Simulation of Power Grid Network using MySQL with PHP Applications
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CIS 551

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URL to Project:

The project and all applications can be found at:
https://ix.cs.uoregon.edu/~dempseyi/final/applications.html

Project Summary:

My database-based simulation stores information on power grids, as defined by power stations, the grids they feed into, the households and cities they serve, and the companies and employees who maintain them. Each of the preceding has its own entity set and table, and some of the relations will have tables as well. In particular, contracts between cities and power companies are defined as a table, as are customer-grid connections. In addition to the usual identifying information for each kind of entity (name, SSN, address, state, etc.), power stations have information on the total amount of power generated per year, and the relationship between grids and consumers contain information on the annual energy consumption and the cost per kilowatt-hour.

As projected now, the tables will be the following:
- companies(comp_id,name, HQ location, # employees, yearly revenue)
- employees(eSSN, ename,companyid,position, address,city, salary)
- cities (name, state, population)
- households(SSN,name,address,city)
- grids(grid_no,area, # users) (Note: this is a weak entity set dependent on the power stations that feed into it)
- power stations (id_no , name,state, yearly MW-hr production,company_id, energy source)
- grid-consumer connections(annual energy use, cost/kW-hr)
- city-power company contract(duration, yearly cost)

Applications consist of standard queries that pull information regarding the grid. These include finding the average cost of electricity (in dollars/kW-hr) for a given state, finding the average salary by position, finding the employees for a given company, locating the contracts entered into by a given city, and finding the power stations operating off of a given fuel source and the grids they feed into.

Logical Design:

The ER Diagram for the project is included in the hardcopy version of the report after this page.

Physical Design + Contents of Tables:

As noted, we have one table for each of the entity sets listed in the Project Summary. All of the attributes mentioned there are included as well, with several additions in order to express the relations between entities. Below is the MySQL code used to create the database, but we will briefly recap each table and its attributes. Companies: Attributes are the company id (the key), the company name, the city in which the company is headquartered, the number of employees in the company, and the company's yearly revenue (in dollars).

Employees: Attributes are the employee's social security number (the key), the employee's name, the id of the company the employee works for, the employee's address and city, and the employee's position and salary.

Cities: Attributes are the city's name, the city's state (both of these compose the key), and the city's population.

Households: Attributes are the homeowner's social security number, the homeowner's name, and the address and city of the household.

Grids: Attributes are the grid number (the part of the key contained in this entity set), the area the grid services, and the number of households served by the grid.

Power Stations: Attributes are the power station id number (the key), the name and state of the station, the yearly energy production (in MW-hr), the id of the company that owns the plant, and the energy source used.

Grid-Consumer Connections: Attributes are the annual energy use (in kW-hr), the cost per kW-hr in dollars, the SSN of the household's homeowner, and the grid number of the grid.

