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This volume contains the Proceedings of the International Workshop on Distributed Computer and Communication Networks (DCCN-2007). The workshop organized by the Institute for Information Transmission Problems (Russian Academy of Science) and the Institute of Information Technologies (Bulgarian Academy of Science) is a continuation of traditional international conferences of the DCCN series. The previous DCCN conferences were held in Bulgaria (Sofia, 1995, 2005, 2006), Israel (Tel-Aviv, 1996, 1997, 1999, 2001) and Russia (Moscow, 1998, 2000, 2003).

The main idea of the workshop is to join and to exchange expertise that scientists from various countries have separately evolved in theoretical and practical aspects of study, design and implementation of distributed computer and communication networks.

The content of this volume is related to the following subjects:

1. Mathematical Methods of Computer Networks Modeling Performance Studies of Computer and Communication Networks
2. Methods and Algorithms for Design and Performance Evaluation of Broadband Wireless Networks
3. Software and Hardware for Distributed Computer Systems and Networks
4. Multicriteria Comparison Analysis of Telecommunication Networks

All papers included into the Proceedings are given in the form presented by authors. The list of DCCN participants includes researchers and engineers from Russia, Byelorussia, Bulgaria, Germany, Canada, Latvia, Republic of Korea, UK, Poland, Tajikistan, Israel, Moldova, Ukraine, Kazakhstan, Australia, USA, and Japan.

The Proceedings are of interest to all people working in the field of computer and communication networks.

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Contents

Approximation Analysis of Symmetric Discrete-Time Polling System with Adaptive Mechanism*

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Abstract

A symmetric discrete-time polling system with adaptive polling mechanism is considered. A server visits queues in cyclic order depending on a state of queues in the previous cycle. In the current cycle, a queue is skipped (not visited) if it was empty in the previous cycle. The skipped queues are polled in the next cycle only. We propose an iterative algorithm for approximate calculation of the queue length and intervisit time distribution.

1 Model

The adaptive polling mechanism with queue skips in a cycle adequately describes the performance of broadband wireless Wi-Fi and WiMax networks where the number of abonent stations is large. When base station polls the abonent ones cyclically it can be impossible to poll all stations in a cycle. One way to solve the problem is to skip (not to poll) some of queues in a cycle. The criteria to skip a queue (abonent station) can be its length at the current [1] or at the previous polling moment [2, 3]. The polling moment of a queue is referred to as a moment when server (base station) check if there are the packets to be transmitted from a queue.

Polling systems with adaptive polling mechanism were investigated on the base of descendant set approach in [2] and mean value analysis [3].

We consider symmetric discrete-time system with a single server and N queues, $N \geq 2$. We suppose that time is divided into equal slots of length 1 and the system state is considered at the end of slot only.

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Multidimensional Life Time Equivalence

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1. Introduction

In a previous work (Dimitrov, 2007), the age of an object is defined as the reading of an individual's internal clock on the background of his/her population. Also, it is noted that age is a relative concept, and for different populations age is measured differently. This fact makes the age comparison a challenging and attractive field of research. This is especially true since there is no etalon of age measuring.

Observations show that age depends on life conditions (Campbell 2006), and is something inherent for the populations. However, aging is more frequently discussed than the determination of the age (Auperin and Nukulin, 2004) and is studied by the means of the reliability theory.

Human beings are learning lessons to recognize (compare) in the age of every other kind of bio object terms of their own population (where usually humans think they are familiar with all the necessary details). As an example, *the age of a dog is taken as a scale proportional of human life: one dog's year of life is equivalent to seven years of human life.* Such simplifications may lead to serious mishaps. The true ways for age comparison are discussed in Dimitrov (2007). His idea of comparing age rests on the equivalence of quantiles of lifetime distributions. This leads to some serious further consequences (e.g. how to read the individual's internal clock), which we will not discuss here. We will focus on the use of this idea in the multi dimensional case.

2. Multidimensional life

There are objects (technical items, bio individuals) where the age gets a two, three, and possibly more dimensional form. The lifetime for almost any system can be measured in more than one "time" scale. For instance, for the automobiles people use two "parallel scales, the calendar age, and the total mileage. For airplanes there could be three "time" scales, the calendar age, the amount of flight time (in the air) and the number of takeoffs and landings. Bio-systems also are subject to wearing and aging. Bio-systems have a proven life-span (something like a maximal value of the life beyond which no copy of the bio-system can pass). According to Koltover 2004, the life span for people is, 120 years.

