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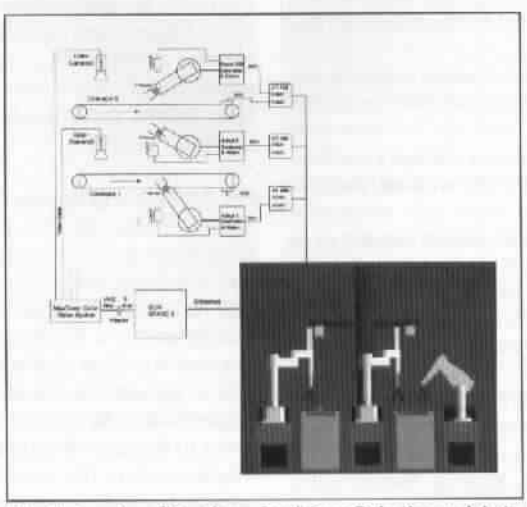
A Subject–Indexed Bibliography of Discrete Event Dynamic Systems

A subject–indexed bibliography of Discrete Event Dynamic Systems is given. Each subject is briefly described and some characteristic topics and references for each subject are listed. The complete reference list is provided on the ftp–site and instructions how to retrieve related files are given.

This paper contains a description of a fairly complete and detailed bibliography of published books, journal, transaction, and conference papers, technical reports and other research publications related to the Discrete Event Dynamic Systems (DEDS) area.

The main objective of the paper is to provide researchers with a comprehensive list of research in DEDS. Moreover, this paper may serve, we hope, as a "look–up table" for literature review purposes, as well as to support the interested researcher in pursuing his/her interest in DEDS and/or in trying to identify new research topics.

The list of references has been divided into subject–indexed areas. Survey and/or general papers may have been listed in more than one subject areas, according to their specific content. All Petri Net related publications, as applied to CIM, FMS and in general automated manufacturing systems, have been listed separately, mainly due to the fact that Petri Net related research is a rapidly evolving and expanding area.



The University of Southern Louisiana Robotics and Automation Laboratory CIM system, shown in schematic and SILMA simulation, is an example of a DEDS system.

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Each subject–indexed reference represents the state–of–the–art developments in the pertinent area. The authors believe that any finer area distinction will not serve a better purpose. This is left to the individual reader.

Due to the obvious space limitations, only selective references are listed in each of the subject area. The complete list of approximately 1,600 references is available to every reader from the ftp–site which contains the complete BibTEX file. Instructions related to how to access this file are given in Section 3.

It is very important to emphasize that a comprehensive list of written books is included in this paper, while the representative 170 references, explicitly sited at the end of the paper, represent only a "flavor" of the voluminous work reported in the literature and is by no means complete.

To facilitate reading the paper, brief descriptions of reported work are presented in each subject–indexed section.

Finally, this work is part of the Discrete Event Systems Technical Activity Committee of the IEEE Robotics and Automation Society. The Committee's goal is to provide an annual, updated comprehensive list of references in DEDS, thus creating a dynamic database available to everyone through the ftp–site.

SUBJECT INDEX

For each subject–index area a short description and several representative references are given.

A LIST OF REPRESENTATIVE BOOKS

Good understanding of the DEDS area requires a knowledge of different topics, like control theory, probability, operation research, etc. Several books which provide a good introduction and a coverage of some advanced topics are listed in the sequel: [6], [7], [8], [11], [13], [15], [16], [17], [14], [19], [20], [21], [24], [22], [25], [27], [34], [40], [42], [43], [44], [46], [47], [49], [54], [56], [58], [59] [62], [64], [67], [68], [73], [77], [75], [79], [81], [83], [86], [87], [88], [89], [91], [92], [94], [99], [107], [109], [117], [114], [116], [120], [128], [129], [130], [131], [133], [134], [135], [136], [145], [148], [151], [156], [164], [170].

Algorithms This subject includes description of various algorithms applied to DEDS problems, as well as the theory of algorithms in general. Most of these algorithms are related to the problems of scheduling, perturbation analysis, control and queues. Their definitions and a representative reference follows:

Scheduling: a sequence of actions is generated to achieve a desired goal [139],

Perturbation analysis: a system is analyzed by introducing a small change in the system parameters (perturbation) [76],

Control: selecting proper actions to achieve desired system behavior [144], and

Queues: study of the stochastic nature of a system [65].

