Robustness of Computational Intelligent Assurance Models When Assessing e-Commerce Sites

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Abstract— **E-commerce assurance platforms continue to emerge in order to facilitate trustworthy transactional relationships between buyers and sellers. However, as the sophistication of the e-commerce environments increase, the risks associated with transacting online also increase which pose a challenge to consumers to freely transact online. Although traditional assurance models are still used by various e-commerce sites, some of these models are not robust enough to provide adequate assurance on key areas of customer concerns in the cyber space. This research proposes a robust intelligent PRAHP framework built on Analytical Hierarchy Process complemented with an evidential reasoning from page ranking. PRAHP algorithms are modularised to run concurrently whose consensus decision takes place in a decision table. PRAHP objectively extracts real-life data directly from each of the 10 e-commerce websites comparatively using assurance attributes: Advanced Security, Policy, Advanced ISO, Advanced legislation and Availability. The assurance of e-commerce sites using PRAHP was experimented on small and large e-Commerce enterprises and validated by determining the effects of varied damping factor d on PRAHP, and comparing with customer's site perceptions. The experimental results demonstrate that the proposed framework is sufficiently robust for current site assurance applications and shows the trustworthiness aspect of the framework in instances of uncertainty.**

Keyword; E-commerce, Assurance, AHP, PR, DT, Assessment, Policy, Legislation

I. INTRODUCTION

As e-commerce continues to be adopted globally, cyber-crime increases as hackers or fraudsters continuously seek means to exploit system vulnerabilities in E-commerce environments. Some of the risks that consumers face includes the risks associated with information security and data privacy breaches which if not addressed could impede e-commerce adoption [15]. Table I provides a list of some well know incidents in the cyber space which shook the e-commerce space. EBay suffered substantially in terms of damage to their reputation when the customer accounts were hacked and unauthorized access was gained to some of the accounts.

As many consumers start converging towards online purchasing, the need for assurance increases.

Table I: Latest cyber-crime statistics adapted from [12] & [2]

Date	Type of fraud	Description	Country	Loss
Apr-15	USA department of Justice: Online identity fraud	theft of personal information to file fraudulent tax returns	USA	U$20 mil
Nov-15	Home Depot: Payment card system and email compromise	56 million cards were compromised and 53 million e-mail addresses stolen	USA and Canada	$62 million on insurance
Jul-14	St. Vincent Breast Center in Indianapolis: Email error	63,000 letters with personal information sent to wrong patients	USA	Not quantified
Jun-14	EBay: A hacking of staff accounts login credentials to access the network	Unathorised access to the network which left 145 million member accounts exposed	Globally	45 million credit cards affected

There are various methods which have been used in an effort to provide assurance in online environments and these include displaying policy statements and third party seals [8]. Some of the traditional assurance methods are effective in providing some level of assurance to the customers but they are not comprehensive enough since assurance is provided in one area, e.g. a policy statement on a website. Policy statements can be very generic and may not always provide adequate information relating to the data management practices. The policy assurance only caters for one dimension of assurance but it does not make use of other mechanisms to provide additional assurance.

The objective of this paper is to discuss various assurance methods and their shortcomings and then propose an e-commerce assurance framework for web trustworthiness evaluations. This paper makes the following contributions:

- Development of a robust intelligent PRAHP framework (Page Ranking-Analytical Hierarchy Process) built on Analytical Hierarchy Process complemented with an evidential reasoning from page ranking. PRAHP algorithms are modularised to run concurrently whose consensus decisions takes place through a decision table.
- PRAHP objectively extracts real-life data directly from each of the 10 small and large e-commerce enterprises for experiments validated by determining the effects of varied damping factor d on PRAHP, and comparing with customer's site perceptions.

To the best of the researchers' knowledge, most studies or AHP related applications often use expert ideas or a subjective method to capture data for pairwise comparison matrices, which could be biased and prone to errors. This paper is arranged as follows: Section II discusses related work and theoretical background on e-commerce assurance systems. Section III explains the development of the proposed cooperative intelligent assurance model. Section IV delves into the experimental evaluations of e-commerce sites. Section V concludes the paper.

II. Related Work and Theoretical Background

A. Related Assurance Systems for e-Commerce

The growing need for e-commerce adoption has resulted in the need for e-commerce assurance for online consumers. As consumers make use of various e-commerce services, they remain vulnerable to online risks associated with data leakage and transaction security, amongst others. As a result, robust assurance measures that will promote trustworthiness of the e-commerce websites are needed.

