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Cloud Service Selection for Online Fashion Retailer – HDM Analysis

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Contents

Abstract

Choosing to move to the cloud is a complex process, and many decisions must be made before completing the migration. This paper identifies key criteria for a company moving to the cloud and offers a model for determining one of the decisions: which cloud service strategy (Infrastructure as a Service (IaaS), Platform as a Service (PaaS), or Software as a Service (SaaS)) should be used for a particular cloud migration project. This paper describes these types of services as well as presents a Hierarchical Decision Model (HDM) structure for choosing a service strategy.

The authors create a Hierarchical Decision Model (HDM) model which may be used as a basis for cloud service strategy decision making at a wide variety of companies. This implementation of the model has been designed for a fictional company, Best Men's Fashion LLC, and the pairwise comparison judgments are based solely upon the priorities of that company.

The cloud service strategy HDM model was developed using four levels of criteria. The first level, the Mission Level, was crafted to be "Determine the model of cloud service strategy for the company." The second level, Objective Level, criteria were gathered from the literature review and expert opinion. The four objectives are Technical, Security, Economic, and Management. To limit the scope of this project as well as keep the expert pairwise comparison data points manageable; the team focused on two criteria per objective on the third level. Security objective has "Protection" and "Migration: Compliance." The technical objective has "Scalability" and "Migration: Technical Complexity." The Economic objective has "Service Charges" and "Migration: costs." Finally, the Management objective has "Support capabilities" and "Migration: Business Complexity." The last level contains the three cloud service strategies which the HDM is comparing. The three strategies are Software as Service (SaaS), Platform as Service (PaaS) and Infrastructure as Service (IaaS).

This model evaluation had two expert panels. The first expert panel which evaluated the priorities of the objectives and criteria in relationship to the mission were the Best Men's Fashion LLC executive team (project team members acting on behalf of the company). These five experts had knowledge of Best Men's Fashion LLC's current strengths and weaknesses and could make decisions on what would be best for the company. The second expert panel was a panel of two external experts with significant cloud strategy experience. This expert panel was tasked with evaluating each of the strategies in relation to the third level criteria. Since these experts had no knowledge of Best Men's Fashion LLC's internal climate and (fictional) situation with IT staffing, they did not participate in the upper tier evaluation.

There were two rounds of analysis in the HDM modeling tool. The first round was ultimately negated as it took all seven experts' opinion into account for all tiers. This round was inconclusive with determining a cloud strategy, so the expert opinions were critiqued in class, revaluated by the team, and a new expert strategy was

developed. The second round was crafted as described above, with the experts divided into business and cloud expertise and only allowed to influence tiers on which they had extensive knowledge.

Scalability, Protection, and Service Charges were top-ranked among all criteria in both the first and second rounds. The team is highly confident that these are the most important criteria a company should evaluate when choosing a cloud strategy.

The results of the second round were more conclusive when compared to the first round results with regards to the strategy choice. In the first round, there was little differentiation between the scores of the strategies with IaaS, a slight leader. In the second, more focused round, IaaS ranked most successfully with a score of .38. SaaS was the second choice with a score of 0.32, and PaaS scored 0.30. Clearly, for Best Men's Fashion LLC, IaaS would be a sound choice. The company could now move on to comparing IaaS vendors.

This model may be used for other companies' decision process in the same situation: anticipating a move to the cloud. The next company would complete a pairwise comparison round of "mission to objective" and "objective to criteria" with their business leaders. If changes in the market are not great, the cloud expert's judgment of criteria to strategy could be reused to save time. If the cloud market has changed greatly than the cloud expert tier should also be reevaluated before making conclusions.

Introduction

Choosing to move to the cloud is a daunting prospect for any company, large or small. In addition to choosing which internet service provider (ISP) to align with, the company must first determine a strategy for where to place their data, codebase and business processes. The company must also determine which of the business systems should be targeted for the cloud. Concerns about data placement between on premise, off premise, or hybrid placement must be considered before engaging with an ISP.

There are three broad types of internet service strategies: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). This paper will describe these types of services as well as present a Hierarchical Decision Model (HDM) structure for choosing a service strategy.

The goal of this paper is to create a HDM model which could be used in the future as a structural foundation for other companies to use as a basis for their decision making. This model has been designed; in particular, for a fictional company, Best Men's Fashion LLC, and the value judgments are based solely upon the priorities that a small company with limited staff, retail, and supply chain websites and the need to focus on core business would make.

Company Profile

The (fictitious) company that will be analyzed in this project is Best Men's Fashion LLC. The company is a three year old start-up headquartered in Portland Oregon. In addition to the Portland office, the company also has locations in China and Mexico. China and Mexico are primarily focused on manufacturing.

Best Men's Fashion LLC is the premier men's luxury fashion online retailer for the executive who desires to look great at work but has no interest in choosing the clothes himself. The company will send a stylist selected complete outfit with shirt, pants, jacket or sweater, and socks to the customer, ready to wear to work. The customer may send unwanted items back at no cost. The company has an online retail presence which is hosted on premise with several servers dedicated to the supply chain, including custom applications for the stylists.

The company is currently funded by venture capital and has ramped up to 100 employees. Of those employees, there are two IT support staff, five developers and one IT manager. The manager and IT support staff handle both the server support for the website and supply chain software, as well as employee hardware and software issues. Collaboration cloud software has been used in this company since it was funded, and support for this is included in software support. The manager spends 50% of his time as support staff and would like to have more time to focus on IT strategy.

The five developers are divided in the following manner: 1 Python developer on internal tools which are custom to this company, two front end developers for the website and as needed on tools UI, two java and python developers who develop server side code for the website and supply chain integration.

IT Strategy and Considerations

The IT staff has come to the consensus that the following systems will be targeted to move to an off-premise cloud solution:

- Website – bestmensfashion.com – java, and python
- Supply chain servers with custom java and python applications

Based on this company and these targeted technology systems, this HDM project will evaluate the three cloud strategies (IaaS, PaaS, and SaaS) to determine which one will be most successful for Best Men's Fashion LLC. Further evaluation, following the service type decision, the right ISP vendor will need to be chosen.

Benefits of Cloud

The IT and Business staff have evaluated that the benefits of moving to the cloud are large, with regard to the long term and on-demand scalability. This scalability is needed due to business projections of 20% year over year growth of website traffic as

well as seasonal demand which will cause fluctuations in the amount of users. It is expected that website up-time will be increased with moving to a cloud model, due to failover and redundancy mechanisms.