City-Power Company Contracts: Attributes are the duration of the contract, the yearly cost of the contract, and the city and power company involved.

```
-- MySQL Administrator dump 1.4
--
-- -------------------------------------------------------
-- Server version       5.0.24a-log


/*!40101 SET @OLD_CHARACTER_SET_CLIENT=@@CHARACTER_SET_CLIENT */;
/*!40101 SET @OLD_CHARACTER_SET_RESULTS=@@CHARACTER_SET_RESULTS */;
/*!40101 SET @OLD_COLLATION_CONNECTION=@@COLLATION_CONNECTION */;
/*!40101 SET NAMES utf8 */;

/*!40014 SET @OLD_UNIQUE_CHECKS=@@UNIQUE_CHECKS, UNIQUE_CHECKS=0 */;
```

```sql
/*!40014 SET @OLD_FOREIGN_KEY_CHECKS=@@FOREIGN_KEY_CHECKS,
FOREIGN_KEY_CHECKS=0 */;
/*!40101 SET @OLD_SQL_MODE=@@SQL_MODE,
SQL_MODE='NO_AUTO_VALUE_ON_ZERO' */;


--
-- Create schema grid
--

CREATE DATABASE IF NOT EXISTS grid;
USE grid;

DROP TABLE IF EXISTS `grid`.`companies`;
CREATE TABLE  `grid`.`companies` (
  `comp_id` tinyint(4) unsigned NOT NULL auto_increment,
  `comp_name` varchar(255) NOT NULL,
  `HQ_loc` varchar(255) NOT NULL,
  `num_employees` int(20) unsigned NOT NULL,
  `yearly revenue` mediumint(20) unsigned NOT NULL,
  PRIMARY KEY  (`comp_id`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

/*!40000 ALTER TABLE `companies` DISABLE KEYS */;
LOCK TABLES `companies` WRITE;
INSERT INTO `grid`.`companies` VALUES  (101,'Pacific
Power','Portland',6000,5700000),
 (102,'Southwest Electric','Phoenix',10000,10000000),(103,'PNW Natural
Gas','Seattle',15000,15000000),(104,'Mojave Solar','',5000,2000000),(105,'New
England Oil and Gas','Boston',8000,12000000),(106,'Northeast Power
Utility','Burlington',9000,14000000);
UNLOCK TABLES;
/*!40000 ALTER TABLE `companies` ENABLE KEYS */;

DROP TABLE IF EXISTS `grid`.`employees`;
CREATE TABLE  `grid`.`employees` (
  `essn` int(20) unsigned NOT NULL,
  `ename` varchar(255) NOT NULL,
  `companyid` tinyint(4) unsigned NOT NULL,
  `position` varchar(255) NOT NULL,
  `address` varchar(255) NOT NULL,
  `city` varchar(255) NOT NULL,
  `salary` mediumint(20) unsigned NOT NULL,
  PRIMARY KEY  (`essn`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

```sql
/*!40000 ALTER TABLE `employees` DISABLE KEYS */;
LOCK TABLES `employees` WRITE;
INSERT INTO `grid`.`employees` VALUES  (541890067,'Roger Miller',101,'Safety
Inspector','678 Lupine Dr. Apt. 10','Beaverton',70000),(890768894,'Dennis
Sellers',102,'Process Engineer','102 Sunshine
Blvd.','Tucson',110000),(541200067,'Jackie Collins',101,'Process Engineer','189
Sunset Highway','Beaverton',120000),(891208894,'Suzanne Harper',102,'Safety
Inspector','25 Blackrock Dr. Apt. 2','Phoenix',65000),(542550067,'Ahmed
Wilson',101,'Systems Analyst','95 Stark St.','Portland',115000),(890554895,'Fred
Thomas',102,'Systems Analyst','700 Sandstone
Court','Phoenix',110000),(891238894,'Jacob Wills',103,'Safety Inspector','78 Rain
St.','Seattle',80000),(544320067,'Emily Craig',103,'Systems Analyst','103 Tacoma
Rd.','Seattle',125000),(890554894,'Curtis Briggs',103,'Process Engineer','1123
Emerald Ln. Apt. 6','Seattle',100000),(321238894,'Willis Palmer',104,'Safety
Inspector','82 Sunny Day Circle','Albuquerque',60000),(124320067,'Catherine
Haynes',104,'Systems Analyst','120 Carlyle
St.','Albuquerque',95000),(854354894,'Buddy Doyle',104,'Process Engineer','290
Mojave Rd. Apt. 8','Albuquerque',105000),(321238135,'Sally
Hemsworth',105,'Safety Inspector','24 Cambridge
Dr.','Boston',72000),(124320543,'Jeff Brody',105,'Systems Analyst','212 Lexington
St.','Hartford',130000),(854354567,'Lyle Preston',105,'Process Engineer','890
Cambridge Way','Boston',115000),(124343243,'Priscilla Dempsey',106,'Systems
Analyst','300 Maple St.','Burlington',140000),(854355647,'Gabriel
Gabsworth',106,'Process Engineer','96 Connecticut
Dr.','Hartford',120000),(324538135,'Pamela Nicks',106,'Safety Inspector','87 Cedar
Rd.','Burlington',80000);
UNLOCK TABLES;
/*!40000 ALTER TABLE `employees` ENABLE KEYS */;

