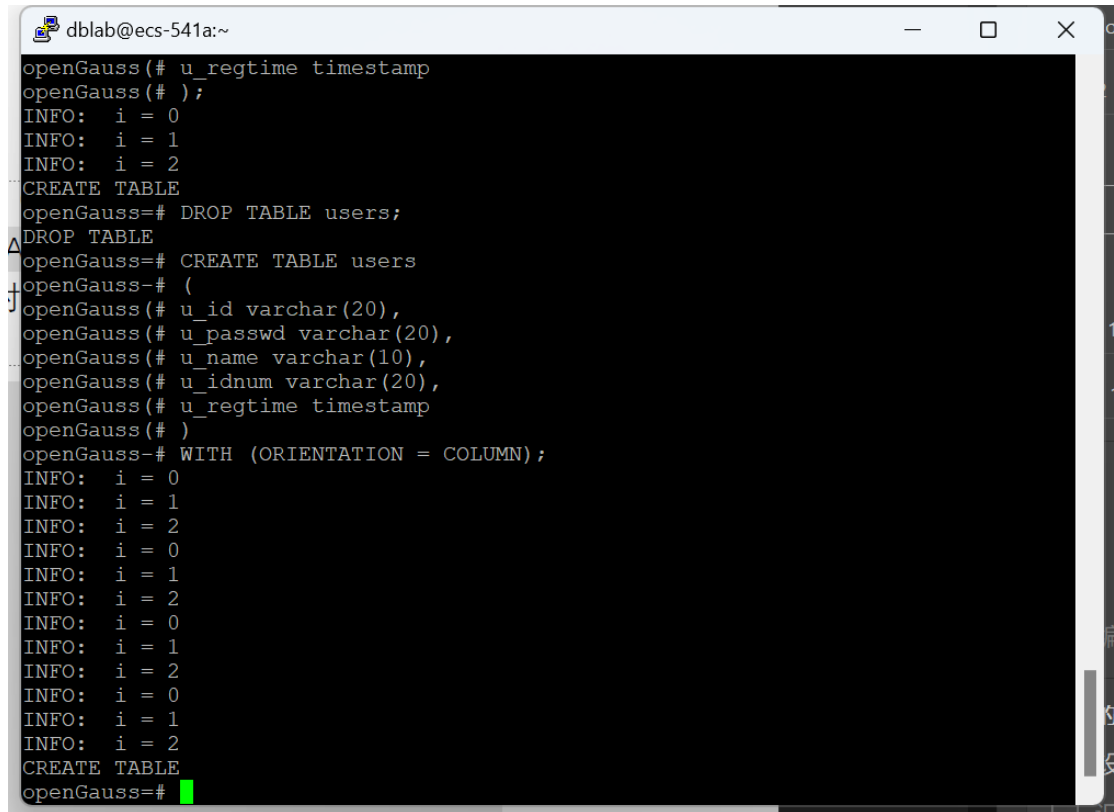


## 第 7 章 表的创建与系统表

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1. 完成实验步骤 7.4.1，创建 user 行存表和列存表。



```
dblab@ecs-541a:~  
openGauss=# u_regtime timestamp  
openGauss=# );  
INFO: i = 0  
INFO: i = 1  
INFO: i = 2  
CREATE TABLE  
openGauss=# DROP TABLE users;  
DROP TABLE  
openGauss=# CREATE TABLE users  
openGauss=# (  
openGauss=# u_id varchar(20),  
openGauss=# u_passwd varchar(20),  
openGauss=# u_name varchar(10),  
openGauss=# u_idnum varchar(20),  
openGauss=# u_regtime timestamp  
openGauss=# )  
openGauss=# WITH (ORIENTATION = COLUMN);  
INFO: i = 0  
INFO: i = 1  
INFO: i = 2  
INFO: i = 0  
INFO: i = 1  
INFO: i = 2  
INFO: i = 0  
INFO: i = 1  
INFO: i = 2  
INFO: i = 0  
INFO: i = 1  
INFO: i = 2  
CREATE TABLE  
openGauss=#
```