An additional benefit is that the core business of creating the best experience for the customer can be the focus of more employees. IT Staff can be less tasked with maintaining the server lab, and more targeted on employee support and creating the applications that are needed for this unique product experience.

Challenges of Cloud

One of the largest challenges for Best Men's Fashion's cloud strategy is that migration will be complex both technically and process-wise. Technically, the migration will involve moving the code, data, and developers to the cloud model. One of our highest concerns is that the engineers will also need to address privacy issues for both company secrets and customer data.

There are also substantial business migration concerns. The business' supply chain processes are executed by non-technical business analysts and stylists. These non-technical users will need to be trained on the new site, including some possible differences once the code is migrated. All processes will need to be tested and validated before opening the new location of the site and supply chain for business. It should be expected that there will be difficulties in this process and possibly down-time if the migration is not highly managed.

Another concern is the costs of a cloud solution. The management expects that there will be substantial upfront costs for the technical migration, training and employee time. Reoccurring monthly costs will also need to be managed, but that management strategy will largely be dependent upon which ISP is ultimately chosen as ISP monthly costs can vary due to support tiers, time of day, and the amount of data.

Off-premise cloud solutions inherently create a dependence upon the ISP. This dependence will be for mission critical systems in the case of Best Men's Fashion. If the systems become offline, the business can suffer. If the systems are hacked, the company's reputation and trust can be lost. It is truly that a business moving to the cloud is placing a foundational reliance upon the ISP. Best Men's Fashion's management is aware of this issue and continues to desire the move, due to the benefits listed above.

Literature Review

The Hierarchical Decision Modeling is a technical tool used in project selection, resource allocation and evaluation decision making. The objective of HDM is to assist the user to reach quantifiable judgmental value using ratio scales by a series of pairwise comparisons. The underlying assumption that each decision has number perspectives and each perspective has number of criteria to consider [1].

Thus, combination of the perspectives, quantifiable or nonquantifiable, and the supporting criteria help in determining the strategy (decision). HDM is a process using multi-level decisions and utilizing multiple criteria through separating the overall system into several hierarchical levels.

HDM is a process based on reaching out to independent panel of selected experts who respond to questions by dividing 100 points between two alternatives at a time. The allocation of the points represents each expert's judgment independently with respect to a specific criterion. The 100-point scale is from 1 to 99. The zero value is avoided to eliminate mathematical difficulties; however, if such a consideration is given, the expert selects 50-points each means the judgment is neither important nor unimportant [1].

HDM is based on pairwise comparison analysis using linear algebra and matrix analysis. The goal is to find the eigenvalue and the eigenvector for each consideration in the matrix. In other words, pairwise comparison is a method used to determine how to evaluate alternatives by providing an easy and reliable means to rate and rank decision-making criteria. Weights are used and assigned to criteria and the results are normalized. The comparison is implemented in two stages:
1) Determine qualitatively which criteria are more important (i.e. establish a rank order of the criteria)
2) Assign to each criterion a quantitative weight such that the qualitative rank order is satisfied.

The process is based on three methods which differ in their underlying scale. At first the measurement is based on a range from an ordinal perspective (i.e. weighting by ranking). The second step is constructing an interval by weighted ranking. The third step is to calculate the ratio scale which is the pairwise comparison value. The three steps summarized below are based on the document titled "Hierarchical Decision Modeling (HDM)," by Dundar F. Kacaglu.

Step 1 - Completion of the pairwise comparison matrix: two considerations are evaluated at a time in terms of their relative importance. Index values from 1 to 99 are used. If criterion A is exactly as important as criterion B, this pair receives an index of 1. If A is much more important than B, the index is 99. All degrees are possible in between when comparing A to B. For a "less important" relationship, the fractions would be closer to 50 points. The values are entered row by row into a cross-matrix. The diagonal of the matrix contains only values of 1. First, the right upper half of the matrix is filled until each criterion has been compared to every other one. [1]

Step 2 - Calculating the criteria weights: the weights of the individual criteria are calculated. First, a normalized comparison matrix is created: each value in the matrix is divided by the sum of its column. To get the weights of the individual criteria, the mean

of each row of this second matrix is determined. These weights are already normalized; their sum is 1.

Step 3 - Assessment of the consistency matrix: a statistically reliable estimate of the consistency of the resulting weights is made.

How objectives & criteria are determined:

Theoretically, each level of the hierarchy consists of multi-dimensional alternative choices or decision elements as noted in the graph below as level 1. Multi-criteria objectives lead to multiple sub-criteria are shown as in level 2. At the bottom of the graph, we have multiple output results from multiple actions are shown in level 3.

The decision element at a specific level has an impact on several elements at the next nod level in the connecting lines. Let's say, we are seeking to make an operational level decision to produce to select a cloud model of technology that contributes to several or maybe all the sub-criteria at the target level. Consequently, reaching our fulfillment level i.e. the goal, that contributes to several or all the objectives. The figure below depicts how the goal, the criteria and the alternatives are related.
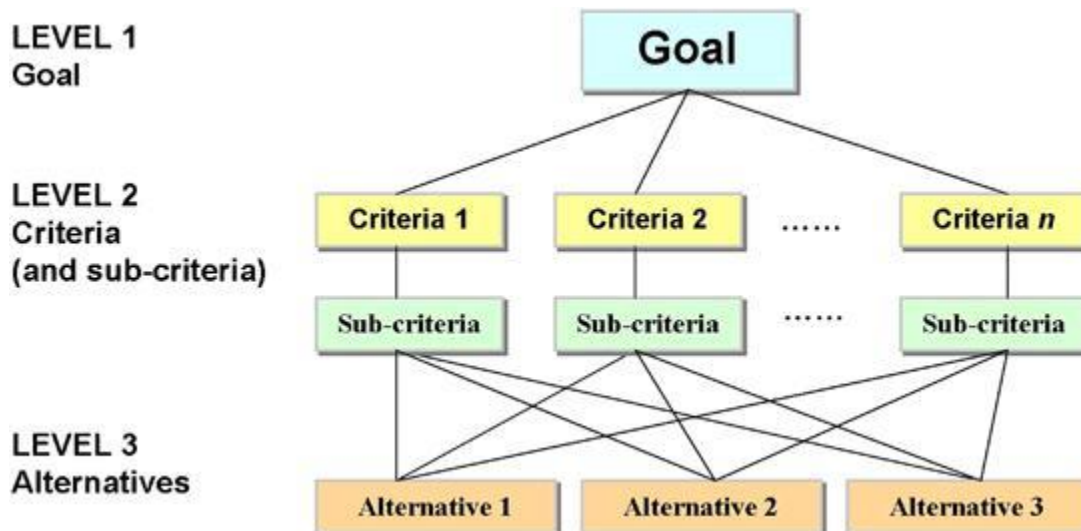
Figure 1 HDM conceptual framework