Various assurance mechanisms have been developed to promote trustworthiness [1][22] in the e-commerce environment and these will be discussed in the next sections.

(1)Policy statements

Policy statements that clearly articulate responsibility and accountability of an e-commerce store pertaining to the protection of information or the reliability of services are normally displayed on the face of e-commerce websites. Examples of these policies are privacy policies and refund policies. Policies in an e-commerce website give the consumer assurance about the measures that will be taken to ensure issues such as the ability to provide secure, reliable and trusted services. Policies enable online stores to share some of their practices on data security, information sharing and how information is distributed. An example of a policy statement can be found on [10]. Although the policy statements are meant to be accessed, read and understood, some of the statements are outdated.

(2) Legislation

The e-commerce environment has no geographical boundaries. A party to a transaction in an e-commerce environment takes a risk in matters such as trusting the online store with personal information, without knowing the location of the information. Secondly, in the event of a data privacy or security breach, it may be necessary to know which laws will be applicable. Ecommerce sites such as [20] mention their participation in the US, European Union and Switzerland safe harbour programs which look at the privacy and collection of information related breaches.

(3)Third party seals

Third party seals are issued by third party service providers after an online store has met a stated set of requirements. The seal is placed on the face of a website to provide assurance to the consumer about the trustworthiness of a website. The [22] is an example of a third party seal which provides assurance to the customers about safe data practices applied by the online store [20]. There are other seals that are in the form of automated tools that are run on the websites to scan the websites for different security vulnerabilities; this is done to demonstrate to customers that the company is maintaining best practice and proactive security programs to protect the customer information. It is only when the results of the scan are satisfactory that a secure seal can be placed on the face of the website e.g. [13].

(4)Online monitoring tools

In the e-commerce environment, customers need constant assurance that the services will be available all the time or when needed. Availability of online services is paramount to customers. Customers need assurance in order to trust the website before they can transact. Companies such as [10] have developed various tools which the consumer can utilize to monitor various aspects of the e-commerce website's performance with regards to availability. The only challenge with the use of such tools is that the data used for monitoring purposes may be open to scrutiny since it is not given as an independent assurance measure.

(5)Best practice standards

Standards offer assurance to customers in terms of the online store's ability to guarantee compliance with best practice standards. In the e-commerce environment, the Payment Card Industry Data Security Standards (PCI-DSS) is upheld to guard against losses that may be incurred as a result of poor data security controls[14][18]. The PCDI-DSS [13] compliance requires fulfilling its 12 requirements. This includes, amongst others, building and maintaining a secure network, protecting the cardholder data and maintaining an information security policy.

B. Analytical Hierarchy Process (AHP)

The analytical hierarchy process (AHP) is an approach which is used for multi-decision making more especially, where complex decisions need to be made [5]. In this study, AHP has been used to come to a conclusion regarding the state of every attribute of the proposed assurance model. This method will also be used to create a formal structure of assessment on the proposed assurance model attributes. The attributes that will be assessed are: adaptive legislation (L), advanced security, policy (AS), availability (A) and the adaptive ISO standards (ISO). These attributes were chosen based on their level of importance in e-commerce assurance as highlighted in section II (A). AHP arranges these attributes in a structure that makes it conducive for an assessment of these attributes in a decision on the website's overall state of trustworthiness. The technique firstly aims to classify the attributes into distinct groups with the aim of constructing a hierarchy of attributes where the lower hierarchy is limited by the upper one. The steps 1 to 4 are involved in the AHP technique.

(1) Construct the judgement matrix

The AHP techniques use the 1-9 marking method to constitute the judging matrix, which will be useful in deciding which website rating combinations give a red, green or amber status. The judging matrix consists of nine variables that is, *extremely less important, very strongly less important, strongly* *less important, moderately less important, equal importance, moderately more important, strongly more important, very strongly more important, extremely more important.*

(2) Development of judgement scenarios by conducting a pairwise comparison

$$Z = \{z_{ij}\} = \left(\begin{bmatrix} z_{11} & \dots z_{1n} \\ \vdots & \vdots \\ z_{n1} & \dots z_{nn} \end{bmatrix} \right) \qquad (1)$$

where Z=comparison matrix. The principle behind our method is the concurrent activation of the AHP and page ranking techniques to complement each other.

