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New Cyber Risk: Premises for an Insurance Coverage

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In literature, we have not found insurance policies created to evaluate and to pay the damages that follow an attack of computer piracy. Encouraged by the widespread attacks via the Internet and after having considered the extent of such a problem, a mass phenomenon so far, we would like to write our reflections on the cyber risks via web which, beyond any material damages, can also cause damages to the image and privacy violation. On the analogy of the coverage regarding health insurance, three levels of damage can be identified with regard to the functionality of the computer.In this paper, we have hypothesized a structure of the probabilistic model in order to describe the damages after the networking. Therefore, we have proposed a possible solution to the problem through insurance policies. The aim of this working is not to propose a technological solution, but to hypothesize the actuarial premises for the coverage about net damages.

Field of Research: Insurance and cyber risk.

1. Introduction

The use of the Internet favors the transmission of information and programs. Some of these programs (viruses) are lines of code that modify the software and/or the information contained in a terminal, We refer hereinafter to a terminal as any device that can be connected to the web (via the Internet and/or Intranet).The virus is a form of violence, deceitful and invasive, for which, at the moment, no reliable tools of prevention and defense exist. Following the use of the net, these viruses multiply and become more and more advanced (*Trojan, Worm*).

The aim of this working paper is not to propose a technological solution, but to hypothesize the actuarial premises for the coverage about net damages. By risk of cyber piracy (hackers) we mean the possibility to receive a virus that limits the operation of the terminal (The malfunctioning of the terminal can be caused by an interruption of connection, a loss of data, a transmission of information to a third not-authorized party, a missed access to applications, a

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limited use of the memory, a reduction of speed – regardless the risk time, both in economic and programmable terms.).In this paper, a via-web connected computer is the object of the coverage. Starting from multistate models for health insurance (Pitacco, 1995; Pitacco & Olivieri,1997), we have hypothesised two typologies of computer policies:
- ADC (Activities of Daily Cyber)
- GCU (Good Cyber Use)

2. Literature Review

The virus is a programme that generates other programmes, being this process an automatic procedure (Base minima di sicurezza, 2002).
The first virus (Figure 1) has been created by the mathematician von Neumann (1948).

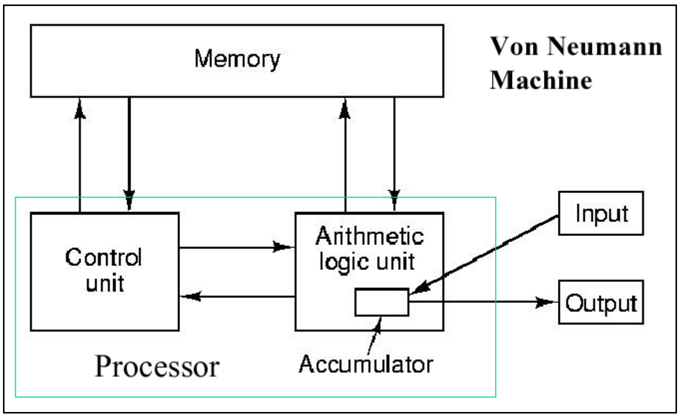

Figure 1

Solomon and Slade (http://www.cknow.com/vtutor/vthistory.htm) have studied and classified the main viruses since 1981.Cohen (1987) has examined the algorithm describing the propagation of a virus through a test on the virus known as Elk Cloner (1981).

Other Authors (Wang, C., J.C. Knight, M. Elder, 2000; Wang, Y & Wang, C. 2003; Zou, Towsley, Gong, 2004) have proposed stochastic models of propagation for specific typologies of viruses (*Worm*, *Trojan* and so on).
Symantec Internet Security Report has shown that Hackers use more and more such worms in order to exploit known vulnerabilities and, therefore, to create accesses to a huge number of systems. The 64% of new attacks have concerned vulnerability of recent software; the reason is that antivirus companies have not had enough time to study the holes of the antivirus itself and the hackers have had much time to attack. It is evident that old software are safer than young ones. The same research has shown that Hackers use more and more the worms in order to exploit known vulnerabilities and, therefore, to create accesses in a huge number of systems.
I
n the *Official Journal* of March 22, 2002 a document was published under the title "Base minima di sicurezza" it deals with the guidelines for the individualization of the protection measures for the Public Administration. The same document shows that most programs for terminal safety are not able to neutralize all the possible threats. In this paper, we aim at proposing an actuarial

