Utility Implementation for Cyber Risk Insurance Modeling

Dinesh Kumar Saini, Imran Azad, Nitin B Raut and Lingaraj A. Hadimani

***Abstract*— In this paper an attempt is made to implement utility theorem in cyber risk insurance modeling. The university network is considered for the study and all possible cases of the network insurance is considered in the paper. University network environment is prone to security risk so to minimize the burden of security, it is analyzed that university networks must be covered under insurance schemes. In the paper we formulated the premium amount to be paid for the insurance.**

***Index Terms*—utility theorem, cyber infrastructure, risk, insurance, modeling**

I. INTRODUCTION

Information security conscious managers of organization have the responsibility to advise their senior management of the level of risks faced by the information systems. This requires managers to conduct vulnerability assessment as the first step of a risk analysis approach. The goal is to assess the expected damages due to attacks, and managing the risk of attacks. As the world is moving towards the knowledge-economy, electronic communication has grown by leaps and bounds. Researches and surveys across the world have already triggered alarm bells for safeguarding organizations' interests and protecting information and data in electronic format and have pegged the same as the most important and critical task. An attempt has been made to study the effect of cyber risk insurance in the cyber space environment for network services. By using the utility factor model, critical analysis has been made for the insured and non-insured network users in the environment about their range of the premium paid to the insurance company.

The world has changed more rapidly in the last 50 years than in the entire history of mankind. The right to information, transparency of transactions, critical data collection, and customer delight are some of the new mantras of this New World. Fast response time has become critical for survival. The electronic media these days is replacing the traditional approach of file and paper systems everywhere. A new trend emerging in world is to have information online process for almost all the activities, which need high level of network and system level security as well as high level of network availability. Cost involved in conducting such online secure transactions is huge which runs into several million dollars .This is the reason why we need some process which can reduce risk to certain extent. Cyber insurance plays a vital role to reduce these risks to certain extent.

Every year security breach in computer systems causes immense economic damages worldwide leading to failure of network services. It is very difficult to quantify these damages. Ross Anderson [2] in his paper "Why information security is hard- An Economic perspective" has studied that neither manufacture nor users have an interest in investing into security measures within their perspective of responsibility. Computer security requires the consideration of both technical means as well as economic principles. Several researchers like Perry Luzwick and Anderson [1, 2], studied the effect of security breaches over the failure of network services. In today's global e- space concept, the critical success factor of most of the organization is decided by efficient and proper utilization of network service. Most of the world university today uses network services either in form of LAN, WAN or MAN as well as SAN. Internet, Intranet and Extranet are some of the main network services used by most of the universities provided by Internet work service providers. The risk of hacking and attacks of malicious objects like virus, worms, Trojans, bots etc. looms large on them. Various software and hardware devices have been used to protect them against such malicious attacks, but they do not guarantee to be successful completely. To reduce the financial loss due to e-risk, insurance will be viable option where revenue losses can be compensated.

In brief we can say that for the university going for cyber-insurances are quite useful to tackle information security risks as well as down time of the network so that universities can compensate with the losses incurred by network services.

II. CLASSIFICATION OF CYBER RISK IN UNIVERSITY ENVIRONMENT

Rainer Bohme [10] in his paper Cyber-Insurance Revisited has discussed the different types of cyber risks. In the present day university network scenarios(Fig.1); we propose the implementation of utility model for the university network environment discussed in Section VI, for which the following classifications can be made:

1. Risk to security components like firewall, anti-virus, unauthorized access, service denial etc.

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2. Failure of internet service providers
3. Application service provider failure
4. Identity thefts
5. Internal Attacks
6. Denial of services (DOS)
7. Cyber- Extortion

III. Classification of Cyber Risk in University Environment

S.No.	Direct Risk	Indirect Risk
1.	Unavailability of Network Services	Damage of brand and reputation
2.	Hackers may leak the crucial information	Transactional noncompliance with regulations
3	Confidential information can be leaked	Inadvertent discloser
4.	Un-authorized access to data and applications	Law suites and third party liability claims
5.	Discloser of secrete university plans	Deterioration of market capitalization

IV. Classification of Cyber Risk in University Environment

There are large numbers of insurance products, which are available with different flavors like ordinary, professional, commercial, liability, property, security etc. There are several insurance companies which provide coverage against different types of e-risk, universities network systems etc. Security of Network, Functionality and Performance are three important parameters which plays vital role in cyber insurance.

