

Highly Available Mobile Services Infrastructure Using Oracle Berkeley DB

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Introduction

The rapid spread of wireless voice and data networking teaches consumers to expect always-on service. GSM/GPRS and CDMA/1xRTT coverage is nearly universal in even moderately populated areas. WiFi and WiMAX hotspots are common in public areas and private homes, and deployment of municipal-area wireless data networks, while limited today, is accelerating. At the same time, the line between voice and data in mobile systems is blurring, with the advent of VoIP using wireless transmission.

Mobile operators find that their subscribers demand better network coverage, new services and constant availability. Telecommunication equipment and systems providers, as a result, find that their operator customers need more network infrastructure, and need those systems to deliver services even in the face of hardware or software failures in the field. Because many of these devices are deployed in remote locations, they must generally be resilient and require little or no human administration.

Reliability, availability, fault tolerance and lights-out operation are fundamental, baseline properties, not features. They must be designed into systems from the beginning, not added as an afterthought. Operators today need hardware and software built using components that are themselves fault-tolerant and built for high availability.

This solution brief describes several ways that network equipment manufacturers and software vendors rely on Oracle Berkeley DB to build industry-leading infrastructure for sale to service providers.

Berkeley DB in Mobile Infrastructure

Berkeley DB is at the core of critical network services from industry leaders around the world. Some of the ways in which hardware and software vendors and operators rely on Berkeley DB are shown in Figure 1.

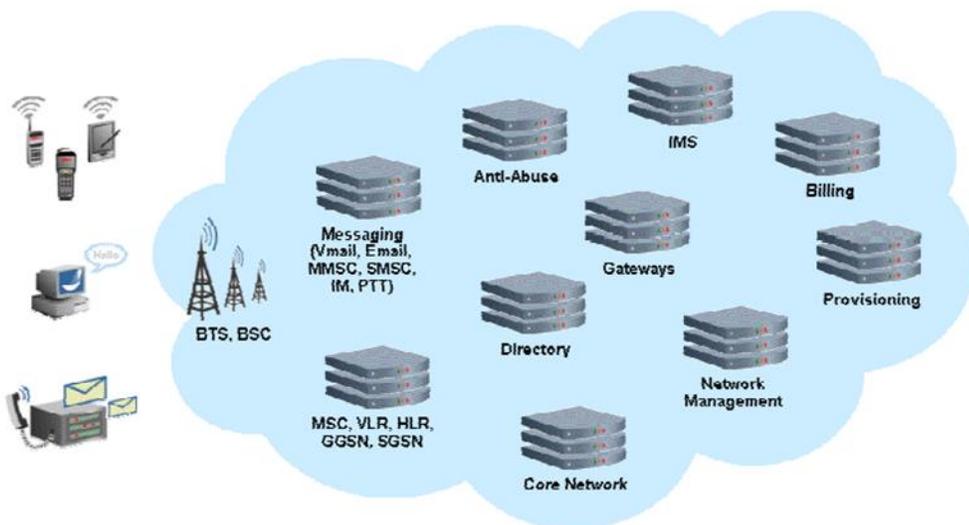


Figure 1 - Network infrastructure services that use Oracle Berkeley DB

Berkeley DB is the backing store for many commercially available, carrier-class directory, email and messaging servers. It is at the core of billing, provisioning and network management systems, in core network elements such as routers, gateways and base stations, and in next-generation IMS and VoIP services. It is flexible enough to support the very different workloads required by this variety of applications, and fast and reliable enough for operators to deploy in production networks with confidence.

Highly Available Storage Services

Berkeley DB provides highly available, fault-tolerant storage for application data. Because Berkeley DB stores data in its application-native format, no run-time format conversion is required. Because Berkeley DB executes directly in the address space of the application using it, there is no inter-process communication overhead and the system makes fewer copies of data. These features and others mean that Berkeley DB outperforms client/server and relational systems in many common deployments.

In mobile infrastructure, however, reliability and availability are even more important than single-node performance. Berkeley DB uses the same enterprise-grade data management techniques employed by enterprise relational database systems to guarantee the integrity and availability of user data. In addition, Berkeley DB offers high availability via data replication, so that an application can continue to operate even if one or more blades or servers in a distributed system fail.

Figure 2 shows a typical carrier-grade deployment architecture. The system is based on a collection of blade servers. Each of the blades uses board-level redundancy in the chassis to survive failure of any single in-chassis component.

