

SACEPAF+ : An Intelligent Tutoring System Using a Learning Machine Companion

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Abstract : Many intelligent tutoring systems (ITS) using a learning machine companion called Learning Companion Systems (LCS) has been developped these last years. These systems involve three agents : a teacher, a student and a companion. The principle of these systems use the idea that the social interaction have an influence on the cognitive development. The basic idea is that the student can learn from his mistakes and can benefit from the companion's mistakes. The companion is looked for assistance, and other times as a troublemaker. The goal of the learning companion is to stimulate thought collaboration competition and demonstration.

This paper outlines the architecture of a intelligent tutoring system based on the double test learning (DTL) strategy and using a companion as a co-student. The system called SACEPAF+ is proposed to teaching the elementary calculus for the student of the first primary school. The DTL strategy introduce a companion or co-student in the learning session which receives the same training as the human student. So, we have two students which have the same level of knowledge. The idea of the DTL strategy, which contains four phases, is based on that the student will benefit from the co-student's mistakes and his behavior. When the training phase is completed, the tutor will test the co-student. In this phase called Post-Test1, the student will follow the interaction between the tutor and the co-student and he can mention observations about the behavior of the co-student in a notebook which is created for that fact. This interaction consists of a sequence of question/answer which is evaluated by the tutor. The second phase called post-test2 begins when the co-student finished the first phase. In this phase, the tutor will evaluate the human student which will react to the interaction without his notebook.

We propose a student model taking into account the DTL strategy for the evaluation phase. A prototype of the SACEPAF+ system has been developed on a IBM PC/AT computer under DELPHI 3 environment. A validation of the system is currently in progress of realization with a group of students chosen from a class of a primary school.

Keywords : Artificial Intelligence, Intelligent Tutoring System, Student-Model, Learning environment, DTL strategy, Elementary calculus, LCS, Companion, Co-student.

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Proposition d'un algorithme d'allocation mémoire avec seuil fixe dans un routeur internet pour améliorer la QoS offerte aux applications temps réel.

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Résumé : Ce travail s'inscrit dans le cadre de la recherche sur la qualité de service : QoS "*Quality of Service*" des applications multimédia et temps réel. L'objectif de la présente étude est de définir tout d'abord les besoins en terme de QoS des applications MultiMédia (MM) et temps réel (TR) tournant sur internet puis analyser la gestion de QoS et sa relation avec la gestion des ressources, pour arriver enfin à choisir la ressource mémoire tampon d'un routeur internet comme objet d'étude. Nous proposons dans ce cadre un algorithme d'allocation de la mémoire tampon avec seuil fixe afin d'améliorer la qualité de service "QoS : *Quality of Service*" offerte au trafic temps réel passant par ces routeurs. Une analyse des résultats ainsi que les perspectives seront données à la fin de ce papier.

Avec l'apparition des réseaux haut débit, et l'amélioration des techniques de communication par l'évolution des services offerts, à la fois performants et mieux adaptés aux nouvelles contraintes (par exemple, les contraintes temporelles...); il devient possible d'envisager l'utilisation des applications MultiMédia (MM) sur des réseaux étendus. Néanmoins, pour fournir la meilleure qualité de service (QoS) possible aux applications, il est nécessaire de choisir et de définir les services qui leur conviennent le mieux.

L'internet, étant le réseau mondial le plus populaire à l'heure actuelle, la tendance est d'y faire tourner des applications MM et Temps Réel (TR) comme la vidéoconférence, le télé-enseignement... Les recherches sont intensivement menées dans ce sens pour fournir des garanties sur la QoS offerte à ces applications. En effet, le « working group » de l'IETF (Internet Engineering Task Force) travaillant sur les services intégrés de l'internet (INTSERV) a fait plusieurs propositions de services : le service à charge contrôlée, le service à taux de transmission garanti, ... ; qui essaient tous d'améliorer la QoS par différents moyens (contrôle d'admission, réservation de ressources...).

Nous allons à travers ce document, étudier les différents besoins en terme de QoS des applications MM et TR sur internet. En particulier, le délai et sa relation avec les pertes et la capacité de stockage à l'intérieur du réseau. Nous allons donc proposer un cadre de gestion d'allocation de la ressource mémoire dans un routeur internet permettant de diminuer les pertes pour le trafic MM et TR.

Recognition of Handwritten Arabic Words by a Structural Method

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Abstract: In this paper, we present a structural method for machine recognition of handwritten Arabic words, without prior segmentation into characters. Our method is based on transforming topological and geometrical features extracted from the thinned word image to a graph representing its structure. By topological and geometrical features, we mean the main descriptors of the word such as loops and their shapes; connected components number; feature points, cusp point, inflection and diacritic points; horizontal and vertical segments, and oblique segments with their slopes. The nodes of this graph represent the different point kinds, while the edges are the different lines connecting these points. As result, recognition procedure of unknown word consists in the identification of model graphs sub-set that match well its graph. Model graphs, representing recognition lexicon will be obtained from an off-line training step.

