St. Petersburg University
Graduate School of Management

Master in Management Program

HEALTHCARE INFORMATION SYSTEM

SELECTION MODEL FOR MEDICAL CLINICS

Master's Thesis by the 2nd year student

Concentration — Master in Management

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St. Petersburg

2016

ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

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АННОТАЦИЯ

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Описание цели, задач и основных результатов	Целью данного исследования является разработка модели выбора медицинской информационной системы в медицинских учреждениях. Данное исследование основано на сравнительном анализе 50 информационных систем (30 Российских и 20 зарубежных) и 6 интервью с экспертами из Санкт-Петербургских медицинских учреждений, которые уже имеют опыт в использовании подобных информационных систем. В ходе исследования было выделено 13 характеристик медицинских информационных систем: 5 ключевых и 7 дополнительных. Данные характеристики были использованы при создании модели выбора информационной системы. Чтобы сократить алгоритм и избежать дублирования ветвей дерева решения были использованы переменные. Вопросы в разработанной модели просты для понимания обычного сотрудника медицинских учреждений и не требуют специальных знаний в области информационных технологий.
Ключевые слова:	здравоохранение, информационные системы, медицинские информационные системы, модель выбора, модель выбора информационной системы

ABSTRACT

Author:	Vera Mikhnevich
Title of thesis:	Healthcare Information System Selection Model for Medical Clinics
Faculty:	Graduate School of Management (St.-P. State University)
Major subject:	Management (MIM)
Year:	2016
Academic Advisor's name:	Professor Tatiana A. Gavrilova
Description of the goal, tasks and main results	The issue of selecting an appropriate healthcare information system is a very essential one. If implemented healthcare information system doesn't fit particular healthcare institution; it wastes its resources and its efficiency decreases. The purpose of this research is to develop a healthcare information system selection model to assist the decision-making process of choosing healthcare information system. Appropriate healthcare information system helps healthcare institutions to become more effective and efficient and keep up with the times. The research is based on comparison analysis of 50 healthcare information systems and 6 interviews with experts from St-Petersburg healthcare institutions that already have experience in healthcare information system utilization. 13 characteristics of healthcare information systems: 5 key and 7 additional features are identified and considered in the selection model development. Variables are used in the selection model in order to narrow the decision algorithm and to avoid duplication of brunches. The questions in the healthcare information systems selection model are designed to be easy-to-understand for common a decision-maker in healthcare institution without permanent establishment.
Keywords:	healthcare, information system, healthcare information system, medical information system, selection model, information system selection model, decision algorithm

List of Content

Introduction

Health is rooted to everyday life of every person all over the world; no doubt it is one of the most essential parts of peoples' lives.

IT technologies nowadays are deeply rooted not only in people's everyday life, but in almost all areas of business; and healthcare industry is not an exception. There are several segments in healthcare: scientific, which is responsible for inventions of new methodologies, equipment and medicines, and administrative which is performed by public and private healthcare institutions. Both of these segments are important, though only the latter will be considered in this paper. Information technologies appeared in healthcare institutions in 1960s with first electronic applications and the industry is moving forward very fast, especially recent years.

Currently, IT solutions become more and more advanced and seem to bring lots of benefits. Healthcare institutions all over the world started implementing modern technologies; such systems are called healthcare information systems. Many researches and studies concerning healthcare information systems were conducted to explore the benefits of IT solutions implementation and the implementation process itself. However there is still a big issue – how companies should choose healthcare information systems that would fit their needs? There is a gap in studying the preliminary stage of healthcare information systems implementation – selection of appropriate system.

A plenty of healthcare institutions implement healthcare information systems to increase efficiency and automate some processes and this innovation becomes more and more popular. However there are so many different kinds of systems with different functionality that managers, who are supposed to choose the system become confused as they don't know which system would fit the healthcare institution the best.

In Russia this issue becomes a hot topic as the healthcare industry develops and healthcare information systems gain popularity. Technologies entered both governmental and private sectors of the industry. To be more efficient and competitive clinics start to implement healthcare information systems, so the issue of healthcare information systems selection becomes very essential. In case information system doesn't fit particular healthcare institution, for example there are unnecessary functions; healthcare institution

wastes its resources and the efficiency decreases. Therefore, it is necessary to select an appropriate healthcare information system to get all the potential benefits.

The purpose of this research is to develop a healthcare information system selection model to assist the decision-making process of choosing healthcare information system. The research is based on comparison analysis of several healthcare information systems and expert opinion of several healthcare institutions that already have experience in healthcare information system utilization.

The research questions of this study are as following:

1. What are healthcare information systems characteristics that affect the selection process?
2. How healthcare institutions select healthcare information systems?
3. How to select an appropriate healthcare information system?

The first chapter it focused at defining and describing what healthcare information system is and for what purpose it is needed. Then different modern peculiarities of healthcare information systems are distinguished and described.

The second chapter is aimed at collecting and analyzing data for creating a healthcare information systems selection model. 50 different healthcare information systems are reviewed and compared. Based on the comparison the main features of healthcare information systems are identified and described. Then interview questionnaire for experienced in information systems usage healthcare institutions is created. The purpose of the interview with experts is to identify how particular healthcare institutions selected their healthcare information systems, what factors they were guided by and if their opinion about the selection criteria has changed.

In the third chapter healthcare information system selection model for healthcare institutions is developed based on the healthcare information systems comparison analysis and on the results of the interviews. The selection model is aimed at helping healthcare institutions to choose an appropriate healthcare information system according to their needs.

Chapter 1. Healthcare information system - theoretical review

1.1 Healthcare information system and its importance: state of the art

1.1.1 What is healthcare information system

Healthcare is a very essential industry that relates to most, if not all of us. This industry is one of the largest and fast growing sectors in the world. Moreover, healthcare is one of the world's most critical industries [Bernard, 2013]. It is a heavily human-oriented and knowledge-intensive, healthcare processes and their management have a direct impact on healthcare service quality and related costs, and the reputation of the healthcare institution [Quaglini, 2010]. Healthcare is known as an industry where cutting edge technologies and modern scientific breakthroughs are used to cure diseases more effectively and to be able to reveal the most dangerous for peoples' lives diseases at very early stages. Nevertheless, generally healthcare industry is enormously slow in implementing emergent technologies for improving administrative needs and management practices [Wickramasinghe, Mills, 2001]. Despite this fact new technologies enter the industry and become more and more popular.

There are many different challenges in the healthcare industry and it is generally recognized that the prime solution to them is introduction and usage of information technologies and systems in healthcare [Stegwee and Spil, 2001, 1–10]. Healthcare management challenges and the possible solutions to them are described and discussed in the next part.

There are different opinions on what is a healthcare information system; some researches assume such system to be an information portal for end-customers, while others consider healthcare information system to be an integrated solution for healthcare institutions. Therefore, it is necessary to consider definitions of healthcare information system proposed by different researchers to determine the one which will be used in this study.

According to World Healthcare Organization (WHO) healthcare information system is a system that integrates data collection, processing, reporting, and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services.[1]

[1] World Health Organization (1993)

Some researches name such systems Hospital Information System and give them the following definitions. Healthcare information system is a set of computer systems and telecommunications equipment, which is designed to manage all hospital information, medical and administrative matters [Mersini, Sakkopoulos, Tsakalidis, 2013]. It is a comprehensive system supported by computers and designed to deal with different kinds of information in hospitals. Mersini, Sakkopoulos and Tsakalidis (2013) identified three key issues on which such systems are focused. Firstly, healthcare information systems help medical employees to be more effective and efficient. Secondly, such systems help to increase the healthcare services' quality. Finally, information systems in healthcare institutions are used to manage costs.

According to other researchers healthcare information system combines communication and information technologies. Such systems include a wide range of functions from electronic patients' medical records and prescriptions to new services aimed at reducing data errors and queuing and waiting time [Matysiewicz, Smyczek, 2009].

In business terms healthcare information system is a knowledge-based, decision support aid that provides immediate assistance, guidance and feedback.

The main goal of a healthcare information system is to enable healthcare institutions to provide better medical care and to assist managing costs. Also there are several secondary objectives associated with healthcare provision itself. These targets are improvement of intercommunications among medical employees, reduction of waiting time, and supporting the decision making during medical care. From the point of managing costs the goal of healthcare information systems is to decrease personnel expenses, medical assistance time and administrative burdens and to improve management of healthcare institution resources.

In this study healthcare information system is a computer-assisted system that deals with different kinds of information from medical records to internal documents that aims at providing high quality medical care and managing costs of the healthcare institution.

The process of healthcare information systems development and their functionality is reviewed for better understanding of the issue what such information systems are and how they operate.

First healthcare information systems appeared in 1960s and their main function in those times was to enter patient care requests in computer systems of healthcare institution [Saba, Johnson, Simpson, 1994]. In 1971 World Health Organization developed 8 main criteria every healthcare information system should meet:

1. Ability to identify persons positively by name and place – name, date of birth, race, gender and postal code should be recorded to identify patient.
2. Avoiding unnecessary data agglomeration – no useless data, no doubling of data, one medical record for one patient.
3. Problem or trend orientation – ability to research by diagnosis related group – a scheme of classifying patients in a way that the type of patient treated by the healthcare institution relates to the carried costs [Averill et al, 2003].
4. Goal orientation to assist monitoring evaluation.
5. Functional and operational terms employment – the system should be able to generate standardized reports with standard terms and standard codes.
6. Records of data that refers to population groups, services, resources and outcomes of medical care – all the recorded data should be categorized for facilitating the data input and search.
7. Brief, unambiguous and imaginative information expression – ease of use of input and output.
8. Feedback and appropriate sharing of data – interdepartmental collaboration and Internet capability.

Listed healthcare information systems criteria are rather disputable; they are not precisely described and partly overlapping. Firstly, it is not clear what data is considered to be useless, there is no criterion of useful for healthcare institution information. Also if all the data should be categorized and the input points are standardized how the recorded information can be useless? Then it is hard to imagine how medical records can be imaginative as it stated in requirement 7. Moreover nothing is said about the ability to connect with other systems which is essential, too, as it would facilitate information exchange with other institutions.

The requirements to healthcare information systems were far from ideal, thus in 2008 World Health Organization reworked the list and identified a set of 4 primary functions that enable healthcare information system to maintain and improve the efficiency of health care.

1. data generation – the data collection process by which input information reaches a database
2. data compilation – the ability to categories data and to drill it
3. data analysis and synthesis – the ability to create reports
4. communication and use – the ability to exchange information within the system

All these functions are needed for healthcare information systems to be able to work properly: collect, process, store, report and share data. Also 7 additional functions that allow healthcare information systems to be a tool facilitating the process of making decisions and affect the efficiency and effectiveness of the organization were determined:

1. alert and early warning capability
2. supporting patient and health facility management
3. enabling planning
4. supporting and stimulating research
5. permitting health situation and trends analysis
6. supporting global reporting
7. underpinning communication of health challenges to diverse users [World Health Organization, 2008].

This list was supposed to complement the primary functions; however there are some overlaps between the lists. Both primary and additional healthcare information system functions point out the ability of creating reports named “data analysis and synthesis” and “supporting global reporting” respectively. Also “underpinning communication of health challenges to diverse users” meaning the ability to communicate with other professionals to solve the problem is similar to primary communication function. Another questionable point is “supporting and stimulating research” function, it is incomprehensible how this function can be performed.

Wager, Lee, & Glaser (2009) in their research proposed a list of healthcare information systems functions, too. From the researchers point of view every healthcare information system should perform the following functions: e-health records and prescriptions, computer assisted sorting and entry of suppliers’ orders. However several essential functions like information exchange or cost planning were not included in the list, so the necessary functionality of healthcare information systems was not fully identified.

In this study the list of necessary healthcare information system functions combines the proposals of the World Health Organization and Wager el at (2009). As a result the following list of healthcare information systems functions was created.

1. Electronic health records (including data generation and data compilation)

A healthcare information system should have standardized input form to record only useful information about the patient, this form can be developed by the healthcare institution itself according to its activities, for example the range of services – the number of medical fields covered (surgery, stomatology, cardiology, etc.) It will facilitate the process of imputing the data a lot. HIS also should be able to triage data into different categories and subcategories and derive only issued. It is very essential that no data should be doubled; only one medical record should be created for one patient.

2. Enabling planning

This function is needed for better management of healthcare institution's costs. The system should contain information about equipment, inventories and costs from operations to provide a base for administrative decision making.

3. Data analysis and synthesis

HIS should create standardized reports with standard terms and standard codes that are brief and clear. With the help of this function the outputs of the system would be easy to get and understand. Reports should be created for all information stored at the system related both to patients and the clinic itself (costs, etc.). Also this function includes alert and early warning capability, which means that the system checks the results of the medical tests comparing them to "normal" for healthy person values and to the historical values and highlights mismatching or significant changes. Warning capability should refer to management of costs, too, if the actual data doesn't match the plan the system should report it to the responsible person.

4. Communication and data exchange

All the data collected and stored in the system including reports should be available for all physicians in the system as many medical fields are interconnected. Also physicians should have an ability to share data and collaborate with each other to solve complicated and questionable issues. As a result healthcare institution will identify diseases earlier and provide higher quality treatment.

The range of healthcare information system users is quite broad; the system can be utilized by administrative staff, medical professionals, nurses and technical specialists of a healthcare institution. Also government institutions, insurance companies, customers and other members of healthcare industry can be users of healthcare information systems; it depends on the particular solution.

Classifications of healthcare information systems

Nowadays there is a great range of healthcare information systems and different researchers have their own classifications of such systems. The point is that these classifications are really different and sometimes it is rather difficult to understand how they related to each other.

For instance, only Chen (2006) has 4 different categorizations of healthcare information systems. Firstly, he divides information systems by functional areas and identifies four main types of them: administrative, financial, clinical and research. Similar classification of healthcare information systems was proposed by Stone (2014), who suggested dividing information systems into 3 groups: clinical, administrative, and management support. However, Stone highlights that to get full benefits of such systems usage these groups should be used together. Currently, mentioned functions are integrated in the majority of modern healthcare information systems.

The second classification of healthcare information systems suggested by Chen (2009) divides information systems into groups by the “extent of structure that they impose on working practice”: providing access to information, information tools and enforcement of rules meaning automatization process.

The third classification proposed by Chen (2006) suggests splitting healthcare information systems according to their span across the healthcare institution, so the information systems can be individual, work group, organizational and outside organization. However, according to the researcher’s explanation healthcare information systems mostly refer to organizational ones as they are used by employees in the whole organization.

The last categorization proposed by Chen (2006) refers to the purpose of the healthcare information system. This classification divides information systems to

transaction processing systems, management information systems, decision support systems and office automation systems.

Generally, according to the list of functions healthcare information systems are supposed to have [World Health Organization, Wager el at, 2009] Chen's classification is not suitable for this study because it considers different parts of healthcare information systems as different systems. Nowadays healthcare information systems are modular in nature and combine different functions and as a result have several purposes. Therefore, none of classifications proposed by Chen (2009) is going to be used in this study, moreover as healthcare information systems become more complex these classifications are no longer seem to be viable.

Jones et al (2014) suggested their own classification of healthcare information systems. The researchers consider that the information systems can be split into 3 groups: electronic medical records, electronic health records and personal health records. These groups differ by the width of usage, where e-medical records include records only from a particular medical professional, e-health records – records from all patients' clinicians and personal health records differ from the previous type by the patient's ability to access and manage it.

This classification is more suitable for single-function healthcare information systems that are focused on managing patients' data. However, this study is mainly focused on multi-function healthcare information systems, which are more spread on the market.

All in all there are different characteristics by which healthcare information systems can be divided into groups, however, these classifications can hardly be used together as there is no connection among groups from different classification. Thus healthcare information systems with particular function, for instance, can refer to different purposes or span differently across the organization. It makes it even more difficult to understand the variety of existing information systems. This leads to a "zoo" problem, which is very typical one for IT-systems selection. This problem refers to the difficulty of choosing one information system from a great variety on the market [Gavrilova, 2003]. As there were more than 650 different healthcare information systems in Russian market in 2012 according to official statistics [Gusev, 2012] is seems that the "zoo" problem in this sphere is a topical one.

1.1.2 Importance of Healthcare Information System implementation

Healthcare information systems implementation gains popularity nowadays as it helps to overcome challenges of the healthcare management mentioned in the previous part. To prove the importance of healthcare information systems usage the main benefits and opportunities of such systems implementation are considered in this part.

There are different opinions about benefits that such systems bring and the beneficiaries who enjoy them. The majority of researches suppose that the range of both advantages and those who enjoy them are quite broad. However there is another point of view. For instance, Shin-Yuan Hung et al (2014) in their study mentioned that some researchers believe that the only beneficiaries from the healthcare information systems adoption are healthcare institution's investors who enjoy increases in profits because of declined operational costs and customers who get higher quality services faster. Medical care personnel in turn perceive HIS adoption as additional workload and face lots of obstacles mainly in the context of up-and-running healthcare information systems.

The opposite opinion supported by the majority of the researches is that healthcare information systems can help overcome many challenges the healthcare management faces nowadays. There are several opinions about the most significant challenges in healthcare. According to Goldberg and Wickramasinghe (2002) the main challenge for healthcare industry in general is cost effectiveness and cost efficiency of provision healthcare services of high quality. It is essential for medical care providers to control and manage costs and raise productivity without affecting the quality, despite the fact that healthcare consumers are rather not sensitive to the cost of medical services.

Wickramasinghe and Mills (2001) consider that the key challenges of management in healthcare industry nowadays are costs that increase exponentially, customer who became much more empowered and informed and focus shifted from curing itself to the diseases prevention [Wickramasinghe, 2002]. Healthcare spending increase can be explained by several changes in today's world. Life expectancies lengthen and the standard of living advances; such situation creates more opportunities to get medical care of high quality. Moreover technological progress creates new opportunities for treating diseases and providing healthcare services [Demirkan, 2013].

According to Nambiar and Sethi (2013) one of the biggest challenges in healthcare management is financial one – healthcare spending need to be optimized while the quality of care should be improved. This issue is really essential for different stakeholders from customers and healthcare providers to government agencies [Nambiar, Sethi, 2013]. According the Institute of Medicine report, approximately $750 billion which is about 30% of healthcare spending in US are spend in vain as this money don't contribute to healthcare outcomes advancement. This fact confirms the problem of mismanagement in healthcare industry.

There are some more key challenges in healthcare industry highlighted by Nambiar and Sethi (2013). These challenges include rising costs of medical assistance, increasing of number of patients, aging of population and shortage of healthcare workers.

The real challenge in healthcare management nowadays is how to find, collect, analyze and manage information to make people's lives healthier and easier, by contributing not only to understand new diseases and therapies but also to predict outcomes at earlier stages and make real-time decisions [Asri et al, 2015].

Gibbons, Arzt et al (2007) believe that one of the big issues in healthcare industry is interoperability of information among different healthcare institutions. This creates two more problems: "problems in communication among healthcare departments" and "problems in communication with different organizations", which can be solved by using a proper healthcare information system [Gibbons et al, 2007].

Caldeira et al (2011) support the idea that healthcare information systems usage brings a lot of benefits. The researchers identified 54 benefits that the healthcare organization including personnel and patients can get from investing in HIS implementation. The main outcomes are costs reduction or financial results improvement, raising satisfaction of patients and improvement of working conditions in healthcare institutions. Also Caldeira et al created a classification of the benefits that consists of 8 groups according to the sphere benefited. The list of benefits groups with the most notable examples is provided below.

1. Greater precision in diagnosis and clinical prescription
    a. Faster and better justified clinical decision making
    b. Reduction in radiation levels received by patient
2. Reduction in costs for tests and clinical analyses

    a. Reduction in the number of inventory for tests ordered
    b. Reduction in number of analyses ordered (no doubling)
3. Greater systematicity in information for management purposes
    a. Computation of the real cost per patient treated;
    b. Real time processing and emission of invoices in Emergency Room.
4. Reduction in personnel costs (in different departments of the institution)
5. Reduction in costs for facilities, equipment and material supplies
    a. Reduction in paper and office supplies consumption
    b. Elimination of the use of printed/photocopied forms
    c. Elimination of paper based exchange
6. Improved patient service
    a. Reduction in patient waiting time for various operations
    b. Increase in confidentiality and security of personal and health data in clinical files
7. Improved working conditions for professional health workers
    a. Elimination of difficulties in reading handwriting in different orders
    b. Reduction in administrative work
    c. Improvement in quality of consultations among physicians
8. Increase in activity–outpatient appointments
    a. Coping with the rise in outpatient appointments

Ammenwerth et al (2000) and Versel (2002) made a suggestion that the main benefit of healthcare IT solutions is the increased access to clinical information; all other benefits follow it. In 2006 Anderson added one more key benefit from electronic system implementation – facilitating communications with external medical databases. It gives physicians an opportunity to collaborate with their colleagues from other institutions and reduce diagnosis and treatment inaccuracy. Also the workload of the healthcare personnel is reduced in case of new patients come from another healthcare institution, if all medical records can be shared there is no need to double it. It gives benefits for the patients, too, as they don't have to spend their time for doubling procedures and get more accurate healthcare.

Altowaijri, Mehmood and Williams (2010) state in their article that there is a huge number of factors that confirms the need of Information and communications technology (ICT) based healthcare. The main drivers which justify the necessity of such shift in healthcare industry are system inefficiencies, rising healthcare costs, a large number of

medical errors, increased demand for access to high-quality medical care, great variations in quality of care, ageing population and more transparency of government spending, including healthcare ones. The researchers admit that unfortunately there are some social reasons like sensitivity, privacy and trust and lack of efficient business models which do not allow using the full potential of ICT [Altowaijri, Mehmood and Williams, 2010].

Daniel Walsh et al (2005) propose that as a result of healthcare information systems adoption the level of flexibility and portability in workflow of healthcare institution increases significantly; institutions become able to update healthcare records immediately and respond more quickly and with more appropriate actions.

Healthcare information systems can provide a prompt way to access and process huge volumes of patients' information, help to avoid paper wasting and save storage space. Also such information systems bring an essential benefit of solving the issue of human errors [Bamiah, 2012].

Another healthcare information system utilizing benefit is the speed of processing information. Different medical activities, for example, drug monitoring and maintenance, laboratory tests, patient medical records exchange among medical providers generate a lot of information that need a huge number of people or just a system to be processed. Also the information system is active and accessible at any time; this feature solves the problem of on time transmission of correct data, which is one of key success factors for offering high-quality medical services.

Matysiewicz and Smyczek (2009) mention such benefits of healthcare information system as increased access to data and resources of healthcare institution, enabling customers to make informed decisions and increasing level of their satisfaction by improving quality of care and arranging internal organizational processes and transactions.

Shahin, Moudani, Chakik and Khalil (2014) stated that healthcare information systems can be also used to decline the chance of misdiagnosis and eliminate irrelevant treatment using systematic analysis of electronic healthcare records [Kraft, Desouza, Androwich, 2003], consequently, the patients' safety improves and the cost/time expenses reduce.

There is a large number of benefits that implementation of healthcare information system brings to the healthcare institutions and different stakeholders like medical

employees, patients, etc. The quality of medical services increase, the amount of human errors and misdiagnosis decrease, the costs and recourses are managed in a more effective and efficient way; and this is not the end of the list of healthcare information systems usage advantages. Therefore, it becomes obvious why such systems implementation becomes more and more popular nowadays in different healthcare institutions all over the world.

1.2 Modern peculiarities of Healthcare information systems: state of the art

There is a huge number of different healthcare information systems in the world; however there are several specific points connected to all of them. These things are mainly connected to newly, compared to the healthcare information systems foundation, developed technologies. Mobile-commerce (M-commerce), Big data and Cloud computing issues are the most significant ones as they bring more benefits and open more opportunities to healthcare information systems utilization. In this part these modern technologies are described and discussed from the point of their operation, benefits and challenges with reference to the healthcare industry. It is necessary to consider this information to distinguish how modern technologies influence the industry and how they are related to healthcare information systems and the issue of their selection.

1.2.1 Mobile-Commerce in healthcare

M-commerce is a term founded in 1997 by Kevin Duffey which means delivery of electronic commerce capabilities directly to the customer, anywhere and anytime, through wireless technology. In healthcare industry M-commerce is technology that exchanges or transmits medical information using mobile devices. Mobile technologies have already become an integral part of people everyday life and now they are spreading to other industries and healthcare is not an exception. Mobile applications for healthcare as healthcare information systems are designed to increase quality of healthcare services, decrease costs and improve research and teaching. It worth mentioning that such applications can be a part of a healthcare information system and make it even more effective and efficient as it would become more accessible. Mobile technologies in healthcare are gaining popularity as deal with different medical issues and patients' groups and also can be used by a great number of people [Klug et al, 2010; Karan et al, 2012; Boulos et al, 2011].

Goldberg and Wickramasinghe (2002) listed the requirements to m-commerce in healthcare. There are 3 main parties that are directly relevant to the healthcare institution and m-commerce in healthcare: customer, producer and management. According to these participants the requirements are divided into 3 groups. The application should satisfy all the requirements from each perspective.

1. Customer

From the consumer point of view there are 3 main requirements to m-commerce in healthcare: flexibility, value-adding and mobile technology basis. Requirement of flexibility implies the need to be accessible anytime, anywhere and anyhow. M-application should add value to the consumer though improving productivity, personalization and adaptability to localization. The latter requirement refers to enhancing the quality of life with the help of innovative and distinguishing characteristics of mobile technology.

2. Producer

From the producers' point of view there are also 3 requirements to m-commerce in healthcare: modularity, layers and bundling. According to the first specification m-applications in healthcare should be built from several separate parts (modules) that can be recombined in order to adapt the product or service to a particular context. Such requirement is needed to provide flexibility of the application. Layers requirement refers to building the application in layers to make it possible to add attributes and characteristics. This makes the healthcare m-commerce adaptable to such things as customer personalization, localization, brand profiles, and privacy. This requirement is connected to the value-adding one from the customer perspective. The last element of the producer perspective is bundling which means combining modular products and services to get more out of using the mobile technology basis.

3. Management

There are 3 vital requirements from the management point of view: 1) value/cost ratio, 2) primary activities [Porter, 1985] and 3) business model. The firs requirement refers to showing a good value in terms of application cost against similar solutions. The development of revenue model and pricing strategy is based on value/cost ratio. The second element means the presence of unique, innovative features opposed to similar products and services in terms of primary activities of the firm (logistics, production, marketing, services). The last requirement assumes the use of innovative and distinguishing characteristics of mobile technologies in healthcare to encourage new business models.

