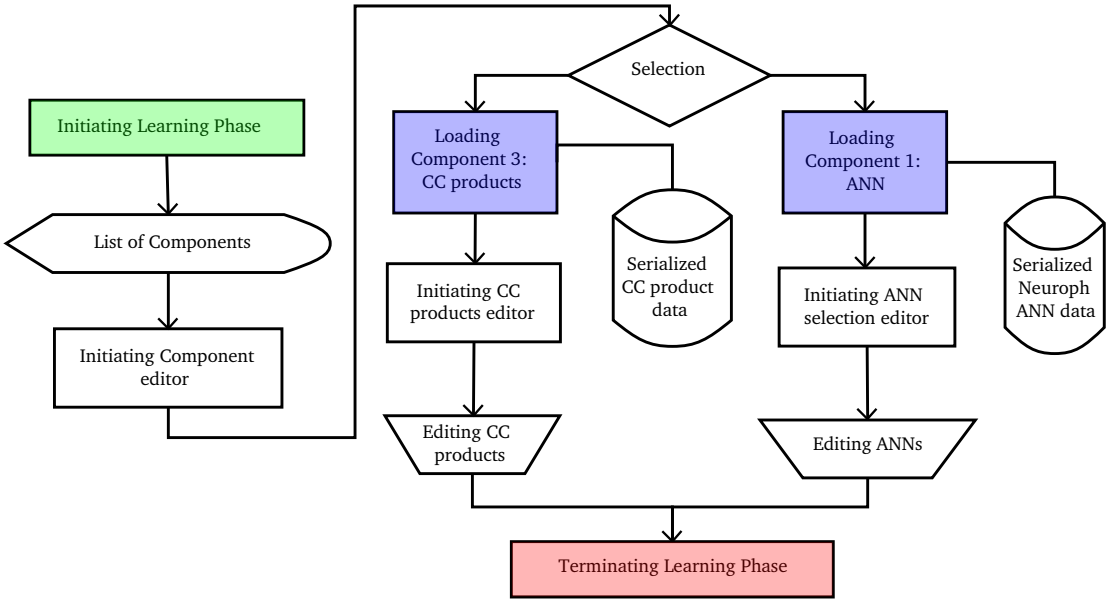


Fig. 16: *Learning Phase of the Decision Support Algorithm; Coloring scheme: start-green, component-blue, end-red.*

- The Learning Phase: The Learning Phase (Fig. 16) indicates training of the ANN of the program. This way the existing neural network can be edited by further training. Another option is to replace existing neural networks to retrieve a more consistent insight in enterprises behaviour in another geographic area, e.g. USA. This phase is also responsible for input of available Cloud Computing products on the market accessible to the enterprise. This phase includes the interaction of components 1 and 3.

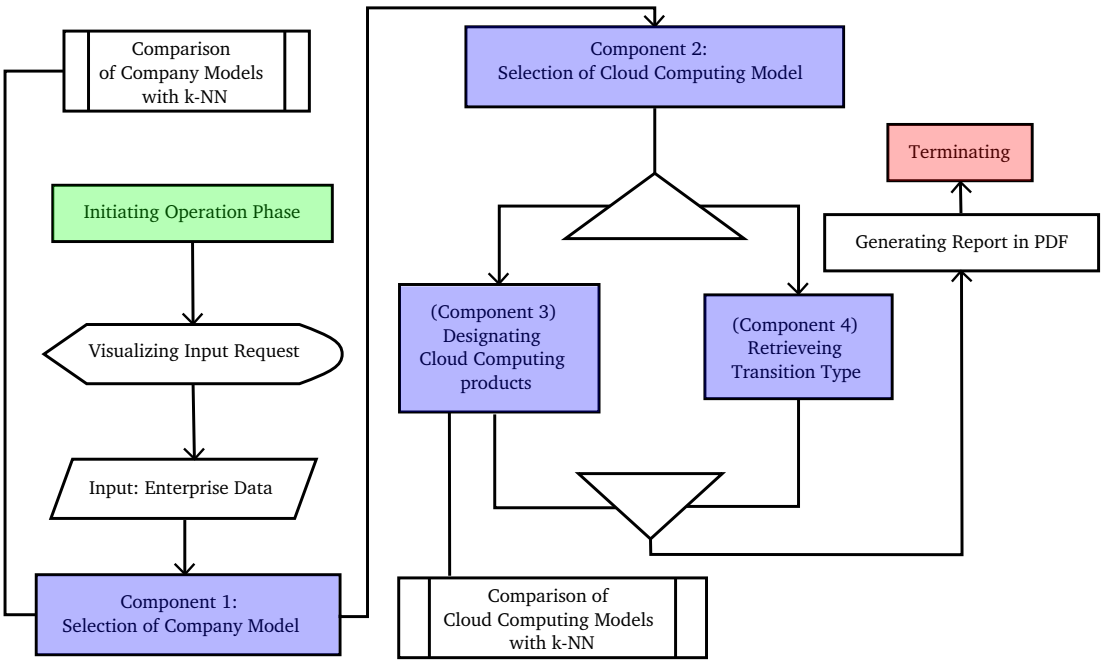


Fig. 17: *Operational Phase of the Decision Support Algorithm;*
Coloring scheme: start-green, component-blue, end-red.

- The Operational Phase: The Operational Phase (Fig. 17) indicates the retrieval of a suggestion for the enterprise whose specifications are given by the user as an input. This phase includes the interaction of all 4 components.

The algorithm is implemented as an extension to the “DataAnalyser” program written in this study. Each of the components and data sources has been represented as a separate class. The program is written in Java to allow multi-platform support.

8 Implementation

This chapter explains the implementation of the decision support algorithm. It shows how each step of the described algorithm relates to the code and what changes were undertaken in the implementation without effecting the work-flow of the algorithm negatively.

8.1 Limitations

The data utilized as input is not in raw format and has already been analysed and converted into the respective Excel Tables. As this data -inquired from the Eurostat website- is not officially provided in a standardized format, it can not be guaranteed

that the data input and training part ,i.e. Learning Phase, will be functional in future. Therefore the Learning Phase has not been summarized to a single program but has been implemented as two separate programs;

- DataSetGenerator
- DataTrainer

The branch regarding editing CC products has been not implemented and does require to be edited in the source code beforehand the execution.

The Operational Phase has been implemented as described in the algorithm with the exception that components 3 and 4 are executed serially instead of parallel. The implementation have been made as a single program;

- CloudComputingAssessmentApp

It is important to note that respective files containing serialized objects of the trained ANN's is required to be available before executing the program.

8.2 Implementation of the Learning Phase

The Learning Phase requires conversion of the data on Excel tables into a format suitable to train ANNs. As the data on each table consists of two parts; attribute and value the first program utilized is the “DataSetGenerator”. The “DataSetGenerator” simply adds an array as a prefix for each value which indicates the values position (i.e. the selected attribute associated to the value) [*Fig. 18*].

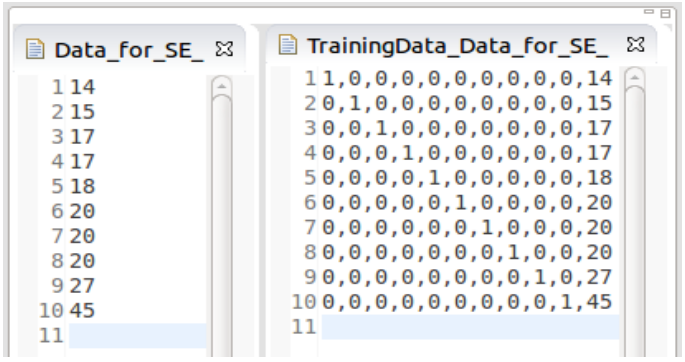


Fig. 18: *Conversion by “DataSetGenerator” with the input file on the left and output file on the right.*

Note that the “DataSetGenerator” has not been explicitly mentioned in the described algorithm as it is assumed that before the learning phase starts the data is provided in the correct format. The conversion functionality is provided through the “read”, “generate” and “write” methods as shown in Fig. 19.

```
11 public class DataSetGenerator {
12     public static void main(String[] args){
13         System.out.println("Generating Data Sets... \n");
14 
15         List<String> rawFileNames = new ArrayList<String>();
16 
17         rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure2.data");
18         rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure3.data");
19 
20         rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure4.data");
21         rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Table1.data");
22         rawFileNames.add("Use of cloud computing services isoc_cicce_use_Data.data");
23         rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure5.data");
24 
25         rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure6.data");
26         rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure7.data");
27         rawFileNames.add("Obstacles that limit prevent the use of cloud computing services isoc_cicce_obs_
28 
29         for(int i=0; i<rawFileNames.size(); i++) {
30             System.out.println("Generating Data Set"+ (i+1) +".. ");
31             System.out.println(rawFileNames.get(i));
32             File f= new File(rawFileNames.get(i));
33             read(f);
34         }
35     }
36 
37     private static void read(File file) {
80 
81     private static void generate(List<String> rawFileContent, String fileName) {
108 
109    private static void write(List<String> trainingData, String fileName) {
```

Fig. 19: *Code snippet from DataSetGenerator with its three private methods vital for its functionality.*

The program “DataTrainer” covers main functionality described in the algorithm introduced as the “Learning Phase”. Below is the association of program parts to the described components from the algorithm;

- Initiating Learning Phase, → `main(String[] args)`
- Loading Component 1: ANN, → `read(File file)`
- Serialized Neuroph ANN data, → Neuroph API, SLF4J library
- Editing ANNs and → `train(double[][] _input, double[][] _output, String fileName)`
- Terminating Learning Phase. → `public static void testNeuralNetwork(NeuralNetwork nnet, DataSet testSet)`

Both in “DataSetGenerator” and “DataTrainer” program's the data belonging to diferent sources, i.e. data subject to be isolated in separate ANNs are to be entered manually in the source code as shown in Fig. 20.

```
18 public class DataTrainer {
19
20     public static void main(String[] args) {
21         System.out.println("Initiating the Training Sessions... \n");
22         List<String> rawFileNames = new ArrayList<String>();
23
24         rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure2.data");
25         rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure3.data");
26
27         rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure4.data");
28         rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Table1.data");
29         rawFileNames.add("TrainingData_Use of cloud computing services isoc_cicce_use_Data.data");
30         rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure5.data");
31
32         rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure6.data");
33         rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure7.data");
34         rawFileNames.add("TrainingData_Obstacles that limit prevent the use of cloud computing services is
35
36         for(int i=0; i<rawFileNames.size(); i++) {
37             System.out.println("Training with Data Set"+ (i+1) +".. ");
38             System.out.println(rawFileNames.get(i));
39             File f= new File(rawFileNames.get(i));
40             read(f);
41         }
42     }
43
44     private static void read(File file) {
89
90     private static void train(double[][] _input, double[][] _output, String fileName) {
129
131    public static void testNeuralNetwork(NeuralNetwork nnet, DataSet testSet) {
143
```

Fig. 20: *Code snippet from DataTrainer with its three private methods vital for its functionality.*

8.3 Implementation of the Operational Phase

The Operational Phase has been implemented as an extended version of the initially developed “DataAnalyser” program by adding the capability to interpret its results through utilization of the Company- and Cloud Computing Models developed as a part of this study.