Keywords: handwritten Arabic words, off-line recognition, preprocessing, features extraction, graph, training, and similarity degree.

Résumé : Dans ce papier, nous présentons une méthode structurale pour la reconnaissance des mots arabes manuscrits, sans segmentation explicite en caractères. La méthode proposée est basée sur la transformation des primitives topologiques et géométriques extraites à partir de l'image amincie de mot en un graphe représentant sa structure. Par primitives topologiques et géométriques, on entend les principaux descripteurs du mot tels que: boucles et leurs formes; le nombre de composantes connexes; les points caractéristiques, de rebroussement, d'inflexion, et diacritiques; les segments horizontaux, verticaux et obliques avec leurs pentes. Les nœuds du graphe représentent les différents types de points, tandis que les arcs sont les différents segments de ligne joignant ces points. Par conséquent, la reconnaissance consiste à identifier le sous-ensemble des graphes modèles qui s'appartient le mieux au graphe de mot inconnu. Les graphes modèles représentant le lexique de reconnaissance, sont obtenus dans une étape d'apprentissage hors-ligne.

Mots clés : mots arabes manuscrits, reconnaissance hors-ligne, prétraitement, extraction de primitives, graphe, apprentissage, degré de similarité.

Un algorithme de compression d'images fixes en vue d'une Transmission progressive

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Résumé : Dans cet article, on propose une méthode de compression d'images fixes basée sur un codage imbriqué utilisant la Transformée en Cosinus Discrète (DCT) adaptée à la transmission progressive. Cette approche consiste à quantifier successivement chaque coefficient DCT du bloc en un certain nombre de bits. Les bits les plus significatifs de ces coefficients quantifiés sont regroupés ensemble pour former la première couche qui sera codée et transmise au premier niveau de la transmission progressive. La seconde couche est constituée des seconds bits significatifs et ainsi de suite jusqu'au dernier bit. L'ordre du codage correspond à l'importance de chaque bit.

Mots clés : Compression d'images, Transformée en ondelettes, Quantification Vectorielle, Transmission progressive.

Les contraintes imposées dans les systèmes de compression d'images sont différentes selon que l'on transmet l'information ou qu'on la stocke. Pour le stockage, la compression des images est motivée par le besoin de réduire l'espace mémoire exigée pour son stockage. Dans ce cas, il est important d'employer des techniques de compression qui permettent une parfaite reconstruction des données à partir de leur forme compressée, sans prendre en compte le temps nécessaire pour le codage, ce qui permet d'utiliser des techniques de compression plus complexes et plus performantes. Par contre, pour la transmission, la contrainte essentielle est le temps réel, ce qui impose souvent une limitation au niveau de la complexité de la méthode de compression utilisée. Dans ce cas, on s'intéresse aux techniques qui accomplissent le maximum de réduction dans la quantité des données à transmettre (moins d'information à transmettre d'où un temps de transmission minimum), en préservant une fidélité assez raisonnable de l'image.

La transmission des images de haute résolution à travers un canal de transmission à faible débit, pose toujours un problème, au niveau du temps nécessaire pour sa transmission, surtout si la transmission conventionnelle ligne par ligne (séquentielle) est utilisée. Dans ce cas l'image ne sera pas identifiée rapidement, ce qui ne donnera pas l'opportunité au récepteur de commencer à l'examiner ou même interrompre sa transmission à n'importe quelle étape.

Réflexions autour d'un environnement de modélisation coopératif pour la méthodologie SADT

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Résumé : Les techniques de travail coopératif prennent une importance croissante dans la plupart des applications informatiques faisant intervenir le travail de groupe. Cependant, l'étude menée sur les méthodes d'analyse et de conception des systèmes d'information, a montré que la plupart d'entre elles s'intéresse surtout à l'organisation des données et des traitements. En revanche, la méthodologie SADT se démarque de cette tendance, du fait qu'elle privilégie le travail de groupe. Ainsi, l'objectif de cet article est d'analyser les possibilités d'intégration des concepts de base du travail coopératif dans le processus de modélisation défini par la procédure du cycle auteur/lecteurs de SADT. Nous visons ainsi, créer un Environnement de Modélisation Coopératif autour de SADT. Pour cela, nous présentons d'abord les concepts fondamentaux caractérisant l'utilisation de SADT, et en particulier le cycle auteur/lecteurs qu'est à la base du processus de modélisation de la méthode. Nous mettons en évidence les niveaux où la coopération peut intervenir, et soulignons les enrichissements sémantiques possibles de l'environnement que nous envisageons. Nous proposons un modèle SADT pour organiser les tâches des différents membres du groupe, au sein de notre environnement.