Life spans have also most of the functional components of the bio-systems. Life span for people's brain is 250 years. Many readers may remember at least one case of their experience with others as seen in the following: "I am 22 years old but my joints are so bad. Doctors say, my joints are as in a 65 years old man…"

Components of most electronic technical devices and systems also have their specific life span (these we call age variables), and interacting they determine the life span of the entity. At the time of death every one of these "age variables", say X, Y, ..., and Z, have certain values.

Let us consider the two dimensional case. The probability of the pair (X, Y) not to survive certain values (x, y), namely $P(X \le x,\ Y \le y)$ is called *joint lifetime probability distribution* and is denoted by $F_{X,Y}(x, y)$. The probability to survive both values (x, y), we call the *Survival Function,* and will be denoted by $S_{X,Y}(x, y) = P(X > x, Y > y)$. We introduce two definitions of two dimensionally measured equivalent ages, and claim that each may have meritorious reason for consideration.

Definition 1 (*Optimistic*): *We say that two individuals with two dimensional ages* (X_1, Y_1) *and* (X_2, Y_2) *have equivalent ages* $(T_1^{(1)}, T_2^{(1)}) = (T_1^{(2)}, T_2^{(2)})$ *if it is true that*

$$F_{(X_1,Y_1)}(T_1^{(1)}, T_2^{(1)}) = F_{(X_2,Y_2)}(T_1^{(2)}, T_2^{(2)}). \tag{1}$$

Notice, that we have a whole *set of equivalent age,* not just unique pairs $(T_1^{(1)}, T_2^{(1)}) = (T_1^{(2)}, T_2^{(2)})$, but many. Even in the frame of just one population with a two dimensional age (X, Y), for any number p within the interval (0, 1) all the points on the curve

$$\mathbf{C}_p : \{(x_p, y_p);\ F_{X,Y}(x_p, y_p) = p\} \tag{2}$$

are points whose coordinates trace all *individuals of the same (equivalent) age.* Only individuals whose value of the probability $F_{X,Y}(x, y) = q$ is less than p can be called *younger,* i.e. we can say that $(x,y) < (x_p, y_p)$. The curve **C** given by equation (2) is the set of equivalent ages of the individuals at level p.

Analogously, in the three (and higher) dimensional ages we will have surfaces of equivalent ages, and an order between ages can be given according to the level of the respective surface on which these ages belong. Everybody who shares our opinion would agree how reasonable the following examples are.

Examples:

1. ***Fair Pricing of Used Cars***

Assume that X is the calendar age of a car, and Y is its mileage. When buying a car people usually are interested in these two car characteristics. Assume, other car' features are equivalent (color, impression), and the joint distribution of (X,Y) is known. In most cases a correlated bivariate normal distribution would fit the data. Then all the used cars of the same brand with individual values of age x and mileage y laying on the curve of equivalent ages should have the same price.

2. ***Warranty costs for used items - an estimation.***

Assume we are in the situation as indicated by the above example with the age of the car is $X=x$, and the mileage is $Y=y$. At the time of purchase of a used car we are offered an extended warranty for extra pay. The conventional "extended warranty" is offered for an addition a to the age component x, and addition b to the second component y (in this case this is the mileage) of the car. In other words, if the pair (X,Y) measuring the age fails in the rectangle $R=[x, x+a]\times[y, y+b]$, some of the repair expenses will be covered by the warrantor.

There are many possible warranty policies in consideration (Blischke and Murthy, 1996). In the context of our age definition, if on average for a failure within the box R the warrantor must reimburse an amount M, then the expected warranty expenses for the offered additional extended warranty will be equal to the quantity

$$Q(x,y;a,b)=M\cdot[F(x+a,y+b)-F(x,y)]$$

The same expected costs for the extended warranty will be incurred for any item sold on the curve of equivalent ages (x_p,y_p) for the cars on sale as defined by (2) with $q=F(x,y)$, and if the extended warranty will be given for both age components by the differences $\bar{a}=x_q-x_p$ and $\bar{b}=y_q-y_p$, where (x_q,y_q) are coordinates of any point on the curve of equivalent ages $\mathbf{C}_q$, where q is chosen as $q=F(x+a, y+b)$.

