**Mobile devices in Smart Grid**

**1 INTRODUCTION**

This project focuses on smart grid system, where mobile devices play an importantl role in gathering and distribution of information, a home side server which will monitor and automate home jobs and a utility side server which keeps a global view of many home servers and monitors real time power peaks and real time power costs including overall optimization.

* 1. **ACKNOWLEDGEMENT**

We would like to thank Dr. Arindam Mukherjee for providing the motivation to explore the possibilities of implementation in this project.

**1.2 TEAM MEMBERS**

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**2 SYSTEM DESIGN**

Smartphone plays an important part of information gathering and exchange in this project. The smartphone acts like a gateway for home and utility server to interact with each other and exchange information related to customer. The home server database and utility’s master server both have customer’s important information.. Simulated annealing is used as an algorithm for optimization of schedule and cost. The cost optimization depends on day ahead cost information from utility and instantaneous power envelope (for utility side optimization) information from utility.

**2.1 ARCHITECTURE**

Considering the requirements, our architecture is implemented as shown below. Smartphone communicates with home server and updates the database, also when it communicates with utility (future work) it does the same.

HOME SERVER -------- Mobile

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UTILITY SERVER

**Simulated annealing:**

When the utility server receives the requested schedules of various appliances from the database, it calculates the best cost for a user. For the purpose of parallel computing, Map/Reduce programming model is implemented and to get the lowest cost possible with best possible optimization, simulated annealing is implemented. The inputs are stored in a CSV file format and contain the appliance identification number, name, power rating, minutes of operation, preferred start time, preferred end time, soft or hard constraint . Here, the deciding energy factor for optimization in simulated annealing is the total cost of the power consumed by all the appliances of a user.

The cost for scheduling each appliance is calculated based on the cost from look-ahead price obtained from Duke’s website, minutes of operation of the appliance, its power rating and the spot price. The spot price is 0 if the appliance operates when the load on the power station is below peak power. If the power of operating the appliance exceeds the peak power at the given time, spot price is added to the original cost of operation depending on the time taken to operate the appliance. At this point the spot price is a hard coded value and the hours when the load exceeds peak power is obtained from another database. At this point of time, the power consumption is not added to the load database as the user may reject the schedule. Once the optimized cost is reached in simulated annealing the best schedule time (depending on hard and soft constraint) for each appliance is sent back to the user.

**Updating Database:**

Imagining that the consumer is satisfied with the schedule generated by utility server and presses a commit button, the load has to be added to existing load prediction of the day.

Once the data of predicted power consumption and start and end time of schedule is received for each appliance, the power load is added to the existing power load database. A bash script is running continuously to check for the change in commit status, if the user commits then the database of hourly power gets updated and real time cost is updated.

Future Scope for the utility Server: This project has a huge scope for enhancements, some of the possible enhancement that can performed for the utility server are:  Web crawling for picking the spot price for peak hours  If after a commit to schedule, the user changes his mind and wants to reschedule, the load of the schedule has to be subtracted from the power database.

**HOME SERVER**

**SCHEDULING DESIGN :**

While running simulated annealing, the constraints are checked for each appliance and depending on the constraints a random start time is selected. Adding the operation time gives us the end time and depending on this random start time, time slots of 5 minutes are created and cost for each 5 minute slot is computed based on the “Day Ahead Cost” provided on the duke energy website. The total cost of the appliance is then added and returned for that randomly selected time slot. It is important to note that we have also included the “tardiness factor” for cost computation and also we have taken measures to calculate precise cost.

**COST CALCULATION:**

The precise cost calculation problem comes if an appliance is scheduled to start on a particular time for example, say 01:00 on a 24 hour scale and ends at 02:10. So, the calculation of cost from 01:00 to 02:00 is not an issue because the power is in watt hour and the day ahead cost changes only after an interval of one hour. But for calculating cost for the 10 minutes, i.e. from 2:00 to 2:10. The power needs to be scaled from watt hour to the watt minutes and then the cost needs to be computed for this 10 minutes. This problem has been taken care of by our algorithm. This is done by splitting our duration from start time to end time into 5 minute slots and the calculation of cost is been done for each 5 minute slot. This approach provides us the precise cost for each appliance.

**RESULTS**

We were able to demonstrate a successful end to end integration of mobile app, home server and utility server. Utility server is still an open ended research content, as there are many concepts which can be refined and deployed or even implemented for the first time.

**CONCLUSION AND FUTURE SCOPE**

We were successfully able to demonstrate a basic implementation of the open ended project statement. A Further work can be done on this which will lead this concept to deployment.