model for the coverage of the consequential computer risks from the use of the net, for example Assicurazioni Generali has proposed "Polizza reti" and "Polizza di tutti i rischi informatici" (www.generali.it) but, to our knowledge, the actuarial models of reference have not been made known.

3.The cyber risk

It is necessary to catalogue the cyber risks with the purpose of individualizing the component at the basis of the GCU and ADC coverage. An insurance policy pertains to a risk that refers both to an economic element (a covered interest) and to a probabilistic element (harmful events and their probabilities).
In order to classify the level of gravity and, therefore, of riskiness of the viruses, Symantec proposes:

a) the degree of spread;
b) the seriousness of the damage;
c) the speed of virus propagation.

It is not interesting to classify the viruses on the basis of the technical characteristics, but on the basis of the damages they can provoke.
On the analogy of the coverage regarding health insurance, three levels of damage can be identified with regard to the functionality of the computer:

Computer Insurance	Health Insurance
No damage (nd)	Self-sufficient
Repairable damage (rd)	Temporary invalidity
Partially repairable damage (prd)	Permanent invalidity
not repairable damage (nrd)	Death

Table 1

We indicate with *(1,…, m)* the m-vector of computer activities (operating system, email management, operation of the programmes, management of the database), and with $(\omega_1, \ldots, \omega_m)$ $(\omega_i \in \mathbf{N})$ the vector of the weights attributed to such activities; we define with

$$\alpha_j = \begin{cases} 0 & \text{no damage} \\ 1 & \text{partially repairable damage} \\ 2 & \text{not repairable damage} \end{cases} \qquad 1$$

the discreet aleatory variable describing the level of damage of the *j-th* computer activity, so that $j=1,\ldots,m$
In this paper, we assume that $\omega_1= \ldots =\omega_m=1$, and if $\omega_i=s$, it is possible to replace such activity with s activity $(i1, \ldots, is)$ of weights $\omega_{i1}= \ldots =\omega_{is}=1$. On the analogy of health insurance, the Barthel index, as previously described through the aleatory variable, measures the general level of damage

$$\alpha = \sum_{j=1}^{m} \alpha_j \qquad 2$$

where α=0 corresponds to the level of non damage, or initial level, while α=2m to the general level of non repairable damage.
Since the determinations of the aleatory variable α_j can be hypothesized with regard to the different levels of partially repairable damage, the formula (1) is replaced with (3)

$$\alpha_j^{(\tau)} = \begin{cases} 0 & \text{no damage} \\ \tau & \text{partially repairable damage} \\ 2 & \text{not repairable damage} \end{cases} \qquad 3$$

where $0<\tau<2$ and consequently the (2) formula is generalized as follows:

$$\alpha^{(\tau)} = \sum_{j=1}^{m} \alpha_j^{(\tau)} \qquad 4$$

where $\alpha(\tau)=0$ *it* corresponds to the non-existent general damage and $\alpha(\tau)=2m$ to the general level of a non repairable damage.
The probabilistic model of a computer coverage is schematized in the Figure 2 below.
On the analogy of the construction of multistate models (Barracchini, 2007), a status of the computer corresponds to every level of damage: $S=\{nd, rd, prd^{(1)}, prd^{(2)}, \ldots, prd^{(n)}, nrd\}$.
The status of the computer are defined through the following equations (5,…,9):

