Project 4 Document

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Project Requirement
1. generate undo/redo logs for City and Country Tables.
2. move those logs to another machine that has a copy of the same data and apply the logs and observe that the data has changed

   extra work we are proud of:
      Not only we can recover the update operations on another machine, we can recover insert, even create table operations, this is to say, we can build the relation from scratch as long as we have log, even in that machine, the original data doesn't exists.

Assumption
1. The total size of dataset will not exceed the limit of memory.
2. The transactions were processed correctly and no abruption occurs.

Design
   There are 6 classes in the Logging project, they are.

Log	Log is a list of Log items. The log item structure are: (TransactionID, fields, oldFields, newFields)
	<table><tr><td>TransactionID: Transaction unique ID</td></tr><tr><td>fileds: location where the records need to be changed, structure: row:column1:column2:...</td></tr><tr><td>oldFields: used for undo</td></tr><tr><td>newFields: used for redo</td></tr></table>
Relation	Based on the implementation of project 3. information about: records of the relation, fields name of the relation, and other basic operations defined in project 3: open(),getNext(),close() etc.
Transaction	abstract class, define the transaction structure: including transactionID, transactionType, which will be used in Log. Currently three kind of transactions extend the abstract class: ● InsertTransaction ● UpdateTransaction ● CreateTableTransaction

RecoveryBasedOnLog	Given log and relation, this class parse the log item to transactions and apply the transactions in relation to recover the changes on the backup relation.
Main(Runnable, step1)	Class for create relation and generate log
TestRecovery(Runnable, step2)	class for applying log of transactions and recover things from original machine to target machine

Test Results

1. Generate undo/redo logs for City and Country Tables.

To make the results clear, we select first ten records from City as CityTest and Country as CountryTest tables and generate logs.

step 1: we read table CityTest, CountryTest, and increase the corresponding population column by 2%, simultaneously, we write logs.

The result are like:

```
<terminated> Main (4) [Java Application] /Library/Java/JavaVirtualMachines/jdk1.8.0.jdk/Contents/Home/bin/java (Apr 15, 2015, 11:04:21 AM)
############################ Begin Operations On CityTest ####################
increase population by 2%
Log Log_0998d530-3d96-4e2a-b253-e638bb4639eb is generated
############################ Begin Operations On CountryTest ##################
increase population by 2%
Log Log_0db9836e-2389-48dc-be76-d92cf5504d35 is generated
```

