IBM Cloudscape/Derby

IBM developerWorks Live!
Developing on open standards databases
Agenda

- Cloudscape History
- Cloudscape and Derby
- Cloudscape Components
- Connecting to Cloudscape
  - Embedded
  - Network Server
- Demos
What is Cloudscape? What is the Apache Derby Project?

Cloudscape is a Java-based relational database technology with just a 2 megabyte footprint that simplifies application development and makes it even easier to deploy them – no DBA required!

By open sourcing Cloudscape, IBM hopes to accelerate development of Java-based applications and drive more innovation around Linux and Java.

IBM Donated Cloudscape to Apache where it is now know as the Derby Project

Small Foot Print
2MB

Java Based

Fully Embeddable or Server-based

SQL’92

Upwardly Compatible with

http://incubator.apache.org/derby/
Cloudscape and Derby

- IBM Cloudscape 10.0 is Apache Derby 10.0
- Why open-source Cloudscape
  - Promote standards-based application development
  - Further’s IBM commitment to open-source and Linux
- Version available at:
  - incubator.apache.org/derby
  - www.ibm.com/developerworks/cloudscape
- Application development support documentation available on the developerworks website
Brief History

- 1996 – Cloudscape, Inc. startup – Oakland, CA
- 1997 – JBMS 1.0
- Apr 1999 – Cloudscape 2.0
- Dec 1999 – Acquired by Informix Software
- June 2001 – Cloudscape 4.0
- July 2001 – Acquired by IBM
- Dec 2001 – IBM Cloudscape 5.0
- 2003 – IBM Cloudscape 5.1, FP1 & FP2
  - Significant IBM use as a component
- Aug 2004 – Open Sourced
  - IBM contributes code to Apache as Derby
- Sep 2004 - IBM Cloudscape 10.0 released
Apache Derby

- IBM contributed the code to Apache Software Foundation as Derby
- Apache DB project sponsored Derby into incubation at Apache
- Derby up and running at Apache
  - http://incubator.apache.org/derby

Derby is an effort undergoing incubation at the Apache Software Foundation. Incubation is required of all newly accepted projects until a further review indicates that the infrastructure, communications, and decision-making process have stabilized in a manner consistent with other successful ASF projects. While incubation status is not necessarily a reflection of the completeness or stability of the code, it does indicate that the project has yet to be fully endorsed by the ASF.
Derby & IBM Cloudscape

- Single code line, at Apache
- IBM Cloudscape is snapshot of Derby
  + Service & Support
  + Windows, Linux or Java installer
  + Packaging of DB2 Universal JDBC Driver
  + Translated documentation & error messages
  + Sample database
- IBM Cloudscape team continues development on Derby
Pure Java

- **Database code written using the Java programming language**
- **Write Once Run Anywhere**
  - Requires a J2SE 1.3 or Higher
  - Any hardware, any operating system
- **Single binary does run everywhere**
  - Linux, Windows, MacOs, AIX, Solaris, Z/OS, AS400, OS/390, …
  - Supported on any platform with a virtual machine
  - Tested on a core set
- **Database on-disk format is platform independent too!**
Cloudscape/Derby – Guidelines
So what’s the catch

- **Fully functioned database in a small package**
  - has to be a catch?

- **Not an enterprise database – That’s DB2**
  - High transaction rates, hot backup, terabytes, data warehousing, information integration, OLAP …
  - That’s all for DB2 to handle

- **Not a PDA database – That’s DB2 Everyplace**
  - Users will not be successful on severely constrained hardware, e.g. Palm
  - Require a J2SE VM
Cloudscape/Derby Guidelines

- Performance dependent on your application
- However, if you fall into these categories you can be successful with Cloudscape

- Java is not slow! Today’s virtual machines contain Just In Time (JIT) compilers that compile interpreted byte code to native machine code
  - Optimizing for the execute time code paths
Guidelines -- 1-2 cpu machines

- Cloudscape is thread safe, and takes advantage of Java threading and synchronization.

- Not optimized to take advantage of more than 2 cpus, scaling will be limited on 4 or more.

