

# **Gurjeet Singh**

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- Database internals/Systems Software Engineer and Architect with over 17 years of experience.
- Proficient in C, Database Internals, PostgreSQL internals, GNU/Linux and Windows.
- Fair exposure to C++, NodeJS, GoLang, Java, Oracle, MS-SQL Server, Solaris OS.
- Engineering lead with a strong sense of ownership in everything I do.

I have spent most of my career developing RDBMS internals, including my work on Oracle's Cost Based Query Optimizer and active major contributions to the PostgreSQL open source community; see the "Detailed Work Experience" section for details.

I have spoken/presented at Conferences; see the "Speaking Engagements" section.

I have 8 years of experience as a PostgreSQL Database Architect, Administrator, Trainer and Consultant. In these roles I helped customers learn Postgres development, Postgres internals, helped tune their databases, migrated them from other databases to Postgres, as well as custom solutions development and Postgres data recovery.

## **Qualifications:**

### ***1. Agile/Scrum Master***

When: January, 2015  
Institution: Scrum Alliance

### ***2. Post Graduate Diploma in Advanced Computing***

Duration: Feb 2001-July 2001  
Institution: C-DAC (Center for Development of Advanced Computing)

### ***3. Bachelor of Engineering (Mechanical)***

Duration: 1996-2000  
Institution: Gulbarga University, India.

## **Fields of Interest:**

Real Time Operating Systems, OS internals, Compilers, and RDBMS.

## **Skills:**

**Programming Languages:** C, C++, Perl, Shell-scripting (Windows NT and Unix) and some assembly.

**Operating Systems:** Windows 9x, Windows NT, Sun Solaris, GNU-Linux.

**Database Management Systems:** SQL, Oracle's PL/SQL, Microsoft's TSQL, Oracle, MS-SQL server, and an expert in Postgres RDBMS.

**Web Technologies:** NodeJS, AngularJS, XML, HTML, JavaScript, Web 2.0, PHP.

## **Work Experience (summary):**

### **1. Open Source**

**Designation:** Hacker/Developer

**Duration:** 2005 – Now

**Description:** Contributor to Postgres project. Developed projects of my own. Speaker at conferences. See “Detailed Work Experience” section for details.

### **2. Supabase Inc.**

**Designation:** Fellow Engineer

**Duration:** Sep. 2021 – now

**Description:** Contribute to Postgres community, and start/work on company’s long-term projects.

### **3. GE Digital**

**Designation:** Principal Engineer

**Duration:** May 2016 – Aug. 2021

**Description:** Creator and Service Owner of Postgres-as-a-Service. Service Owner of Blobstore service, inherited from another colleague.

### **4. Amazon Web Services**

**Designation:** Software Development Engineer

**Duration:** May 2015 – May 2016

**Description:** Architect and develop Amazon Aurora for Postgres. Help with Amazon RDS Postgres.

### **5. Thales e-Security, San Jose, CA., USA**

**Designation:** Senior Engineer, Database Specialist

**Duration:** Nov. 2014 – May 2015

**Description:** Design and develop an HSM (Hardware Security Module) Manager using service-oriented architecture. Also, migrate a long-standing market-leading hardware key-manager from embedded MySQL to Postgres.

### **6. EnterpriseDB Corporation, Boston, MA., USA**

**Designation:** Database Architect

**Duration:** Feb. 2011 – Oct. 2014

**Designation:** Principal Systems Engineer

**Duration:** Feb. 2010 – Jan. 2011

**Description:** Worked on database internals and contributed to Open Source Postgres database. My work as a primary/sole contributor includes Index Advisor, Reindex Primary Key Indexes, Postgres Hibernate, DBYardstick Benchmark development. I also co-lead the Postgres Plus Cloud Database and Postgres Enterprise Manager projects.

In consulting role, I helped customers and partners perform Architectural Health Checks of Postgres databases, perform database migrations, conduct trainings, develop custom

replication solutions to other database, etc. while also participate in Postgres community contributing code patches and features.

**7. EnterpriseDB Software India Pvt. Ltd., Pune, India.**

**Designation:** Lead Engineer.

**Duration:** July 2006 – Jan. 2010

**Description:** Researching new features and implementing them in the EnterpriseDB RDBMS (which is based on PostgreSQL). Act as Trainer, Consultant and Remote-DBA for customers and partners, on different occasions.

**8. CommVault Systems (India) Pvt. Ltd., Hyderabad, India.**

**Designation:** Software Engineer.

**Duration:** May 2005 – July 2006

**Description:** Develop and bug-fix the Report Generation Server, developed in C++, which interacts with MS-SQL Server for its data storage needs.