DROP TABLE IF EXISTS `grid`.`cities`;
CREATE TABLE  `grid`.`cities` (
 `name` varchar(255)NOT NULL,
 `state` char(3) NOT NULL,
 `population` mediumint(20) unsigned NOT NULL,
  PRIMARY KEY  (`name`,`state`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

/*!40000 ALTER TABLE `cities` DISABLE KEYS */;
LOCK TABLES `cities` WRITE;
INSERT INTO `grid`.`cities` VALUES
('Portland','OR',600000),('Beaverton','OR',90000),('Seattle','WA',650000),('Tucson','
AR',530000),('Phoenix','AZ',1450000),('Albuquerque','NM',556000),('Boston','MA',6
20000),('Hartford','CT',125000),('Manchester','NH',110000),('Burlington','VT',4200
0);
UNLOCK TABLES;
/*!40000 ALTER TABLE `cities` ENABLE KEYS */;
```

```sql
DROP TABLE IF EXISTS `grid`.`households`;
CREATE TABLE  `grid`.`households` (
  `homeowner_ssn` int(20) unsigned NOT NULL,
  `homeowner_name` varchar(255) NOT NULL,
  `address` varchar(255) NOT NULL,
  `city` varchar(255) NOT NULL,
  PRIMARY KEY  (`homeowner_ssn`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

/*!40000 ALTER TABLE `households` DISABLE KEYS */;
LOCK TABLES `households` WRITE;
INSERT INTO `grid`.`households` VALUES  (504981134,'Ann Seidel','57 Stark
St.','Portland'),(789549800,'Mack Rice','102 Lakeshore
Lp.','Beaverton'),(556774352,'Emily White','987 Mesa Way Apt.
2','Tucson'),(908774567,'Jack Sussman','786 Sandstone
Ln.','Phoenix'),(762458876,'Richard Turnquist','556 Washington
St.','Seattle'),(845009987,'Jennifer Orin','56 Scott Dr.','Portland'),(876564412,'Mary
Oliver','624 Sandstone Court','Phoenix'),(768901234,'Scott Barrett','5609 Ranch
Rd.','Tucson'),(873464412,'Jane Goodwin','765 Sunset
Highway','Beaverton'),(768920234,'Scott Barrett','920 Overcast
Ave.','Seattle'),(873464403,'Brody Rast','290 Mojave Rd. Apt.
4','Albuquerque'),(468920234,'Jenny Lasz','345 Carlyle
St.','Albuquerque'),(873394403,'Betty Gable','67 Cambridge
St.','Boston'),(488912234,'Geoff Oren','92 Harvard
Ave.','Boston'),(874594403,'Larry Salters','360 Maple
St.','Burlington'),(488912235,'Mary Olpen','200 Cedar
Rd.','Burlington'),(874594414,'Scott Murphy','876 Wind Rock Ln. Apt.
43','Manchester'),(488912246,'Jen Peri','321 Seaside
Ave.','Manchester'),(874594425,'Lex Alder','78 Cherry Orchard
Circle','Hartford'),(488912257,'Greta Darmer','900 Heart Ln.','Hartford');
UNLOCK TABLES;
/*!40000 ALTER TABLE `households` ENABLE KEYS */;

DROP TABLE IF EXISTS `grid`.`power_stations`;
CREATE TABLE  `grid`.`power_stations` (
  `id_no` tinyint(4) unsigned NOT NULL auto_increment,
  `name` varchar(255) NOT NULL,
  `state` char(3) NOT NULL,
  `fuel_type` varchar(255) NOT NULL,
  `company_id` tinyint(4) unsigned NOT NULL,
  `MWe_capacity` int(20) unsigned NOT NULL,
  PRIMARY KEY  (`id_no`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