2. 完成实验步骤 7.4.2，就其中给出的系统表属性，画出系统表 pg\_class、pg\_attribute、pg\_type 之间的关系的 ER 图。

dblab@ecs-541a:~

oid	relname	reltuples	relkind
1247	pg_type	719	r
30			
24586	pg_delta_24583	0	r
5			
9730	gs_client_global_keys_args	0	r
4			
24592	pg_cudesc_24583_index	0	i
2			
24583	users	0	r
5			
24593	pg_toast_24589	0	t
3			
24595	pg_toast_24589_index	0	i
2			
24589	pg_cudesc_24583	0	r
10			
6124	pg_subscription_oid_index	0	i
1			
6125	pg_subscription_subname_index	0	i
2			
11925	pgxc_prepared_xacts	0	v
1			
11933	pg_shadow	0	v
18			
11929	pg_roles	0	v
27			

--More--

dblab@ecs-541a:~

14930	name	2216
14937	id	20
24583	u_id	1043
24583	u_passwd	1043
24583	u_name	1043
24583	u_idmm	1043
24583	u_regtime	1114
24583	ctid	27
24583	xmin	28
24583	cmin	29
24583	xmax	28
24583	cmx	29
24583	tableoid	26
24583	xc_node_id	23
24586	u_id	1043
24586	u_passwd	1043
24586	u_name	1043
24586	u_idmm	1043
24586	u_regtime	1114
24586	ctid	27
24586	xmin	28
24586	cmin	29
24586	xmax	28
24586	cmx	29
24586	tableoid	26
24586	xc_node_id	23
24589	col_id	23
24589	cu_id	26
24589	min	25
24589	max	25
24589	row_count	23
24589	cu_mode	23
24589	size	20
24589	cu_pointer	23
24589	magic	23
24589	extra	25
24589	ctid	27
24589	xmin	28
24589	cmin	29
24589	xmax	28
24589	cmx	29
24589	tableoid	26
24589	xc_node_id	23
24592	col_id	23
24592	cu_id	26
24592	chunk_id	26
24593	chunk_seq	23
24593	chunk_data	17
24593	ctid	27
24593	xmin	28
24593	cmin	29
24593	xmax	28
24593	cmx	29
24593	tableoid	26
24593	xc_node_id	23
24595	chunk_id	26
24595	chunk_seq	23

(1415 rows)

