



EMERGING SCOPE OF MEDICAL LABORATORIES SYSTEMS USING CLOUD COMPUTING FROM END-USER PERSPECTIVE

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Abstract

In today's world the rapid and reliable information extraction has become everybody's need. Cloud computing is one of the emerging technology solutions to answer this query. This technology is providing many opportunities to the users in different terms to produce rapid and cost effective solution. This study helps in understanding the scope of the cloud computing as a solution in the field of medical laboratory systems. A study has been conducted to determine the need of the services required by the users in medical laboratory system. The preference recorded during the study by the participants are recorded and analyzed to replace traditional medical laboratory system. A cloud based model has been discussed to transfer and contain patient's data using a web based cloud hosted application. This expert system will ensure the data handling in different defined classes using decision trees. A cell phone key based user verification technique shall be discussed for data sharing among doctors and the hospital for further consultation by the user.

Keywords: Medical Laboratory System, Cloud Computing, Expert Systems, Decision Trees.

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Özet

Günümüzde bilginin hızlı ve güvenilir bir şekilde sağlanması herkesin temel ihtiyacı haline gelmiştir. Bulut bilişim bu bağlamda yenilikçi teknoloji çözümü olarak dikkate alınabilir. Bulut teknolojileri son kullanıcıya hızlı ve maliyet avantajı sağlayacak yeni fırsatları sunar. Bu çalışmanın amacı medikal laboratuvarlar için bulut bilişimi hızlı ve güvenilir çözüm sağlaması noktasında ortaya çıkacak bir sistemin kapsamını anlamaktır. Bu çalışmada son kullanıcının hangi hizmetlere ve gereksinimlere bulut bilişim bağlamında ihtiyaçları olduğu ortaya konulmuştur. Son kullanıcının öncelikleri dikkate alınarak geleneksel medikal laboratuvar sistemlerinin yerine bulut bilişim kullanımı analiz edilmiştir. Verinin transferi ve kullanılması noktasında bulut tabanlı bir model tartışılmıştır. Bu modeli bir uzman sistemi olarak uygulanması noktasında karar ağaçlarının kullanımının uygunluğu irdelenmiştir. Sağlık uzmanları ve hastanelerin veri paylaşımı için cep telefonu tabanlı anahtar kullanımı ile doğrulama tekniği tartışılmıştır.

Anahtar Kelimeler: Medikal Laboratuvar Sistemi, Bulut Bilişim, Uzman Sistemler, Karar Ağaçları.

INTRODUCTION

Cloud computing is playing vital role in the field of medical science by providing the reliable information exchange mechanism which is helpful for all patients, doctors and medical staff (Riedl B., 2007). Both government and private organizations are looking to find a reliable as well as a cost effective solution for information interchange to store the reliable patients medial data (Ibraimi L., 2009). Distributed computing environment including medical record data management system using number of network security method is fast and efficient service support for users.

Several research has been conducted to understand the significance of cloud computing in healthcare systems for patients, doctors and hospital services with an objective to take the decision on the basis of medical analysis data test report (Rolim C., 2010). In traditional medical laboratory system, the patient visits the laboratory to give a sample and the medical laboratory staff member collects the sample and enters the results manually into the traditional database. Figure 1 shows the traditional medical laboratory work in detail.

Figure 1. Traditional Medical Laboratory System



The results are generated on the local database and the patient needs to visit the medical laboratory again to collect the results. Communication and information technology is making possible to bring better facilities to the people. The need of a secure and reliable information exchange system is a question for cloud computing for its users. People need more quick to response medical services which are even more secure and reliable under the cloud (Louk M., 2014). The traditional medical laboratory systems with old traditional laboratory reports producing techniques has less advantages as compared to the latest technology reports (William R., 1995). This research describes the possibility of cloud adoption to replace the traditional old medical laboratory systems which can provide more user data protection (Thilakanathan D., 2014). Patients medical reports data will be stored using cloud services in encryption from to ensure the authorized user access (Li M, 2010). Mobile verification system can be used to exchange the medical information in order to ensure the secure use of the medical data by its users. A web based application can be a choice for data manipulation which can be hosted Software as a service (SAAS) whereas Platform as a service (PAAS) layer shall manage the software operations in cloud (Giessmann A., 2012). This research provides new technique of cloud model for medical laboratory systems using software as a service (Zhang R., 2010) which allows user to pass the lab test reports using a mobile authentication system.