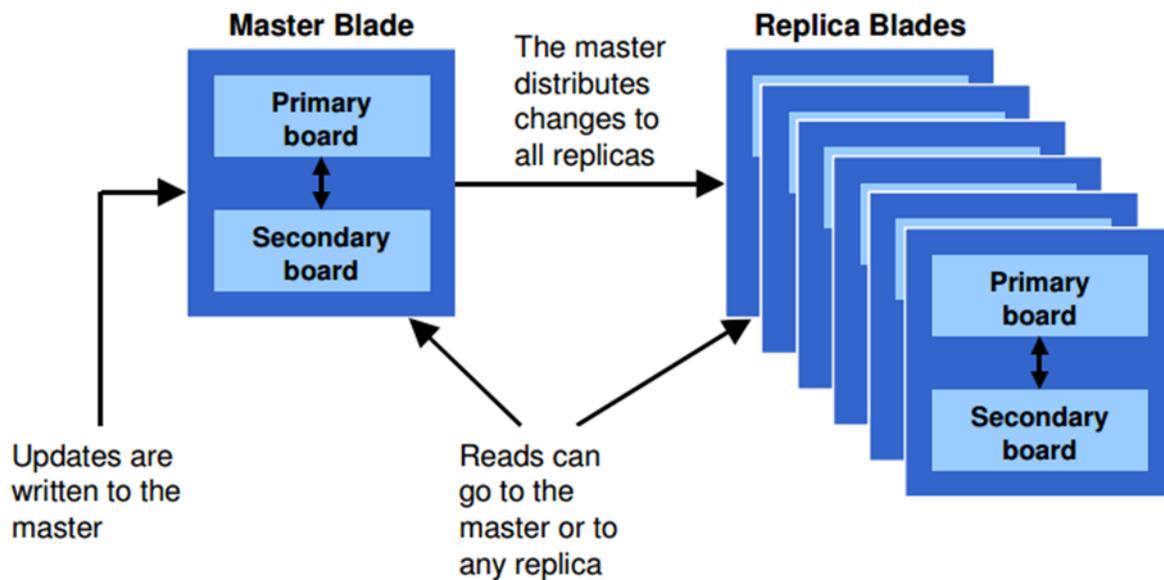


Figure 2 - Redundant distributed blade architecture for carrier-grade systems

Note that the architecture uses pairwise redundancy inside each blade server, but includes several redundant blade servers to back up the master. Inside each blade, the secondary board is essentially a hot standby. By contrast, the redundant blades are able to share the system's workload under normal conditions. Adding blades adds reliability, because the system will run even if more than one blade fails, but also adds performance and scalability.

Berkeley DB provides a single, unified replication framework that operates across boards in a chassis and across servers on a network. The framework can take advantage of special-purpose communication channels like proprietary backplane or bus architectures inside a single blade, and standards-based networking like IP over Ethernet among blades.

When updates arrive at the master, the resulting changes are distributed to all replicas. In Figure 2, the replicas include the local secondary board as well as the other blade servers that participate in the system. Each replica accepts the changes and applies them to a local copy of the database. Carrier-grade systems can require that all replicas receive and acknowledge the changes before the updating transaction commits on the master – strong synchronization – or can permit the master simply to transmit them without waiting for acknowledgment.

In the event that any replica fails, it is simply removed from the replication group. Later, if it recovers and restarts, it can rejoin the group and receive copies of the changes that it needs to bring its local copy of the database up to date.

Replicas watch for failure of the master. After a configurable delay with no communication from the master, the replicas hold an election to select a new master. The elected replica is promoted, and can begin processing updates. It distributes the changes to the rest of the replicas in the same way that the previous master did. If the master recovers, it can rejoin the replication group as a normal replica, and will receive the changes it missed from the new master.



Integrated Storage Management

Storage services in mobile infrastructure must be built directly into the system. A separate database server, even if it runs on the same physical hardware, incurs unacceptable costs at runtime. These include context switches, interprocess synchronization and communication overhead, and unnecessary data copying.

Because Berkeley DB is built directly into the address space of the system using it, it avoids these costs. System data is stored in its application-native format, so no translation is required. Rather than going out of process for storage and retrieval, the application uses process-local function calls to the Berkeley DB library.

The result is a very high-speed, integrated data management service. In fact, customer benchmarks show that Berkeley DB can be significantly faster (up to several orders of magnitude faster) than a client-server relational engine, without sacrificing the integrity, reliability, scalability and availability that carrier-grade systems demand.

Lights-Out Deployment

Mobile infrastructure systems are often deployed in geographically isolated locations. Technician visits are rare. These systems must operate reliably around the clock, must adapt to fluctuations in traffic, and must survive and recover from a wide variety of hardware, electrical and system failures. As a result, mobile designers must build self-administering systems for lights-out deployment, with no regular maintenance required.

Berkeley DB was designed from the ground up for embedded use in this type of system. All of the administrative and maintenance tasks normally handled by a human DBA are instead handled automatically by the application.

Backups, recovery, checkpoints and so on do not require human intervention so the overall application can run in a completely unattended fashion.