openGauss=#

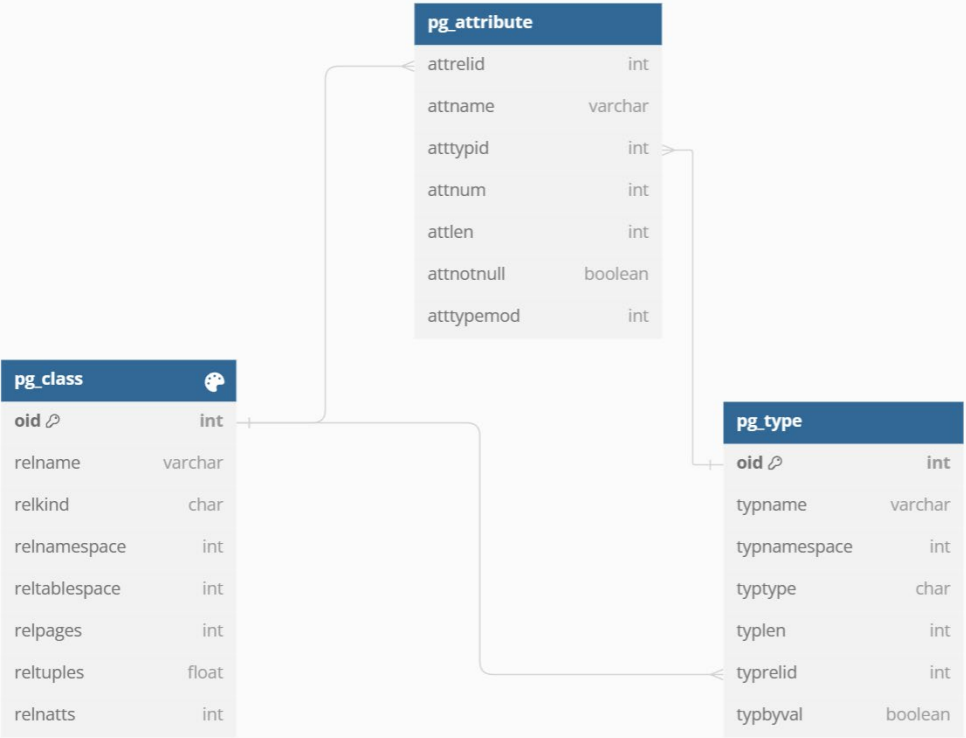
```
dblab@ecs-541a:~  
24593 | chunk_seq | 23  
24593 | chunk_data | 17  
24593 | ctid | 27  
24593 | xmin | 28  
24593 | cmin | 29  
24593 | xmax | 28  
24593 | cmax | 29  
24593 | tableoid | 26  
24593 | xc_node_id | 23  
24595 | chunk_id | 26  
24595 | chunk_seq | 23  
(7485 rows)  
  
openGauss=# SELECT attrelid, attname, atttypid, attnum FROM pg_attribute, pg_class  
attrelid | attname | atttypid | attnum  
-----  
24583 | xc_node_id | 23 | -8  
24583 | tableoid | 26 | -7  
24583 | cmax | 29 | -6  
24583 | xmax | 28 | -5  
24583 | cmin | 29 | -4  
24583 | xmin | 28 | -3  
24583 | ctid | 27 | -1  
24583 | u_id | 1043 | 1  
24583 | u_passwd | 1043 | 2  
24583 | u_name | 1043 | 3  
24583 | u_idnum | 1043 | 4  
24583 | u_regtime | 1114 | 5  
(12 rows)  
  
openGauss=#
```

```
dblab@ecs-541a:~  
openGauss=# SELECT oid, typename, typelen, typtype, typrelid FROM pg_type;  
oid | typename | typelen | typtype | typrelid  
-----  
16 | bool | 1 | b | 0  
17 | bytea | -1 | b | 0  
18 | char | 1 | b | 0  
19 | name | 64 | b | 0  
20 | int8 | 8 | b | 0  
21 | int2 | 2 | b | 0  
5545 | int1 | 1 | b | 0  
22 | int2vector | -1 | b | 0  
23 | int4 | 4 | b | 0  
24 | regproc | 4 | b | 0  
25 | text | -1 | b | 0  
26 | oid | 4 | b | 0  
27 | tid | 6 | b | 0  
28 | xid | 8 | b | 0  
31 | xid32 | 4 | b | 0  
29 | cid | 4 | b | 0  
30 | oidvector | -1 | b | 0  
32 | oidvector_extend | -1 | b | 0  
33 | int2vector_extend | -1 | b | 0  
34 | int16 | 16 | b | 0  
86 | raw | -1 | b | 0  
87 | _raw | -1 | b | 0  
88 | blob | -1 | b | 0  
3201 | _blob | -1 | b | 0  
90 | clob | -1 | b | 0  
3202 | _clob | -1 | b | 0  
71 | pg_type | -1 | c | 1247  