Remark 1. In two, and higher dimension the value of the joint distributions decreases when adding an additional dimension. In other words, adding an additional time (age) characteristic to an already existing set of time characteristics will make this object look "younger" than it use to be with a lesser number of characteristics to consider. This is due to the fact that

$$F_{(X_1,X_2,\dots,X_{n-1})}(T_1,T_2,\dots,T_{n-1})\geq F_{(X_1,X_2,\dots,X_{n-1},X_n)}(T_1,T_2,\dots,T_{n-1},T_n),$$

whose interpretation could be the "probability to die before the expiration of set of n univariate times $(T_1,T_2,\dots,T_{n-1},T_n)$ is less than the probability to die before the

expiration of set of n-1 univariate times $(T_1,T_2,\dots,T_{n-1})$". We do not forget that multidimensional age is the entire sequence $(T_1,T_2,\dots,T_{n-1},T_n)$. Therefore, it seems more likely to survive the highest dimension age than an age of lower dimension. This may sound like paradox, but it is proven fact!

This is why we are led to call this definition of age equivalence (and model for age comparison) an *OPTIMISTIC DEFINITION*.

However, our approach allows an alternative, which we discuss in the sequel.

Definition 2 (*Pessimistic*): *We say, two individuals with two dimensional ages* (X_1,Y_1) *and* (X_2,Y_2) *have equivalent ages* $(T_1^{(1)},T_2^{(1)})=(T_1^{(2)},T_2^{(2)})$ *if it is true that*

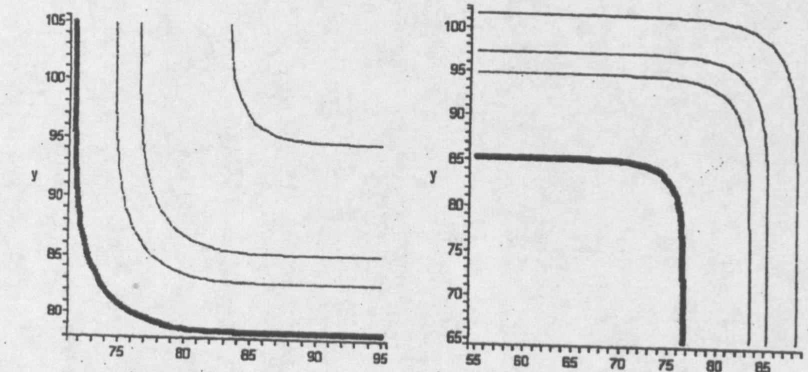
$$S_{(X_1,Y_1)}(T_1^{(1)},T_2^{(1)})=S_{(X_2,Y_2)}(T_1^{(2)},T_2^{(2)}).\tag{3}$$

Notice that as in the optimistic case, we have a whole *set of equivalent ages*, not just a unique pairs $(T_1^{(1)},T_2^{(1)})=(T_1^{(2)},T_2^{(2)})$. Even in the frame of just one population with a two dimensional age (X, Y), for any number p within the interval (0, 1) all the points on the curve

$$\mathbf{C}_{1-p}:=\{(x_p,y_p);\ S_{X,Y}(x_p,y_p)=1-p\}\tag{4}$$

are points whose coordinates trace all *individuals of the same (equivalent) age*. Only individuals whose value of the survival probability $S_{X,Y}(x,y)=1$-q is larger than 1-p (i.e. the chances not to survive are $p>q$) can be called *younger*, that is, we have a natural order between multidimensional ages by saying that $(x_q,y_q)<(x_p,y_p)$. The curve $\mathbf{C}_{1-p}$ given by equation (4) is the set of equivalent ages of the individuals at level 1 - p. And this curve is quite different from the curve given by equation (2).

Examples. In the next figures we show the pessimistic and optimistic curves of equivalent ages in the case of bivariate normal distribution, with mean value (80,90), standard deviations (5,7), and moderate correlation of .6, and strong correlation of .95 respectively. As we can see from reading the graphs, in the moderate correlation case and using the pessimistic definition the age (80,77) is equivalent to the age (72,88) at 5% level of mortality. For the respective 95% level of survival the optimistic definition gives as equivalent the ages (60, 86), and (76, 68). For the strong correlation case we see as equivalent at the same level the ages (80, 78) and (72, 83) in pessimistic case, and (60, 85) equivalent to (76, 76) from the optimistic graph. An immediate conclusion is that low correlation causes wider range of equivalent ages.

