

SQLite Record Recovery

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1. SQLite!

2. SQLite 구조

3. 레코드의 삭제

4. 삭제된 영역 추적

5. 레코드 복원 기법

SQLite!

- What is..
- and why?



What is..

- DataBase! (Local DB)
- Open Source & Library
- Small & Fast
- SQLite & MySQL, MSSQL, Oracle.. etc
 - RDBMS의 장점 계승
 - 표준 SQL 쿼리 사용
- SQLite & plist, xml .. etc
 - 어플리케이션 단위 운용
 - 활용 방안 유사
 - ✓ 운용 데이터 저장 및 활용

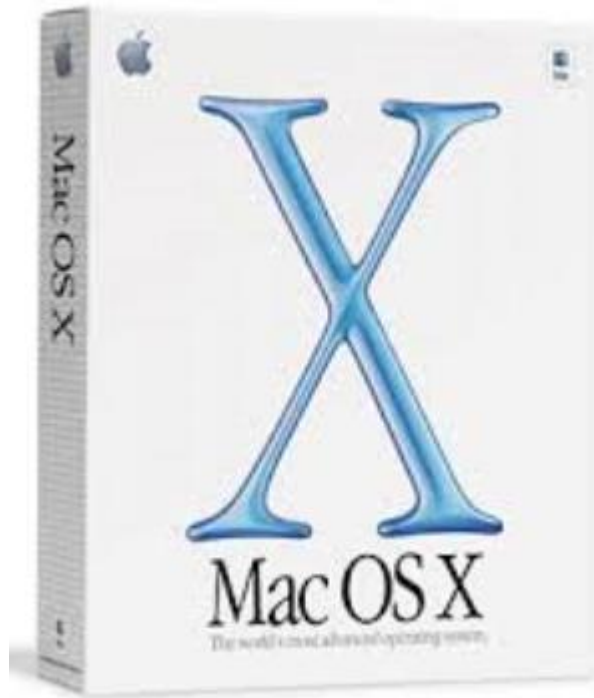


Name	Object	Type	Schema
android_metadata	table		CREATE TABLE android_metadata (locale TEXT)
pdu	table		CREATE TABLE pdu (_id INTEGER PRIMARY KEY,thr...
canonical_addresses	table		CREATE TABLE canonical_addresses (_id INTEGER ...
threads	table		CREATE TABLE threads (_id INTEGER PRIMARY KE...
pending_msgs	table		CREATE TABLE pending_msgs (_id INTEGER PRIMA...
words	table		CREATE VIRTUAL TABLE words USING FTS3 (_id IN...
words_content	table		CREATE TABLE 'words_content'(docid INTEGER PRI...
words_segments	table		CREATE TABLE 'words_segments'(blockid INTEGER ...
words_segdir	table		CREATE TABLE 'words_segdir'(level INTEGER,idx I...
addr	table		CREATE TABLE addr (_id INTEGER PRIMARY KEY,m...
part	table		CREATE TABLE part (_id INTEGER PRIMARY KEY,mi...
rate	table		CREATE TABLE rate (sent_time INTEGER)
drm	table		CREATE TABLE drm (_id INTEGER PRIMARY KEY,_d...
sms	table		CREATE TABLE sms (_id INTEGER PRIMARY KEY,thr...
raw	table		CREATE TABLE raw (_id INTEGER PRIMARY KEY,da...
attachments	table		CREATE TABLE attachments (sms_id INTEGER,cont...
sr_pending	table		CREATE TABLE sr_pending (reference_number INT...
sqlite_autoindex_words_segdir_1	index		
typeThreadIdIndex	index		CREATE INDEX typeThreadIdIndex ON sms (type, ...

..					
shell.c	124,070	31,291	75%	C Source	
sqlite3.c	5,239,373	1,371,737	74%	C Source	
sqlite3ext.h	26,110	4,694	83%	C/C++ Header	
sqlite3.h	360,297	96,586	74%	C/C++ Header	
sqlite3.def	4,444	1,115	75%	Export Definiti...	
sqlite3.dll	650,725	332,755	49%	응용 프로그램...	



약진!





Digital Forensics & SQLite Analysis

- 포렌식 분석가와 SQLite 분석?!
 - 활용도 ↑
 - ✓ 스마트폰 포렌식
 - ✓ Mac Artifact 분석
 - SQLite 파일 구조의 특징
 - ✓ 다소 복잡하고 체계적인 방법으로 레코드를 적립
 - ➔ 구조를 분석하여 레코드 복원을 해보는 것으로 파일 구조 분석 및 복원에 대한 학습에 효과적

Structure of SQLite DataBase

- File Structure
- Page Structure
- Cell Structure



SQLite DataBase File

- 전체 구조
 - 페이지 단위(Number of header page == 1)

```
00000000 53 51 4C 69 74 65 20 66 6F 72 6D 61 74 20 33 00 SQLite format 3.
00000010 02 00 01 01 00 40 20 20 00 00 00 0C 00 00 00 05 .....@ .....
00000020 00 00 00 00 00 00 00 00 00 00 00 04 00 00 00 04 .....
00000030 00 00 00 00 00 00 00 00 00 00 01 00 00 00 00 .....
      :
00000120 25 01 81 13 69 6E 64 65 78 4F 76 65 72 46 6C 6F %...indexOverFlo
00000130 77 54 65 73 74 49 6E 64 65 78 4F 76 65 72 46 6C wTestIndexOverFl
00000140 6F 77 54 65 73 74 04 43 52 45 41 54 45 20 49 4E owTest.CREATE IN
00000150 44 45 58 20 5B 4F 76 65 72 46 6C 6F 77 54 65 73 DEX [OverFlowTes
00000200 0D 01 1F 00 02 00 E9 00 01 34 00 E9 00 E9 00 00 .....e..4.e.e..
00000210 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000220 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000230 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000240 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000250 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
      :
00000400 00 00 00 00 31 30 31 30 31 30 31 30 31 30 31 30 ....101010101010
00000410 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000420 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000430 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000440 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000450 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
      :
00000600 0A 00 00 00 02 01 9D 00 01 CA 01 9D 01 88 33 30 .....E...^30
00000610 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 303030303030303030
00000620 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 303030303030303030
00000630 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 303030303030303030
00000640 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 303030303030303030
00000650 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 303030303030303030
      :
      :
```

Page 1
(Header Page)

Page 2,3,4..
(Table B-Tree, Index B-Tree, Free, OverFlow)



SQLite DataBase File

- Header Page
 - DataBase Header

```

00000000 53 51 4C 69 74 65 20 66 6F 72 6D 61 74 20 33 00 SQLite format 3.
00000010 02 00 01 01 00 40 20 20 00 00 00 0C 00 00 00 05 .....@ .....
00000020 00 00 00 00 00 00 00 00 00 00 00 04 00 00 00 04 .....
00000030 00 00 00 00 00 00 00 00 00 00 00 01 00 00 00 00 .....
          ⋮
00000120 25 01 81 13 69 6E 64 65 78 4F 76 65 72 46 6C 6F %...indexOverFlo
00000130 77 54 65 73 74 49 6E 64 65 78 4F 76 65 72 46 6C wTestIndexOverFl
00000140 6F 77 54 65 73 74 04 43 52 45 41 54 45 20 49 4E owTest.CREATE IN
00000150 44 45 58 20 5B 4F 76 65 72 46 6C 6F 77 54 65 73 DEX [OverFlowTes
    
```

**Page 1
(Header Page)**

	0x0	0x1	0x2	0x3	0x4	0x5	0x6	0x7	0x8	0x9	0xA	0xB	0xC	0xD	0xE	0xF
0x00	Header String															
0x10	Page Size				File change counter				DataBase Size							
0x20	Free Page Offset				Free Page Number				The schema cookie				The schema format number			
0x30	Default page cache size				Incremental vacuum settings				text encoding				user version			
0x40	incremental-vacuum mode															
0x50	Reserved for expansion												The version-valid-for number			
0x60	SQLITE_VERSION_NUMBER															

- **SQLite DataBase Signature** : SQLite 데이터베이스 식별 정보
- **Page Size** : 페이지 크기(0x200 alignment)
- **Text Encoding** : 문자열 인코딩(0: UTF-8 , 1: UTF-16 LE , 2: UTF-16 BE)
- **Auto Vacuum mode** : 삭제 시 데이터 자동 정리 여부



SQLite DataBase File

- Header Page
 - Schema String

```
00000000 53 51 4C 69 74 65 20 66 6F 72 6D 61 74 20 33 00 SQLite format 3.
00000010 02 00 01 01 00 40 20 20 00 00 00 0C 00 00 00 05 .....@ .....
00000020 00 00 00 00 00 00 00 00 00 00 00 04 00 00 00 04 .....
00000030 00 00 00 00 00 00 00 00 00 00 00 01 00 00 00 00 .....
                                     ⋮
00000120 25 01 81 13 69 6E 64 65 78 4F 76 65 72 46 6C 6F %...indexOverFlo
00000130 77 54 65 73 74 49 6E 64 65 78 4F 76 65 72 46 6C wTestIndexOverFl
00000140 6F 77 54 65 73 74 04 43 52 45 41 54 45 20 49 4E owTest.CREATE IN
00000150 44 45 58 20 5B 4F 76 65 72 46 6C 6F 77 54 65 73 DEX [OverFlowTes
```