Mots clés : Coopération, SADT, Modélisation, Interface multi-utilisateurs, Cycle auteur/lecteurs, Mediaspace, T.C.A.O., Kit, Collecticiel, Workflow.

Abstract : Cooperative work techniques have gained a wide applicability in most of computer applications requiring group work. However, the studies performed on the methods of information system analysis and design, had show, that most of them is interessent especially in the data-organization and process-automation. But, the SADT method deviates from this trend, and it privilege the group work organization. This paper aim to analyze the possibilities of integrating Computer Support Cooperative Work (CSCW) concepts in SADT-modelling process as defined by the author/readers cycle proceeding of SADT. We aimed again create about SADT a modelling environment based essentially on cooperative work. We first present the fondamental concepts characterizing the SADT utilization, in particular the author/readers cycle which is the basis of the modelling process, and where it involving members of the SADT-group takes place. An emphasis is placed on the levels where cooperation intervenes. and we accentuate the semantically enrichment of this environment that we envisaged. We propose a SADT-model for the tasks organisation of the different members of the group in this environment.

Key-words : Cooperation, SADT, Modilling, Multiuser Interface, Author/readers cycle, Mediaspace, C.S.C.W., Kit, , Groupware, Workflow.

Vers une architecture multi-agents pour les systèmes à bases de connaissances temps réel.

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1. INTRODUCTION

We present a scheduling rule, called OPBM, which prioritizes jobs by an index computed for each job as a weighted sum of the proportion of time it has been processed and the proportion of time it has been waiting for processing. Our motivation for studying these priorities is to answer a question raised in Bruns and Yanahit [1996]. They were inquiring whether any demonstration functions yield to an index policy. OPBM is a deterministic function which yield to an index policy. It has been shown in Hsu and Prasad [1997] that schedulers, some of which are deployed by IBM operating systems in the Computer Science Laboratory of the university of Iowa, in some cases as interrupt scheduling. They called this particular priority and implemented it in the kernel of an operating system. Multi-programmed systems designs often implement priority disciplines depending on system performance.

They argued that the choice of the bands allow to derive some of the known algorithms and prove that a policy for scheduling queues and its implementation will be more efficient than others.

RÉSUMÉ: Cet article s'inscrit dans la réflexion qui vise à pouvoir tirer partie de l'approche multi-agents pour concilier le comportement temps réel et le raisonnement progressif. De ce fait, nous présentons une architecture générale pour les systèmes à bases de connaissances temps réel. Cette architecture, constituée de couches d'agents, est basée sur une décomposition fonctionnelle. Le raisonnement progressif adopté par les agents 'anytime', impliqués dans l'architecture, permet d'améliorer la continuation de système face à l'environnement qu'il contrôle.

Mots clés : systèmes mulit-agents, systèmes temps réel, anytime, raisonnement progressif.

Single-machine scheduling of deteriorating or delaying stochastic jobs with dynamic priority.

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Abstract : We consider a scheduling rule, called OPBM, which prioritizes jobs by an index computed for each job as a weighted sum of the proportion of time it has been processed and the proportion of time it has been waiting for processing. We prove that it is a well known deteriorating jobs or delaying jobs single-machine scheduling problems. An expression of this dynamic priority is interpreted as a net-reduction in the processing of a job and an other one as a delay caused or a time to repair a breakdown. Concerning the behavior of this scheduling scheme, three results are stated. OPBM is shown to be a deterioration function which yield to an index policy. The processor or the machine is not supposed to be subject to breakdown, jobs are independent and the preemption is allowed. An implementation of this priority is presented.

Keywords : completion (or Hazard) rate, mean residual lifetime, stochastic scheduling, index rule and OPBM.

1. INTRODUCTION

We present a scheduling rule, called OPBM, which prioritizes jobs by an index computed for each job as a weighted sum of the proportion of time it has been processed and the proportion of time it has been waiting for processing. Our motivation for studying these priorities is to answer a question raised in Browne and Yechiali [1990]. They were inquiring whether any deterioration functions yield to an index policy. OPBM is a deterioration function which yield to an index policy. It has been shown in Haro and Proust [1992] that schedulers, some of which are employed by E3I's operating system, at the Computer Science Laboratory at the university of Tours, in France, operate as hyperbolic schedulers. They defined this particular priority and implemented it in the kernel of an operating system. Multi-programmed system designers often implement priority disciplines expecting to improve system performances.

They showed that the choice of the bounds allow to derive some of the known strategies and prove that it makes the schedule equitable and its implementation still maintains this property.

