INTEGRITY CONSTRAINTS MAINTENANCE FOR PARALLEL DATABASES

By

FERAS AHMAD HAMED HANANDEH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

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بسم الله الرحمن الرحيم

"كما أرسلنا فيكم رسولا منكم يتلو عليكم ءايتنا ويزكيكم ويعلمكم الكتاب والحكمة ويعلمكم مالم تكونو تعلمون"

To my First Teachers: My Father and Mother
To my wife and lovely kids:
Sara, Ahmad and Rama
To my lovely sisters and brothers

Feras

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirement for the degree of Doctor of Philosophy

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Chairman : Associate Professor Hamidah Ibrahim, PhD

Faculty   : Computer Science and Information Technology

This research work proposed a standard framework for maintaining integrity in
parallel database systems. A model consisting of two main modules has been
successfully implemented. This framework is flexible and can be extended easily as
the framework is designed in a modular fashion where each module has a clear
function, input and output and interacts easily with the other modules.

A constraint verification method is proposed to check the consistency between the
integrity constraints in the constraint base. The proposed method is based on the
construction of *Modal Records* to determine if a newly defined constraint is not
contradicting with an existing constraint set.

A constraint simplification approach is proposed to simplify the integrity constraints
in the constraint base. Deriving and checking a simplified version of the integrity
constraint called integrity tests can gain efficiency. Efficient maintenance of integrity
is a critical problem, since checking the validity of a large number of integrity

constraints against a large database is crucial to the database systems. The derivation of these integrity tests is not trivial, adding to the cost of integrity maintenance.

The strength of the proposed approach is that it combines the advantages of the substitution as well as the theorem proving technique in the previous work. The proposed approach is based on substitution and requires no resolution search. It requires no complex transition axioms to describe the update operations. The proposed method is considered as a general one since it derives complete integrity tests for first order constraints. In addition, it derives sufficient tests for key, referential and semantic integrity constraints. The complete and sufficient integrity tests can be applied before the update operation is performed. Moreover, it can be extended to deal with transition integrity constraints, which are excluded from the previous approaches. Transition integrity constraints are important since they give relationships between the two states that an update or transaction is required to obey.

As the research interest is in parallel database system, this research has proposed a virtual rule partitioning method for maintaining database integrity by dynamically partition the table(s) to accommodate with parallel integrity subsystem. Therefore, there will be no fixed partitions specified during the design process, which result in time consuming for the system to locate the proper partition of data, for fulfilling the requirement of the integrity test. The presented method is benefited from the direct access method because the tuples in each partition are indexed according to the test attribute during the execution of the integrity test. The test attribute is the attribute of the generated test that is substituted by the submitted update operation.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai
memenuhi keperluan untuk ijazah Doktor Falsafah

PENYELENGGARAAN KEKANGAN INTEGRITI UNTUK PANGKALAN DATA SELARI

Oleh

FERAS AHMAD HAMED HANANDEH

Julai 2006

Pengerusi   :   Profesor Madya Hamidah Ibrahim, PhD

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Kajian ini bertujuan untuk memberikan model umum yang menyeluruh dalam
penyelenggaraan integriti pangkalan data selari. Sebuah model yang terdiri dari dua
model utama telah berjaya dibangunkan. Rangkakerja ini adalah fleksibel dan mudah
dilanjutkan sebagaimana rangkakerja direka dalam fesyen modular di mana setiap
modul mempunyai fungsi modul yang jelas, *input* dan hasil serta berinteraksi dengan
mudah antara modul yang lain.

Kaedah penyemakkan kekangan dicadangkan untuk menyemak konsisten antara
kekangan integriti dalam kekangan asas. Keadah yang dicadangkan adalah
berasaskan pada pembinaan Modal-modal Rekod untuk mengenalpasti samaada
kekangan yang baru dihasilkan tidak bertentangan dengan set kekangan yang wujud.

Pendekatan permudah kekangan dicadangkan untuk memudahkan kekangan-
kekangan integriti dalam kekangan asas. Perolehan dan penyemakan adalah versi
yang mudah bagi kekangan integriti yang dipanggil pengujian integriti yang boleh
memperolehi keberkesanan. Pengelengaraan yang berkesan bagi integriti adalah

masalah yang kritikal, sejak penyemakan kesahihan nombor yang besar bagi kekangan integriti bertentangan dengan pangkalan data yang besar adalah genting kepada sistem pangkalan data. Asalan bagi pengujian integriti adalah tidak penting dan ia menambahkan kos penyelengaraan integriti.

Kekuatan kajian ini adalah pada pembangunan kaedah yang menggabungkan kelebihan bagi penggantian dan begitu juga pada pembuktian teorem. Kajian ini berdasarkan kaedah pengantian yang tidak memerlukan carian resolusi. Ia juga tidak memerlukan transaksi aksiom yang komplek untuk menerangkan operasi kemaskini. Kaedah yang dicadangkan ini, boleh dianggap sebagai kaedah umum kerana ia menghasilkan ujian-ujian integriti yang lengkap untuk kekangan tahap pertama. Tambahan lagi, ia menghasilkan ujian-ujian yang mencukupi untuk kekunci, rujukan, dan semantik kekangan integriti. Ujian-ujian yang lengkap dan mencukupi boleh dilaksanakan sebelum operasi kemaskini dilaksanakan. Lagipun ia boleh dilanjutkan untuk berurusan dengan transaksi kekangan integriti, yang dikecualikan dari kaedah sebelum ini. Transaksi kekangan integriti adalah penting kerana ia memberi hubungan antara dua keadaan di mana kemeskini atau transaksi perlu dipatuhi.

Dalam sistem pangkalan data selari ini, kajian ini mencadangkan satu kaedah peraturan pembahagian maya untuk penyelenggaraan pangkalan data yang secara dinamik membuat pembahagian jadual untuk memenuhi integriti sub-sistem selari. Oleh itu, tiada pembahagian tetap pada proses rekabentuk yang mana boleh memakan masa sistem dalam menempatkan pembahagian data yang sesuai bagi memenuhi keperluan ujian integriti. Kaedah yang dibentangkan mendapat kebaikan dari kaedah pencapaian terus kerana *tuples* setiap pembahagian diindekskan

berdasarkan ujian atribut semasa perlaksanaan ujian integriti. Atribut pengujian ialah atribut dalam ujian yang dijanakan yang digantikan oleh operasi pengemaskinian yang dihantar.

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Feras Ahmad Al-Hanandeh

July 2006

I certify that an Examination Committee has met on 25 July 2006 to conduct the final examination of Feras Ahmad Hamed Hanandeh on his Doctor of Philosophy thesis entitles "Integrity Constraints Maintenance for Parallel Databases" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be a warded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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FERAS AHMAD HANANDEH

Date:

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