RESEARCH BACKGROUND

Software as a Service

The cloud computing is getting famous in providing cost effective solution for small and medium size enterprise (SME's) and individual business holders. Software as a service is getting popular solution to avoid heavy software development and its maintenance expenses for SME's and other individual business holders (Giessmann A, 2013). Similar solution has been designated in health care systems to deliver the emergency information in the medical health care (N. Karthikeyan 2012) using SAAS. Use of software has come up with a lot of ease in our daily life (Beauvisage T., 2009) but developing a software that covers all the desired requirements of user is a bigger challenge. To avoid all the complex phases of software development life cycles SAAS is a useful solution open for every type of business and use (Espadanal M, 2012). Keeping the view of SSA in mind a study has been conducted to provide the cloud based solution to replace the paper work with the computer aided software in the government medical hospitals (Memon A.A. , 2014). The computer aided software is not only a time saving fast solution as compare to the manual paper work in hospitals, but it can also save the medical records for their future needs. Another interesting research shows the use of a cloud based medial software to keep the medial data for patients and other entities using SAAS (Li M, 2010). With an attractive offer like pay as much as you use (Espadanal M, 2012; Güner E.O., 2014) has made the cloud adaptation more attractive for its users keeping SAAS as an option.

Platform as a Service

The term platform as a service has total new meanings meaning for industry in cloud computing context in recent years. Providing platform with variety of tools to design, create and test software's using the cloud based resources is really charming solution to avoid heavy capital investment (Giessmann A., 2012). In a similar study in healthcare system impact of this layer has been studied in order to understand its impact. This layer also provide many additional features of the middleware's like database, operating systems, file systems, load balancing and many others (Mathew S., 2013). Another useful research has been conducted in the medical consultation application in the cloud which explains the paas layer role during data manipulation between physicians and the application. The paas model provides platform for users to host the desired solutions with an offer of metered billing for them (Güner E.O., 2014).

Decision Tress and Mobile Device Verification

The security has been an important issue for the end users to ensure the quality and authorized access to the data form day one (Louk M., 2014). Several studies have been conducted to ensure the data security using cloud models. A research has been followed in healthcare to flash the security issues (Zhang R., 2010) in cloud context. To increase the user authentication and security for mobile device in cloud another system has been proposed with more advantages for users in secure data transfer. The users can connect a cloud based application using a mobile phone service while keeping the security (Jia W., 2011). Decision tree classification technique approach can also be used to sort different data sets as every different medical test has a different data set class. Dataset classifier has been defined on this concept, which is used to test data class and sort them accordingly. The obtained data is presented into the decision support system to take the required action (Li M, 2010). The final information will be shared using the mobile device. Mobile phones can act like platform as a service in health care systems (Bharat P B . 2012). These mobile devices can send and receive information to enhance the security of the user data (Khana A.N., 2013).

Change Adoptability Factors

Since cloud services are more promising and attractive enough for users, why people feel hesitation to adopt cloud as a solution is a common question itself. Several research studies have been made to evaluate user behavior while transferring them towards new technology from an old one in use. A study on ATM machine users has been conducted which shows that some people avoid to adopt technology change due to certain threats they may have (Shafiq M., 2011). Adoptability of new system and its usability may depend on the user behavior towards the change as well (Shafiq M. , 2014) that can be one of a reason not to adopt new services.

PILOT STUDY

We are living in the science age where several new technologies are serving in healthcare. Several invention techniques have been developed to investigate human body diseases like X-ray investigation, blood tests, CT-scan and so many others. Purpose behind this investigation is to provide physicians sufficient clinical grounds to determine the actual disease. The role of medical investigations has become more and more vital with every development in the field of science (Kanchanaraksa S., 2008). The availability of medical record data has increased with the importance of the medical report data in problem diagnostics. A large number of medical laboratories are preparing the critical most medial record data on papers having no proper data backup even in recent days (William R., 1995). Many medical laboratories deliver medical reports without keeping reliable data backup and cross verification system and so many deaths have been observed cases improper or poor medical data record. The improper medical data and poor medical report presentation is one of the reason in poor diagnoses (Adane W., 2013).