step 2: Open corresponding logs to see if we successfully record our operations.

```
Main.java    Log_0998d530-4e2a-b253-e638bb4639eb.txt
1 Update_b9bfb09d-9273-4eba-bf3b-d43493e45728:CityTest/0/4:1/Kabul/AFG/Kabol/1780000/:1/Kabul/AFG/Kabol/1815600/
2 Update_d4903650-fe35-45ba-870e-1cc3c04e5b70:CityTest/1/4:2/Qandahar/AFG/Qandahar/237500/:2/Qandahar/AFG/Qandahar/242250/
3 Update_8ca1b1d1-6f9b-47d9-8bd7-70a77c9ba1e3:CityTest/2/4:3/Herat/AFG/Herat/186800/:3/Herat/AFG/Herat/190536/
4 Update_2d93e197-f482-46bf-b19c-1a69b0061df6:CityTest/3/4:4/Mazar-e-Sharif/AFG/Balkh/127800/:4/Mazar-e-Sharif/AFG/Balkh/130356/
5 Update_56e0aa60-c56e-43ae-9af4-ef3e33d8e5ec:CityTest/4/4:5/Amsterdam/NLD/Noord-Holland/731200/:5/Amsterdam/NLD/Noord-Holland/745824/
6 Update_1c3db6ca-cb27-4c21-b0f1-12c521bf2ac6:CityTest/5/4:6/Rotterdam/NLD/Zuid-Holland/593321/:6/Rotterdam/NLD/Zuid-Holland/605187/
7 Update_b093d9e9-7187-4b09-9d3d-9c9d46021eb5:CityTest/6/4:7/Haag/NLD/Zuid-Holland/440900/:7/Haag/NLD/Zuid-Holland/449718/
8 Update_58c92a1f-1cbd-4605-9602-998bbcf83dc2:CityTest/7/4:8/Utrecht/NLD/Utrecht/234323/:8/Utrecht/NLD/Utrecht/239009/
9 Update_38d16523-5763-49d8-a3b5-2acb80d21568:CityTest/8/4:9/Eindhoven/NLD/Noord-Brabant/201843/:9/Eindhoven/NLD/Noord-Brabant/205880/
10 Update_e8d3c7cd-89cb-4eba-a339-7111743b7822:CityTest/9/4:10/Tilburg/NLD/Noord-Brabant/193238/:10/Tilburg/NLD/Noord-Brabant/197103/
11
```

```
Main.java    Log_0998d530-3d96-4e2a-b253-e638bb4639eb.txt    Log_0db9836e-2389-48dc-be76-d92cf5504d35.txt
1 Update_d5378fb0-0672-48ed-ae60-d366c9d09072:CountryTest/0/6:ABW/Aruba/North America/Caribbean/193/NULL/103000/78.4/828/793/Aruba/Nonmet
2 Update_fdf6001f-4fee-459d-a721-c7e7d6da1157:CountryTest/1/6:AFG/Afghanistan/Asia/Southern and Central Asia/652090/1919/22720000/45.9/59
3 Update_348aa9e6-b6db-4692-a1b6-4cbbd7e49095:CountryTest/2/6:AGO/Angola/Africa/Central Africa/1246700/1975/12878000/38.3/6648/7984/Angol
4 Update_c69dbcc4-363c-46d4-86b9-ea4d26b08609:CountryTest/3/6:AIA/Anguilla/North America/Caribbean/96/NULL/8000/76.1/63.2/NULL/Anguilla/D
5 Update_f6d7a104-3cad-4bbc-b5ae-3ef5343fe5e6:CountryTest/4/6:ALB/Albania/Europe/Southern Europe/28748/1912/3401200/71.6/3205/2500/Shqipi
6 Update_ef6d8d82-b75e-4307-aa58-159098abadc9:CountryTest/5/6:AND/Andorra/Europe/Southern Europe/468/1278/78000/83.5/1630/NULL/Andorra/Pa
7 Update_e25d4563-ff69-4a4f-8ebb-71bf39dd8f31:CountryTest/6/6:ANT/Netherlands Antilles/North America/Caribbean/800/NULL/217000/74.7/1941/
8 Update_156e42f5-82a5-4d76-a391-be8654d36894:CountryTest/7/6:ARE/United Arab Emirates/Asia/Middle East/83600/1971/2441000/74.1/37966/368
9 Update_cb462d9c-bd7a-4276-a239-d1dc5e6596b9:CountryTest/8/6:ARG/Argentina/South America/South America/2780400/1816/37032000/75.1/340238
10 Update_4559a354-7214-4eaf-a9c3-18f4c67955e9:CountryTest/9/6:ARM/Armenia/Asia/Middle East/29800/1991/3520000/66.4/1813/1627/Hajastan/Rep
```

2 move those logs to another machine that has a copy of the same data and apply the logs and observe that the data has changed

In testRecovery, we have the original relations of CityTest and CountryTest, but the population fields are old values, we need to apply the log and do the update transactions recorded on log. Then the relations will be updated to the version which have the "increase by 2%" feature.

The original data of CityTest:(E column indicates population)

	A	B	C	D	E
1	Kabul	AFG	Kabol	1780000
2	Qandahar	AFG	Qandahar	237500
3	Herat	AFG	Herat	186800
4	Mazar-e-Sha	AFG	Balkh	127800
5	Amsterdam	NLD	Noord-Hollar	731200
6	Rotterdam	NLD	Zuid-Holland	593321
7	Haag	NLD	Zuid-Holland	440900
8	Utrecht	NLD	Utrecht	234323
9	Eindhoven	NLD	Noord-Braba	201843
10	Tilburg	NLD	Noord-Braba	193238

After the recovery step, we can see the population fields are increased by 2%(Last column).

```
<terminated> testRecovery [Java Application] /Library/Java/JavaVirtualMachines/jdk1.8.0.jdk/Contents/Home/bin/java (Apr 15, 2015, 11:17:44 AM)
###################### Begin Recovery Operations by log of CityTest ###############

Relation CityTest is recovered successfully from Log_c9f65d7a-8c73-4b0e-ba13-9b80531f8c1d

The whole table is:

1,Kabul,AFG,Kabol,1815600
2,Qandahar,AFG,Qandahar,242250
3,Herat,AFG,Herat,190536
4,Mazar-e-Sharif,AFG,Balkh,130356
5,Amsterdam,NLD,Noord-Holland,745824
6,Rotterdam,NLD,Zuid-Holland,605187
7,Haag,NLD,Zuid-Holland,449718
8,Utrecht,NLD,Utrecht,239009
9,Eindhoven,NLD,Noord-Brabant,205880
10,Tilburg,NLD,Noord-Brabant,197103
```

Similarly , for CountryTest relation in the recovery machine(G columns indicates the population),