75 | pg_attribute | -1 | c | 1249  
bool | 1 | b | 0
```

```
dblab@ecs-541a:~  
14928 | snapshot | -1 | c | 14927  
14933 | pg_toast_14927 | -1 | c | 14932  
24585 | users | -1 | c | 24583  
24584 | _users | -1 | b | 0  
24588 | pg_delta_24583 | -1 | c | 24586  
24587 | _pg_delta_24583 | -1 | b | 0  
24591 | pg_cudesc_24583 | -1 | c | 24589  
24590 | _pg_cudesc_24583 | -1 | b | 0  
24594 | pg_toast_24589 | -1 | c | 24593  
(726 rows)  
  
openGauss=# SELECT attrelid, attname, atttypid, typname, typelen, typtype, typrelid  
FROM pg_attribute, pg_class, pg_type WHERE pg_attribute.attrelid = pg_class.oid  
AND pg_attribute.atttypid = pg_type.oid AND pg_class.relname='users';  
attrelid | attname | atttypid | typname | typelen | typtype | typrelid  
-----+-----+-----+-----+-----+-----+-----  
24583 | xc_node_id | 23 | int4 | 4 | b | 0  
24583 | tableoid | 26 | oid | 4 | b | 0  
24583 | cmax | 29 | cid | 4 | b | 0  
24583 | xmax | 28 | xid | 8 | b | 0  
24583 | cmin | 29 | cid | 4 | b | 0  
24583 | xmin | 28 | xid | 8 | b | 0  
24583 | ctid | 27 | tid | 6 | b | 0  
24583 | u_id | 1043 | varchar | -1 | b | 0  
24583 | u_passwd | 1043 | varchar | -1 | b | 0  
24583 | u_name | 1043 | varchar | -1 | b | 0  
24583 | u_idnum | 1043 | varchar | -1 | b | 0  
24583 | u_regtime | 1114 | timestamp | 8 | b | 0  
(12 rows)  
  
openGauss=#
```

```
openGauss=# SELECT typname, typelen, typtype, typrelid FROM pg_class, pg_type WHERE  
pg_class.oid = pg_type.typrelid AND pg_class.relname='users';  
typname | typelen | typtype | typrelid  
-----+-----+-----+-----  
users | -1 | c | 24583  
(1 row)
```

```
openGauss=# SELECT oid, reltype FROM pg_class WHERE relname='users';  
oid | reltype  
-----+-----  
24583 | 24585  
(1 row)
```