To ease the understanding of implementation and maintenance of the code each component is placed in a package named respectively and all classes not belonging to the decision support algorithm are placed in a root package named “at.ac.univie.cs.c-caa”. The components are executed in the order stated by the class containing the main method as shown in Fig. 21.

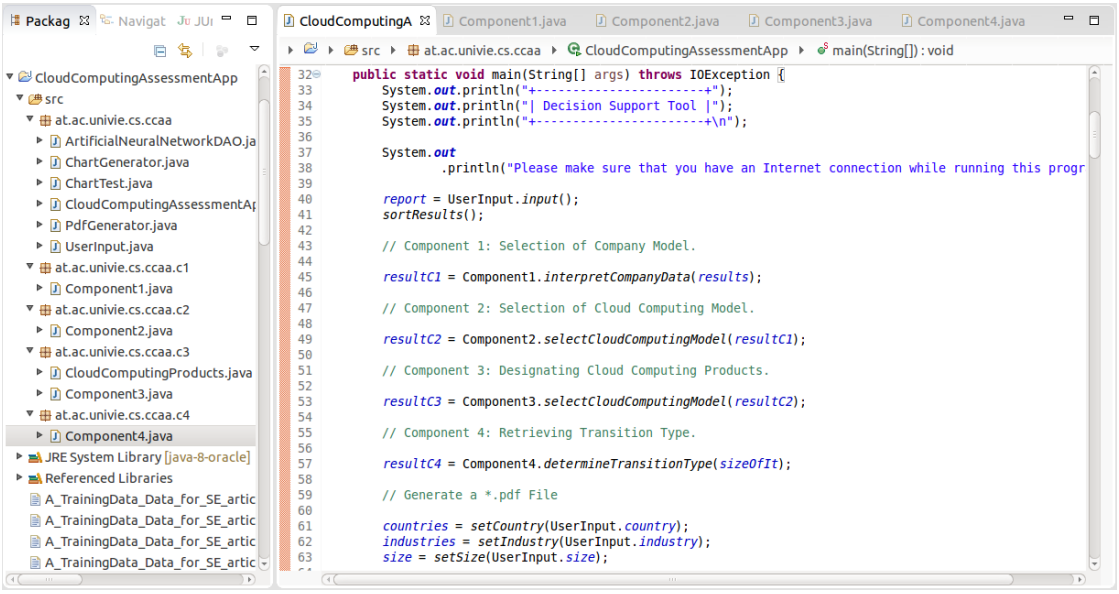


Fig. 21: *File Structure and a Code Snippet from the "CloudComputingAssessmentApp" program's main() method showing the execution order of the implementation.*

Below is the association of program parts to the described components from the algorithm;

- Initiating Operation Phase, →

```
public class CloudComputingAssessmentApp { ..
      public static void main(String[] args) { .. }
}
```

- Visualizing Input Request, →

```
public class UserInput { .. }
```

- Input Enterprise Data, →

```
public class UserInput { .. }
```

- Component 1: Selection of Company Model, →

```
public class Component1 { ..
      public static String interpretCompanyData(List<Double>
            results) throws IOException { .. }
}
```

- Component 2: Selection of Cloud Computing Model, →

```
public class Component2 { ..
      public static HashMap<String, List<Double>>
      selectCloudComputingModel(String result) { .. }
```

```
}
```

- (Component 3) Designation of Cloud Computing products, →

```
public class Component3 { ..
      public static String selectCloudComputingModel(
                  HashMap<String, List<Double>> resultC2){ .. }
}
```

- (Component 4) Retrieving Transition Type, →

```
public class Component4 { ..
      public static String determineTransitionType(
            int sizeOfIt) { .. }
}
```

- Generating Report in PDF, →

```
public class PdfGenerator { .. }
```

- Terminating. →

```
public class CloudComputingAssessmentApp { ..
      public static void main(String[] args) { .. }
}
```

An attempt has been made to visualize with a radar plot in the generated PDF-File. For this purpose `charts4j` API for Google Charts has been utilized. Due to the lack of support and documentation for this package the visualization quality was limited.

A detailed explanation regarding implementation of each Component written as Comment (in green) is given below;

- **Component1:**

```
// Each component is implemented in a separate package with a
respective name indicating components number such as for component 1
it is entered as c1
package at.ac.univie.cs.ccaa.c1;

// All required libraries are imported. Note that classes for common
utilization are not classified by placing them into a special
packages based on their task
import java.io.IOException;
import java.util.List;
import at.ac.univie.cs.ccaa.ChartGenerator;
import at.ac.univie.cs.ccaa.CloudComputingAssessmentApp;
import at.ac.univie.cs.ccaa.PdfGenerator;
```

```
/**
 * Selection of Company Model.
 */
public class Component1 {
// The model information which has been computed through the ANN
trained in scope of this study has been taken from Table 4 and stored
as arrays.
      static double[] modelA = { 9, 7, 10, 7, 3, 7 };
      static double[] modelB = { 2, 4,  6, 5, 4, 4 };
      static double[] modelC = { 2, 3,  6, 5, 9, 0 };

// To store the information on given company an array has been
declared, in which respective data will be added after computation.
Note that for both computation of company data and computation of
data for each model same ANN is utilized.
      static double[] company = null;

// The method interpretCompanyData() is called with a list, which
contains the output of ANNs for the given company data.
      public static String interpretCompanyData(List<Double> results)
throws IOException {
            String result = null;

// Once the results-List is delivered, it needs to be scaled in the
same fashion as the data for models was scaled in Table 4.
            company = translate(results);
// Each model is compared separately with the company data and a
value is returned indicating the level of similarity between two
arrays. As there are three models defined here, three comparisons are
to be executed.
            double comA = compare(company, modelA);
            double comB = compare(company, modelB);
            double comC = compare(company, modelC);

// As the scaled data of the company is available to us at this point
this information is forwarded to ChartGenerator to create the *.png
file which contains the radar plot.
            ChartGenerator.radarplot(company);

// The comparison is made straightforward through a number of if-
statements which at the end assign the name of the designated model
to the result variable.
            if ((comA <= comB) && (comA <= comC)) {
                  result = "A";
            }
            else if ((comB <= comA) && (comB <= comC)) {
                  result = "B";
            }
            else {
                  result = "C";
            }

// The result variable is also passed to the respective variable in
PdfGenerator as it is used in the *.pdf output.
            PdfGenerator.companyModel = result;
            return result;
      }
```

```
// The compare method delivers a value indicating the level of
similarity between the data in company and model arrays. The
similarity is computed by calculating the difference of value tuples
at the same position in each array.
	private static double compare(double[] company, double[] model)
{
		double res = 0;
		for (int i = 0; i < company.length;) {
			res += Math.abs(company[i] - model[i++]);
		}
		return res;
	}

	private static double[] translate(List<Double> results) {
		double[] _company = new double[results.size()];
		for (int i = 0; i < results.size(); i++) {
// As the highest value returned by the ANN for the cluster for
companies with highest CC utilization was 53.59, this value has been
used to scale both the values of each model and the values for the
company.
			double res = ((results.get(i) / 53.59) * 10);
			if (res > 10)
				res = 10;
			_company[i] = res;
			if (i == 0)
				CloudComputingAssessmentApp.sizeOfIt = (int)
res;
		}
// Finally, the model name matching the companies specifications is
given as return value. This value indicates the company model.
		return _company;
	}

}
```

- **Component2:**

```
// Each component is implemented in a separate package with a
respective name indicating components number such as for component 2
it is entered as c2
package at.ac.univie.cs.ccaa.c2;

// All required libraries are imported. Note that classes for common
utilization are not classified by placing them into a special
packages based on their task
import java.util.ArrayList;
import java.util.HashMap;
import java.util.List;
import at.ac.univie.cs.ccaa.PdfGenerator;

/**
 * Selection of Cloud Computing Model.
 */
public class Component2 {
```

```
// The model information for each Cloud Service Provider is stored in
lists. Note that the values have been retrieved through the
definition of the respective models specifications and listed in
Table 6.
      static List<Double> _CloudModelA = new ArrayList<Double>();
      static List<Double> _CloudModela = new ArrayList<Double>();
      static List<Double> _CloudModelB = new ArrayList<Double>();
      static List<Double> _CloudModelb = new ArrayList<Double>();
      static List<Double> _CloudModelC = new ArrayList<Double>();

// The arrays containing model data have at each position binary
values (0 or 1) which indicates whether the respective service is
offered by the Cloud Service Providers of that cloud model.
      static double CloudModelA[] = { 1, 1, 0, 1, 1, 0, 1 };
      static double CloudModela[] = { 1, 1, 0, 1, 0, 0, 0 };
      static double CloudModelB[] = { 1, 0, 1, 1, 0, 1, 1 };
      static double CloudModelb[] = { 0, 0, 1, 1, 0, 0, 0 };
      static double CloudModelC[] = { 0, 0, 1, 1, 0, 0, 0 };

// Depending on the type of company (i.e. company model) a list of
cloud computing models is created which will then be utilized to
designate matching cloud computing service providers for that
company.
      public static HashMap<String, List<Double>>
selectCloudComputingModel(String result) {
            for(int i=0; i<7; i++) {
                  _CloudModelA.add(CloudModelA[i]);
                  _CloudModela.add(CloudModela[i]);
                  _CloudModelB.add(CloudModelB[i]);
                  _CloudModelb.add(CloudModelb[i]);
                  _CloudModelC.add(CloudModelC[i]);
            }
            HashMap<String, List<Double>> map = new HashMap<String,
List<Double>>();
            if(result=="A") {
                  PdfGenerator.ccModel += "A";
                  PdfGenerator.ccModel += "a";
                  PdfGenerator.ccModel += "B";
                  PdfGenerator.ccModel += "b";
                  PdfGenerator.ccModel += "C";
                  map.put("A", _CloudModelA);
            };
            if(result=="B") {
                  PdfGenerator.ccModel += "B";
                  PdfGenerator.ccModel += "b";
                  PdfGenerator.ccModel += "C";
                  map.put("B", _CloudModelB);
            }
            if(result=="C") {
                  PdfGenerator.ccModel += "C";
                  PdfGenerator.ccModel += "b";
                  map.put("C", _CloudModelC);
            }
            return map;
      }
}
```