**9. Oracle India Private Ltd., Bangalore, India.**

**Designation:** Member Technical Staff.

**Duration:** Nov 2003 – May 2005

**Description:** Suggesting and implementing new features, and fixing defects in the *Cost Based Optimizer* module of the Oracle RDBMS, on Solaris and Linux platforms.

**10. Aztec Software and Services Ltd., Bangalore, India.**

**Designation:** Developer.

**Duration:** Sept 2003 – Nov 2003

**Description:** Designed *External Stored Procedures* feature for an RDBMS product, which was being developed for a customer.

**11. Vaman Technologies (R&D) Ltd, Mumbai, India.**

**Designation:** Junior Software Engineer.

**Duration:** July 2001 – Sept 2003

**Description:** Worked on various components of an RDBMS, including the TPC-C benchmarking utility, the Query Parser, Procedural Language support, OS independent kernel, and the OS abstraction layer.

## **Detailed Work Experience:**

### **1. Open Source**

**Duration:** 2005 – now

#### **Projects:**

- **PostgreSQL RDBMS**

**Language:** C

**Role:** Contributor

**Description:** Postgres is the most advanced Open Source RDBMS

#### **Contributions:**

- Found and fixed a Security Vulnerability: <http://bit.ly/1xfwQv0>
- Developed feature to replace the Primary Key index of a table.
- Developed Index Advisor.
- Improved Postgres' interaction with Linux's OOM Killer.
- Developed the \ir command for psql utility.
- Fixed a Windows-only race condition.
- Improve pgbench to support large databases for benchmark tests.
- Various other contributions: <http://bit.ly/1q208OG>
- Postgres-hackers mailing list participation: <http://bit.ly/1oeQaUu>

- **Speaking Engagements at Conferences**

**Role:** Speaker

- **Postgres Open**

- 2015 - Postgres Inside Out

- 2014 - How Databases Work - For Developers, Accidental DBAs and Managers

- 2013 - How Postgres is different from (read BETTER than) your database

- 2011 - Introducing Postgres Enterprise Manager

- 2011 - Why you should NOT move away from Oracle

- 2011 - Postgres Plus Cloud Database

- **PGCon**(Postgres Hackers' annual conference)

- 2011 - Best Practices with Ora2Pg

- **Other Open Source Projects**

- Developed DBYardstick - Lightweight TPC-C Benchmark in NodeJS.

- <http://bit.ly/dbyardstick>

- Developed ZFS File System driver for Docker containers.

- [http://bit.ly/docker\\_zfs\\_driver](http://bit.ly/docker_zfs_driver)

- Postgres blogs.

- <http://bit.ly/1uqN8BG>

- <http://bit.ly/1uqNb09>

- <http://bit.ly/1tCskcz>

## 2. *Supabase Inc.*

**Designation:** Fellow Engineer

**Duration:** Sep. 2021 – now

**Description:** The company develops and provides Backend-as-a-Service. The service utilizes the features of Postgres database, and the open-source tools in its ecosystem, to provide the WebApp developers first-class support for User Management, Authentication, Authorization, and automatic generation of REST APIs for the tables in the database. The unique selling point of the Service is that it is all open-source, can be self-hosted, and all data resides in customers' Postgres database. The service is dubbed as "The Open Source Firebase Alternative".

**Contributions:** My primary responsibilities are to contribute to the Postgres community, in the way of developing patches, reviewing patches, and participating in community discussions. My company-facing role involves initiating and working on projects that will be helpful to the company's future 3-5 years down the line.

## 3. *GE Digital, San Ramon, CA, USA*

**Designation:** Principal Engineer

**Duration:** May 2016 – Aug. 2021

Apart from the projects listed below, I am a Bar Raiser at the interviews. Along with another Principal Engineer, I also helped define the interviewing process to reduce false positives in phone interviews.

### ***Projects:***

#### ***Postgres-2.0 Service***

**Language:** Golang

**Team Size:** 6

**Role:** Creator, Service Owner

**Description:** GE Digital's Predix platform helps Industrial companies collect and analyze data, and develop new applications to get new insights from their data. This project provides Postgres-as-a-Service to the Predix platform's customers.

**Contributions:** With one team member, I started and released this project to replace the previous Postgres-as-a-Service since that had many architectural problems. This service provisions and manages Amazon RDS instances for customers. As a Service Owner, I am responsible for design, development, support, and maintenance of this service. I now lead the team of 6 engineers.