Applications. Various theoretical models (Petri Nets, stochastic, perturbation) are applied to particular problems like flexible manufacturing systems [5], resource sharing [35], transportation [111], real–time systems [155], etc. The models are used for analysis, synthesis, control and performance evaluation of a wide variety of DEDS.

Assembly. The assembly related references are divided into two main categories:

Plan generation: generatation of a sequence of actions or to schedule tasks to achieve desired functioning of the system [29],[157],[167], and,

*Error recovery:*recovery from errors during the execution of a plan [85],[104].

A recently developed approach is based on the concept of "reverse assembly", widely referenced in recent studies.

Automation. This subject is closely related to assembly because the solution process for the problems of the plan generation and the error recovery involves automatization and generalization, i.e., for a given class of assembly processes a more or less general model (Petri Nets, hierarchical control) is used to automatically create plans and/or error recovery procedures. Representative references include [4], [10], [167], [169].

Concurrency. Concurrency includes coordination, control and error recovery of a set of concurrently competing processes. Real–time constraints, temporal semantics, resource sharing are some of the problems to be solved. Analysis, performance evaluation and verification of concurrent systems provide a way to measure the quality of the control process. Concurrency is not limited to the assembly and manufacturing systems, but it is also used in databases, distributed systems, protocols, etc. [93], [109], [122], [152].

Control. Various theoretical and practical aspects of the control of DEDS, like stability, robustness, controllability, etc. have been explored. This subject has the most references, due to the fact that the control is crucial to the system theory and therefore to DEDS [25], [46], [69], [91], [102], [108], [124], [161].

Hierarchical Control. Hierarchical control utilizes the structure of hierarchical, multilevel systems, and provides a more efficient way to control automated manufacturing systems by studying parts of the system at different level of abstraction, detail, and organizing the sequence of tasks to be executed in a hierarchical way [41], [74], [118], [165], [168].

Manufacturing. Manufacturing overlaps heavily with scheduling, automation and robotics. Various theoretical results are applied to this specific class of applications, e.g. design, analysis, performance evaluation, etc. [4], [32], [55], [78], [92], [127], [140], [154].

Markov Chains. The memoryless property of many real–time DEDS processes enables the application of Markov chains as a powerful tool for analysis. Various simulations, numerical methods, sensitivity analysis are applied to determine properties of the modeled DEDS [86], [130], [146], [159], [166].

Observers. As a part of sensitivity analysis and constructibility, observability is an important property of any DEDS. Observability is considered both during the design and implementation phase of a system [101], [125], [142], [150].

Operations Research. Methods of operation research are integrated with the system theory to provide solutions for problems like queueing networks, scheduling, etc. [2], [66], [70].

Perturbation Systems. Research reported in this area follows theoretical developments in perturbation analysis [31], [38], [62], [72], [143], [153].

Petri Nets. Petri Net models are extensively used in the modeling of DEDS. This includes ordinary Petri Nets, restricted Petri Nets, timed Petri Nets and high–level Petri Nets models. They provide a model for a very general DEDS. Properties of Petri Nets are used to determine or verify properties of the modeled system. Petri Nets and their modifications provide a very powerful mathematical and graphical tool for the study and evaluation of a wide class of systems. [1], [42], [51], [81], [82], [110], [170].

Queues. As a part of probability and queuing theory, queues are used to model discrete processes of stochastic nature. Potentially complex networks of queues can be analyzed

either by simulation or by analytical methods. Since a simulation approach is not always feasible, different exact or approximative analytical methods are developed. These include decomposition, aggregation/disaggregation, etc. Parametric and sensitivity analysis is needed to test the quality of a solution [9], [30], [57], [63], [162].

Real–time Systems. Real–time constraints imposed on these systems mean that for every DEDS process, there are deadlines that need to be fulfilled. To meet these deadlines, coordination, scheduling, resource management and control must be well implemented. Temporal logic, fault–tolerance and the synchronous approach to reactive systems are some of the ways related to how to model real–time systems. Real–time programming is addressed because it differs significantly from the standard programming style [18], [39], [90], [137], [145].

Robotics. Robotics is applied to assembly and autonomous control systems. Multisensor fusion is an important prerequisite for successful use of robots. Remote manipulation, tracking and task-sequencing planning are some of the problems involved. Error recovery is necessary to build an autonomous robot [4], [37], [136], [158], [167].

