

Estimation of Power Distribution in Substation Components using Object Oriented Analysis and Design

S P Angelin Claret^{1,2*} and M Germanus Alex³

¹Research & Development Centre, Bharathiar University, Coimbatore - 641 046, Tamil Nadu, India

²Department of Computer Applications, SRM University, Chennai-603203, Tamil Nadu, India

³Kamarajar Govt Arts & Science College, Surandai, Tirunelveli-627859, Tamil Nadu, India

Received 24 November 2015; revised 03 October 2016; accepted 09 February 2017

An object oriented model for the estimation of power that is distributed to the substation components is analysed and designed. The substation component comprises agriculture, industrial and residential regions. The important contribution of this paper is to evaluate the distribution of power in specified time slot of six hours and calculate the average power distributed to the substation components. The object oriented analysis (OOA) is examined in the first level and object oriented design (OOD) in the next level. The object oriented principles encapsulation, polymorphism and inheritance is effectively carried out for the power distribution system. The distribution results are shown by the mat lab and starUML softwares. The unified modelling language (UML) is used to show the structural form of power distribution system and its components in a simplified form.

Keywords: OOAD, OOA, OOD, Power Distribution System, UML

Introduction

The power distribution system is extensively complex and large. Most of the techniques are carried out to obtain the solution for load flow and power losses. In power system engineering, object oriented analysis and design (OOAD) methodology was accepted as an alternative over other methodologies due to its flexibility, reusability and maintainability. Literature concentrates various applications of object oriented concepts for the power distribution system. The operational performance of the power distribution system in terms of determining hours of power supply as well as obtaining the probabilities of consecutive hours of power at any time of a day for the 11kv distribution power system⁶. They explained about the operational and failure features of the network in terms of availability and quality of power, types of fault and frequency of occurrence of faults. Periodical estimation of power distribution is evaluated by kilo-volt-ampere hours. Hence, the determination of hours of power supply for the 11kv power distribution system is extended for the average estimation of power for the first six hours time intervals for the individual and combined components of substation. In

this paper, the power that is distributed to the components of substation will be estimated by the OOAD principles¹⁰. The component of substation is partitioned into three regions. The classified regions in our work are agricultural, commercial and residential⁸. The ohm's law is used to find the voltage, current and power. The object oriented concepts polymorphism, encapsulation and inheritance principles is used to develop the programming concepts. The object oriented analysis (OOA) is performed in the first level and object oriented design (OOD) is considered in the next level. The structural form is effectively shown by the unified modelling language (UML).

Object Oriented Analysis of Power Distribution System

Object oriented analysis states, the requirements needed to solve the particular problem domain. In this, the power distribution system is taken as the key concept. The requirement needed for the power distribution system is analyzed in the analysis phase. The power distribution system is taken as main class and the substation is considered as the sub class. The substation receives 33kV of power from the distribution system⁵. This 33kV is stepped down to 11kV and distribute to the base station computer. The

*Author for Correspondence
E-mail: spangelin@rediffmail.com

base station computer is used for the stepped down activities. From here it is distributed to the agriculture, commercial and residential regions⁶.

Application of UML for Power Distribution System

The UML is used in presenting the object-oriented solution in an efficient manner. In UML diagrams three different perspectives may be used, which are conceptual, specification and implementation³. The class diagram and activity diagram are shown here for the principles of power distribution system.

Class diagram

A class diagram is a collection of static modelling elements such as classes and their relationships, connected as a graph to each other and to their contents. The class diagram consists of three partitions. The class name, attributes and operations. In Figure 1, the power distribution system, substation,

agriculture, commercial and residential are the class names. The power distribution system is the main class. It uses pds_id as an attribute and step down () as an operation. The power distribution system class receive the power from the transmission system and distribute to the next component. The substation class receives the power from the power distribution system component and distributed to its subclasses. The attributes volt, power and current are used to step down the power and ss_id is used to denote the substation identification. The operations accept () and distribute () is used to receive and distribute the power from the main class to the sub classes. Figure: 1. Class Diagram representing the overview of Power Distribution System. The individual sub classes' agriculture, commercial and residential consists of volt, power and current as an attribute to evaluate the power received from the substation. The operation receive () is used to accept the power from the