(3) Priority vector to weight the elements of the matrix [23]

*(4)*The eigen value is used to assess the strength of the consistency ratio *(CR)* of the comparative matrix to determine whether to assess the output or not .In equation (2), *RI* stands for the random consistency index and *CI* stands for the consistency index, *n* represents the size of the matrices and lamda(λ) is the largest eigen value.

$$CR = \frac{CI}{RI}, CI = \frac{(\lambda_{max} - n)}{(n-1)} \qquad (2)$$

It is only when the CR<10% for the judgment matrix that the results will be deemed to have reached a satisfactory level with regards to the consistency. When the comparison matrices are not consistent, the elements must be adjusted on the judging matrices until the test is consistent.

C. Page Ranking (PR)

The page ranking technique is a mathematical model which is used to determine the level of e-commerce assurance. According to a model proposed by [17], EAR stands for the e-commerce assurance rating. Our e-commerce based EAR model is shown in equation (3).

$$\text{EAR (A)} = (1-d) + d\left(\frac{EAR(t1)}{c(t1)}\right) + \dots\dots + d\left(\frac{EAR(tn)}{c(tn)}\right) \qquad (3)$$

For the websites linking to A,c(t1)…(tn) which are the number of outgoing links from a website (out degree) and d is a damping factor, usually set to 0.85. Since page rank assigns a high score to a node if it is pointed to by highly ranked nodes, it is highly applicable in advancing website trustworthiness based on e-commerce assurance.

D. Decision Table (DT)

A decision table is a tool which is used to present complex decision logic in an easily understandable manner. This table provides the elements which can be deemed to be pre-requisites for consideration before a decision can be made. The following areas are covered in a decision table: conditions, actions (decisions) and rules as shown in Table II .

Conditions are those factors for consideration in a business decision e.g. before a learner driver can be awarded a driver's license. The actions in a decision table refer to the steps to be taken when a business decision has to be made. Following from the example of a learner driver, the actions would be to issue the driver's license or reject. Rules are a combination of conditions and actions that constitute the business decisions [21].

TABLE II : Decision Table

		Rules		
Conditions	1	2	3	4
• Passed the learner's course			y	
• Medically fit			y	
• >=18 year old			Y	
Actions	1	2	3	4
• Issue driver's license				
• Reject driver's license				

III. The Development of Proposed Cooperative Intelligent Assurance

A. PRAHP Assurance Framework

The PRAHP framework is divided into three sections i.e. Page ranking, AHP and the decision table sections.

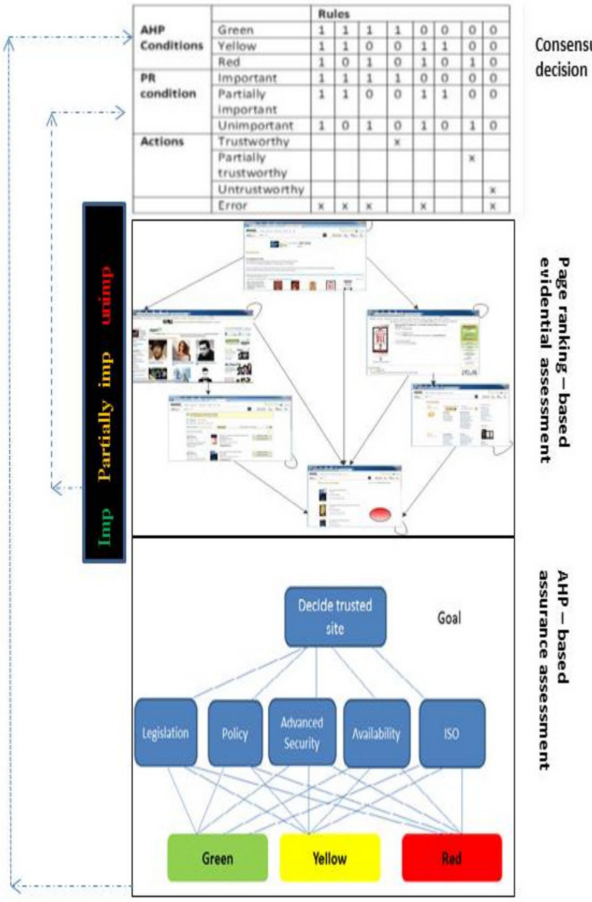

Figure III (a): PRAHP Assurance Framework

The AHP section focuses on the website attribute assessment, page ranking focuses also on evidential attribute assessment using data read from the site and the consensus decision is reached by a combination of the AHP and page rank results.