Scheduling. Various approaches to the scheduling problem are discussed,including linear programming, Petri Nets, Lagrange relaxation, and heuristics. Scheduling problems are studied in the context of manufacturing systems, real–time systems, fault–tolerance and job–shop scheduling [2], [33], [53], [100], [119], [160].

Simulation. Simulation is a process through which a system model is evaluated numerically, and the data from this process are used to estimate various quantities of interest. Several simulation methods (Monte Carlo, regenerative, discrete–time) and simulation programming languages (GPSS, SIMSCRIPT II.5) are applied to various problems, such as manufacturing scheduling problem, queues, and Markov chains. Sensitivity analysis, accuracy and performance continuity is also explored [13], [36], [61], [97], [132].

State Machines. Different models of (finite) state machines are applied to various problems. Control of DEDS is modeled as a hierarchical state machine. A temporal logic is introduced in the state machine and such extended state machine is used for system specification and modeling [23], [112], [163].

State Space. The state of the system at a time instant t represents a (measurable) behavior of the system. The set of all possible values that the state may take, the state space, is in the general case very large. Problems of estimating the state–space size and developing new approaches to reduce the state–space or to deal with its complexity are described here [60], [113], [158].

Supervisors. Supervisors and supervisory controls refer to the form of control which involves enabling/disabling actions in a system. Such control involves predictability, lookahead policies, languages generated by the control process, modularity, Petri Nets models, etc. [103], [126], [147], [149].

Survey Papers. Although the authors are not aware of a survey paper which covers the whole DEDS area, several survey papers cover some of the subjects, including Petri Nets, perturbation analysis, control architectures, scheduling theory, and queuing networks [3], [12], [28], [45], [48], [50], [52], [71], [80], [84], [95], [96], [98], [105], [106], [121], [123], [141].

Theory. A good knowledge of topics related to the DEDS area, like control theory, probability, etc., requires a good knowledge of the related theory. This is especially true for system theory (control, hierarchical control, observers, supervisors), probability (Markov chains, queues, simulation), automata theory, etc. Selected papers and books provide a good introduction and as well as coverage of advance level topics [26], [79], [107], [115], [120], [138].

HOW TO OBTAIN THE COMPLETE REFERENCE LIST

All references listed here can be reached by using ftp. The ftp–site is **ftp.cacs.usl.edu** and the references are stored in the directory **pub/deds** in the file **deds.bib** (BIBTEX format). In addition, for each subsection in Section 2, there are three related files which contain selected references, one in BIBTEX format, one in PostScript format, and one containing **\cite** commands to be used together with **deds.bib**. In addition, a LATEX file used to generate a PostScript file is provided. References which don't fit well in a single category are also listed. The **README** file contains information about all bibliography related files and how to use them.

An example of the ftp–session follows:

```
% ftp ftp.cacs.usl.edu
Connected to basin.cacs.usl.edu.
220 basin.cacs.usl.edu FTP server...
Name (basin.cacs.usl.edu:user): anonymous
331 Guest login ok, send ident as password.
Password:
230 Guest login ok, access restrictions apply.
ftp> cd pub/deds
250 CWD command successful.
ftp> get deds.bib
200 PORT command successful.
150 ASCII data connection for deds.bib ...
226 ASCII Transfer complete.
local: deds.bib remote: deds.bib
411339 bytes received ...
ftp> quit
221 Goodbye
```

If only a particular topic is needed, e.g., Petri Nets, selected references can be retrieved by getting the following files:

petri.bib A list of selected references in the BIBTEX format,

petri.ps A list of selected references in Postscript format,

petri.cite A list of indexes of selected references (ocite commands), and,

petri.tex A LATEX file used to generate **petri.ps**.

Therefore, for any of the subject areas, the related files are *area*.**bib**, *area*.**ps**, *area*.**cite**, and *area*.**tex**.

CONCLUSION

The major objective of this subject–indexed bibliography paper has been to summarize and group most research publications in the area of DEDS. As a result of this effort, it is believed that, through this extensive list, the present research di-

rections related to several issues (modeling, synthesis, analysis, control, simulation, performance evaluation) of DEDS, will become more evident and clear. The reader will be able to isolated the most promising techniques related to the study of a specific aspect of an automated manufacturing system, or even define new directions in research.

The authors' wish is to serve continuously the professional community by providing on an annual basis an updated list of references, thus keeping track of current research and developments in this area.

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