With one team member I am developing a Kubernetes based Postgres-as-a-Service, as the next generation of this service.

I'm also the Service Owner of the Blobstore service, and am responsible for feature enhancements, support, and maintenance of the service.

## 4. *Amazon Web Services, Palo Alto, CA, USA*

**Designation:** Software Development Engineer

**Duration:** May 2015 – May 2016

### ***Projects:***

#### ***i. Amazon Aurora for Postgres***

**Language:** C, C++

**Team Size:** 8

**Role:** Senior Engineer

**Description:** Amazon RDS is a market leader in providing Relational Databases in the Cloud. This project developed PostgreSQL compatible Amazon Aurora database.

**Contribution:** I am one of the founding team of 3. I am the primary contributor to the Postgres Transaction Log implementation. I helped team with knowledge of other Postgres internals like shared- memory operations and disk-IO subsystems.

**ii. Postgres RDS**

**Language:** C

**Team Size:** ~10

**Role:** Senior Engineer, Postgres Internals Specialist

**Description:** Amazon RDS is a market leader in providing Relational Databases in the Cloud. RDS Postgres team develops and maintains the Postgres engine within the Amazon RDS umbrella.

**Contribution:** Although I was hired for Amazon Aurora Postgres, due to my past experience with Postgres internals I was engaged with this team and quickly became a component owner of the Postgres code. I am involved in code reviews of the changes made to the Postgres database core and extensions, and I ensure the stability and security aspects of the Amazon-custom changes to the Postgres code.

**5. Thales e-Security, San Jose, CA, USA.**

**Designation:** Senior Engineer, Database Specialist

**Duration:** Nov. 2014 – till date

**Projects:**

**i. Central Manager**

**Language:** TypeScript, JavaScript, C++; NodeJS, AngularJS 1.x

**Team Size:** 8

**Role:** Senior Engineer, Database Specialist, Technology Generalist

**Description:** The company is a leader in Hardware Security Modules. Central Manager is being developed to monitor and manage the large estates of these devices.

**Contribution:** The project is in infancy, with aggressive release dates. I have been instrumental in strongly advocating and getting a buy-in for an array of technologies we'll use to develop this product: Vagrant and TypeScript needed a hard-sell, and also had to vote down some bad choices being made.

**ii. KeyAuthority**

**Language:** C++

**Team Size:** 3

**Role:** Senior Engineer, Database Specialist

**Description:** keyAuthority is a FIPS compliant Encryption Key Management (KMIP/TKLM) product.

**Contribution:** After years of success, the product has hit a performance wall in terms of load the embedded MySQL database can serve. I am responsible for migrating the product to Postgres, while keeping the custom secure replication and HA features intact, and improve the database performance.

**6. EnterpriseDB Corporation, Boston, MA.**

**Designation:** Database Architect  
**Duration:** Feb. 2011 – till date

**Designation:** Principal Systems Engineer  
**Duration:** Feb. 2010 – Jan. 2011

**Projects:**

**i. *Enable Postgres to Reindex Primary Keys***

**Language:** C  
**Team Size:** 1  
**Role:** Architect and Engineer

**Description:** Reindexing the index of a primary key constraint in Postgres requires dropping and recreating the constraint, which also requires an exclusive lock for a prolonged period. This is impractical in production environment if the table is huge. This feature allows users to pre-create an index concurrently (which doesn't require exclusive lock), and then swap this index with the index behind the primary key in one quick command: ALTER TABLE ADD UNIQUE/PRIMARY KEY USING INDEX.

**Contribution:** I came up with the idea, wrote the code and submitted the patch. The maintainers of Postgres project reviewed it before applying the patch to the core Postgres.

**ii. *Postgres Hibernator***

**Language:** C  
**Team Size:** 1  
**Role:** Architect and Engineer

**Description:** After a restart, the database loses all the shared-memory cache, and this causes the application performance to be very slow until that cache is reconstructed over a long time. The Postgres Hibernator extension rebuilds this cache automatically after the restart so that the application performance after the restart is the same as before the restart.

**Contribution:** I came up with the idea, wrote the code and developed the extension.

**iii. *Found and Fixed a Security Bug in Postgres***

**Language:** C  
**Team Size:** 1  
**Role:** Architect and Engineer

**Description:** I discovered a security bug in Postgres which allows a normal database user to gain superuser privileges. I developed a bug-fix that prevents such escalation of privileges. This security vulnerability was assigned CVE number: CVE-2009-4136.