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
ABW	Aruba	North Americ	Caribbean	193	NULL	103000	78.4	828	793	Aruba	Nonmetropo	Beatrix	129	AW
AFG	Afghanistan	Asia	Southern and	652090	1919	22720000	45.9	5976	NULL	AfganistanAf	Islamic Emira	Mohammad	1	AF
AGO	Angola	Africa	Central Africa	1246700	1975	12878000	38.3	6648	7984	Angola	Republic	Jos Eduardo	56	AO
AIA	Anguilla	North Americ	Caribbean	96	NULL	8000	76.1	63.2	NULL	Anguilla	Dependent T	Elisabeth	62	AI
ALB	Albania	Europe	Southern Eur	28748	1912	3401200	71.6	3205	2500	Shqipia	Republic	Rexhep Mejc	34	AL
AND	Andorra	Europe	Southern Eur	468	1278	78000	83.5	1630	NULL	Andorra	Parliamentar	tt	55	AD
ANT	Netherlands	North Americ	Caribbean	800	NULL	217000	74.7	1941	NULL	Nederlandse	Nonmetropo	Beatrix	33	AN
ARE	United Arab	Asia	Middle East	83600	1971	2441000	74.1	37966	36846	A	Emirate Fede	Zayid bin Sul	65	AE
ARG	Argentina	South Americ	South Americ	2780400	1816	37032000	75.1	340238	323310	Argentina	Federal Repu	Fernando	69	AR
ARM	Armenia	Asia	Middle East	29800	1991	3520000	66.4	1813	1627	Hajastan	Republic	Robert	126	AM

After the recovery step, we can see the population fields are increased by 2%(column 7).

```
######################## Begin Recovery Operations by log of CountryTest ###############

Relation CountryTest is recovered successfully from Log_72912ab7-95a4-4310-bbbc-6b6a355d0b85

The whole table is:

ABW,Aruba,North America,Caribbean,193,NULL,105060,78.4,828,793,Aruba,Nonmetropolitan Territory of The Netherlands,Beatrix,129,AW
AFG,Afghanistan,Asia,Southern and Central Asia,652090,1919,23174400,45.9,5976,NULL,AfganistanAfqanestan,Islamic Emirate,Mohammad Oma
AGO,Angola,Africa,Central Africa,1246700,1975,13135560,38.3,6648,7984,Angola,Republic,Jos Eduardo dos Santos,56,AO
AIA,Anguilla,North America,Caribbean,96,NULL,8160,76.1,63.2,NULL,Anguilla,Dependent Territory of the UK,Elisabeth ,62,AI
ALB,Albania,Europe,Southern Europe,28748,1912,3469224,71.6,3205,2500,Shqipia,Republic,Rexhep Mejdani,34,AL
AND,Andorra,Europe,Southern Europe,468,1278,79560,83.5,1630,NULL,Andorra,Parliamentary Coprincipality,tt,55,AD
ANT,Netherlands Antilles,North America,Caribbean,800,NULL,221340,74.7,1941,NULL,Nederlandse Antillen,Nonmetropolitan Territory of Th
ARE,United Arab Emirates,Asia,Middle East,83600,1971,2489820,74.1,37966,36846,A,Emirate Federation,Zayid bin Sulta,65,AE
ARG,Argentina,South America,South America,2780400,1816,37772640,75.1,340238,323310,Argentina,Federal Republic,Fernando,69,AR
ARM,Armenia,Asia,Middle East,29800,1991,3590400,66.4,1813,1627,Hajastan,Republic,Robert,126,AM
```

Extra work:

Not only can we recover the update operations on another machine, we can recover insert, even create table operations, this is to say, we can build the relation from scratch as long as we have log, even in that machine, the original data doesn't exists.

```
<terminated> Main (4) [Java Application] /Library/Java/JavaVirtualMachines/jdk1.8.0.jdk/Contents/Home/bin/java (Apr 15, 2015, 11:54:01 AM)
############################# Extra work #############################
######################## Begin Operations On CityTest ###################
Build Relation from data
increase population by 2%
Log Log_b0562add-cacd-4c72-82e6-8c88d105ead2 is generated
Build Relation from log
Relation CityTest is recovered successfully from Log_f9428c84-b103-4080-bcec-a6dc45d35adb.txt
```