- **Component3:**

```
// Each component is implemented in a separate package with a
respective name indicating components number such as for component 3
it is entered as c3
package at.ac.univie.cs.ccaa.c3;

// All required libraries are imported. Note that classes for common
utilization are not classified by placing them into a special
packages based on their task
import java.util.HashMap;
import java.util.List;
import at.ac.univie.cs.ccaa.PdfGenerator;

/**
 * Designating Cloud Computing Products.
 */
public class Component3 {
      public static String selectCloudComputingModel(
                  HashMap<String, List<Double>> resultC2) {

// The main purpose of this component is to find out the matching
Cloud Computing Service Providers to the given company
            String product =
CloudComputingProducts.findProduct(resultC2);

            PdfGenerator.ccProduct = product;
            return product;
      }
}

// Each component is implemented in a separate package with a
respective name indicating components number such as for component 3
it is entered as c3
package at.ac.univie.cs.ccaa.c3;

import java.util.ArrayList;
import java.util.HashMap;
import java.util.Iterator;
import java.util.List;
import java.util.Map;

public class CloudComputingProducts {
// Cloud Computing Service Providers needs to be interpreted and
represented in a similar fashion to the Cloud Computing Models to
make a comparison possible. In this implementation 3 Service
Providers have been interpreted based on the list of products and
services from their website. Relevant information can be found in
Table 6

      // https://aws.amazon.com/products/?nc2=h_l2_p
      static double amazon[] = { 0, 1, 0, 1, 0, 0, 1 };

      // https://cloud.google.com/products/
      static double google[] = { 0, 1, 1, 1, 0, 0, 0 };

      // https://azure.microsoft.com/en-us/
```

```
	static double microsoft[] = { 0, 1, 1, 1, 0, 1, 1 };

	static List<Double> _amazon = new ArrayList<Double>();
	static List<Double> _google = new ArrayList<Double>();
	static List<Double> _microsoft = new ArrayList<Double>();

	@SuppressWarnings("rawtypes")
	public static String findProduct(HashMap<String, List<Double>>
resultC2) {
		for(int i=0; i<7; i++) {
			_amazon.add(amazon[i]);
			_google.add(google[i]);
			_microsoft.add(microsoft[i]);
		}
		HashMap<String, List<Double>> product_map = new
HashMap<String, List<Double>>();
		product_map.put("Amazon", _amazon); // Amazon.A
		product_map.put("Google", _google); // Google.C
		product_map.put("Microsoft", _microsoft); // Microsoft.B

		String product = "";
		int value = 0;

// Please note that the selected CC Model receives an advantage as
the products are compared to a respective data set (here: array). The
control order such as A -> a -> B -> b -> C is not separately
enforced in this implementation.
		Iterator it1 = product_map.entrySet().iterator();
		while (it1.hasNext()) {
			Map.Entry pair = (Map.Entry) it1.next();
			Iterator it2 = resultC2.entrySet().iterator();
			while (it2.hasNext()) {
				Map.Entry pair2 = (Map.Entry) it2.next();
				int comp = compare(pair.getValue(),
pair2.getValue());
// Among all possibilities the better result is selected and the
preceded result will be discarded.
				if(comp>value) {
					product = (String) pair.getKey();
					value=comp;
				}
			}
		}
		return product;
	}
// The comparison is made through incrementing similarity value for
each fit.
	@SuppressWarnings("unchecked")
	private static int compare(Object object, Object object2) {
		List<Double> p1 = (List<Double>) object;
		List<Double> p2 = (List<Double>) object2;
		int res = 0;
		for(int i = 0; i<p1.size(); i++) {
			if(p1.get(i).equals(p2.get(i))) res++;
		}
		return res;
	}
```

```
}
```

- **Component4:**

```
// Each component is implemented in a separate package with a
respective name indicating components number such as for component 3
it is entered as c3
package at.ac.univie.cs.ccaa.c4;

/**
 * Retrieving Transition Type.
 */
public class Component4 {

// The transition type is determined based solely on the size of IT.
Relevant information on clustering can be found in Table 3.
      public static String determineTransitionType(int sizeOfIt) {
            if (sizeOfIt >= 1 && sizeOfIt <= 3)
                  return ""
                              + "Instant Transition: The Instant
Transition suggests the replacement of enterprise's existing IT
infrastructure overnight. This type is the fastest and least fault
tolerant type of transition as any incompatibility or error effects
directly the performance of enterprise's operations. The Instant
Transition is suitable for small size enterprises with small or non-
existing IT infrastructure, i.e. start-up companies. ";
            else if (sizeOfIt >= 4 && sizeOfIt <= 7)
                  return ""
                              + "Department Level Transition: The
Department Level Transition is about adoption of selected Cloud
Computing products at one department at a time. This type of
transition has a moderate duration and as it is not limited with one
service also less fault tolerant. The Department Level Transition is
suitable for enterprise's with medium size IT infrastructure. ";
            else if (sizeOfIt >= 8 && sizeOfIt <= 10)
                  return ""
                              + "Service Level Transition: The
Service Level Transition indicates the adoption of the new technology
for one service at a time. Provided that there are no or little
interoperability problems between services each service realized with
classical IT infrastructure will be replaced with a service on the
Cloud. This type of transition is highly fault-tolerant and allows
observation of changes in the performance. The disadvantages of this
transition is the high transition time compared to other two
transitions and the requirement that the service architecture remains
the same during transition phase. Service Level Transition is
suitable for enterprises with a large existing IT infrastructure. ";
            else
                  return "Error: Company size out-of-defined-
boundaries. ";
      }

}
```

9 Functional Test

This chapter describes the functional test executed on the implementation of the Decision Support Algorithm. The aim of the testing is to provide a proof-of-concept on the working principles of the implemented program.

As no enterprise data was available to this study which provides information on an enterprise before and after utilization of Cloud Computing products and how the decision has been conducted this evaluation lacks a real world test-case. Thus assumptions based on enterprises specifications are used to justify/disapprove the outcomes and potential shortcomings of the implemented Decision Support Algorithm.

9.1 Test Approach

The test for the Decision Support Algorithm is executed by creating three use cases with expected decisions of enterprises management in regard of Cloud Computing implementations and comparison of the expected decisions with the output of the Decision Support Algorithm.

Each of the use-cases contains information on fictive enterprises such as the industries it operates in, the countries where the enterprise is active and its size. The performance of each proposal for Cloud Computing implementation is then interpreted through comparison with the expected result.

9.2 Simulation and Simulation Results

The Simulation is conducted through a text-based program named “CloudComputingAssessmentApp” which is developed by extending the “DataAnalyser” program's features respective the description of the Operational Phase of the algorithm visualized in Fig. 16.

As a difference to the algorithm components 3 and 4 are in the program not executed parallel (e.g. through multi-threading) but after each other. The step “Generation of PDF Report” requires the output of both components to proceed with its execution.

The ranking of different Cloud Computing Models -ordered by their level of fitness for the Company Model in question- is computed in a way that the specifications for the best fit is determined and other models are ordered by their likeliness to the model depicted as best fit. It has been observed in multiple iterations of the program with dif-

ferent input that the resulting preference list of Cloud Computing Models corresponds to the list determined in Chapter 7.1.2.

For selection of Cloud Computing Products information on 3 Cloud Computing Service Providers are entered (i.e. hard-coded): Amazon Web Services, Google Cloud and Microsoft Azure.

The products of each Service Provider are not evaluated in an isolated way from other products of the same Service Provider. Instead each Service Provider is evaluated by taking all of its products in regard. This way it is aimed that proposed products can be acquired for better financial conditions through making the company act as a whole-buyer.

Product information on each of the service provider is obtained through the respective website as shown in Fig. 22. The list of offered products are utilized to interpret the Service Provider's specifications and later to compare it with other Service Providers.

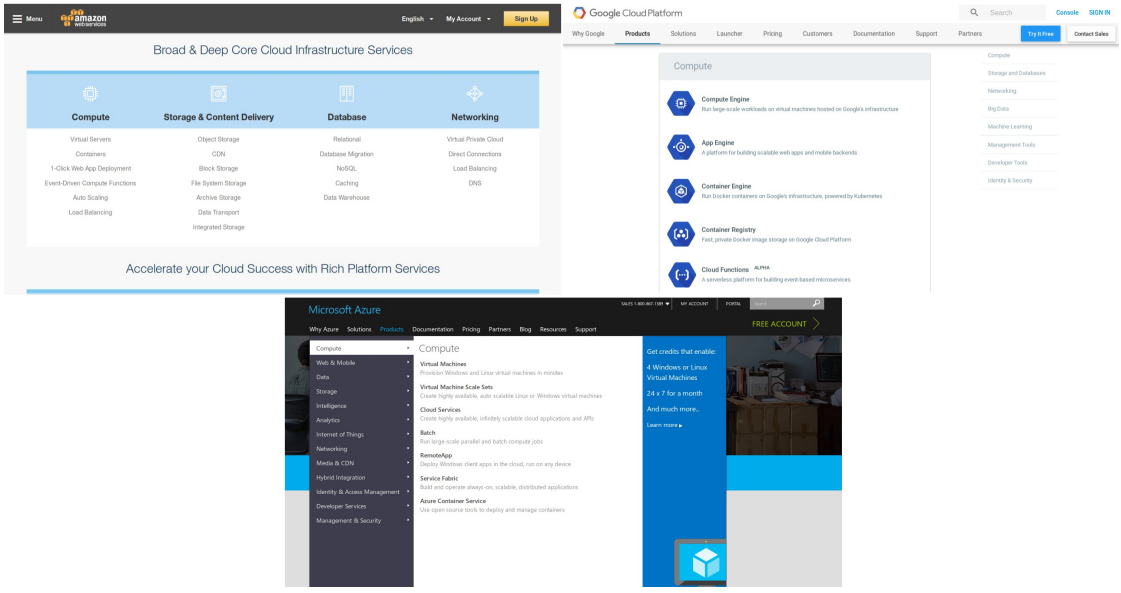


Fig. 22: *Products of Cloud Computing Service Providers: Amazon Web Services [26], Google Cloud [27] and Microsoft Azure [28].*

The evaluation of each Service Provider is conducted based on whether the Service Provider does offer a product satisfying the requirements of the attribute for “Interoperability” and “Encryption”. For other attributes it is checked what kind of product the Service Provider offers.

Evaluation of the three Service Providers included in the simulation results (2016) as shown in Fig. 20 based on the information gathered through respective websites.

In Table 6, it can be seen that the differences between selected Service Providers are distributed to attributes “Perimeterised/De-Perimeterised”, “Interoperability” and “Encryption”. This implies on variations regarding market policy of Service Providers and as a result their targeted customer segments (i.e. Company Models).

Attributes / Service Provider	Amazon Web Services	Google Cloud	Microsoft Azure
External/Internal	0	0	0
Proprietary/Open	1	1	1
Perimetrised/De-Perimeterised	0	1	1
In-/Outsourced	1	1	1
Standard/Individualised SLA	0	0	0
Interoperability	0	0	1
Encryption	1	0	1

Table 6: *Interpretation of Products of Cloud Computing Service Providers in regard of Cloud Computing Model Attributes defined in scope of this study.*

Once the decision is made regarding which Cloud Computing Service Provider should be preferred, their products are to be acquired based on the detailed report indicating expected utilization of different products. The exact information on which products should be obtained is not a part of this studies scope to preserve neutrality to Service Providers, prevent any biased decision.

The simulation program is designed to point out the best fitting Service Provider in terms of compatibility with companies assumed requirements and to provide percentage values indicating what type of Cloud Products are expected to be acquired by the company.