LOCK TABLES `power_stations` WRITE;
```

```sql
INSERT INTO `grid`.`power_stations` VALUES  (1,'Cholla Power
Plant','AZ','coal',102,414),(2,'Bonneville Dam','OR','hydro',101,1189),(3,'Yuca Power
Plant','AZ','gas',102,264),(4,'Biglow Canyon Wind
Farm','OR','wind',101,450),(5,'Chehalis Generation
Facility','WA','gas',103,520),(6,'Satsop Combustion
Turbine','WA','gas',103,650),(7,'Cimarron Solar
Facility','NM','solar',104,37),(8,'Mystic Generating
Station','MA','gas',105,2000),(9,'Fore River Generating
Stations','MA','gas',105,730),(10,'Comerford
Hydroelectric','NH','hydro',106,140),(11,'Sheffield Wind Farm','CT','wind',106,40);
UNLOCK TABLES;
/*!40000 ALTER TABLE `power_stations` ENABLE KEYS */;

DROP TABLE IF EXISTS `grid`.`grid_household_connections`;
CREATE TABLE  `grid`.`grid_household_connections` (
  `home_ssn`int(20) unsigned NOT NULL,
  `grid_id` tinyint(4) unsigned NOT NULL,
  `annual_kWhr_use` int(20) unsigned NOT NULL,
  `cost_per_kWhr` float(5,5) unsigned NOT NULL,
   PRIMARY KEY  (`home_ssn`,grid_id)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

LOCK TABLES `grid_household_connections` WRITE;
INSERT INTO `grid`.`grid_household_connections` VALUES
(504981134,2,10932,.12),(789549800,2,12000,.15),(556774352,1,17000,.10),(908
774567,1,14000,.11),(762458876,2,9000,.18),(845009987,2,8500,.17),(876564412
,1,10500,.09),(768901234,1,11000,.10),(873464412,2,8765,.16),(768920234,2,120
64,.18),(873464403,1,11005,.13),(468920234,1,10076,.16),(873394403,3,10076,.1
4),(488912234,3,12006,.10),(874594403,3,6509,.18),(488912235,3,14000,.09),(87
4594414,3,10075,.13),(488912246,3,9687,.08),(874594425,3,12000,.11),(4889122
57,3,9870,.12);
UNLOCK TABLES;
/*!40000 ALTER TABLE `grid_household_connections` ENABLE KEYS */;

DROP TABLE IF EXISTS `grid`.`city_power_co_contracts`;
CREATE TABLE  `grid`.`city_power_co_contracts` (
  `city` varchar(255) NOT NULL,
  `companyid` tinyint(4) unsigned NOT NULL,
  `years_duration` tinyint(4) unsigned NOT NULL,
  `yearly_cost` int(20) unsigned NOT NULL,
   PRIMARY KEY  (`city`,`companyid`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