} Page 1
(Header Page)

```
00000120 25 01 81 13 69 6E 64 65 78 4F 76 65 72 46 6C 6F %...indexOverFlo
00000130 77 54 65 73 74 49 6E 64 65 78 4F 76 65 72 46 6C wTestIndexOverFl
00000140 6F 77 54 65 73 74 04 43 52 45 41 54 45 20 49 4E owTest.CREATE IN
00000150 44 45 58 20 5B 4F 76 65 72 46 6C 6F 77 54 65 73 DEX [OverFlowTes
00000160 74 49 6E 64 65 78 5D 20 4F 4E 20 5B 4F 76 65 72 tIndex] ON [Over
00000170 46 6C 6F 77 54 65 73 74 5D 20 28 5B 4F 76 65 72 FlowTest] ([Over
00000180 46 6C 6F 77 54 65 73 74 5D 29 74 01 07 17 25 25 FlowTest])t...%
00000190 01 81 2B 74 61 62 6C 65 4F 76 65 72 46 6C 6F 77 ..+tableOverFlow
000001A0 54 65 73 74 4F 76 65 72 46 6C 6F 77 54 65 73 74 TestOverFlowTest
000001B0 02 43 52 45 41 54 45 20 54 41 42 4C 45 20 5B 4F .CREATE TABLE [O
000001C0 76 65 72 46 6C 6F 77 54 65 73 74 5D 20 28 0D 0A verFlowTest] (..
000001D0 20 20 5B 4F 76 65 72 46 6C 6F 77 54 65 73 74 5D [OverFlowTest]
000001E0 20 54 45 58 54 2C 20 0D 0A 20 20 5B 4F 76 65 72 TEXT, .. [Over
000001F0 46 6C 6F 77 54 65 73 74 32 5D 20 54 45 58 54 29 FlowTest2] TEXT)
```

- 생성 시의 Query 형태(문자열)로 저장
- 복원 시 필드 명 확인에 필요(가능할 경우 획득)



SQLite DataBase File

Pages in the SQLite database file Pages

- **Pages for Table B-Tree(Main target)**

- Pages for Index B-Tree(Get Row ID)

- Overflow Page

- Free Page

```
00000000 53 51 4C 69 74 65 20 66 6F 72 6D 61 74 20 33 00 SQLite format 3.
00000010 02 00 01 01 00 40 20 20 00 00 00 0C 00 00 00 05 .....@ .....
00000020 00 00 00 00 00 00 00 00 00 00 00 04 00 00 00 04 .....
00000030 00 00 00 00 00 00 00 00 00 00 00 01 00 00 00 00 .....

                                Page 1
00000120 25 01 81 13 69 6E 64 65 78 4F 76 65 72 46 6C 6F %...indexOverFlo
00000130 77 54 65 73 74 49 6E 64 65 78 4F 76 65 72 46 6C wTestIndexOverFl
00000140 6F 77 54 65 73 74 04 43 52 45 41 54 45 20 49 4E owTest.CREATE IN
00000150 44 45 58 20 5B 4F 76 65 72 46 6C 6F 77 54 65 73 DEX [OverFlowTes

00000200 0D 01 1F 00 02 00 E9 00 01 34 00 E9 00 E9 00 00 .....é..4.é.e..
00000210 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000220 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000230 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000240 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000250 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....

                                Page 2
                                :
00000400 00 00 00 00 31 30 31 30 31 30 31 30 31 30 31 30 ...10101010101010
00000410 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000420 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000430 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000440 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000450 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010

                                Page 3
                                :
00000600 0A 00 00 00 02 01 9D 00 01 CA 01 9D 01 88 33 30 .....E...~30
00000610 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 3030303030303030
00000620 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 3030303030303030
00000630 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 3030303030303030
00000640 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 3030303030303030
00000650 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 3030303030303030

                                Page 4
                                :
                                :
                                :
```

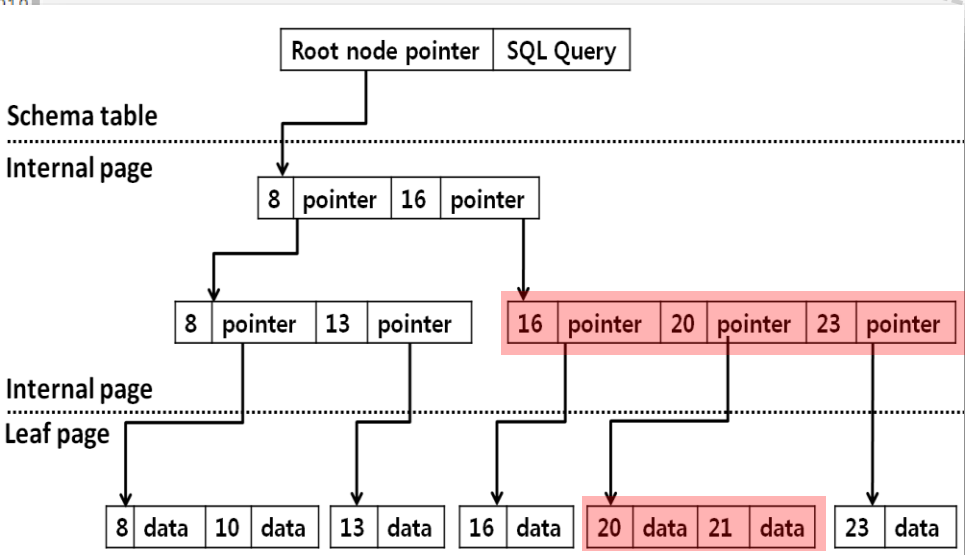


Table B-Tree Overview

```

00000000 53 51 4C 69 74 65 20 66 6F 72 6D 61 74 20 33 00 SQLite format 3.
00000010 02 00 01 01 00 40 20 20 00 00 00 0C 00 00 00 05 .....@ .....
00000020 00 00 00 00 00 00 00 00 00 00 00 04 00 00 00 04 .....
00000030 00 00 00 00 00 00 00 00 00 00 00 01 00 00 00 00 .....
          ⋮
00000120 25 01 81 13 69 6E 64 65 78 4F 76 65 72 46 6C 6F *...indexOverFlo
00000130 77 54 65 73 74 49 6E 64 65 78 4F 76 65 72 46 6C wTestIndexOverFl
00000140 6F 77 54 65 73 74 04 43 52 45 41 54 45 20 49 4E owTest.CREATE IN
00000150 44 45 58 20 5B 4F 76 65 72 46 6C 6F 77 54 65 73 DEX [OverFlowTes
00000200 0D 01 1F 00 02 00 E9 00 01 34 00 E9 00 E9 00 00 .....ê..4.ê.e..
00000210 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000220 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000230 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000240 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
00000250 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
          ⋮
00000400 00 00 00 00 31 30 31 30 31 30 31 30 31 30 31 30 ....101010101010
00000410 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 1010101010101010
00000420 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 10101010101010
00000430 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 10101010101010
00000440 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 10101010101010
00000450 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 10101010101010
          ⋮
00000600 0A 00 00 00 02 01 9D 00 01 CA 01 9D 01 88 33 30 .....E....
00000610 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 30303030303030
00000620 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 30303030303030
00000630 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 30303030303030
00000640 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 30303030303030
00000650 33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30 30303030303030
          ⋮
          ⋮
  
```

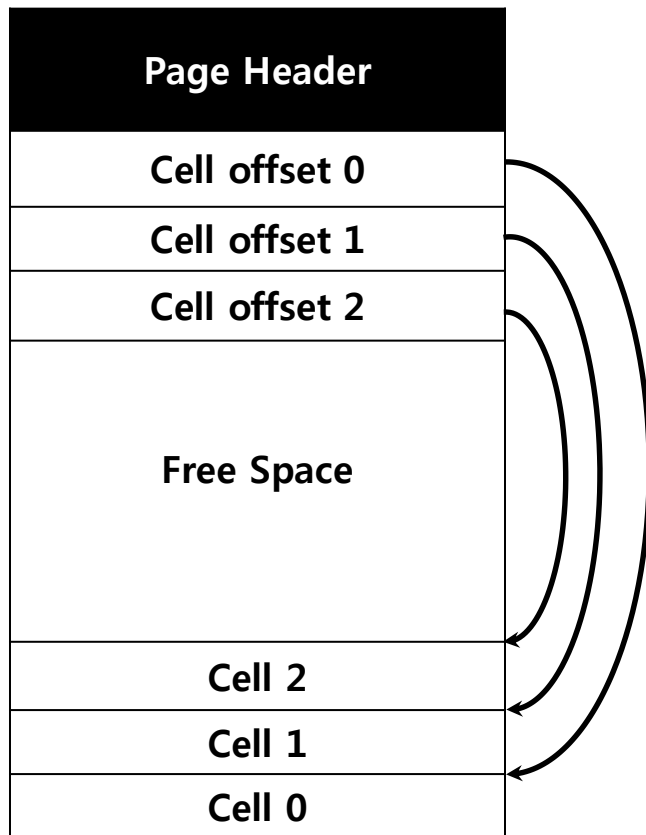
- Tree의 각 노드
 - 하나의 페이지
- Internal 페이지
 - 하위 페이지의 번호를 포함
- Leaf 페이지
 - 실제 데이터(레코드)를 포함