$nd=\{\alpha : \alpha = 0\}$ 5

$rd = \{\alpha : 0 < \alpha \le \alpha^{(1)}\}$ 6

$prd^{(1)} = \{\alpha : \alpha^{(1)} < \alpha \le \alpha^{(2)}\}$ 7

$prd^{(n)} = \{\alpha : \alpha^{(n)} < \alpha < 2m\}$ 8

$nrd=\{\alpha : \alpha = 2m\}$ 9

where $0 < \alpha^{(1)} < a^{(2)} < \alpha^{(n)} < 2m$.
If $n=2$ the model is represented by the Figure 2 below:

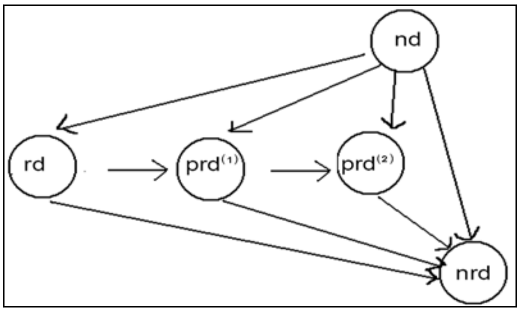

Figure 2: Cyber Multistate Model

4. A probabilistic model

In order to present the probabilistic model (As regards life insurances, the probability of death is an increasing function of the age of the insured party;

as regards health insurances, the probability of not self-sufficiency is an increasing function of the age of the insured party, as it can be deduced by the tables of survival), it is necessary to observe that the probability that a software can be damaged by a virus changes according to its time of introduction on the market: if the construction of a software is recent, there will be less possible updates aiming at closing the backdoors.
We indicate with:

- y: the weighted average age of the software contained in a computer (the weights are subjectively assigned to every software component);
- $P(r_x)$: the probability to be r_x days in the x status;
- $r_{x(\alpha)}$ the number of the days of permanence in the status x with a level of damage α

The unpredictable variable r_x, is the sum of all the dichotomy unpredictable variables ($x \in S$):

$$\sum_{0<\alpha\leq 2m} \sum_{i=1}^{365} r_{x(\alpha)}^{(i)} = r_x \qquad 10$$

with

$$r_{x(\alpha)}^{(i)} = \begin{cases} 1 & \text{if in } i^{th} \text{ day the computer is in x status on } \alpha \text{ level} \\ 0 & \text{if in } i^{th} \text{ day the computer is not in x status on } \alpha \text{ level} \end{cases} \qquad 11$$

We are defining the following probabilities through the equations (12,…,16)

P_y^x with $x \in S$ 12

the probability that a computer of y average age is in the year of coverage, (from y to $y+1$), in x status,

${}_{r_x}P_y^x$ with $x \in S$ 13

the probability that a computer of y average age is in the year of coverage, (from y to $y+1$), in x status for a period of length r_x.
In the probabilities (12) and (13) the initial status is *nd*, therefore, they result equivalent to the probabilities (12.a) and (13.a) respectively

$P_y^{nd,x}$ with $x \in S$ 12.a

${}_{r_x}P_y^{nd,x}$ with $x \in S$ 13.a

Furthermore, we define with the formula (14) below the probability that a computer of y average age is in the year of coverage, (from y to $y+1$), in the status x_I (status of input), and that it can be found, at the end of the year of coverage, in the status x_O (status of output).

$P_y^{x_I, x_O}$ with $x_I, x_0 \in S$ 14

The formula (15) is the probability that a computer of *y* average age is in the year of coverage (from *y to y+1*), in the status x_I, and it can be found, at the end of the year of coverage, in the status x_O, after passing through *x* status

$P_y^{x_I, x_O, x}$ with $x, x_I, x_0 \in S$ 15

The formula (16) is the probability that a computer of *y* average age is in the year of coverage (from *y to y+1*), in the status x_I, and that it can be found, at the end of the coverage, in the status x_O, after passing through *x* status for a general period r_x:

${}_{r_x}P_y^{x_I, x_O, x}$ with $x, x_I, x_0 \in S$ 16

A list of the features of the probabilistic functions (12,… ,16) is shown below: normality (17), sufficiency (18), Chapmann-Kolmogorov's Equations (19), monotony (20).