The log generated showed as below:

```
🗋 Main.java    🗋 Recovery of CityTest.txt    🗋 Log_f9428c84-b103-4080-bcec-a6dc4 ⊠    🗋 Log_0998d530-3d96-4e2a-b253-e638b    🗋 Log_0db9836e-2389-48dc-be76-d92cf    🗋 testRecovery.java
 1 Create_11c113c9-4303-42a2-9ffb-4d822b9ec356:CityTest/Code/Name/Country Code/District/Population/::
 2 Insert_71ab9dfc-a907-4bd6-9b8b-5ea160532cc2:::1/Kabul/AFG/Kabol/1815600/
 3 Insert_eff785c5-232e-494f-8cdb-5682d1644a6d:::2/Qandahar/AFG/Qandahar/242250/
 4 Insert_7fc3792a-05bd-4738-a46b-15b201349412:::3/Herat/AFG/Herat/190536/
 5 Insert_80031ee4-2ed9-4f21-8fd5-751aa74521c1:::4/Mazar-e-Sharif/AFG/Balkh/130356/
 6 Insert_382412c7-ffc2-4717-89a2-989de09b2c33:::5/Amsterdam/NLD/Noord-Holland/745824/
 7 Insert_23b7a33f-5651-4fa7-ae73-5bb1712e98ea:::6/Rotterdam/NLD/Zuid-Holland/605187/
 8 Insert_9dbdd56b-8e20-42ed-8021-371bae6915c6:::7/Haag/NLD/Zuid-Holland/449718/
 9 Insert_58c9d989-a9d7-4001-835c-59e37e6ba479:::8/Utrecht/NLD/Utrecht/239009/
10 Insert_2cb9ae1a-6011-45e3-8b14-87eac447c999:::9/Eindhoven/NLD/Noord-Brabant/205880/
11 Insert_46bfd13a-f846-4b29-8df9-6a90e08c4734:::10/Tilburg/NLD/Noord-Brabant/197103/
12 Update_8cf811a0-925a-4f3d-ada1-ff76b6b8314a:CityTest/0/4:1/Kabul/AFG/Kabol/1780000/:1/Kabul/AFG/Kabol/1815600/
13 Update_70a8deb4-424a-472e-bc68-bd81f6ca6d66:CityTest/1/4:2/Qandahar/AFG/Qandahar/237500/:2/Qandahar/AFG/Qandahar/2422!
14 Update_746b6878-ed63-47d2-b063-9a06bfc8ed53:CityTest/2/4:3/Herat/AFG/Herat/186800/:3/Herat/AFG/Herat/190536/
15 Update_8aea9c55-2000-436b-b68f-567c6cf1979a:CityTest/3/4:4/Mazar-e-Sharif/AFG/Balkh/127800/:4/Mazar-e-Sharif/AFG/Balkl
16 Update_df4ef4c5-b357-47c7-a02e-f756f8ae8bba:CityTest/4/4:5/Amsterdam/NLD/Noord-Holland/731200/:5/Amsterdam/NLD/Noord-H
17 Update_cf79dfd6-6e36-4b43-b05b-673e54de42ed:CityTest/5/4:6/Rotterdam/NLD/Zuid-Holland/593321/:6/Rotterdam/NLD/Zuid-Hol
18 Update_5b343057-763b-40d5-abbe-29d1ccbd885d:CityTest/6/4:7/Haag/NLD/Zuid-Holland/440900/:7/Haag/NLD/Zuid-Holland/4497!
19 Update_26bf6c69-9444-4640-8883-e5455c1d47ed:CityTest/7/4:8/Utrecht/NLD/Utrecht/234323/:8/Utrecht/NLD/Utrecht/239009/
20 Update_f66b15c7-9096-4866-9006-547f841bc1e8:CityTest/8/4:9/Eindhoven/NLD/Noord-Brabant/201843/:9/Eindhoven/NLD/Noord-H
21 Update_f6d832fe-8f53-4ad5-9c40-01eb1632cb78:CityTest/9/4:10/Tilburg/NLD/Noord-Brabant/193238/:10/Tilburg/NLD/Noord-Br
```

The Relation recovered showed below(Notice that even no original data, we still get the exactly the same updated relation as we show before, this means once we have the log, we have everything.)

```
1  1,Kabul,AFG,Kabol,1815600
2  2,Qandahar,AFG,Qandahar,242250
3  3,Herat,AFG,Herat,190536
4  4,Mazar-e-Sharif,AFG,Balkh,130356
5  5,Amsterdam,NLD,Noord-Holland,745824
6  6,Rotterdam,NLD,Zuid-Holland,605187
7  7,Haag,NLD,Zuid-Holland,449718
8  8,Utrecht,NLD,Utrecht,239009
9  9,Eindhoven,NLD,Noord-Brabant,205880
10 10,Tilburg,NLD,Noord-Brabant,197103
```