Source:

The process of evaluation between each internal relationship in such a hierarchy requires an assignment of a numerical value to each branch of the hierarchical network structure shown in the Figure 1 above. The values are assigned in such a way as to represent the relative contribution of an element at one level to an element in the next level. As this process is completed for all consecutive levels, an evaluation model is developed to obtain the relative measure of effectiveness for each element at the

bottom of the decision hierarchy in terms of the elements at the top. In other words, each of the items that make level 2 has a percent value, were the sum is equal 1. And, the sum value of each sub-criteria is equal to the criteria respective at the level 2. (I.e. the upper limit for the number of relationships is defined by the product of the number of elements at the sublevels).

Use of experts & Delphi:

The Delphi method is a structured communication technique or a process, developed as a systematic, and interactive with an iterative component which relies on a panel of experts in a subject matter. The experts are preselected based on predefined criteria; each answer questionnaires or completes pairwise comparisons of an HDM model in two or more rounds. After each round, a facilitator provides an anonymized summary of the experts' judgements, in a result table, from the previous round as well as the reasons for the judgments. [5]

Experts are encouraged to revise their earlier answers considering the replies of other members in the panel. The objective during this process is to decrease and converge towards the "most reasonable" answer / judgement. Finally, the process is stopped after a predefined stop criterion e.g. number of rounds, achievement of consensus, or stability of results (reduce inconsistency level).
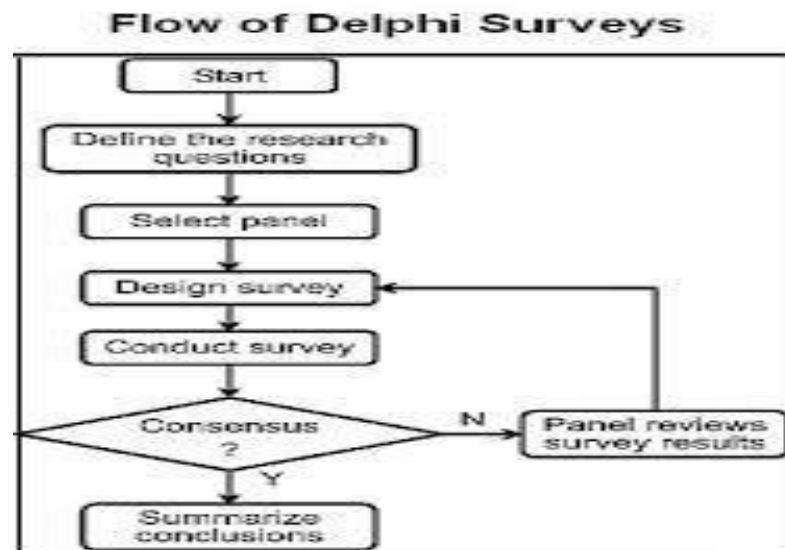
Figure 2 Delphi Method [5].

Delphi is based on the principle that decisions from a structured group of individuals are more accurate than those from unstructured groups. The technique can also be adapted for use in face-to-face meetings, and is then called mini-Delphi. Delphi has been widely used for business forecasting, commonly used among fund managers and stock picking analysts and has certain advantages over another structured forecasting approach.

There are four key characteristics to implement a successful Delphi technique. 1) Anonymity of the participants, 2) Structuring of information flow, 3) Regular feedback, and 4) role of the facilitator. Figure 2 showing the Delphi process in a flow chart [5].

Cloud Computing Models

Cloud-computing providers offer services in three main different models. Per the National Institute of Standards and Technology (NIST) the three standard models are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). Often portrayed as layers in a stack: infrastructure, platform and software-as-a-service; however, such understanding should not lead to the misconception that these platforms need to be implemented in coordination or in an order.

Thus, it is common to implement SaaS without using the underlying PaaS or IaaS layers, and equally possible to run a program on IaaS and access it directly, without wrapping it as SaaS. [2]

The following definitions are based on The NIST Definition of Cloud Computing:

"Software as a Service (SaaS). The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

Platform as a Service (PaaS). The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

Infrastructure as a Service (IaaS). The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls)." [2]

HDM Model

The HDM model (Figure 3), was developed using four levels of criteria. Mission, Objectives, Criteria, and Strategy. The explanation and rationale for choosing these criteria are as follows.

Mission

The "Mission," of this HDM model, is to "Determine the model of cloud service strategy for our company." In this specific scenario, a mid-size fashion company, looking to move their IT operations to the cloud. While this mission is specific to a fashion

company, this model could be applied to any business; different experts would be required. This is a common scenario many businesses face; there are pros and cons to moving their IT infrastructure from in-house to the cloud. There are many cloud service options a company must evaluate, this model is designed to aid in choosing which cloud service model a business should move its operations to. This model does not recommend any specific cloud service provider; it recommends one of 3 cloud service options (SaaS, PaaS, IaaS). Additional models would be required, to choose a specific provider.

Objectives

Objectives (Figure 3) consists of 4 criteria. Technical, Security, Economic, and Management. Objectives were chosen based on a thorough analysis of expert opinions, and literature reviews. When a business is looking to move its services to the cloud, they are looking for specific benefits to the company. Examples include increased focus on business, faster time to market, increased business agility, reduced operational costs, and lower development costs. These four objectives cover all concerns, and objectives a company must consider when looking to move its services to the cloud. It's important to note that additional objectives were evaluated, and considered by the team. These four objectives were deemed to be the most important objectives a company must evaluate. Due to time limitations on the scope of this project, no more than four objectives were added to the model. Future models, could have several more objectives, for example, "Political".

Technical Objective

Technical considerations to evaluate when deciding to move operations to a cloud service.

Security Objective

Security considerations to evaluate when deciding to move operations to a cloud service.

Economic Objective

Financial considerations to evaluate when deciding to move operations to a cloud service.

Management Objective

Business/management considerations to evaluate when deciding to move operations to a cloud service.