Pages

- Page Structure



- Page Header
 - Table – b-tree
 - Offset 0
 - 0x05 - Internal page
 - 0x0D – Leaf page
 - Size
 - 12 Byte – Internal page
 - 8 Byte - Leaf page
- Cell Offset
 - 2byte Big endian integer



Pages

- Page headers

- Internal Page header

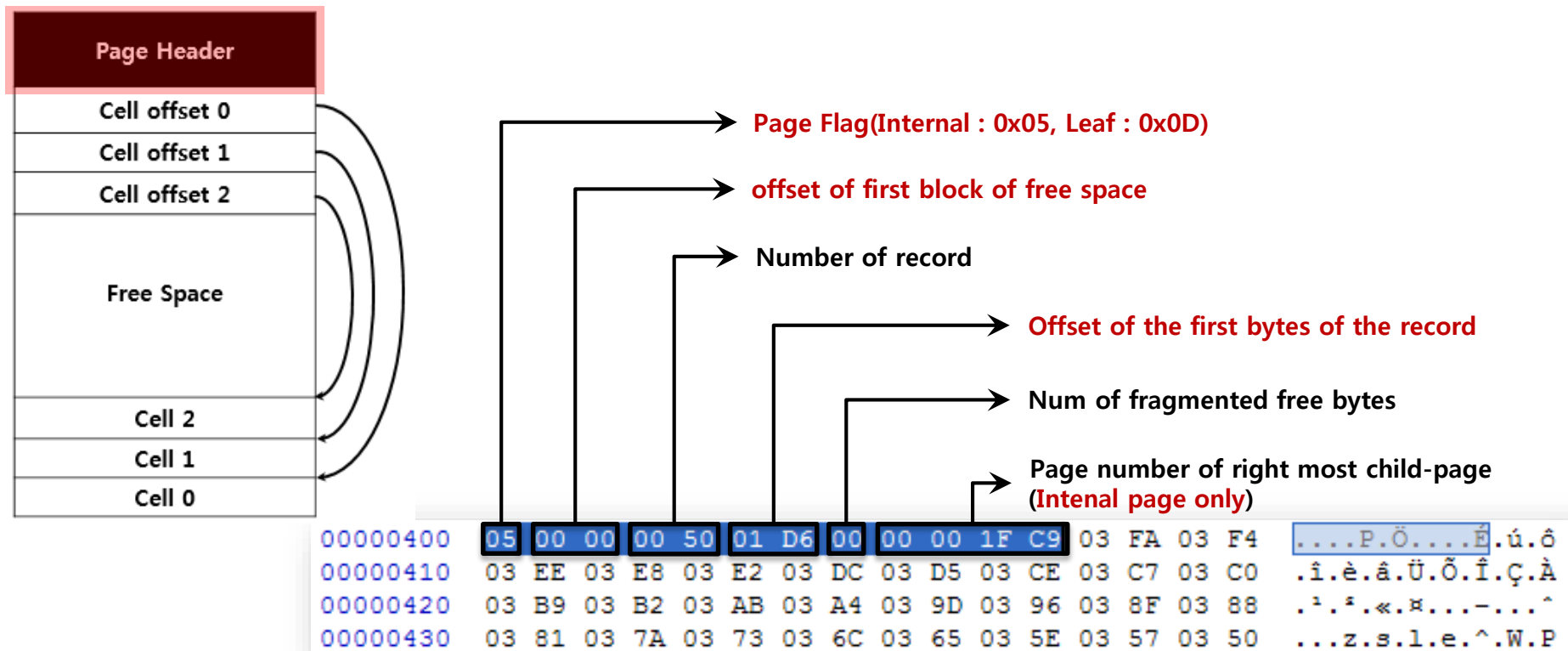


Table B-Tree

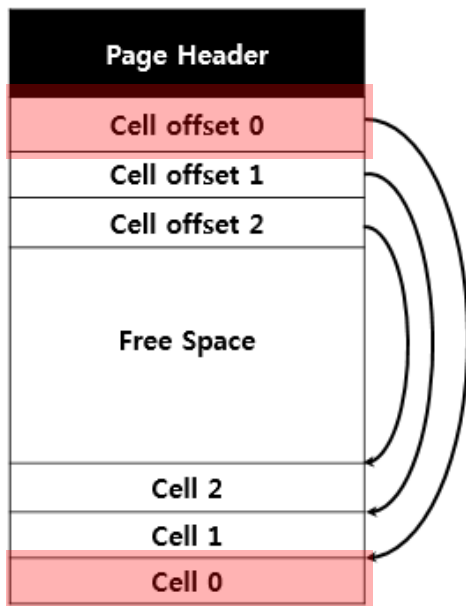


Pages

- Page Header
- Cell Offsets
- Cells
- Links

$0x200 + 0x134 = 0x334$ $0x200 + 0xE9 = 0x2E9$

00000200	0D 01 1F 00 02 00 E9 00 01 34 00 E9 00 E9 00 00	.....é..4.é.é..
00000210	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
00000220	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
00000230	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
00000240	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
00000250	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
00000260	00 00 00 00 00 00 00 00 00 00 00 CC 85 49 85 49	.....Ï...I...I
00000270	33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30	3030303030303030
00000280	33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30	3030303030303030
00000290	33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30	3030303030303030
000002A0	33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30	3030303030303030
000002B0	33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30	3030303030303030
000002C0	33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30	3030303030303030
000002D0	33 30 33 30 33 30 33 30 33 30 33 30 33 30 33 30	3030303030303030
000002E0	33 30 33 30 33 30 33 30 34 03 03 6F 00 30 30	3030303034..o.o.00
000002F0	30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30	0000000000000000
00000300	30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30	0000000000000000
00000310	30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 00	0000000000000000.
00000320	00 00 15 00 33 30 33 30 33 30 33 30 33 30 33 30	...30303030303030
00000330	33 30 33 30 85 41 01 05 85 49 85 49 31 30 31 30	3030..A.....I...I1010
00000340	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
00000350	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
00000360	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
00000370	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
00000380	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
00000390	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
000003A0	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
000003B0	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
000003C0	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
000003D0	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
000003E0	31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30	1010101010101010
000003F0	31 30 31 30 31 30 31 30 31 30 31 30 00 00 00 03	101010101010....





Cells – Internal Cell

- Internal Cell
 - 트리 순회를 위해 존재

Child page number	Var Int(Unknown)
-------------------	------------------

```
00008FA0 00 00 00 66 82 4C 00 00 00 60 82 39 00 00 00 57 ...f,L...`,9...W̄
00008FB0 82 24 00 00 00 51 82 11 00 00 00 56 81 7E 00 00 ,$....Q,....V.~..
00008FC0 00 50 81 69 00 00 00 4C 81 55 00 00 00 4A 81 42 .P.i...L.U...J.B
00008FD0 00 00 00 47 81 2D 00 00 00 41 81 1A 00 00 00 39 ...G.-...A.....9
00008FE0 81 06 00 00 00 2C 74 00 00 00 35 62 00 00 00 31 .....,t...5b...1
00008FF0 4D 00 00 00 2E 39 00 00 00 27 26 00 00 00 26 12 M....9...'&...&.
```




Cells – Internal Cell

Simulation(B-Tree Traverse) – mmssms.db

```

00000000 53 51 4C 69 74 65 20 66 6F 72 6D 61 74 20 33 00 SQLite format 3.
00000010 10 00 01 01 00 40 20 20 00 00 2B 59 00 00 01 6A .....@ ..+Y...j
00000020 00 00 00 00 00 00 00 00 00 00 00 00 4C 00 00 04 .....L....
00000030 00 00 00 00 00 00 00 19 00 00 00 01 00 00 00 45 .....E
          .
00000550 07 07 17 13 13 01 94 79 74 61 62 6C 65 73 6D 73 ..... "ytablesms
00000560 73 6D 73 09 43 52 45 41 54 45 20 54 41 42 4C 45 sms.CREATE TABLE
00000570 20 73 6D 73 20 28 5F 69 64 20 49 4E 54 45 47 45 sms (_id INTEGE
00000580 52 20 50 52 49 4D 41 52 59 20 4B 45 59 2C 74 68 R PRIMARY KEY,th
          .
00000FD0 00 24 40 00 00 00 1C 21 00 00 00 1D 3C 00 00 00 . $@....!....<...
00000FE0 1B 1A 00 00 00 21 17 00 00 00 1A 2F 00 00 00 20 .....!...../...
00000FF0 0B 00 00 00 1F 3E 00 00 00 1E 28 00 00 00 23 3F .....>.... (...#?
    
```