- Not limited to 2 cpu machines
  - E.g. can run Cloudscape in a monitoring application on a 8 way box.
Guidelines – Less than 50Gb of data

- Cloudscape is limited to a single logical disk
- Transaction log can be separated to a separate disk to benefit performance
- Hence most applications will be limited by disk throughput for a single disk
  - Can offset with large page cache
- Fast disk controller can help
- Can use multiple physical disks through RAID devices or OS software striping
  - But that is tending away from zero admin
Guidelines – 20-30 Active Connections

- 20-30 connections concurrently executing SQL statements
- 20-30 is a typical number for an application server connection pool
- QA runs 300 connections during system stress tests
- Connections are limited by memory, low overhead per connection
Guidelines – 100-500 updates per second

- Depends on complexity of updates and transactions
- Depends on level of read activity
- Cloudscape implements group commit for the transaction log to allow a single disk flush to commit multiple transactions
Guidelines Summary

- Those are guidelines, not hard and fast rules, not hard limits

- **Test you own application with Cloudscape to get an idea of performance**
  - Ensure the JIT has kicked in – run for a while

- **Guidelines verified with an industry standard benchmark on a 2cpu box where Cloudscape can match enterprise class databases**
Demo: A Linux Environment
Cloudscape Tooling
Basic Tools

- Cloudscape provides three command line Java tools
  - ij – JDBC scripting tool
    - Like DB2’s command line processor
    - JDBC neutral, can be used against other JDBC drivers
  - dblook – schema extraction tool for Cloudscape
  - sysinfo – Cloudscape version information
    - Output essential for technical support
UI Tools Supporting Cloudscape

- DB2’s MTK – migration to DB2 UDB
- Eclipse plugins
- Any IDE supporting JDBC
- Any tool supporting JDBC including reporting tools
Cloudscape - JDBC
What is JDBC?

- Sun Microsystems JavaSoft developed the specifications for a set of APIs that allow Java applications to access relational data

- A set of classes that support basic SQL functionality for connecting to a database, executing SQL statements, and processing results

- JDBC is by far the most commonly used API for JAVA applications to access DB2 UDB resources

- An application written using JDBC uses only dynamic SQL
Cloudscape database

- A database is a single folder containing set of Cloudscape data files
- Created by making a connection request with the create=true attribute
- Database name maps to relative or absolute path
- No pre-configuration of space
- Transaction log contained in folder, or optionally in another folder (disk) for recoverability
Using Cloudscape

- Cloudscape’s API is JDBC and SQL
- If you already know these then using Cloudscape will be easy
- If you don’t then there are many books on these subjects and Cloudscape is an excellent database to learn on
- JDBC is the API for Cloudscape, not an add-on
Standard JDBC Driver & Connection Code

- Most JDBC applications have code similar to

```java
// get from properties, ui form etc.
String driverClassName = ...  
String databaseURL = ...

// Load the JDBC Driver
Class.forName(driverClassName);

// Open a connection to the database
Connection conn =  
    DriverManager.getConnection(databaseURL);
```
Cloudscape Specific Start Up Code …

- **Nothing!**

- **Loading the Cloudscape JDBC driver starts the embedded engine**
  - The engine is the runtime code that supports multiple databases & provides services to those databases such as an error log.

- **Making a connection request to the database starts that database, if it was not already running**
  - Starting a database means its files are opened, initial catalog information loaded into memory etc.
Cloudscape specific shut-down options

- Standard JDBC API but specific to Cloudscape

- 1) Do nothing – exiting VM will stop Cloudscape
  - Recovery will be run on next start

- 2) Shutdown a single database
  - Make a connection request to the database with the attribute shutdown=true

- 3) Shutdown all databases and the engine
  - Make a connection request without a database name but with the attribute shutdown=true
Embedded JDBC Support

- **JDBC 2.0 and 3.0 driver implementations**
  - Single driver to the application, automatically detects required JDBC level and loads correct code

- **DataSource support including Connection Pool and XA for integration with application servers**

- **Statements, PreparedStatements, CallableStatements, ParameterMetaData, Savepoints, holdable ResultSets, statement batching, isolation levels, ...**
Demo: Cloudscape Utilities
Cloudscape/Derby – Embedded Engine
Embedded Usage

- Database only accessible from single JVM
- Java/JDBC only
- No network connectivity

- Typically is single application per JVM (but could be multiple)
Embedded database