They indicated and gave some efficient hints of the associated algorithm and an adaptation to obtain an equitable sharing scheduler is introduced. The processor or the machine is not supposed to be subject to breakdown, jobs are independent and the preemption is allowed.

N jobs are to be processed sequentially on a single machine. They are supposed to be within the shop at the time 0. With each job « i » is associated an instantaneous priority

$$p_i(t) = \frac{M_i t_i^w(t) + m_i t_i^p(t)}{t} \text{ for } t = 1, 2, \dots \text{ and } p_i(0) \in [m_i, M_i] \quad (*)$$

where m_i and M_i are real-values. $t_i^p(t)$ and $t_i^w(t)$ are respectively the time spent processing job i and the time spent waiting for processing during $[0, t]$. At each time t , we carry out the job with the highest priority. This means that when a job is to be selected among those waiting, the one with the highest priority is selected. We break the tie with Round-Robin rule. Scheduling jobs according to the formula (*) is said OPBM rule. This means in French « Ordonnancement par priorités bornées en Moyenne ».

The remainder of this paper is organized as follows : session2 is devoted to the definition of Bandit processes. This tool will be used to prove that OPBM is a Gittins rule. The OPBM model is shown to be a deteriorating or delaying jobs scheduling problem. Concerning the behavior of these priorities, three results are stated in section 3. In section 4, an implementation of these priorities is given. Finally a summary and further work are provided in section 5.

2. BANDIT PROCESSES

A theoretical approach to stochastic scheduling which is entirely distinct from queuing theory recently has been developed by Gittins and his colleagues. Their method assigns a dynamic allocation index to each job and then schedules the jobs in decreasing order of this index. These indices are updated as the jobs are processed, thus allowing the schedule to be adapted to the actual pattern of arrivals and processing times. Papers of importance are Gittins [1979, 1989], Gittins and Glazebrook [Git77] and Whittle [Whi80].

A bandit process is a Markov decision process (Ω, U, P, F, C, a) where: Ω is the state space of the process and may be finite, countable or continuous.

U is the decision set, consisting of just two elements c or 1 (continue) and w or 0 (wait).

P is a probabilistic law of motion; that is, for each $x \in \Omega$ and $u \in U$, $P(x, u)$ defines a probability distribution over some σ -field of subsets of Ω . Thus if $x \in \Omega$ and the state of the process at time t is

$x(t)$, when decision $u(t)$ is applied $\Pr \left[x(t+1) \in X \mid x(t), u(t) \right]$ is well defined by

$\int_x dP[x(t), u(t)]$. Particularly $\forall A \in P(\Omega)$, $\Pr[A \mid x, u]$ is the probability that the state y of the

process immediately after the time t belongs to A conditioning that at time t the process was at state x and the control u ($u \in U(x)$) was applied.

C is a cost function from $\Omega \times \Omega$ in $\mathbb{R}$.

a the discount factor, a real number ($0 \leq a \leq 1$).

A transition at time t from $x(t)$ to $x(t+1)$ involves an incremental cost $a^t c[x(t), x(t+1)]$.

The total cost accruing if the process describes a trajectory $\{x(t) : t = 0, 1, \dots\}$ is

$$\sum_{t=0}^{\infty} a^t c[x(t), x(t+1)].$$

$t \geq 0$

P and C must satisfy the following conditions:

$$\Pr \left[x(t+1) = x(t) \mid u(t) = 0 \right] = 1, \forall t, x(t) \in \Omega. c[x, x] = 0, \forall x \in \Omega, \forall t.$$

This definition may be extended to the case of semi-Markov decision processes. For some authors these processes are also called Adaptive control processes.

A family of alternative bandit processes is a set of bandit processes

$\{(\Omega_i, U, P_i, C_i, a) : 1 \leq i \leq n\}$ such that at each time t ($t = 0, 1, 2, \dots$), the decision element " c "

(or 1) is applied to just one process i , w being applied to the others.

The factor discount " a " is the same for all the processes.

A simple family of alternative bandit processes is a set of alternative bandit processes which are all always included in the decision set. It is denoted by SFABP. In stochastic scheduling problems, at time t , the time spent processing job i models such family. The problem is to find an optimal strategy for the decision of a simple family of alternative bandit processes (i.e. a strategy for choosing i at each time t), in the sense of leading to minimal total expected cost. In some literature these processes are also called Semi-Markov Decision Processes. We suppose that the set of states is countable. After observing the state of the process an action is chosen from the set U . If the process is at state " i " at time t and the action " a " is chosen, then a cost $c(i, a)$ is incurred and the next state is chosen with probability $p_{ij}(a)$.