Normality 17

$0 \le P_y^x \le 1$ 17.a

$0 \le {}_{r_x}P_y^x \le 1$ 17.b

$0 \le P_y^{x_I, x_0} \le 1$ 17.c

$0 \le {}_{r_x}P_y^{x_I, x_0} \le 1$ 17.d

$0 \le {}_{r_x}P_y^{x_I, x_0, x} \le 1$ 17.e

Sufficiency 18

$\sum_{x \in S} P_y^x = 1$ 18.a

$\sum_{x \in S} {}_{r_x}P_y^x = 1$ 18.b

$\sum_{x_0 \in S} P_y^{x_I, x_0} = 1 \qquad \forall x_I \in S$ 18.c

$\sum_{x_0 \in S} \sum_{r_x = 0}^{365} {}_{r_x}P_y^{x_I, x_0} = 1 \qquad \forall x_I \in S$ 18.d

$$\sum_{x_0 \in S} \sum_{x \in S} \sum_{r_x = 0}^{365} {}_{r_x}P_y^{x_I, x_0, x} = 1 \qquad \forall x_I \in S$$ 18.e

Chapmann-Kolmogorov's Equations 19

$$P_y^{si,x} = \sum_{x \in S} \sum_{x_1 \in S} {}_{\tau}P_y^{si,x_1} \cdot {}_{1-\tau}P_{y-\tau}^{x_1,x} \quad \text{with} \quad 0 \le \tau \le 1,$$ 19.a

$$\begin{aligned} {}_{r_x}P_y^{si,x} &= \Pr(r_x) \cdot P_y^{si,x} = \\ &= \Pr(r_x) \cdot \sum_{x \in S} \sum_{x_1 \in S} {}_{\tau}P_y^{si,x_1} \cdot {}_{1-\tau}P_{y-\tau}^{x_1,x} \quad \text{with} \quad 0 \le \tau \le 1, \end{aligned}$$ 19.b

$$P_y^{x_I,x_0} = \sum_{x_0 \in S} \sum_{x \in S} {}_{\tau}P_y^{x_I,x} \cdot {}_{1-\tau}P_{y-\tau}^{x,x_0} \quad \text{with} \quad 0 \le \tau \le 1,\ x_I \in S$$ 19.c

$${}_{r_{x_0}}P_y^{x_I,x_0} = \Pr(r_{x_0}) \cdot P_y^{x_I,x_0} = \Pr(r_{x_0}) \cdot \sum_{x_0 \in S} \sum_{x \in S} {}_{\tau}P_y^{x_I,x} \cdot {}_{1-\tau}P_{y-\tau}^{x,x_0}$$
$$\text{with} \quad 0 \le \tau \le 1,\ x_I \in S$$ 19.d

$$\begin{aligned} {}_{r_x}P_y^{x_I,x_0,x} &= \Pr(r_x) \cdot P_y^{x_I,x_0,x} = \Pr(r_x) \cdot P_y^{x_I,x} \cdot P_y^{x,x_0} = \\ &= \Pr(r_x) \cdot \sum_{x \in S} \sum_{x_1 \in S} {}_{\tau_1}P_y^{x_I,x_1} \cdot {}_{\tau-\tau_1}P_{y+\tau-\tau_1}^{x_1,x} \cdot \sum_{x_0 \in S} \sum_{x_2 \in S} {}_{\tau_2}P_{y+\tau}^{x,x_2} \cdot {}_{1-\tau-\tau_2}P_{y+\tau-\tau_2}^{x_2,x_0} \\ & \qquad 0 \le \tau_1 \le \tau_2 \le \tau \le 1 \end{aligned}$$ 19.e

Monotony

$$P_y^x \ge {}_{r_x}P_y^x \ge {}_{r_x^/}P_y^x \qquad \text{with} \qquad r_x^/ > r_x$$ 20

The probabilities (12,…,16), that verify the Chapmann-Kolmogorov's equations, describe a trial stochastic discreet Markov (Hoem, 1988)

On the analogy of health insurance, we are going to introduce this probabilistic model in the continuous $\{Z(y);\, y \ge 0\}$ with *y* as a continuous parameter and *Z(y)* $\in$*S* as a discreet status.