The PRAHP assurance framework shown in Figure III(a) is used to show how the two techniques, i.e. AHP and page ranking work together to assess the website attributes to give a final website overall rating regarding its trustworthiness. Sections 1-5 explain the significance of the assurance attributes used in this framework.

(1) Adaptive legislation as an assurance measure (L)

E-commerce stores have begun to identify the importance of legislation as an assurance measure to gain consumer trust. Due to the data privacy breaches in cyber security, legislation has been identified as a strong assurance measure. Customers need assurance in terms of the applicable legislation in the event of data security or privacy breaches [9]. Some of the online stores such as [1], have stated compliance to some of the legislation. However; other e-commerce players do not refer to any legislation that they comply with. In this study adaptive legislation has been identified as an assurance measure in order to cater for the ever changing laws which may govern the e-commerce environment.

(2) Adaptive ISO standards as an assurance measure (IS0)

There are various best practice standards which various online stores may choose to implement, for example the payment card industry standard is a standard which many e-commerce retailers that deal with transaction processing seek to comply with as it provides good assurance with the customers about the safety of their personal information. The International Organization for Standardisation provides a diverse range of standards covering areas such as quality management and information security. An example of a service provider who has acquired a seal of compliance to an ISO 27001 security standard is [11].

(3) Policy as an assurance measure (P)

Privacy policies and other assurance related policies are often displayed on the websites as assurance measures which communicate the practices adopted by the e-commerce providers. An example of a policy statement is the privacy policy statement displayed by [6] .The policy has also been chosen as the assurance attribute to be included in the proposed PRAHP assurance framework based on its relevance.

(4) Advanced user security login as an assurance measure(AS)

In the e-commerce environment, goods and services are normally procured online where user account creation is mandatory. Assurance is normally achieved by having secure login controls and where possible added security controls such as encryption of customer or transaction information. An example of an e-commerce website with advanced security login is [7]. The proposed framework included the advanced security login as an assurance measure which will provide robust security of online transactions.

(5) Site availability as an assurance measure(A)

Availability of systems and other relevant resources is vital in the e-commerce environment. [10] is an example of an online store which offers tools to monitor availability amongst other indicators and these act as assurance measures that the infrastructure can be trusted. Availability has been selected as an assurance measure because of the criticality of the availability of transactions and systems.

B. PRAHP Mathematical and Algorithmic Development

The algorithm in Figure III (b) outlines the detailed steps which include equations that were applied for both the AHP (on the left side) and page ranking (on the right side) of the Figure III (b). This is done to demonstrate how the final result was arrived at.

ALGORITHYM 1: PRAHP concurrent model for assessing concurrent e-commerce sites

Module 1: AHP running parallel to PR

INPUT: Data parameters captured from sites
OUTPUT: Eigenvectors/priority vectors in %

Step 1: Construct a paired comparison matrix w.r.t goal

A =

	L	P	AS	A	ISO
L	1	1/3	1/5	7	9
P	3	1	3	5	7
AS	5	1/3	1	9	3
A	1/7	1/5	1/9	1	3
ISO	1/9	1/7	1/3	1/3	1

Table 3.2: Paired comparison matrix level-1 with regards to goal

Step2:For reciprocal: $a_{ji} = \frac{1}{a_{ij}}$

Step 3: Normalise the matrix in step 2 by dividing each element by the column sum.

Step 4: Normalised principal eigenvector, average across rows. Each row added and then divided by n,5

Step 5: In order to check the consistency of our observations using eigenvalue as:

$\lambda_{max} = S_1(V_1) + S_2(V_2) + S_3(V_3) + \cdots =$

Step 6: Calculate consistency index

$CI = \frac{\lambda max - n}{n-1}$ (error<1%)

Step 7: Repeat steps 1-6 to construct a paired comparison matrix w.r.t. other levels 1, 2,…,n

Step 8: Compute composite vectors based on all the levels above as:

$G = (V_{L1L} * V_{L2L}) + (V_{L1A} * V_{L2A}) + \ldots\ldots = V1\%$
$Y = (V_{L1L} * V_{L2L}) + (V_{L1A} * V_{L2A}) + \ldots\ldots = V2\%$
$R = (V_{L1L} * V_{L2L}) + (V_{L1A} * V_{L2A}) + \ldots\ldots = V3\%$