LOCK TABLES `city_power_co_contracts` WRITE;
INSERT INTO `grid`.`city_power_co_contracts` VALUES
('Tucson',102,5,2500000),('Phoenix',102,3,1500000),('Albuquerque',104,1,700000)
```

,('Portland',101,10,5000000),('Beaverton',101,15,3500000),('Seattle',103,7,300000
0),('Boston',105,15,4500000),('Burlington',106,10,2000000),('Hartford',105,4,3000
000),('Manchester',106,5,2500000);
UNLOCK TABLES;
/*!40000 ALTER TABLE `city_power_co_contracts` ENABLE KEYS */;

DROP TABLE IF EXISTS `grid`.`grids`;
CREATE TABLE `grid`.`grids` (
 `grid_num` tinyint(4) unsigned NOT NULL auto_increment,
 `area` varchar(255) NOT NULL,
 `num_users` int(20) unsigned NOT NULL,
 `power_id_no` tinyint(4) unsigned NOT NULL,
 KEY (`grid_num`),
 KEY `FK_grid_1` (`power_id_no`),
 CONSTRAINT `FK_grid_1` FOREIGN KEY (`power_id_no`) REFERENCES
`power_stations` (`id_no`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

LOCK TABLES `grids` WRITE;
INSERT INTO `grid`.`grids` VALUES (1,'Southwest',300000,1),(2,'Pacific
Northwest',500000,2),(1,'Southwest',150000,3),(2,'Pacific
Northwest',300000,4),(2,'Pacific Northwest',375000,5),(2,'Pacific
Northwest',450000,6),(1,'Southwest',12000,7),(3,'Northeast',650000,8),(3,'Northea
st',400000,9),(3,'Northeast',55000,10),(3,'Northeast',11000,11);
UNLOCK TABLES;
/*!40000 ALTER TABLE `grids` ENABLE KEYS */;

/*!40101 SET SQL_MODE=@OLD_SQL_MODE */;
/*!40014 SET FOREIGN_KEY_CHECKS=@OLD_FOREIGN_KEY_CHECKS */;
/*!40014 SET UNIQUE_CHECKS=@OLD_UNIQUE_CHECKS */;
/*!40101 SET CHARACTER_SET_CLIENT=@OLD_CHARACTER_SET_CLIENT */;
/*!40101 SET CHARACTER_SET_RESULTS=@OLD_CHARACTER_SET_RESULTS */;
/*!40101 SET COLLATION_CONNECTION=@OLD_COLLATION_CONNECTION */;
/*!40101 SET CHARACTER_SET_CLIENT=@OLD_CHARACTER_SET_CLIENT */;

List of Applications:

The available applications are as follows:

findAvgCost: This takes a pair of state initials as input and returns the average cost
per kW-hr for that state. The tables affected in the underlying query are
households, cities, and grid_household connections.

avgSalary: This takes no input, but returns the average salary for each position
across all companies. The only table used by the underlying query is employees.

findEmployees: This takes the name of a company as input and returns the list of employees for that company. The tables affected in the underlying query are companies and employees.

findContracts: This takes the name of a city and returns the following for any contract that the city has entered into: the city itself, the duration of the contract, the yearly cost of the contract, the company involved, and the company's HQ location. The tables affected in the underlying query are companies and city_power_co_contracts.

findPowerStations: This takes the name of a fuel source and returns the names of all power stations that use that fuel, as well as the grid they feed into and the company that operates them. The tables affected in the underlying query are power_stations, companies and grids.

Implementation Code:

The PHP code for the applications is linked to off of the URL for the overall project.

User's Guide:

Once one has navigated to the URL for the project, using each of the applications should be fairly straightforward. For applications requiring input, simply enter the desired information (e.g., the name of a city) into the text box provided and click 'Submit.' The prompt on the webpage includes information on which input is valid and which will produce a non-empty result for each application. For the application 'avgSalary,' which requires no input from the user, simply click 'Submit.'

Conclusion:

My project has developed a simulation of a power grid linking companies, generating stations, and consumers, with a focus on geographic divisions and areas. Within these categories, it relates data pertaining to energy usage and employee statistics, as well as utility contracts and company revenues. While the data contained is not necessarily 100% realistic, it could be easily adapted to accurately reflect things such as average cost of electricity across regions, average energy use, and grading of professions by salaries.

Given additional time on this project, I would have liked to devote more work to issues of normalization and reduction of redundancy. In particular, I feel that the tables grids and power stations and the relation between them could be improved through some manner of consolidation.

In addition, I would have liked to expand the application list to move beyond simple queries to include modifications of the database in place. In the 'world' simulated by the database, this could refer to bringing a new power plant online or

decommissioning an old one. It might also refer to the expiration of contracts and the signing of new ones, changes in the price of electricity, and movement of people from city to city. The issue that kept me from implementing this here was concerns over how to revert the database back to the original form so that one user's modifications would not carry over into another's use of the applications.