Criteria

Criteria (Figure 3) consists of 2 criteria per objective. Due to time limitations on the scope of this project, no more than two criteria per objective was added to this model. The original model consisted of 4 criteria per objective. To narrow this to two expert opinion, and literature review was used to reduce the number of criteria by 50%.

Technical Criteria

Technical Objectives (Figure 3) consisted of 2 criteria. Scalability, and Migration: Technical Complexity.

Scalability includes speed, latency, and reliability. This criterion would pertain to the company's current technical architecture, and which cloud service strategy would create the best scalability for the business. Scalability is a criterion all businesses must consider when deciding on a cloud service strategy.

Migration: Technical Complexity, pertains to the company's current technical architecture, and which cloud service strategy would allow for the most efficient migration to the cloud. Migration can be a very costly endeavor, with little return on investment, if not considered when evaluating moving to the cloud. Examples include trying to move existing services to a cloud service strategy that does not support current infrastructure.

Security Criteria

Security Objectives (Figure 3) consisted of 2 criteria. Protection, and Migration: Compliance to new standards.

Protection is security measures in regards to data center protection (building, fire, surveillance, etc.). Communication protection (data encryption, secure cryptographic protocols, firewall, etc.). Operation protection (access control, role management, virus protection, etc.)

Migration: Compliance to new standards is methods to avoid being fined for compliance violations, to manage risk factors as well as to manage processes and decision rights. Examples include cloud encryption standards (FIPS 140-2), Payment Card Industry Data Security Standard (PCI), and identity management that monitors application access and authorization.

Economic Criteria

Economic Objectives (Figure 3) consisted of 2 criteria. Service Charge, and Migration: Costs.

Service Charging defines how the cloud service strategy is charged. Examples include volume based, time-based, and account based. This criterion also considers the available booking concept, such as pay-per-use, subscription fee, and market-based prices.

Migration: Costs, are the costs to consider when moving existing infrastructure, to the specified cloud service model (SaaS, PaaS, and IaaS).

Management Objectives (Figure 3), consisted of 2 criteria. Support capabilities, and Migration: Business Complexity.

Support capabilities define what support is offered and under which mechanisms (phone, online, etc.); including information such as multilingual support, worldwide offices, and local contact options.

Migration: Business Complexity defines the business complexity in migrating the business from its current solution, to the cloud service strategy. This includes all management functionality including training time, and ease of moving employees to the new platform.

Strategy

The Strategy (Figure 4), of this model, is what cloud service strategy a company should use. To limit the scope of this project, cloud service strategies were narrowed down to 3(IaaS, SaaS, PaaS). Many other cloud service strategies exist, from expert opinions, and literature reviews, the 3 in this model are the most common cloud service strategies companies move their services to.

It's important to note that this model and the strategy does not encompass all the different cloud service providers within a specific cloud service strategy. A different model would need to be created to evaluate a specific provider, within a cloud strategy option. Having a cloud service strategy chosen greatly narrows the scope of decisions a company must consider when evaluating to move services to the cloud. Figure 4, outlines the three cloud strategies this model evaluates. Considering each cloud—Figure 4—provides a good overview, and examples of the next step a company must take to decide on a provider. Choosing a service provider would be a good area for an additional HDM model to be evaluated. See figure 5, for the 3 strategies, and benefits each one offers.
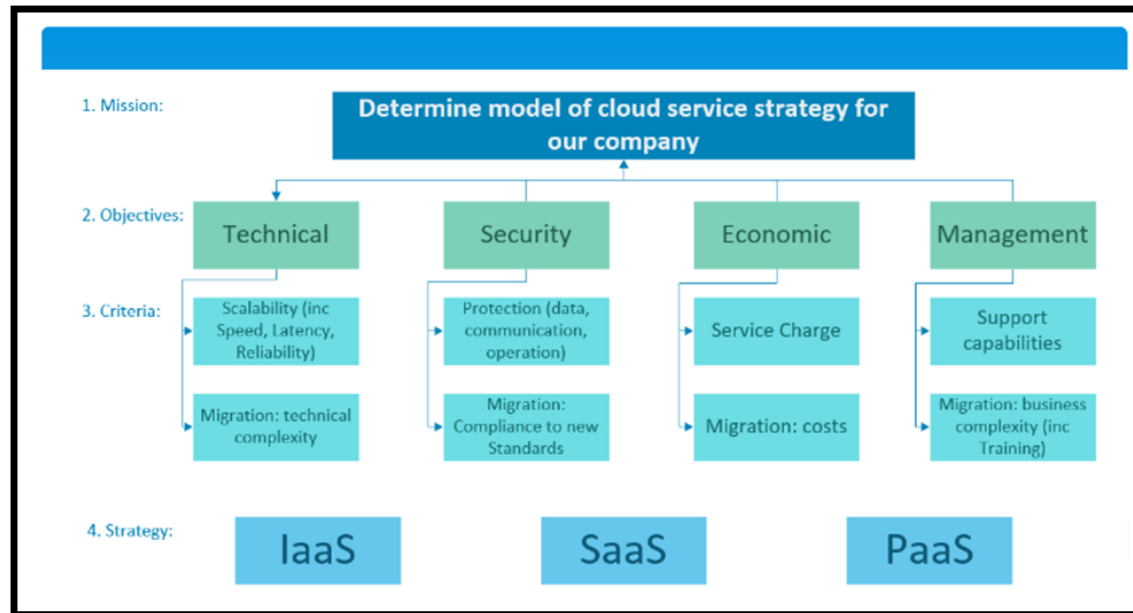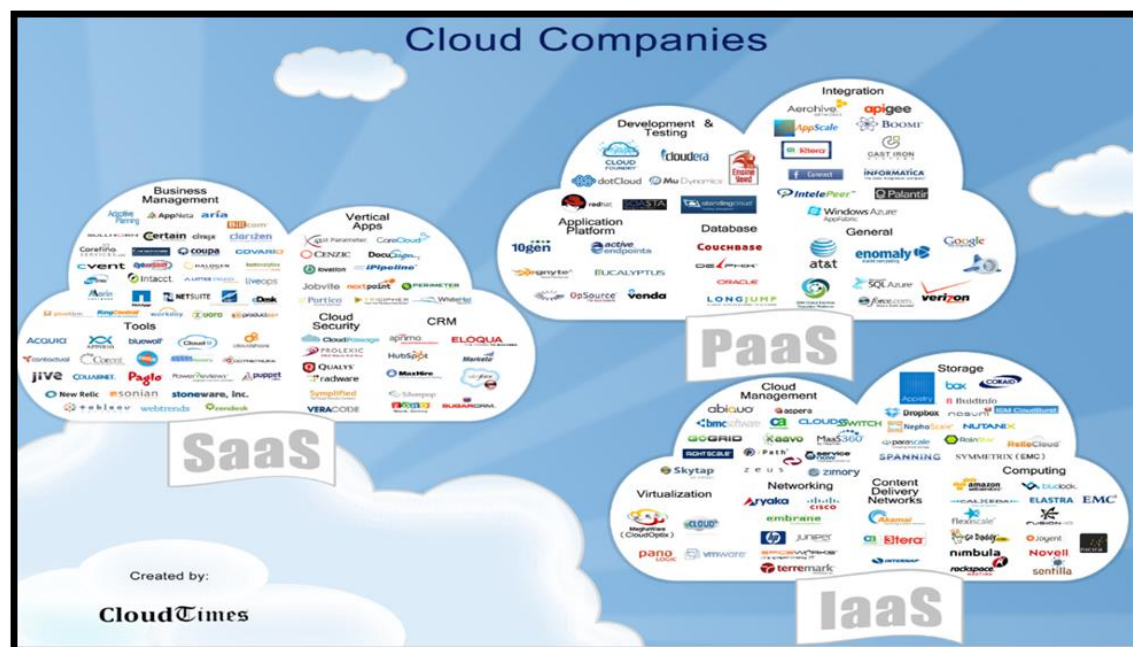
Figure 3 – Team 1 HDM Model