Step 9: Make consensus decisions as:
Site A = AHP(V1) + PR(Pi) = {T, PT,UT}….
.. . Site N = AHP(V3) + PR(Pi) = {T, PT, UT}

Module 2:PR running parallel to AHP

INPUT: Web pages N, self-links, inbound/outbound links
OUTPUT: Page ranks in terms % of importance

Step 1: Construct a binary link matrix Lij,
Lij =

$$\begin{cases} If \quad page \quad j \rightarrow page\, i, & L_{ij} = 1 \\ otherwise & , \quad zero \end{cases}$$

Step 2: Compute the number of outbound link Cj

per column: $C_j = \sum_{i=1}^{N} L_{ij}$

Step 3: Compute to normalise the link matrix in step 2 as: $\frac{L_{ij}}{C_j}$

Step 4: Set initial value of page rank as number of outbound links: Pj = Cj

Step 5: Compute the sum product for each row as:

$$\sum_{i=1}^{N} \left(\frac{L_{ij}}{C_j} \right) P_j$$

Step 6: Set the value of damping factor d, e.g. 0.85

Step 7: Compute the next value of page rank as:

$$P_i = (1-d) + d \sum_{i=1}^{N} \left(\frac{L_{ij}}{C_j} \right) P_j$$

Step 8: Iterate step 7 until convergence, i.e. Pi ≥ Pj

Step 9: Merge Pi with step 9 of AHP as evidential reasoning

Figure III (b): PRAHP Assurance Framework Algorithm

IV. Experimental evaluations on E-commerce Sites

A. Experimental Setup

A selection of 10 e-commerce websites was done and categorized based on the number of the links (inbound, outbound and external links). The real names of the websites that have been assessed have been withheld for confidentiality reasons and they have been replaced by website names: A up to J.

The description of the websites has been added to illustrate the type of e-commerce service offered by a particular website.

Table IV: E-commerce website description

Website name	E-commerce website description	Size of website in terms of links
A	South African IT news website	Small
B	South African online payment service providers	Medium
C	International events reservations	Large
D	South African restaurants and shopping advertisements and specials	Small
E	South African online auctions	Medium
F	Targeted marketing services through social media	Medium
G	One of the biggest networking sites which sells advertising packages for businesses	Large
H	South African e-commerce site which sells a diverse range of commodities and services	Medium
I	Events online booking platform	small
J	International e-commerce website that sells a variety of commodities	Large

A selection of key attributes was identified based on the importance of these attributes in terms of the literature and also as evidenced by the use of these attributes by some of the websites reviewed for the purposes of this study. The e-commerce assurance attributes introduced in section III are adaptive legislation (L), ISO standards (ISO), availability (A), advanced security (AS) and policy (P). The assessment of the website attributes was conducted using the macro based AHP assessment tool [3] which allowed for the capturing of the attributes and the assigning of weights using the scale shown in Figure IV

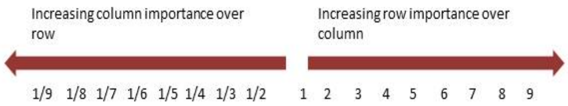

Figure IV: AHP weighting scale

As an example we use this scale to assess the level of importance of two attributes in an e-commerce site .Assume that the attribute adaptive ISO is strongly more important than policy (P), then in terms of the value that would be assigned according to this scale it would be on the far right e.g. 5 then the inverse would be 1/5. In short ISO/P = P/ISO; 5/1 = 1/5.

In order to ensure reliability of the weightings, real data from the websites was used which was a combination of qualitative and quantitative measures on the assessment of that information. These rating scales would be in percentage form and the sum total of these percentages for each attribute i.e. policy, legislation, ISO, availability and advanced security add to a 100%. Each attribute percentage constituted level-1 vectors.

B. *Experiment 1: PRAHP Assurance for Small and Large E-commerce Enterprises*

(1)AHP:Pairwise Comparison Matrix Level-1 with Respect to the Goal

The aim of this section is to demonstrate how each of the attributes in website A was assessed using the tool with reference to the goal. As depicted in Tables IV(a)&IV(b), the attributes are assessed through the comparison of a pair of attributes such as policy and legislation using the scale in figure IV. A weighting is assigned based on the degree of importance of an attribute e.g. a comparison between policy and ISO favored policy according to Table IV (a).