GITTINS and JONES [1972] gave the first existence theorem of these priorities called dynamic allocation indices denoted DAI's and called by Whittle [1980], GITTINS' indices. These indices represent a ratio of an expected cost over an expected elapsed time in the workshop. They also represent a stopping cost. Nash [1973] was the first who gave a characterization of these indices. Gittins and Glazebrook [1977], Gittins [1979] etc... have contributed in this field.

Theorem GJ[1972]

Given a family of alternative bandit processes $\{ (\Omega_i, U, P_i, C_i, a) : 1 \leq i \leq n \}$

there exist functions $\{ v_i : \Omega_i \longrightarrow \mathbb{R}, 1 \leq i \leq n \}$ such that the choice $u_i(t) = 1$ is optimal when

the states of the processes at time t are $x_i(t)$ ($1 \leq i \leq n$) if and only if

$$v_i(x_i(t)) = \min_{1 \leq j \leq n} v_j(x_j(t)).$$

Provided that for the set of strategies such that this optimal strategy is applied from some time t onwards, with the possible exception of a single decision-time, the contribution to the expected loss which arises after time t tends uniformly to zero as t tends to infinity.

The characterization of these indices v_i ($1 \leq i \leq n$) is given by the result below.

Theorem N : [1973]

If $v_i(x_i)$ is defined and finite for all $x_i \in \Omega_i$, then $v_i(x_i)$ is the unique finite solution of the two equations :

$$v_i(x_i) = \frac{E \left[\sum_{t=0}^{t^*-1} a^t C_i[x_i(t), x_i(t+1)] \right]}{1 - E a^{t^*}} \quad (N_1)$$

$$\text{and } t^* = \min_{t \geq 0} \{ t, v_i(x_i(t)) \geq v_i(x_i) \} \quad (N_2) \quad \text{and where } x_i = x_i(0)$$

A rule of scheduling jobs according to the theorem of Gittins and Jones [1972] and the theorem of Nash [1973] is called *an index rule*.

3. THE MODEL OPBM : A DETERIORATING OR DELAYING PROBLEM

OPBM scheduling rule can be modeled as two well-known problems. It can be expressed as a problem of deteriorating jobs and jobs subject to delay.

3.1 OPBM : A single-machine scheduling problem of deteriorating stochastic jobs.

We call jobs whose processing times increase over time *deteriorating jobs*.

At each time t , $t_i^p(t) + t_i^w(t) = t$. The formula (*) become, for all t , $t = 1, 2, \dots$

$$p_i(t) = M_i + (m_i - M_i) \frac{t_i^p(t)}{t} = M_i - \Delta_i \frac{t_i^p(t)}{t}$$

$$\text{Hence } A_i(t) = t \frac{p_i(t)}{m_i} = (1 + \alpha_i) t_i^p(t) - \alpha_i \cdot t = t_i^p(t) - \alpha_i (t - t_i^p(t))$$

$$\text{Where } \alpha_i = - \frac{M_i}{m_i} \in \mathbb{R}^+.$$

We suppose that P_i is the processing requirement of job i at $t = 0$. For all i , it is assumed to be independent of P_j , $i \neq j$.

The constant $\alpha_i = -\frac{M_i}{m_i}$ is the deterioration rate of job i . If job i is not yet complete,

its residual processing grows at rate α_i .

$\alpha_i (t - t_i^p(t))$ is the increase in i 's residual processing as a result of processing given to other jobs during $[0, t]$.

$A_i(t) = t \frac{p_i(t)}{m_i}$ can be interpreted as a « Net reduction » in job i 's residual processing as a consequence of all processing during $[0, t]$, where $p_i(t)$ is its priority.

This model is used in many industrial applications, for instance in the planning of machine maintenance or service and in steel production where the material will cool during the waiting periods. Inventory model for deteriorating items with instantaneous supply, a perishable product, linear or non-linear increasing demand and shortage. Items deteriorate while in storage. Decay in radioactive elements, spoilage in food grain storage, pilferage from on-hand inventory. In scheduling steel rolling mills, if the temperature of an ingot, while waiting in a buffer between the furnace and the rolling machine, has dropped below a certain temperature, then the ingot needs to be reheated to bring it up to the temperature required for rolling. The re-heating time of the ingot depends on its waiting time in the buffer and is thus schedule-dependent.

Assume that time evolves in discrete epoch of N , the set of integer-value.

OPBM belongs to the class of preemptive linear deterioration models in which the processing requirement of a job grows linearly as it awaits processing i . It can be considered as a model which belongs to the class of Markov decision processes where :

1) $U = \{c, w\}$ the set of the actions

2) Jobs : The jobs are individual.

3) Decision, decision epochs : The time evolves in discrete steps of size 1. Job completion's will not necessarily occurs at integer time points. The deterioration phenomenon means that an increase in processing requirements experienced by jobs will not necessarily an integer.