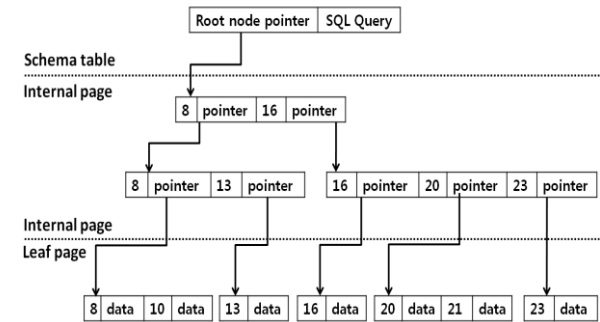
Root Page: 확인

Internal Page Flag 확인

```

00008000 05 00 00 00 5F 0D CC 00 00 00 01 56 0F FB 0F F6 ..... .I....V.ú.ó
00008010 0F F1 0F EC 0F E7 0F E2 0F DC 0F D6 0F D0 0F CA .ñ.i.ç.á.Ü.Ö.Đ.Ê
00008020 0F C4 0F BE 0F B8 0F B2 0F AC 0F A6 0F A0 0F 9A .Ä.¼.,.².-.!.š
00008030 0F 94 0F 8E 0F 88 0F 82 0F 7C 0F 76 0F 70 0F 6A ."Ž.^.,.|.v.p.j
00008040 0F 64 0F 5E 0F 58 0F 52 0F 4C 0F 46 0F 40 0F 3A .d.^.X.R.L.F.@.:
00008050 0F 34 0F 2E 0F 28 0F 22 0F 1C 0F 16 0F 10 0F 0A .4... (. ".....
          .
00008FA0 00 00 00 66 82 4C 00 00 00 60 82 39 00 00 00 57 ...f,L...`,9...W
00008FB0 82 24 00 00 00 51 82 11 00 00 00 56 81 7E 00 00 , $...Q,....V.~..
00008FC0 00 50 81 69 00 00 00 4C 81 55 00 00 00 4A 81 42 .P.i...L.U...J.B
00008FD0 00 00 00 47 81 2D 00 00 00 41 81 1A 00 00 00 39 ...G.-...A.....9
00008FE0 81 06 00 00 00 2C 74 00 00 00 35 62 00 00 00 31 .....t...5b...1
00008FF0 4D 00 00 00 2E 39 00 00 00 27 20 00 00 00 26 12 M....9...'&...&.
    
```

Cell 위치 확인



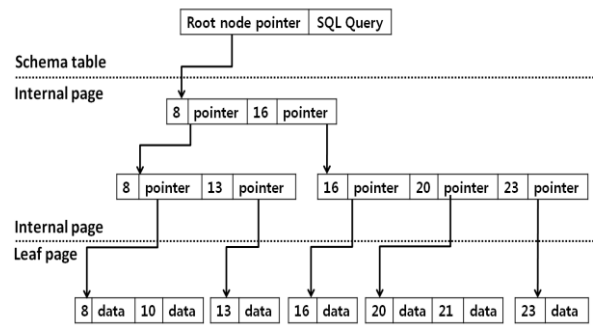


Cells – Internal Cell

Simulation(B-Tree Traverse) – mmssms.db Root(Internal Page)

```

00008000 05 00 00 00 5F 0D CC 00 00 00 01 56 0F FB 0F F6  ...._I...V.ù.ò
00008010 0F F1 0F EC 0F E7 0F E2 0F DC 0F D6 0F D0 0F CA  .ñ.i.ç.â.Û.Ö.Ê.Ê
00008020 0F C4 0F BE 0F B8 0F B2 0F AC 0F A6 0F A0 0F 9A  .Ä.¼. . . . . .š
00008030 0F 94 0F 8E 0F 88 0F 82 0F 7C 0F 76 0F 70 0F 6A  ."Ž. . . . . .|v.p.j
00008040 0F 64 0F 5E 0F 58 0F 52 0F 4C 0F 46 0F 40 0F 3A  .d.^X.R.L.F.@.:
00008050 0F 34 0F 2E 0F 28 0F 22 0F 1C 0F 16 0F 10 0F 0A  .4...(". . . . .
      :
00008FA0 00 00 00 66 82 4C 00 00 00 60 82 39 00 00 00 57  ...f,L...`,9...W
00008FB0 82 24 00 00 00 51 82 11 00 00 00 56 81 7E 00 00  ,$....Q,...V.~..
00008FC0 00 50 81 69 00 00 00 4C 81 55 00 00 00 4A 81 42  .P.i...L.U...J.B
00008FD0 00 00 00 47 81 2D 00 00 00 41 81 1A 00 00 00 39  ...G.-...A.....9
00008FE0 81 06 00 00 00 2C 74 00 00 00 35 62 00 00 00 31  ....,t...5b...1
00008FF0 4D 00 00 00 2E 39 00 00 00 27 26 00 00 00 26 12  M....9...'&...&
  
```



자식 페이지 번호 확인

Data Page Flag 확인

Leaf Page

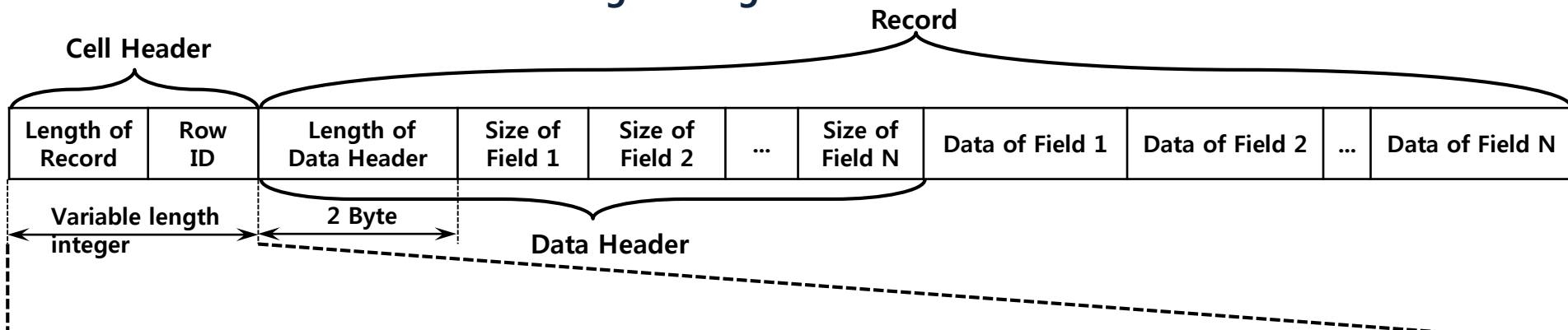
```

00025000 0D 00 00 00 12 00 E8 00 0F 39 0E 5C 0D 69 0C 8A  ....è..9.\.i.S
00025010 0B AA 0B 20 0A 5B 09 75 08 8F 07 C2 06 E1 06 01  .*. .[.u...Â.á..
00025020 05 21 04 40 03 60 02 7F 01 A5 00 E8 00 00 00 00  .!@.`...¥.è....
00025030 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  .....
00025040 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  .....
00025050 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  .....
      :
00025FA0 3A 35 38 0A 2A 31 37 33 37 35 20 0A EC A7 80 EA  :58.*17375 .iSèè
00025FB0 B8 89 20 31 30 2C 30 30 30 EC 9B 90 0A EC 97 B0  ,% 10,000i>..i-è
00025FC0 EB B9 9B EB 82 98 EB 9D BC 20 0A EC 9E 94 EC 95  è² >è,~è.¼ .iž"iè
00025FD0 A1 20 31 2C 36 31 35 2C 32 33 35 EC 9B 90 06 01  ; 1,615,235i>...
00025FE0 42 9D 8F 9C 27 00 84 30 31 39 30 30 30 31 34 33  B..æ'.,019000143
00025FF0 31 31 35 39 39 35 30 30 30 FF 01 42 9D 8F 9C 27  115995000ÿ.B..æè
  
```



Cells – Leaf Cell

- Cell Header and Variable length integer

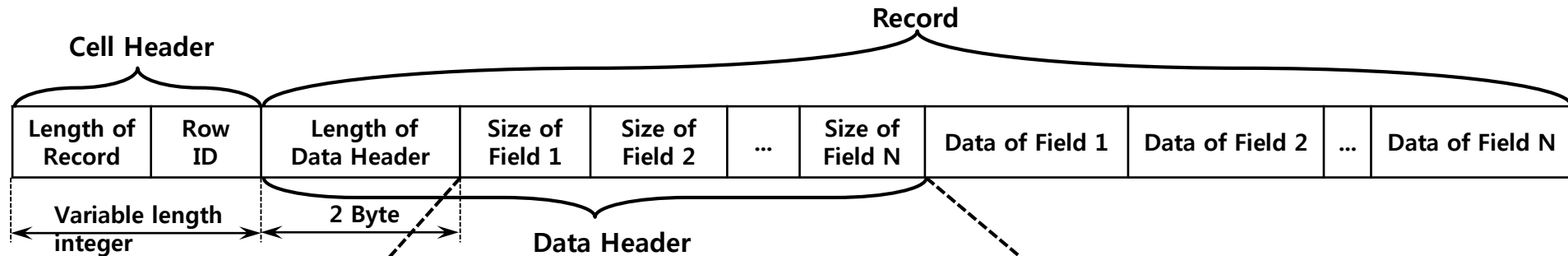


Byte	Value range	Bit pattern
1	7 bit	0XXXXXXXX
2	14 bit	1XXXXXXXX 0XXXXXXXX
3	21 bit	1XXXXXXXX 1XXXXXXXX 0XXXXXXXX
4	28 bit	1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 0XXXXXXXX
5	35 bit	1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 0XXXXXXXX
6	42 bit	1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 0XXXXXXXX
7	49 bit	1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 0XXXXXXXX
8	56 bit	1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 0XXXXXXXX
9	64 bit	1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX 1XXXXXXXX XXXXXXXXXX