Figure 4 – Cloud Strategies

Model	What it offers	What you move	Best for
SaaS	Turnkey software functionality	Content and business processes	Commodity tools(mail, collaboration, word processing) and simple forms
PaaS	A platform that runs your code, with API's	Your source code	New, relatively simple applications where you don't need control over network topology, OS, or data location
IaaS	Virtual infrastructure rented by the hour	Your OS or VM	Variable workloads, testing and QA, massively parallel tasks

Source: http://sanderstechnology.com/2014/oracle-cloud-strategy-breakfast/13066/#.WLyrpDvyuUk

Figure 5 – Cloud Service Strategies

Results and Discussions

Our expert panel consists of seven experts, including five team members acting as the executives of Best Man's fashion and two external experts who are cloud service consultants. All seven members completed the pairwise comparison on all three levels.

We conducted two rounds of analysis on the results from HDM tool. Our first-round analysis took into accounts all seven experts' inputs on all three levels of pairwise comparisons. Since we have explanations on all our missions, objectives and criteria in the online HDM tool, we assumed that all experts had knowledge of the company's need, as well as the technical aspects of all different types of cloud services. The results of our first-round analysis show that Security is the company's top concern among all objectives when migrating its IT to cloud servers. Among all criteria, Protection, Scalability and Service Charge ranked top three. These are the criteria the company should pay close attention to when making the decision. The preferred cloud service type concluded from the first round of analysis is IaaS, with a score of 0.35. SaaS comes second with a close score of 0.34. Although IaaS is the winning choice of cloud service in this model, there is no major differentiation between IaaS and SaaS, due to the close scores, which makes the decision inconclusive.

Considering the suggestions and recommendations during our class presentation, we conducted a second round of analysis on the model and pairwise comparison data. During the second round of analysis, we only counted the five team members' inputs for level 1 and level 2 comparisons, and only counted the two external experts' inputs for level 3 comparisons. The reason for conducting round two is that the executives understand the company's mission, objectives, and criteria under each objective. They are not technical experts and may not be able to make sound decisions on the third level of alternatives. As for the external cloud experts, they are versed in

the technical details of three types of cloud service alternatives. However, they are not members of this company and are not familiar with the mission and detailed operation of the company. The results of the second round of analysis show that Security is still the top concern of the company when migrating to the cloud. Scalability, Protection, and Service Charge ranked top 3 among all criteria. These are the same three top criteria from the first round of analysis, with minor differences in actual weights. IaaS came out as the winner again during this second round of analysis with a score of 0.38. SaaS came as the second choice with a score of 0.32. The difference between IaaS and SaaS strategies is more significant compared to round one. IaaS is the clear winner. We believe that the result from the second round of comparison is more convincing.

Detailed HDM model comparison results and our analysis are discussed in the following sections of this report.

First Round of Analysis

All seven experts were asked to make the pairwise comparison of all objectives, criteria, and alternatives. All seven experts' pairwise comparison results were counted towards the final decision.

Table 1 - Level 1 Comparison Results

	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	EXP 7	AVG	Std dev
Technical	0.22	0.49	0.18	0.14	0.27	0.16	0.30	**0.25**	0.12
Security	0.42	0.28	0.33	0.23	0.38	0.23	0.22	**0.30**	0.08
Economic	0.23	0.12	0.27	0.43	0.16	0.27	0.25	**0.25**	0.10
Management	0.13	0.11	0.22	0.20	0.18	0.34	0.23	**0.20**	0.08
Inconsistency	0.09	0.06	0.01	0.01	0.01	0.02	0.01		
							Total	1.00	

The level 1 comparison results show that among all objectives, Security is the company's top concern when migrating to the cloud; this is due to the nature of Best Men's Fashion's business sector. Best Men's Fashion is an online retail company. The company has lots of confidential customer identification and finance information, as well as online transaction information. This information needs to be kept at the highest level of privacy. Any leakage of such information could be fatal to the company's reputation and might be subject to fines if any online financial transaction related to federal compliance code is violated.

Migration is ranked the least significant objective. This shows that the company is confident in its management ability, especially within its IT department. Some of the IT management team members have previous experience in cloud migration and are familiar with the process. The company is least concerned over managing the migration.