- **Database engine becomes an integral part of the Java application**
- **No additional process**
  - Runs in application’s virtual machine
  - Database requests now just method calls within the JVM
- **Start & shutdown controlled by application**
- **Just a library to Java applications**
  - Shipped in a single jar file
- **Becomes invisible to the user**
  - No battles over must use DB2, Oracle, MS-SQL etc.
Small Footprint

- **Engine jar file is around 2Mb**
  - Optional Jar files
    - Network server ~150k
    - Tools ~200k

- **Runtime memory use**
  - Dependent on application, data caching etc.
  - Can run when Java heap memory restricted to 4Mb
  - Have run in machines with only 16Mb physical memory
Standards

- **SQL**
  - SQL92, SQL99, SQL2003, SQL/XML, …

- **Java**
  - J2SE 1.3, 1.4
  - JDBC 2.0 & 3.0
  - J2EE – certified as a JDBC driver for J2EE 1.4 & 1.3
  - J2ME/OSGi
Complete Relational Engine

- Multi-user, multi-threaded, transactions, row locking, isolation levels, lock deadlock detections, crash recovery, backup & restore

- **SQL**
  - Tables, indexes, views, triggers, procedures, functions, temp tables
  - foreign key and check constraints
  - joins, cost based optimizer

- **Data caching, statement caching, write ahead log, group commit**

- **Multiple databases per system**
Remember!

- Pure Java
- Embedded database
- Small footprint
- Standards based
- Complete relational database engine

- Easy to use embedded database
Cloudbase Network Server
Cloudscape’s client/server mode

- Access from a single JVM in embedded mode can be a restriction
- Network Server allows Cloudscape to act as a traditional client server database
Network Server Clients

- **JDBC using DB2 Universal JDBC Client**
  - Different driver and JDBC URL to embedded

- **ODBC/CLI using DB2’s Universal ODBC/CLI client**
  - Enables PHP / Perl / .NET
Traditional Client Server

- Multiple Client applications
  - Remote or local
  - JDBC, CLI, ODBC, PHP

Client Applications via

- JDBC
- CLI/ODBC
- PHP on top of ODBC

Clients provided by IBM DM
Network Server Security Risks

- Changes security environment – open TCP/IP port on machine running Cloudscape

- Cloudscape’s limited authorization means any remote read-write user can
  - Create a Java procedure or function that executes Java code on the server machine
  - Say, shutdown the server using java.lang.System.exit
  - Attempt to read/write files on the system
Network Server Security Risk Avoidance

- **By default**
  - Only accepts connections on loop back address
  - Restricts admin commands to local host

- **Before configuring to listen on external address (socket)**
  - Enable user authentication
  - Run the network server with the Java 2 Security Manager enabled
    - Procedures and functions will have no permissions
    - Application code can be granted permissions
  - For intranet applications, ensure your firewall blocks the network server port
Embedded Network Server

- Adds on to embedded engine to provide access to database from outside the application’s VM
  - Same host or remote host
- Allows developers to work on database while stand alone application is running
- Allows reporting capability to be added onto a stand alone application
- Enabled by property setting and additional jar file, no code changes to application
Embedded Network Server

- Especially useful developing & debugging embedded database usage (i)
- Connect to running application with schema browsers etc.
Demo: Accessing a Network Server
Cloudscape - Security
Security Environment

- A typical Cloudscape database is not maintained on disks in a server machine in a locked room with armed guards or video surveillance.
- A typical Cloudscape database is on a laptop, desktop, kiosk, machine in a closet, machine in a cell-tower, etc.
- This means the data can be easily accessed without going through the application or database engine.
  - Steal the disks and use a binary editor.
Security Warning

- Application and/or database level security can not solely protect data
- Therefore reliance on them can lead to a false sense of security.
- E.g. using GRANT/REVOKE to disallow update access to the salary table to Fred does not provide any security if Fred can modify the data on disk directly, to award himself a 7 figure salary
- This is true for any database system
Cloudscape Database Encryption

- Cloudscape allows databases to be encrypted on-disk to increase security of widely dispersed data.
- Complete database encryption using standard Java Cryptography Extension (JCE), provided by JVM.
- DES, DESede or algorithm selected by application (e.g. Blowfish).
- Encryption key can be stored externally to database (e.g. smart card) or within the database protected by a password.
- Performance impact depends on strength of algorithm and frequency of disk access. Around 10% slowdown using DES with moderate disk access.
Cloudscape Authentication