It has been taken into account that sometime patient also has to spend more money in repeating the medical tests for further consultation as the previous medical record cannot be provided by the previous medical test laboratory (Hillestad R., 2016). Some of the major problem in traditional medical laboratories system are subjected to poor data presentation (on paper reports), no proper data backup provided if required, more financial loss in case of repeating tests, difficult medical test data sharing (among hospital, doctor and others) for users, more time taking to collect reports by hand (Hillestad R., 2016; Kanchanaraksa S., 2008; William R., 1995).

To understand the user difficulties with the traditional medical laboratory systems in more detail a pilot study has been conducted keeping in account the system difficulties. To conduct this study a semi structured questioner has been designed to distribute among the fifty-one (51) randomly selected study participants during November 2015 in urban area of Istanbul.

A simple two questions survey was distributed among the randomly selected users who have an experience of medical laboratory at least once in their life to study the user experiences about the traditional medical laboratory system. The study questions were detailed enough to record user experience about traditional medical laboratories. This may suggest exploring a problem area of traditional medical laboratory system for their users. The manual medical report collection in traditional medical laboratory provides extra financial load on users and make the process difficult enough to avoid (Adane W., 2013; William R., 1995).Table 1 show the responses of the users when they were asked to provide their feedback about medical laboratory systems experience. Result show that a considerable majority of research participant may have accessibility and usability threat factor while having medical lab experience (Shafiq M. , 2014; Shafiq M., 2011).

Table 1. Pilot study results about laboratory experience

Question Description	Q1- have you ever been to any medical laboratory for medical test in your life?		Sum	Percentage	Accessibility Threat Factor	Usability Threat Factor	Adoptability Threat Factor
	Q2- was the traditional medical laboratory system complex enough to collect reports?						
	Answer Portfolio of Q2.	Match of Q1 with Q2					
	1 years	2 years					
1.Never	16	0	16	16x100/51	=31.37		
2. Some Times	19	07	26	26x100/51	=50.98		
3. Often	4	5	9	09x100/51	=17.64		

The results of Q1 and Q2 in table 1 shows that 31.37% respondents has avoided the medical laboratory system for their medical tests even if the need to have some in their lives, this can be due to accessibility threat factor (Shafiq M. , 2014). The reasonable 50.98% percent respondent has exercised this process only once in their life this can be addressed as usability threat factor (Shafiq M. , 2014). This can be taken as a reason that user finds the traditional medical laboratory system process difficult to obtain results which are a big flaw. If we calculate the total threat factor which is the sum of booth accessibility threat factor and usability threat factor it becomes 82% approximately. The initial findings of the pilot study segregate the study population into two groups and sixteen respondents who do not have medical laboratory experience even once in their life were excluded from further study.

To expand our study on the next level, we conducted another user survey to understand the difficulties that users may find in the traditional medical laboratory systems. We excluded 16 participants out of 51 because of having no medical laboratory experience with them and we are left with 35 respondents who have at least an experience in medical laboratory systems. An eight items questionnaire has been designed to study the need the difficulties of the users regarding the traditional laboratory systems. This survey form help in learning user requirements in traditional new medical laboratory systems. Each questionnaire has been designed to highlight the difficulties and previous experience of participants about the traditional medical laboratory system. This questionnaire has a five point's likert scale. The participants shall determine the level of their ease and comfort they feel within this scale. The results were examined in order to generate valuable results and user difficulties.

A total of 35 respondents were included in this study to answer the question to understand and record the user's experiences in the medical laboratories. Table 2 shows the details of the survey study as below.