If t is a decision time, the next decision for an uncompleted job chosen for processing at t will be $t + 1$ or the time of j 's completion, whichever occurs sooner.

4) State and state transitions. We define a state of job i at decision time t by :

$$X_i(t) = \begin{cases} C(\text{completion}) & \text{if } i \text{ has been completed by } t \\ \{A_i(t), B_i(t)\} & \text{otherwise} \end{cases}$$

$$B_i(t) = \max_{s \in D_i} A_i(t) = \max_{s \in D_i} t \frac{p_i(t)}{m_i} \quad \text{where } D_i = \{0, 1, \dots, t\}.$$

The state of the process at t is $X(t) = \{X_1(t), \dots, X_N(t)\}$.

5) Policies : The preemptive policy OPBM will be used for choosing an uncompleted job for processing at each decision epoch. We break the tie with Round Robin rule.

6) Cost structures : The criterion assumes a discount factor α , $\alpha \in [0, 1[$ and attempts to minimize the expected total discounted cost.

For any trajectory $\{x_t, t \in \mathbb{N}\}$ and for any policy π , we define :

$$V_{\pi}(i) = E_{\pi} \left[\sum_{t=0}^{\infty} \alpha^t c(x_t, a_t) / x_0 = i \right], \quad i \geq 0.$$

E_{π} represents the conditional expectation given that the policy π is employed.

We assume that $c(x_t, a_t)$ are bounded and $\alpha < 1$. $V_{\pi}(i)$ represents the expected total discounted cost incurred when the policy π is employed and the initial state is i .

3.2 OPBM: A single-machine preemptive scheduling problem of stochastic jobs subject to delay .

From the definition of OPBM,

$t_i^w(t) = \frac{t}{\Delta_i} [P_i(t) - m_i]$ and $t_i^p(t) = \frac{t}{\Delta_i} [M_i - P_i(t)]$ are respectively the time spent waiting for processing and the time spent processing job i during $[0, t]$.

Each job i has a processing requirement P_i at time 0 which is independent of the P_j , $j \neq i$.

Let us define a process $Y(t) = (Y_1(t), \dots, Y_N(t))$,

with $Y_i(t) = (X_i(t), D_i(t), Z_i(t))$, where $X_i(t) = t_i^p(t)/N$, $D_i(t) = t_i^w(t)/N$ and

$Z_i(t)$ is an indicator variable, which takes the value 1 if job i has completed prior to t and is otherwise 0. Also we have $X_i(0) = D_i(0) = Z_i(0) = 0$, $1 \leq i \leq N$.

The stochastic process $\{D_i(t) = t_i^w(t)/N, t \in \mathbb{N}\}$ is called the delay process.

If job i is given a single unit of processing at time t , having received x units of processing prior to t , then no further processing can take place until time $t + 1 + D_i(x + 1) - D_i(x)$.

$$D_i(x + 1) - D_i(x) = (1/N) [t_i^w(x + 1) - t_i^w(x)] =$$

$$\begin{aligned} & (1/N) \frac{(x+1)}{\Delta_i} [P_i(x+1) - m_i] - (1/N) \frac{x}{\Delta_i} [P_i(x) - m_i] \\ &= (1/N) \left\{ \frac{x}{\Delta_i} [P_i(x+1) - P_i(x)] + \frac{1}{\Delta_i} [P_i(x+1) - m_i] \right\} \end{aligned}$$

$$\text{Hence } D_i(x + 1) - D_i(x) = (1/N) \left\{ \frac{x}{\Delta_i} [P_i(x+1) - P_i(x)] + \frac{1}{\Delta_i} [P_i(x+1) - m_i] \right\}$$

is interpreted as the delay caused by the $(x + 1)$ st unit of processing received by job i or the time to repair a breakdown. This scheduling problem is a Markov breakdown process.

Optimal policies are determined by Gittins index when discounted rewards are earned at job completion times. The same cost structure is defined as above.

Our goal is to prove that OPBM maximizes the total reward over all policies. It is equivalent to show that it is a Gittins index rule.

The delayed-jobs model is a SFABP with the following features :

States : the state of the system at time t is $Y(t) = (Y_1(t), \dots, Y_N(t))$,

with $Y_i(t) = (X_i(t), D_i(t), Z_i(t))$, where $X_i(t) = t_i^p(t)/N$, $D_i(t) = t_i^w(t)/N$ and

$Z_i(t)$ is an indicator variable, which takes the value 1 if job i has completed prior to t and is otherwise 0. Also we have $X_i(0) = D_i(0) = Z_i(0) = 0$, $1 \leq i \leq N$.

Actions : At each decision epoch, one of the uncompleted jobs is chosen for processing.

State transitions : The state of all jobs other than i remain unchanged through a transition.