Goldberg and Wickramasinghe (2002) found that m-commerce in healthcare can help healthcare institution to succeed in 4 critical management activities: improving patient care, increasing quality of services, reducing costs and enhancing teaching and research. The usage of wireless and mobile technologies can help to reduce costs through reducing IT infrastructure costs and achieving rapid healthcare delivery improvements. There are 6

essential points connected to improving patient care and healthcare quality, some of them were considered by other researchers:

- safety in healthcare – the patient shouldn't be injured during medical care;
- effectiveness – services based on scientific knowledge should be provided only to those, who need them, under and overuse are not allowed;
- patient-centering – care should be provided with respect to personal needs, desires and values of the patient;
- timeliness – waiting time and sometimes harmful delays should be reduced for both patients and personnel;
- efficiency – avoiding time and resources waste;
- equitability – the quality of medical care should be independent from individual characteristics of the patient.

Kuiper (2008) considered two (1st and 5th) points in his study. He considered "safety in healthcare" as reduction of medication errors and misdiagnosis, which can be realized with the help of mobile technologies as they provide immediate access to data and eliminate reliance only on memory. The researcher states reduction of healthcare costs for "efficiency" from the Goldberg's and Wickramasinghe's (2002) list, which implies saving different kinds of resources including time and money.

One of the benefits distinguished in Buck's et al (2005) study is similar to the point of "patient-centering". Buck et al considers that mobile technologies help medical professionals to concentrate on building relationships with their patients instead of paying attention only to documentation during the appointment. Thus portable technologies help not only to increase the level of medical care as the medical employee delves more into the patient's problem, but also increases customer satisfaction as he feels more important.

Another benefit of mobile technologies usage was proposed by Cleland et al (2007). The researchers consider that one of the most essential advantages of mobile technologies is communication issue – medical professionals can communicate with their colleagues without face-to-face consultation, save a lot of time and get immediate response.

Mersini, Sakkopoulos and Tsakalidis (2013) studied a specific issue that refers to m-commerce in healthcare – QR codes. Quick Response code (QR code) is a matrix, two-dimensional barcode that has square shape and contains coded information [Santos-Pereira et al, 2012]. To get access to the information such codes should be scanned and decoded

with special quick response software. This software doesn't require any special equipment as it is available on every smartphone that has touch-screen and camera, some phones have scanners built in camera and don't require even special application.

The researchers found that managing QR codes through information system, significantly improves interoperability inside healthcare institution and its divisions. In the study the authors propose to use QR codes for easy access and managing the patient's medical information. Also Mersini et al (2013) proposes to use SQLite in healthcare practices. SQLite[2] is an embedded SQL database engine without a separate server process, which reads and writes directly to ordinary disk files. This helps to avoid doubling and makes managing information much easier. The proposed mobile solutions can not only save time, but also they improve planning in laboratories through timely updates, so they can schedule their tasks more effectively. Time management improvements refer not only laboratories but also the health personnel reducing the office work. As a result medical personnel have more time for patients and provide patients with more comprehensive treatment.

Overall, utilization of such mobile applications as QR codes and SQLite improves the work of the whole medical unit, provides an opportunity to join up different healthcare facilities and шimprove the performance of healthcare information system to which the mobile application is embodied.

There are also some challenges connected with the usage of mobile technologies. Ding, Iijima and Ho (2004) identified two main challenges of mobile commerce usage – usability and technical. The former refers to less convenience of portable devices usage compared to personal computers – they have smaller screens and keyboards, also the number of messages and browsing of information is rather limited. The latter relates to the rather low computer power of mobile devices, small amount of memory and shortage of bandwidth and data transfer capacity. The technical challenge was also mentioned by Schwiderski-Grosche and Knospe (2002) in addition to two other issues. Firstly, portable devices are usually subjects to theft and destruction as they are rather fragile, so they are considered as non-durable access devices. Another challenge of mobile devises proposed by Schwiderski-Grosche and Knospe (2002) is security threat and the level of safety usually depends on a particular mobile application. However, not all of them provide all necessary security mechanisms.

[2] Android SQLite: http://www.sqlite.org

Generally mobile technologies are used in healthcare industry to increase the level of flexibility of medical professionals as it enables them to access data from anywhere anytime. Also it gives medical employees more opportunities for communication and consequently it increases the overall quality of medical care and the level of patients' satisfaction.

1.2.2 Big Data in healthcare

The next specific point about healthcare information systems is connected to the recent changes in healthcare sector. The amount of information in the healthcare industry is growing beyond the processing capacity of the healthcare organizations very fast. 26 billion mobile devices were estimated to be functional by 2020 and generate the amount of traffic large enough to place it in the category of big data [Middleton, Kjeldsen and Tully, 2013]. At the same time there is a plenty of other sources of medical information like medical professional, equipment and so on. Therefore, the volume of information in healthcare industry is increasing significantly and the issue of Big Data usage becomes a topical one. The McKinsey Global Institute estimates a $100 billion increase in profits annually, if Big data strategies are leveraged to the fullest potential [Groves, Kayyali, Knott, Kuiken, 2013].

The term "big data" refers to the agglomeration of large and complex data sets that are beyond traditional data management systems' the capabilities to store, manage, and process it in a timely and economical manner [Patil and Seshadri, 2014].

Several studies [Asri et al, 2015; Mathew, Pillai, 2015; Marr, 2015] consider 5 specific features of Big Data that can be applicable to different industries, including healthcare: volume, variety, velocity, veracity and value.

1. Volume

As it was already mentioned medical data grows dramatically; health care systems use terabytes and petabytes of different information. Digitized medical data is coming in from both internal and external sources, it comes from portable devices, wearable sensors and monitoring devices [Jiang et al, 2014; Salih, Salih, Abraham, 2014], electronic patients' records and clinical notes, medical equipment, etc. Mathew and Pillai (2015) identified 6 main sources of different types of healthcare data: providers – medical data; payers – applications and data on expenditures; researchers – academic studies; customers and marketers – consumer behavior and feedback data; government – population and public health data and developers – R&D in new medical devices and pharmaceutics. According

to KPMG report [Galloro, 2008], the volume of healthcare data reached 150 exabytes in 2013, and it is increasing at a prominent rate of 1, 2 – 2, 4 exabytes a year.

2. Variety

Medical information is generated by at least 6 different sources [Mathew, Pillai, 2015] and is quite complex. This data can be divided into 3 groups by the arrangement: structured, semi-structured and unstructured. Structured one, like clinical data, is easy to manipulate, store and analyze by machine. However, the majority of medical data: office medical records, doctor notes, paper prescriptions, images, and radiograph films is unstructured or semi-structured. Such types of data are more complicated to process and analyze. One of the most challenging aspects in healthcare connected to Big data is that traditional data is combined with new forms of data. And it is impossible to avoid this mixture as the latter is necessary to get the best medical solution for a specific patient.

3. Velocity

Big data analytics needs the real-time data processing, while the data is continuously generated in large volumes.

4. Veracity

Healthcare data can be of different quality, pertinence and meaning, while for achieving effective results in data analytics the high quality data is needed.

5. Value

The data should be valuable otherwise it is useless. The value of data depends on quality of governance strategy and mechanism.

To get the benefits the healthcare Big data should be properly processed and analyzed. Big data analytic tools are used for this purpose. Nambiar and Sethi (2013) believe that Big Data analytics can revolutionize the whole healthcare industry. The authors mention that analytical tools can improve operational efficiencies and the quality of clinical trials monitoring, enhance forecasting and epidemics responses planning and optimize expenditures at all levels of healthcare industry from end-customers to healthcare institutions and government. Moreover, analytical tools improve searching necessary information during the care provision and make medical practices safer, faster, more efficient and cost effective [Nambiar, Sethi, 2013]. According to Bernard (2013) the top priority of Big data usage in healthcare industry is enhancing effectiveness of medical treatment, especially chronic diseases' and reducing the number of readmissions. Another

significant benefit of healthcare Big data analytics is that it allows to capture insights from data gathered from sources indicated by Institute of Medicine (IOM) as critical gaps: researches, clinical care and operational settings. Healthcare can also be improved by evidence-based learning model powered by Big data analytical tools [IMS Institute, 2012]. Nambiar and Sethi (2013) suppose that Big data analytics can help to move from mass medicine to more personalized care using patient specific data like genomics by profiling of similar patients and their responses. Mathew and Pillai (2015) and Patil and Seshadri (2014) believe that healthcare sector should focus on prediction and prevention activities to improve the outcomes of medical care and it can be reached by using Big data analytics. Patil and Seshadri (2014) suppose that the analysis of medical information can enable a shift from reactive to proactive healthcare which will definitely improve the quality and decrease the costs of medical care.

Researchers distinguish 3 types of Big data analytics: Predictive, Descriptive and Prescriptive analytics [Houser et al, 2012; Chen, Mao, Liu, 2014]. The first type – Predictive Analytics is used to predict the future through different statistical approaches. It searches through the large patient data sets and processes this data to forecast individual patient outcomes. Descriptive Analytics uses the past and current medical data to identify trends; also it is used to improve the quality of healthcare decisions. Prescriptive analytics refers to predictive type of analytics and is used to facilitate decision making process by prescribing necessary actions. This type of Big data analytics is commonly used in evidence based medicine in order to increase the quality of medical care and to improve business practices.

Asri, Mousannif, Moatassime and Noel (2015) defined 3 main aspects where Big data analytics can be useful in healthcare.

1. Patients

Big data analytics can help patients make the right decision timely. As a result the analytical tool provides patient with “proactive care” recommendations or informs if there is a need of change in the lifestyle to avoid health condition degradation. Also the patients get the opportunity to share their private information in order to help other people and become more social-responsible and may be save some one life. This aspect was also studied by Sheriff et al (2015) and included in “pathways” right living and right care. Rudin at al (2014) and Mathew and Pillai (2015) explored this aspect, too, and named it “clinical decision support”. However, this issue refers to predicting outcomes and offering alternative treatments, which is connected to “proactive care”. Also analysis of data from

personal wearable devices as a part of “personalized care” plays a large role in healthcare as it enables to detect the disease at a very early stage even before the development of visible symptoms [Mathew, Pillai, 2015].

2. Researchers and Developers (R&D)

Big data analytics can be used to improve researches about new diseases and therapies. Google, for instance, has applied algorithms of data mining and machine learning to detect influenza epidemics through search queries [Ghani et al, 2014; Lazer et al, 2014]. This issue was also mentioned by Sheriff et al (2015) in right innovation “pathway” and by Mathew and Pillai (2015) in their research.

3. Healthcare providers

Big data analytics can help healthcare institutions to recognize high risk population and act appropriately (i.e. propose preventive acts). Sheriff et al (2015) reviewed similar issue named right provider and considering the issue of gaining more professionalism and effectiveness and as a result select better treatment. According to W. Raghupathi and V. Raghupathi (2014) Big data analytics can be also used in evidence based medicine by using statistical and quantified data as evidence in stating diagnosis.

Another aspect in healthcare industry, where Big data analytics can be useful was defined by Konasani et al (2012). Researchers suggested using different predictive models to detect frauds at the point of transactions.

Apart from benefits Big data usage has some challenges and limitations in usage. Mathew and Pillai (2015) in their research identified 8 Big Data challenges in healthcare industry.

1. No standards for medical information

There is a really huge stream of medical data from different sources from different agents and there is no common standard even for particular types of information. For example receipts or patients records can differ in different institutions, so it is difficult to process such semi- or unstructured medical data.

2. Heterogeneous sources of data

Medical data is spread across different departments of healthcare institutions where it is created and collected. Such dispersion is a significant barrier for data integration, especially taking into account the previous challenge.

3. Skilled resources

A particular set of knowledge and skills is required to use Big data solutions. As such solutions are not so widespread in healthcare industry nowadays there is a shortage of such specialists as data scientists and data analysts who have the needed competences.

4. Privacy and security

Privacy and security issue is very significant in healthcare industry as medical information is private and shouldn't be disclosed without owner permission. The challenge is that traditional privacy and security measures don't work with massive and streaming data sets and there is a need to improve them according to the Big data requirements.

5. Infrastructure Issues

Some healthcare institutions have already implemented information systems and their compatibility with new technologies is quite questionable. Therefore, integration of new technologies like Big data analytics becomes rather complicated.

6. Insufficient real time processing

Despite the fact that Big data analytics can process huge amount of data it cannot do it immediately because of such features of Big data as volume and variety. It means that time delays can occur during the data processing, which can potentially lead to lower quality of care, especially if the situation requires immediate actions and leaves no time for processing.

7. Analysis of analytical results

To receive desired outcome in a form of useful valuable data the data should be interpreted in a right way. The combination of several factors can be understood and interpreted differently, so the analyst should get the proper clinical support.

8. Data Quality

To make decisions related to patients care the data should be reliable, so the quality of the Big data analysis is very essential. The quality of the analysis outcome is often influences by the input information, if it was low-quality data it is likely to get the result of the same quality.

Asri, Mousannif, Moatassime, Noel (2015) highlighted 5 limitations of the Big data usage that are similar to Mathew and Pillai (2015) limitations. Firstly, the utilization of Big data can be complicated because the input data is heterogeneous – in different format from different sources. Secondly, the quality of medical data which is usually unstructured,

improper, and non-standardized is a serious limitation of getting the proper result of the analytics. Then Big data requires quite large investments not only in the technology purchase itself, but in personnel, too, as the Big data usage requires specific set of competences. It means that the healthcare institution needs not only a data analyst but also some training for the medical personnel so they can work with the system, otherwise there won't be any data for analysis. The last limitation defined by the researchers is the great variation and errors in the results which cannot be excluded unless the input data is of not so high quality and heterogeneous.

Analyzing the main challenges and limitations of the Big data usage it can be seen that the initial and one of the most significant problems is heterogeneity of the medical data. In the research of Mathew and Pillai (2015) some viable solution of the problem is proposed. Firstly, the authors follow Zhang, Sarcevic, and An (2013) path and suggest implementing three-tier architecture, where client tier provides access to the system, middle tier defines the rules and processing tier that deals with data itself. The processing tier includes heterogeneous medical data collection from different sources and data extraction from multiple sources, which is stored in NoSQL database. Middle tier converts extracted healthcare data to standard format like XML or HL7 through reference information model. Client tier realizes interpretation of data analysis, which should use clinical support to drawn appropriate conclusions. The analysis of medical data is performed by both middle and client tier.

Generally, Big data is used in healthcare industry as analytical tool that processed a huge volumes of data generated by different sources like equipment, medical professionals, laboratories and so on. Such tools are necessary to generalize information and identify trends related to different issues from epidemics to internal usage of resources.

1.2.3 Cloud computing in healthcare

Another specific point of healthcare information systems is Cloud computing. Cloud computing is an approach based on delivering software, infrastructure and the whole computation platform as a service over the Internet by large data computing centers on pay-as-you-go base [Gibbons et al, 2007].

Mell and Grance (2010) define cloud computing as "a model for enabling convenient, on demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or

service providers' interaction". In other words cloud computing means storing information in the Internet for a fee on third-party servers instead of having own on premises servers.

Liu and Park (2014) consider that nowadays at least 4% of medical data have already been downloaded and stored online in clouds in 2014 and this number is expected to grow to 20.5% in 2015.

According to Bamiah, Brohi, Chuprat, Berhad (2012) there are 5 main unique features of cloud computing: on-demand self-service, ubiquitous network access, resource pooling, rapid elasticity and pay-per-use pattern, which seem to be the main advantages of such solutions. The last feature (pay-per-use) gives healthcare institutions an opportunity to use the newest software, which results in significant decrease of operating costs because of covering only the most important issues.

The researchers defined 4 main types of clouds depending on the extent of access to it: private, public, community and hybrid. Private cloud has strong security features and works within single organization. Public cloud can be used by industry group or the society. Community cloud can be accesses by a several companies sharing the same interest. Hybrid cloud is characterized by combination of two or more cloud types' features. [Bamiah et al, 2012].

Chang, Chou and Ramakrishnan (2009) determined 4 key features that every cloud computing solution should perform. The first attribute of cloud computing is information sharing and privacy protection which intends the ability to access data in particular boundaries. The second feature is service composition, coordination, and competition which imply using information from different sources to provide complex and high-quality medical care. The third trait of cloud solutions is safety, security and scalability which means that the ecosystem of healthcare institution should be protected from external attacks, while the individual organisms should be protected from unfair competitions and practices. Also a sufficient amount of resources should be provided so that the ecosystem can grow and be sustainable. The last attribute is self-governing and automated management, which intends system complexity and the operational costs reduction.

From the technical perspective healthcare is aimed at providing reliable medical information quickly, safely and efficiently. And cloud computing helps to achieve this goal by providing data persistence, durability and security as well as high computational power [Dawoud, Takouna, Meinel, 2010]. From the medical point of view easy access to e-health

records is a very essential point. Providing ability to access personal medical history much easier and quicker comparing to general data centers cloud computing improves healthcare services by speeding up treatment and avoiding complications [Feng, Chen, Liu, 2010; Hu, Lu, Khan, Bai, 2012]. Hu, Lu, Khan and Bai (2012) compared traditional solutions of e-health to cloud computing and defined a number of benefits of the latter. Cloud solutions offer integrated platform for eHealth services (cloud healthcare information systems) and provide large infrastructure, quick access, and efficient storage. As the most significant issue in healthcare is efficient sharing of information cloud computing has a great advantage in this sphere in contrast with traditional solutions. Cloud computing is believed to be a new technology with good performance in storing and accessing information [Hu, Lu, Khan, Bai, 2012].

Bamiah, Brohi, Chuprat, Berhad (2012) pointed out a significant issue in healthcare industry – the process of converting traditional paper-based records to electronic format was not efficient enough. Implementation costs of electronic patients' records are rather high, moreover it requires not only resources, but also integration and maintenance. Cloud computing solves this problem as it reduces the complexity and costs referring to ownership and maintenance; and provides the ability to share and manage EHRs and as a result improves tracking patients and diseases. It allows healthcare institutions focus on utmost importance activity – delivery of medical services rather than managing IT infrastructure issues [Bamiah et al, 2012]. Another significant for healthcare industry feature of cloud computing is providing data backups and recovery capabilities performed by replicating information in several locations for higher level of availability and safety [AI, 2012].

Laohakangvalvit and Achalakul (2014) identified 3 essential for healthcare industry targets that can be achieved through cloud-based healthcare information systems utilizing. Firstly, cloud solutions reduce the costs of processing and storing medical data amounts of which are continuously increasing. Secondly, it provides an access and interoperability of electronic patients' records. Finally, cloud-based healthcare information systems reduce time necessary for development of new applications. One of the brightest examples of such solutions usage is the emergency cases. There are many critical situations when medical data from previous healthcare institution is needed immediately. If necessary records are not delivered timely, the accuracy of the diagnosis and treatment can be lower or it can even lead to medical errors. In such cases cloud-based systems would help to avoid unpleasant consequences [Laohakangvalvit, Achalakul, 2014].

Houlding (2011) supposes that cloud computing can be used in different fields of healthcare, for example, it can improve emergency support by providing an immediate access to results of laboratory tests. In public healthcare, for instance, using cloud computing in healthcare information systems can improve information tracking for better maintenance of diseases response, monitoring of adverse drug effects or even chemical or biological attacks.

Cloud solutions have some challenges connected with its usage. One of the primary issues is that cloud data storing requires constant connecting to the Internet as all the data is located on remote servers provided by a third-party company [Aljabre, 2012; Miller, 2009]. The security issue of cloud storages is one of the most essential and the most arguable issues concerning cloud solutions. Grossman (2009), Aljabre (2012) and Miller (2009) consider this issue to be a drawback of cloud computing. The researchers suppose that cloud storage is not safe, firstly, because the data is accessible for the third-parties (the cloud server providers) and also it can be hacked and in this case the data can be accessed by unauthorized people.

The second challenge of cloud solutions is that the usage is affected much by technical characteristics of the equipment. Grossman (2009) considers the latency-related and bandwidth-related issues, which means that there can be some delays in response of the servers or slow speed of work because of not enough capacity of the internet equipment. According to the researcher this issue refers to all remote applications that need Internet connection. Miller (2009) and Aljabre (2012) also highlight the issue that cloud solutions can be slow and have lags in responses, which is similar to the “latency-related” issue of Grossman (2009). Also the researchers considered the problem of poor work in case of low speed connection, which causes slow working, too, but has another reason.

Miller (2009) and Aljabre (2012) in their studies reviewed two more challenges of using cloud solutions: limited features and unsafety in term of losing data. The researchers believe that internet applications can be not “as full-featured as” the desktop-based ones. Many web applications have a full range of functions, however not all of them, so it is necessary to check the functionality before shifting to cloud solutions. The last issue is the threat of losing data, which means that in case of cloud going down the user lose all the data if there are no backups and according to Miller (2009) very few cloud storage users make additional backups on physical carrier.

Generally, cloud computing in healthcare is used for storing different kinds of data in the internet without using on premises servers. This type of data storing has its own advantages and disadvantages and it is difficult to determine clearly if it worth using or not. Therefore, this issue of healthcare information systems is going to be included in the selection model.

All the mentioned newly developed technologies can be used in Healthcare together. Combining different solutions increases the effectiveness and efficiency of the medical care. Demirkan (2013) supposes that cloud healthcare information systems used together with big data presented by electronic medical records and modern mobile solutions like biosensors and wearable devices has a really great potential in delivering sustainable, intelligent and automated medical services. Also this idea is supported by the fact that different authors studied the particular technology in tandem with another one. Big Data analytics is often reviewed in conjunction with mobile devices that produce huge amount of data to be analyzed. For instance, Nambiar and Sethi (2013) believe that Big Data is a very useful tool in enhancing the healthcare system when there are so many sources of medical information, especially mobile ones. Bamiah, Brohi, Chuprat and Berhad (2012) believe that cloud solutions can gather data from different sources and then integrate and analyze it in real-time. This definition reminds Big data functions and it can be assumed that cloud computing here is considered along with Big data technologies. Cloud computing is also tightly connected to mobile technologies, too, as one of the advantages of the cloud services is an opportunity to reach it anytime and anywhere which assumes mobile devices usage.

Some challenges of the particular technologies were already mentioned. However there are some challenging issues that are relevant to all healthcare information systems regardless of what technologies are used. According to several researchers the major problem of healthcare information systems utilization is a security and privacy issue. According to a study of Ponemon Institute LLC (2012) more than 90% of healthcare institutions had at least one security breach during the several past years. The study also shows that healthcare institutions were attacked mostly by insiders rather than external parties. Patil and Seshadri (2014) believe that, while healthcare institutions enjoy the benefits of modern technologies like Big data and cloud computing, security and privacy issues become the center of emerging threats and vulnerabilities. Therefore, real-time security risks analysis is really necessary in prosperous healthcare industry [Demirkan, 2013]. Altowaijri, Mehmood, Williams (2010) and Nambiar and Sethi (2013) also defined

maintaining of patients' medical information privacy and security to be one of the most important areas for attention in healthcare sector.

From the point of view of Slonim, Callaghan, Daily, Leonard, Wheeler, Gollmar, Young, (2007) and Chang, Chou and Ramakrishnan (2009) another critical challenge in healthcare industry today is "deficient care linkage" (DCL). There is a need of better communication among multiple specialists during treatment of a patient with comorbidity compared to usually carried out. For this purpose standards-based infrastructure (compatible healthcare information system) should be implemented, otherwise there appears a challenge of common accessibility of information and data sources.

Demirkan (2013) in his research distinguished another critical point for healthcare information systems – coordination challenge. This issue is connected not only to technical compatibility of systems like the DCL challenge but also to the social aspect like common language and system complexity.

Bamiah, Brohi, Chuprat and Berhad (2012) distinguished 5 main challenges for healthcare information systems. Two of the challenges second and third were studied by other researchers, too [Kuziemsky et al, 2011; Yang et al, 2012].

- Heterogeneous healthcare computing infrastructure issue, which is similar to the DCL one, where information can't be accesses because of incompatibility of information systems in different healthcare institutions.
- Limited access to patient data during decision making process and ineffective communication process among medical professionals. Kuziemsky et al (2011) found that difficulties are caused by the fact that usually necessary information can be accessed only from the place of care, which makes it less flexible. Moreover, patients' care team members can be scattered in various institutions, which decreases the effectiveness of communication a lot.
- Current technologies are insufficient to deal with modern solutions in terms of dynamicity, scaling and low cost. Not all information systems can handle huge amounts of data, also some modern solutions are non-affordable in terms of costs for small and medium healthcare institutions [Yang et al, 2012].
- Healthcare institutions usually store information data on-premises and incur both human and environmental threats.
- Volume, velocity, and variety of medical information is continuously grows and it leads to two main challenges for healthcare institutions: increased complexity and IT costs.

1.3 Research gap

The research area of healthcare information systems combines such areas as healthcare and information technologies in general. Nowadays, it includes such particular areas of information technologies as Big data, Cloud computing and M-Commerce as they are becoming an integral part of healthcare information systems.

There are different studies focused on several aspects of healthcare information systems. Different researchers, for example, Shin-Yuan Hung et al (2014), Wickramasinghe (2002) and Caldeira et al (2011) studied the issue of healthcare information systems' importance and benefits that they bring to healthcare institutions and different groups of stakeholders. The development of healthcare information systems is also a quite studied area. Such authors as Wager, Lee, & Glaser (2009) studied the basic functionality of such systems. Implementation and adoption phases are also studied well and there are many researches that cover this topic. For example Saba et al (1994) and Hung et al (2014) studied the issue of healthcare information systems adoption by nurses.

However, there is a limited number of researches focused at selection of healthcare information systems, which is the initial stage of the information systems implementation. Therefore, this issue is considered as a research gap. The identified research gap is graphically presented on figure 1.