There are three case studies created to test the simulation program and the accuracy of the decision support tool.

The first case study is as follows; “The company is located in Macedonia and is active only in construction industry. I has only 4 employees and works as contractor. ”.

The second case study is; “The company is located in Belgium and is active in construction industry. It has over 100 employees. ”.

The third case study is as follows; “The company is based in Belgium, but also operates in Bulgaria, Czechoslovakia, Denmark and Germany. It is mainly active in information and communication sector and has also scientific and technical activities. Lately the company has entered also into real estate and electric, gas billing activities together with supporting operations.

9.3 Discussion of Results

For the three test cases created to represent different scenarios the Cloud Computing Assessment Application is used to generate a report on expected Cloud Computing requirement of the company in question based on similar companies on the market.

Each report consists of date and a short summary on the companies specifications for which the analysis has been conducted.

In Fig. 23 the title and summary of the report for the first test case is shown. The entered input for this test case into the program is (ordered by request for input of respective attribute); [31] [1] [3].

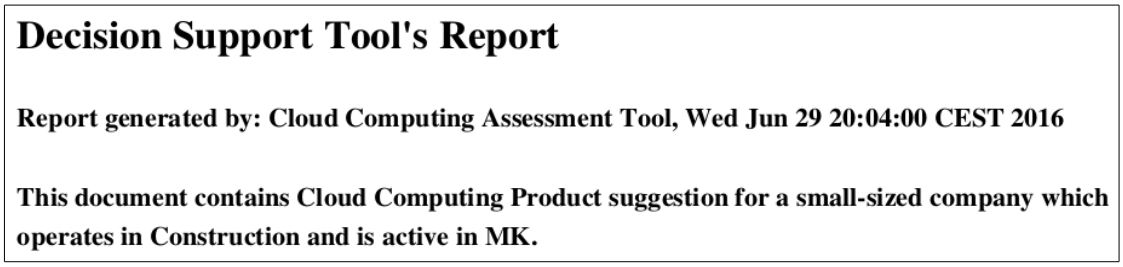


Fig. 23: *Title of the Report with summary of the given company specifications.*

The expectancy for the companies utilization of Cloud Computing Solutions is given as 14.91%. This low number implies that it is not critical for the company to take Cloud Computing into consideration in their IT infrastructure. The report chapter A also provides information on which level of processes (Fig. 24) are expected to utilize Cloud Computing Solutions if the company decides to utilize them.

A. Inquiry on necessity of Cloud Computing usage:

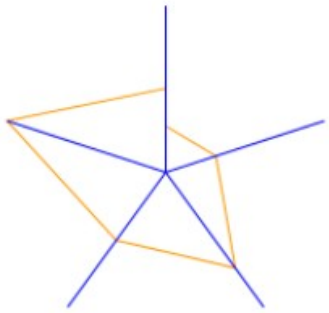
There is a 14.91% probability that the company may use for its business activities Cloud Computing Solutions. The given company may use Cloud Computing Solutions with 16.63% probability in its medium level activities and for 8.48% probability in its high level activities.

Fig. 24: *Chapter A of the generated Report.*

Chapter B of the report contains information on which type of products are expected to be bought and chapter C draws attention on the challenges the company needs to take care of for Cloud Computing implementation.
The analysis result regarding companies expected IT utilization, its Company Model (& a visual representation of it) and suggested Cloud Computing Service Provider as best fit is shown in Fig. 25.

The attributes and their associated values on radar chart are starting from the top and in clock-wise are;

1. Size of IT: 14.91%
2. Utilization Pattern: 16.96%
3. Sensetivity of Data: 38.01%
4. Criticality of Work: 27.02%
5. Countries of Activity: 63.0%
6. Reliance on IT: 26.99%



The company has been designated as Model C.
As best match the Cloud Computing Model Cb has been designated.
From all available CC products the product Google has been selected as the perfect fit.

Fig. 25: *Analysis Result of the first Test Case.*

As the company described in the first test case is operating in a country where Cloud Computing utilization is limited and which has a comparatively more fragile economy and as the industry of the company (i.e. construction) has very limited usage of IT it is expected that the company has low requirements regarding “Interoperability” and “Encryption”.

The analysis result therefore complies with the expectations as the company is associated with a Company Model, which does have the minimal requirements in terms of IT utilization and the proposed company for Cloud Computing Solutions does provide most basic functionalities compared to other options taken into consideration in the simulation environment.

The company from second test case does also operate in construction industry but it is based in a economically stronger country and has higher number of employees, thus it is a larger company. The analysis result regarding companies expected IT utilization, its Company Model (& a visual representation of it) and suggested Cloud Computing Service Provider as best fit is shown in Fig. 26.

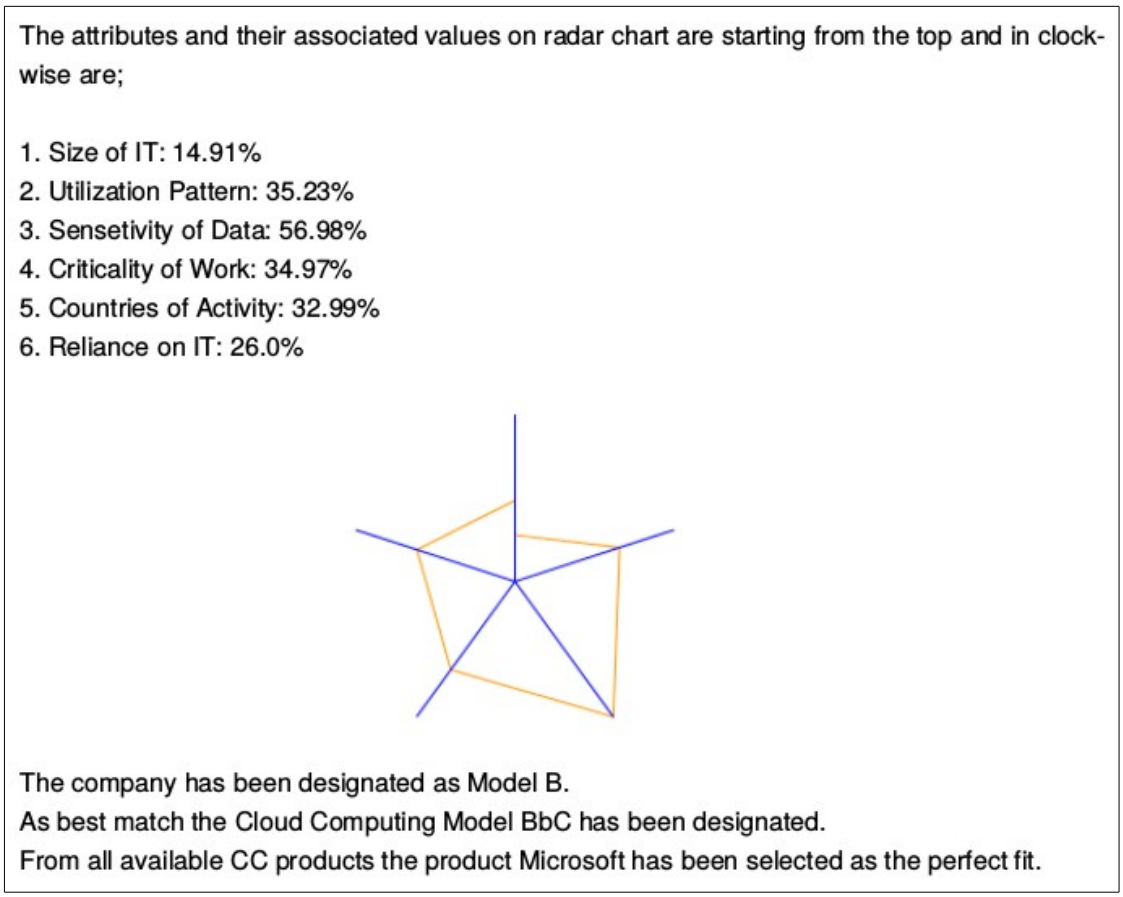


Fig. 26: *Analysis Result of the second Test Case.*

Due to the larger size and operating in an market eager to implement Cloud Computing solutions it is expected that the company has a moderate Cloud Computing implementation. As the company is associated to the Company Model which represents companies with medium IT utilization, it is important that the Service Provider offers "Encryption" feature for higher security and "Interoperability" feature allowing the company to adjust its Cloud Computing usage by enabling it to migrate its Cloud Infrastructure easily.

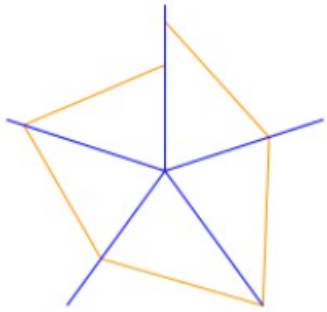
The analysis result complies with the expectations for this company.

The third test case is about a company with extreme IT utilization which operates in multiple countries each having a market trend of high Cloud Computing utilization.

The analysis result regarding companies expected IT utilization, its Company Model (& a visual representation of it) and suggested Cloud Computing Service Provider as best fit is shown in Fig. 27.

The attributes and their associated values on radar chart are starting from the top and in clockwise are;

1. Size of IT: 48.15%
2. Utilization Pattern: 35.23%
3. Sensetivity of Data: 56.98%
4. Criticality of Work: 34.97%
5. Countries of Activity: 47.71%
6. Reliance on IT: 34.16%



The company has been designated as Model A.
As best match the Cloud Computing Model AaBbC has been designated.
From all available CC products the product Amazon has been selected as the perfect fit.

Fig. 27: *Analysis Result of the third Test Case.*

As the company in question for the third test case has comparatively high IT utilization it is expected that the Service Provider for Cloud Computing provides "Encryption" to

increase security. However it is not expected for companies associated with this Company Model to change their Service Provider frequently thus the “Interoperability” feature is not critical.
The analysis result complies with the expectations for the third test case.

10 Summary and Conclusion

The utilization of Cloud Computing Solutions increased dramatically during the last decade and it is expected that this increase will continue also in the future. Both companies with an established classical IT infrastructure and companies with hybrid IT infrastructure do require tools which would help them in planning to convert their IT Systems to take maximum advantage of Cloud Computing Solutions. As it is challenging to estimate the requirements for IT utilization for a company, there is a tendency that enterprises get into a stall-mate situation where they take too much time to adapt their IT infrastructure. This causes inefficiency and lost of market position due to lack of improvements in enterprises processes.

The aim of this study was to propose a Decision Support Tool for small- and medium-sized enterprises to assist them in implementation of Cloud Computing Solutions and adapt their IT infrastructure respectively.

To minimize the complexity of the designed algorithm, market data on current trends of companies in various industries has been utilized and integrated into the Decision Support Tool with help of ANNs. The type of ANN was selected as Multilayer Perceptron with Backpropagation due to its suitability for pattern recognition. Furthermore Company- and Cloud Computing Models have been developed to abstract any given company specification to compile information on its expected behaviour even in cases where there is no 1:1 example for such a company existing on the market with given specifications.