As regards health insurance, with the following formula:

$${}_tP_y^{x_I,x_O} = \Pr\{Z(y+t) = x_O \,|\, Z(y) = x_I\}$$

we indicate the probability that a person of age *y*, in a status x_I, (input status), after *t* time, and his/her age is therefore *y*+*t* (*t*>0), is in a status x_O (output status). In a cyber contest, through previous formulas, we have indicated with *y* the weighting average age of the software. The age of the software, running in the terminal, is to be referred to as a "biologic age" and not as a "real or calendar age". After *t* time, the expiry date of the terminal, *y*=y+t*, is different from that in health insurance because the average age of the software changes in fun-ction of *t*: but in the case of the software, if *t* grows up, the average age of the software itself can grow up, grow down or remain the same.

The variation of the average age of the software depends on:

- The average age y grows up, for example to substitute an old software for a new one;
- The average age can remain the same because the age of the new software balances the other;
- The average age y grows down, due to placing of a newly produced software into the terminal.

If the fluctuation of the average age is negative, the terminal will be it younger than was before the placing of the new software; in this case we would have a greater probability to infect the terminal, because the antivirus would not be available.The function of the average age of the terminal and the infection probabi-lity can be described by a survival table in function of a cyber risk.
This table can be corrected with the age-shifting method that (used to the cor-rection of the longevity risk in life/health insurance), in our case, we can de-fine month-shifting. We have seen the average age change in both directions.
We suppose that a technological asset, such as a computer or another ma-chine connected to the net, can be updated with new software every t months – in other words, its average age can remain the same for t months.
For this reason the average age changes.

The dynamic probability of damage is given by (21):

$$P_{y:y^*}^{x_I,x_0} = \Pr\{Z(y^*) = x_0 \,|Z(y) = x_I\} \quad \text{or} \qquad 21$$
$${}_tP_y^{x_I,x_O} = \Pr\{Z(y+t) = x_O \,|Z(y) = x_I\}$$

the probability that a computer of y average age, in the x_I status, to y^* ave-rage age is in the x_O status, and with the (22)

$$\mu_y^{x_I,x_O} = \lim_{y^*\to y} \frac{P_{y:y^*}^{x_I,x_0}}{y^* - y} \qquad x_I, x_O \in S\,,\, x_I \neq x_O \quad \text{e} \quad y^* \neq y \qquad 22$$

the immediate intensity of transition.
With the formula (23) we are defining the total intensity of exit from the x_I status

$$\mu_y^{x_I} = \sum_{x_0 \in S} \mu_y^{x_I,x_0} \qquad 23$$

According to actuarial purposes, we are interested in the functions of intensity (22), being they continuous (and limited) or constant at intervals due to their greater easiness to be implemented.

In the case of the homogeneous Markov process, the immediate inten-sities of transition are considered as constant functions (Pitacco & Olivieri, 1997, page 25):

$$\mu_y^{x_I,x_O} = \lim_{y^*\to y} \frac{P_{y:y^*}^{x_I,x_0}}{y^* - y} = \mu^{x_I,x_0} \qquad 22.a$$

Following (22), we have 22.b

$$\mu_y^{x_I} = \sum_{x_I \neq x_0} \lim_{y^* \to y} \frac{P_{y:y^*}^{x_I,x_0}}{y^* - y} = \lim_{y^* \to y} \frac{\sum_{x_I \neq x_0} P_{y:y^*}^{x_I,x_0}}{y^* - y} = \lim_{y^* \to y} \frac{1 - P_{y:y^*}^{x_I,x_I}}{y^* - y} \qquad 22.b$$

We now have the tools to write the Kolmogorov's differential equations in the continuous case, fixing the *y* average age of entry of the computer under insurance cover.