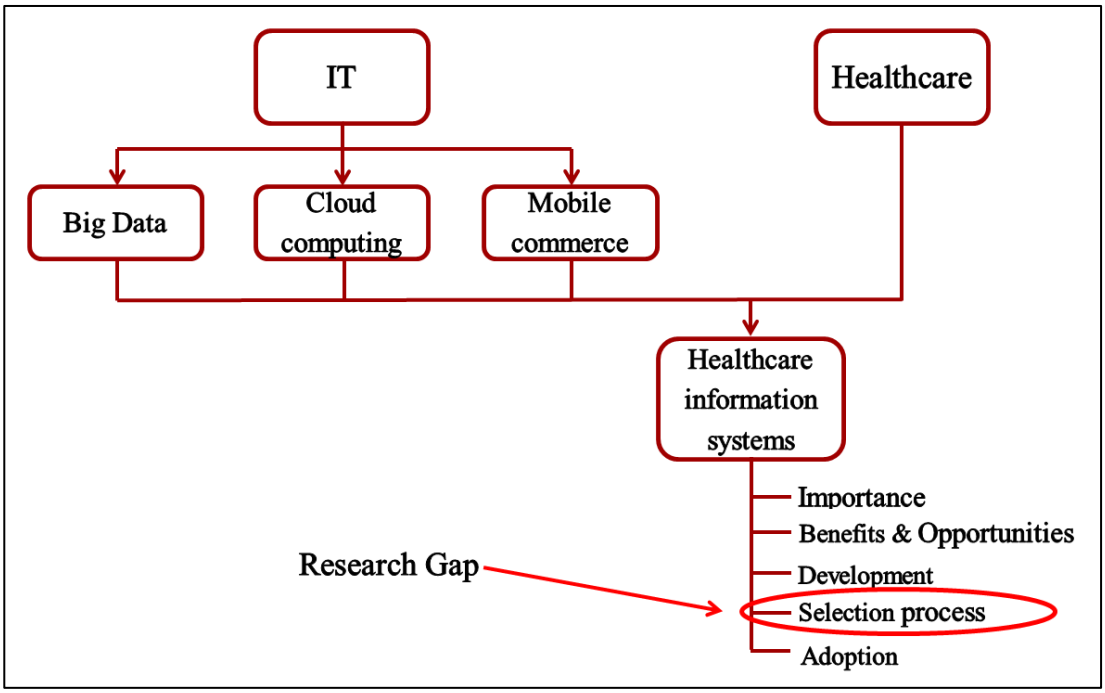

Figure 1. Research gap

The issue of selecting an appropriate healthcare information system is a very essential one. If the organization pays little attention to selection of healthcare information system and as a result the system doesn't fit particular healthcare institution, for example there are unnecessary functions; healthcare institution wastes its resources and the efficiency decreases.

It was found that there is a plenty of different classifications of healthcare information systems. It seems that it should be easier to select an information system if they are classified. However, the situation is the other way round because there is no unique categorization of healthcare information systems. Moreover suggested classifications are not connected to each other and consider different features of the systems which makes the selection process even more complicated. Also some classifications can't be fully applied to modern healthcare information systems as they consider particular features of modern systems, the majority of which are integrated and modular, as different systems.

The great variety of different healthcare information systems and different classifications of the systems create a kind of a "zoo problem", which means the difficulty to pick one option from the huge variety, especially when for a common user they seem very similar. Selection process of healthcare information systems if quite complicated for healthcare institutions because there are more than 650 systems and around 240 developers on the market [Gusev, 2012] and all of them seem to be unique, so the decision-makers become confused and can select not suitable information system.

Therefore, the purpose of this research is to develop a healthcare information system selection model to assist the decision-making process of choosing healthcare information system. The research is based on comparison analysis of several healthcare information systems and expert opinion of several healthcare institutions that already have experience in healthcare information system utilization.

The research questions of this study are as following:

1. What are healthcare information systems characteristics that affect the selection process?
2. How healthcare institutions select healthcare information systems?
3. How to select an appropriate healthcare information system?

The result of this study is the development of a healthcare information systems selection model that will help healthcare institutions without permanent establishment to choose from a large number of healthcare information systems the one that suits the institution the most. After answering the questions of the model healthcare institution receives the list of recommended features of healthcare information systems basing on which it should select the system.

1.4 Summary of Chapter 1

There are different opinions on what is a healthcare information system; some researches assume such system to be an information portal for end-customers, while others consider healthcare information system to be an integrated solution for healthcare institutions. According to World Healthcare Organization healthcare information system is a system that integrates data collection, processing, reporting, and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services. The main goal of a healthcare information system is to assist delivery of high quality medical care and better cost management.

The main healthcare information systems benefits highlighted by different researchers are:

- increased access to clinical information
- facilitating communications among medical professionals
- quicker respond and more appropriate medical actions
- reduced number of human errors
- saving papers and storage space
- high speed of processing information

There is a huge number of different healthcare information systems in the world; however there are several specific points connected to all of them. M-commerce, Big data and Cloud computing issues are the most significant ones as they bring more benefits and open more opportunities to healthcare information systems utilization. These technologies can be used in healthcare together. Combining different solutions increases the effectiveness and efficiency of the medical care.

There are some challenging issues that are relevant to all healthcare information systems regardless of what technologies are used. The major challenges of healthcare information systems utilization are:

- security and privacy issue;
- “deficient care linkage” (DCL);
- coordination challenge;
- limited access to patient records during decision making process;
- ineffective communication among medical professionals;
- complexity and increased IT expenditures.

There is a plenty of healthcare information systems on Russian market and several classifications of such systems, which can be hardly connected to each other and generalized. Therefore, there is a great problem of choosing the appropriate healthcare information system for a particular healthcare institution.

This research is focused at facilitating the decision-making process of choosing healthcare information system. The result of this study is a healthcare information systems selection model that will help healthcare institutions without permanent establishment to choose from a large number of healthcare information systems the one that suits the institution the most.

Chapter 2. Methodology of healthcare information system selection

2.1 Modern Methods of Business Research

Research methodology is a systematic path followed to solve a research problem [Rajasekar et al, 2013]. Research methodology includes a range of research methods and techniques used during the study to answer the research questions and the logic that lies behind their choice [Kothari, 2004]. There is a great variety or research methods and techniques that can be used during researches. Two research methods were used during this study to answer the research questions: content analysis and interviews.

To answer the first research question (What are healthcare information systems characteristics that affect the selection process?) content analysis of existing healthcare information systems was conducted. This method is usually used for qualitative analysis for identifying general information from the existing sources [Kothari, 2004]. Therefore, content analysis is used in this study for distinguishing healthcare information systems characteristics. 30 Russian and 20 foreign existing healthcare information systems were studied through the company web-sites' content and systems' reviews if there were any. A comparison table of 50 healthcare information systems was created based on the gathered information.

To answer the second research question (How healthcare institutions select healthcare information systems?) an interview method is used. This method is used to collect relevant and reliable data [Kahn, Cannell, 1957]. According to Dochartaigh (2002) data can be assessed by the reputation of the source, which means that data from well-known source is more likely to be reliable. Several interviews with experts from well-known healthcare institutions in St-Petersburg were conducted to identify the initial selection criteria and if they have changed after getting some experience in using healthcare information systems. Two types of questions were used during the interviews: open-ended and multiple-choice questions. Open questions are designed to encourage a respondent to characterize a situation or event in extensive manner [Torrington, 1991]. In this study the aim of such questions was to identify the initial selection criteria of healthcare information system and the reasons of choosing and ways of using particular options of the system features. Multiple-choice (closed) questions are usually used to confirm some facts or to gather some specific information [Folkestad, 2008]. In this research such questions were used to identify the most frequently selection options of the

information systems features and the most significant selection criteria from experienced users the point of view.

As the number of responses is less than 40 no computer-based analytical tools can be used for analyzing the results, therefore, traditional method is used [Adams et al., 2007]. Cross-case analysis method is used in order to analyze the results of the interview because it gives an opportunity to get deeper understanding of phenomenon and at the same time generalize received information [Miles, Huberman, 1994]. This method of analyzing results of interviews is commonly used for structured interviews with clearly defined requirements to selecting respondents [Folkestad, 2008]. Interviews conducted during this study have a clear structure as 27 questions were created in advance; also there were several requirements to the respondents: the respondents' healthcare institution should have implemented healthcare information system and the respondent should have been involved into decision-making process.

The detailed description of the utilized research methods is provided in the sections 2.2 (Comparison analysis of healthcare information systems) and 2.3 (Analysis of the interviews with experts from healthcare institutions) below.

2.2 Comparison analysis of healthcare information systems

To create healthcare information system selection model it is necessary to understand what is healthcare information system in reality is and how it works. For this purpose content analysis of existing healthcare information systems was used. 50 different healthcare information systems, 30 Russian and 20 foreign ones, were analyzed and then a comparison table of reviewed healthcare information systems was created. Every healthcare information system was studied through the company web-site and several reviews if there were any. As a result the main characteristics of the systems were identified: platform, deployment, features, portable device access, patient portal, big data analytics, and training programs. A part of the comparison table is presented on figure 2.

	A	B	C	D	E	F	G	H	I
1	Healthcare Information System	Price	Platform	Deployment	Features	Patient Portal Software	Language	Big Data	Training
2	A.I.med	1100$ per working place	mac; windows	cloud; on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	no	En	no	yes
3	Accumed	35000$	mac; windows	cloud; on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	yes	En	no	yes
4	AdvancedMD	200$ per working place per month	mac; windows; linux	cloud; on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	no	En	yes	yes
5	AllegianceMD	set individually	mac; windows; linux	cloud	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	yes	En	yes	yes
6	Amulet	from 199$	windows	on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support; Biometric autintification	no	Rus	no	yes
7	ArchiMed	18000 rub per working place	windows	on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support; sms notification	no	Rus	no	yes
8	Artemida	set individually	windows	on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	no	Rus	no	no
9	athenaOne	set individually	mac; windows; linux	cloud	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	no	En	no	yes
10	Avicenna	set individually	windows	on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	no	Rus	no	yes
11	Bars	set individually	mac; windows; linux; UNIX	cloud	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	no	Rus	yes	yes
12	Cyfluent	50$ per working place per month	mac; windows	Cloud	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	yes	En	no	yes
13	DOKA+	5000 - 32000 rub (2-21 working places)	windows	Cloud	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	no	Rus	no	no
14	DrCloudEMR	set individually	mac; windows; linux	cloud	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support; build-in reminder	yes	En	yes	yes
15	Electronic Case History	500 rub	windows	on premises	Electronic medical record	no	Rus	no	no
16	EMC Med Infrastructure	set individually	N/I	Cloud	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support; Infrastructure	depends on apps	Rus	yes	yes
17	Everest	set individually	windows	on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	no	Rus	yes	yes
18	HIS qMS	set individually (subscription fee)	windows; linux	cloud	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	yes	Rus	yes	yes
19	IMC:LPU	set individually	windows	on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support	no	Rus	no	yes
20	Infoclinic	set individually	windows; linux	cloud; on premises	Electronic medical record; Medical billing; Patient scheduling; Medical accounting; Communications systems; Image support; sms notification; works with 1-200 employees	yes	Rus	yes	yes

Figure 2. Comparison table of existing healthcare information systems

Platform characteristic intends metafamilies of graphical interface–based operating systems which are compatible with the particular healthcare information system. There are 3 most frequently used operating systems on which the analyzed systems run: Mac OS, Microsoft Windows and Linux. Windows operating system is compatible with all reviewed healthcare information systems. Also several healthcare information systems are compatible with UNIX and OpenVMS operational systems. This issue is worth considering for companies, which have not Windows operating system. For instance, if a company with Mac OS purchases the software compatible with Windows as it requires the usage of Microsoft Internet Explorer, it will face the problem with installation which can be solved

only though additional soft installation. This solution may be useless in some cases; also it requires extra payments, firstly, for additional software and, secondly, for additional work.

Deployment characteristic implies the place where all data is located. There are two options of deployment – cloud-based or on premises. Cloud based deployment suggests locating data on third-party servers and requires only computers or other devices to access the data. This type of deployment implies that the healthcare organization doesn't have to own any servers because they are rented from the software provider. On premises deployment requires usage of client's hardware including both servers and computers or other devices for access. Also all the hardware is placed at client's location. Information stored in cloud can be accessed via the internet, while information stored on premises servers can be accessed from computers via the local network or from other devices via Wi-Fi network. Both options have its benefits and drawbacks and usually users don't know what they should choose. As cloud technology is a modern solution and it delivers new exciting advantages, described in the previous part, the majority of users choose it even if it is not needed.

So there is a need to identify when there is a need to choose cloud technology and when on premises deployment is the best solution for an organization. One of the biggest traps connected to this choice is comparing cloud and on premises options in only one dimension – monthly subscription costs and the costs of new hardware / software [Wlodarz, 2014]. However there are much more things to consider while choosing the appropriate deployment option.

Heat Software company suggests a questionnaire which can help potential users to choose cloud or on premises deployment. There are 8 key questions to consider before choosing the deployment option, which help to determine the most suitable solution.

1. Do you focus on year 1 costs or a long-term total cost of ownership?

If the organization focuses on year 1 costs it should choose cloud service as the cost of on premises option is 50-75% higher during this period. From the point of total cost of ownership for organizations working more than 3 years it is preferably to use on premises deployment. Also those, who prefer annual subscription model, should choose cloud technologies, while those, who prefer perpetual license model, should choose on premises deployment.

However, Wlodarz (2014) suggests another point of view – anyway total cost of ownership of the hardware and software exceeds the sum of subscription fee. Usually the life-cycle of hardware is 5 years of 24/7 usage [Garretson, 2010]. Wlodarz calculated and compared a generic line of business app server on premises and the cloud one hosted up in a large Azure virtual machine. The results of the calculation are presented on figure 3.

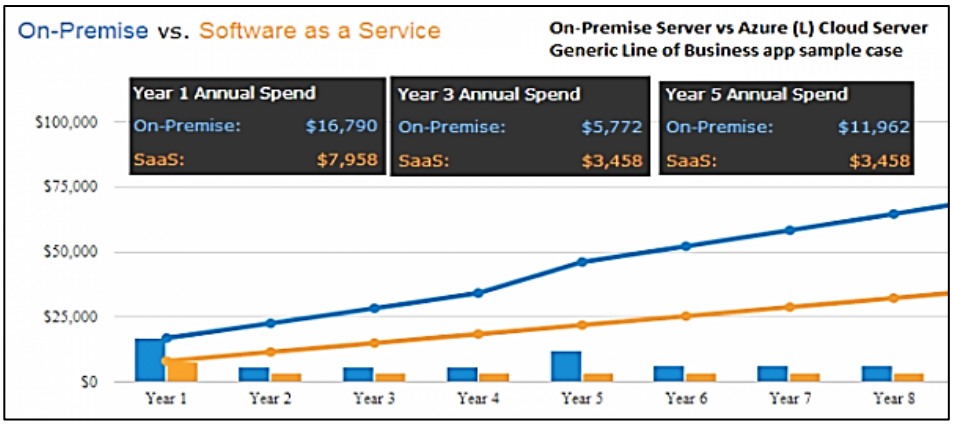

Figure 3. Cost of on premises and cloud deployment Derrick Wlodarz's case

Source: Derrick Wlodarz, 2014

The graph on the figure 3 shows that the total cost of ownership several times exceeds the subscription fee. The author reviewed a particular case, so the results of another one can be different, so it was decided to look at a standard template seen as common situation in this calculator. The calculation was made with the help of Total Cost of Ownership Calculator on the web-resource of Software Advice Company, which is a part of Gartner – the world's leading information technology research and advisory company; so it was considered as reliable source. The standard template of such calculations is presented on figure 4.

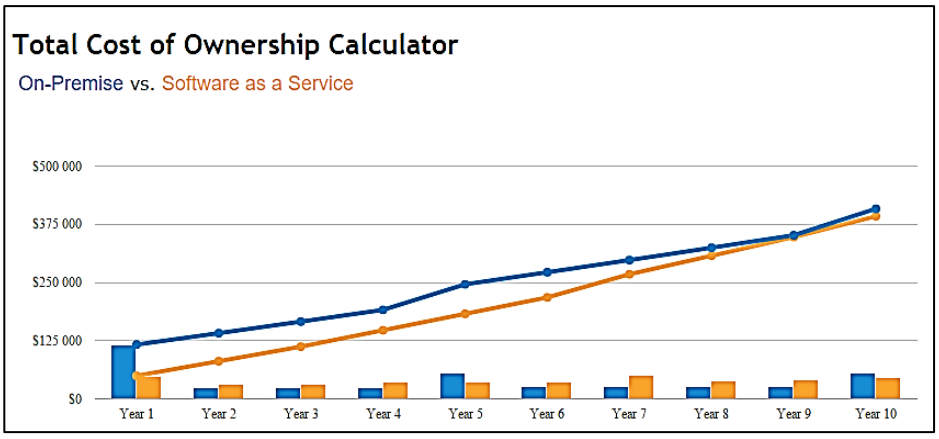

Figure 4. Cost of on premises and cloud deployment standard template

Source: Total Cost of Ownership Calculator, http://www.softwareadvice.com/tco/

It can be seen that in common case the sum of periodical subscription payment reaches the total cost of ownership only in year 9, which is nearly twice exceeds the hardware life-cycle. It means that in common case it is more beneficial for the organization in terms of costs to use cloud technologies. Also it should be admitted that companies shouldn't ignore the average hardware life-cycle because stretching hardware lifespan is followed by several risks: risk of unexpected failure during the work or migration to new software, which can cause data loss; and more costly data migration fees because of obsolescence of used technologies [Wlodarz, 2014].

2. What is the state of your IT resources?

If the company has its own IT specialist, who can manage and upgrade local network, hardware and software Heat Software company recommends to use on premises deployment as well as if the company already owns all or the major part of needed equipment. In case the company has no local system administrator and no or obsolete servers and no desire to replace them it should use cloud services. Also if there is no place to locate the hardware it is better to move the data offsite and use cloud technologies.

3. Does your organization have experience with Cloud?

There is no sense for the company which currently uses cloud solutions even in another field, is satisfied with it and already pays for cloud solution support to change the deployment option. As well the company which uses applications and systems deployed on premises and have no cloud solutions shouldn't implement them. Also if the executive team of organization does not trust cloud technology and see it as unreliable there is no need to use it.

4. What is your history with Application upgrades?

If the company has a skilled IT professional with right skills and the upgrade process is established on premises deployment of the system is preferred. When the company is lacking in-house skills and experienced several upgrade failures it worth using cloud services.

5. Rate your readiness for 'out-of-the-box'?

According to Heat Software company method on premises deployment is preferred by the companies, which have unique business processes and need a lot of customization. While the cloud option is preferred by those which embrace standard applications for instance because of bad experience with custom applications and have quite standardized business.

However, currently, in medical software market both cloud and on-premises based solutions are highly customizable. In terms of technical features like data capacity cloud services are usually more flexible as they provide almost unlimited space on their servers, while in case of on-premises deployment the amount of space is limited by the user's capacity of servers. In terms of features and alignment with business processes cloud systems cannot immediately be modified within existing modules to suit the customer needs, which might adversely affect a customer's competitive advantage [Belt, 2015]. Cloud providers don't have the time and sometimes bandwidth to customize the services for each client, so such service is usually charged additionally.

6. How are your users distributed?

Companies which have reliable Internet access and highly distributed user base are suggested to use cloud based solutions. Organizations with low number of locations and high quality servers are suggested to use on premises deployment.

Suggested by Heat Software company answers refer to organizations which already have cloud or on premises system deployment. If the company already has high quality servers it doesn't need to choose the deployment option. Also the quality of hardware and Internet access are not related at all to the distribution of users.

7. Are Capital Expense or Operating Expense budgets more favorable?

The company which prefers operating expenses, paying rather small periodical subscription fees and have rather small financial impact per year should use cloud based services. If the company prefers capital expenses, perpetual license and doesn't mind to face large financial impact in the first year it should deploy the solution on premises.

This question is similar to the first one and is based on the idea that the sum of subscription payments reaches the total cost of hardware ownership after 3 years of usage. According to Gartner member information the common situation differs from this assumption by 3 times. It worth reformulate this question and ask potential users if they are ready to invest quite a lot of money or it is more convenient for them to pay periodically.

The method of choosing the healthcare information system deployment suggested by Heat Software company seems to be incomplete as it lacks several essential issues related to cloud or on premises solutions issues. First of all the price of software and hardware for on premises deployment and the subscription fee for cloud deployment are not all needed payments connected with the utilization of both of them. For on premises

solutions public utility payments are usually forgotten to be included in total cost of ownership. Commonly one server uses from 500 to 1200 watt[3]. The average price of electricity (kw/h) in USA is about $ 0,125[4], in Europe the average price is € 0,18[5] which is about $ 0,2 (€1 = $1,0995), in Russia – ₽3 which is $0,04 ($1 = ₽73,8). A server 850 watt average uses (850watt* 24hours*365 days)/1000 = 7446 kw per year. It means that an average server usage costs $893,5 in US, $1489, 2 in Europe and $297,8 in Russia; these costs should be included in total cost of ownership of each server. Such costs for computers and other devices are not included because they do not differ in case of another deployment option. Talking about cloud based solution there are some extra fees which users usually don't take into account choosing the deployment model. Cloud storage providers offer unlimited inbound bandwidth, which means that their clients can upload almost any amounts of information on the server. However, some of them limit free outbound bandwidth, which means that the users can download from server only a particular amount of data. If the user needs to download more data from server the provider offers this service for an additional fee. For instance, Microsoft Azure provides users with 5GB of free outbound any additional outbound is charged extra $0.12 in average per GB[6]. So if the company uses 1TB/month it is charged additional $120 per month.

Another issue is uptime – the official rates of average uptime of cloud and on premises solutions are similar [Wlodarz, 2014]. However, using cloud services the user can't control or even influence the uptime, while on premises deployment is the user responsibility. Concerning this issue the choice of the deployment options is an issue of trust to provider and desire to shift the responsibility.

The last issue affecting the choice of deployment option is time of implementation. Cloud based solutions require around a month to implement which is much less than the time of on premises ones implementation.

One of the most controversial issues concerning choosing the deployment option is the security issue. There is no common opinion which option is safer. From the one hand the security system is usually breached within a company's own boarders, often by employees [Ponemon Institute LLC, 2012; Perry, 2013]. Though from the other hand, firstly, the company could be sharing space and services with its biggest competitors and

[3] J.T. Barett, How Much Electricity Does a Computer Use Per Hour?
[4] The U.S. Energy Information Administration (EIA), Short-Term Energy and Summer Fuels Outlook, 2016
[5] Fondation EurActiv, Evan Lamos, Electricity prices in Europe, 2015
[6] Microsoft Azure website: https://azure.microsoft.com/en-us/pricing/details/data-transfers/

lose some competitive advantages in case of breach. Also if the security system of the server provided is breached all the data leaks, while internal breaches can be conducted for getting some particular information. Also modern information systems have authentication functions and it will be easier to detect the violator and perhaps prevent the data transmission.

All in all there are 9 issues to consider while choosing the deployment model:

- State of IT resources
- Experience with cloud solutions
- History with application upgrades
- Need to customize
- Users distribution
- Readiness to invest
- Total cost of ownership vs total cost of cloud service usage
- Trust to provider and desire to shift the responsibility
- Time of implementation

The majority of healthcare information systems on the market are multifunctional. Only one of the fifty analyzed software solutions (2%) had only one function – electronic medical record; other systems have a number of different functions. About 75% of reviewed healthcare information systems have 6 main functions:

- electronic medical record
- medical billing
- patient scheduling
- medical accounting
- communications systems
- image support.

Electronic medical record (EMR) function facilitates creating and storing information about patients in a form of digital patient records. It assists in tracking demographics, patient notes and history. This feature of the healthcare information system is a primary one as it digitalizes personal information of patients and performs as the first step to personalization of the medical care.

The second function is medical billing which manages the process of receiving the payment for rendered by a healthcare institution services. This function supports working with both individual patients using paid services and health insurance companies.

Medical billing includes such steps as coding, claim scrubbing, eligibility inquiry, electronic claim submission, payment posting and reporting.

The next function is patient scheduling which facilitates the process of making appointments of patients' visits. Except for making appointments this function usually includes reminders and automated control of visits execution.

Another essential function of healthcare information system is medical accounting. It automates accounting procedures and assists in keeping track of purchases, payrolls and accounts receivable, managing billing and prepare financial statements.

Communication function allows healthcare institution employees to contact each other to discuss some issues or to get necessary information. Also this function supports electronic document automation which improves communication and saves time by removing the need to walk between the medical offices.

The last function image support allows to store and exchange images data like X-rays, CAT scans, MRIs etc. It assists in storage, searching, manipulating and distributing of such information.

Besides specified functions there are several unique features provided by some of the software solutions. All in all, there are 7 additional functions that can be used in healthcare information systems:

- biometric authentication
- integration with governmental systems
- SMS reminder
- build-in reminder
- 3D reconstruction
- allergy checks
- handwriting and speech recognition

For example, Amulet healthcare information system offers biometric authentication used for verification of medical professional identity for secure access to the electronic system. This function improves the safety and security of the patients' information and

helps to avoid internal security breaches which happen more frequently according to Third Annual Benchmark Study on Patient Privacy and Data Security conducted by Ponemon Institute LLC in 2013.

Medical software Medved proposes an ability of integration with governmental information systems. It means that healthcare institutions using Medved are able to redirect and receive data and documents to and from other governmental institutions.

3 healthcare information systems from the list ArchiMed, Infoclinic and Medexis have such additional function as SMS reminder. This feature is an application for independent arrangement of SMS-mailing which can compose SMS templates, schedule mailing on a specific date and time and track delivery status of every sent SMS. With the help of this functions healthcare institutions remind their clients of the date and time of the appointment and decrease non-attendance rate.

DrCloudEMR has similar to SMS notification function – build-in reminder. This reminder can be used both by medical workers and patients. Medical workers can fill in their calendar and the system reminds about important dates, for instance the deadlines for submitting the report. From the clients' point of view this function is similar to the SMS notifications; it reminds of the appointments on the patient portal.

Healthcare information system Jemys offers function of 3D reconstruction. From a set of successive sections this function creates a three-dimensional array; sections of the array are displayed on the screen and the section planes can be interactively changed. 3D reconstruction allows not only creating volumetric objects, but also it provides an opportunity to zoom, rotate, measure the distance and change light, color and transparency of the object. This function is not new and unique in general as there is such software on the market, however healthcare information systems usually don't provide such functions.

MediTouch EHR has a build-in function of allergy checks. This function implies an automatic check at the point of care of patient's allergy list and an alert if the patient is allergic to a medicine that is going to be prescribed. This function increases the efficiency of care and decreases the time of care by removing the necessity to check this information by hand.

Sevocity and PrognoCIS healthcare information systems have handwriting and speech recognition function, which facilitates data entry as it allows inputting information without using a keyboard. This function can be especially useful for aged medical workers,

who can be not so skilled in typing or have poor eyesight. Handwriting recognition can also interpret intelligible written text from paper documents or photographs by optical scanning, which makes work with paper-based document much easier and allows gradually digitalizing all the documents in the healthcare institution.

The next identified characteristic of healthcare information systems is portable device access. This feature allows medical personnel to reach the healthcare information system not only from personal computers in the office, but from their tablets and mobile phones, too. This ability gives medical professional an opportunity to be more flexible and assist in many essential tasks. Usually healthcare information systems have a special module in a form of specific mobile application to provide such access. This module can be included in the basic configuration of healthcare information systems or sometimes it can be purchased as an additional one depending on the system provider. In case of using cloud deployment mobile devices connect to the information system through the Internet, while in case of on premises deployment the access realized via the local network.