V. Nomenclature

L : Local network
G : Global network
A : Initial amount invested for network facility (L or G)
ISP : Internet Service Provider
LAN : Local Area Network
WAN: Wide Area Network
MAN: Metro Area Network
SAN : Storage Area Network
LL : Loss Local
LP : Loss Personal
LG : Loss Global
LD : Total Loss
EUI : Expected utility of insured users
EUN I: Expected utility of non-insured users

VI. Utility Model

The basic premise of the utility theory is used to find out the expected utility of the insured and non-insured users which is shown in equations (1) and (2) respectively as shown in Fig.2.

$$EU_I = a\ EU[A-(P+0)] + b\ EU[A-(P+L_P)] + c\ EU[A-(P+L_L)] + d\ EU[A-(P+L_P+L_L)] + e\ EU[A-(P+L_G)] + f\ EU[A-(P+L_G+L_P)] + g\ EU[A-(P+L_G+L_L)] + h\ EU[A-(P+L_D)] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$EU_{NI} = a\ EU[A-0] + b\ EU[A-L_P] + c\ EU[A-L_L] + d\ EU[A-(L_P+L_L)] + e\ EU[A-L_G] + f\ EU[A-(L_G+L_P)] + g\ EU[A-(L_G+L_L)] + h\ EU[A-(L_G+L_P+L_L)] \quad \ldots\ldots\ldots \quad (2)$$

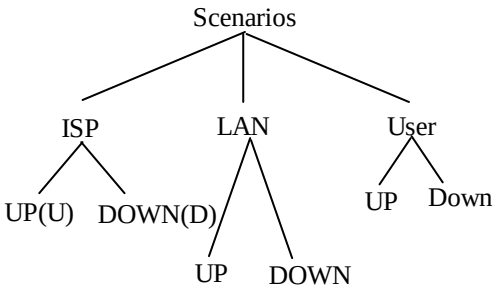

Fig. 1 Campus network: Scenario diagram

A study for the various utility functions of variations in risk premium with the attitude of user's risk profile is analyzed as depicted in table I.

TABLE I
Outcome Probabilities of Insured Network

Scenarios	Proba-bility	Loss	Premi-um	Utility
ISP Up, LAN Up, User Up	a	0	P	A-(P+0)
ISP Up, LAN Up, User Down	b	L_P	P	A-(P+L_P)
ISP Up, LAN Down, User Up	c	L_L	P	A-(P+L_L)
ISP Up, LAN Down, User Down	d	L_P+L_L	P	A-(P+L_P+L_L)
ISP Down, LAN Up, User Up	e	L_G	P	A-(P+L_G)
ISP Down, LAN Up, User Down	f	L_G+L_P	P	A-(P+L_G+L_P)
ISP Down, LAN Down, User Up	g	L_G+L_L	P	A-(P+L_G+L_L)
ISP Down, LAN Down, User Down	h	L_D	P	A-(P+L_D)

Case I: When the user is risk neutral

When the user is risk neutral its U (A) = A. Under this attitude of user, its expected value of utility when insured

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and non-insured is given in the equations (3) and (4) respectively.

$EU_{Insured} = A\,(a + b + c + d + e + f + g + h) - P\,(a + b + c + d + e + f + g + h)$ ..…… (3)

$EU_{Non\text{-}Insured} = A\,(a + b + c + d + e + f + g + h) - a.\,0 - b\ L_P - c\ L_L - d\ (L_P+L_L) - e\ L_G - f\ (L_G+L_P) - g\ (L_G+L_L) - h\ (L_G+L_P+L_L)$ ……. (4)

The basics of utility theory tells us that

$EU_{Insured} \geq EU_{Non\text{-}Insured}$ ..... (5)

Therefore, $A - P \geq A - b\ L_P - c\ L_L - d\ (L_P+L_L) - e\ L_G - f\ (L_G+L_P) - g\ (L_G+L_L) - h\ (L_G+L_P+L_L)$ ……. (6)