<u>Kolmogorov's forward differential equations</u>
The (24) is defined as forward, since the average age of entry, *y*, under an insurance cover is fixed while the average age of exit y^* changes:

$$\frac{dP_{y:y^*}^{x_I,x_0}}{dy^*} = \sum_{x \neq x_0} P_{y:y^*}^{x_I,x} \cdot \mu_{y^*}^{x,x_0} - P_{y:y^*}^{x_I,x_0} \cdot \mu_{y^*}^{x_0} \qquad 24$$

<u>Kolmogorov's backward differential equations</u>
The (25) is defined as backward, since the two values of the average age of the terminal, *y* and y^*, operate in opposite ways:

$$\frac{dP_{y:y^*}^{x_I,x_0}}{dy} = P_{y:y^*}^{x_I,x_0} \cdot \mu_{y^*}^{x_I} - \sum_{x \in S} P_{y:y^*}^{x,x_0} \cdot \mu_y^{x_I,x} \qquad 25$$

Therefore, we have that $y>y^*$, $y<y^*$ or $y=y^*$.
The formula (24) can be obtained on the basis of the equations of Chapmann-Kolmogorov (19.c), properly modified:

$$\frac{dP_{y:y^*}^{x_I,x_0}}{dy^*} = \sum_{x \neq x_0} P_{y:y^*}^{x_I,x} \cdot \mu_{y^*}^{x,x_0} - P_{y:y^*}^{x_I,x_0} \cdot \mu_{y^*}^{x_0} \quad \forall x_I, x_0, x \in S, \forall y^*, \ 0 \leq y \leq y^*$$

with $P_{y:y}^{x_I,x_0} = \delta^{x_I,x_0}$, as the initial condition, where

$$P_{y:(y^*+\Delta y^*)}^{x_I,x_0} = \sum_{x \neq x_0} P_{y:y^*}^{x_I,x} \cdot P_{y^*:(y^*+\Delta y^*)}^{x,x_0} + P_{y:y^*}^{x_I,x_0} \cdot P_{y^*:(y^*+\Delta y^*)}^{x_0,x_0}$$

The immediate intensities of transition come from the following relationships:

$$\frac{P_{y:(y^*+\Delta y^*)}^{x_I,x_0} - P_{y:y^*}^{x_I,x_0}}{\Delta y^*} = \sum_{x \neq x_0} P_{y:y^*}^{x_I,x} \cdot \frac{P_{y^*:(y^*+\Delta y^*)}^{x,x_0}}{\Delta y^*} + P_{y:y^*}^{x_I,x_0} \cdot \frac{P_{y^*:(y^*+\Delta y^*)}^{x_0,x_0} - 1}{\Delta y^*}$$

Since

$$1 - P_{y:(y^*+\Delta y^*)}^{x_0,x_0} = \sum_{x \neq x_0} P_{y^*:(y^*+\Delta y^*)}^{x_0,x}$$

we have that

$$\frac{P^{x_I,x_0}_{y:(y^*+\Delta y^*)} - P^{x_I,x_0}_{y:y^*}}{\Delta y^*} = \sum_{x \neq x_0} P^{x_I,x}_{y:y^*} \cdot \frac{P^{x,x_0}_{y^*:(y^*+\Delta y^*)}}{\Delta y^*} - P^{x_I,x_0}_{y:y^*} \cdot \frac{P^{x_0,x}_{y^*:(y^*+\Delta y^*)}}{\Delta y^*}$$

from which the formula (24) is obtained when $\Delta y^* \to 0$.

However, the study of the conditions of the existence of solutions for the probabilities of transition for which it can be referred to Pitacco-Olivieri (1997), lies outside the purposes of the present work.