3. 完成实验步骤 7.4.4，验证添加代码的执行效果，查看输出的表信息和表的属性列信息。

```
(openGauss=# CREATE TABLE users
(
u_id varchar(20),
u_passwd varchar(20),
u_name varchar(10),
u_idnum varchar(20),
u_regtime timestamp
)
);
INFO:
relation's object id : 32772
pg_class->relname : users
pg_attribute->attname :
attr[0].attname : u_id typname : varchar typlen : -1
attr[1].attname : u_passwd typname : varchar typlen : -1
attr[2].attname : u_name typname : varchar typlen : -1
attr[3].attname : u_idnum typname : varchar typlen : -1
attr[4].attname : u_regtime typname : timestamp typlen : 8
CREATE TABLE
+openGauss=#
```

## 第 8 章 表的页面存储结构

1. 完成实验步骤8.4.1节，安装pageinspect插件。

```
dblab@ecs-541a:~/opengauss-compile/openGauss-server-v3.0.0/contrib/pageinspect
rver-v3.0.0/../../binarylibs-v3.0.0/dependency/openeuler_aarch64/libcurl/comm/inclu
de -I/home/dblab/opengauss-compile/openGauss-server-v3.0.0/../../binarylibs-v3.0.0/
component/openeuler_aarch64/dcf/include -I/home/dblab/opengauss-compile/openGaus
s-server-v3.0.0/../../binarylibs-v3.0.0/dependency/openeuler_aarch64/zstd/include
-c -o ginfuncs.o ginfuncs.cpp
g++ -std=c++11 -D GLIBCXX_USE_CXX11_ABI=0 -fsigned-char -DSTREAMPLAN -DPGX -mar
ch=armv8-a+cr -O0 -Wall -Wpointer-arith -Wno-write-strings -fnon-call-exception
s -fno-common -freg-struct-return -pipe -Wendif-labels -Wmissing-format-attribut
e -Wformat-security -fno-strict-aliasing -fwrapv -g -DENABLE_GSTRACE -fno-aggres
sive-loop-optimizations -Wno-attributes -fno-omit-frame-pointer -fno-expensive-o
ptimizations -Wno-unused-but-set-variable -fstack-protector -Wl,-z,relro,-z,now
-Wl,-z,noexecstack -std=c++14 -pthread -D_REENTRANT -D_THREAD_SAFE -D_POSIX_PTH
READ_SEMANTICS -fpic -shared -o pageinspect.so rawpage.o heapfuncs.o btreesfuncs.
o fsmfuncs.o ginfuncs.o -L../../src/common/port -pthread -L/home/dblab/opengauss
-compile/openGauss-server-v3.0.0/../../binarylibs-v3.0.0/dependency/openeuler_aarch
64/zlib1.2.11/comm/lib -I/home/dblab/opengauss-compile/openGauss-server-v3.0.0/.
./binarylibs-v3.0.0/dependency/openeuler_aarch64/zlib1.2.11/comm/include -L/home
/dblab/opengauss-compile/openGauss-server-v3.0.0/../../binarylibs-v3.0.0/dependency
/openeuler_aarch64/zstd/lib -I/home/dblab/opengauss-compile/openGauss-server-v3.
0.0/../../binarylibs-v3.0.0/dependency/openeuler_aarch64/zstd/include -L/home/dblab
/opengauss-compile/openGauss-server-v3.0.0/../../binarylibs-v3.0.0/platform/openeul
er_aarch64/Huawei_Secure_C/comm/lib -L/home/dblab/opengauss-compile/openGauss-se
rver-v3.0.0/../../binarylibs-v3.0.0/dependency/openeuler_aarch64/openssl/comm/lib -
L/home/dblab/opengauss-compile/openGauss-server-v3.0.0/../../binarylibs-v3.0.0/buil
dtools/openeuler_aarch64/libstd/gcc7.3.0/comm/lib -L/home/dblab/opengauss-compile
/openGauss-server-v3.0.0/../../binarylibs-v3.0.0/dependency/openeuler_aarch64/libc
group/comm/lib -L -L/home/dblab/opengauss-compile/openGauss-server-v3.0.0/../../bin
arylibs-v3.0.0/dependency/openeuler_aarch64/unixodbc/lib -L/home/dblab/opengauss
-compile/openGauss-server-v3.0.0/../../binarylibs-v3.0.0/dependency/openeuler_aarch
64/libobs/comm/lib -L/home/dblab/opengauss-compile/openGauss-server-v3.0.0/../../bi
narylibs-v3.0.0/dependency/openeuler_aarch64/kerberos/comm/lib -L../../src/gstra
ce//common -L/home/dblab/opengauss-compile/openGauss-server-v3.0.0/../../binarylibs
-v3.0.0/dependency/openeuler_aarch64/numactl/comm/lib -L/home/dblab/opengauss-co
mpile/openGauss-server-v3.0.0/../../binarylibs-v3.0.0/dependency/openeuler_aarch64/
libcurl/comm/lib -L/home/dblab/opengauss-compile/openGauss-server-v3.0.0/../../bina
rylibs-v3.0.0/dependency/openeuler_aarch64/jemalloc/debug/lib
[dblab@ecs-541a pageinspect]$ make install
/usr/bin/mkdir -p '/home/dblab/opengauss-compile/openGauss-server-v3.0.0/dest/li
b/postgresql'
/usr/bin/mkdir -p '/home/dblab/opengauss-compile/openGauss-server-v3.0.0/dest/sh
are/postgresql/extension'
/usr/bin/mkdir -p '/home/dblab/opengauss-compile/openGauss-server-v3.0.0/dest/sh
are/postgresql/extension'
/bin/sh ../../config/install-sh -c -m 755 pageinspect.so '/home/dblab/opengauss
-compile/openGauss-server-v3.0.0/dest/lib/postgresql/pageinspect.so'
/bin/sh ../../config/install-sh -c -m 644 ./pageinspect.control '/home/dblab/ope
ngauss-compile/openGauss-server-v3.0.0/dest/share/postgresql/extension/'
/bin/sh ../../config/install-sh -c -m 644 ./pageinspect--1.0.sql ./pageinspect--
unpacked--1.0.sql '/home/dblab/opengauss-compile/openGauss-server-v3.0.0/dest
/share/postgresql/extension/'
[dblab@ecs-541a pageinspect]$
```