Case Studies

Berkeley DB is used broadly in mobile infrastructure systems. While this list is not exhaustive, it does give some indication of the variety of ways that mobile infrastructure software and equipment vendors use Berkeley DB within their products.

Mobile Gateways

Mobile gateways move data across dissimilar networks. For example, WAP gateways act as a proxy between mobile networks and the Internet via optimized markup language and transmission protocol. A key service in a WAP gateway is fast conversion between mobile and IP network addresses. Once an IP connection is established, the gateway must record the mapping between the addresses. WAP gateways often rely on hardware and software redundancy to deliver uninterrupted service in the face of failures.

Several WAP gateway developers use Berkeley DB to store and retrieve address mappings between networks, as well as to record network state and history, device configuration, and to log events during normal operation for billing and diagnostic purposes.

Because Berkeley DB can manage addresses in native format, address allocation and lookup are very fast. Event logging and other data storage services can be integrated with address management services, so that address allocation and the log entry recording the operation take place in a single transaction.



Berkeley DB's replication service distributes updates among a collection of systems, so that one or more failures in the network do not interrupt service delivery. Once an address is allocated, any of the replicas can be used to look up inter-network address mappings. This increases throughput and scalability of the gateway.

Mobile Messaging Services

Mobile operators increasingly derive revenue not from simple voice services, but also from higher-value data services for which customers are willing to pay a premium. Email, voicemail, multimedia messaging, instant messaging and push-to-talk systems are examples.

Berkeley DB is widely used by mobile messaging developers for message storage. Messages are not inherently relational in structure, and access patterns to the data are known at design time and static. Some systems such as email and voicemail store messages for indefinite periods of time, while others such as MMS and instant messaging are inherently store-and-forward applications. Messages for a particular subscriber may arrive at any time, including at times when her handset is off the network. In either case, the messaging network infrastructure must store the message reliably and queue it for delivery to the subscriber when the mobile device appears on the network.

Berkeley DB's reliable storage services, coupled with the replication features provided by Berkeley DB High Availability, guarantee that messages will survive in the network until delivery is possible.

Operational Support Systems and Business Support Systems

Operators use Operational Support Systems (OSS) and Business Support Systems (BSS) to manage critical functions surrounding the services themselves—billing, provisioning and service fulfillment, and network management and service assurance.

Billing systems need to capture a large volume of data, then mediate and transform the data for downstream accounting, auditing, and bill generation systems. Pre-paid billing systems need to check subscriber account balances with low latency, in order to determine whether or not to allow the transaction. Fraud systems monitor large volumes of data for suspicious patterns. Several of these systems rely on the performance, reliability and availability of Berkeley DB to manage the critical billing data that enables operators to avoid revenue loss.

Provisioning, activation, and service fulfillment systems need to manage a large volume of configuration information. Configuration information is typically stored on disk due to its size, and it is mostly static, but this data must normally be parsed and loaded into program structures at startup. One of the most challenging requirements of these systems is recovery time after an electrical outage or a hardware/software failure. Berkeley DB is often used for managing this configuration information, providing a fast, indexed storage engine for data stored on disk.

In network management systems, the network is constantly monitored for problems. Fault tracking and management is one of the most demanding areas from a performance perspective. The system must be capable of capturing and storing large volumes of network alarm and performance data coming at high speeds from multiple sources. The data must be filtered and correlated with network topology and customer records, so that specific problems can be isolated and identified. All the key information must be logged so that diagnosis and repair can be conducted in the most efficient manner. In network management systems, Berkeley DB is often used as a buffer to capture faults, cache data for analysis, and store the logs.

Mobile Devices and Terminals

Mobile handsets are not just personal communication devices. They are increasingly sophisticated computing platforms, with significant processing power and memory and powerful user interfaces. Mobile operators are rolling



out more, and more interesting, applications and services to subscribers. These include presence and location-based services, mobile commerce, multimedia and streamed content, business applications, and more.

As a result, the handsets themselves require more sophisticated software infrastructure to support the new services. Handset OEMs have embedded Berkeley DB within mobile handsets because of its small footprint, reliability, zero administration, and ease of deployment. As the built-in data manager, Berkeley DB is used to store contacts and calendar information. It is also used by the messaging client to store text, multimedia, email and instant messages locally. It is used for the file system for photos, videos, MP3, ringtones, Java applets and business documents.

Summary

Oracle Berkeley DB is used very broadly used within mobile infrastructure software, equipment and devices. Berkeley DB delivers carriergrade performance, reliability, scalability and availability in an embeddable package, eliminating the need for separate hardware and human administration, which greatly lowers total cost of ownership.

To learn more about Berkeley DB, please visit <https://www.oracle.com/database/berkeley-db/db.html> where you can download the full Berkeley DB product, complete with documentation, source code, test code and sample code. For more information, contact us at berkeleydb-info_us@oracle.com.



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