Demonstration of the Kolmogorov's Backward Differential Equation:

On the basis of analogous reflections,

$$P^{x_I,x_0}_{(y-\Delta y):y^*} = P^{x_I,x_I}_{(y-\Delta y):y} \cdot P^{x_I,x_0}_{y:y^*} + \sum_{x \neq x_0} P^{x_I,x}_{(y-\Delta y):y} \cdot P^{x,x_0}_{y:y^*}$$

it follows that the formula (25) comes true:

$$\frac{dP^{x_I,x_0}_{y:y^*}}{dy} = P^{x_I,x_0}_{y:y^*} \cdot \mu^{x_I}_{y^*} - \sum_{x \in S} P^{x,x_0}_{y:y^*} \cdot \mu^{x_I,x}_{y} .$$

5. Premises for an insurance cover: ADC (Activities Daily Cyber) and GCU (Good Cyber Use)

In case of an insurance policy against terminal damages following the use of the net, to every status of damage:

$$nd, rd,\ prd^{(1)},\ prd^{(2)}, \ldots,\ prd^{(n)},\ nrd\ ,$$

a level of compensation is guaranteed.

If the coverage ADC (Activities Daily Cyber) is adopted, the general compensation for a damage in the *x* status, $x \in S$, is defined by

$$R^{ADC}_x = r_x R_x \qquad 26$$

where:

- r_x is the aleatory number of days necessary to restore the computer to the initial status, *nd*, from x status of damage
- R_x is the "daily allowance".

R_x is dependent from the type of policy and from the operational characteristics of the insured asset, therefore the general compensation for a damage in the status x, $x \in S$, is defined by the good use of the insured asset.

If the coverage GCU (Good Cyber Use) is adopted, the unique compensation R^{GCU}_{α}, with regard to the incapability of developing particular cyber activities among the m-listed in the policy, is defined by

$$R_{\alpha}^{GCU} = \begin{cases} 0 & \text{if} \quad 0 \le \alpha < \alpha_{\min} \\ R_{\alpha}^{/} & \text{if} \quad \alpha_{\min} \le \alpha \le 2m \end{cases} \qquad 27$$

In both these insurance forms, the limit of liability and/or the allowance can be used. A policy can contain, separately or jointly, ADC and GCU coverage
The fair premia in the two coverage are, respectively:

$$\Pi_x^{ADC} = E\left(R_x^{ADC}\right) = E\left(r_x R^{ADC}\right) = \sum_{0<\alpha\le 2m}\left(\sum_{x(\alpha)\in S} r_{x(\alpha)} R^{ADC}{}_{r_{x(\alpha)}} P_y^{si,x(\alpha)}\right) \qquad 28$$

and

$$\Pi_{\alpha}^{GCU} = E\left(R_{\alpha}^{GCU}\right) = \sum_{x\in S}\left(\sum_{\alpha_{\min}\le\alpha\le 2m} R_{\alpha}^{/} P_y^{si,x(\alpha)}\right) \qquad 29$$

On the basis of (29), it is clear that the GCU policy covers all the status of damage, whose level is at least equal to the minimum one previously fixed α_{min} . The analytical study of the expressions of the premium will be the subject of a research next to come: for instance, the initial status, as in the probabilities (28) and (29), is different from *nd.*

6.Conclusion

The probabilistic model on cyber risks, based on some possible status of damage, is an application of multistate models to the damage insurance. In this paper, two typologies of policies have been introduced: ADC and GCU for any machine connected to the net under an insurance cover.
This working paper is only at a preliminary status.
The dynamic aspects of premium evaluation we would like to study in depth are the following:

- if the software changes, the *y* average age changes;
- if the computer software is modified (set up or erased) during the period of insurance cover, the probability distribution of claim changes.

On the basis of actuarial equivalence, for every *t*, belonging to the interval of [*0,1*] insurance cover, the result is that:

$$\Pi(t) = \mathrm{P}(\mathrm{t}) \cdot R(t) \qquad 30$$

with

$\Pi(t)$: fair premium
$P(t)$: probability distribution of the claim
$R(t)$: compensation.

Furthermore,

- if the probability distribution changes, the equation (30) is valid, provided that the premium or the compensation are fair;

- as regards the compensation: for instance, a variable limit of liability can be due;
- as regards the premium: integrations, linked to technological indexes, can be due;
- an analogous dynamic approach can be applied to life/health insurance when they refer to the biological age and not to the real age.
-

As regards the premium evaluation, technological indexes or age, even when *ad hoc*, can also be evaluated in analogy with the index-linked contracts.

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