

Table of Contents

Acknowledgements	ix
About the Author	xi
About the editors	xiii
Dr. Richard Hipp	xiii
Heather Mahalik	xiii
Brett Shavers	xiv
Eric Zimmerman	xiv
Chapter 1 Introduction	1
SQLite SQL basics	4
Creating a table	4
Inserting data into a table	9
Simple queries	10
References	12
Chapter 2 SQLite database file format	13
Pages	14
Database header	15
B-trees	17
B-tree pages	20
Page Header	20

Table leaf pages.....	22
Cell Pointer Array	24
Cells & Records.....	25
Varints	25
Negative varints.....	27
Record structure.....	28
Interior table B-tree page record format	28
Leaf table B-tree record format	28
Interior index B-tree record format	29
Leaf index B-tree record format.....	29
Table leaf pages.....	29
Records/Serial types.....	32
Table interior pages.....	38
Index B-tree leaf tables	43
Index B-tree interior tables	46
WITHOUT ROWID tables	49
Overflow pages.....	50
Freeblock records.....	56
Pointer map pages.....	59
Lock-byte page	62
Freelist pages.....	63
Summary	65

References..... 65

Chapter 3 SQLite record recovery 67

 Secure delete..... 68

 Structure intact..... 70

 Case 1 – A record with a valid entry in the cell pointer array 70

 Orphaned records 73

 Case 2 – Invalid serial types array 74

 Case 3 – Length of serial types does not match payload length 74

 Case 4 – Valid record 75

 Case 5 – ALTER TABLE utilized since the record was stored 78

 Case 6 - SQLite’s loose affinity rules..... 80

 Partial records 83

 Example – A decoded record, before it is deleted 83

 Partial record recovery 90

 Case 7 – Decoding from byte zero..... 93

 Case 8 – Decoding from byte one 93

 Case 9 – Decoding a cell with an overwritten record length 95

 Enable Null Trim 97

 Changes to working copy databases 98

 Summary 101

 References..... 101

Chapter 4 SQLite rollback journals 103

Rollback Journal file format.....	106
The Journal Header	107
The journal page record	108
Page checksum	108
Journals in practice.....	109
Journal modes	110
Transaction walkthrough.....	111
Transactions	115
Master Journals	116
Rollback journal Forensics.....	117
Examining the content of a DB in the presence of a HOT journal.....	118
Examining the content of a DB in the presence of a COLD journal.....	121
Secure Delete	129
Summary	129
References.....	129
Chapter 5 Write-Ahead Logs	131
Write-Ahead Log file format.....	133
The Write-Ahead Log header	134
Checksum algorithm.....	134
SQLite WAL Frame header.....	135
The Shared Memory file (-shm).....	135
The Write-Ahead Log in practice.....	136

Checkpoints	140
Write-Ahead Log Forensics	141
Why you should not use non-forensic tools.....	141
Peeling back WAL history	144
Determining when a record was added/deleted	150
Secure delete.....	160
Summary	160
References.....	160
Chapter 6 The Schema	161
The database schema.....	162
Table constraints	169
Foreign keys.....	171
Indexes	174
Triggers.....	176
Views	182
Summary	185
References:.....	185
Chapter 7 SQL.....	187
SQLite SELECT statement	187
Column aliases.....	190
WHERE clause.....	191
JOINS.....	194

LEFT JOIN/LEFT OUTER JOIN.....	196
INNER JOIN	202
CROSS JOIN	204
NATURAL JOIN.....	206
Aggregate functions	207
Count().....	207
Sum()	207
Min(), Max(), Avg()	207
Group By.....	208
Group_Concat()	209
Dates and times in SQLite.....	211
Displaying using inbuilt SQLite functions	211
Forensic Browser for SQLite datetime SQL extensions	216
Forensic Browser for SQLite display functions.....	217
SQLite core functions	218
String handling.....	218
SubStr().....	219
InStr().....	221
Hex()	224
Length()	224
Lower(), Upper()	224
Typeof()	224

Case statements	225
Attaching a second database	226
Union/Intersect/Except.....	227
Common Table Expressions	229
Recursive Common Table Expressions	230
Built-in queries in The Forensic Browser for SQLite.....	234
Summary	235
References.....	236
Chapter 8 Odds and Ends	237
Introduction.....	237
FTS	237
R*TREE.....	241
Encryption	244
Passwords vs. keys	248
Dealing with BLOBs and structured data	249
ROWIDs	250
Summary	252
References.....	253
Chapter 9 Case study iOS sms.db	255
The structure of the iOS sms.db.....	255
Sample questions	259
Q. Can you create a report on all recovered messages?.....	259

Q. Is there any evidence of deleted messages?	267
Q. Can you recover any deleted messages?	269
Q. Are there any other ways of determining who the third party is?	272
Q. Can you determine when the specified messages were deleted?	283
Q. Why is it so difficult to link a user to a deleted message?.....	286
Summary	295