As a result the developed tool was seen to be able to conduct calculations regarding the best fitting Cloud Computing Service Provider for any given company specification. The developed Decision Support Tool should be seen as a proof-of-concept for the procedure developed and described in scope of this study. Such a tool can be improved by taking more specifications on companies in consideration such as their financial status and short & long term price politics applied to their industry sectors.

11Appendices

Appendix I: User Guide for the Cloud Computing Assessment Application

The Cloud Computing Assessment Application utilizes data on Cloud Computing usage by companies from member states of the EU provided by Eurostat. The application requires ANNs trained with such data to become operational. This guide explains the steps necessary to train the ANNs and run the Cloud Computing Assessment Application.

Learning Phase (i.e. Training of ANNs)

STEP 1: First, the Excel files designated as significant to indicate Cloud Computing Usage of companies are selected. Then, data from relevant tables of these files are copied into a text file. This step is executed manually.

In Fig. 28 this process is visualized for a single table from an Excel file. This and following processes needs to be applied evidently to all files/tables as a batch.

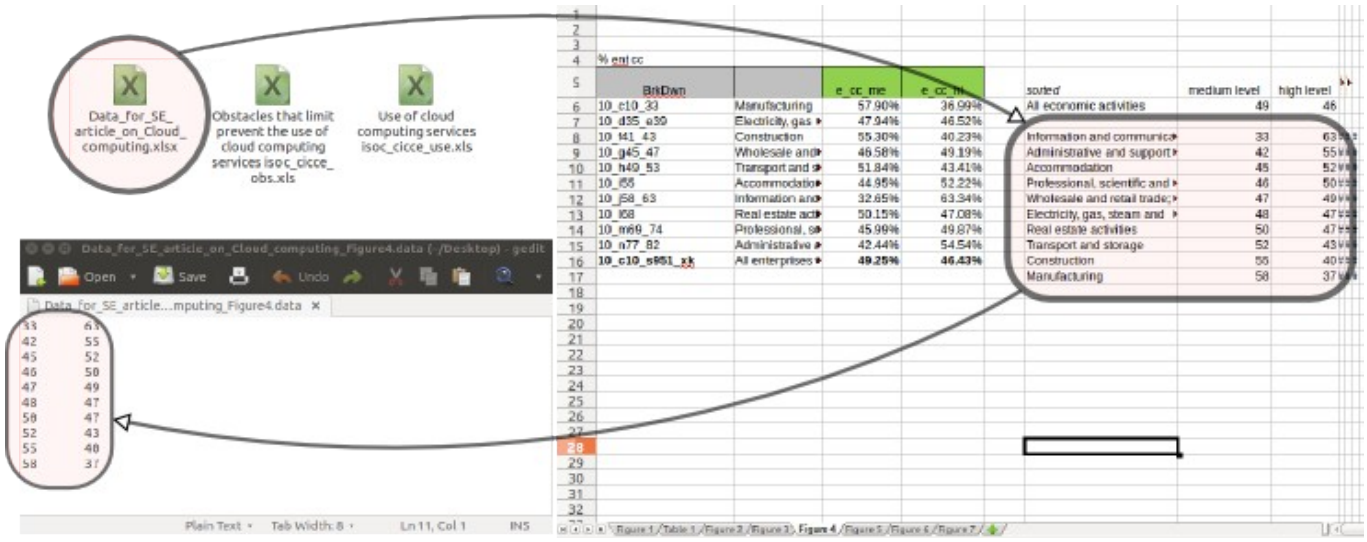


Fig. 28: *Preparing data for reformatting.*

STEP 2: Once the data for each table is stored in a separate file a prefix is to be added to each line to indicate the respective attribute. The prefix consists of “0”s and “1”s and implies the input neurons of the ANN to be trained.

Through the “DataSetGenerator” program this prefix is added for each file automatically and all edited files are saved with the prefix in their file name “TrainingData_”.

STEP 3: Once the training data files have been generated the program “DataTrainer” is to be executed to train the respective ANNs. In Fig. 29 is the conversion of training data -stored as a text file- to a trained ANN -stored as a serialized object in a text file-.

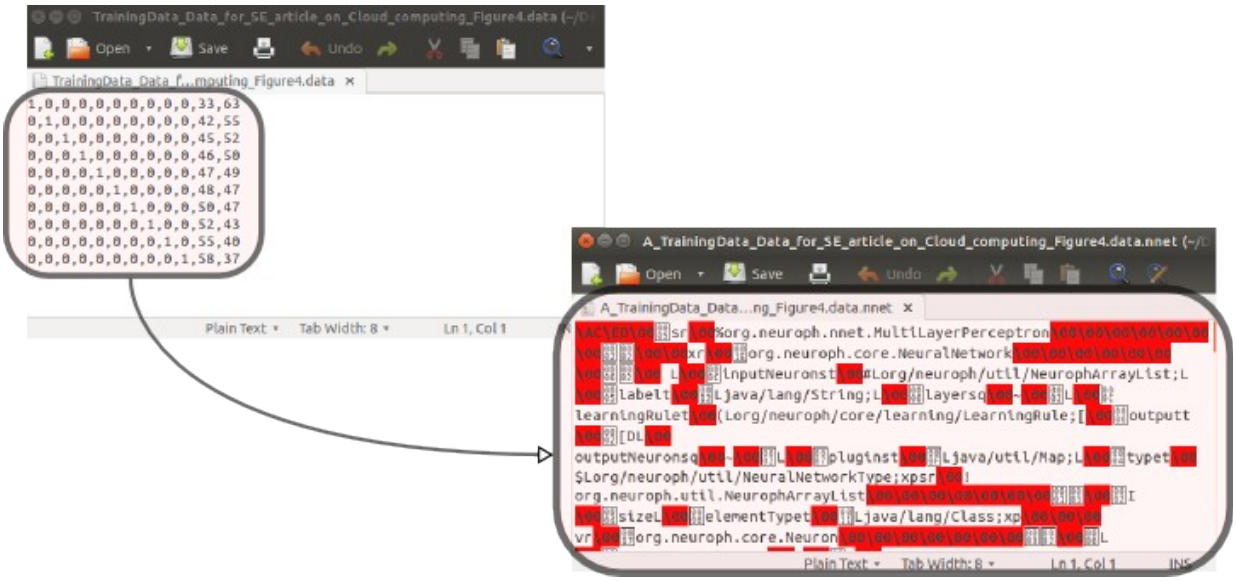


Fig. 29: *Training ANN with the program “DataAnalyser”.*

Once all data is used to train respective ANNs, the required ANN files are ready to be used by the Cloud Computing Assessment Application program.

Please note that all tables need to be trained in a separate file (Fig. 30) and all trained ANNs are required to be made available to the Cloud Computing Assessment Application. It is also important to note that all table names are hard-coded in programs and may need to be edited manually.

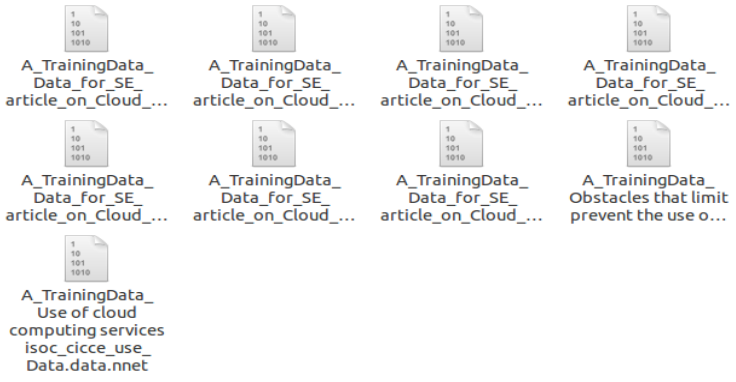


Fig. 30: *Trained ANNs in scope of this study.*

Operational Phase (i.e. Receiving Decision Support for Cloud Computer Services)

STEP 1: First, make sure that the computer where the program is going to be executed has Internet connection. This is required to create the radar plot by accessing Google Charts service. It is also required that the computer has Java Runtime Environment 1.8 or higher installed and the program has access to all the ANNs files.

STEP 2: Run the application and follow instructions on the command-line. Please note that to receive a PDF report you will need to enter the countries and industries the company operates in and its size (Fig. 31).

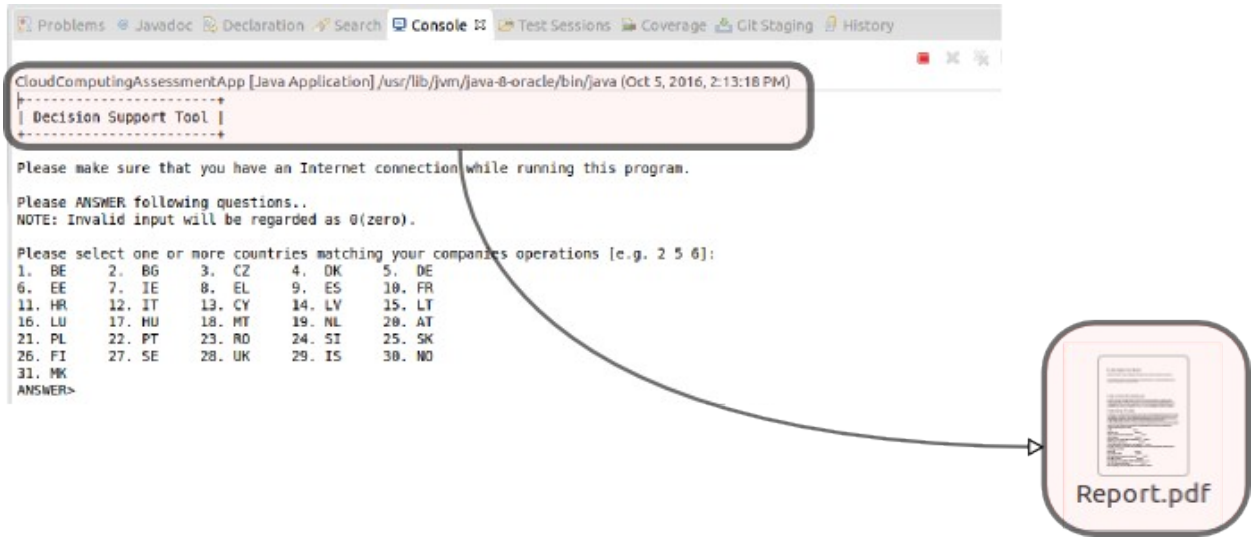


Fig. 31: *Running the program and generating a PDF report.*

The program will overwrite the PDF report each time it is executed. Therefore it is advisable to rename the PDF file if it is wished to be kept. The program also creates a *.png file which contains the radar plot. Feel free to delete the *.png file as it will be contained also in the generated report.