Table IV (a): pairwise comparison

	L	P	AS	A	ISO
L	1	1	½	1	1
P	1	1	1	2	2
AS	2	1	1	2	2
A	1	½	½	1	1
ISO	1	½	½	1	1

Table IV (b) AHP-1

L	0.174	17.4%
P	0.256	25.6%
AS	0.285	28.5%
A	0.142	14.2%
ISO	0.142	14.2%

Table IV(c) : Last iteration for convergence

	L	P	AS	A	ISO
L	0.174418619	0.2	0.17442	0.174419	0.174418599
P	0.255813942	0.3	0.25581	0.255814	0.255813951
AS	0.284883719	0.3	0.28488	0.284884	0.284883725
A	0.14244186	0.1	0.14244	0.142442	0.142441863
ISO	0.14244186	0.1	0.14244	0.142442	0.142441863

Table IV (d) : AHP-4

L	0.17	17.4%
P	0.26	25.6%
AS	0.29	28.5%
A	0.14	14.2%
ISO	0.14	14.2%

CI=0.01526 λ=5.061046513

Half the matrix was populated diagonally where the rest of the cells were automatically calculated. Normalisation as inverse is done through the automated iteration process which results in the convergence of the last iteration in Table IV(c) &IV(d). According to the percentage allocation, the advanced security (AS) attribute has the highest assurance rating as shown in Table IV(b) and IV(d).The normalisation is done through the automated iteration process which results in the formation of the last iteration in Table IV(d) which shows the final result of the normalised matrix with the lamda and the consistency index. One can see the results are valid with CI=0.01526 which is less than 1 % stated in step 6 on the AHP side on Fig III (b).

(2) AHP:Pairwise Comparison Mattrix level-2 with Regards to Level- 1

The aim of the level 2 comparison matrix is to assess the level of importance of each assurance indicators (RAG) with respect to level-1 attributes.

The indicator names amber and yellow will be used interchangeably for the purposes of this study. In this case the Policy attribute for website A was assessed by utilising the red, amber and green indicators to determine the level of importance. Each indicator was assigned a weighting based on Figure IV e.g. 1/7 based on the level 1 importance and this was automatically calculated by the Automated macro tool. Tables V (a) &V (b) show the initial assessment of RAG indicators based on level-1 attribute i.e. policy. Half the matrix was diagonally populated and the rest of the cells were automatically calculated by the tool. The sum of these status percentages added up to 100% and this constituted the level-2 vectors.

Table V (a): pairwise comparison

	R	A	G
R	1	1/2	1/3
A	2	1	1/3
G	3	3	1

Table V (b): AHP-1

R	0.174	17.4%
A	0.228	22.8%
G	0.598	59.8%

Table V(c): Last iteration for convergence

	R	A	G
R	0.173913055	0.173913037	0.173913
A	0.228260873	0.22826088	0.228261
G	0.597826073	0.597826083	0.597826

Table V(d): AHP-4 with reference to level 1(policy)

R	0.174	17.4%
A	0.228	22.8%
G	0.598	59.8%

λ=3.067029 CI=0.03351

(3)Composite Vectors

The results of attributes assessment on level 1 and 2 were combined to come up with composite vectors which are the AHP overall website rating.

This is illustrated in step 8 of Fig III (b) on the page ranking side. Equations (4), (5) & (6) were used for composite vectors calculations. The following descriptions are used in equations (4),(5) & (6):

V_{L1L} =Vector from level 1 matrix legislation
$V_{L2L=}$ Vector from level 2 matrix legislation
$V_{L1A=}$ Vector from level 1 matrix availability
$V_{L2A=}$ Vector from level 2 matrix availability
* =Multiplied by

$G = (V_{L1L} * V_{L2L}) + (V_{L1A} * V_{L2A}) + \ldots\ldots = V_1\%$.......(4)
$A = (V_{L1L} * V_{L2L}) + (V_{L1A} * V_{L2A}) + \ldots\ldots = V_2\%$.......(5)
$R = (V_{L1L} * V_{L2L}) + (V_{L1A} * V_{L2A}) + \ldots\ldots = V_3\%$........(6)

Table V (e): Composite matrix % for website A

R	20.0%
A	30.0%
G	50.0%

Based on the composite vector equations given in subsection 3, the results of the RAG status show the percentage allocation as shown in table V (e). From the AHP results only one can see that the website A is safer to transact in since green has the highest percentage indicator, but final PRAHP assurance rating is complemented with evidential assessment of page ranking.