**Contribution:** Discovered and fixed the bug.

**iv. *DBYardstick: Lightweight Database Benchmark Application***

**Language:** JavaScript, TypeScript, NodeJS  
**Team Size:** 1  
**Role:** Architect and Engineer

**Description:** Running an OLTP benchmark requires a huge investment in hardware, and a large fraction of that is spent to buy many high-end workstations to run just the client applications. I implemented a

lightweight OLTP/TPC-C benchmark that can run thousands of client applications on a mere laptop. This implementation can reduce the cost of running TPC-C benchmarks significantly, and these savings can be used to buy better hardware to run the database system under test.

**Contribution:** Idea, research, implementation and scalability testing.

v. ***Postgres Plus Cloud Database***

**Language:** Java

**Team Size:** 3-4

**Role:** Architect and Engineer

**Description:** PPCD is an application for database infrastructure provisioning, management, scalability and fault tolerance. It allows the user to create Postgres databases in the cloud (Amazon AWS, OpenStack, etc.), create read-replicas of that database, perform load balancing among replicas, increase storage/disk as needed, and perform automatic failover in case of master node failure.

**Contribution:** Design and architect the whole project in collaboration with Java application architects. Developed various components in a cloud-provider agnostic way, so that more cloud providers can be easily supported.

vi. ***Postgres Enterprise Manager***

**Language:** SQL, C++

**Team Size:** 3-4

**Role:** Architect and Engineer

**Description:** PEM is an application for managing, monitoring and forecasting a large-scale installation of Postgres databases. It enables users to create custom alert notifications on abnormal conditions reported by the database agents, forecast the resource usage so that upgrades and maintenance operations can be planned.

**Contribution:** I designed and implemented extremely flexible and customizable alert notification subsystem. It allows the user to define new *types/templates* of alerts, and create alerts based on those templates, all without the need to wait for PEM developers to implement a new feature request.

vii. ***Enable pgbench to test large databases***

**Language:** C

**Team Size:** 3

**Role:** Architect and Engineer

**Description:** pgbench is a TPC-B like benchmark utility, and it is the standard tool the Postgres project uses to test performance improvements in the database. pgbench was not capable of running tests for databases initialized with a scale-factor larger than 21474.

**Contribution:** I, along with other community members, improved the code to handle that case, while maintaining the validity of pgbench results obtained in the past.

viii. ***Enable psql to process package of scripts***

**Language:** C

**Team Size:** 1

**Role:** Architect and Engineer



**Description:** psql is the de facto command-line utility/shell of the Postgres project. The feature enables the user to create a set of related SQL scripts that can be processed as one unit/package irrespective of the files' location in the filesystem.

**Contribution:** I came up with the idea and developed the feature.

#### **ix. Miscellaneous**

Other projects, customer-facing or otherwise, that I worked on for cannot be listed here for brevity, and for restrictions imposed by customers' Non Disclosure Agreements. In brief, though:

- a) Migrated an ERP system from Sybase to Postgres  
This included full-text search migrations as well.
- b) Performed Architectural Health Checks (AHC) of Postgres databases.  
Developed the first AHC code, procedures and documents; still in use today at EDB.
- c) Recovering data from corrupted databases.
- d) Slony/Postgres replication setup.
- e) Auditing custom Postgres builds/packages.
- f) RemoteDBA services on-boarding of customers.
- g) Advising a customer on Postgres Internals, who chose to fork Postgres code.
- h) Conducted DBA and Developer training.
- i) Oracle to Postgres migration assessments.
- j) Designed and developed a custom replication solution for Postgres-to-Oracle.
- k) Presented talks at Postgres conferences.

## **7. EnterpriseDB Software India Pvt. Ltd., Pune, India.**

**Designation:** Lead Engineer.

**Duration:** July 2006 - till date

### **Projects:**

#### **i) CRC Slicing-by-8**

**Language:** C

**Team Size:** 1

**Role:** Developer

**Description:** This is a novel fast CRC generation algorithm developed by Intel. This algorithm runs at under 3 cycles per byte (vs. 7) and thus triples the performance of existing CRC implementations. Slicing-by-8 uses an 8KB cache footprint.

**Contribution:** Integrated the ‘Slicing-by-8’ algorithm developed by Michael E. Kounavis, into the Postgres code and benchmarked the performance. Although it proved to be better than the standard CRC calculation, it was not accepted by the Postgres community since the performance of the algorithm heavily depended on the CPU cache’s hotness with the algorithm’s data.