Appendix II: Code of DataSetGenerator.java

```
1.import java.io.BufferedReader;
2.import java.io.BufferedWriter;
3.import java.io.File;
4.import java.io.FileReader;
5.import java.io.FileWriter;
6.import java.io.IOException;
7.import java.io.PrintWriter;
8.import java.util.ArrayList;
9.import java.util.List;
10.
11.
12.public class DataSetGenerator {
13.   public static void main(String[] args){
14.     System.out.println("Generating Data Sets... \n");
15.
16.     List<String> rawFileNames = new ArrayList<String>();
17.
18.     rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure2.data");
19.     rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure3.data");
20.
21.     rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure4.data");
22.     rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Table1.data");
23.     rawFileNames.add("Use of cloud computing services isoc_cicce_use_Data.data");
24.     rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure5.data");
25.
26.     rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure6.data");
27.     rawFileNames.add("Data_for_SE_article_on_Cloud_computing_Figure7.data");
28.     rawFileNames.add("Obstacles that limit prevent the use of cloud computing services isoc_cicce_obs_D
ata.data");
29.
30.     for(int i=0; i<rawFileNames.size(); i++) {
31.       System.out.println("Generating Data Set"+ (i+1) +".. ");
32.       System.out.println(rawFileNames.get(i));
33.       File f= new File(rawFileNames.get(i));
34.       read(f);
35.     }
36.   }
37.
38.   private static void read(File file) {
39.     List<String> rawFileContent = new ArrayList<String>();
40.
41.     try(BufferedReader br = new BufferedReader(new FileReader(file))) {
42.       for(String line; (line = br.readLine()) != null; ) {
43.
44.
45.         String[] tokens = line.split("\\s+");
46.         for(int i=0; i<tokens.length; i++) {
47.           if(isInteger(tokens[i])){
48.             if(i==0 && tokens.length==1) {
49.               rawFileContent.add(tokens[i]);
50.             }
51.
52.             if(i==0 && tokens.length>1) {
53.               rawFileContent.add(tokens[i] + ",");
54.             }
55.
56.             if(i>0 && i!=tokens.length-1) {
57.               rawFileContent.size();
58.               String s = rawFileContent.get(rawFileContent.size()-1);
59.               rawFileContent.set((rawFileContent.size()-1), s+tokens[i] + ",");
60.             }
61.
62.             if(i!=0 && i==tokens.length-1) {
```

```
                rawFileContent.size();
                String s = rawFileContent.get(rawFileContent.size()-1);
                rawFileContent.set((rawFileContent.size()-1), s+tokens[i]);
              }

            }
          }

      }


    } catch(Exception e) {
      System.out.println("Something went wrong.. ");
    }

    generate(rawFileContent, file.getName());

  }

  private static void generate(List<String> rawFileContent, String fileName) {
    List<String> trainingData = new ArrayList<String>();

    System.out.println("size=" + rawFileContent.size());

    List<String> prefixForRawFileContent = new ArrayList<String>();
    for(int i=0; i<rawFileContent.size(); i++) {
      String e="";
      for(int y=0; y<rawFileContent.size(); y++) {
        if(y==(rawFileContent.size()-1)) {
          if(y==i) e+="1";
          if(y!=i) e+="0";
        } else {
          if(y==i) e+="1,";
          if(y!=i) e+="0,";
        }
      }
      prefixForRawFileContent.add(e);
    }

    for(int t=0; t<rawFileContent.size(); t++) {
      trainingData.add(prefixForRawFileContent.get(t) + "," + rawFileContent.get(t));
      System.out.println(trainingData.get(t));
    }

    write(trainingData, fileName);
  }

  private static void write(List<String> trainingData, String fileName) {
    try {
      PrintWriter out = new PrintWriter(new BufferedWriter(new FileWriter("TrainingData_" + fileName, t
rue)));

      for(int i=0; i< trainingData.size(); i++) {
        out.println(trainingData.get(i));
      }

      out.close();
    } catch (IOException e) {

    }
  }

  public static boolean isInteger(String s) {
    try {
      Integer.parseInt(s);
    } catch(Exception e) {
      return false;
```

```
    }
    return true;
  }

}
```

Appendix III: Code of DataTrainer.java

```
import java.io.BufferedReader;
import java.io.File;
import java.io.FileReader;
import java.util.ArrayList;
import java.util.Arrays;
import java.util.List;

import org.neuroph.core.NeuralNetwork;
import org.neuroph.nnet.learning.MomentumBackpropagation;
import org.neuroph.nnet.MultiLayerPerceptron;
import org.neuroph.core.data.DataSet;
import org.neuroph.core.data.DataSetRow;
import org.neuroph.util.TransferFunctionType;

/**
* This program reads the training sets and trains & saves respective Multi Layer Perceptron for each set.
*/
public class DataTrainer {

  public static void main(String[] args) {

    System.out.println("Initiating the Training Sessions... \n");

    List<String> rawFileNames = new ArrayList<String>();

    rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure2.data");
    rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure3.data");

    rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure4.data");
    rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Table1.data");
    rawFileNames.add("TrainingData_Use of cloud computing services isoc_cicce_use_Data.data");
    rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure5.data");

    rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure6.data");
    rawFileNames.add("TrainingData_Data_for_SE_article_on_Cloud_computing_Figure7.data");
    rawFileNames.add("TrainingData_Obstacles that limit prevent the use of cloud computing services isoc_cicce_obs_Data.data");

    for(int i=0; i<rawFileNames.size(); i++) {
      System.out.println("Training with Data Set"+ (i+1) +".. ");
      System.out.println(rawFileNames.get(i));
      File f= new File(rawFileNames.get(i));
      read(f);
    }
  }

  private static void read(File file) {
    try(BufferedReader br = new BufferedReader(new FileReader(file))) {
      List<String> fileContent = new ArrayList<String>();
      for(String line; (line = br.readLine()) != null; ) {
        fileContent.add(line);
      }

      System.out.println("Number of input neurons: " + fileContent.size());
      String[] temp = fileContent.get(0).split(",");
      System.out.println("Number of output neurons: " + (temp.length-fileContent.size()));

```

```
57.       double[][] _input  = new double[fileContent.size()][fileContent.size()];
58.       double[][] _output = new double[fileContent.size()][temp.length-fileContent.size()];
59.
60.       for(int o=0; o<fileContent.size(); o++) {
61.         String[] tokens = fileContent.get(o).split(",");
62.         for(int i=0; i<tokens.length; i++) {
63.           if(isInteger(tokens[i])){
64.             if(i<fileContent.size()) {
65.               _input[o][i]=Double.parseDouble(tokens[i]);
66.             } else {
67.               _output[o][i-fileContent.size()]=Double.parseDouble(tokens[i])/100;
68.             }
69.
70.           }
71.         }
72.       }
73.
74.       for(int e=0; e<_input.length; e++) {
75.         for(int i=0; i<_input.length; i++) {
76.           System.out.print(_input[e][i] + " ");
77.           for(int y=0; y<_output[e].length; y++) {
78.             System.out.print(_output[e][y] + " ");
79.           }
80.         }
81.         System.out.println("");
82.       }
83.
84.       train(_input,_output, file.getName());
85.
86.     } catch(Exception e) {
87.       System.out.println("Something went wrong.. ");
88.       System.out.println(e);
89.     }
90.   }
91.
92.   private static void train(double[][] _input, double[][] _output, String fileName) {
93.     int in  = _input.length;
94.     int out = _output[0].length;
95.
96.     // create training set (logical XOR function)
97.     DataSet trainingSet = new DataSet(in, out);
98.
99.     for(int i=0; i<in; i++) {
100.        trainingSet.addRow(new DataSetRow(_input[i],_output[i]));
101.      }
102.
103.      // create multi layer perceptron
104.      MultiLayerPerceptron myMlPerceptron = new MultiLayerPerceptron(TransferFunctionType.SIGMOID, in,
in*2, out);
105.
106.      // set learning parametars
107.      MomentumBackpropagation learningRule = (MomentumBackpropagation) myMlPerceptron.getLearnin
gRule();
108.      learningRule.setLearningRate(0.0001);
109.      learningRule.setMomentum(0);
110.      learningRule.setMaxError(0.00001);
111.
112.      // learn the training set
113.      myMlPerceptron.learn(trainingSet);
114.
115.      // test perceptron
116.      System.out.println("Testing trained neural network");
117.      testNeuralNetwork(myMlPerceptron, trainingSet);
118.
119.      // save trained neural network
120.      myMlPerceptron.save("A_" + fileName + ".nnet");
121.
```

```
    // load saved neural network
    @SuppressWarnings("rawtypes")
    NeuralNetwork loadedMlPerceptron = NeuralNetwork.createFromFile("A_" + fileName + ".nnet");

    // test loaded neural network
    System.out.println("Testing loaded neural network");
    testNeuralNetwork(loadedMlPerceptron, trainingSet);

  }

  @SuppressWarnings("rawtypes")
  public static void testNeuralNetwork(NeuralNetwork nnet, DataSet testSet) {

    for(DataSetRow dataRow : testSet.getRows()) {

      nnet.setInput(dataRow.getInput());
      nnet.calculate();
      double[ ] networkOutput = nnet.getOutput();
      System.out.print("Input: " + Arrays.toString(dataRow.getInput()) );
      System.out.println(" Output: " + Arrays.toString(networkOutput) );

    }
  }

  public static boolean isInteger(String s) {
    try {
      Integer.parseInt(s);
    } catch(Exception e) {
      return false;
    }
    return true;
  }
}
```