Portable devices can be used by medical professionals in 3 main ways: for information and time management, for communication, which are similar to healthcare information system functions, and for education. Using mobile devices during the workflow improves such aspects as information and time management. Portable device access gives medical personnel an opportunity to access and maintain health records on the go outside the office, so there is no need to return back to the office to accomplish this job. Though mobile devices users can reach two main types of information: professional information: medical literature, podcasts and calculators, textbooks and guidelines or drug references; and patient related information: electronic medical records, laboratory information systems or picture archiving and communication systems. Information searching is the most popular activity among mobile devices users, which occupies around 50% of “phone time” [Chase, 2013]. Also mobile application contains all information about clinician’s appointments, so it helps him to be everywhere on-time.

Portable device access function also facilitates communication and consulting process, especially with colleagues in different locations. It decreases the average waiting for response time and increases the response rate as all the personnel is always available through mobile application and can reply almost immediately. Using mobile devices can also be used for communication with long-distance patients, who can send clinicians text or pictures regarding problems or questions. This opportunity is connected rather to

general portable devices usage in healthcare institutions than to their compatibility with the information system. However it worth noting because it plays a large role in the caring process as it helps patients to be treated timely and avoid unpleasant consequences [Kiser, 2011]. Using mobile devices users obtain the following communication capabilities – voice calling, video conferencing, e-mails, text and multimedia messaging. According to Wallace, Clark and White (2012) study about 85% of medical personnel use portable devices at least once a day for clinical purposes like information and time management or communication with colleagues.

Mobile devices are used by medical professionals for education and training purposes, too. Watching professional web videos is one of the most frequently performed activity; 67% of medical personnel use laptops for this purpose, 29% – tablets and 13% – smartphones [Chase, 2013]. Currently mobile devices have become a “learn anywhere” resource for accessing information or double-checking knowledge [Payne, Wharrad, Watts, 2012; Wallace, Clark and White, 2012]. For education purpose clinicians usually use already mentioned sources of professional information: textbooks, medical calculators, drug references, etc.

Using portable devices during the workflow also helps to improve patient management. High level of availability of medical records, lab tests and other needed information and the communication function of the mobile solutions enable to make more precise and appropriate diagnosis and prescriptions. This, in turn, makes the clinical decision-making at the point of care more effective and efficient in terms of time and accuracy [Mosa, Yoo, Sheets, 2012; Mickan et al, 2013].

In general portable devices access feature allows medical professionals to perform some of the healthcare information systems functions like information and time management and communication and consulting remotely. Furthermore using mobile devices like phone and tablets gives clinicians and opportunity to educate and double-check their knowledge.

Another feature of some healthcare information systems is availability of a patient portal. Patient portal is an online application for the healthcare institution clients used to interact with the medical care provider via the Internet. Usually such portals are available for patients 24/7. As portable device access function this one can be a part of the basic configuration of healthcare information systems or can be purchased as additional module depending on the system provider. Michelle Holmes, a principal with ECG Management

Consultants in Seattle, considers the average price of the patient portal to be about $30-$40 per provider per month in US. There are two main types of patient portals: one-way communication ones, which enable patients to interact with the information system only and two-ways communication portals, which allow patients to contact medical professionals, including providers, care teams, and administrative staff [Terry, 2015]. Patients use secure user name and password to log in to their personal accounts on the portal.

There are several features that are available for patients. Firstly, patient portal enables users to schedule appointments and view and refill requests online. This function facilitates choosing the proper date and time of the appointment, especially compared to the phone call, because all the available appointments are listed on the screen. Also it allows avoiding extra visits to the medical provider. This feature helps to reduce the number of phone calls and queues in the healthcare institutions and increase efficiency of administrative processes.

The next feature of the patient portal is ability to access personal medical records, visit summaries and lab tests results. This function helps patients to keep abreast of the latest news and visit the medical provider timely. However, it is important to take into account self-treatment trend in some countries, for instance in Russia. Searching information from the medical reports patients follow treatments, that can be inappropriate and even worsen the situation, found in the Internet without visiting the medical adviser. Self-treatment is frequently followed by incorrect self-diagnosis that can lead to unpleasant and sometimes harmful effects like masking of a severe disease, incorrect choice of therapy, dangerous drug interactions and delays in seeking medical advice when needed [Ruiz, 2010].

That’s why some patient portals have another feature – patients’ education. The primary goal of this feature is to increase the general medical education of the patients, so they would take less reckless actions and care more about their health. Portals can be used to send educational materials and preventive and chronic care alerts to patients to inform them about the first signs and preventive measures of some diseases and so on. Patient general medical education helps to reduce the number of self-treatments and helps patients to understand the importance of timely professional visits.

Some patient portals also offer an opportunity to pay bills online through the personal account or sometimes without logging in. This function is quite popular,

especially among young users. Software Advice Company conducted a survey and identified that the most popular patient portal features among aged customers and men are scheduling meetings with clinicians and requests for refilling prescriptions. Young patients and women at the same time use patient portal more frequently to get results of laboratory tests and pay for medical services [Eastwood, 2014].

Another feature of patient portal is secure messaging. This function is available only in two-way connection portals as it assumes direct contact to the medical professionals. Using this function patient can ask their medical adviser different questions, clarify prescriptions and as a result avoid extra visits. It facilitates the communication process as patients can almost immediately ask the question online instead of going to the healthcare institution or hanging on the telephone line waiting for a response. Moreover it's easier for medical personnel to answer to a message or e-mail on a patient portal than to answer a phone call.

However, there is a challenge – how to attract patients to the portal and make them use it. One of the main reasons of patients' reluctance is connected with the alignment of the portal's work with the healthcare institution's business processes and its usability. According to Software Advice study 34% of the patients name "unresponsive staff" the top frustration factor of the patient portal, the second one is "confusing interface" mentioned by 33% of the respondents.

All in all there are 5 main functions provided by patient portal as a module of a healthcare information system:

- Scheduling appointments and managing requests
- Access personal medical information
- General medical education
- Paying bills
- Secure messaging

Functions 1-4 are available on both one- and two-ways communication portals, while the last feature can be uses only on the latter ones. The number of available functions is different on different patient portals and depends on the medical software provider.

The next characteristic of the healthcare information systems is availability of Big data analytics. Big Data analytics in healthcare is usually used for curing diseases, improving quality of life, avoiding preventable deaths and predicting epidemics [Marr,

2015]. This function is necessary for analysis of heterogeneous data and reports creation. Big data analytics function processes huge amounts of data continuously generated by different kinds of medical equipment, for instance radiological apparatus, electrocardiographs or MRI machines. Therefore this function is necessary in healthcare institutions that use different medical equipment to make the analysis more convenient.

The last identified characteristic is training programs availability. Training program is needed for medical personnel, who are going to use the healthcare information system, to get acquainted with the system, its interface and functions. This education is needed teach future users how the system works to avoid problems and wasting time during the workflow. Implementing the healthcare information system is aimed at increasing effectiveness and efficiency of the healthcare institution, improving services and as a result patients' satisfaction, so medical personnel should be able to somehow use the system when it is put into practice. In case medical professionals learn on the fly all the processes will speed down and the level of patients' disappointment will increase. The majority of medical software providers consider training programs as an integral part of the information systems, while the others deliver it as an additionally paid service. Usually medical software providers have several special programs for different kind of personnel (administrative, medical, IT, etc.) within the training course which lasts from 1-2 days to more than a week. Also healthcare institutions are also provided with phone or online consultations, which can be free or paid in most cases depending on the available hours and the need of personal consultations.

For instance, SP.ARM company offers courses in 6 different fields regarding different modules and functions of its healthcare information system qMS. The company offers the following training programs:

- Analytics HIS qMS – introductory courses on analytical tools of the information system qMS. These courses are addressed to skilled IT-professionals and medical statisticians. The goal of the courses is to teach users to solve problems in the processing and analysis of data using analytical tools in qMS system. There are 2 courses in analytics: general course «Analytics in qMS" and "Analytical potential qMS». The courses last 5 and 3 working days respectively.
- Administration of healthcare information system qMS – the course is designed for administrators, and employees participating in the implementation and maintenance of the system in medical institutions. The course lasts 10 working days.

- Laboratory information system management – the course is intended for laboratory professionals, medical assistants, laboratory technicians, and IT specialists who carry out configuration of the system and consult end-users. The courses last 1 working week.
- qMS Pharmacy – the course is held for specialists in the field of medicines and medical products inventory control within the healthcare organization and lasts 4 working days.
- Introduction to qWord-XML development – the course is designed for professionals in working with databases. During the training, users learn how to work in qWord-XML environment in such fields as development of graphical user interface, output forms and mechanisms of interaction with databases. The course lasts 3 working days.
- Managing Caché database – the course is addressed to professionals who ensure the functioning of Caché database in the contracting authority (usually system administrators or database administrators). The course lasts 2-3 working days.

All in all the comparison analysis of 50 different healthcare information systems revealed that there are X main characteristics of healthcare information systems with several options for each. The characteristics of healthcare information systems are:

- platform (operating system)
- data storage deployment
- portable device access
- patient portal
- features
- Big data analytics
- training programs

The functionality was divided into 2 main parts: common functionality, which is almost the same for all reviewed healthcare information systems, and additional functionality, which means some extra functions that might be unnecessary for some healthcare institutions. All in all there are 13 different functions, 6 main and 7 additional, that reviewed healthcare information system can offer to its users:

- electronic medical record
- medical billing
- patient scheduling

- medical accounting
- communications systems
- image support
- biometric authentication
- integration with governmental systems
- SMS reminder
- build-in reminder
- 3D reconstruction
- allergy checks
- handwriting and speech recognition

2.3 Analysis of the interviews with experts from healthcare institutions

Based on characteristics of healthcare information systems identified through comparative analysis a list of 27 questions was created. It was designed only for healthcare institutions that have already implemented and started to use healthcare information system. The aim of the survey is to identify based on what criteria healthcare institutions choose healthcare information systems in fact. It consists of 2 types of questions: open-ended and multiple choice questions. The questions are based on different characteristics of healthcare information systems that can be used by healthcare institutions. Also there are some questions aimed at identification of the reason of selection the particular function or option. The survey questions and answer options are presented in the Table 1 below.

Table 1. The survey for healthcare institutions

1. What is the name of the healthcare institution?	
2. What healthcare information system do you use?	
3. How many employees utilize healthcare information system?	
4. Do you have an employee who supports the healthcare information system?	Yes No Healthcare information system provider supports the system
5. Who selected the healthcare information system?	
6. What factor influenced healthcare information system selection the most?	

7. Were there any specific trainings for employees about how to use the information system?	Yes, trainings were included in the information system purchase Yes, trainings were additional to the information system purchase Yes, trainings were conducted by our employee No, employees learned on fly
8. Which operating system is installed in your healthcare institution?	Windows Linux Mac OS Other:
9. Do you use own servers for data storing?	Yes No
10. Do you use cloud services for data storing?	Yes No
11. Why did you choose data storage type you use? (on premises / cloud)	
12. Which portable devices your employees use during the working process?	Don’t use portable devices Smartphones Tablets Notebooks Other:

13. Do you use any special application for mobile devices that provide access to the information system?	Yes, application from healthcare information system provider Yes, application from third party provider No
14. Are there any analytical functions in the healthcare information system that you use? How do you use these functions?	
15. If there are no analytical functions in your information system, would you like to use them? How would you use them?	
16. Do you have special electronic appointments function?	Yes No
17. Do you have patient portal with personal account for patients?	Yes No
18. How do patients often communicate with your medical institution?	Personal visit Phone Internet Other:
19. How important is the cost of a healthcare information system for you?	Primary Important Important enough It does not matter Generally it is not a selection criterion

20. What payment method for healthcare information system is more advantageous for you?	Recurring payments One-time payment Other:
21. Do you trust data protection to third parties?	Yes, information system provider Yes, third party organization No
22. What method of data protection is used at your healthcare institution?	
23. Is there user authentication in your healthcare information system?	Yes No
24. Are there different access rights to the different categories of staff in your information system?	Yes No
25. Is there any category of employees that can use information system without any access restrictions? Which category?	Yes: No
26. Do you pay attention to the protection against internal security threats?	Yes No

27. Please mark all the factors that you consider to be important when choosing a healthcare information system.	Supported operating system The type of data storage Support for portable devices Patient portal Analytical functions Staff training Other:

The sample of healthcare institutions that answered the survey consists of 6 different medical institutions from St.-Petersburg. The names of the healthcare institutions are not disclosed by the wishes of the respondents, so in this study they are named healthcare institutions A – F.

Healthcare institution A is a huge multidisciplinary clinic that was found in 1980s. It has 5 big centers in St.-Petersburg and employs more than 1000 people who work in more than 30 different medical directions. Healthcare institution A utilizes healthcare information system qMS for about 5 years.

Healthcare institution B is a multidisciplinary clinic that was found in 2000s. It had 3 branch offices in St-Petersburg, however due to the significant expansion of activities from 2012 it has one big clinic in the center of St-Petersburg. Healthcare institution B works in about 20 different medical directions. This medical institution utilizes healthcare information system Medialog for about 4 years.

Healthcare institution C is a multidisciplinary clinic that was found more than 200 years ago. It has 2 huge clinics in St-Petersburg with more than 200 medical professionals employed. Healthcare institution C works in about 20 different medical directions. This medical institution utilizes its own healthcare information system for about 3 years.

Healthcare institution D is a highly specialized clinic that was found in 2000s in St-Petersburg. It is a network of 6 active rehabilitation clinics, 2 of them are located in Moscow and 4 – in St-Petersburg mostly in the northern part of the city. Healthcare institution D specializes in 2 main directions: neurology and orthopedics and several

related directions such as ultrasonography, massage, physiotherapy and some others. Healthcare institution D employs about 130 medical specialists with 15 years of working experience in average. This medical institution utilizes healthcare information system Medialog for about 8 years.

Healthcare institution E is a multidisciplinary clinic that was found in 2000s. It has 13 centers in 10 cities including Moscow and St-Petersburg. Healthcare institution E works in about 20 different medical directions. This medical institution utilizes healthcare information system Infoclinic for about 5 years.

Healthcare institution F is a huge multidisciplinary clinic that was found in 2000s. It has 13 medical centers in 8 districts of St.-Petersburg and employs about 700medical professionals who work in more than 30 different medical directions. Healthcare institution F utilizes healthcare information system Medialog for more than 10 years.

The answers for the survey from all healthcare institutions were analyzed. As a result it was found that in most cases healthcare institutions gave similar answers. However there are some differences among them, too.

6 interviewed healthcare institutions use 4 different healthcare information systems. The most popular healthcare information system is Medialog used by 3 respondents (50%); one institution utilizes healthcare information system designed specifically for it, 2 others use qMS and Infoclinic healthcare information systems.

In majority of the interviewed healthcare institutions the number of employees more or less differs from the number of healthcare information system users and sometimes from the number of “working places” in the system. The number of healthcare information system copies for offices in medical institution is meant by the number of “working places”. However, the difference between these numbers is rather big. For example, healthcare institution B answered that 25 medical professionals utilize the system, but on the web-site of the system producer the number of “working places” for this clinic is 10, which is much lower than the number of employees who use the system. Also healthcare institution F has the same case of employing about 700 medical professionals but using only 250 “working places” according to information of the system producer web-site. There can be 2 possible explanations of this situation. Firstly, it can be due to the fact that several institutions’ B medical professionals use the same office, computer and working place in the system according to their timetable. So there is no need for an

individual copy in the system for every employee. Also the producer could indicate only initial number of purchased copies and lose sight of others which were bought later. Also in healthcare institution C the number of healthcare information system users is much lower than the number of employees because the system is used mostly for getting statistical information, not for medical care. In other healthcare institutions the number of system users differs from the number of employees because usually nursing staff doesn't have personal "working places" and use the system much less compared to medical professionals.

Talking about the support of healthcare information systems 5 respondents told that the system producer is responsible for this issue and performs all the tunings and updates. Healthcare institution B answered that it hasn't its own employee to be responsible for this issue, so it can be assumed that it uses the services the third-party company or specialist as this option was not included in the question. The majority of medical institutions (A, C, E and F) have IT-department or IT-specialist who help to maintain used hardware and software and took part in healthcare information system selection; however as other institutions they don't perform the support activities on their own. So it can be concluded that it is more convenient for them to use the external support and this issue is essential for the system selection.

In the majority of healthcare institutions (4 of 6) healthcare information system was selected by medical professional with the help of the IT specialists. Three of these medical institutions (A, C and F) are quite large and have IT specialist among employees; another one hired an IT-specialist before the information system was selected, so he took part in the selection process, too. What is more healthcare institution C didn't purchase ready-made information system; it was designed specifically for it. In healthcare institutions B and D the choice was made by chief accountant and administrative staff respectively. Therefore, their choice was based on the references about the system and the list of deployments. It means that at present special IT knowledge seems to be needed to understand all the peculiarities of the healthcare information systems to make the deliberate choice. The choice of healthcare institutions that used IT-specialists help was more perceived as IT-specialists know more in technical field and have special background that helps them to understand technical issues better and faster. Also their choice was based on several criteria like functionality, technical support in St-Petersburg, modularity, software-base of the platform and domestic development. Nevertheless not all IT-specialists possess the necessary knowledge and can take into account all the necessary

criteria. As it can be seen from the results of the survey some essential issue were not considered during the healthcare information system selection process. For example, such criteria as type of the data deployment or special educational trainings provision were not taken into account. Also despite the fact that the choice was based on the functionality in the majority of the healthcare institutions that used IT-specialist help the question of how the necessary functionality was identified remains open. There are 3 main paths concerning the functionality of the healthcare information system: purchasing the system with the largest number of different function, purchasing the system with minimum necessary functions and purchasing the system with the optimal functions necessary for particular healthcare institution. Taking into account the choice of the healthcare institutions A, E, F it can be concluded that they chose the third path as the selected systems don't have the widest or the narrowest range of functions. The main threat of this path is choosing functions that are not really needed, so there is a question how correctly the optimal list of functions is identified. A particular function may seem very attractive, but it can be unsuitable for a healthcare institution. For example, application for mobile devices access can bring many benefits to the medical institution, however before considering this function as necessary it worth thinking about the suitability. If there are many aged medical professionals, there is no opportunity to provide medical practitioners with compatible mobile devises or the mobile devices usage rate is low the advantage of this function will be much lower than it seemed to be.

Judging by the results of the survey all the reviewed healthcare institutions have some functions in the information system that they don't use. For example, healthcare institution A uses information system qMS that has special electronic appointments function for its patients, however the majority of the patients communicate with it by phone. 5 of 6 healthcare institutions have this function, but only 2 of them marked Internet as one of the most frequent way to communicate with the medical institution. In healthcare institution D, for instance, medical professionals use smartphones quite often, but there is no mobile device access function in its healthcare information system. While healthcare institution F has such function because employees use tables on the work place. What is more only healthcare institution C has private accounts for patients, however as it was already mentioned healthcare information system is used mostly for statistical reports than for medical care. Moreover patients usually use phone and personal visits to communicate with the institution, so it is unclear why this feature was included in the system. It means that every function necessity should be considered carefully with respect to a particular

healthcare institution to identify the optimal list of necessary functions and range them as some functions can be indispensable, while other just beneficial, whether it is a specifically designed or purchased system. This issue is going to be solved by the healthcare information system selection model that will be created as a result of this study. It will facilitate the selection of the necessary functions, suitable healthcare information system and help to avoid ineffective choice.

All respondents who purchased ready-made healthcare information systems received educational trainings as an obligatory part of the system purchase. The majority of ready-made healthcare information systems providers offer educational training on how to use the information system for free as a part of the purchase of for a fee as an additional service. So during the selection process it is important to consider if there is a need in such trainings and if yes which option of educational training purchase is more convenient. For example, if the majority of employees have already used similar system may be there is no need in obligatory trainings for all the staff.

The majority (5 of 6) of the interviewed medical institutions use solely on premises data storing. 3 of them do not trust external parties the security of patients' information and prefer to be independently responsible for data leak prevention that's why they store data on their own servers. Also healthcare institution D considers servers to be more secure than cloud deployment, but it entrusts the security issue to the provider because of his reputation and absence of its own IT specialist. Healthcare institution B supposes on premises deployment to be the cheapest way of storing data despite the fact that it is not true considering the total cost of ownership; however this is the opinion of the institution. Also it entrusts the security issue to a third-party company. Healthcare institutions use different methods of data protection like data encryption, firewalls, etc. All of them have user authentication in the healthcare information systems to prevent external people access to confidential data and personalize system usage. Also all interviewed medical institutions have different access rights for the different categories of staff, so every employee uses only necessary for him/her information. Also these two actions help to protect against internal security threats, which are more frequent than external ones [Ponemon Institute LLC, 2012; Perry, 2013]. Also personalized usage of the information system facilitates the process of disturber identification. In 4 of 6 healthcare institutions there is only one group of people which can use information system without any access restrictions – system administrator. In healthcare institution C except system administrator the director has no access restrictions in the information system. In healthcare institutions B there is no

category of employees that can use information system without any access restrictions. As it can be seen from the survey there is no unified way of providing data security, they are similar but not identical, so there is a need for every healthcare institution to decide what means it would utilize and what the optimal level of security is.

Every interviewed healthcare institution has a large flow of patients and, accordingly, a large flow of new data. This data is in different formats: images, tables, text, etc. Interviewed healthcare institutions use analytical tools in their information systems for statistical reports of different levels and times, so it can be concluded that this function is a necessary one, which is frequently used. For instance, getting analytical features was the main purpose of implementing healthcare information system in healthcare institution C.

All the interviewed healthcare institutions, except institution C, considered the information system cost issue as important, but not primary one. Considering the main information system selection criteria mentioned by healthcare institutions the issue of how the system works is much more important for the majority of them. Talking about the way of payment half of the respondents mentioned the pay as you buy option which means the gradual purchase of modules. Also 2 healthcare institutions prefer one-time payment. It is interesting fact that healthcare institution B would prefer recurring payments, which are typical for cloud deployment, however it stores data on own servers. This contradiction shows that some healthcare institutions may not have clear vision of reasons for choosing particular information system features.

The last question of the survey was aimed at identifying which factors are considered to be important for selecting the information system after the healthcare institutions got experience in this sphere. Only healthcare institution C almost didn’t change its mind about the selection criteria. This can be explained by the fact that this healthcare institution ordered a system specifically designed for them. Other interviewed healthcare institutions purchased their healthcare information systems and based their choices on what seemed to be the most important. After some time of usage the information system and the interview they changed the opinion of what is essential to consider. All the options of the last question were selected at least once; the most popular ones are educational trainings, analytical functions and the deployment type, which were not initially considered as selection criteria at all.

Generally, the respondents were divided into two groups according to the initial parties involved in the selection process. The first group of respondents (healthcare

institutions A, C, E and F) selected healthcare information system with the help of IT specialists and the initial selection criteria were functionality of the system, technical support in St-Petersburg (domestic region) and domestic development, which means than only Russian information systems were considered as alternatives. The second group of healthcare institutions (B and D) selected their information systems without any IT support and relied on the list of healthcare information system deployments and references.

However, after getting experience in utilizing healthcare information systems both groups' opinion about selection criteria of information system became more or less similar. Supported operating system, type of data storage deployment, portable devices support, patient portal, analytical functions and staff training were mentioned as "experienced" healthcare information system selection criteria at least once.

2.4 Summary of chapter 2

In this study 2 methods of business research were used: comparison analysis and expert opinion.

Firstly, 50 different healthcare information systems: 30 Russian information systems and 20 foreign ones were reviewed, and then the comparison table was created. As a result of healthcare information systems comparison analysis the main characteristics of the systems were identified: platform, deployment, features, portable device access, patient portal, big data analytics, and training programs. Then every identified characteristic was described in terms of possible options to use and functionality.

Then based on the comparison analysis of healthcare information systems a questionnaire for experts from St-Petersburg healthcare institutions experienced in healthcare information systems utilization was created. The aim of the survey is to discover the experts' opinion on the healthcare information system selection criteria. 6 different healthcare institutions participated in the survey. Firstly, healthcare institutions mentioned different criteria of selecting healthcare information systems, which they used being unexperienced in this issue. However, after several years of healthcare information systems utilization interviewed healthcare institutions changed their initial opinion. Generally, all the options identified through the healthcare information systems comparison analysis were selected at least once. The most popular characteristics appeared to be educational trainings, analytical functions and the deployment type, which were not initially considered as selection criteria at all.

Finally, the results of the experts' opinion analysis showed that all of the healthcare information systems characteristics should be considered during the healthcare information system selection model creation.

Chapter 3. Development of healthcare information system selection model for medical clinics

3.1 Healthcare information system selection model

The healthcare information system selection model is aimed at facilitating the process of selecting an information system for a healthcare institution without permanent establishment. This model is going to help a decision maker to choose characteristics of healthcare information system that are necessary for a particular healthcare institution. As it was already mentioned it is rather difficult for a person without specific knowledge to understand if a particular characteristic or function of the information system is really needed or it only seems to be necessary. There are different peculiarities of using different characteristics of the systems which will be included in the selection model to reveal decision makers from the necessity deal with them. From the healthcare institution point of view the selection model will look like a survey where after several easy-to-understand questions it gets a list of necessary healthcare information system characteristics. From the technical point of view the selection model is a decision-tree that includes the identified characteristics of the healthcare information system and their options.

There are 13 identified characteristics of the healthcare information systems; every characteristic has 2 or 3 options to choose from. The characteristics are: the operating system, deployment, patient portal, portable device access, Big Data analytics, training programs and 7 additional functions of healthcare information system: biometric authentication, integration with government systems, SMS reminder, build-in reminder, 3D reconstruction, allergy checks and handwriting and speech recognition. The first characteristic has 6 different options to choose, the next two have 3 options, while other presumes only 2 options presence or absence. All in all there would be approximately 55 000 different combinations (lists) of healthcare information system characteristics. A decision tree with such a huge number of results can hardly be realized and presented, so for the purpose of study additional functionality of the healthcare information systems will be presented as a separate part. Also it was decided to use variables in the decision algorithm to narrow the decision tree, so that branches do not repeat several times. The result of the healthcare information system selection algorithm is a list of functions recommended to a particular healthcare institution depending on the answers. Created healthcare information system selection model is entirely presented in Appendix 1. Different parts of the model are described in details and presented further in this chapter.