Table 2 – Level 2 Comparison Results

		EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	EXP 7	AVG	Weights
Technical	Scalability	0.75	0.70	0.40	0.70	0.55	0.41	0.63	0.59	**0.15**
	Technical Migration	0.25	0.30	0.60	0.30	0.45	0.59	0.37	0.41	**0.10**
Security	Protection	0.70	0.75	0.40	0.40	0.75	0.27	0.61	0.55	**0.17**
	Migration Compliance	0.30	0.25	0.60	0.60	0.25	0.73	0.39	0.45	**0.13**
Economic	Service Charge	0.60	0.75	0.60	0.60	0.75	0.39	0.66	0.62	**0.15**
	Migration Cost	0.40	0.25	0.40	0.40	0.25	0.61	0.34	0.38	**0.09**
Management	Support	0.60	0.75	0.60	0.50	0.60	0.36	0.56	0.57	**0.11**
	Business Migration	0.40	0.25	0.40	0.50	0.40	0.64	0.44	0.43	**0.09**
									Total	1.00

The level 2 comparison results show that Protection, Scalability, and Service Charge are among the top three criteria the company would consider when choosing the right cloud service type. Business migration and technical migration ranked the lowest among all criteria.

Since security is the company's top concern when migrating to the cloud, there is no surprise that protection is the most important criteria to consider. After migrating to the cloud, the company needs to work closely with the cloud service provider to provide the satisfactory level of data protection, communication protection, and operation protection.

Scalability is one of the major reasons the company will want to migrate to the cloud. The capability to meet the company's growth is essential. The company projected a year over year growth of 20% in the coming years. The cloud service choice needs to be able to handle this growth without significant successive migration efforts or additional charges.

Service Charge as a repeated cost is important to the financial health of a company. Whether this charge would increase significantly over time with the growth of the company needs to be carefully considered and counted into the total cost of production. Migrating to cloud computing is expected to be a cost-effective way of doing business. A good calculation and estimate of cloud service charges will help improve the profit margin of the company.

The company has an experienced IT department. Best Men's Fashion's IT manager has previous experience in cloud migration; this helps to make the migration process easier for both business and technical areas. IT staff's knowledge in cloud server management adds confidence to the top management team of this company over the technical aspect of this migration.

Table 3 - Level 3 Comparison Results

To determine the right cloud service strategy	IaaS	SaaS	PaaS	Inconsistency
EXP 1	0.50	0.21	0.29	0.02
EXP 2	0.27	0.31	0.42	0.01
EXP 3	0.33	0.35	0.32	0
EXP 4	0.31	0.4	0.29	0.01
EXP 5	0.41	0.32	0.27	0
EXP 6	0.33	0.48	0.19	0.01
EXP 7	0.32	0.31	0.37	0.04
Mean	**0.35**	**0.34**	**0.31**	
Minimum	0.27	0.21	0.19	
Maximum	0.50	0.48	0.42	
Std. Deviation	0.07	0.08	0.07	
Disagreement				0.064

The level 3 comparison results show that IaaS, with a score of 0.35, is the No. 1 cloud service type that suited the company's need. SaaS, with a score of 0.34, is the close second choice. The difference between IaaS and SaaS is very small. 2 out of 7 experts scored IaaS as the first choice. 3 out of 7 experts scored SaaS as the first choice. IaaS get the highest average score partially due to one of the experts scored IaaS with a very high score of 0.5. It could be viewed as an outlier in this set of data; this makes the final decision in IaaS less convincing. Simply looking at the scores, it seems that both IaaS and SaaS could be the final decision from this model.

Based on our research and literature review, we are confident with the HDM model we set up for this problem. We believe that our HDM model covers all criteria that need to be considered when making this decision. After taking the comments from the class presentation and more discussion within our group, we found out that our evaluation method in this round of analysis is flawed. It was an inaccurate assumption to include all seven experts' pairwise comparison inputs in each of the three levels of comparison.

The company executives in the expert panel are not technical experts. They have very limited knowledge on how cloud computation and cloud migration works. Their pairwise comparisons in level 3 on each alternative are not reliable. Their inputs in level 1 and level 2 comparisons are valuable since they are the group of people that

manage the company and are most familiar with the company's current condition and future needs. In contrast, the two external experts' inputs in level 3 comparisons are valuable, since both are cloud migration consultants. They are familiar with all technical issues and barriers a company could face during migration. However, they are not familiar with the company's internal operation. Their inputs on level 1 and level 2 comparisons are mostly based on their general knowledge of companies of similar scale, and therefore are less reliable.

To resolve this issue in the first round of analysis, we conducted a second round of analysis on the HDM model.

Second Round of Analysis

To test the HDM model and fix our problem in the expert panel use, we conducted a second round of analysis. During the second round of analysis, we divided the seven experts into two panels. Panel one consists of the five team members acting as the executive team. Panel two consists of the two external cloud migration consultants. Expert panel one is used to make pairwise comparisons in level 1 and level 2 of this model. Expert panel two is used to make pairwise comparisons in level 3 only.

Table 4 – Level 1 Comparison Results

	EXP 1	EXP 2	EXP 4	EXP 6	EXP 7	AVG	Std dev
Technical	0.22	0.49	0.14	0.16	0.30	**0.26**	0.14
Security	0.42	0.28	0.23	0.23	0.22	**0.28**	0.08
Economic	0.23	0.12	0.43	0.27	0.25	**0.26**	0.11
Management	0.13	0.11	0.20	0.34	0.23	**0.20**	0.09
Inconsistency	0.09	0.06	0.01	0.02	0.01		
					Total	1.00	

The results of level 1 comparison show that Security is still the company's top concern in migration to the cloud. Management objective has the least concern. These results agree with those from the first-round analysis. Security is indeed critical to Best Men's Fashion as an online retail company. It should be given the highest level of consideration when making the decision of cloud migration.

Table 5 - Level 2 Comparison Results

		EXP 1	EXP 2	EXP 4	EXP 6	EXP 7	AVG	Weights	std dev
Technical	Scalability	0.75	0.70	0.70	0.41	0.63	0.64	**0.17**	0.13
	Technical Migration	0.25	0.30	0.30	0.59	0.37	0.36	**0.09**	0.13
Security	Protection	0.70	0.75	0.40	0.27	0.61	0.55	**0.15**	0.20
	Migration Compliance	0.30	0.25	0.60	0.73	0.39	0.45	**0.13**	0.20
Economic	Service Charge	0.60	0.75	0.60	0.39	0.66	0.60	**0.16**	0.13

	Migration Cost	0.40	0.25	0.40	0.61	0.34	0.40	**0.10**	0.13
	Support	0.60	0.75	0.50	0.36	0.56	0.55	**0.11**	0.14
Management	Business Migration	0.40	0.25	0.50	0.64	0.44	0.45	**0.09**	0.14
								Total	1.00	

The level 2 comparison results show that Scalability, Protection, and Service Charge are still ranked as the top three decision criteria for this migration. These results are also consistent with those from the first round of analysis, with minor differences in weights only. Technical migration and business migration are still ranked the lowest among all criteria.