Appendix IV: Code of DataAnalyser.java

```
import java.util.ArrayList;
import java.util.List;
import java.util.Scanner;

import org.neuroph.core.NeuralNetwork;

@SuppressWarnings({ "rawtypes", "deprecation" })
public class DataAnalyser {
  NeuralNetwork network1 = NeuralNetwork.load("A_TrainingData_Data_for_SE_article_on_Cloud_computing_Figure2.data.nnet");
  NeuralNetwork network2 = NeuralNetwork.load("A_TrainingData_Data_for_SE_article_on_Cloud_computing_Figure3.data.nnet");
  NeuralNetwork network3 = NeuralNetwork.load("A_TrainingData_Data_for_SE_article_on_Cloud_computing_Figure4.data.nnet");
  NeuralNetwork network4 = NeuralNetwork.load("A_TrainingData_Data_for_SE_article_on_Cloud_computing_Figure5.data.nnet");
  NeuralNetwork network5 = NeuralNetwork.load("A_TrainingData_Data_for_SE_article_on_Cloud_computing_Figure6.data.nnet");
  NeuralNetwork network6 = NeuralNetwork.load("A_TrainingData_Data_for_SE_article_on_Cloud_computing_Figure7.data.nnet");
  NeuralNetwork network7 = NeuralNetwork.load("A_TrainingData_Data_for_SE_article_on_Cloud_computing_Table1.data.nnet");
  NeuralNetwork network8 = NeuralNetwork.load("A_TrainingData_Obstacles that limit prevent the use of cloud computing services isoc_cicce_obs_Data.data.nnet");
  NeuralNetwork network9 = NeuralNetwork.load("A_TrainingData_Use of cloud computing services isoc_cicce_use_Data.data.nnet");

  static List<String> report = new ArrayList<String>();

  static String country  = "";
```

```
22.  static String industry = "";
23.  static String size     = "";
24.
25.  public static boolean isInteger(String s) {
26.    try {
27.      Integer.parseInt(s);
28.    } catch(NumberFormatException e) {
29.      return false;
30.    }
31.    return true;
32.  }
33.
34.  public static void main(String[] args) {
35.    System.out.println("+------------------------+");
36.    System.out.println("| Decision Support Tool |");
37.    System.out.println("+------------------------+\n");
38.
39.    System.out.println("Please ANSWER following questions.. ");
40.    System.out.println("NOTE: Invalid input will be regarded as 0(zero). ");
41.
42.    country  = country_selection();
43.    industry = industry_selection();
44.    size     = size_selection();
45.
46.    uin_n1(10, industry);
47.    uin_n2(31, country);
48.
49.    uin_n3(10, industry);
50.    uin_n4(5,  size);
51.    uin_n7(31, country);
52.    uin_n9(31, country);
53.
54.    uin_n5(2,  size);
55.    uin_n6(10, industry);
56.    uin_n8(31, country);
57.
58.
59.    for(int i=0; i<report.size(); i++) {
60.      System.out.println(report.get(i));
61.    }
62.  }
63.
64.  private static String size_selection() {
65.    System.out.println("\nPlease select size of your company [e.g. 2]: ");
66.    System.out.println("1.  large");
67.    System.out.println("2.  medium");
68.    System.out.println("3.  small");
69.    System.out.println("4.  no specification regarding company size (aka. average)");
70.    System.out.println("5.  small and medium");
71.
72.    System.out.print("ANSWER> ");
73.
74.    @SuppressWarnings("resource")
75.    Scanner reader = new Scanner(System.in);
76.    String a = reader.nextLine();
77.    return a;
78.  }
79.
80.  private static String industry_selection() {
81.    System.out.println("\nPlease select one or more industries matching your companies operations [e.g. 2
5 6]: ");
82.    System.out.println("1.  Construction");
83.    System.out.println("2.  Transport and storage");
84.    System.out.println("3.  Manufacturing");
85.    System.out.println("4.  Wholesale and retail trade; repair of motor vehicles and motorcycles");
86.    System.out.println("5.  Accommodation");
```

```
87.      System.out.println("6.  Electricity, gas, steam and air conditioning; water supply, sewerage, waste man
agement and remediation activities");
88.      System.out.println("7.  Administrative and support service activities");
89.      System.out.println("8.  Real estate activities ");
90.      System.out.println("9.  Professional, scientific and technical activities ");
91.      System.out.println("10. Information and communication ");
92.
93.      System.out.print("ANSWER> ");
94.
95.      @SuppressWarnings("resource")
96.      Scanner reader = new Scanner(System.in);
97.      String a = reader.nextLine();
98.      return a;
99.   }
100.
101.   private static String country_selection() {
102.      System.out.println("\nPlease select one or more countries matching your companies operations [e.g.
2 5 6]: ");
103.      System.out.println(""
104.            + "1.  BE     "
105.            + "2.  BG     "
106.            + "3.  CZ     "
107.            + "4.  DK     "
108.            + "5.  DE     " + "\n"
109.            + "6.  EE     "
110.            + "7.  IE     "
111.            + "8.  EL     "
112.            + "9.  ES     "
113.            + "10. FR     " + "\n"
114.            + "11. HR     "
115.            + "12. IT     "
116.            + "13. CY     "
117.            + "14. LV     "
118.            + "15. LT     " + "\n"
119.            + "16. LU     "
120.            + "17. HU     "
121.            + "18. MT     "
122.            + "19. NL     "
123.            + "20. AT     " + "\n"
124.            + "21. PL     "
125.            + "22. PT     "
126.            + "23. RO     "
127.            + "24. SI     "
128.            + "25. SK     " + "\n"
129.            + "26. FI     "
130.            + "27. SE     "
131.            + "28. UK     "
132.            + "29. IS     "
133.            + "30. NO     " + "\n"
134.            + "31. MK     "
135.            );
136.
137.      System.out.print("ANSWER> ");
138.
139.      @SuppressWarnings("resource")
140.      Scanner reader = new Scanner(System.in);
141.      String a = reader.nextLine();
142.      return a;
143.   }
144.
145.   @SuppressWarnings("resource")
146.   private static void uin_n1(int input_length, String a) {
147.      String s = ("\nA. Inquiry on necessity of Cloud Computing usage");
148.      report.add(s);
149.
150.      String[] tokens = a.split("[ ]+");
151.      double arr[] = new double[input_length];
```

```
152.
153.     for(int i=0; i<tokens.length; i++) {
154.       if(isInteger(tokens[i]) && Integer.parseInt(tokens[i])>0){
155.         for(int e=0; e<arr.length; e++) {
156.           if(e==Integer.parseInt(tokens[i])-1) {
157.             arr[e]=1;
158.           }
159.         }
160.       }
161.     }
162.
163.     new DataAnalyser().calculate1(arr);
164.   }
165.
166.   private void calculate1(double[] input) {
167.     network1.setInput(input);
168.     network1.calculate();
169.     double[] output = network1.getOutput();
170.     interpreter1(output);
171.   }
172.
173.   private void interpreter1(double[] output) {
174.     String s = ("\nResult: " + "There is a " + (double)((int)(output[0]*10000))/100 + "% probability that t
he company may use for its business activities Cloud Computing Solutions. ");
175.     report.add(s);
176.   }
177.
178.   @SuppressWarnings("resource")
179.   private static void uin_n2(int input_length, String a) {
180.     String[] tokens = a.split("[ ]+");
181.     double arr[] = new double[input_length];
182.
183.     String[] _tokens = new String[tokens.length];
184.     for(int k=0; k<tokens.length; k++) {
185.       if(Integer.parseInt(tokens[k])==1) {
186.         _tokens[k]="11";
187.       }
188.       if(Integer.parseInt(tokens[k])==2) {
189.         _tokens[k]="27";
190.       }
191.       if(Integer.parseInt(tokens[k])==3) {
192.         _tokens[k]="15";
193.       }
194.       if(Integer.parseInt(tokens[k])==4) {
195.         _tokens[k]="5";
196.       }
197.       if(Integer.parseInt(tokens[k])==5) {
198.         _tokens[k]="24";
199.       }
200.       if(Integer.parseInt(tokens[k])==6) {
201.         _tokens[k]="16";
202.       }
203.       if(Integer.parseInt(tokens[k])==7) {
204.         _tokens[k]="8";
205.       }
206.       if(Integer.parseInt(tokens[k])==8) {
207.         _tokens[k]="28";
208.       }
209.       if(Integer.parseInt(tokens[k])==9) {
210.         _tokens[k]="17";
211.       }
212.       if(Integer.parseInt(tokens[k])==10) {
213.         _tokens[k]="21";
214.       }
215.       if(Integer.parseInt(tokens[k])==11) {
216.         _tokens[k]="10";
217.       }
```

```
218.       if(Integer.parseInt(tokens[k])==12) {
219.         _tokens[k]="3";
220.       }
221.       if(Integer.parseInt(tokens[k])==13) {
222.         _tokens[k]="25";
223.       }
224.       if(Integer.parseInt(tokens[k])==14) {
225.         _tokens[k]="30";
226.       }
227.       if(Integer.parseInt(tokens[k])==15) {
228.         _tokens[k]="18";
229.       }
230.       if(Integer.parseInt(tokens[k])==16) {
231.         _tokens[k]="20";
232.       }
233.       if(Integer.parseInt(tokens[k])==17) {
234.         _tokens[k]="26";
235.       }
236.       if(Integer.parseInt(tokens[k])==18) {
237.         _tokens[k]="18";
238.       }
239.       if(Integer.parseInt(tokens[k])==19) {
240.         _tokens[k]="7";
241.       }
242.       if(Integer.parseInt(tokens[k])==20) {
243.         _tokens[k]="23";
244.       }
245.       if(Integer.parseInt(tokens[k])==21) {
246.         _tokens[k]="29";
247.       }
248.       if(Integer.parseInt(tokens[k])==22) {
249.         _tokens[k]="19";
250.       }
251.       if(Integer.parseInt(tokens[k])==23) {
252.         _tokens[k]="31";
253.       }
254.       if(Integer.parseInt(tokens[k])==24) {
255.         _tokens[k]="14";
256.       }
257.       if(Integer.parseInt(tokens[k])==25) {
258.         _tokens[k]="12";
259.       }
260.       if(Integer.parseInt(tokens[k])==26) {
261.         _tokens[k]="1";
262.       }
263.       if(Integer.parseInt(tokens[k])==27) {
264.         _tokens[k]="4";
265.       }
266.       if(Integer.parseInt(tokens[k])==28) {
267.         _tokens[k]="9";
268.       }
269.       if(Integer.parseInt(tokens[k])==29) {
270.         _tokens[k]="2";
271.       }
272.       if(Integer.parseInt(tokens[k])==30) {
273.         _tokens[k]="6";
274.       }
275.       if(Integer.parseInt(tokens[k])==10) {
276.         _tokens[k]="22";
277.       }
278.     }
279.     tokens = _tokens;
280.
281.     for(int i=0; i<tokens.length; i++) {
282.       if(isInteger(tokens[i]) && Integer.parseInt(tokens[i])>0){
283.         for(int e=0; e<arr.length; e++) {
284.           if(e==Integer.parseInt(tokens[i])-1) {
```

```
285.                 arr[e]=1;
286.               }
287.             }
288.           }
289.       }
290.
291.       new DataAnalyser().calculate2(arr);
292.   }
293.
294.   private void calculate2(double[] input) {
295.       network2.setInput(input);
296.       network2.calculate();
297.       double[] output = network2.getOutput();
298.       interpreter2(output);
299.   }
300.
301.   private void interpreter2(double[] output) {
302.       String s = ("Result: " + "The given company may use Cloud Computing Solutions with " + (double)
((int)(output[0]*10000))/100 + "% probability in its medium level activities and for " + (double)((int)
(output[1]*10000))/100
303.               + "% probability in its high level activities. ");
304.       report.add(s);
305.   }
306.
307.   @SuppressWarnings("resource")
308.   private static void uin_n3(int input_length, String a) {
309.       String s = ("\nB. Inquiry on the type of CC solutions");
310.       report.add(s);
311.
312.       String[] tokens = a.split("[ ]+");
313.       double arr[] = new double[input_length];
314.
315.       for(int i=0; i<tokens.length; i++) {
316.           if(isInteger(tokens[i]) && Integer.parseInt(tokens[i])>0){
317.               for(int e=0; e<arr.length; e++) {
318.                   if(e==Integer.parseInt(tokens[i])-1) {
319.                       arr[e]=1;
320.                   }
321.               }
322.           }
323.       }
324.
325.       new DataAnalyser().calculate3(arr);
326.   }
327.
328.   private void calculate3(double[] input) {
329.       network3.setInput(input);
330.       network3.calculate();
331.       double[] output = network3.getOutput();
332.       interpreter3(output);
333.   }
334.
335.   private void interpreter3(double[] output) {
336.       String s = ("\nResult: " + "The " + (double)((int)(output[0]*10000))/100 + "% of CC solutions are exp
ected to be used in medium level activities and " + (double)((int)(output[1]*10000))/100
337.               + "% in high level activities. ");
338.       report.add(s);
339.   }
340.
341.   @SuppressWarnings("resource")
342.   private static void uin_n4(int input_length, String a) {
343.       String[] tokens = a.split("[ ]+");
344.       double arr[] = new double[input_length];
345.
346.       for(int i=0; i<tokens.length; i++) {
347.           if(isInteger(tokens[i]) && Integer.parseInt(tokens[i])>0){
348.               for(int e=0; e<arr.length; e++) {
```

```
            if(e==Integer.parseInt(tokens[i])-1) {
              arr[e]=1;
            }
          }
        }
      }

      new DataAnalyser().calculate4(arr);
  }

  private void calculate4(double[] input) {
      network4.setInput(input);
      network4.calculate();
      double[] output = network4.getOutput();
      interpreter4(output);
  }

  private void interpreter4(double[] output) {
      String s = ("Result: " + "The use of Cloud Computing Services (est. as " + (double)((int)
(output[0]*10000))/100 + "%) is expected to consist of \n"
            + (double)((int)(output[1]*10000))/100 + "% Delivered from shared servers of service providers
(public cloud) and \n"
            + (double)((int)(output[2]*10000))/100 + "% Delivered from servers of service providers exclusi
vely reserved for the enterprise (private cloud). ");
      report.add(s);
  }

  @SuppressWarnings("resource")
  private static void uin_n7(int input_length, String a) {
      String[] tokens = a.split("[ ]+");
      double arr[] = new double[input_length];

      for(int i=0; i<tokens.length; i++) {
        if(isInteger(tokens[i]) && Integer.parseInt(tokens[i])>0){
          for(int e=0; e<arr.length; e++) {
            if(e==Integer.parseInt(tokens[i])-1) {
              arr[e]=1;
            }
          }
        }
      }

      new DataAnalyser().calculate7(arr);
  }

  private void calculate7(double[] input) {
      network7.setInput(input);
      network7.calculate();
      double[] output = network7.getOutput();
      interpreter7(output);
  }

  private void interpreter7(double[] output) {
      String s = ("Result: " + "The given company is expected to use following Cloud Computing Solutions w
ith respective percentages as below; \n"
            + "E-mail                                    " + (double)((int)(output[1]*10000))/100 + "\n"
            + "Storage of files                          " + (double)((int)(output[2]*10000))/100 + "\n"
            + "Hosting the enterprise's database(s)              " + (double)((int)(output[3]*10000))/100 + "\n
"
            + "Office software                           " + (double)((int)(output[4]*10000))/100 + "\n"
            + "Financial or accounting software applications      " + (double)((int)(output[5]*10000))/100 +
"\n"
            + "CRM software applications                 " + (double)((int)(output[6]*10000))/100 + "\n"
            + "Computing power for enterprise's own software      " + (double)((int)(output[7]*10000))/100
+ "\n"
            );
      report.add(s);
```

```
409.  }
410.
411.  @SuppressWarnings("resource")
412.  private static void uin_n9(int input_length, String a) {
413.    String[] tokens = a.split("[ ]+");
414.    double arr[] = new double[input_length];
415.
416.    for(int i=0; i<tokens.length; i++) {
417.      if(isInteger(tokens[i]) && Integer.parseInt(tokens[i])>0){
418.        for(int e=0; e<arr.length; e++) {
419.          if(e==Integer.parseInt(tokens[i])-1) {
420.            arr[e]=1;
421.          }
422.        }
423.      }
424.    }
425.
426.    new DataAnalyser().calculate9(arr);
427.  }
428.
429.  private void calculate9(double[] input) {
430.    network9.setInput(input);
431.    network9.calculate();
432.    double[] output = network9.getOutput();
433.    interpreter9(output);
434.  }
435.
436.  private void interpreter9(double[] output) {
437.    String s = ("Result: " + "The given company is expected to buy following Cloud Computing Solutions
with respective percentages as below; \n"
438.        + "Buy E-mail                                " + (double)((int)(output[1]*10000))/100 + "\n"
439.        + "Buy Storage of files                      " + (double)((int)(output[2]*10000))/100 + "\n"
440.        + "Buy Hosting the enterprise's database(s)          " + (double)((int)(output[3]*10000))/100 + "
\n"
441.        + "Buy Office software                       " + (double)((int)(output[4]*10000))/100 + "\n"
442.        + "Buy Financial or accounting software applications   " + (double)((int)(output[5]*10000))/100
+ "\n"
443.        + "Buy CRM software applications                 " + (double)((int)(output[6]*10000))/100 + "\n"
444.        + "Buy Computing power for enterprise's own software   " + (double)((int)
(output[7]*10000))/100
445.        );
446.    report.add(s);
447.  }
448.
449.  @SuppressWarnings("resource")
450.  private static void uin_n5(int input_length, String a) {
451.    String s = ("\nC. Inquiry on limitations of Cloud Computing usage");
452.    report.add(s);
453.
454.    String[] tokens = a.split("[ ]+");
455.    double arr[] = new double[input_length];
456.
457.    if(isInteger(tokens[0]) && Integer.parseInt(tokens[0])>0){
458.      if(Integer.parseInt(tokens[0])==1) {
459.        arr[0]=0;
460.        arr[1]=1;
461.      } else {
462.        arr[0]=1;
463.        arr[1]=0;
464.      }
465.    }
466.
467.    new DataAnalyser().calculate5(arr);
468.  }
469.
470.  private void calculate5(double[] input) {
471.    network5.setInput(input);
```

```
    network5.calculate();
    double[] output = network5.getOutput();
    interpreter5(output);
  }

  private void interpreter5(double[] output) {
    String s = ("\nResult: " + "The limitations and their respective percentages for holding companies back is as follows; \n"
          + "Risk of a security breach                                " + (double)((int)(output[0]*10000))/100 + "\n"
          + "Uncertainty about applicable law, jurisdiction, dispute       " + (double)((int)(output[1]*10000))/100 + "\n"
          + "resolution mechanism  \n"
          + "Uncertainty about the location of data                    " + (double)((int)(output[2]*10000))/100 + "\n"
          + "Problems accessing data or software                       " + (double)((int)(output[3]*10000))/100 + "\n"
          + "Difficulties in unsubscribing or changing service provider    " + (double)((int)(output[4]*10000))/100 + "\n"
          + "High cost of buying cloud computing services                " + (double)((int)(output[5]*10000))/100 + "\n"
          + "Insufficient knowledge of cloud computing                 " + (double)((int)(output[6]*10000))/100
          );
    report.add(s);
  }

  @SuppressWarnings("resource")
  private static void uin_n6(int input_length, String a) {
    String[] tokens = a.split("[ ]+");
    double arr[] = new double[input_length];

    String[] _tokens = new String[tokens.length];
    for(int k=0; k<tokens.length; k++) {
      if(Integer.parseInt(tokens[k])==1) {
        _tokens[k]="3";
      }
      if(Integer.parseInt(tokens[k])==2) {
        _tokens[k]="5";
      }
      if(Integer.parseInt(tokens[k])==3) {
        _tokens[k]="1";
      }
      if(Integer.parseInt(tokens[k])==4) {
        _tokens[k]="4";
      }
      if(Integer.parseInt(tokens[k])==5) {
        _tokens[k]="6";
      }
      if(Integer.parseInt(tokens[k])==6) {
        _tokens[k]="2";
      }
      if(Integer.parseInt(tokens[k])==7) {
        _tokens[k]="10";
      }
      if(Integer.parseInt(tokens[k])==8) {
        _tokens[k]="8";
      }
      if(Integer.parseInt(tokens[k])==9) {
        _tokens[k]="9";
      }
      if(Integer.parseInt(tokens[k])==10) {
        _tokens[k]="7";
      }
    }
    tokens = _tokens;