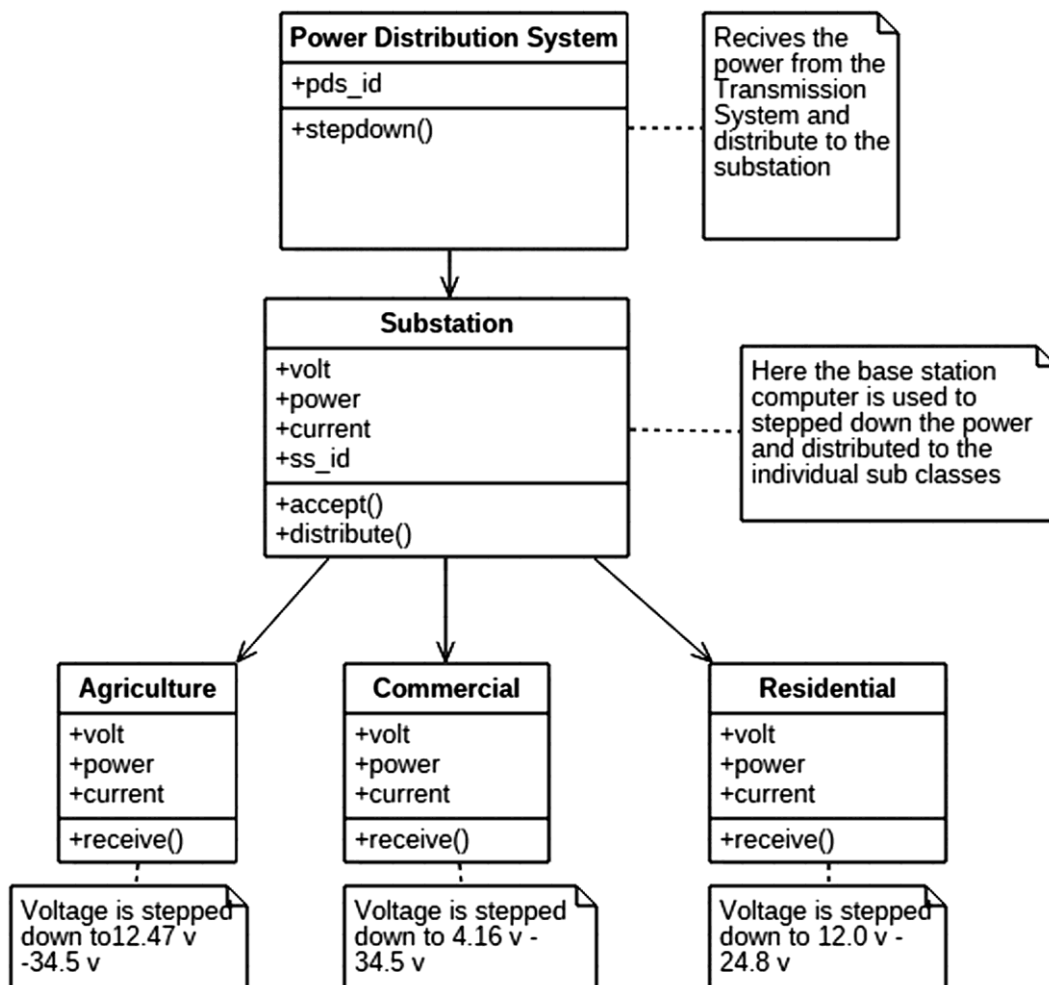


Fig.1- Class Diagram representing the overview of Power Distribution System

substation component. The agriculture class is stepped down to 12.47V to 34.5V, the commercial class is stepped down to 4.16V to 34.5 V and residential class is stepped down to 12.0V to 24.8V. The power will be distributed only within the stepped down ranges to the respective regions. The class diagrams do not show temporal information, which is required in dynamic modelling². The main task of object modelling is to graphically show what each object will do in the problem domain, describe the structure and the relationships among objects by visual notation¹¹.

Activity diagram

The purpose of an activity diagram is to provide a view of flows inside a use case or several among several classes. An activity diagram is similar to a state chart diagram, where a token denoted by a black dot represents an operation¹². In Figure 2, the name of the activity is shown by the round box symbol; the diamond symbol represents the decision takes place in between the activities. The end of the operation is shown by the black dot enclosed by a circle. When an operation symbol appears within an activity diagram

or other state diagram, it indicates the execution of the operation⁹. The substation operation receives the power from the transmission lines and based upon the voltage level it is distributed to the agriculture, commercial and residential operations.

Object Oriented Design of Power Distribution System

In the design phase, consider each substation divisions as an object. Evaluate the power distributed for a six hours time interval and average distribution of power in all the three regions for six hours time intervals. In the following sections of this paper, the class names are given in Arial to differentiate it from the normal text. Figure: 2. Activity Diagram represents the power distribution system.