#### **ii) Optimizer Hints**

**Language:** C

**Team Size:** 2

**Role:** Design and development

**Description:** This feature provides a way for the user to instruct the Query Optimizer which access paths to choose when the user knows that she has better knowledge about the data pattern than the Optimizer does.

**Contribution:** Did the Low Level Design of the feature, for implementing it as cleanly as possible in the Postgres’ Scanner, Parser and Query Optimizer. Faced some issues with the Lex and Yacc implementations, hence implemented a separate hand-coded scanner-cum-parser just for recognizing the hints in the query.

Designed and implemented the FULL, INDEX, NO\_INDEX, ALL\_ROWS and FIRST\_ROWS hints. Co-implemented and reviewed the USE\_NL, NO\_USE\_NL, USE\_HASH, NO\_USE\_HASH, USE\_MERGE, NO\_USE\_MERGE hints. Designed and implemented Global Hints feature, which can be used to provide hints for relations/queries inside sub-queries and inline-views.

#### **iii) Index Adviser**

**Language:** C

**Team Size:** 1

**Role:** Developer

**Description:** Index Adviser is a plugin for Postgres that leverages Postgres’ capability to make use of external Query optimizers. It injects an additional step into the query optimization phase and creates virtual indexes based on the WHERE and GROUP BY clauses of the query. Based on the estimated difference in cost of the two phases, it recommends new indexes.

**Contribution:** Migrate the code from Postgres version 7.4 to 8.2; in the process, performed a major cleanup. Add additional features to take into consideration the new Bitmap Index Scans. Add the ability to store the recommendations in a user-definable physical relation. Submit it to the Postgres community, and follow it up till it is accepted by the community.

**iv) Training**

Conducted training for Customers and Partners, to train them on Postgres and EnterpriseDB on the following topics: SQL and PL/PGSQL programming for developers, internals and management tasks for DBAs. The training lasts between 3 to 5 days.

**v) Consulting**

Provide consultancy for Customers, wherein I provided help and support in Database development, administration and maintenance tasks.

**vi) RemoteDBA**

I acted as Remote-DBA for various clients, for periods ranging from 3 to 6 months. As a Remote-DBA I have been involved in architecture review, schema and data migration from other RDBMSs, do maintenance work like dumps/reloads, maintaining cron jobs, etc.

**8. CommVault Systems (India) Pvt. Ltd., Hyderabad, India.**

**Designation:** Software Engineer.

**Duration:** May 2005 – July 2006

**Modules worked on:**

**i) QNet**

**Duration:** May 2005 – July 2006

**Language:** C++, SQL, T-SQL

**Team Size:** 2

**Role:** Development and Maintenance

**Description:** The QNet server is responsible for taking a client's requests, and generating XML report for the clients' consumption. The reports contain description of the various Backup and Restore tasks performed by the Flagship product CommVault-QiNetix. The data is stored in MS-SQL Server, and the front-end clients were written in Java.

**Contribution:** I added new features for one release and managed the whole code during the upgrade from one release to the other.

**9. Oracle India Private Ltd., Bangalore.**

**Designation:** Member Technical Staff.

**Duration:** Nov 2003 – May 2005

**Modules worked on:**

**i) Cost Based (Query) Optimizer (CBO):**

**Duration:** Nov 2003 – May 2005

**Language:** C

**Team Size:** 5

**Role:** Diagnostics and Defect Resolution

**Description:** The Cost Based Optimizer (CBO) tries many transformations with the query; some based on heuristics and some based on cost. Heuristics include view merging and subquery unnesting. The cost based decisions are made for access path analysis. Finally, the best plan is chosen based on the least cost.

**Contribution:** Resolving performance issues and bugs encountered in CBO. Also, suggested a new enhancement for optimization, but couldn't finish it by the time I left.

#### ***10. Aztec Software and Services Ltd., Bangalore.***

**Designation:** Developer.

**Duration:** Sept 2003 – Nov 2003

##### **Projects Undertaken:**

###### ***i) Extended Stored Procedures (ESPs):***

**Duration:** Sept 2003 – Nov 2003

**Language:** C++

**Team Size:** 2

**Role:** Developer

**Description:** ESP will enable the developers of Pervasive SQL RDBMS to call their external stored procedure, implemented in a language of their choice, from within the database.