The first healthcare information system characteristic to consider is operating system. There are 3 main options: Windows, Linux and Mac OS, but some organizations have more than one operating system installed. There are 2 main options of having several operating systems installed in a healthcare institution: having several operating systems installed on one PC or different operating systems on different PCs. The main reason why healthcare institutions can have several operating systems is that different operating systems have its own uses and advantages. Having several operating systems allows switching between them quickly and having the best tool for the job [Hoffman, 2014]. There is some software that works only on “old” operating systems and is not supported by the modern ones, so there is a need to have an “older” version of operating system to use such software. Also some programs work only on particular operating system, only on Mac OS or only on Windows, so to use them on the same PC there is need to install both operating systems. If healthcare institution has different operating systems on different PCs information system can be installed on all PCs in case it is compatible with both operating systems. If several operating systems are installed on the same PC there is a need to choose the platform for healthcare information system installation. In choosing between operating systems to install healthcare information system there are 2 main points. Firstly, the choice can be made basing on the frequency of operating system usage. Healthcare information system is going to be used in every-day working activities, so it is more convenient to install it on the primary operating system which is usually used during the work. Also if Windows is installed on the PC it can be chosen as a platform for information systems as almost all of them are compatible with this operating system, therefore there will be more options to choose from. This characteristic has 6 possible outcomes: Windows, Linux, Mac OS, Windows & Linux, Windows & Mac OS and Linux & Mac OS. The part of the healthcare information system selection model reflecting operating system characteristic is presented on Figure 5.

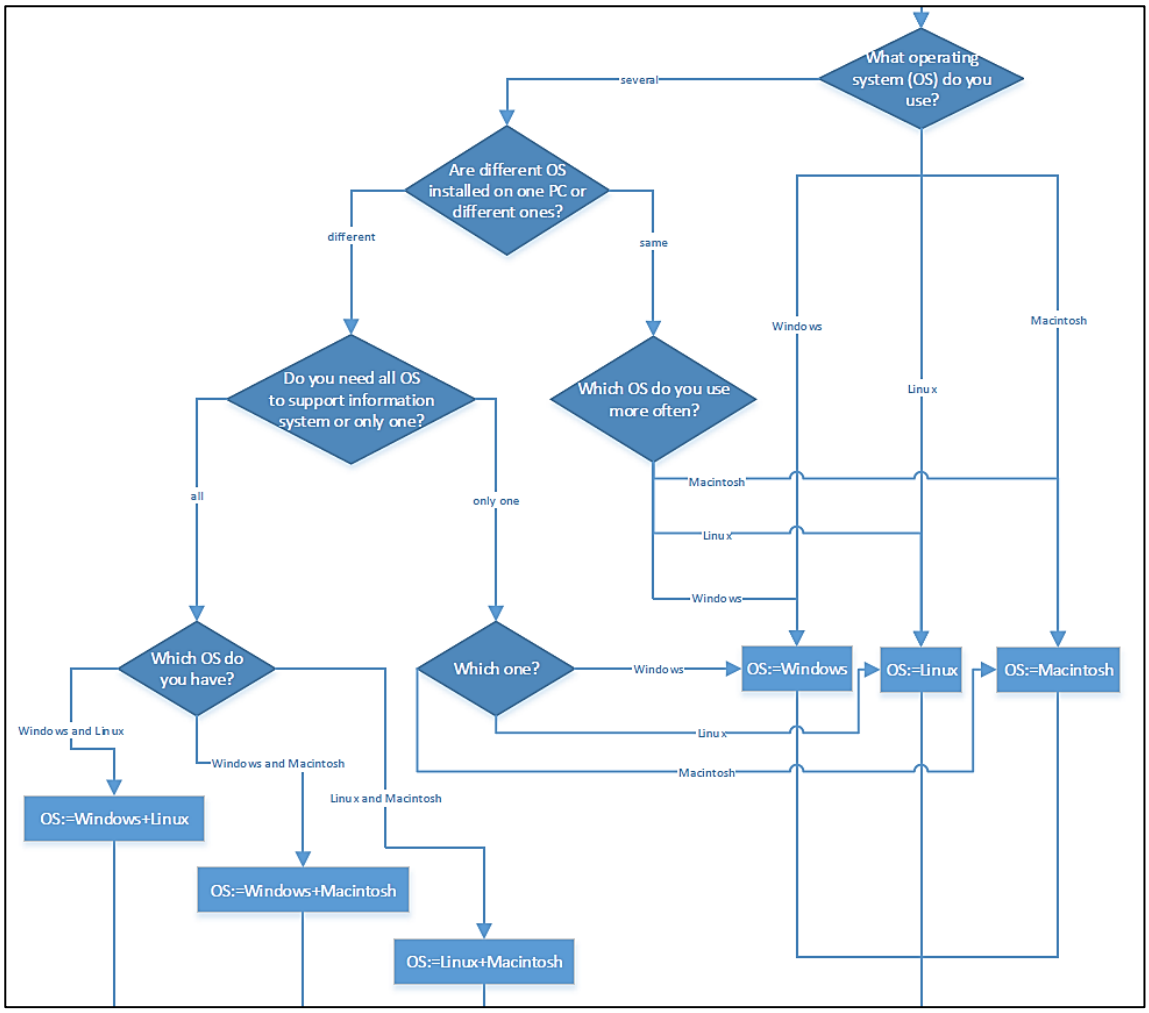

Figure 5. Healthcare information system selection model – operating system selection

The next healthcare information system feature to consider is deployment of data storage. There are two main options of deployment from the point of view of data storing: cloud and on premises, however the latter can be divided into 2 options considering the provider services: on premises deployment with provider support and on premises deployment without such service. Therefore there are 3 options of deployment that can be chosen: cloud deployment, on premises deployment with provider support and on premises deployment without provider support. Firstly, it is needed to choose between two main options; then in case of on premises deployment selection it is necessary to choose the option related to the support services. In the previous part 9 issues to consider while choosing the deployment model were defined by combining different researchers' point of view:

- State of IT resources
- Experience with cloud solutions
- History with application upgrades

- Need to customize
- Users distribution
- Readiness to invest
- Total cost of ownership vs total cost of cloud service usage
- Trust to provider and desire to shift the responsibility
- Time of implementation

To make a decision algorithm there is a need to use only cutoff factors which enable to definitely choose which characteristic option should be selected. This requirement excludes such questionable issues of deployment as need to customize and total cost of ownership vs total cost of cloud service usage. Currently, in medical software market both cloud and on premises deployment solutions are highly customizable and there is no exact answer which is worth choosing in a particular case. Also total cost of ownership vs total cost of cloud service usage is rather ambiguous issue as the decision if the organization is ready to invest is influenced by many different factors like current state of IT resources or trust to third parties. The remaining 7 issues are included in the selection model. Also there are 2 issues that absolutely cut off one of the options. Firstly, cloud based solutions require continuous and reliable Internet access and if there is no stable Internet connection, there is no other way than selecting on premises deployment. Another issue is an opposite one, on premises deployment requires a server room and if there is no place for locating servers the only way is cloud deployment. In all other situations the preferable deployment of the data storage depends on the decision maker choice.

First of all it is important to identify if the healthcare institution has servers that can be used for data storage. Usually the life-cycle of such hardware as servers is 5 years of 24/7 usage [Garretson, 2010]. So it is essential that servers can be uses at least for a couple of years. If servers are out of date it is essential to identify is the healthcare institution going to replace them regardless the implementation of the healthcare information system. The question about replacing servers in the near future arises if servers are 3 years old or more.

The next point is the time of information system implementation. According to information given of the healthcare information systems providers' web-sites implementation of the system on cloud-based solutions takes less time and equals approximately to a month or less. Implementation of the information system on premises

takes more time, respectively. Therefore, if the time limits are essential for the healthcare organization cloud deployment would be more suitable without considering other factors.

Another important issue concerning the type of deployment is rather subjective and argued; there is no common opinion which type of deployment is more secure. As both types are safe enough this issue is more about trust to third parties and willing to be personally responsible for security of data. The next point is the location of the healthcare institution.

Several experts recommend using cloud data storage in case of dispersed locations [Crump, 2008; Byrne, 2011; Pinkett, 2015]. So if there are several healthcare institution centers located remotely from each other it is more convenient to use cloud solutions. Generally, scattered locations can be connected and store data on premises, however it is more complicated to organize such network and also it requires a good Internet connection, too. It worth noting that if healthcare institution is located in one place it doesn't mean that it shouldn't use cloud solutions.

Payment method is another issue that influences the choice of deployment type. Some healthcare institutions prefer to make one-time payment for the healthcare information system or modular payments, which suppose initial one-time payment for a module and subsequent payments for additional modules if they are considered as necessary. This type of payment is typical for on premises deployment as the software is considered to be a product and requires purchasing a license to use a solution. Some healthcare institutions prefer periodical payments for the information system. This type of payments is typical for cloud data storage as the software is considered to be a service of delivering application through the Internet and requires a subscription fee.

Experience of using cloud services plays a rather significant role in choosing the deployment model. If an organization got positive experience of using cloud storage it is more likely that it would like to continue using it. Negative experience of cloud based data storing would prevent the organization from using such storage again with a high probability [Wlodarz, 2014]. This is a natural reaction of a human being to avoid something that turned to be bad.

The last point to consider is willing to try cloud data storing. It is connected with the previous one, so those, who had negative experience of cloud solutions usage, are more likely to avoid trying it again. While having good experience is likely to cause willing to

use it again. However, the decision is highly subjective and is influenced by many factors including tacit ones.

Some decision maker choices can contradict each other, in such case the decision maker has to select the point that is more important for him. For example, healthcare institution would like to implement the information system very quickly, but at the same time it would like to be personally responsible for the data security. In this situation the decision maker has to choose what is more important for him the time of implementation or the security issue as these choices lead to different deployment models.

Talking about the options of on premises deployment, the choice depends on the availability of internal human resources. If the healthcare institution has IT- specialist(s) who are able to support the healthcare information system and the hardware it makes sense to choose on premises deployment without support, especially taking into account the fact that the majority of information system providers offer remote support in case of some problems. Finally, there are 3 options of deployment that can be chosen: cloud deployment, on premises deployment with provider support and on premises deployment without provider support. The part of the healthcare information system selection model reflecting data storage deployment is presented in Appendix 1.

The next characteristic of healthcare information systems is portable devise access. This feature allows medical personnel to reach the healthcare information system not only from personal computers in the office, but from their tablets and mobile phones, too. The main benefit of this function is providing a high level of flexibility for medical professionals. It is very convenient to have an access to information at different locations of the healthcare institution. However, unlike medical professional in hospitals, who needs to move around medical chambers, medical professional in healthcare institutions without permanent establishment have fixed personal offices and don't need to move around the institution on job purposes. So it seems that this benefit of portable devices access is a bit overestimated as not all medical professionals need so much flexibility and the opportunity of remote access as a result. Almost all medical professionals in most cases need different tests results to diagnose and treat the patient. Medical tests, except of lab tests, are usually presented in graphical format: MRIs, X-rays, ultra-sonographies, electrocardiograms, gastroscopies, etc. To evaluate the results of medical examinations it is more convenient to see them on a big high resolution screen to catch all the details. Portable devices like tablets can also be used for assessing medical examinations results as they also can have

rather big screen with high resolution. However, Evaluation of the tests results is not the only duty that medical professionals do; there is also a need to fill in the medical records and type prescriptions which is more convenient to do with a physical keyboard rather than on the virtual one. According to some tests the typing speed is a bit higher on a physical keyboard among experienced portable device users and almost twice higher among average portable device users [McCracken, 2010; McKinlay, 2012; Shultz, 2014]. It can be explained by the fact that the physical keyboard is more commonly and frequently used, especially by adults; also physical keyboard buttons are fixed and have tactile feedback, so there is less possibility to confuse adjacent buttons [McKinlay, 2012]. Also onscreen typists use fewer fingers (usually two thumbs) than physical keyboard typists, who usually use 6 fingers in average. Therefore personal computers are more beneficial and convenient for medical professionals' in healthcare institutions without permanent establishment every day activities than portable devices. Also if there is a need to double check any information it is more familiar to do it on PC and there is no need to use portable devices as it doesn't bring any benefits. Communication with colleagues can be realized through the smartphone; however it doesn't require special application or access to the information system. The last issue to consider is nurses, who help medical professionals in healthcare institutions without permanent establishment. Their common job is to write prescriptions and make referrals to other medical professionals if it is necessary and make appointments. This job can be done using portable devices, however patients can make their appointments by themselves, especially taking into account the need of aligning the appointments to personal timetable. Also it is irrational to provide several technological units to one office as the nurse can use the PC in the office while the medical professional is talking to the patient. Also usually medical professional dictate information to record to the nurse during the examination; this also proves the absence of necessity in 2 technical devices. Finally, despite the popularity of portable devices usage this feature is considered to be unnecessary for healthcare institutions without permanent establishment as its main benefit – flexibility is not used in such organizations. Therefore this characteristic was excluded from the healthcare information system selection model.

Another characteristic of healthcare information system is availability of patient portal. Patient portal allows patients online access to their health data and bring almost no direct benefits to the healthcare institution. The main advantage of the patient portal is that it adds value to the healthcare institution services [Reicher et al, 2015; Guercio, 2014; Guerrero, 2015]. Also some patient portals consider themselves as value-added service

[North Alabama Health Information Exchange]. Therefore, if healthcare institution wants to add value to its patients it should include patient portal in the healthcare information system. There are 2 different options of patient portal: one direction patient portal and two direction patient portal. Two direction patient portals bring more value to patients as they can communicate with the healthcare institutions and get initial consultations remotely. Moreover, it can decrease the number of self-treatments as the patient can consult online and exactly know if there is a need to visit the medical professional. From the healthcare institution point of view two direction patient portal costs more, but at the same time it can increase the rate of attendance because of self-treatment decrease. Also patients will be more loyal and switching cost for them will become higher. However, the medical professional is not able to communicate with patients online during the working hours, so there is a need to hire wide-profile medical consultant to reply the questions. Therefore, both types of patient portals bring value to patients; two direction patient portals add more value for customers, but cost more. It is difficult to precisely define which one is better as both have its own advantages and disadvantages. So the decision maker should define which option is more suitable for him and what is more preferable to save money or to bring more value to patients and increase loyalty. The part of the healthcare information system selection model reflecting patient portal feature is presented on Figure 6.

Healthcare information systems have such function as Big Data analytics. This function is necessary for processing heterogeneous information of different formats and creating report of different levels and time. Medical information is heterogeneous – medical record of one patient can include such information formats as text, images, tables and sometimes even videos. To process this data special analytical tools are necessary. Therefore, if healthcare institution uses special medical equipment like radiological apparatus, electrocardiographs or MRI machines it is necessary to include Big Data Analytics module to the information system. Also this feature is needed if healthcare institution is willing to get statistics and have an ability to drill it up and down. Getting statistical reports can be used not only for keeping track of the KPIs, but for optimizing business processes and making decisions, too. Big Data analytics is a good business intelligence tool that helps in all activities of a healthcare institution from the medical care to procurement and finance. So if healthcare institution has special medical equipment, wants to keep track of the statistics or is willing to optimize its work it should include Big Data analytics module into its healthcare information system. Generally, there are two

options: to implement Big Data analytics or not. The part of the healthcare information system selection model reflecting Big Data analytics feature is presented on Figure 6.

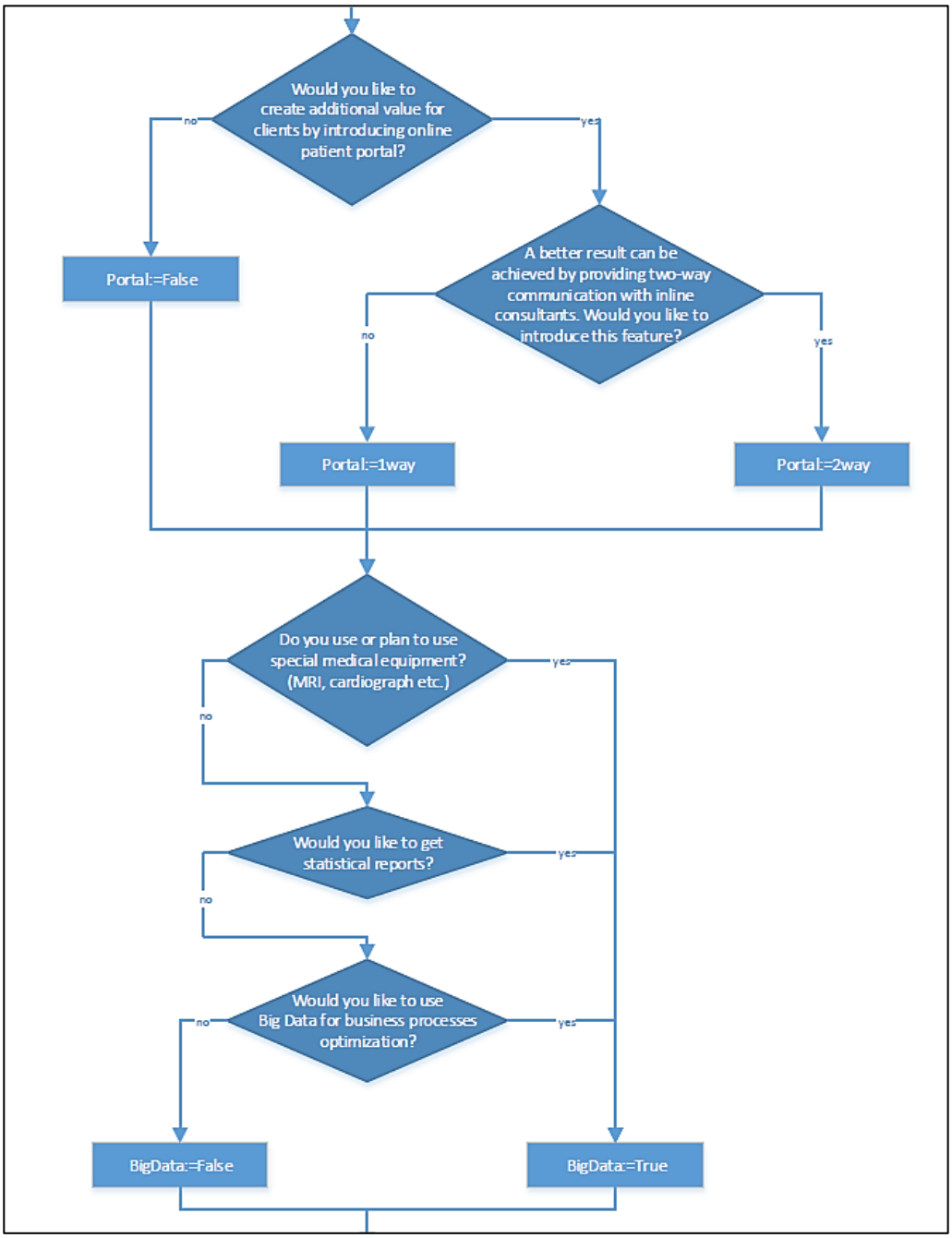

Figure 6. Healthcare information system selection model – patient portal feature & Big Data analytics

The last primary characteristic of healthcare information system is training programs. The majority of healthcare information systems providers offer training programs that can be included in the information system purchase or provided on the provider web-site for free or can be purchased as additional service. Training programs are absolutely necessary for unexperienced users or those, who are not sure in their skills. Also

healthcare institution might not purchase training programs if it has internal resources for education, for example there is an employee, who is familiar with information systems and can teach others how to use it. Generally, there are two options: to get educational trainings or not. The part of the healthcare information system selection model reflecting training programs is presented on Figure 7.

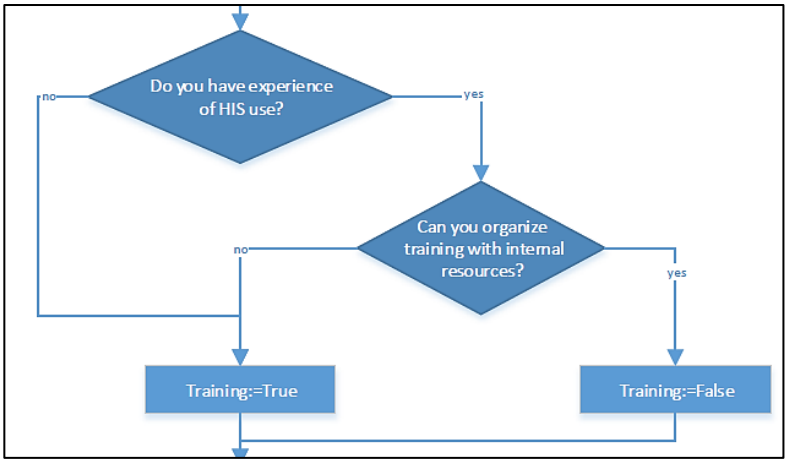

Figure 7. Healthcare information system selection model – training programs

Finally, there are 5 key characteristics to consider in the first part of the selection model: operating system, data storage deployment, availability of patient portal, Big Data analytics and training programs. Portable device access was excluded from the selection model as it was considered to be unnecessary for healthcare institutions without permanent establishment.

There are also 7 additional functions of healthcare information systems each of which has two options to implement it or not.

The first function to consider is biometric authentication. Biometric authentication is a tool that uses unique biological characteristics of a person to verify identity for secure access to electronic systems. This feature is used for a great variety of activities from searching for known individuals to verifying that the individual has no identity in the system at all. However, the primary goal of this feature is providing high level of security of the information system as all the actions are aimed at not giving access to “external” no the system individuals [Wayman et al, 2005]. The security of information systems using traditional authentication methods (logins and passwords) usually suffer from 4 main problems. Firstly, it is recommended to use complex passwords that include numbers, letters, and special symbols. Such passwords are very hard to remember and it takes time to input them, that’s why many organizations take risk and don’t use so complex ones

[Jackson, 2013; Orloff, 2015]. Secondly, it is recommended to change passwords several times a year to protect the information from brutes. However, not all organizations follow this advice as it can be difficult to remember new passwords. The problem of remembering passwords leads to the third security threat – some users write down their passwords and moreover sometimes attach them to the monitor screen. The last security threat is exchanging passwords among the users in case someone didn't come to the job and shared password to the colleague to provide access to his account. All these problems can be solved by using biometric authentication as unique biological characteristics can't be exchanged or hacked. Also biometric authentication is recommended to use if healthcare institution employs aged medical professionals who have good IT skills to use information system but it is hard for them to remember logins and passwords. It worth noting that as this feature is necessary for those who concern much about the information security it is a bit illogically to implement it on the cloud solutions as the organization entrusts this essential issue to third parties. However, if the function is used to facilitate authentication process it can be utilized. The algorithm of deciding on the necessity of the biometrical authentication feature is presented on figure 67.

Talking about aged medical professional without any IT skills it is recommended for healthcare institutions to implement handwriting and speech recognition function. It is very hard to make aged employees without IT skills to use information system and it is likely that they would resist and use paper-based medical records as this procedure is familiar to them. This problem can be solved by handwriting and speech recognition function that enables to convert handwritten text into e-format. The algorithm of deciding on the necessity of the handwriting and speech recognition function is presented on figure 7.

The next additional feature is 3D reconstruction, which is needed for those, who already use such software and would like to combine it with the healthcare information system. Talking about integration with government systems this function as the previous one is necessary for those who exchange documents with the governmental institutions. The algorithms of deciding on the necessity of the 3D reconstruction and integration with government systems functions are presented on figure 8.

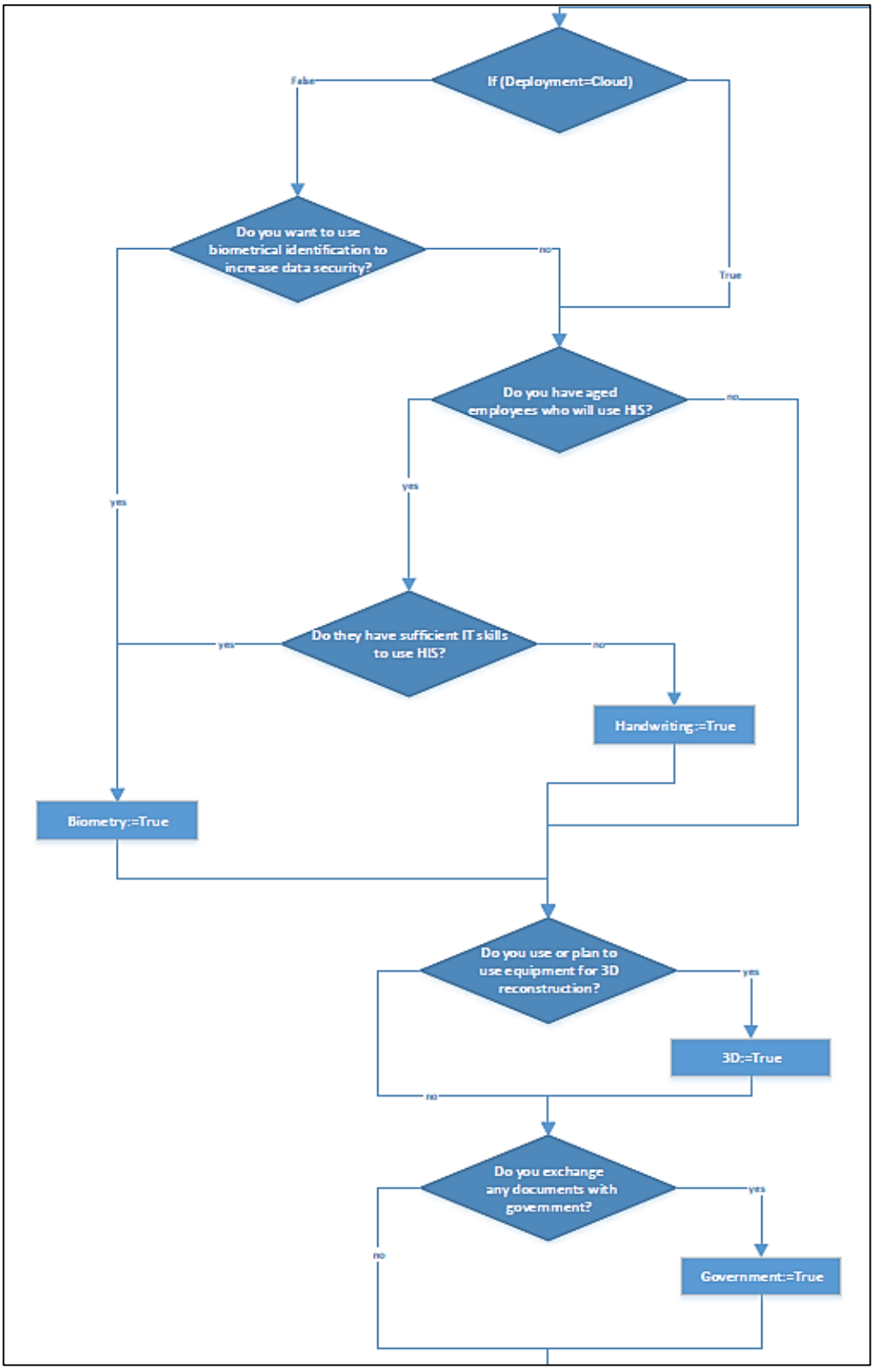

Figure 8. Healthcare information system selection model – additional healthcare information systems functions: biometrical authentication, handwriting and speech recognition, 3D reconstruction, integration with government systems

The next feature is SMS reminder, which is used to remind patients of their appointments. This additional function is necessary for healthcare institutions with high level of missing appointments without any notifications. There is also a similar feature – build-in reminder, which is used not only for patients' recalling, but also for medical personnel. From the users' point of view it works like a calendar and reminds medical professionals of important events. This feature is needed if medical personnel frequently forget and miss deadlines and meetings. As this feature pertly overlaps the previous one there is no need to include both in the information system simultaneously. The algorithm of deciding on the necessity of the SMS reminder or Build-in reminder is presented on figure 9.