Cells – Leaf Cell

- Data Header and transfer table

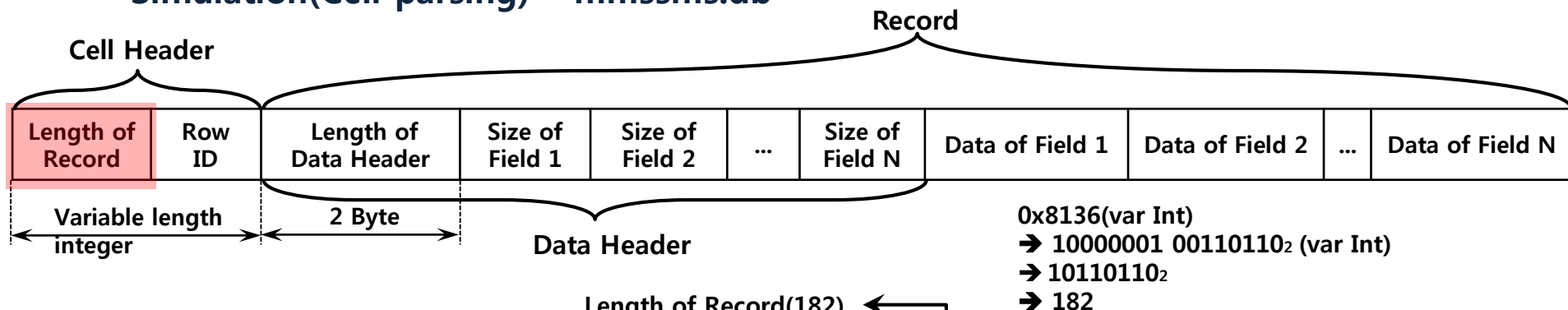


Value	Data Type	Data Size
0	NULL	0
N (N=1-4)	Signed Integer	N
5		6
6	-----	8
7	IEEE float	8
8-11	Reserved	
N>12 (N:even)	BLOB	(N-12)/2
N>13 (N:odd)	TEXT	(N-13)/2



Cells – Leaf Cell

- Simulation(Cell parsing) – mssqlms.db

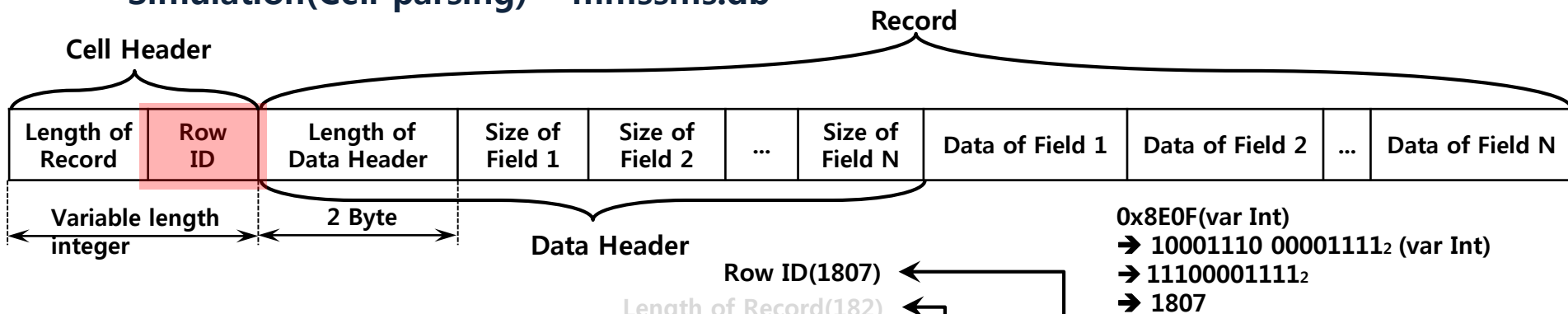


Offset (h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
00155E70	33	33	37	FF	01	46	84	76	FA	05	FF	81	36	8E	0F	40
00155E80	00	02	23	00	05	08	00	08	09	01	01	00	00	81	01	00
00155E90	08	08	08	09	08	00	00	00	00	00	00	00	00	08	00	00
00155EA0	00	00	00	00	00	00	00	05	08	02	23	23	01	00	08	08
00155EB0	01	09	08	08	00	00	00	08	08	08	08	08	05	01	08	01
00155EC0	24	30	31	30	39	32	36	31	32	33	33	37	01	46	84	76
00155ED0	F3	AF	FF	02	EC	9B	94	EA	B0	84	20	EC	95	88	20	ED
00155EE0	85	8C	EC	8A	A4	ED	8A	B8	20	28	74	65	73	74	20	66
00155EF0	6F	72	20	6D	6F	6E	74	68	6C	79	20	6D	61	67	61	7A
00155F00	69	6E	65	20	6F	66	20	61	68	6E	6C	61	62	29	01	46
00155F10	84	76	F3	AF	00	84	30	31	30	39	32	36	31	32	33	33
00155F20	37	30	31	30	39	32	36	31	32	33	33	37	FF	02	01	46



Cells – Leaf Cell

- Simulation(Cell parsing) – mssqlms.db

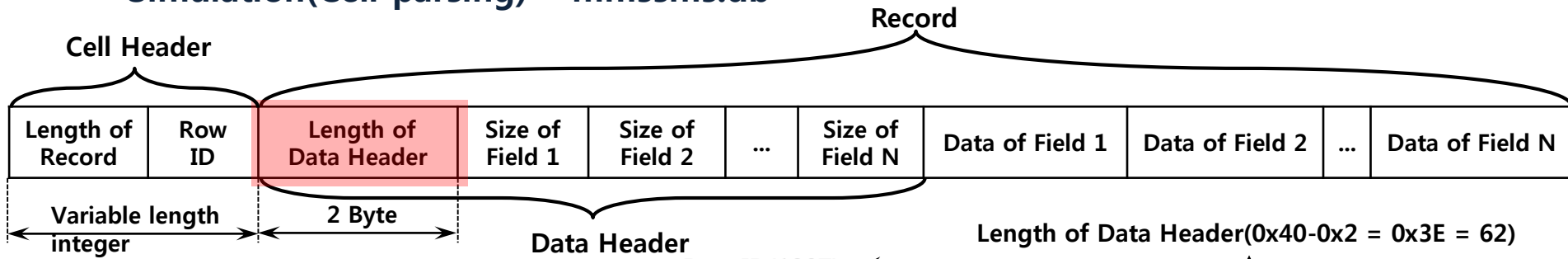


Offset (h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
00155E70	33	33	37	FF	01	46	84	76	FA	05	FF	81	36	8E	0F	40	337ÿ.F„vú.ÿ.6Ž.@
00155E80	00	02	23	00	05	08	00	08	09	01	01	00	00	81	01	00	..#.....
00155E90	08	08	08	09	08	00	00	00	00	00	00	00	00	08	00	00	.....
00155EA0	00	00	00	00	00	00	00	05	08	02	23	23	01	00	08	08##....
00155EB0	01	09	08	08	00	00	00	08	08	08	08	08	05	01	08	01	.....
00155EC0	24	30	31	30	39	32	36	31	32	33	33	37	01	46	84	76	\$01092612337.F„v
00155ED0	F3	AF	FF	02	EC	9B	94	EA	B0	84	20	EC	95	88	20	ED	óÿ.ì>“ê°„ ì•^ ì
00155EE0	85	8C	EC	8A	A4	ED	8A	B8	20	28	74	65	73	74	20	66	..ËiŠ×iŠ, (test f
00155EF0	6F	72	20	6D	6F	6E	74	68	6C	79	20	6D	61	67	61	7A	or monthly magaz
00155F00	69	6E	65	20	6F	66	20	61	68	6E	6C	61	62	29	01	46	ine of ahnlab).F
00155F10	84	76	F3	AF	00	84	30	31	30	39	32	36	31	32	33	33	„vó̄..0109261233
00155F20	37	30	31	30	39	32	36	31	32	33	33	37	FF	02	01	46	701092612337ÿ..F