2. 完成实验步骤8.4.2节，使用gsq|创建表和插入数据。

```
dblab@ecs-541a:~/opengauss-compile/openGauss-server-v3.0.0
railway=# CREATE TABLE orders
railway=# (
railway(# o_id int,
railway(# o_uid varchar(20),
railway(# o_tdate date,
railway(# o_tid varchar(10),
railway(# o_sstation varchar(20),
railway(# o_estation varchar(20),
railway(# o_seattype smallint,
railway(# o_carriage smallint,
railway(# o_seatnum smallint,
railway(# o_seatloc char(1),
railway(# o_price money,
railway(# o_ispaid boolean,
railway(# o_ctime timestamp,
railway(# CONSTRAINT pk_orders PRIMARY KEY (o_id)
railway(# );
NOTICE: CREATE TABLE / PRIMARY KEY will create implicit index "pk_orders" for t
able "orders"
CREATE TABLE
railway=# ALTER TABLE orders ADD CONSTRAINT fk_orders_users FOREIGN KEY (o_uid)
REFERENCES users(u_id); ALTER TABLE orders ADD CONSTRAINT fk_orders_train FOREIGN
N KEY (o_tid) REFERENCES train(t_id); ALTER TABLE orders ADD CONSTRAINT fk_order
s_station_start FOREIGN KEY (o_sstation) REFERENCES station(s_name); ALTER TABLE
orders ADD CONSTRAINT fk_orders_station_end FOREIGN KEY (o_estation) REFERENCES
station(s_name);
ALTER TABLE
ALTER TABLE
ALTER TABLE
ALTER TABLE
railway=# INSERT INTO orders VALUES(1,1,'2022-04-29','G2002','天津','北京南',2,
8,7,'F',54,1,'2022-04-27 16:00:12'); INSERT INTO orders VALUES(2,4,'2022-04-29',
'G321','天津南','福州',1,4,7,'A',742.5,1,'2022-04-27 17:00:12'); INSERT INTO or
ders VALUES(3,3,'2022-04-29','G1709','天津西','重庆西',2,9,3,'D',929,1,'2022-04
-27 18:00:12'); INSERT INTO orders VALUES(4,2,'2022-04-29','G305','天津西','长
沙南',4,11,7,'E',657.5,1,'2022-04-27 19:00:12'); INSERT INTO orders VALUES(5,5,'
2022-04-29','G321','沧州西','合肥南',3,18,7,'E',325.5,0,'2022-04-27 20:00:12');
INSERT INTO orders VALUES(6,7,'2022-04-29','G1709','郑州东','西安北',7,20,2,'F
',206.5,1,'2022-04-27 10:00:12'); INSERT INTO orders VALUES(7,9,'2022-04-29','G3
05','石家庄','武汉',1,8,2,'B',287.5,0,'2022-04-27 09:00:12'); INSERT INTO order
s VALUES(8,8,'2022-04-30','G2608','天津西','北京南',2,8,2,'C',56,1,'2022-04-28
09:00:12');
INSERT 0 1
INSERT 0 1
INSERT 0 1
INSERT 0 1
INSERT 0 1
INSERT 0 1
INSERT 0 1
INSERT 0 1
railway=# CREATE EXTENSION pageinspect;
```

3. 完成实验步骤8.4.3节，根据分析users表页面结构的例子，分析orders表页面结构，画出orders表页面结构图（可使用Visio等画图工具）。

创建一个新的表 orders2，与 orders 表结构完全相同，只是表名不同。

执行一条插入语句，执行下列语句并查看返回结果：

```
railway=# SELECT * FROM page_header(get_raw_page('orders2', 0));
lsn      | tli | flags | lower | upper | special | pagesize | version | prune_xid
```



```

-----+-----+-----+-----+-----+-----+-----+-----+-----+-----
0/244CE98 | 0 | 0 | 44 | 8096 | 8192 | 8192 | 6 | 16056

```

可以看到，lower 列的值恰为 44。页面大小为 8192 字节，upper 列的值为 8096，即刚插入的第 1 条元组占用了 96 字节。

```

      lsn      | tli | flags | lower | upper | special | pagesize | version | prune_xid
-----+-----+-----+-----+-----+-----+-----+-----+-----+-----
-----

```

```

0/2460C30 | 0 | 0 | 48 | 8000 | 8192 | 8192 | 6 | 16065

```

可以看到，lower 列值此时变为了 48，增加了 4，验证了一个元组指针占用 4 字节。upper 列值此时变为了 8000，减少了 96，验证了此表的一个元组数据占 96 字节。

将剩余的 7 条元组插入：

```

      lsn      | tli | flags | lower | upper | special | pagesize | version | prune_xid
-----+-----+-----+-----+-----+-----+-----+-----+-----+-----
-----

