A Probabilistic Approach to Reduce the Number of Deadline Violations and the Tardiness of Workflows

Johann Eder[1], Hannes Eichner[2], and Horst Pichler[2]

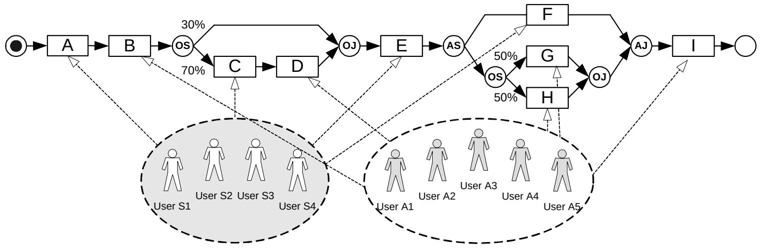
[1] University of Vienna, Austria
[2] University of Klagenfurt, Austria

Abstract. Process prioritization strategies, based on a probabilistic temporal model, are applied to reduce the number of deadline violations and the tardiness of workflows.

Process prioritization techniques are applied to optimize process criteria, like may be the number of deadline violations or the tardiness (amount of lateness). [1, 5] already showed that deadline-oriented strategies to sort work-lists, like *Earliest Deadline First*, are superior to *FIFO* or mere random selection strategies. Nevertheless, these approaches do barely consider uncertainties, which arise during process execution. They stem mainly from two aspects, undeterminable in advance: the actual duration of a task, and decisions made at conditional split points. This renders the calculation of exact temporal models at build time impossible; estimations, in the form of average values or interval representations, must be applied. To incorporate these uncertainties in a build time-calculated temporal model, we introduced a probabilistic approach. It aims at calculating temporal properties, like valid execution intervals, for each activity in the process. Temporal properties are not represented as scalars or intervals, but as *time histograms*, which are used to assess the current temporal status in a probabilistic way, e.g. to forecast the probability of a future deadline violation, or to predict the remaining execution time with a given certainty. Applied during run time, this enables pro-active features like early detection and avoidance of eventually arising deadline violations. For further details please refer to [3, 2, 4].

Based on this probabilistic model we introduce two new prioritization techniques. *Most Probable Deadline Violation (MPDV)* sorts the work list of a workflow participant according to deadline violation probabilities. The more likely a future deadline violation is the higher it will be ranked. This strategy aims at keeping the number of instances which violate their deadline as low as possible. *Lowest Proportional Slack (LPS)* sorts the work list according to available buffer time, and aims at minimizing the tardiness of processes. Slack can (basically) be consumed without risking a future deadline violation. Proportional slack sets the available slack in relation to the rest execution time. LPS needs a probability as input parameter – for the subsequent scenario LPS-70 (70%) proved to be ideal.

Figure 1 shows a workflow with a parallel block and two conditional blocks, augmented with branching probabilities for conditional splits. Two groups of



strategy	Øtat	min tat	max tat	w/in DL	DL viol.	Ø tard. %
Random	124,6	40,1	358,7	917,3	82,7	28%
FIFO	123,8	39,5	252,6	934,5	65,5	19%
EDF	112,8	40,8	227,2	982,6	17,4	11%
MPDV	134,6	40,8	205,9	987,5	12,5	5%
LPS-70	132,4	40,7	202,4	983,3	16,7	3%

Fig. 1. Workflow Model with Resources and Simulation Results

participants are specified, along with allowed activity assignments. From the workflow log, produced by prior simulation runs, we extracted probabilistic information (branching and durations). It was used to calculate the probabilistic temporal model, which we applied at subsequent simulation runs. To generate non-uniform workload peaks, we introduced artificial burst followed by pauses. After each block of 25 started processes, with an inter-arrival frequency specified by an exponential distribution with mean 8, we inserted a random break, specified as exponential distribution with mean 50. This scenario produces high temporary work load peaks which result in long work lists (stalling behavior). The deadline was set to 190. The average simulation results (100 runs with 1000 processes each) show the turnaround time (*Øtat, min tat, max tat*), the average number of process instances that finished within the deadline (*w/in DL*), the average number of process instances that violated the deadline (*DL viol*) and the average tardiness percentage (*Øtat*).

Strategies, that are not deadline oriented produce, as expected, the highest number of deadline violations along with a high tardiness percentage. In this respect the non-probabilistic EDF-strategy performs better, excelled by MPDV, which produces the least number of deadline violations, and LPS-70, which is better suited to reduce the tardiness percentage.

References

1. G. Baggio and J. Wainer and C. A. Ellis. Applying Scheduling Techniques to Minimize the Number of Late Jobs in Workflow Systems. *Proc. of the 2004 ACM Symposium on Applied Computing (SAC)*. ACM Press, 2004.
2. J. Eder, W. Gruber, M. Ninaus, and H. Pichler Personal Scheduling for Workflow Systems. *Proceedings of the International Conference BPM'03*, Springer Verlag (LNCS 2678), 2003.
3. J. Eder and H. Pichler Duration Histograms for Workflow Systems *Proc. of the Conf. on Engineering Information Systems in the Internet Context*, Kluwer Academic Publishers, 2002.
4. J. Eder and H. Pichler. Probabilistic Workflow Management. Technical report, Universitt Klagenfurt, Institut fr Informatik Systeme, 2005.
5. S. Rhee, H. Bae and Y. Kim. A Dispatching Rule for Efficient Workflow. Concurrent Engineering, Volume 12, Sage Publications, 2004.