If job i is continued at time t , with state $Y_i(t) = (X_i(t), D_i(t), Z_i(t)) = (x, d, 0)$, a state transition will be observed where $X'_i(t) = x + 1$ w.p.1 ;
 $p(D'_i = d' = p(D_i(x + 1) - D_i(x) = d' - d / D_i(x) = d) ;$
 $p(Z'_i = 1) = p(P_i = x + 1 / P_i > x) = \rho_i(x)$, where $\rho_i(x)$ is the completion rate (hazard rate) of job i 's processing requirement. The next decision epoch will occur at time

$t + 1 + (D'_i - d)$. Note that $\sum_{i=1}^N [X_i(t) + D_i\{X_i(t)\}] = t$.

Reward : If t is a decision epoch which leads to i 's completion, this completion is deemed to be at $t + 1 + (D'_i - d)$. A reward of r_i is received then, discounted at rate α , that is a reward of $r_i \alpha^{t+1+D'_i-d}$.

Policies : the rule for choosing an uncompleted job is OPBM. We break a tie with Round Robin rule. Optimal policies are determined by a collection of indices called Gittins indices. We give below two propositions which describe the behavior of our priority. The proofs are not presented in this paper.

Proposition 1 : If job j is not complete at decision epoch t

$$\text{then its priority } p_j(s) < \frac{m_j}{s} P_j, \quad \forall s \in [0, t].$$

Suppose now that job j is chosen for processing at t and that the next decision epoch occurs at $t + \sigma$, where $\sigma \leq 1$. As a consequence of this processing, uncompleted job $k \neq j$ will deteriorate, its processing requirement growing linearly at rate α_k .

Proposition 2 : An uncompleted job k , not being continue at t if the next decision epoch occurs at $t + \sigma$, $\sigma \leq 1$ then :

$$p_k(t + \sigma) = \frac{t}{t + \sigma} p_k(t) - \alpha_k \cdot m_k \cdot \sigma \frac{1}{t + \sigma}$$

For job j undergoing processing at t and cannot be completed with an additional unit of processing

$$\text{then } p_j(t + 1) = \frac{t}{t + 1} p_j(t) + \frac{m_j}{t + 1}. \text{ We assert that OPBM is an index rule.}$$

Theorem3 : OPBM is an index rule or a Gittins index rule and $P_i(t) = M_i - \Delta_i \frac{t_i^p(t)}{t}$ is a dynamic

allocation index denoted DAI.

We can notice that all the results established in the theory of Bandit Processes and Gittins's indices still hold.

4. IMPLEMENTATIONS

We have implemented these priorities. Its provides an asymptotic equitability in the service.

Let $E = \{\tau_i / 1 \leq i \leq n\}$ a set of n jobs.

The occupation rate of the processor (or the occupancy of the processor) by the n processes of (E)

is the real number ρ defined by : $\forall t > 0 \quad \rho(t) = \sum_{i=1}^n t_i^p(t) / t$.

The occupation rate of processor by any process τ_i of (E) is also the real number $\rho_i(t)$ defined by : $\forall i, 1 \leq i \leq n$ and $\forall t > 0, \quad \rho_i(t) = t_i^p(t) / t$.

It is the ratio of $t_i^p(t)$ over $t, t > 0$. At epoch t, τ_i is carried out during $t_i^p(t)$.

Scheduling is equitable for the set of processes $E = \{\tau_i / 1 \leq i \leq n\}$ when

$$\exists \lambda, 0 \leq \lambda \leq 1 : \forall i, 1 \leq i \leq n \text{ and } \forall t > 0, \quad \rho_i(t) = \lambda / n$$

Scheduling is asymptotically equitable for $E = \{\tau_i / 1 \leq i \leq n\}$ if :

$$\exists \beta, 0 \leq \beta \leq 1 : \forall i, 1 \leq i \leq n : \lim_{t \rightarrow \infty} \rho_i(t) = \beta / n.$$

$t \rightarrow \infty$

During a period T_s , the processor carries out one job of the set E . Whenever a tie for the highest priority occurs, the Round-Robin strategy is adopted. Each of the jobs with the highest priority receive a process quantum Q , though. « m » is a lower bound and « M » is an upper bound for the priority. This implementation takes account the whole past history of the process to compute again its priority. The computing is made each T_s time units by the formulae :

$$\forall i, 1 \leq i \leq n \text{ and } \forall j > 0 : P_i(j.T_s) = M - \frac{\Delta P}{j.T_s} t e_i(j-1)$$