The last additional feature of the healthcare information systems is allergy checks. This function implies an automatic check at the point of care of patient's allergy list and an alert if the patient is allergic to a medicine that is going to be prescribed. This function increases the efficiency of care and decreases the time of care by removing the necessity to check this information by hand. Allergy check function can be considered as a risk management tools as it manages the risk of prescribing the wrong medicine and dealing with the negative consequences of such mistake. According to internet journal Medicine in Russia drug allergy is one of the 5 most frequent allergies in Russia. According to Russian Institute of Immunology about 10-20% of the country population suffers from drug allergy in average. Healthcare institutions with higher or equal to country average percentage of drug allergic patients are recommended to include allergy check feature into their healthcare information systems. Other healthcare institutions can implement this feature if they wish. The algorithm of deciding on the necessity of the allergy checks feature is presented on figure 9.

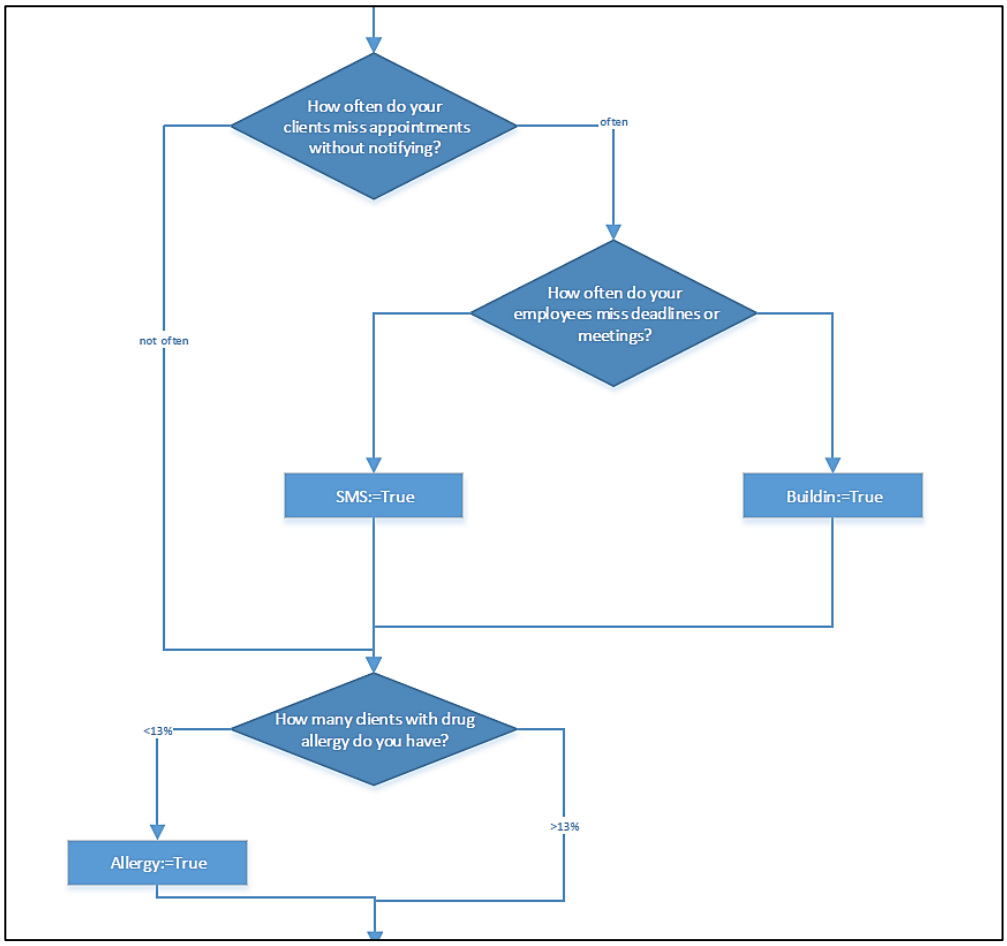

Figure 9. Healthcare information system selection model – additional healthcare information systems functions: SMS reminder, Build-in reminder, Allergy checks

Finally, the second part of the selection model includes 7 additional functions that can be included in the information system or not: biometric authentication, handwriting and speech recognition, 3D reconstruction, integration with government systems, SMS reminder, build-in reminder, allergy checks function. Build-in reminder is the only feature that excludes the usage of another feature (SMS reminder), while all other features are compatible with each other.

As a result healthcare institution gets a list of recommended healthcare information system features from 5 key characteristics: operating system, data storage deployment, availability of patient portal, Big Data analytics and training programs; and 7 additional characteristics: biometric authentication, handwriting and speech recognition, 3D reconstruction, integration with government systems, SMS reminder, build-in reminder, allergy checks function.

3.2 Managerial implications of main findings

The results of this research can be used by healthcare institutions several different ways. Firstly, the results of interviews with experts from healthcare institutions experienced in utilizing healthcare information systems can be used by unexperienced in this issue decision-makers to assess their knowledge in this field. Decision-makers, who are going to select healthcare information system can create the list of their own initial selection criteria and compare it to the opinion of experienced healthcare institutions. If the lists turned up to be similar them decision-maker seems to have enough knowledge in this sphere and can take into account his own opinion. However, he also should use the developed model as there are also different options in each of the criteria and several additional functions. In case the initial decision-maker's criteria don't resemble the "experienced" criteria, decision-maker shouldn't rely on his own opinion because of lack of knowledge and should use the developed model to select the system.

Developed healthcare information system selection model can be useful for both experienced and unexperienced healthcare institutions. Unexperienced healthcare institution without any information system can use the developed model to choose its first healthcare information system that will be appropriate particularly for it. Using the selection model healthcare institution will get recommendations about the options of key healthcare information system features: operating system, deployment, patient portal, Big Data analytics and training programs; and about the necessity to implement any of additional features like biometric authentication, integration with government systems, SMS reminder, build-in reminder, 3D reconstruction, allergy checks or handwriting and speech recognition. As a result healthcare institution will be able to choose healthcare information system that has recommended features.

Talking about healthcare institutions that already have healthcare information system there are two possible ways of utilizing developed selection model. Firstly, it can be used to check suitability of the currently used healthcare information system. In such case healthcare institution should answer the questions of the selection model considering the initial situation before the information system implementation. After going through the whole decision-tree healthcare institution will get the list of recommended features to compare with features of existing information system. As a result current system can be either appropriate or not appropriate for healthcare institution. If the current system was considered not suitable for healthcare institution, it can use the recommended features to

choose the new system or improve the current one if it is modular and necessary modules are available. Secondly, the model can be used by experience healthcare institutions initially for choosing the new information system if they are not satisfied by the current one.

Comparative table of 50 healthcare information systems can also be used by healthcare institutions after getting the list of recommended features from the selection model. Healthcare institutions can select healthcare information systems using appropriate features from the created list of compared systems. Also this comparison table can be used for getting briefly acquainted with the general features of different healthcare information systems.

3.3 Summary of chapter 3

The third chapter is dedicated to the development of healthcare information system selection model for healthcare institutions without permanent establishment. Healthcare institutions with permanent establishment require different methodology and conducting a separate study, so they were not considered in this research. The selection model is aimed at helping healthcare institutions to choose an appropriate healthcare information system according to their needs. This model is presented in a form of an algorithm with easy-to-understand questions. After answering all the questions healthcare institution gets the list of necessary functions that should be included into healthcare information system to be suitable for a particular institution.

The selection model is based on the healthcare information systems comparison analysis and on the results of the interviews. There are 13 characteristics of healthcare information systems considered in the selection model: 5 key features and 7 additional ones. Every characteristic has at least 2 options, so it was decided to use variables in the decision algorithm to narrow it and to avoid duplication of brunches. The questions in the healthcare information systems selection model were designed in the way to be understandable for decision-makers with limited IT knowledge. Therefore, there is no need to deep in technical details of healthcare information systems and to make additional efforts to select and appropriate healthcare information system. The full healthcare information system selection model is presented in Appendix 1.

Limitations and validation

The healthcare information systems selection model created as a result of this study is suitable only for healthcare institutions without permanent establishment. Availability of permanent establishment in healthcare institution requires special modules in healthcare information systems or even special information systems. Also permanent establishment requires individual analysis as it is necessary to consider more factors, for example issues connected with managing beds paces. Therefore, there is a need to conduct a separate study for healthcare institutions with permanent establishment concerning the healthcare information systems selection issue. Consequently, it was decided to exclude healthcare institutions with permanent establishment from this study to narrow the research and focus on a particular field.

Discussion

There are many different challenges in the healthcare industry and it widely agreed that the key solution is information systems and information technology implementation in healthcare management [Stegwee and Spil, 2001, 1–10]. Therefore, the problem of healthcare information systems selection is a topical one as only appropriate healthcare information system can bring all the potential benefits to the healthcare institution.

The research is based on con analysis of 50 different healthcare information systems and expert opinion of 6 healthcare institutions in St-Petersburg that already have experience in healthcare information system utilization.

The content analysis of existing healthcare information systems is aimed at distinguishing key features of such systems and available options regarding these features. After the analysis 13 different features of healthcare information systems were identified. 6 of them were considered as the key characteristics as their options take place in the majority of healthcare information systems. The list of the key features of healthcare information systems is as following:

- operating system
- data storage deployment
- patient portal
- portable device access
- Big Data analytics
- training programs

Though, only 5 of them were then included in the healthcare information system selection model. Portable device access feature was excluded from the list of selection criteria according to the limitations of the study. The main benefit of this characteristic is medical personnel flexibility. However, for medical professional in healthcare institutions without permanent establishment this point ceases to be an advantage as they meet patients is their fixed offices. In case of a permanent work place personal computers have a great advantage over mobile devices like size and resolution of the screen or physical keyboard for more effective typing.

Other 7 features of healthcare information systems were considered as additional functions as they occur only in some of the reviewed information systems. All the additional characteristics were included in the healthcare information systems selection

model with 2 options either existence or absence of the feature. The list of the additional features of healthcare information systems is as following:

- biometric authentication
- handwriting and speech recognition
- integration with government systems
- SMS reminder
- build-in reminder
- 3D reconstruction
- allergy checks.

6 interviews with experts from St-Petersburg healthcare institutions that are experienced in healthcare information systems usage were conducted. The aim of the interviews was to distinguish how healthcare institutions choose healthcare information systems and how the experience affected the selection criteria. There were two main groups of the respondents: healthcare institutions that selected healthcare information system with the help of IT-specialists and healthcare institutions that selected healthcare information system themselves. The main difference among these groups was the initial selection criteria. The first groups based their choice on such criteria as functionality, technical support in St-Petersburg and domestic development. The second group selected information system basing on more subjective criteria like reviews and references. After several years of healthcare information system usage both groups changed their opinion about the selection criteria. All key features of healthcare information systems distinguished from the content analysis were chosen as selection criteria at least once. Basing on this information all the features except portable device access were included in the healthcare information systems selection model.

This study aims at helping healthcare institutions to choose suitable healthcare information system and avoiding wasting financial resources for unnecessary for the particular medical institution features. Appropriate healthcare information system helps healthcare institutions to become more effective and efficient and keep up with the times.

Created healthcare information system selection model is relevant only for healthcare institutions without permanent establishment as there is a separate group of healthcare information systems and modules which are used in clinics with permanent establishment. Further research should be conducted to adapt this selection model to hospitals and other medical institutions which have permanent establishment. This

healthcare information systems selection model can be a base for further researches in this field and the similar methodology can be used to expand the model so that it can be used by healthcare institutions with permanent establishment. Also there is a need to review information systems and modules used for considering places for permanent establishment and other factors connected with this issue.

Besides, there can be more than 7 additional features of healthcare information systems found during the content analysis of 50 selected healthcare information systems. Further studies can take into consideration a greater number of healthcare information systems and include some individually designed systems into comparison to broaden the list of available in healthcare information systems functions. Also more foreign healthcare information systems should be included in the further researches as they can contain more additional features that were distinguished through the comparison analysis during this study.

The last point is that issue of healthcare information systems selection was considered only from technical point of view. However, there can be some features of the healthcare institution that influence the choice. Further researches can be conducted to identify whether any features of organization, for example, size or the number of medical areas, affect the healthcare information systems selection.

Conclusion

Currently, IT technologies are developing in different industries all over the world and healthcare industry is not an exception. Information technologies appeared in healthcare institutions in 1960s with first electronic applications and the industry is moving forward very fast, especially recent years. IT technologies become more and more advanced and attractive.

Healthcare institutions all over the world started implementing modern technologies; such systems are called healthcare information systems. This rapid development of IT solutions brings many opportunities and benefits to healthcare institutions and helps them to become more effective and efficient and to increase the level of care. Many researches and studies concerning healthcare information systems were conducted to explore the benefits of IT solutions implementation and the implementation process itself.

However, the development of technologies brings some challenges, too. It became very difficult for healthcare institutions to define how they should choose healthcare information systems that would fit their needs? There is a gap in studying the preliminary stage of healthcare information systems implementation – the selection of appropriate system.

In Russia this issue becomes a hot topic as the healthcare industry develops and healthcare information systems gain popularity. In case information system doesn't fit particular healthcare institution, for example there are unnecessary functions; healthcare institution wastes its resources and the efficiency decreases. Therefore, it is necessary to select an appropriate healthcare information system to get all the potential benefits.

The purpose of the study was to fill the research gap and identify how to healthcare institutions without permanent establishment should select healthcare information system. This study aims at helping healthcare institutions to choose suitable healthcare information system and avoiding wasting financial resources for unnecessary for the particular medical institution features. Appropriate healthcare information system helps healthcare institutions to become more effective and efficient and keep up with the times.

The research was based on content analysis of 30 Russian and 20 foreign healthcare information systems and expert opinion of 6 healthcare institutions that already have experience in healthcare information system utilization, which are presented in Chapter 2.

As a result a healthcare information systems selection model was created for healthcare institutions without permanent establishment. The development of healthcare information system selection model is presented in Chapter 3. This model is aimed at facilitating the decision making process concerning the issue of choosing an appropriate healthcare information system. The selection model is presented in a form of a decision tree and designed in a way that a decision-maker without special IT knowledge could use it to make a choice. 12 healthcare information system characteristics distinguished during the content analysis of existing solutions were included in the selection model. The significance of the features as selection criteria were proved by their analysis and the expert opinion of healthcare institutions experienced in healthcare information systems usage.

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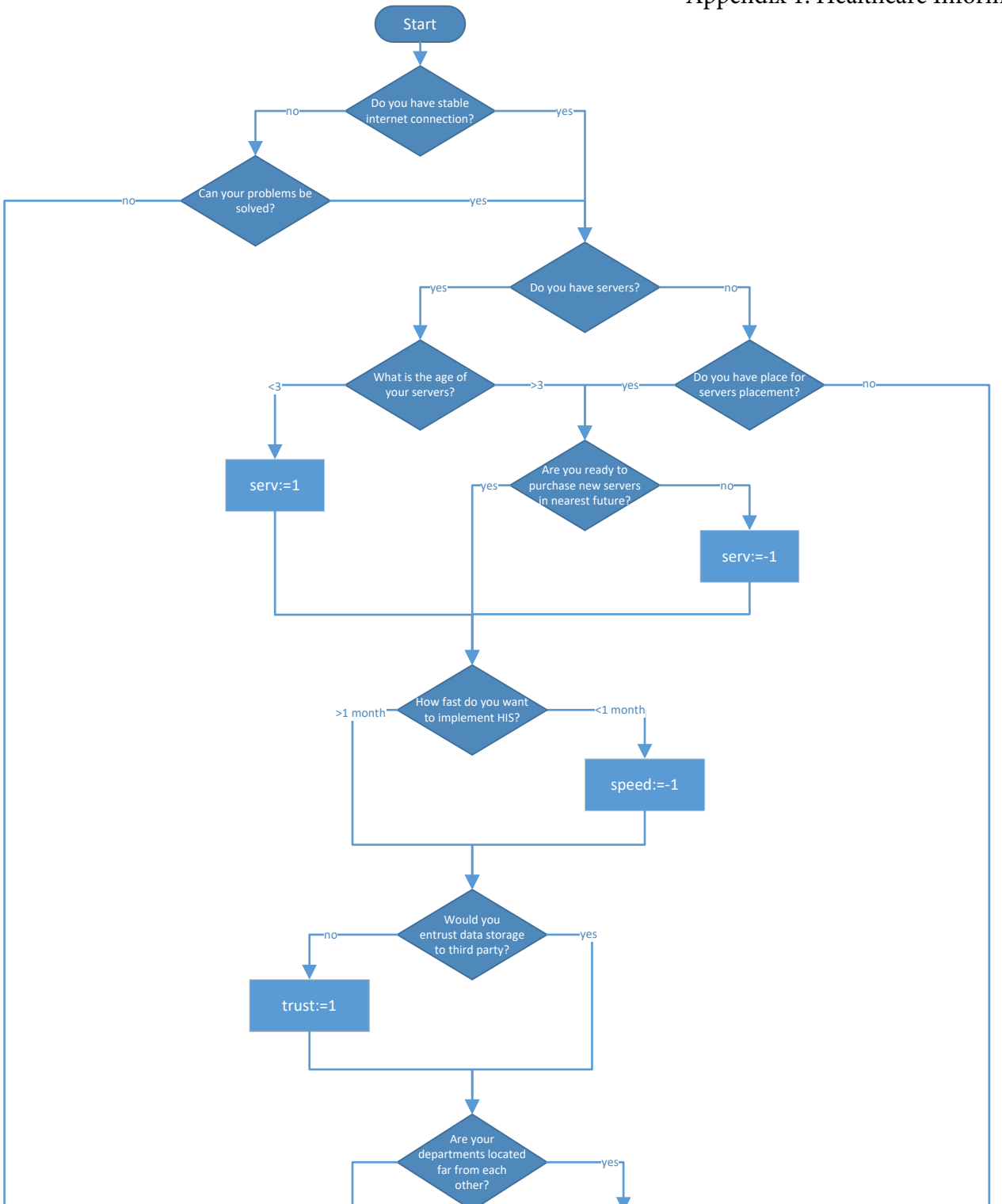
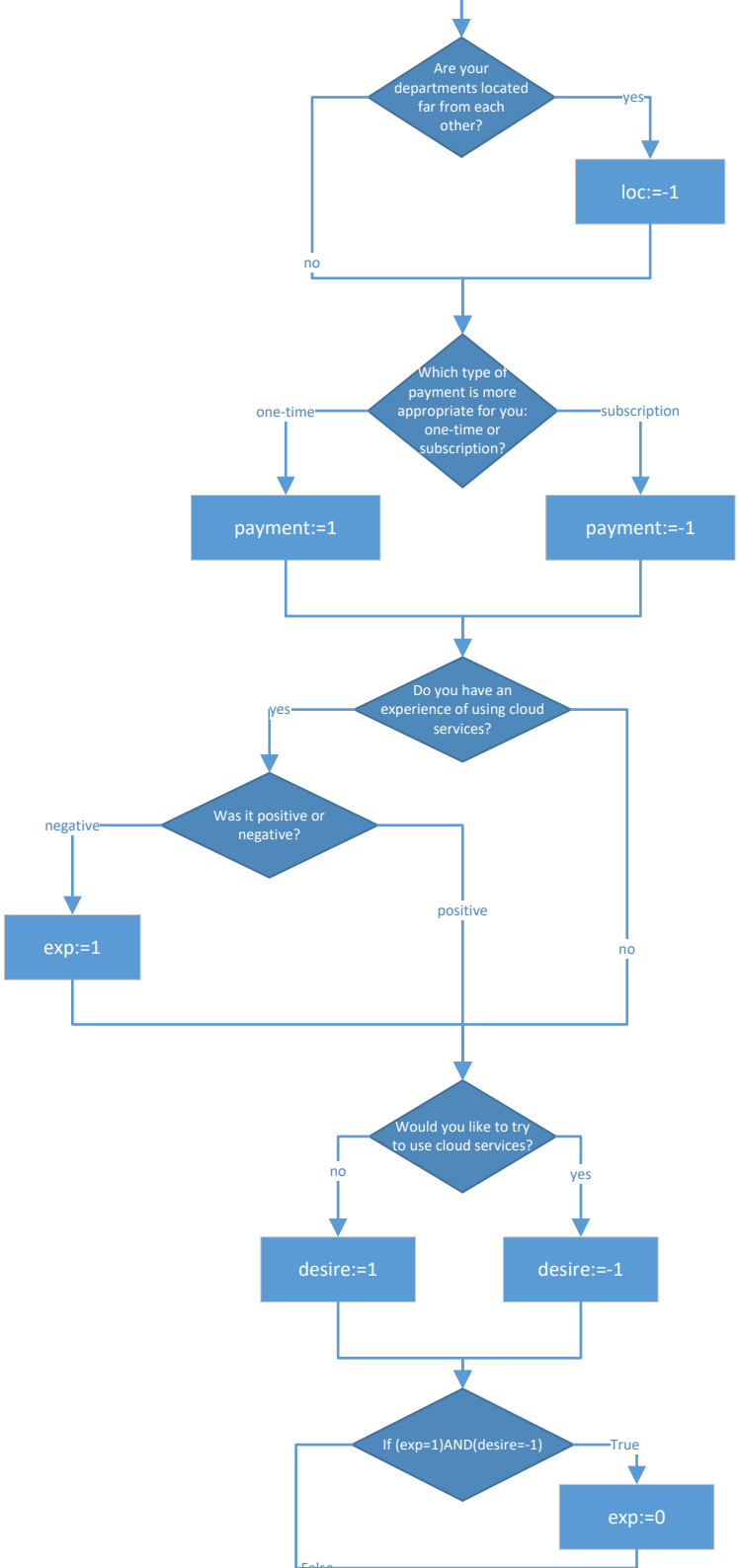
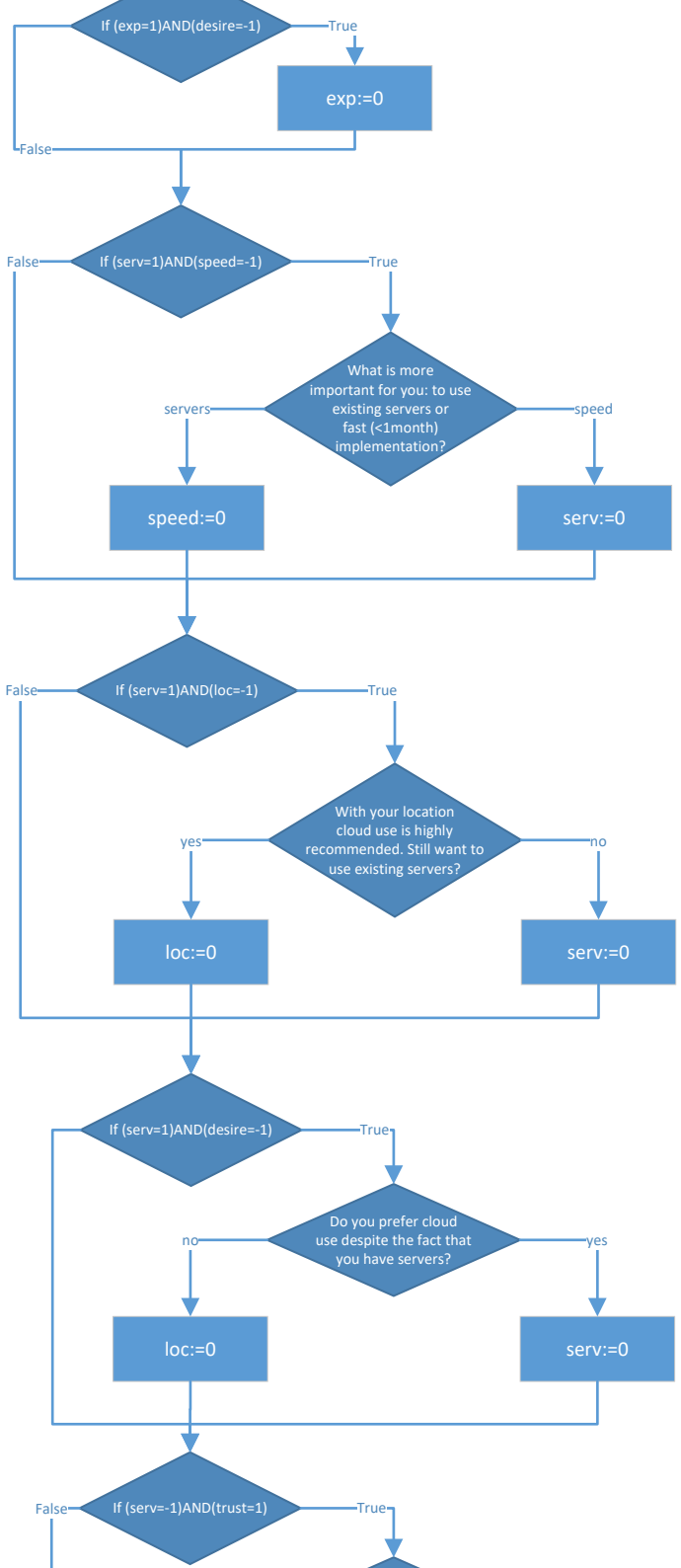
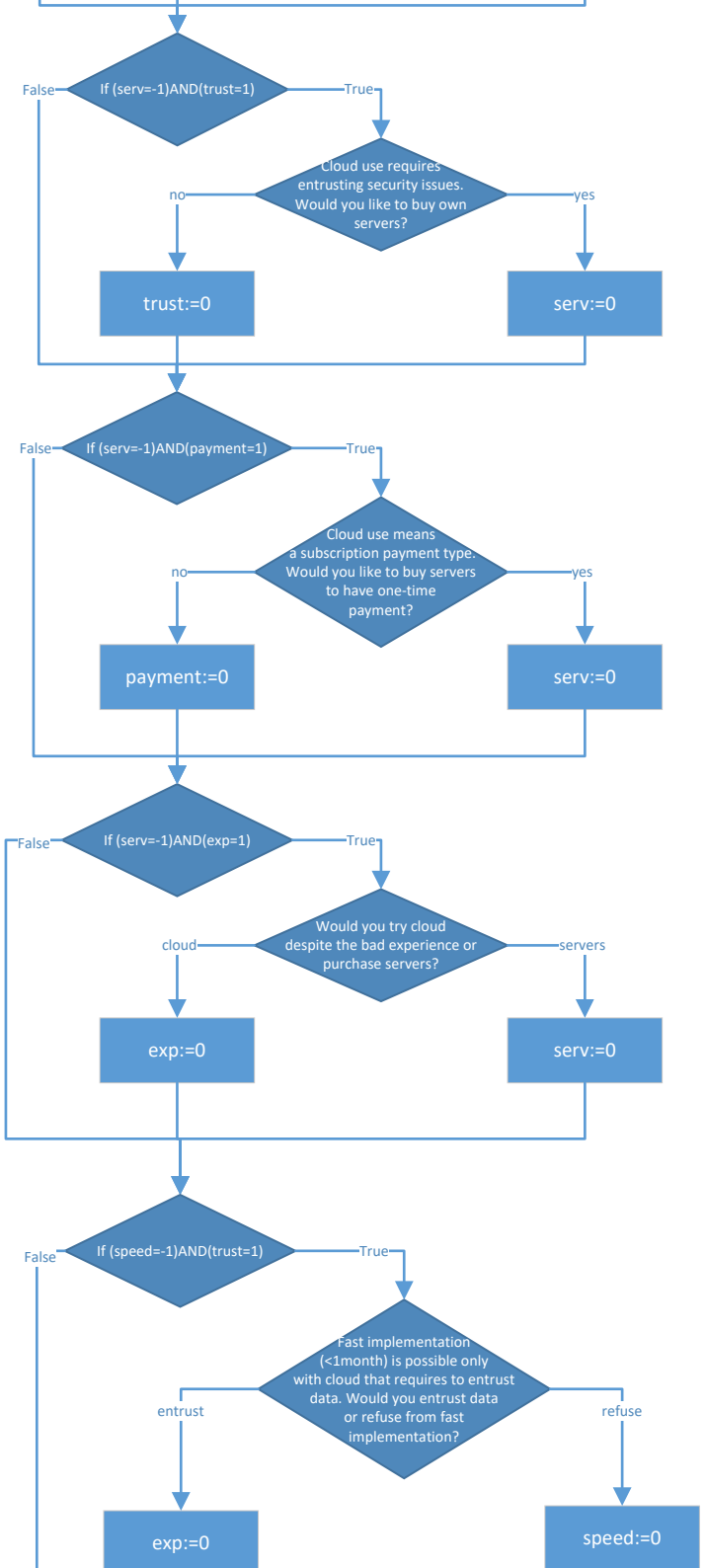
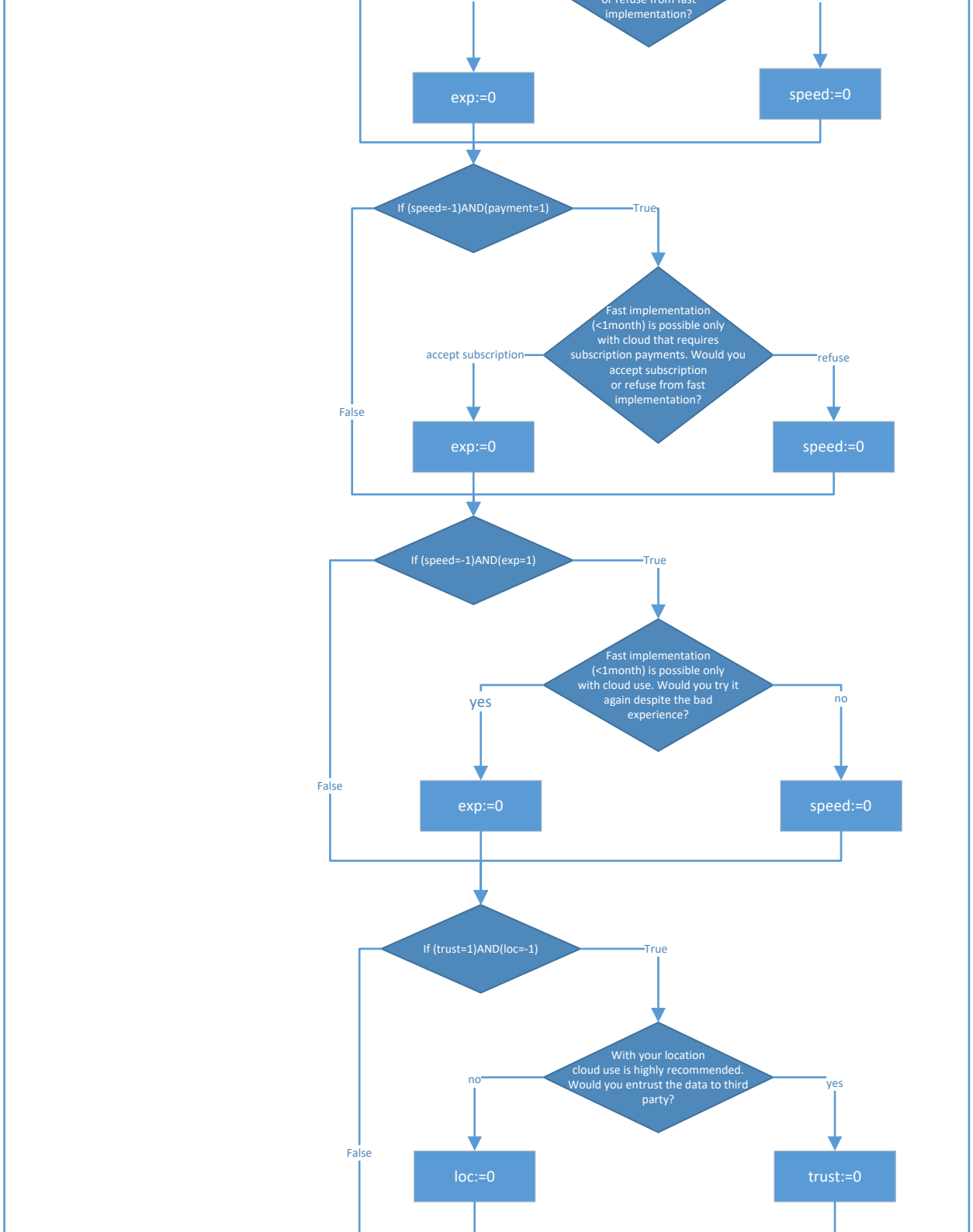
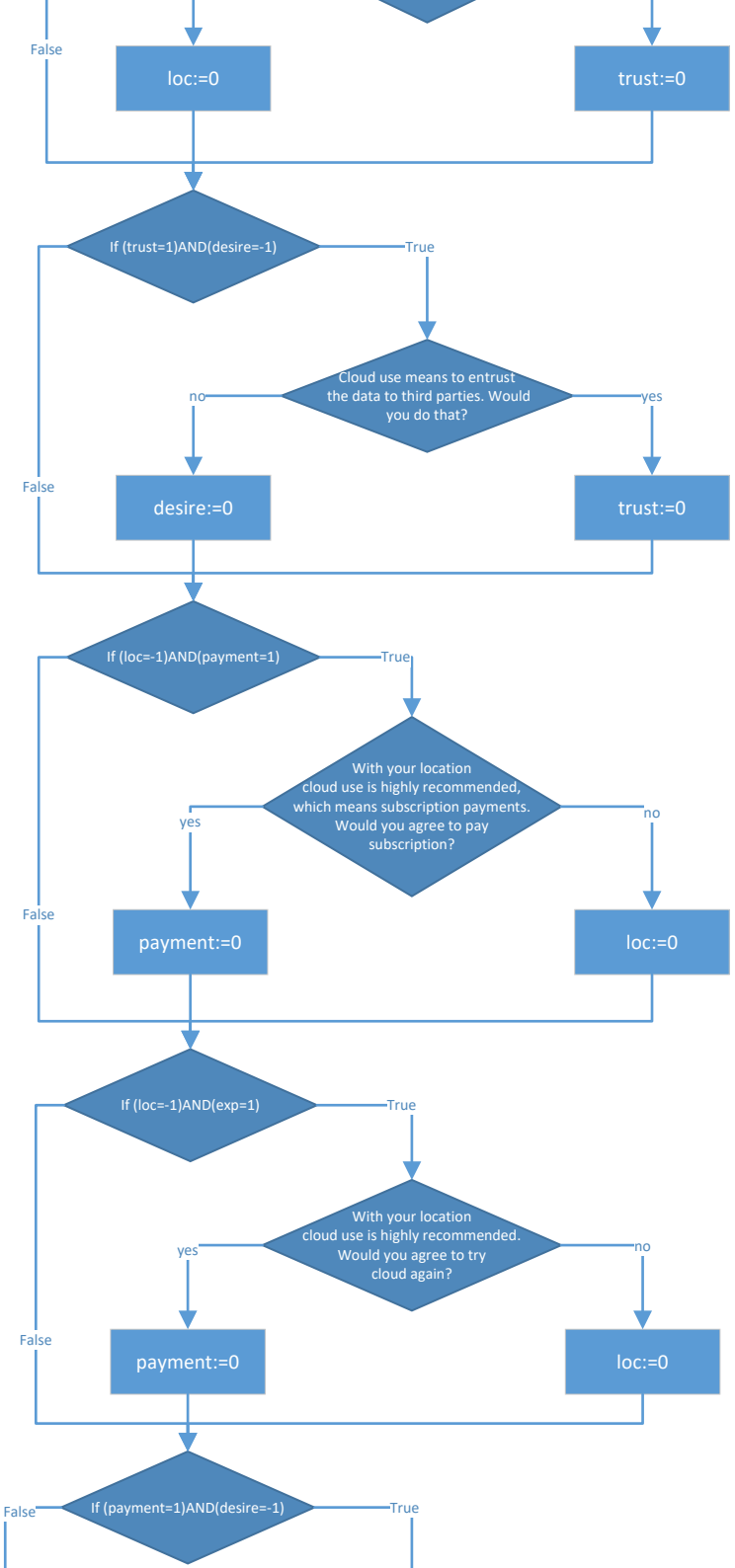