Table 2. User survey likert scale

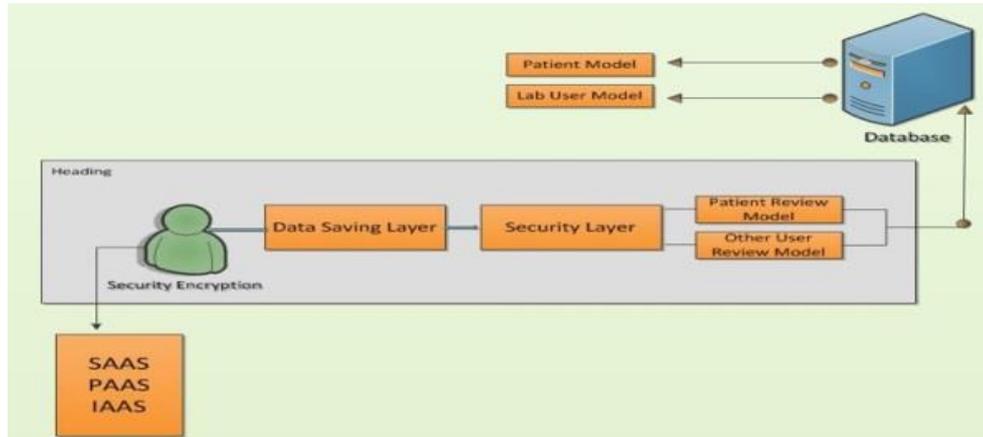
Survey Questions	No of Entrants	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Average
Sharing test report form one laboratory with other in traditional laborite system is possible.	35	0	0	4	3	28	0.56
Online report collection system is easier to get reports.	35	33	2	0	0	0	0.96
Traditional report collection system is more suitable to keep medical record in the long run	35	0	0	0	9	26	0.11
Keeping Medical test reports manually with you is more difficult than the online system.	35	30	3	0	1	1	0.92
Traditional laboratory system result making process should be faster and reliable.	35	33	2	0	0	0	0.93
Security of medical report data is an important issue.	35	22	4	5	2	2	0.61
Availability of the data is an important concern.	35	28	5	0	2	0	0.78
Collecting report from laboratory is an exhausting job.	35	18	13	0	1	3	0.63

Majority users are found to be strongly agreed on a point to carry the medical tests reports with then on a paper is always a difficult task. They proposed to have a computer aided online medical report system rather than having a traditional system. The new system shall provide online data availability with less time and cost effort as well.

PROPOSED MODEL

The argumentation below is based on the framework indicating leadership-driven Innovation Characteristics (see Table 1). We basically suggest and employ three aspects as relevant: exclusively ISPIs- related elements (Ollila & Lyytinen, 2004), relation mechanism, and business innovation. Internal, situational, single organizational unit of ISPI is subject to discussion further.

Our proposed model will be cloud based web application, which can be hosted in cloud as Software, as a service that provides an application interface to manipulate data (upload data, view data, download reports etc.) The PAAS layer will monitor further operation like data storage in cloud database, application execution and data communication between end users. The expert system software will automatically check data and place it accordingly in relevant tables. Figure 2 shows our proposed model

Figure 2. Proposed Model

Users will have full access to the medical data any time using the cloud services. User password will be entered in encrypted form into the cloud database using the application login system for authentication to ensure the user authentication; this encryption process shall be handled on application level. After the security layer expert system will collect data and store it in cloud using encryption techniques (Kaur M., 2013). Once the data has been entered into the cloud database, the expert system will segregate the data into the defined class's i-e patient review model and the other user view model and generate the reports separately for each class. Each user has a unique login and password to access the medical test data. The online data storage ensures the access of data anytime and also the availability of the data whenever it has been required by any user (patient, doctor, hospital, medical laboratory etc.). This will save user time of travelling to collect medical reports and will help in reducing extra cost as well as compare with traditional medical laboratory system.

PROPOSED MODEL HAS THE FOLLOWING FUNCTIONALITIES AND ROLES

The cloud-based environment eliminates the traditional need of software and hardware installation as the services can be hosted by the cloud based services providers. Users will no more asked have typical application on the computers for information interchanges. PASS provides us the software development environment like Google app engine. We can use virtual machines IAAs like Amazon to provide users access on their data. Specially designed medical laboratory software to input user medical record data into cloud base database. A specially designed medical report generating software to generate the test reports according to the provided inputs. Users can be given the encrypted data access to their medical results to maintain the security. The users can apply a mobile device verification system to maintain the privacy control of the user medical data. Medical doctors and hospital staff can view the user data with the permission of the users by using security key for the consultation. Data in the cloud shall be provided to the users openly in the user make a request to the cloud services. If the user needs a privacy of the data, then the data will be in encryption form and it can be decrypt by using the security key features.