- **NONE - default**
  - Connection request with any or no user and/or password will be accepted
  - Application may be enforcing authentication

- **LDAP**
  - Connect to an external LDAP server for authentication

- **BUILTIN**
  - Users and passwords maintained in the database

- **Application defined**
  - Call out to an application Java class to perform authentication
Cloudscape Authorization

- **GRANT/REVOKE** not supported
- **Simple per-database authorization scheme** for a user name set by configuration properties
  - User can connect and read & modify data
  - User can connect in read-only mode
  - User can not connect

- May support **GRANT/REVOKE** in future
Java 2 Security Manager

- Cloudscape supports environments where the Java 2 Security Manager is enabled.
- Requires granting specific Java permissions to the Cloudscape code
  - E.g. read/write database files
- Cloudscape requires only the minimum permissions needed to perform its intended functionality as a database engine
Use Applicable Security

- **Applications can make use of these security features to provide an acceptable level of security for that application**

- **Examples**
  - Monitoring data could use DES encryption as data more than a day old no longer has value
  - A store kiosk could use no database security as data is public (catalog) and physical in-store security exists
  - A laptop home-banking application may require DESede with encryption key stored on a smart card
Cloudscape Customers
IBM Product Use Examples

- **Lotus Workplace Client**
  - Secure client side storage of e-mail and attachments in an encrypted Cloudscape database
  - Hides attachments from worms, viruses

- **WebSphere Portal Server & Application Server**
  - Out of the box experience
  - Installs ready to use system with samples and ready for development of portlets & J2EE applications without having to install and/or configure a database system
IBM Product Use Examples (2)

- **IBM Tivoli Monitoring (ITM)**
  - Storage of system monitoring in an embedded database with network server for ad-hoc reporting
  - In use at high-profile customer site with 100s of machines each running ITM

- **IBM Director**
  - Machine configuration, embedded database, copy on each system sold
External Customer Examples

- **Police Dept**
  - Embedded database application running on laptops in police cars
  - Resource usage main consideration

- **Public Schools**
  - Education applications for enrollment, class scheduling etc.
  - Embedded invisible database as no DBAs on site

- **Edge of network – on demand availability**
  - Push database engine, data and J2EE application to edge servers to off load main database system and provide dynamic load capabilities
  - Partnership with Akamai Technologies
IBM Cloudscape - Summary
Light Embedded Database Segment

- **Segment Characteristics**
  - For the 20-30% of solutions that require an invisible, easy to embed Database.

- **Typical Applications**
  - Simple Transactions
  - Small Web Sites
  - Early Development & Test
  - Point of Sale Systems
  - Small Departmental Applications
  - Larger Application uses a “local” databases to store configuration, user and other persistent data

- **Top Industries**
  - Retail
  - Healthcare

- **Database Characteristics**
  - Very Inexpensive < $500 per machine
  - Small Footprint
  - Small # of Users < 20
  - Small Datasets < 50GB
  - SQL 92
  - Entry Level HA (detect failure, cold restart)
  - Easy to Acquire
  - Ease to Embed
  - Support Single Application

- **Primary Competitors**
  - Progress RDBMS
  - Sybase ASA
  - mySQL (Embedded)
  - Microsoft SQL Server Standard Edition
  - Pointbase
Cloudscape/Derby Messaging

- The open source database for open standards developers for Java and Linux applications
  - Easy to Learn & Use - The easiest database to use with Eclipse
  - Supports leading IDEs - Great for Java & .Net Developers
  - Easy to Acquire – develop & deploy on free open source – or deploy on affordable commercial version for Industry strength support
  - Easy to embed - A 2MB JAR -- drop in and go!
  - Investment Protection -- True Open Standards support means that if your application outgrows Cloudscape it will run on DB2 UDB
  - Runs Virtually Anywhere (java platform independence)
  - Free, Low maintenance cost
  - Linux, open standards, open source!
  - Safe, Reliable, Robust!
References

- Cloudscape Info Center
  http://publib.boulder.ibm.com/infocenter/cldscp10/index.jsp

- DeveloperWorks

- Product site
  http://www.ibm.com/software/data/cloudscape

- Apache site:
  http://incubator.apache.org/derby
The End