We could interpret the similarities in level 1 and level 2 comparison results between the two rounds of analysis as that both internal and external experts have a similar understanding of the objectives and criteria associated with cloud migration. Best Man's Fashion, as an online retail company, has similar concerns and issues as any other companies from the same line of business.

Table 6 – Level 3 Comparison Results

EXP 3

Level-3	Scalability	Technical Migration	Protection	Migration Compliance	Service Charge	Migration Costs	Support	Business Migration	Results
IaaS	0.48	0.27	0.54	0.16	0.16	0.53	0.25	0.51	**0.36**
SaaS	0.21	0.16	0.16	0.6	0.57	0.15	0.43	0.19	**0.32**
PaaS	0.31	0.57	0.3	0.25	0.27	0.32	0.33	0.31	**0.32**
Inconsistency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

EXP 5

Level-3	Scalability	Technical Migration	Protection	Migration Compliance	Service Charge	Migration Costs	Support	Business Migration	Results
IaaS	0.45	0.54	0.4	0.29	0.27	0.4	0.45	0.39	**0.39**
SaaS	0.3	0.26	0.33	0.36	0.4	0.27	0.3	0.32	**0.32**
PaaS	0.25	0.2	0.27	0.35	0.33	0.33	0.25	0.29	**0.29**
Inconsistency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Final Result

Level-3	Scalability	Technical Migration	Protection	Migration Compliance	Service Charge	Migration Costs	Support	Business Migration	Results
IaaS	0.465	0.405	0.47	0.225	0.215	0.465	0.35	0.45	**0.38**
SaaS	0.255	0.21	0.245	0.48	0.485	0.21	0.365	0.255	**0.32**
PaaS	0.28	0.385	0.285	0.3	0.3	0.325	0.29	0.3	**0.30**

Level 3 comparison results show that IaaS, with a score of 0.38, is the No. 1 choice of cloud service type for the company. SaaS, with a score of 0.32, is the second choice. The differences between the first-choice IaaS and the second-choice SaaS is significant. IaaS is the clear winner in this round of analysis.

Results from both experts are very similar to each other. Minimal disagreement found between the two experts. This makes the results of the second-round analysis more convincing than those of the first round. IaaS is the definite choice of cloud service type this company should take.

The similarities between the results from both rounds of analysis also approve that our HDM model is well set up and stable. The use of expert panel in the second round of analysis is more appropriate.
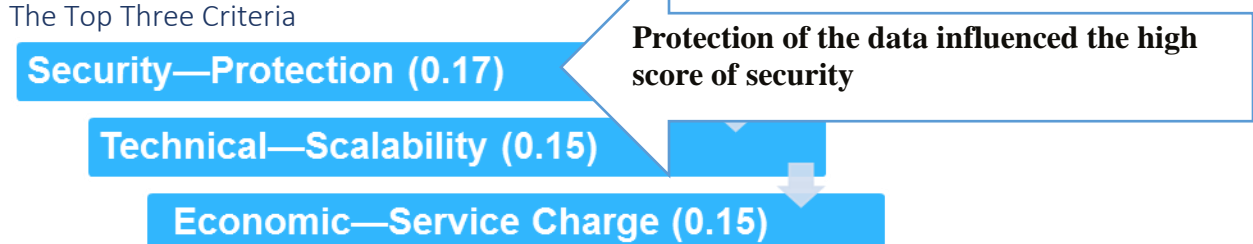
Further analysis of the Results

1st round of analysis

The Top Three Objectives

Security (**0.30**)

Technical (**0.25**)

Economics(**0.25**)

Security is very important! It seems that management capabilities are assumed.

The top three objectives were Security (0.30), Technical (0.25), and Economics (0.25). Management received the lowest score of 0.20. Our first round of analysis determined that security had the most influence in our level 1 comparisons, and management of the new software structure was assumed to be less demanding of all four level our comparisons. The tie between Technical and Economics created questions about the first round of analysis. Since Technical and Economics were part of the company's top 4 objectives, understanding why they were considered equally important is something that needs to be known; the technical and economic objectives are completely different aspects of the business. Understanding the similarities and differences leads us to the 8 criteria that are a level below the objectives.
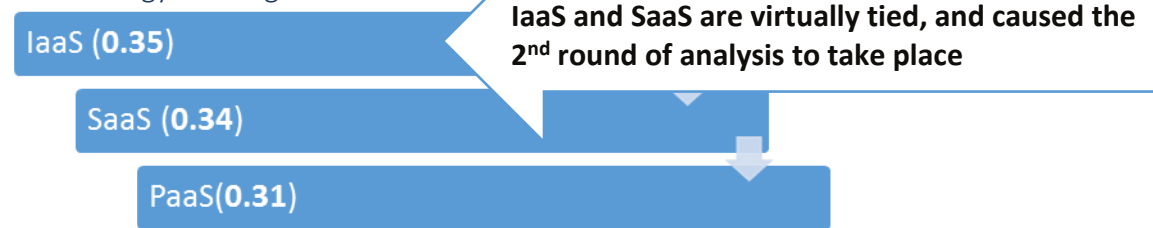
The Top Three Criteria

Security—Protection (0.17)

Technical—Scalability (0.15)

Economic—Service Charge (0.15)

Protection of the data influenced the high score of security

Protection is a criterion of Security, and has the highest score of 0.17. Scalability is a criterion of the Technical objective, and has the score of 0.15. The Service charge is a criterion of the Economic objective, and has of 0.15, which is the same as the Scalability criterion. The migration cost was also a criterion of the Economic objective, and has a score of 0.09. The tie between Scalability and Service charge also led us to believe something was skewing our results. We began to ask ourselves "since we have ties in both the criteria and objectives, are we having the right people answer do the correct pairwise comparisons?" At this point, we began to consider changing who's

performs pairwise comparison for each level of the model. The strategy ranking will give more light to our decision
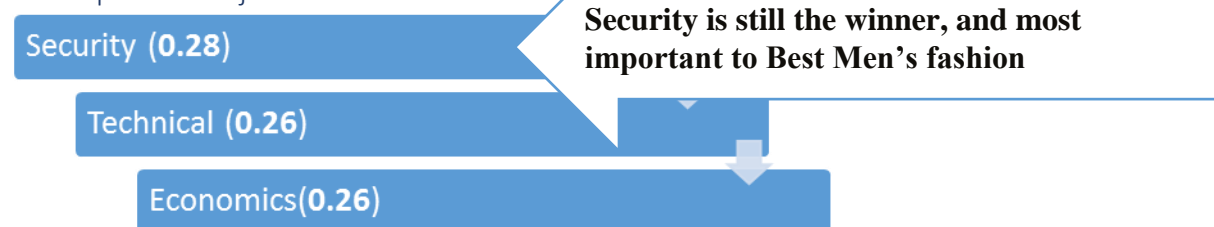
The Strategy Rankings