Start
Do you have stable internet connection?
no
yes
Can your problems be solved?
no
yes
Do you have servers?
yes
no
What is the age of your servers?
<3
>3
yes
Do you have place for servers placement?
no
serv:=1
Are you ready to purchase new servers in nearest future?
yes
no
serv:=-1
How fast do you want to implement HIS?
>1 month
<1 month
speed:=-1
Would you entrust data storage to third party?
no
yes
trust:=1
Are your departments located far from each other?
yes

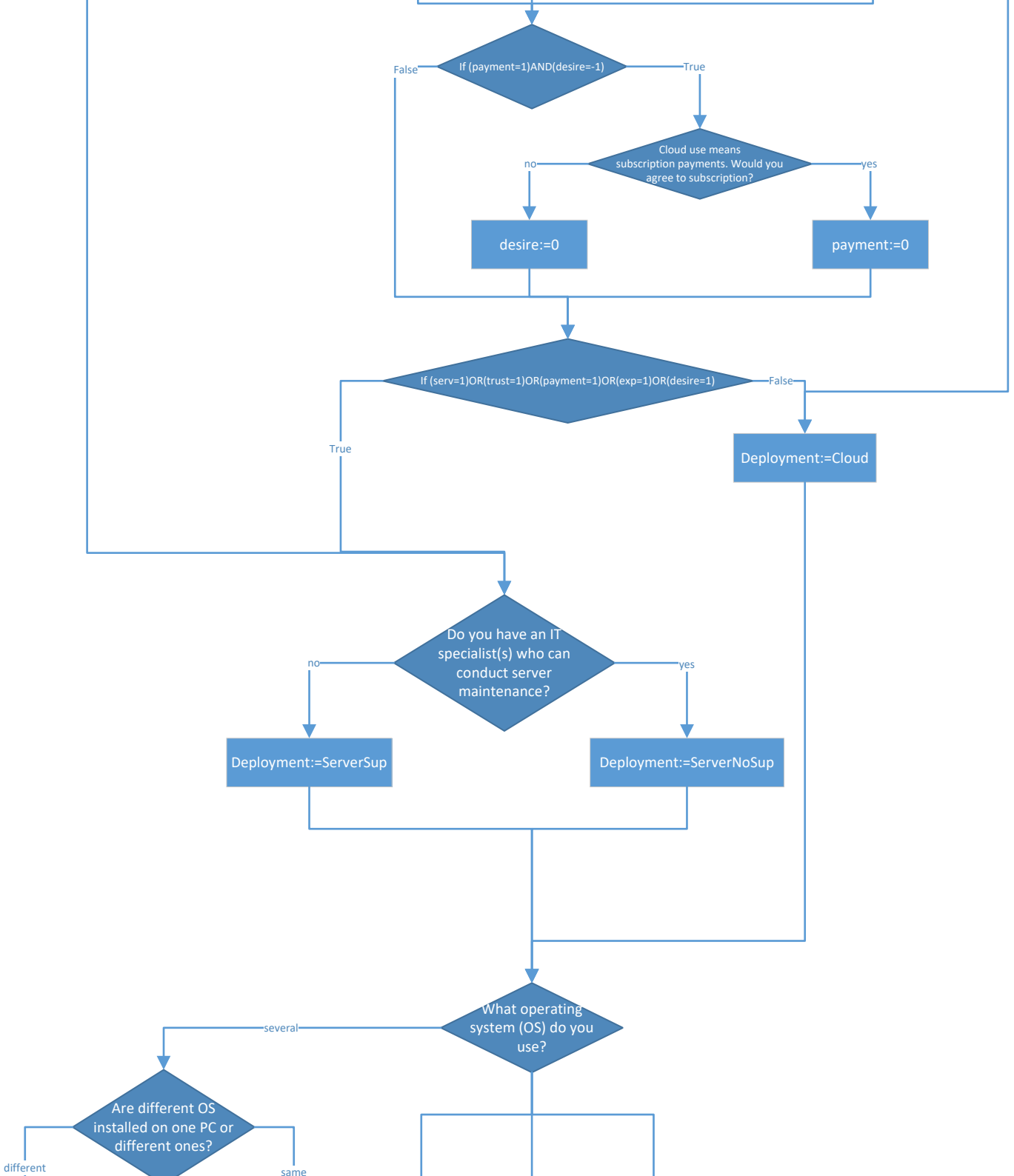

Are your departments located far from each other?
yes
loc:=-1
no
Which type of payment is more appropriate for you: one-time or subscription?
one-time
subscription
payment:=1
payment:=-1
Do you have an experience of using cloud services?
yes
Was it positive or negative?
negative
positive
exp:=1
no
Would you like to try to use cloud services?
no
yes
desire:=1
desire:=-1
If (exp=1)AND(desire=-1)
True
exp:=0

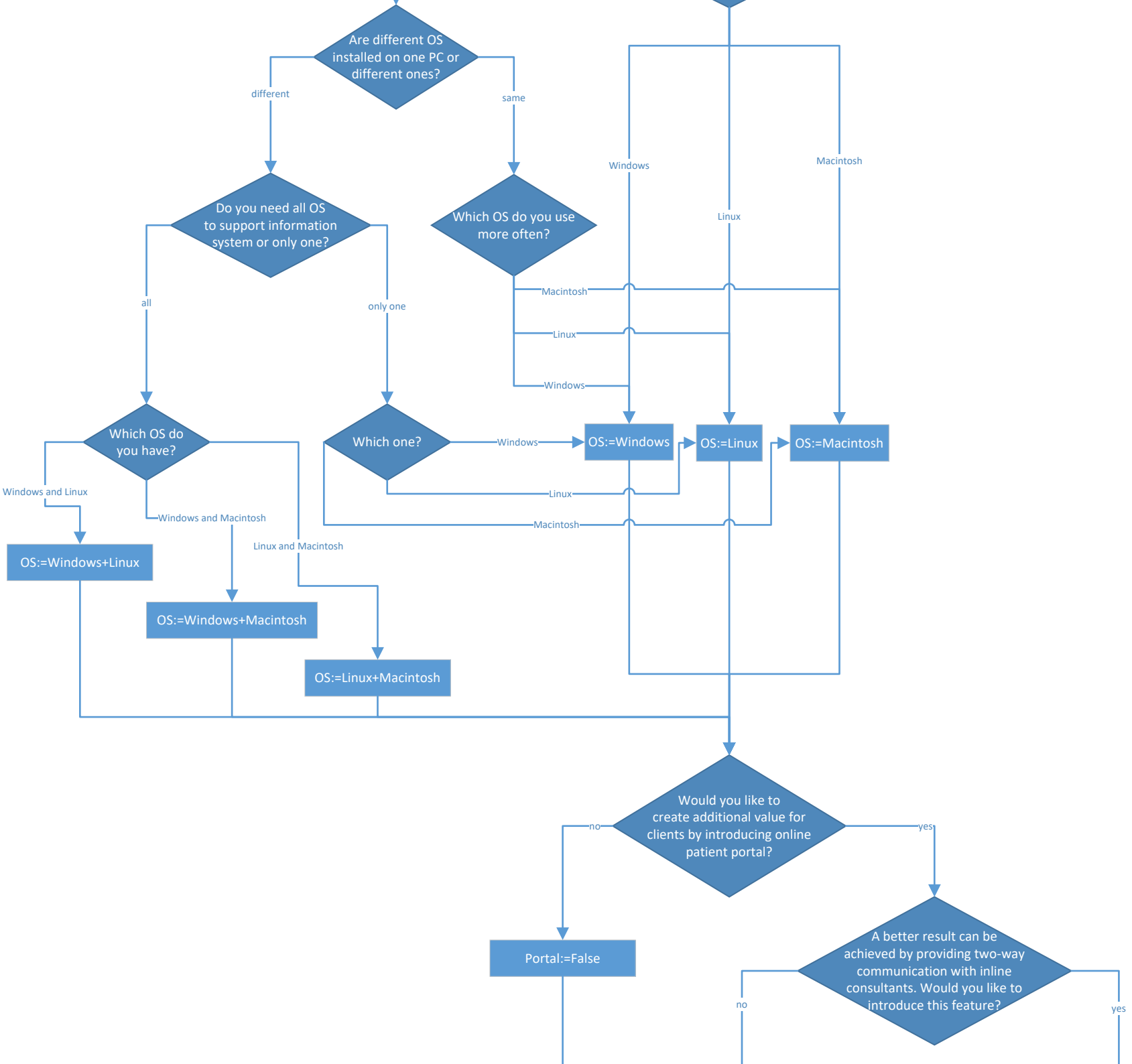

If (exp=1)AND(desire=-1)
True
exp:=0
False
If (serv=1)AND(speed=-1)
False
True
What is more important for you: to use existing servers or fast (<1month) implementation?
servers
speed
speed:=0
serv:=0
If (serv=1)AND(loc=-1)
False
True
With your location cloud use is highly recommended. Still want to use existing servers?
yes
no
loc:=0
serv:=0
If (serv=1)AND(desire=-1)
True
Do you prefer cloud use despite the fact that you have servers?
no
yes
loc:=0
serv:=0
If (serv=-1)AND(trust=1)
False
True

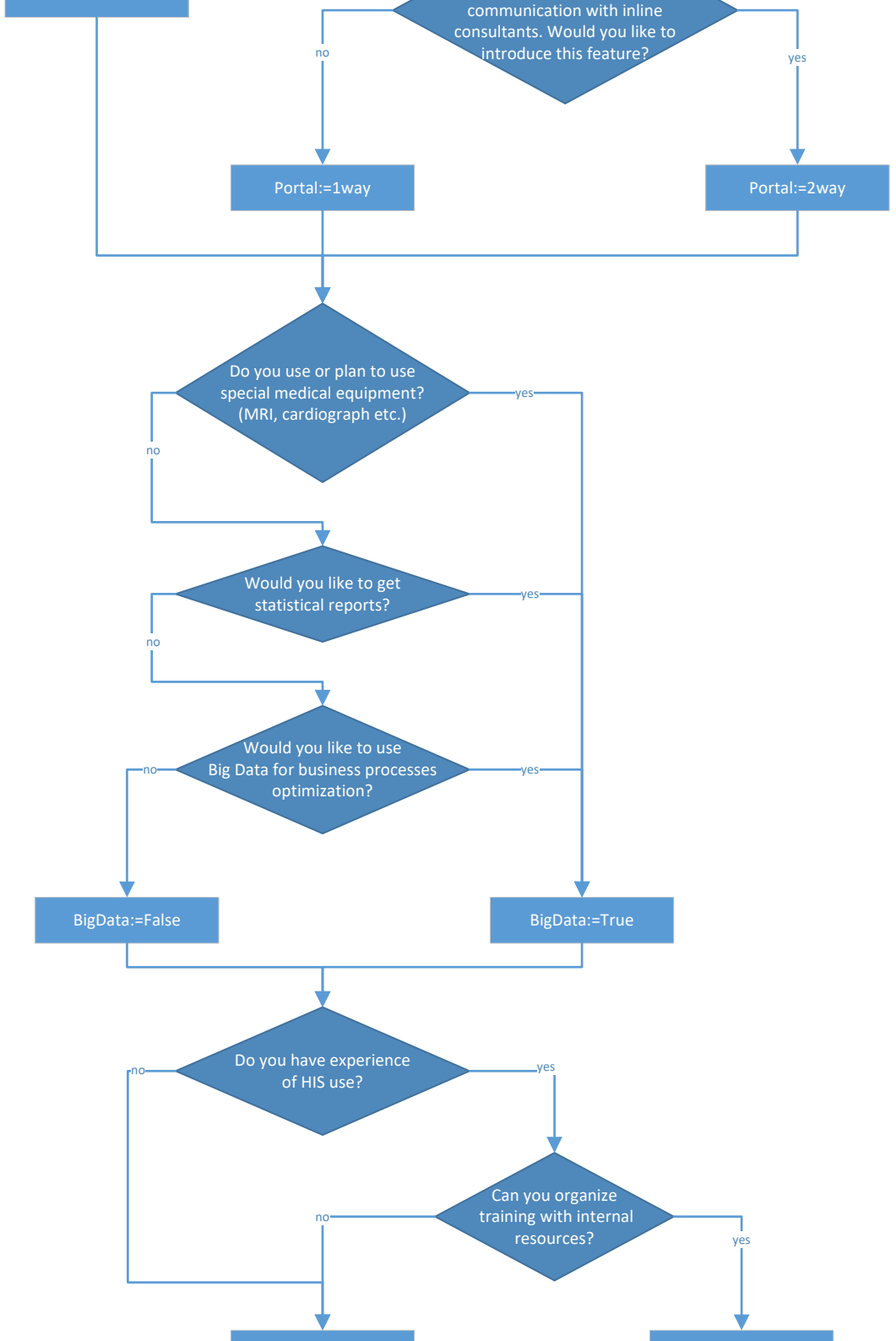

If (serv=-1)AND(trust=1)
False
True
Cloud use requires entrusting security issues. Would you like to buy own servers?
no
yes
trust:=0
serv:=0
If (serv=-1)AND(payment=1)
False
True
Cloud use means a subscription payment type. Would you like to buy servers to have one-time payment?
no
yes
payment:=0
serv:=0
If (serv=-1)AND(exp=1)
False
True
Would you try cloud despite the bad experience or purchase servers?
cloud
servers
exp:=0
serv:=0
If (speed=-1)AND(trust=1)
False
True
Fast implementation (<1month) is possible only with cloud that requires to entrust data. Would you entrust data or refuse from fast implementation?
entrust
refuse
exp:=0
speed:=0

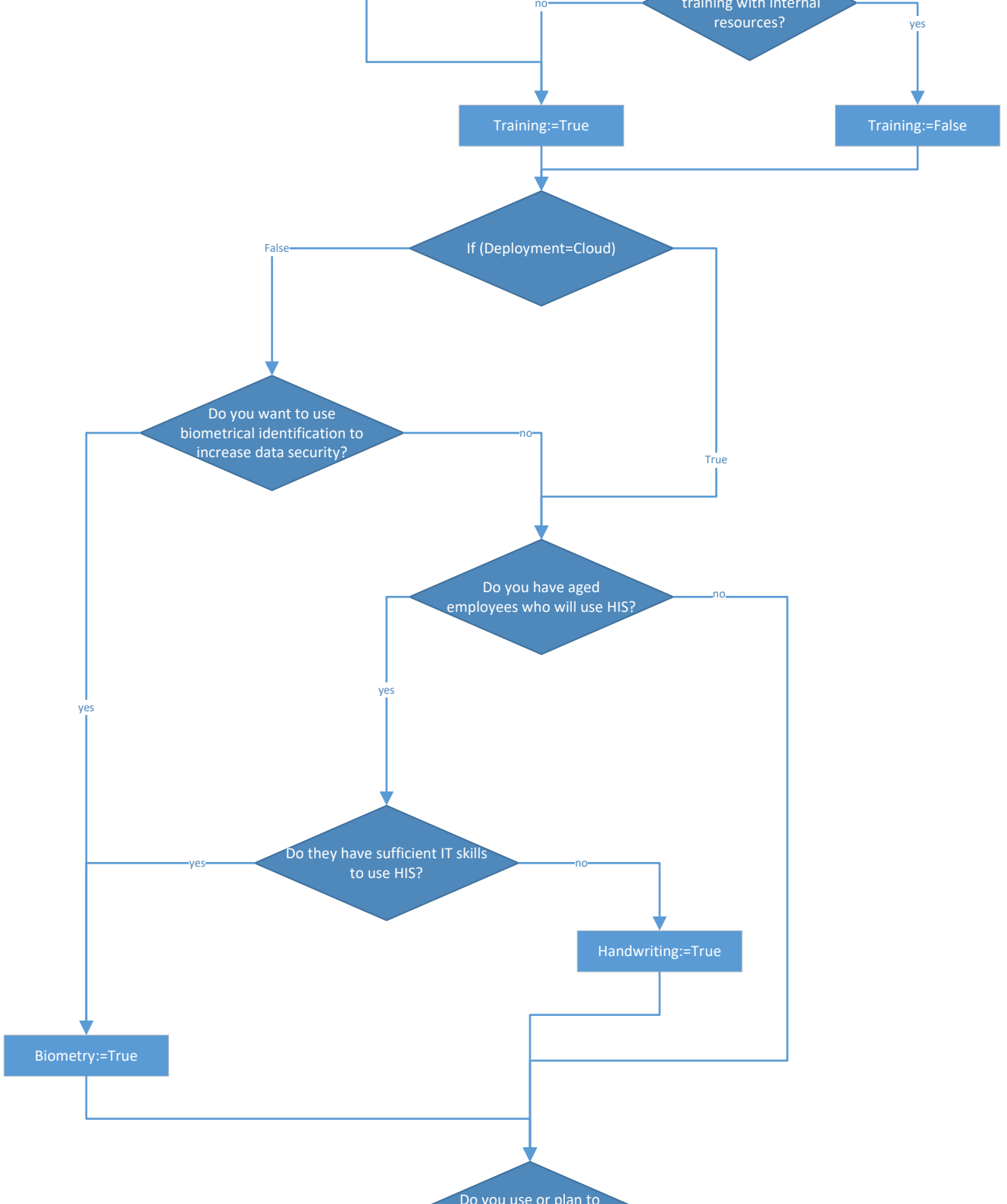

implementation?
exp:=0
speed:=0
If (speed=-1)AND(payment=1)
True
Fast implementation (<1month) is possible only with cloud that requires subscription payments. Would you accept subscription or refuse from fast implementation?
accept subscription
refuse
False
exp:=0
speed:=0
If (speed=-1)AND(exp=1)
True
Fast implementation (<1month) is possible only with cloud use. Would you try it again despite the bad experience?
yes
no
False
exp:=0
speed:=0
If (trust=1)AND(loc=-1)
True
With your location cloud use is highly recommended. Would you entrust the data to third party?
no
yes
False
loc:=0
trust:=0