Cells – Leaf Cell

- Simulation(Cell parsing) – mmsms.db

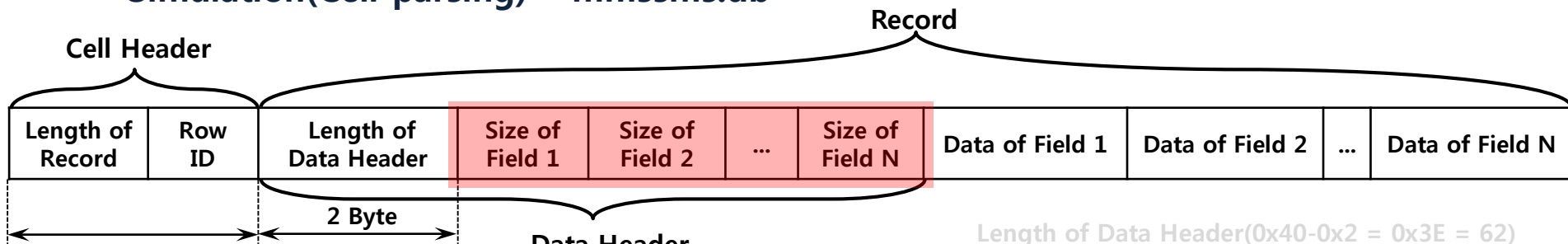


Offset (h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
00155E70	33	33	37	FF	01	46	84	76	FA	05	FF	81	36	8E	0F	40	337ÿ.F,,vú.ÿ.6Ž.@
00155E80	00	02	23	00	05	08	00	08	09	01	01	00	00	81	01	00	..#.....
00155E90	08	08	08	09	08	00	00	00	00	00	00	00	00	08	00	00	.....
00155EA0	00	00	00	00	00	00	00	05	08	02	23	23	01	00	08	08##....
00155EB0	01	09	08	08	00	00	00	08	08	08	08	08	05	01	08	01	.....
00155EC0	24	30	31	30	39	32	36	31	32	33	33	37	01	46	84	76	\$01092612337.F,,v
00155ED0	F3	AF	FF	02	EC	9B	94	EA	B0	84	20	EC	95	88	20	ED	óÿ.ì>”ê°,, ì•^ í
00155EE0	85	8C	EC	8A	A4	ED	8A	B8	20	28	74	65	73	74	20	66	...ÈiŠ×íŠ, (test f
00155EF0	6F	72	20	6D	6F	6E	74	68	6C	79	20	6D	61	67	61	7A	or monthly magaz
00155F00	69	6E	65	20	6F	66	20	61	68	6E	6C	61	62	29	01	46	ine of ahnlab).F
00155F10	84	76	F3	AF	00	84	30	31	30	39	32	36	31	32	33	33	„vó̄...0109261233
00155F20	37	30	31	30	39	32	36	31	32	33	33	37	FF	02	01	46	701092612337ÿ..F



Cells – Leaf Cell

- Simulation(Cell parsing) – mssqlms.db

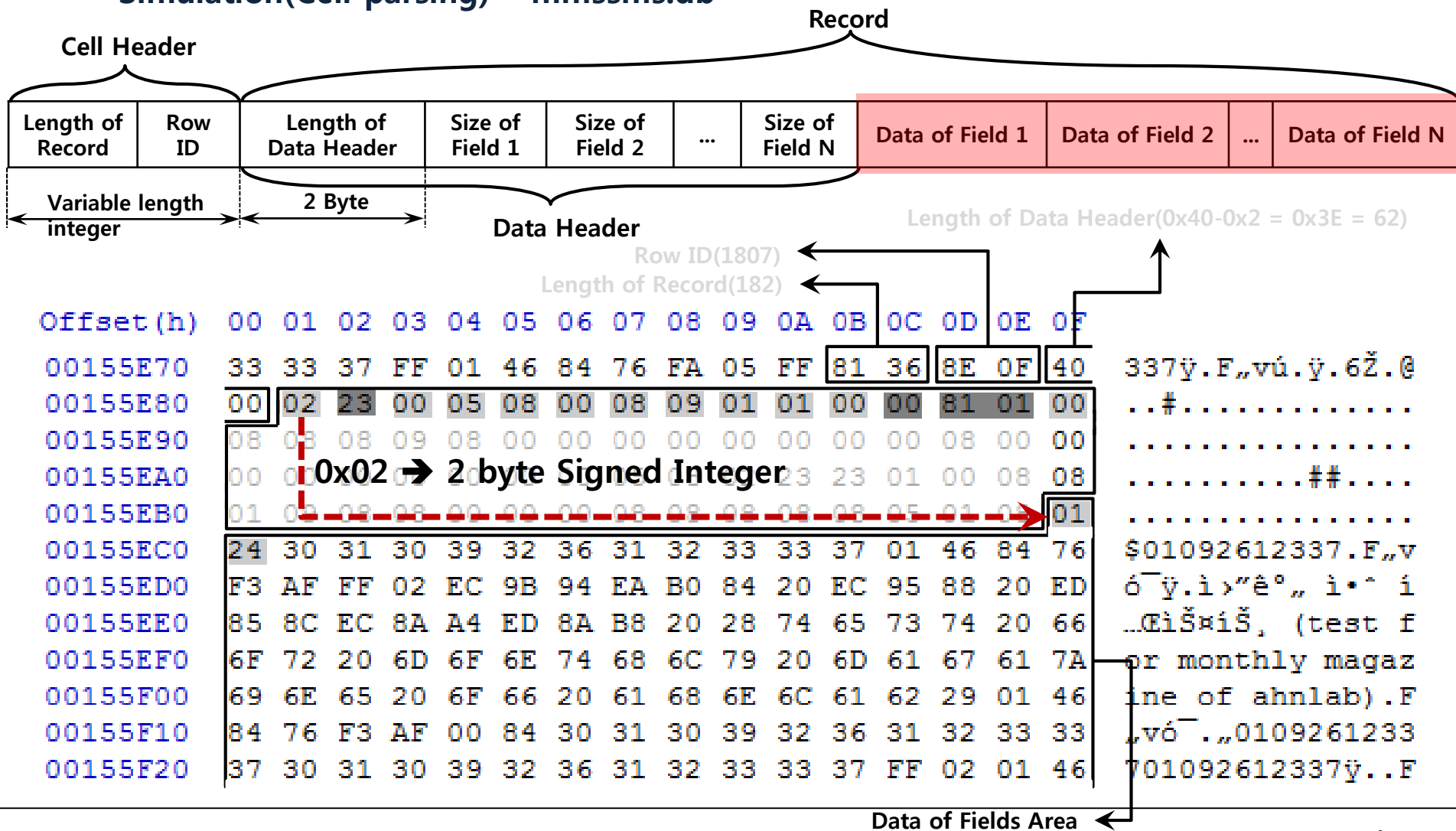


Offset (h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F			
00155E70	33	33	37	FF	01	46	84	76	FA	05	FF	81	36	8E	0F	40	337ÿ.F,,vú.ÿ.6Ž.@		
00155E80	00	02	23	00	05	08	00	08	09	01	01	00	00	81	01	00	..#.....		
00155E90	08	08	08	09	08	00	00	00	00	00	00	00	00	08	00	00	.....	
00155EA0	00	Value		Data Type				Data Size				08##....						
00155EB0	01	09	08	00	08	00	00	00	08	08	08	05	01	08	01	01	.....	
00155EC0	24	30	N(N=1-4)		39	32	36	31	32	33	33	37	01	N	6	84	76	\$01092612337.F,,v	
00155ED0	F3	AF	FF	5	02	EC	9B	94	Signed Integer		54	20	EC	95	6	8	20	ED	óÿ.ì>”ê°,, ì·^ ì
00155EE0	85	8C	EC	6	8A	A4	ED	8A	B8	20	28	74	65	73	8	4	20	66	...ÈiŠ×iŠ, (test f
00155EF0	6F	72	20	7	6D	6F	6E	74	IEEE float		79	20	6D	61	8	57	61	7A	or monthly magaz
00155F00	69	6E	6E	8-11	20	6F	66	20	Reserved		6E	6C	61	62	29	01	46		ine of ahnlab).F
00155F10	84	76	N>12 (N:even)		00	84	30	31	BLOB		39	32	36	30	(N-12)/2		33	33	„vó̄...0109261233
00155F20	37	30	N>13 (N:odd)		39	32	36	31	TEXT		33	33	37	FF	(N-13)/2		01	46	701092612337ÿ..F



