The Deadlock Problem:

A Classifying Bibliography

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The desire for a better utilisation of resources and an acceleration of computing introduced the concept of parallelism with all its difficulties. Soon the danger of eternal delays of processes was discovered and called deadlock. For almost twenty years a lot of publications have dealt with problems considering deadlocks or their environment.

Here we want to give a classification of our collected publications. We do not claim that this collection is complete in any sense, but we hope to have found essential articles (underlined) for nearly all the different topics fitting under the title "Deadlock".

This classification regards different aspects of the problem and cannot always be given unambigiously so that many publications are listed several times. We would appreciate to get knowledge of other interesting articles or textbooks to this theme.

Classification:
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A Surveys

B Textbooks

C Environment

- C1 Process Systems
- C2 Database Systems
- C3 Networks

D Methods

- D1 Detection and Recovery
- D2 Prevention
- D3 Avoidance

E Involved Problems

- E1 Livelock
- E2 Synchronisation and Scheduling
- E3 Locking

F Modelling and Measurement

A: Surveys

There are only some publications tending to give an overview of the problems touched by deadlocks. The listed publications compare intentions and results of different methods against deadlocks.

[Go 78] classifies the hardness of different approaches, [How73], [Mi 82], [Ne 79] an annoted bibliography, [SpSch 83], [Zö 83]

B: Testbooks

We present a list of books which given an introduction to and valuation of the deadlock problem in the context of other problems in operating systems.

[CoDen 73], [KurHeiSa 75], [LorDei 81], [MaDo 74], [Ri 77], [TsBe 74], [We 82], [Zi 80]

C1: Process Systems

These publications refer to ordinary (multi-processing) operaing systems with a fixed resource constitution. A number of processes compete for resources and one central operating systems permits, blocks or cancels the execution of processes. We may call this discipline the classical deadlock problem, although this branch is still very important as the amount of publications indicates.

[CoElSh 71], [De 74], [De 77], [Di 68], [Di 71], [Fo 71], [Gi 80], [Go 78], [Ha 69] referenced in almost all other publications, [Ha 74], [Ha 77], [Hav 68], [He 72], [Hol 71], [Hol 72], [How 73], [IbKa 82], [Ka 77], [Ka 80], [Mi 82] important comparison of methods [ParHa 72], [Ze 76], [Zö 83]

C2: Database Systems(*)

In a database the resource environment may steadily change. Processes want to get access to named information entities under certain rules. A special method, the locking technique, can be referred to under E2.

[BiUn 79], [ChBoTr 74] give a characterisation of resources in database applications, [CheGelMit 83], [GeRe 83], [GlSh 80], [HoRa 82] present a distributed one-phase detection algorithm, [Kila 83], [Ko 81], [Lo 77], [Lo 80], [MeMun 79], [Ob 80], [Pa 82], [Pa 83], [SilKe 82], [SoMa 82], [YaPaKu 79]

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(*) Often the models for distributed databases are special types of networks. In these cases only if the author himself aims at a database application the paper is listed under C2.

C3: Networks

A collection of papers investigating safe message transmission networks or packet switching networks is presented. The term network is frequently used in literature but there is no fixed definition of what constitutes the vertices and nodes. Here we list only papers where the nodes are autonomous and accept or send items using local information only.

[Ahu 79], [Ahu 80], [B/Bo 81], [Da 72], [Holz 82], [RieSm 82] present different mechanisms to control interfering transactions in network operating systems, [RicAg 81], [Si 83], [To 79] gives a collection of easy and efficient rules for safe packet switching networks.

D1: Detection and Recovery

Some authors accept the possibily of deadlocks for their systems (above all in data base systems). Either they presume a very low frequency of deadlock occurences or prepare in advance precautions (e.g. copies of the old environment) for the recovery from the undesired deadlock state. A special technique uses time stamps and cancels transactions or processes exceeding waiting-time limits.

[Ahu 79], [BiUn 79] consider additional logical wait relations, [CheGelMit 83] using time stamps, [GeRe 83] using time stamps, [B/Bo 81], [GlSh 80], [HoRa 82], [Hol 72], [MeMun 79], [Mu 68] gives a lot of inspirations to deadlock detection, [Ob 80], [RieSm 82], [Sc 78], [SilKe 82]

D2: Prevention

A lot of different techniques are gathered under the term prevention. They all do not admit the deadlock situation for their system. Only those processes or transactions are started which cannot produce a deadlock during their whole lifetime. Either the processes have to obey certain rules (hierarchical ordering of resource requests) or they have to provide information about their future (flow charts etc.).

[Ahu 80], [B/Bo 81], [Di 71], [Go 78], [Holz 82] algebraic model to test message transmission between processes, [He 72], [IbKa 82], [Ka 77], [Ka 80] deadlock-freedom is reduced to a special marriage problem, [Mi 82] examines different flow charts, [Si 83], [SoMa 82], [Ta 78]

D3: Avoidance

This method is most frequently discussed and requires the examination of every state transition whether it may lead to a deadlock state or to safe states only. The methods applied here have to be very efficient because the system has to be examined for any change.

[ChBoTr 74], [CoElSh 71], [De 74], [De 77], [Fo 71] proposing a concurrent avoiding algorithm, [Gi 80] checks properties for sets of processes, [Go 78], [Ha 69], [Ha 74], [Ha 77], [Hav 68], [Hol 72] linear bound in the number of processes and resource types, [Lo 77], [Lo 80], [Mi 82], [Ze 76], [Zö 83]

E1: Livelock

Under the term livelock we include all forms of imprevisible delay, often also called starvation, permanent blocking and indefinite delay. Many authors provide in their papers methods against both, deadlock and livelock.

[DeLa 78], [KiLa 83], [Kw 78a], [Kw 78b] gives an overview over different reasons for livelock, [Lo 80] important practical approach to avoid livelocks, Holt's answer to [ParHa 72], [St 82], [To 79], [Zö 83]

E2: Synchronisation and Scheduling

The danger of deadlock and livelock ist influenced by the synchronisation mechanisms and the scheduling strategies used in operating systems. Slight modifications in synchronisation and scheduling may have unexpected consequences on the security of a system.

[Ba 82], [Dad 81], [Di 68], [Holz 82], [KanSil 82] implications of a modified region concept, [Ko 81], [Kw 78], [RicAg 81], [Si 79], [Si 83], [St 82] the impacts of variants of the P/V - operations, [Ta 78]

E3: Locking

The predominantly used concurrency control mechanism in data base systems is called locking. Protocols (a set of rules in form of a table or of a graph) determine the effect of different locks on entities. Here we consider only those papers where locking protocols were outlined against deadlocks.

[ChBoTr 74], [HoRa 82], [KiLa 83], [Ko 81] states and analyses deadlock-free protocols, [MeMun 79], [Pa 82], [Pa 83], [RieSm 82], [SilKe 82], [SoMa 82], [YaPaKu 79]

F: Modelling and Measurement

Only a few articles could be found which analyse or simulate the probability or frequency of deadlock or the behaviour of a system under deadlock control. These problems have not been treated by the theory of queuing networks yet.

[CheGelMit 83], [GrHomObKo 81], [HofSch 82], [MoSeZö 83]

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