(4)Page Ranking

An initial matrix of websites A to J was developed in Table V(f). Where a website connected to another website in terms of the outbound and inbound links, a value of 1 was assigned and where no links were present a value of 0 was captured as shown in step 1 of page ranking side in Fig III (b). The last column of the matrix(Table V(f)) contains the sum total SUM (A+…+J) of the values in a particular row as shown in step 2 and 3 of Figure III(b), the outbound side. The last row, C_J, consists of the sum total SUM= (A+….+J) of all the values in a specific column.

Table V (f): Initial Page Rank Matrix 1

Lij	A	B	C	D	E	F	G	H	I	J	Total
A	1	0	0	0	0	1	0	0	1	1	4
B	0	1	0	0	0	0	0	0	1	1	3
C	0	0	1	0	0	0	0	0	1	1	3
D	0	0	0	1	0	0	0	0	1	1	3
E	0	0	0	0	1	0	0	0	1	1	3
F	1	0	0	0	0	1	0	0	1	1	4
G	0	0	0	0	0	0	1	0	1	0	2
H	0	0	0	0	0	0	0	1	1	1	3
I	1	1	1	1	1	1	1	1	1	1	10
J	1	1	1	1	1	1	0	1	1	1	9
CJ	4	3	3	3	3	4	2	3	10	9	44

Table V(g): Final Page Rank matrix

Lij	A	B	C	D	E	F	G	H	I	J	Sum product	Pi
A	0.25	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.10	0.11	0.98	0.98
B	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.11	0.74	0.78
C	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.10	0.11	0.74	0.78
D	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.10	0.11	0.74	0.78
E	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.10	0.11	0.74	0.78
F	0.25	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.10	0.11	0.98	0.98
G	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.10	0.00	0.56	0.63
H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.10	0.11	0.74	0.78
I	0.25	0.33	0.33	0.33	0.33	0.25	0.50	0.33	0.10	0.11	2.61	2.37
J	0.25	0.33	0.33	0.33	0.33	0.25	0.00	0.33	0.10	0.11	2.30	2.11
PJ	1.0	0.8	0.8	0.8	0.8	1.0	0.6	0.8	2.4	2.1		
Pi	1.0	0.8	0.8	0.8	0.8	1.0	0.6	0.8	2.4	2.1		

Following the matrix in Table V(f), other matrices were created for iterative processes and the final results of the iteration are shown on the Table V(g) which shows the convergence on the last 2 rows. In other words convergence was reached after repeating step 8 of Figure III (b).

According to the information on Table V(f) an additional row was created called P_J; this row contained the Figures from the previous table row C_J.

The aim of the creation of row P_J was to generate normalization values for all the rows and columns where the values in a cell were divided by the corresponding values in cell P_J and the values would be placed in respective cells e.g. the value on the first cell e.g. $L_{ij}/4=0.25$. The value of 0.25 would then be captured on cell $L_{ij.}$ The sum product column was also created which consisted of sum row values as illustrated in step 5 of Figure III(b).The sum product was computed for each row. The algorithm is also illustrated by step 7 of Figure III (b) on the page rank section.

Further iterations were done by simply taking the values on the P_i column and replacing the previous table's P_J values. The iteration was done until convergence of the P_J values and P_i values as shown in Table V(g).

(5)Consensus decision

The results of the AHP and page ranking assessments have been presented in Table V (h), where different combinations yielded different results using equation 7. Statuses results are presented using the following statuses: T=trustworthy, PT=partially trustworthy and UT=Untrustworthy.

$$A = AHP(V_1) + PR(P_i) = \{T, PT, or\ UT\} \qquad (7)$$

Based on decision concepts of the decision table, Table V (h) validates the results of the 10 websites using the proposed PRAHP framework with customers open assessments. The last column shows the comments by customers regarding their dissatisfaction with some aspect of the e-commerce website.