```

```

0/2462020 | 0 | 0 | 72 | 7384 | 8192 | 8192 | 6 | 16065

```

此时，共有 8 个元组，8 个元组指针占用 32 字节，因此 lower 列值为 72；

```

railway=# SELECT * FROM heap_page_items(get_raw_page('orders2', 0));
lp | lp_off | lp_flags | lp_len | t_xmin | t_xmax | t_field3 | t_ctid | t_infomask2 | t_infomask | t_hoff | t_bits | t_oid
-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----
1 | 8096 | 1 | 96 | 16071 | 0 | 0 | (0,1) | 13 | 2050 | 24 |  | 
2 | 8000 | 1 | 96 | 16072 | 0 | 0 | (0,2) | 13 | 2050 | 24 |  | 
3 | 7896 | 1 | 104 | 16073 | 0 | 0 | (0,3) | 13 | 2050 | 24 |  | 
4 | 7792 | 1 | 104 | 16074 | 0 | 0 | (0,4) | 13 | 2050 | 24 |  | 
5 | 7688 | 1 | 104 | 16075 | 0 | 0 | (0,5) | 13 | 2050 | 24 |  | 
6 | 7584 | 1 | 104 | 16076 | 0 | 0 | (0,6) | 13 | 2050 | 24 |  | 
7 | 7488 | 1 | 96 | 16077 | 0 | 0 | (0,7) | 13 | 2050 | 24 |  | 
8 | 7384 | 1 | 104 | 16078 | 0 | 0 | (0,8) | 13 | 2050 | 24 |  | 
(8 rows)

```

插入表中的 8 个元组数据所占字节不同，如图所示，因此 upper 列值为  $8192 - 808 = 7384$ 。

原始数据为



TABLE station

Table trainstop

Table trainrun

```

sql>--> CREATE TABLE trainrun2
sql>--> {
sql>--> (tr_date date,
sql>--> tr_tid varchar(10),
sql>--> tr_seat1 smallint,
sql>--> tr_seat2 smallint,
sql>--> CONSTRAINT pk_trainrun2 PRIMARY KEY (tr_date, tr_tid)
sql>--> );
NOTICE: CREATE TABLE / PRIMARY KEY will create implicit index "pk_trainrun2" for table "trainrun2"
ERROR: relation "pk_trainrun2" already exists
sql>--> CREATE TABLE trainrun2
tr_date date,
tr_tid varchar(10),
tr_seat1 smallint,
tr_seat2 smallint,
CONSTRAINT pk_trainrun2 PRIMARY KEY (tr_date, tr_tid)
);
NOTICE: CREATE TABLE / PRIMARY KEY will create implicit index "pk_trainrun2" for table "trainrun2"
sql>--> ALTER TABLE trainrun2 ADD CONSTRAINT fk_trainrun2_train FOREIGN KEY (tr_tid) REFERENCES train(t_id);
CREATE TABLE
sql>-->
sql>--> INSERT INTO trainrun2 VALUES('2022-04-29','G321',1,10); INSERT INTO trainrun2 VALUES('2022-04-29','G2002',0,21); INSERT INTO trainrun2 VALUES('2022-04-29','G1709',1,4); INSERT INTO trainrun2 VALUES('2022-04-29','G6408',11,30);
INSERT 0 1
INSERT 0 1
INSERT 0 1
INSERT 0 1
INSERT 0 1
sql>--> SELECT * FROM heap_header(get_raw_page('trainrun2', 0));
   tm   |  id  |  flag  |  len  |  uptr  |  Special |  pageid  |  version |  pruned_xid
-----+-----+-----+-----+-----+-----+-----+-----+-----
W/284390 | 0 | 0 | 60 | 7952 | 0192 | 0192 | 0 | 16139
(1 row)

sql>--> SELECT * FROM heap_page_items(get_raw_page('trainrun2', 0));
 ip | ip_off | ip_flags | ip_len | t_xmin | t_xmax | t_field1 | t_oid | t_infomask2 | t_infomask | t_hoff | t_bits | t_oid
-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----
1 | 0144 | 1 | 42 | 16142 | 0 | 0 | (0,1) | 4 | 2050 | 24 | 1 |
2 | 0096 | 1 | 42 | 16143 | 0 | 0 | (0,2) | 4 | 2050 | 24 | 1 |
3 | 0040 | 1 | 42 | 16144 | 0 | 0 | (0,3) | 4 | 2050 | 24 | 1 |
4 | 0000 | 1 | 42 | 16145 | 0 | 0 | (0,4) | 4 | 2050 | 24 | 1 |
5 | 7952 | 1 | 42 | 16146 | 0 | 0 | (0,5) | 4 | 2050 | 24 | 1 |
(5 rows)

```