The processing times at epoch $(j.T_s)$ of each job are computed by :

$$\forall i, 1 \leq i \leq n \text{ and } \forall j > 0 :$$

$$te_i(j.T_s) = te_i((j-1).T_s) + T_s, \text{ only if job } i \text{ has the highest priority}$$

$$te_i(j.T_s) = te_i((j-1).T_s) + Q, \text{ if job } i \text{ is one of the jobs with the highest priority and is in tie.}$$

$$te_i(j.T_s) = te_i((j-1).T_s), \text{ Else.}$$

For each job, the occupation rate of the processor is given by :

$$\forall i, 1 \leq i \leq n \text{ and } \forall j > 0 : \rho_i(j.T_s) = \frac{te_i(j.T_s)}{j.T_s}$$

Example : (Rahal et al [1996])

Within the system, it is assumed that the number of jobs is two. The duration of the period T_s is one (1), the quantum value is one. The priorities may vary in the interval $[1, 10]$ (i.e. $m = 1$; $M = 10$). The initial priorities are $p_1(0) = 1$ and $p_2(0) = 10$.

We schedule the jobs during 100 sec. We have plotted the behavior of the priorities and the occupation rate (occupancy of the processor). See figure 1 and 2.

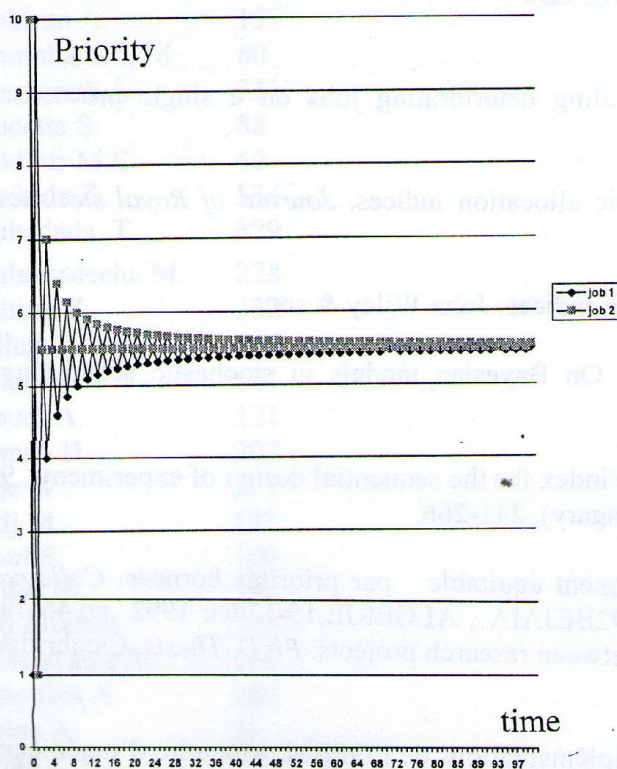


Figure1 : Job's Priorities evolution_

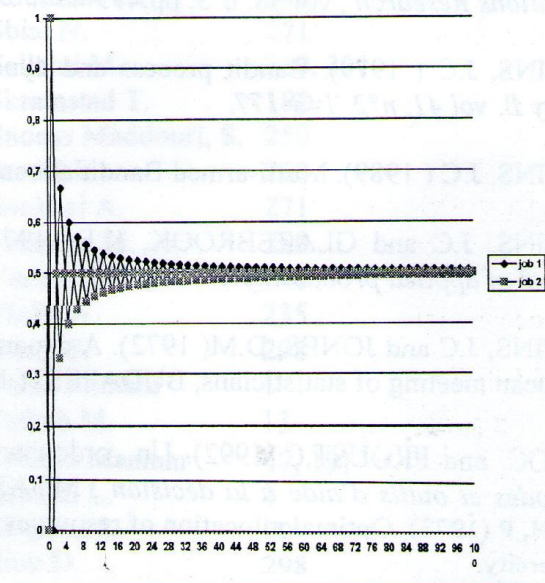


Fig. 2 : Processor Occupation Rate's Evolution

It can be shown graphically that priorities converge to a common value P/n where

$P = \sum_{i=1}^n p_i(t)$ and « n » the number of processes in the system. From this graphic, we see that the occupation rate also converges to a constant value given by λ/n .

5. SUMMARY

We considered a scheduling rule, called OPBM, which prioritizes jobs by an index computed for each job as a weighted sum of the proportion of time it has been processed and the proportion of time it has been waiting for processing. We show that jobs are deteriorating and delaying, in the sense that processing times increase while they are waiting for processing. An expression of this dynamic priority is interpreted as a net-reduction in the processing of a job and an other one as a delay caused or a time to repair a breakdown. As far as the behavior of this extended new scheduling scheme, we stated two results. We proved that OPBM is equivalent to a Gittins index scheduling rule or an index rule. This paper answer a question raised in Browne and Yechiali[1990]. They were inquiring whether any deterioration functions yield an index policy.

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