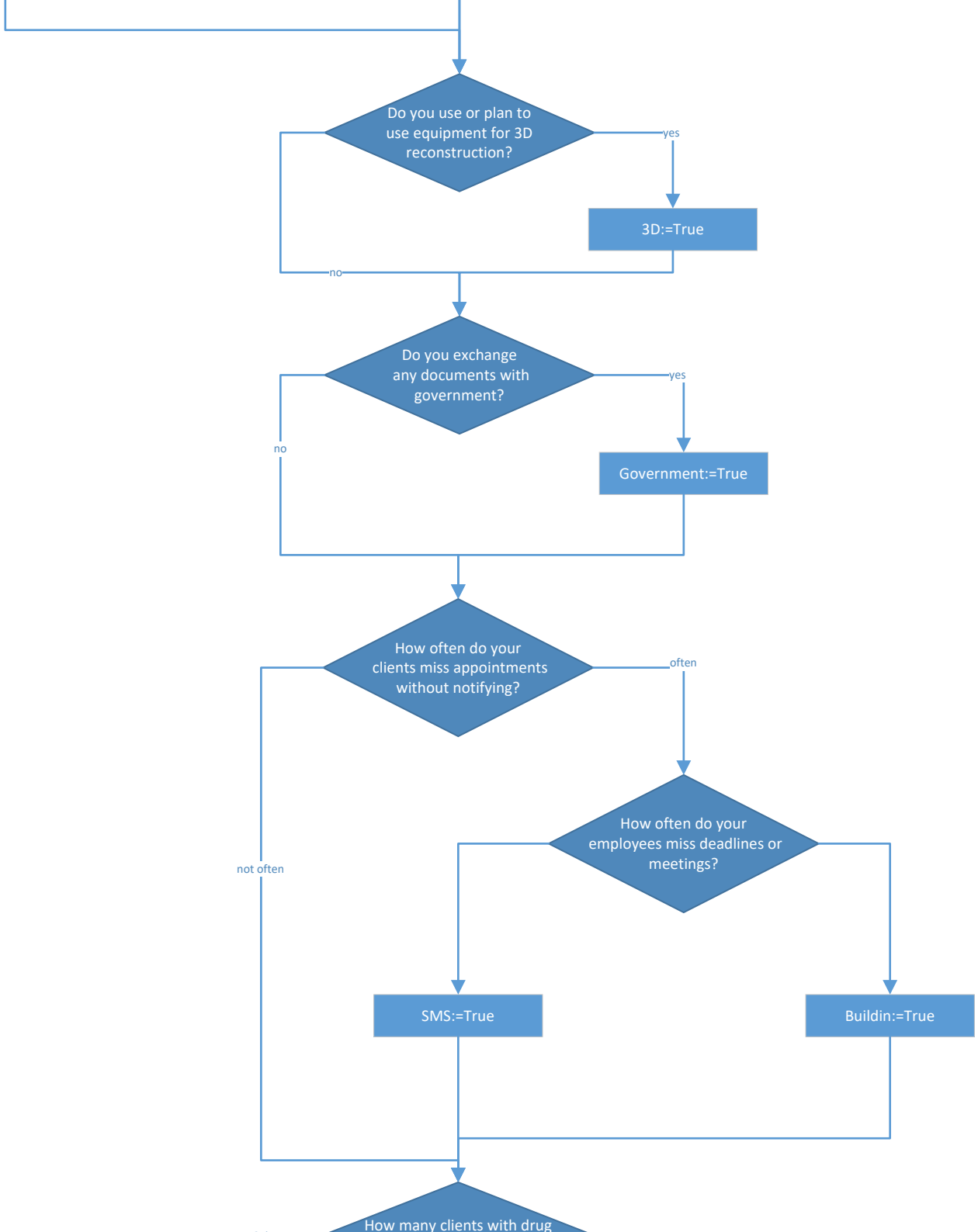

False
loc:=0
trust:=0
If (trust=1)AND(desire=-1)
True
Cloud use means to entrust the data to third parties. Would you do that?
no
yes
False
desire:=0
trust:=0
If (loc=-1)AND(payment=1)
True
With your location cloud use is highly recommended, which means subscription payments. Would you agree to pay subscription?
yes
no
False
payment:=0
loc:=0
If (loc=-1)AND(exp=1)
True
With your location cloud use is highly recommended. Would you agree to try cloud again?
yes
no
False
payment:=0
loc:=0
If (payment=1)AND(desire=-1)
False
True

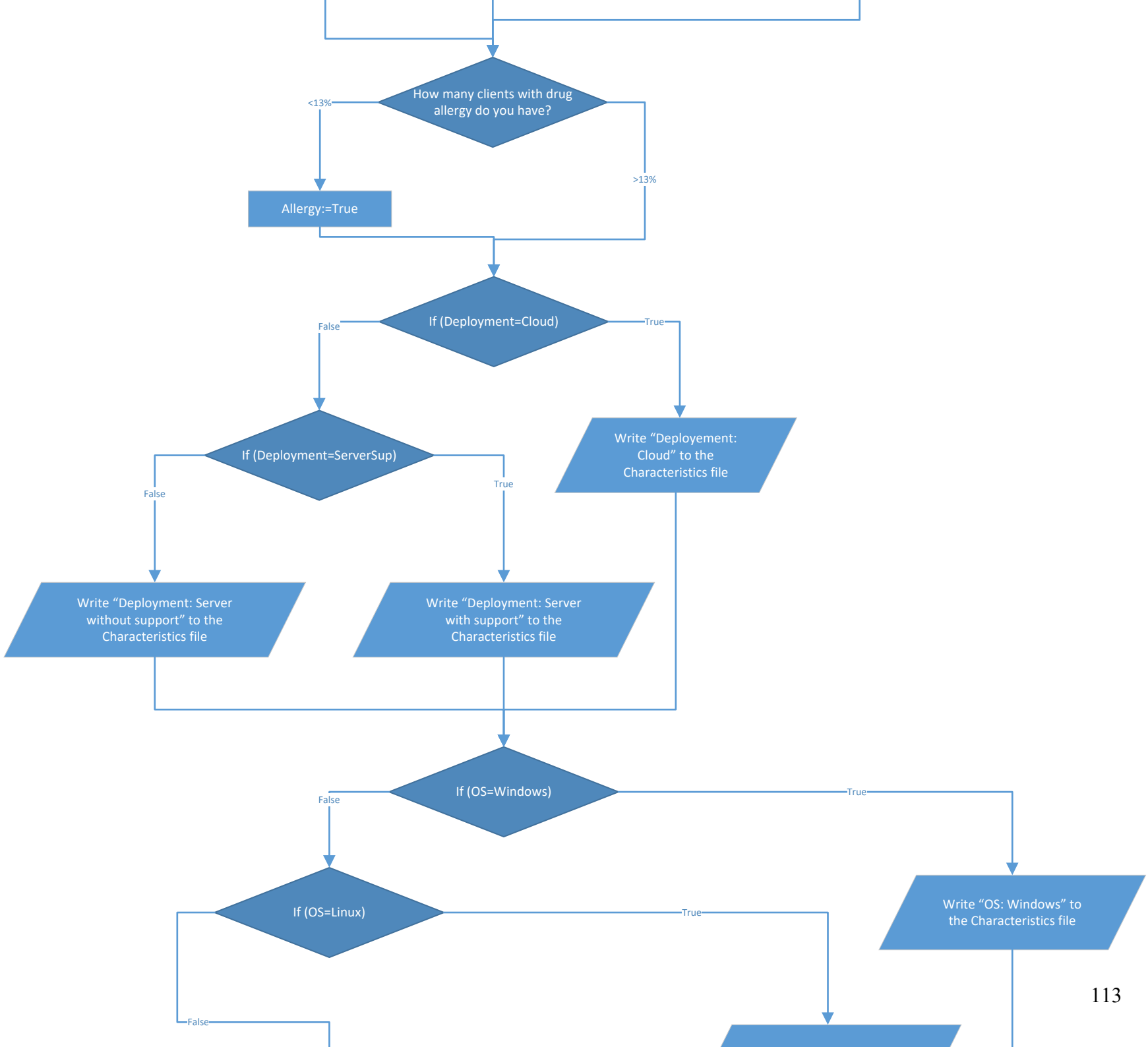

If (payment=1)AND(desire=-1)
False
True
Cloud use means subscription payments. Would you agree to subscription?
no
yes
desire:=0
payment:=0
If (serv=1)OR(trust=1)OR(payment=1)OR(exp=1)OR(desire=1)
False
True
Deployment:=Cloud
Do you have an IT specialist(s) who can conduct server maintenance?
no
yes
Deployment:=ServerSup
Deployment:=ServerNoSup
What operating system (OS) do you use?
several
Are different OS installed on one PC or different ones?
different
same

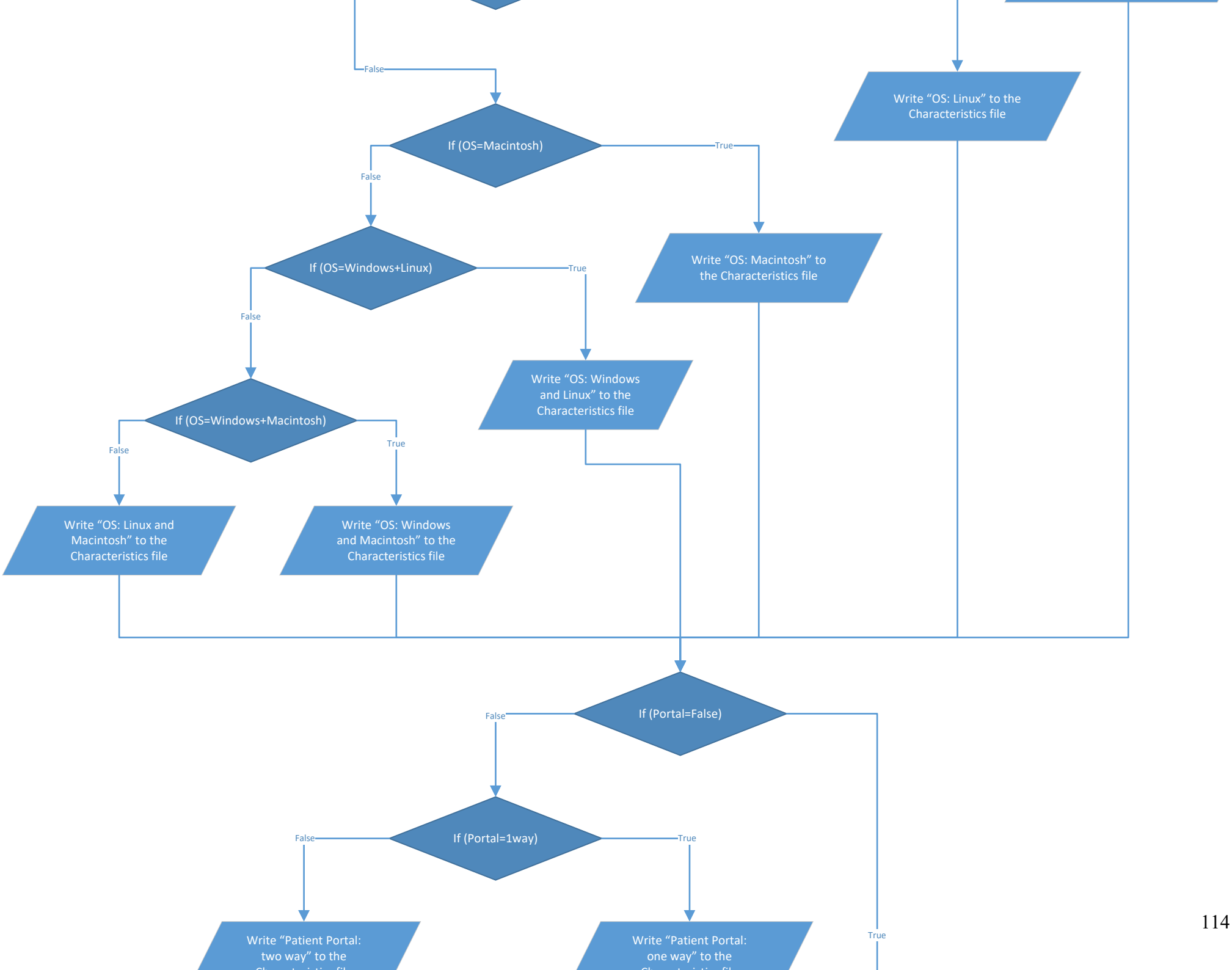

Are different OS installed on one PC or different ones?
different
same
Do you need all OS to support information system or only one?
Which OS do you use more often?
all
only one
Windows
Linux
Macintosh
Macintosh
Linux
Windows
Which OS do you have?
Which one?
Windows
OS:=Windows
OS:=Linux
OS:=Macintosh
Linux
Macintosh
Windows and Linux
Windows and Macintosh
Linux and Macintosh
OS:=Windows+Linux
OS:=Windows+Macintosh
OS:=Linux+Macintosh
Would you like to create additional value for clients by introducing online patient portal?
no
yes
Portal:=False
A better result can be achieved by providing two-way communication with inline consultants. Would you like to introduce this feature?
no
yes

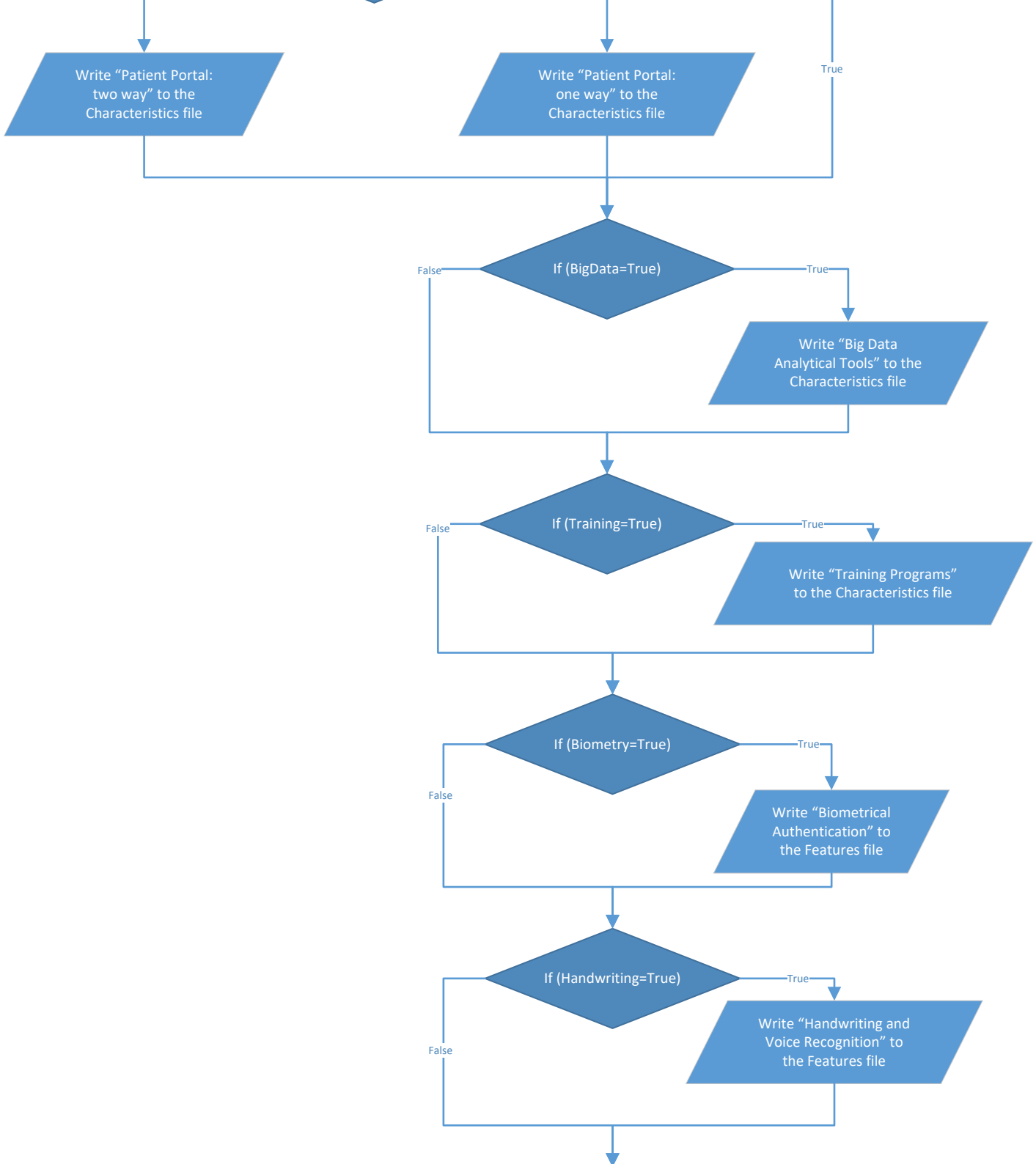

communication with inline consultants. Would you like to introduce this feature?
no
yes
Portal:=1way
Portal:=2way
Do you use or plan to use special medical equipment? (MRI, cardiograph etc.)
yes
no
Would you like to get statistical reports?
yes
no
Would you like to use Big Data for business processes optimization?
no
yes
BigData:=False
BigData:=True
Do you have experience of HIS use?
no
yes
Can you organize training with internal resources?
no
yes

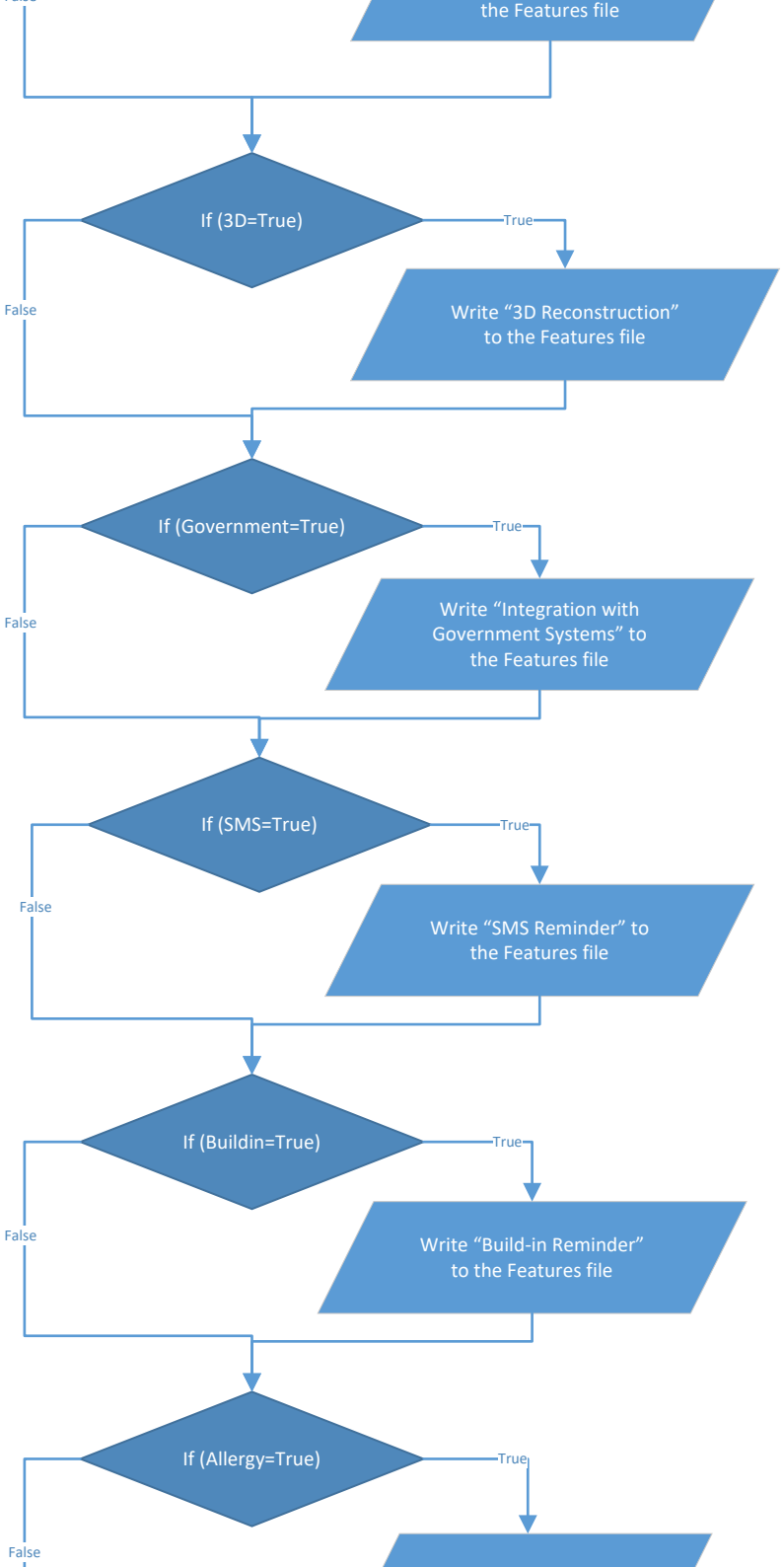

no
training with internal resources?
yes
Training:=True
Training:=False
If (Deployment=Cloud)
False
True
Do you want to use biometrical identification to increase data security?
no
yes
Do you have aged employees who will use HIS?
no
yes
yes
Do they have sufficient IT skills to use HIS?
yes
no
Handwriting:=True
Biometry:=True
Do you use or plan to

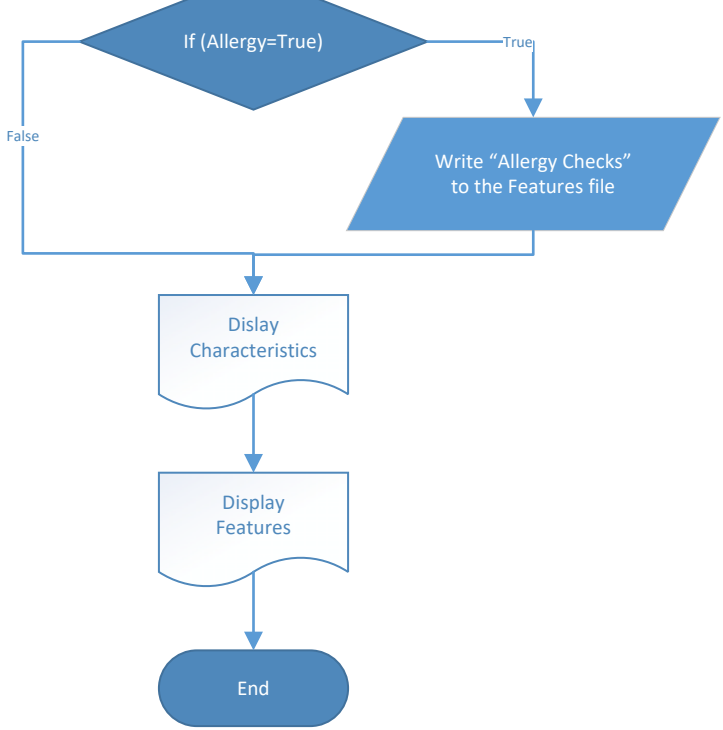

Do you use or plan to use equipment for 3D reconstruction?
yes
3D:=True
no
Do you exchange any documents with government?
yes
Government:=True
no
How often do your clients miss appointments without notifying?
often
How often do your employees miss deadlines or meetings?
not often
SMS:=True
Buildin:=True
How many clients with drug


How many clients with drug allergy do you have?
<13%
>13%
Allergy:=True
If (Deployment=Cloud)
False
True
If (Deployment=ServerSup)
False
True
Write “Deployement: Cloud” to the Characteristics file
Write “Deployment: Server without support” to the Characteristics file
Write “Deployment: Server with support” to the Characteristics file
If (OS=Windows)
False
True
If (OS=Linux)
True
False
Write “OS: Windows” to the Characteristics file


False
Write “OS: Linux” to the Characteristics file
If (OS=Macintosh)
True
False
If (OS=Windows+Linux)
True
Write “OS: Macintosh” to the Characteristics file
False
Write “OS: Windows and Linux” to the Characteristics file
If (OS=Windows+Macintosh)
False
True
Write “OS: Linux and Macintosh” to the Characteristics file
Write “OS: Windows and Macintosh” to the Characteristics file
False
If (Portal=False)
True
False
If (Portal=1way)
True
Write “Patient Portal: two way” to the
Write “Patient Portal: one way” to the
True


Write "Patient Portal: two way" to the Characteristics file
Write "Patient Portal: one way" to the Characteristics file
True
If (BigData=True)
False
True
Write "Big Data Analytical Tools" to the Characteristics file
If (Training=True)
False
True
Write "Training Programs" to the Characteristics file
If (Biometry=True)
True
False
Write "Biometrical Authentication" to the Features file
If (Handwriting=True)
True
False
Write "Handwriting and Voice Recognition" to the Features file


the Features file
If (3D=True)
True
Write “3D Reconstruction”
to the Features file
False
If (Government=True)
True
Write “Integration with
Government Systems” to
the Features file
False
If (SMS=True)
True
Write “SMS Reminder” to
the Features file
False
If (Buildin=True)
True
Write “Build-in Reminder”
to the Features file
False
If (Allergy=True)
True
False


If (Allergy=True)
True
False
Write “Allergy Checks” to the Features file
Dislay Characteristics
Display Features
End