WORKING OF THE SPECIALLY DESIGNED MEDICAL LABORATORY SOFTWARE

This system helps in keeping the medical tests records of the patients

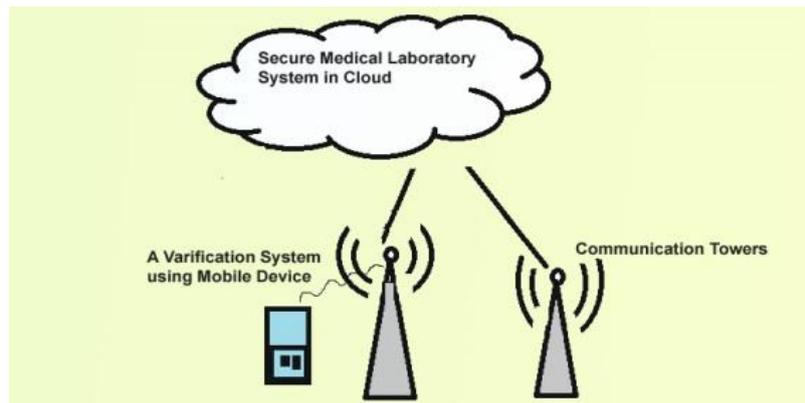
- if (sample serum= 'Pale') then do UT1 (Urine Test)
- else 'Patient is healthy'

Decision trees

- The decision trees are easier to classify result values.
- Software decides itself where to put the value of the medical test.
- The reports are generated after using the decision trees to finalize the test reports.

After once the software has generated the reports, the users can access their results by using the provided login and password system online. To manage data privacy of the user reports, a mobile verification request system has been introduced. Figure 3 show the model of the mobile request verification system in the mobile device.

Figure 3. Mobile Device Verification System Working.



The Medical data of the patients shall be deposited using IAAS cloud. The request shall be posted by the user into the cloud hosted software for data access. A verification code shall be asked by the system to make sure the authentication of the authorized user. The verification code shall be again sent back to the user to authenticate its identity for data access. If the user is an authorized user and have the permission to access the data, he will provide the given verification code and the data access will be granted. The use can share this code with the medical doctor or hospital for consultation and shall remain aware of the private data access. On every access of patients' medical data, a mobile verification alert shall be posted on the provided mobile number.

Advantages

This proposed solution has advantages for,

1. **Patients:** After the user survey, it has been observed that the majority users feel uncomfortable with the traditional laboratory systems in which they were forced to collect the medical reports after the tests from the same laboratory by hand. The traditional process is time taking, and cost extra travelling expense for the users. The proposed solution is totally web-based, in which the users do not need to travel

through the laboratory for report collection and can view the reports using internet. The results will be saved permanently on the cloud-based database this will help users to avoid keeping the record of their medical reports in hard copy formats.

2. **For medical laboratory:** As the entire system is cloud based model, the medical laboratory personals do not need to spend huge amount on expensive IT logistics and no need to hire technical staff for the appropriate working. In addition, their data remains the safe and secure in cloud using IAAS.
3. **For medical doctors and hospitals:** Patients can share their medical reports online by giving access to their personal account to the doctors to provide health care assistance. This can save the time of booth patients, medical staff, and increase reliability as well.

CONCLUSION

This study is helpful in understanding the needs and the problems of the community users in terms of their medical laboratory tests system. This study provides the alternative cloud based solution in the field of medical laboratory systems that has more availability of information with increased reliability in terms of security of their personal data. The use of encryption techniques and mobile device verification facilities provide their users more secure access on their personal data. As cloud computing model is less expensive as compare to the traditional IT services, it gives more cost effective solution to their end users.