```

```
    for(int i=0; i<tokens.length; i++) {
      if(isInteger(tokens[i]) && Integer.parseInt(tokens[i])>0){
        for(int e=0; e<arr.length; e++) {
          if(e==Integer.parseInt(tokens[i])-1) {
            arr[e]=1;
          }
        }
      }
    }

    new DataAnalyser().calculate6(arr);
  }

  private void calculate6(double[] input) {
    network6.setInput(input);
    network6.calculate();
    double[] output = network6.getOutput();
    interpreter6(output);
  }

  private void interpreter6(double[] output) {
    String s = ("\nResult: " + "The factors preventing companies from using CC services based on your industry and their respective percentage of importance are as follows; \n"
        + "Risk of a security breach                    " + (double)((int)(output[0]*10000))/100 + "% \n"
        + "Uncertainty about the location of data        " + (double)((int)(output[1]*10000))/100 + "% \n"
        + "Uncertainty about applicable law, jurisdiction,  " + (double)((int)(output[2]*10000))/100 + "% \n"
        + "dispute resolution mechanism\n"
        + "High cost of buying cloud computing services     " + (double)((int)(output[3]*10000))/100 + "% \n"
        + "Insufficient knowledge of cloud computing       " + (double)((int)(output[4]*10000))/100 + "%"
        );
    report.add(s);
  }

  @SuppressWarnings("resource")
  private static void uin_n8(int input_length, String a) {
    String[] tokens = a.split("[ ]+");
    double arr[] = new double[input_length];

    for(int i=0; i<tokens.length; i++) {
      if(isInteger(tokens[i]) && Integer.parseInt(tokens[i])>0){
        for(int e=0; e<arr.length; e++) {
          if(e==Integer.parseInt(tokens[i])-1) {
            arr[e]=1;
          }
        }
      }
    }

    new DataAnalyser().calculate8(arr);
  }

  private void calculate8(double[] input) {
    network8.setInput(input);
    network8.calculate();
    double[] output = network8.getOutput();
    interpreter8(output);
  }

  private void interpreter8(double[] output) {
    String s = ("\nResult: " + "The factors preventing companies from using CC services based on your location and their respective percentage of importance are as follows; \n"
        + "Risk of a security breach                    " + (double)((int)(output[0]*10000))/100 + "% \n"
```

```
591.            + "Problems accessing data or software              " + (double)((int)(output[1]*10000))/100 + "% \
n"
592.            + "Difficulties in unsubscribing or changing service " + (double)((int)(output[2]*10000))/100 + "
% \n"
593.            + "provider\n"
594.            + "Uncertainty about the location of data           " + (double)((int)(output[3]*10000))/100 + "% \
n"
595.            + "Uncertainty about applicable law, jurisdiction,  " + (double)((int)(output[4]*10000))/100 + "%
\n"
596.            + "dispute resolution mechanism\n"
597.            + "High cost of buying cloud computing services     " + (double)((int)(output[5]*10000))/100 +
"% \n"
598.            + "Insufficient knowledge of cloud computing        " + (double)((int)(output[6]*10000))/100 + "
%"
599.            );
600.      report.add(s);
601.   }
602.
603.}
```

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