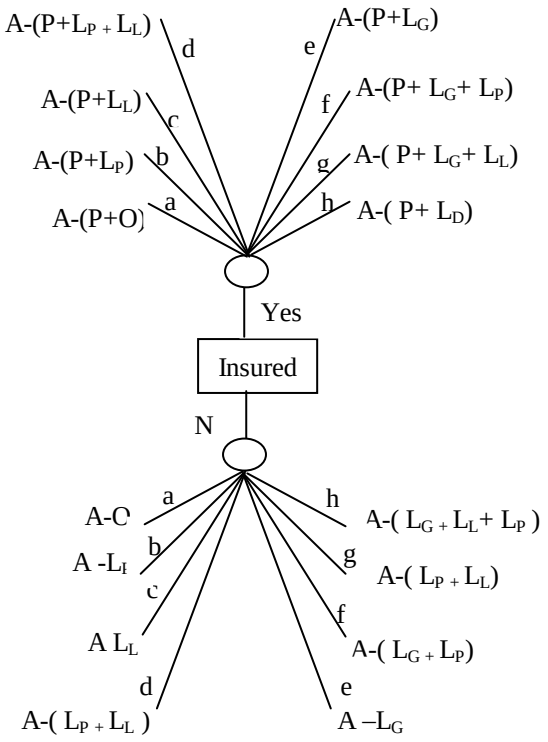

Fig. 2 Decision tree: Utility Payoffs

Case 2*: When the user is not favor of risk.*

Under this assumption,

i) U(A) = A, when the user is insured

ii) $U(A) = E(A) - (S_L/2)\,z^2$, when the user is not insured; where z is a stochastic variable used for expected loss.

Thus the utility of the insured and non-insured user is given in the following expressions:

$EU_{Insured} = A - P$ …… (7)

$EU_{Non\text{-}Insured} = A - b\ L_P - c\ L_L - d\ (L_P+L_L) - e\ L_G - f\ (L_G+L_P) - g\ (L_G+L_L) - h\ (L_G+L_P+L_L) - b\ L_P^2\ S_L/2 - c\ L_L^2\ S_L/2 - d\ (L_P+L_L)^2\ S_L/2 - e\ L_G^2\ S_L/2 - f\ (L_G+L_P)^2\ S_L/2 - g\ (L_G+L_L)^2\ S_L/2 - h\ (L_G+L_P+L_L)^2\ S_L/2$ …….. (8)

Equation (5) holds for Case 2, the premium of a user who does not favor risk is also obtained by using equations (2) and (8).

i.e., $P \leq b\ L_P + c\ L_L + d\ (L_P+L_L) + e\ L_G + f\ (L_G+L_P) + g\ (L_G+L_L) + h\ (L_G+L_P+L_L) + S_L/2\ \{\ bL_P^2 + cL_L^2 + d\ (L_P+L_L)^2 + eL_G^2 + f\ (L_G+L_P)^2 + g\ (L_G+L_L)^2 + h\ (L_G+L_P+L_L)^2\ \}$ …… (9)

In the Table II outcome probabilities for non insured companies are given and premium is computed based on probability, loss and utility.

TABLE II
OUTCOME PROBABILITIES OF NON-INSURED NETWORK

Scenarios	Proba-bility	Loss	Prem-ium	Utility
ISP Up, LAN Up, User Up	a	0	0	A-0
ISP Up, LAN Up, User Down	b	LP	0	A-LP
ISP Up, LAN Down, User Up	c	LL	0	A-LL
ISP Up, LAN Down, User Down	d	LP+LL	0	A-(LP+LL)
ISP Down, LAN Up, User Up	e	LG	0	A-LG
ISP Down, LAN Up, User Down	f	LG+LP	0	A-(LG+LP)
ISP Down, LAN Down, User Up	g	LG+LL	0	A-(LG+LL)
ISP Down, LAN Down, User Down	h	LG+LL +LP	0	A-(LG+LL+LP)

VII. CONCLUSION

Several software and hardware security equipment have been used over the years but not with much relief to University networks. One of the most vital solutions is to pass a proportion of the risk to an insurance company in lieu of a premium. The utility method backed premium calculation, can be effective tool for insurance companies to design insurance products based on the risk profiles of the University network. It is evident from equation (6) that when the user is risk neutral, he will insure only if the premium value is non-negative but less than user's expected loss. Also when then user is not in favor of risk, equation (9) suggests that if the variance from expected loss is high, then he is

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ready to pay a high premium.

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