REFERENCES

- Adane W., M. D. & Abebe M. (2013). Processing medical data: a systematic review. 1-7. Beauvisage T. (2009). *Computer Usage in Daily Life*.
- Bharat P. B.& K. B. P. (2012). Cloud Computing Support for Enhanced Health Applications. *International Journal of Engineering and Innovative Technology*, Vol. 2, 139-141.
- Espadanal M. & Oliveira T. (2012). Cloud computing adoption by firms Paper presented at the *Mediterranean Conference on Information Systems 2012 Proceedings*.
- Giessmann A. & K. S. S. (2013). What are Developers' Preferences on Platform as a Service? An Empirical Investigation. Paper presented at the *2013 46th Hawaii International Conference on System Sciences*.
- Giessmann A., K. S. S. (2012). Business Models of Platform as a Service (PaaS) Providers-Current State and Future Directions. *Journal of Information Technology Theory and Applications*, 13(04), pp. 31-55.
- Güner E.O. & S. E. (2014). Cloud Computing Adoption Factors in Turkish Large Enterprises. Paper presented at the *Pacific Asia Conference on Information Systems*.
- Hillestad R., B. J., Bower A., Girosi A., Meili R., Scoville R., & Taylor R. (2016). Can Electronic Medical Record Systems Transform Health Care? Potential Health Benefits, Savings, And Costs. *At the Intersection of Health, Health Care and Policy*, 1103-1117. doi: 10.1377/hlthaff.24.5.1103
- Ibraimi L., A. M., Petkovic M. & Research P. (2009). Secure Management of Personal Health Records by Applying Attribute-Based Encryption. Paper presented at the *Wearable Micro and Nano Technologies for Personalized Health (pHealth), 2009 6th International*, Oslo.

Jia W., Z. H., Cao Z., Wei L. & Lin X. (2011). *SDSM: A Secure Data Service Mechanism in Mobile Cloud Computing*. Paper presented at *the First International Workshop on Security in Computers, Networking and Communications*.

Kanchanaraksa S. (2008). *Evaluation of Diagnostic and Screening Tests: Validity and Reliability*.

Kaur M., S. R. (2013). Implementing Encryption Algorithms to Enhance Data Security of Cloud in Cloud Computing. *International Journal of Computer Applications*, Vol. 70(18, May 2013), 0975-8887. doi: 10.5120/12167-8127.

Khana A.N., K. M. L., Khanb S.U., Madani S. A. (2013). Towards secure mobile cloud computing- A survey. *Future Generation Computer Systems*, 29, 1278-1299. doi: 10.1016/j.future.2012.08.003.

Li M, S. Y., Ren K., Lou W. (2010). Securing Personal Health Records in Cloud Computing: Patient-Centric and Fine-Grained Data Access Control in Multi-owner Settings. Paper presented at *the Social Informatics and Telecommunications Engineering 2010, USA*.

Louk M., L. H., Lee H. J. (2014). Security System for Healthcare Data in Cloud Computing. *International Journal of Security and Its Applications*, Vol.8, No.3 (2014), 241-248.

Mathew S. (2013). Cloud Computing: A New Foundation Towards Health Care. *03(02)*, 118-121.

Memon A. A., N. M. R., Tahir M., Aamir M., Wagan A.A. (2014). A New Cloud Computing Solution for Government Hospitals to Better Access Patients' Medical Information. *American Journal of Systems and Software*, Vol. 2, 56-59. doi: 10.12691/ajss-2-3-1.

Karthikeyan N., R. S. (2012). Cloud Based Emergency Health Care Information Service in India.

Riedl B., N. T., Goluch G. (2007). A secure architecture for the pseudonymization of medical data. Paper presented at *the Second International Conference on Availability, Reliability and Security, ARES*.

Rolim C., K. F., Westphall C., Werner J., Fracalossi A, Salvador G. (2010). A Cloud Computing Solution for Patient's Data Collection in Health Care Institutions. Paper presented at *the International Conference on Telemedicine and Social Medicine on eHealth*.

Shafiq M., I. M & Rafi Z. (2014). To What Extent System Usability Effects User Satisfaction: A Case Study of Smart Phone Features Analysis for Learning of Novice.

Shafiq M., J.-G. C., Faheem M., Ashraf I., (2011). Skill Specific Spoken Dialogues Based Personalized ATM Desing to Maximize Effective Interaction four Vially Impaired Persona. Paper presented at *the Springer-Verlag Berlin Heidelberg 2011*.

Thilakanathan D., C. S., Nepal S. and Calvo R.A. (2014). Secure Data Sharing in the Cloud. Paper presented at *the Springer-Verlag Berlin Heidelberg 2014*.

William R., H. (1995). The Electronic Medical Record: Promises and Problems *Journal of the American Society fo Information Science*, pg: 772-776.

Zhang R., L. L. (2010). Security Models and Requirements for Healthcare Application Clouds. Paper presented at *the IEEE 3rd International Conference on Cloud Computing, Miami*.