Table V (h): Validation Results

Website labels	Results	Validation comments
A	AHP (Green) + PR (Green)=Trustworthy	No comment==trustworthy
B	AHP (Green) + PR (Red) = Partially Trustworthy	No comment==trustworthy
C	AHP (Amber) + PR (Red) = Untrustworthy	"My husband has died some months ago but I have just discovered that someone has been transacting on his account through your website, how is this possible?"
D	AHP (Green) + PR (Green) = Trustworthy	No comment==trustworthy
E	AHP (Red) + PR (Green)=Partially trustworthy	No comment== Partially trustworthy
F	AHP (amber) + PR (Amber)= Partially trustworthy	No comment== Partially trustworthy
G	AHP (Red) + PR (Red)=Untrustworthy	"I just got notified that someone has logged in with my account from a strange location, how can I stop this?"
H	AHP (Amber) + PR (Red)=Untrustworthy	"my account for this website has been hacked and my e-mail taken over, please help"
I	AHP (Green) + PR (Green)=Trustworthy	No comment==trustworthy
J	AHP (Yellow) + PR (Green)= Partially Trustworthy	No comment==Partially trustworthy

C. Experiment 2: Effects of varied Damping Factor d on PRAHP

Most page ranking based applications use the damping factor *d* as a primary factor in defining rating activities. This is attributed to the fact that most rating applications are robust or sensitive to *d* as this affects the quality of the rating. Therefore, the degree of PR propagation in PRAHP from one page to another by a link is primarily determined by the value of *d* and it is often iterated between 0 and 1. The objective here is to verify a hypothesis that the higher the value of *d*, the larger the effect of inbound links and the more evenly distributed the ratings over the other pages of a site are. By varying *d*, the robustness of PRAHP is also tested evenly at d= 0.2, 0.4, and 0.6 in addition to the results in section IV at d=0.85.This trend is shown in Figure V.

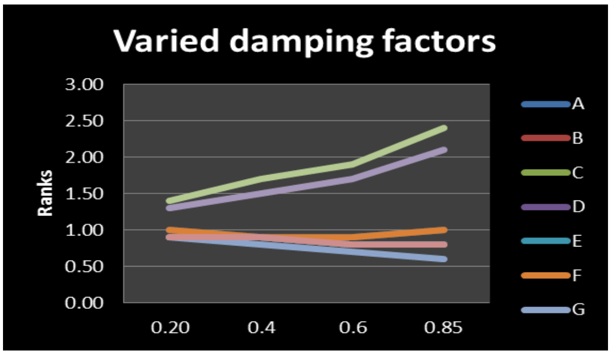

Figure V: Varied damping factors

One can see that the PRAHP model offers a more realistic assessment of website trustworthiness based on the page ranking technique combined with the AHP. Figure V illustrates that as the damping factor increases, the website rank's propagation tend to be distributed.

D. Comparing PRAHP with Classical Approaches

The evaluation of the various assurance methods in comparison with our proposed model PRAHP is shown in Table V(i). Based on the assurance criteria set to assess each assurance method, it is quite evident from the results that although method 3 has certain strengths compared to methods 1 and 2, our proposed model is better than all the 3 methods with regards to the aspects shown in Table V(i).

Table V(i): Comparative analysis of the PRAHP assurance model and other assurance methods

Criteria	Method 1: Policy[7]	Method 2: Third Party Seals [22]	Method 3:Online Monitoring tools [4]	Proposed PRAHP
Level of security and reliability	None	Open to manipulation by third party providers	Partially Secure	Tightened based on cooperative security
Reproduci-bility	Easily reproducible	Complex due to third party requirements	Complex due to different technologies	Made-easy with descriptive algorithm
Data Used	No data is required	Real data	Real data	Real-life data extracted from sites
Model Techniques	none	none	Online scanning techniques	Cooperative PR and AHP
Robustness	no	no	Not robust .Scans tend to focus on a single assurance attribute	Very robust with varied damping factor & sites

V. CONCLUDING REMARKS

Limited research exists on assurance models, consequently, there limited information in the formal literature about the subject. In this research work, the aim was to examine some of the existing e-commerce assurance models to identify gaps in order to propose a robust assurance model, PRAHP for e-commerce sites.

PRAHP used the page ranking technique and the AHP technique to come up with a cooperative rating which is shown in Figure III (a). The AHP technique makes use of pairwise comparison Level 1 and Level 2 to assess the attributes and page ranking as explained in section III(b). These techniques complement each other where each technique performs an independent assessment of the attributes to come up with an overall cooperative rating of a website regarding the website's trustworthiness. The PRAHP framework makes an assessment of the attributes discussed in Section III (A and B). Some of the attributes are adaptive in order to cater for the changes that may occur in future such as the revision of legislations.

A significant contribution of this framework is its ability to calculate e-commerce assurance trustworthiness ratings using the cooperative techniques. Future research should consider having a similar model expanded to include other attributes and also to cloud based environments.

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