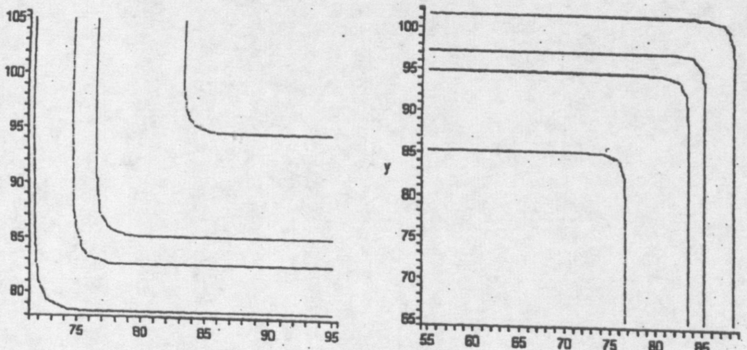


a) Pessimistic Definition b) Optimistic Definition

Equivalent age curves for Two Dimensional Normal Life Distribution with parameters

$\mu_1 = 80, \sigma_1 = 5; \mu_2 = 90, \sigma_2 = 7; \rho = .6$ and

Percentage of total survival 5%, 15%, 25%, and 75%



a) Pessimistic Definition a) Optimistic Definition

Equivalent age curves for Two Dimensional Normal Life Distribution with parameters

$\mu_1 = 80, \sigma_1 = 5; \mu_2 = 90, \sigma_2 = 7; \rho = .95$ and

Percentage of total survival 5%, 15%, 25%, and 75%

Analogously, in the three (and higher) dimensional ages we will have surfaces of equivalent ages, and an order between ages can be given according to the level of the respective surface on which these ages belong when using the survival function.

Remark 2. In two, and higher dimension, the values of the joint survival function also decrease when adding an additional dimension. Adding an additional time (age) characteristic to an already existing set of time characteristics will make this object "appear to be older", and is evaluated as older, since it is used to be evaluated with a lesser number of characteristics in consideration (even when compared with itself). This is due to the fact that

$$S_{(X_1,X_2,\dots,X_{n-1})}(T_1, T_2, \dots, T_{n-1}) \geq S_{(X_1,X_2,\dots,X_{n-1},X_n)}(T_1, T_2, \dots, T_{n-1}, T_n).$$

Its interpretation could be "the probability to survive the expiration of a set of *n* times $(T_1, T_2, \dots, T_{n-1}, T_n)$ is less than the probability to survive the expiration of set of *n-1* times $(T_1, T_2, \dots, T_{n-1})$". Therefore, it is less likely to survive the highest dimension time (age) than an age of lower dimension. In other words, the more age characteristics are taken into account, the more age is added to the object. The age will not change if the object is considered as "perfect" in regard to the newly added characteristic, i.e. when $P(X_n > T_n) = 1$.

This time the proven fact does not sound as a paradox. However, this is our reason for calling this definition of age equivalence (and model for age comparison) a *PESSIMISTIC DEFINITION*. We do expect it to be used more frequently in ages of higher dimensions.

3. Miscellaneous

For the one dimensional ages the two definitions determine the same and unique equivalent ages. Moreover, the unique relationships between probability distributions, density, mortality (failure) rates and its integrals allow lots of interesting interpretations and opportunities for attractive applications (Dimitrov, 2007). In two, and higher dimension joint distributions, the concept of failure rate and integral hazard rate has a variety of expansions (see e.g. Galambos and Kotz, 1978). For now we can not propose any specific approach which may be equivalent relative to the meaning and interpretations offered in the one dimensional case. We expect that either of these possible approaches may bring practically useful interpretations and interesting applications.

A question of general issue that makes the bridge between studies on ages and related risks is the question of modeling dependence between age components. The

Copula approach in the study of multi dimensional dependence should get some specific forms when related to age and aging.

The importance of Gompertz-Makenham distribution in the 1-dimensional case raises a question for its validity in the multi dimensional case. It is known how well it suited to model mortality of one-dimensional life of bio objects. Our knowledge about multi dimensional versions for this distribution is near zero.

The web site http://message.realage.com/ offers a newsletter periodically e-mailed to RealAge members. There exist several options, e.g. to take a RealAge test and to receive health information. They say: "The RealAge test is a science-based health assessment that calculates your biological age (or RealAge) and includes an Age Reduction. The page where you take the test is

http://www.realage.com/ralong/qa/HI.aspx

It contains more than 60 questions (one is about your current age), many with multiple answers, and at the end a number is given as an overall estimate of your real age. We plan to contact them and see what the algorithm of calculations is, and how is it consistent to the approaches offered here.

4. Conclusions

Age of a living individual may not correspond to his/her calendar age. To answer multiple questions related to determination of true ages, and also what is aging and how to keep aging under control, we need to define age. In the present talk we give a definition of multi dimensional age based on the ways to compare and compute ages.

Some additional open problems related to the ideas presented here are briefly sketched.

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