**Contribution:** Low Level Design and Implementation.

#### ***11. Vaman Technologies (R&D) Ltd, Mumbai***

**Designation:** Junior Software Engineer.

**Duration:** July, 2001-Sept, 2003

**Company Profile:** Developing an RDBMS named VAMAN, using internal-multithreading kernel (threads not visible to the OS, hence OS independent), and Finite State Automata. ANSI C is used as the programming language of choice, for its strength and portability. MS-VC++ 6.0 (on Windows-NT) and GCC (on GNU-Linux) were the tools being used for the development of the server and related software.

##### **Projects Undertaken:**

###### ***i) Extended Procedural Language (EPL)***

**Duration:** Dec 2001 – Sept 2003 (18 months approx.)

**Language:** C

**Team Size:** 6

**Role:** Jr. Software Engineer (Design and Implementation)

**Description:** This module adds the procedural language support to the SQL based RDBMS server. It provides various 'High Level programming Language' (HLL) constructs such as 'IF-ELSE', 'FOR', 'WHILE', 'EXCEPTIONS', 'CURSORS', 'PACKAGES', etc.

This, otherwise an independent module, runs as a part of the server and is responsible for communicating with 'Data Manipulation Language' (DML) engine, for performing the data manipulation as desired by the 'EPL programmer'.

EPL also allows 'COMMIT'ing or Rolling back the transactions by communicating with the Transaction manager.

**Contribution:** I have been instrumental in implementing the 'Extended Procedural Language' module since its inception. I was responsible for implementing the 'CURSOR' construct, which fetches data from the DML engine and allows the EPL programmer to iterate through the result-set row-by-row, and perform various operations depending on the contents of the result-set.

I was also responsible for the communication of EPL with the Transaction manager.

#### **ii) Windows-NT Services**

**Duration:** 1 month

**Language:** C

**Team Size:** 1

**Contribution:** Integrated the RDBMS server with Windows-NT services. It allows the server to run with 'System' privileges as a part of the OS, also allowing the RDBMS server to be started and shutdown in sync with the Operating System.

#### **iii) Kernel**

**Language:** C

**Task:** Optimizations

**Description:** Vaman's Kernel provides cooperative multithreading, and it provides OS-independent and hardware-independent threading model, hence it is capable of providing multithreading even in a non-multitasking OS like MS-DOS. It provides various modern OS features, without relying on the underlying OS. These features include: Priority based scheduling, Event-driven architecture, semaphores, thread synchronisation, etc.

**Contribution:** Tried various optimisations, in various parts of the Kernel, like the scheduling algorithm. Optimised the way kernel used to handle the semaphores. Now, instead of iterating through all the semaphores created so far, it has to iterate through only those that have just been signaled.

#### **iv) Resource Library (OSLib)**

**Language:** C

**Task:** Improvements and bug removal

**Description:** This library provides OS independence. It is a collection of subroutines, written in C, that hide the differences in operating systems from the programmer, hence making the code portable. It consists of various modules, such as : Memory-Management, Process-Creation, Network-Communication, File-Handling, etc.

**Contribution:** Added the feature of assigning priorities to the new processes being created under various OSs. Also, removed a potential bug from the Memory manager.

#### **v) SQL Query Parser**

**Duration:** 2 months

**Language:** C

**Team Size:** 10

**Role:** Team Member

**Description:** It is an object-based parser. It parses the input according to a dictionary, which dictates the rules of occurrences of keywords and identifiers, and fills an interface in the 'Object-Operation-Option-Value' format. This interface is then forwarded to the RDBMS server for execution.

**Contribution:** Implemented the 'Grant/Revoke' commands in the Parser module. It prepares the interface describing the permissions a client wants to be Granted to or Revoked from another user. This interface is then used by the server to actually grant or revoke privileges from a user.

#### **vi) ODBC Driver Development**

**Duration:** 2 months

**Language:** C  
**Team Size:** 3  
**Role:** Jr. Software Engineer  
**Contribution:** Implemented the 'SQLExecDirect' function in the ODBC Driver.

**vii) TPC benchmark-C (TPC-C)**

**Duration:** 1 month  
**Language:** C, SQL  
**Team Size:** 1

**Contribution:** Implemented the 'TPC benchmark-C' as described by 'Transaction Processing Council'. It was used for populating the database with the data in conformance with the TPC benchmark-C.

Also designed a primitive HTML based client, implemented as a DLL, which could be used for performing OLTP transactions on the populated database, in conformance with the benchmark.

**viii) RDBMS Views**

**Duration:** 1 month  
**Language:** C  
**Team Size:** 1

**Contribution:** Completely re-designed and re-implemented View-creation module, which was left mid-way by an ex-employee.