Cells – Leaf Cell

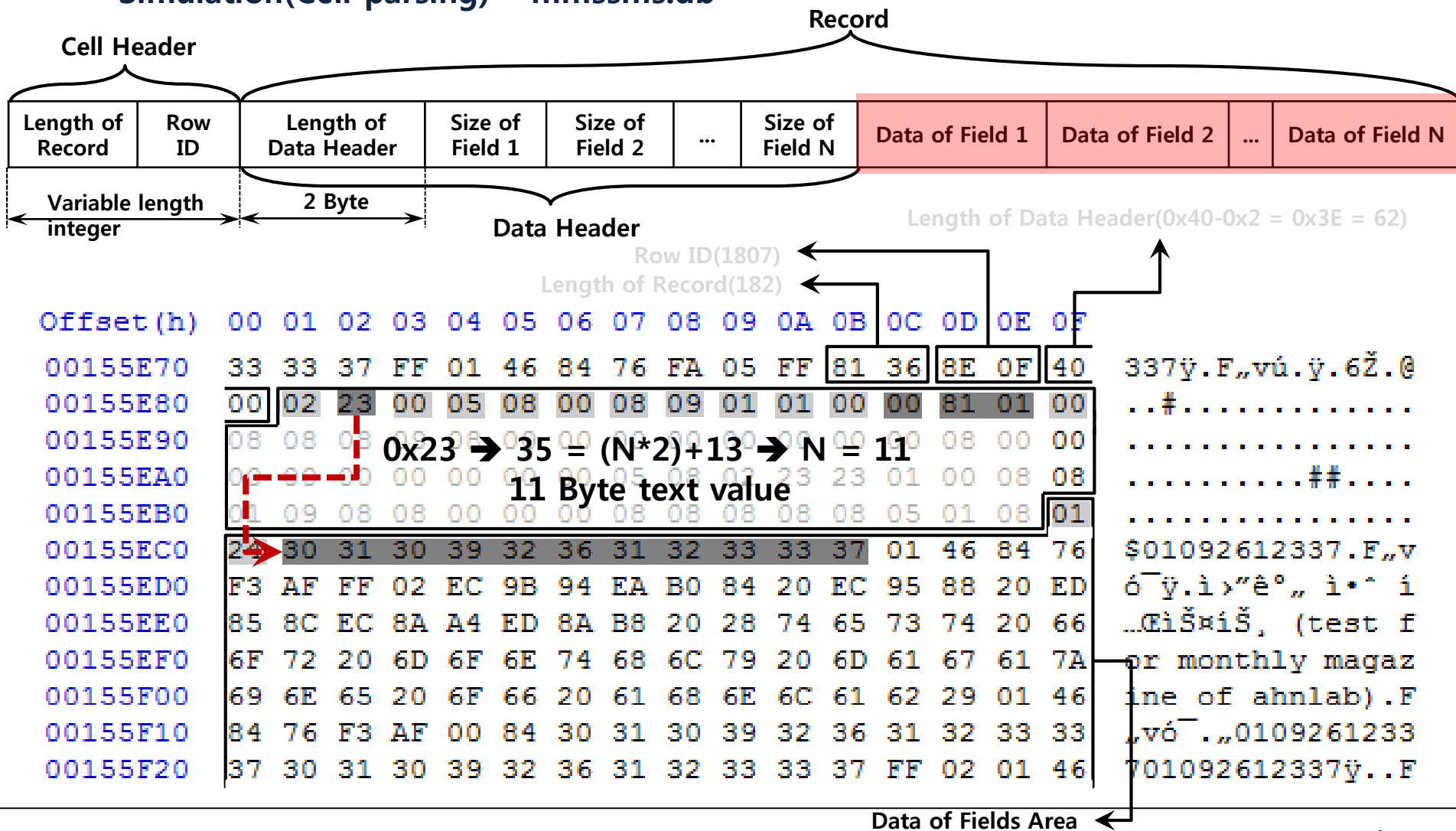
- Simulation(Cell parsing) – mssqlms.db





Cells – Leaf Cell

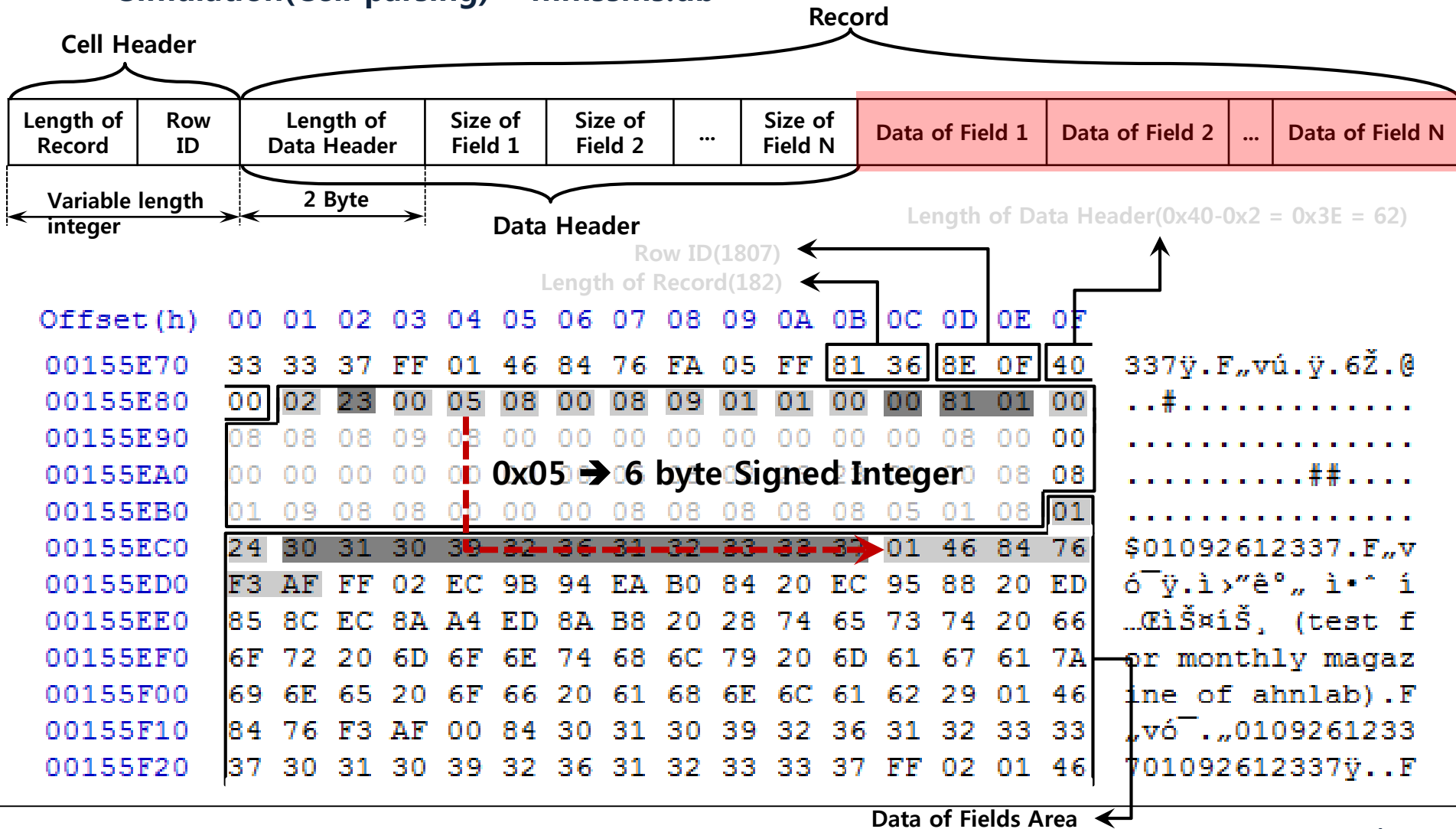
- Simulation(Cell parsing) – mssqlms.db





Cells – Leaf Cell

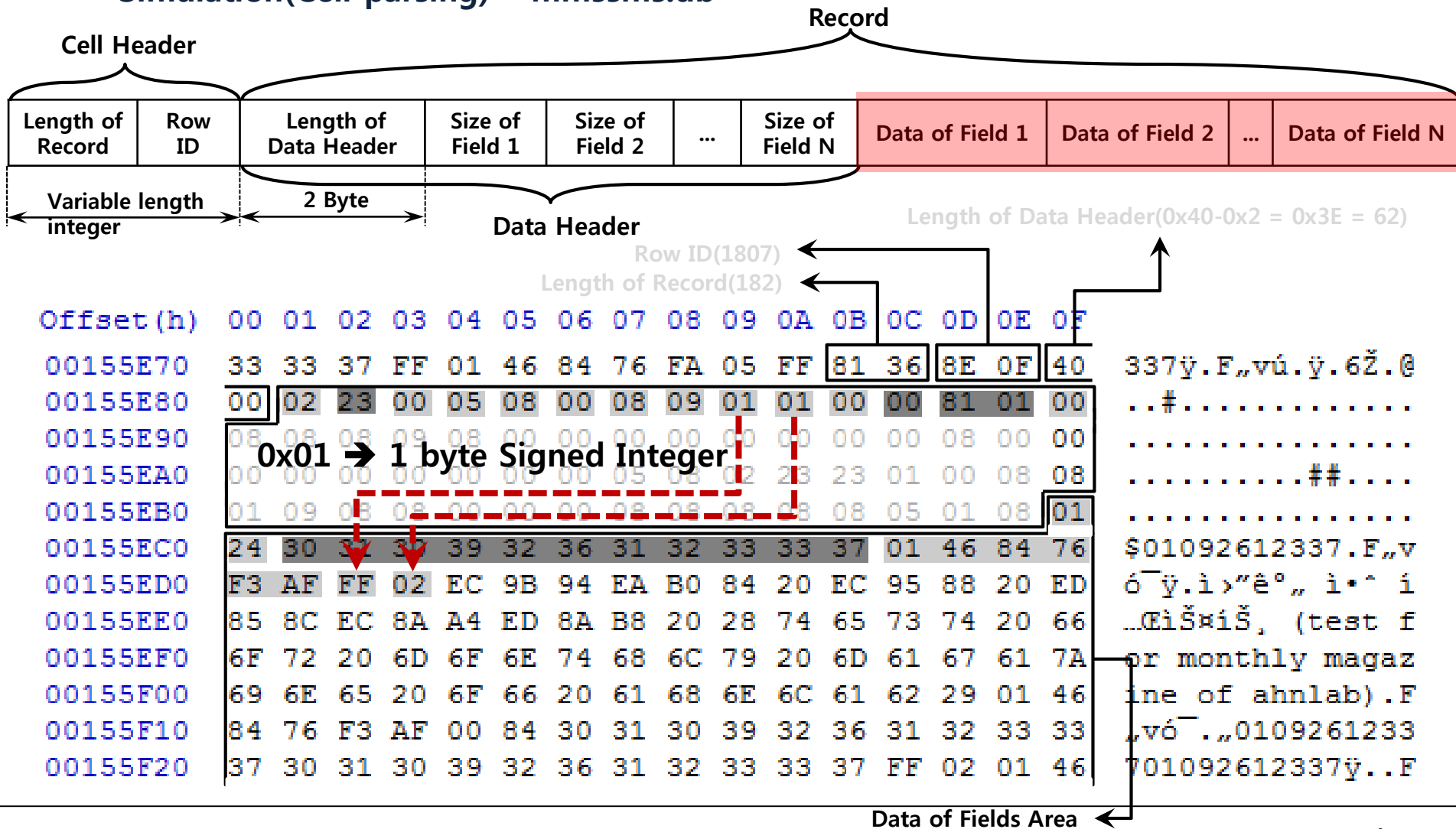
- Simulation(Cell parsing) – mssqlms.db





Cells – Leaf Cell

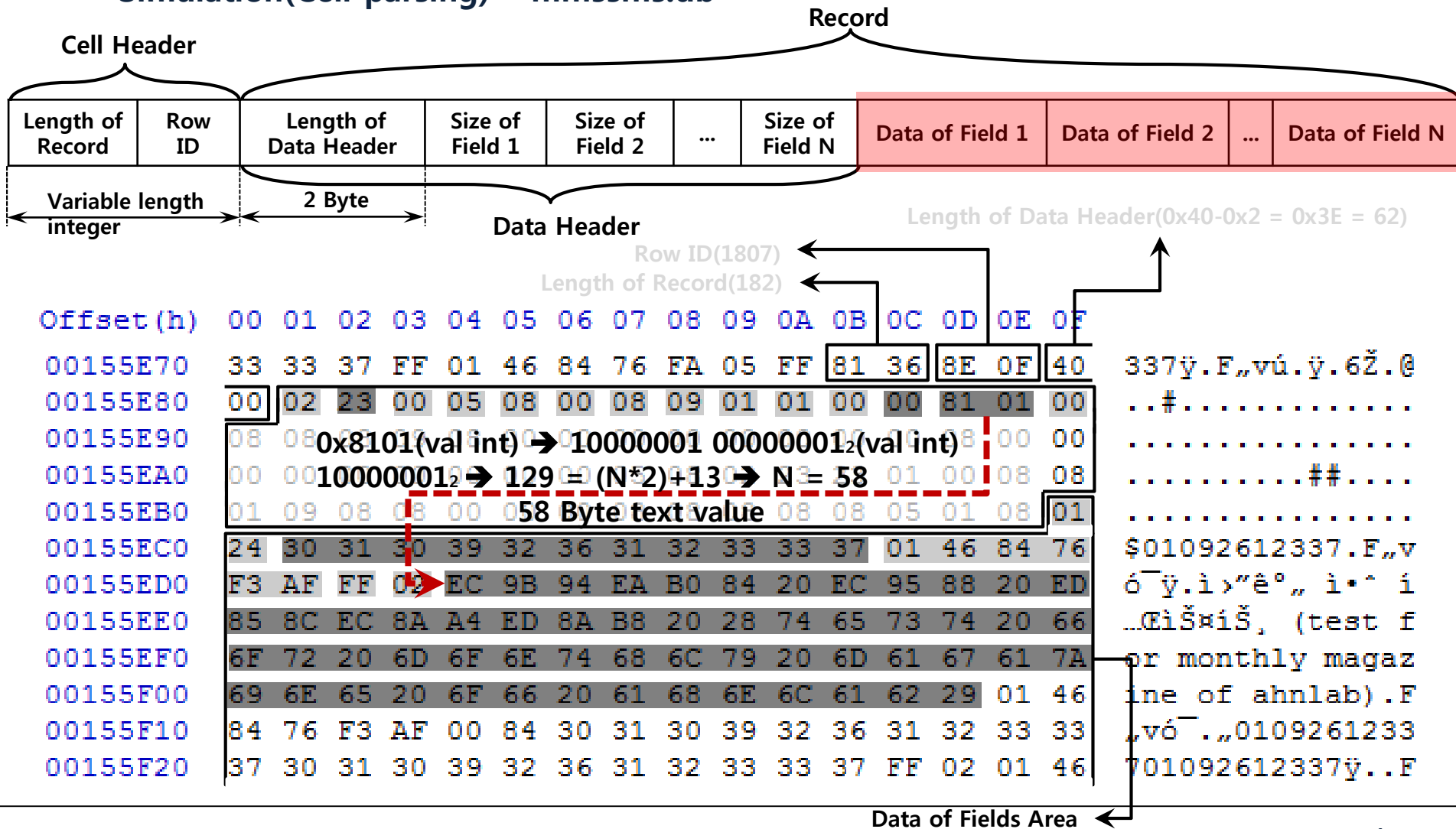
- Simulation(Cell parsing) – mmsms.db





Cells – Leaf Cell

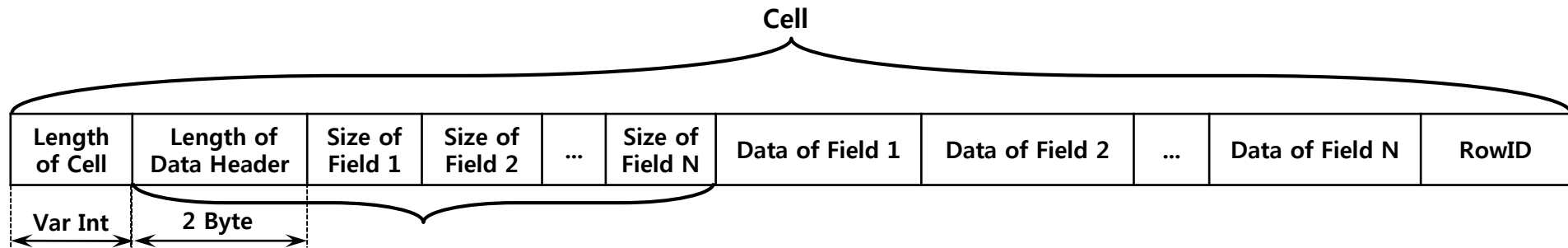
- Simulation(Cell parsing) – mmsms.db





Index B-Tree

- Index 생성시 생성
 - Table B-Tree와 Leaf Cell의 구조를 제외할 경우, 동일
 - Leaf Cell
 - ✓ 셀 최상단의 길이 정보가 자기 자신을 포함
 - ✓ RowID가 최 하단에 위치





Overflow Page

- 연속된 필드의 값을 한 페이지 안에 전부 담을 수 없는 경우 생성되는 페이지
 - 데이터를 계산 시 그 길이에 미처 도달하기 전에 끝나고 마지막 4바이트가 정수형태일 경우
 - 해당 정수가 가리키는 페이지(Overflow Page)에 잔여 값 존재
 - ✓ Overflow Page의 최상위 4바이트는 다음 Overflow Page의 번호(0일 경우 마지막)

```
000003C0 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 1010101010101010
000003D0 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 1010101010101010
000003E0 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 1010101010101010
000003F0 31 30 31 30 31 30 31 30 31 30 31 30 00 00 00 03 101010101010....
```

레코드의 길이에 도달치 못하고 4바이트 정수가 나타난 경우

$$0x200 * (3-1) = 0x400$$

Next overflow page number

해당 정수의 page에 나머지 데이터 존재

```
00000400 00 00 00 00 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 ...1010101010101010
00000410 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000420 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000430 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000440 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000450 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000460 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000470 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
00000480 31 30 31 30 31 30 31 30 31 30 31 30 31 30 31 30 101010101010101010
```



Free Page

- Overflow page와 연결된 필드가 삭제된 경우
 - Overflow page는 free page로 전환
 - 헤더에 Free page 관리를 위한 정보 기록

	0x0	0x1	0x2	0x3	0x4	0x5	0x6	0x7	0x8	0x9	0xA	0xB	0xC	0xD	0xE	0xF
0x00	Header String															
0x10	Page Size								File change counter				DataBase Size			
0x20	Free Page Offset				Free Page Number				The schema cookie				The schema format number			
0x30	Default page cache size				Incremental vacuum settings				text encoding				user version			
0x40	incremental-vacuum mode															
0x50	Reserved for expansion												The version-valid-for number			
0x60	SQLITE_VERSION_NUMBER															



Q & A