IaaS (0.35)

SaaS (0.34)

PaaS (0.31)

IaaS and SaaS are virtually tied, and caused the 2nd round of analysis to take place

IaaS scored 0.35, SaaS scored 0.34, and PaaS scored 0.31. Since we had a tie in the objectives between technical and economic, a tie in the criterion between Scalability and Service charge, and no true winner of the strategy, we knew we had to make some adjustments to our analysis of the model. This situation solidified our decision to create a 2nd round of analysis.
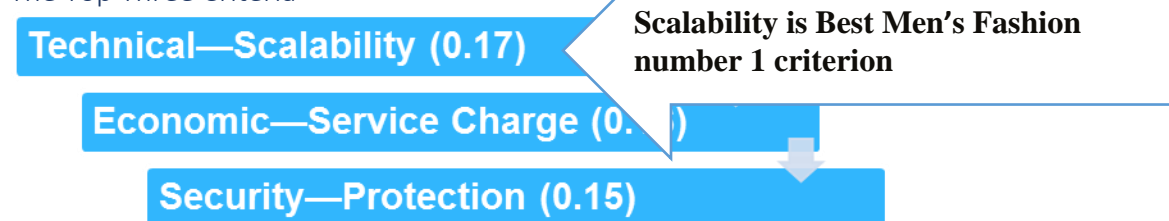
2nd round of Analysis

The Top Three Objectives

Security (0.28)

Technical (0.26)

Economics (0.26)

Security is still the winner, and most important to Best Men's fashion

Removing the cloud expert opinions from comparisons that should be made by the company did not affect the top three objectives rankings. Since security decrease by two points, it showed that the cloud experts valued security more than Best Men's Fashion upper management; this is good information to know. Maybe, best Men's fashion should do more research about the importance of security, so everyone in the company would give security its proper value; aligning to company objectives is very important.

The Top Three Criteria

Technical—Scalability (0.17)

Economic—Service Charge (0. 0)

Security—Protection (0.15)

Scalability is Best Men's Fashion number 1 criterion

Removing the cloud expert opinions from the comparisons reordered the criterion ranking, and showed that Scalability is what's important to Best Men's Fashion. Best Men's wants to be able to grow quickly, with the low variable cost. Although, security is still important to Best Men's because it made it to the top three. One could ask the question "Why is security the number 1 objective when protection is the number three criterion." Migration compliance would be the answer to that question

since it scores 0.13, which 4th when it comes to the criterion is ranking and part of the criterion beneath security.

The Strategy Rankings

IaaS (0.36)

SaaS (0.32)

PaaS(0.32)

IaaS is now a clear winner!
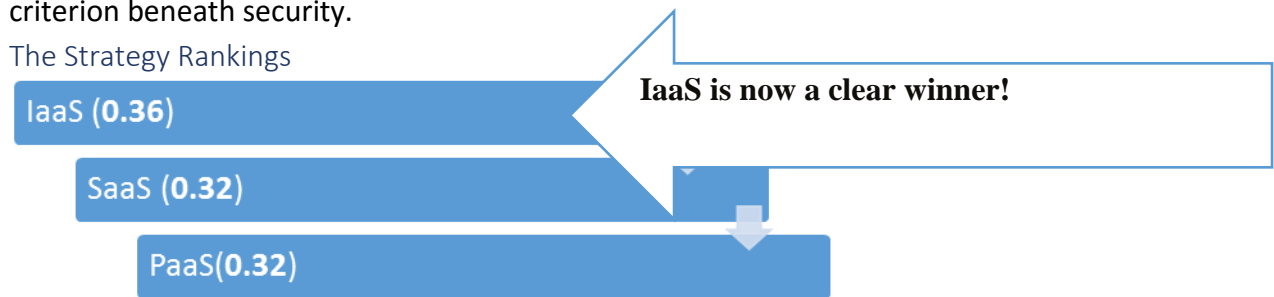
The strategy rankings did not change order, but SaaS lost two points, and IaaS gained one, making IaaS a more definitive leader. With the 2nd round of analysis and the new scoring of the model, IaaS is the best choice because it scored significantly higher than SaaS and PaaS on Scalability and Protection. IaaS did not score the highest on service charge, meaning it is not the cheapest, but the results show that it has the highest security rating. Therefore, Best Men's Fashion must spend more money on service to increase their customer's data security.

Conclusion

Best Men's Fashion LLC is a small online Fashion Retail that is in the process of scaling. To scale efficiently and maintain security, Best Men's Fashion LLC must make the choice of which cloud-based strategy will work best for their company; this decision is very complex. An HDM model was constructed and used as an aid to make this complex decision. The HDM model was built with four levels: mission, criteria, sub criteria, and strategy. At first, all expert's evaluation the HDM model evaluated all four levels. When the first model provided inconclusive results, the team reevaluated the HDM model delivery strategy. With the new HDM delivery strategy, Best Men's Fashion professionals evaluated the first three levels of the HDM model (mission, criteria, and sub criteria), and the cloud professional evaluation the last level (strategy). The new HDM model delivery strategy rectified the inconclusive results of the first model delivery, and IaaS was clearly the best choice for Best Men's Fashion.

Limitations and Future Work

The cloud service provider model can be used for any company planning on migrating their software services to the cloud. Upper management should perform the pairwise comparisons for both the objectives and criteria and the experts should choose the best strategy.   Although, the expert opinions are good for any other uses of the model. The weights of the objective and criteria are relevant only to Best Men's fashion because they are unique to their needs. The strategy weights are global and could be used for any other applications.

Future work should be conducted to find which IaaS platform should be purchased. If an HDM model was created for this purpose, the pairwise comparisons should be conducted by upper management of Best Men's Fashion, or subcontract to a

consulting firm. The pairwise comparisons should not be done by the vendors selling the IaaS service.

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