Designing principles used for power distribution system

OOAD provides huge benefits such as reusability, flexibility and maintainability. The power distribution system is carried out by the polymorphism, encapsulation and inheritance methods⁷. The components of substation consists of the similar attributes i.e., volt, power, current and identical

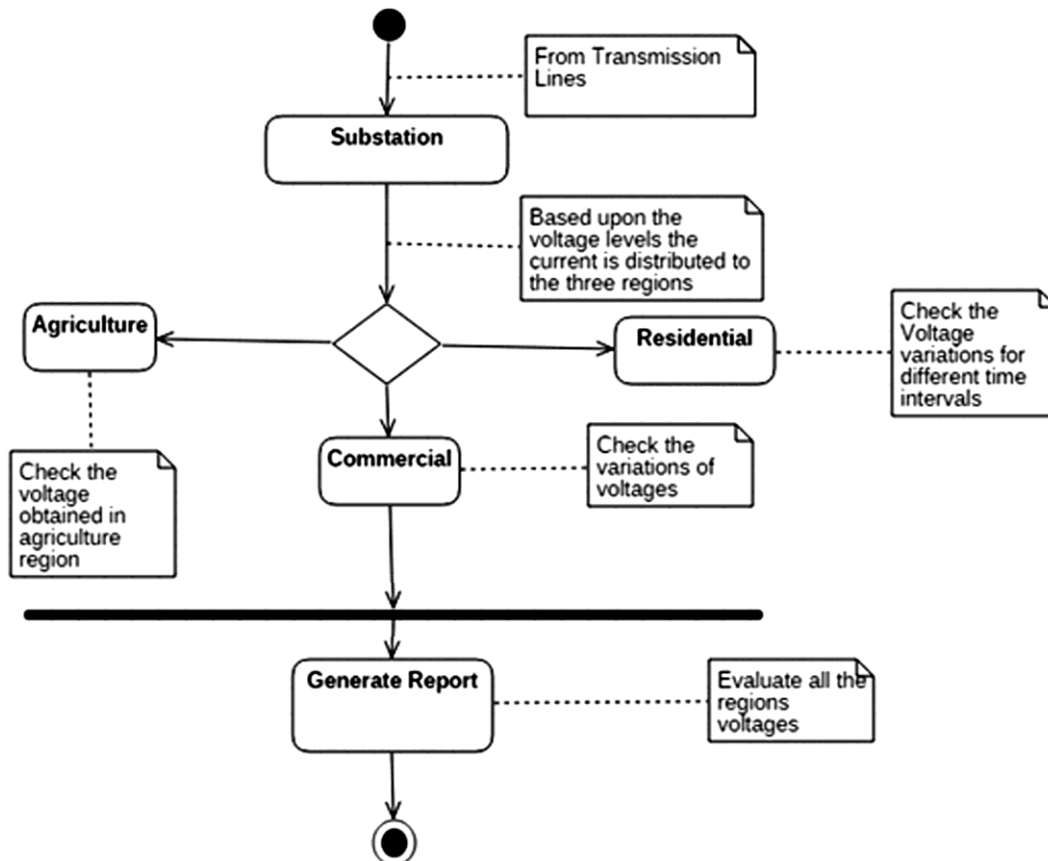


Fig.2- Activity Diagram represents the power distribution system

operation i.e., receive_(). The polymorphism method uses single method in different activities. Encapsulation method uses the components of substation that is binded in a single class power distribution system. Finally the inheritance method inherits the components of substation regions from the substation class and that to from the power distribution system class. The class name, attributes and operations used in each component is shown in Table 1.

Power distribution system calculations

The power distribution system and its components are taken as an object. The object can able to communicate with other objects. The object-oriented design method for power flow calculation is estimated by the principles of ohm's law¹. The ohm's law is used for the calculation of power as shown in Table 2. The mathematical formula of ohm's law is discussed in 3 ways:

- If a current I should flow through a resistor R, the voltage V can be calculated as

$$V=I \times R \quad \dots (1)$$

From (1), the voltage distributed for first six hours and its average can be calculated as

$$V_T=(S_i X+(R_i \times I_i)+(R_a \times I_a)) \quad \dots (2)$$

Where V_T is the total voltage distribution

$S_i X$ is the first six hours distribution

R_i & R_a are the resistor for hour and average distribution

I_i & I_a are the current for hour and average distribution

- If a Voltage flows across a resistor R, the current I can be calculated as

$$I=V/R \quad \dots (3)$$

Table1 -Description of class name, attribute and operations used class diagram

Class Name	Attributes	Operations
Power Distribution System	Pds_id	Stepdown()
Substation	Volt,power,current,ss_id	Accept(),distribute()
Agriculture, Commercial, Residential	Volt,power,current	Receive()

Table2- Mathematical symbols used in ohm's law

Name	Formula Sign	Unit	Symbol
Voltage	V or E	Volt	V
Current	I	Ampere(amp)	A
Resistance	R	Ohm	Ω
Power	P	Watt	W

From (3), the current distributed for first six hours and its average can be calculated as

$$I_T=S_i X+\frac{R_i+I_i}{R_a+I_a} \quad \dots (4)$$

Where I_T is the total current distribution

- From (2) and (4) the resistor R can be calculated as

$$R_T=V_T I_T \quad \dots (5)$$

- The total power P distributed for first six hours and its average is calculated from (2) and (4).

$$P=V_T \times I_T \quad \dots (6)$$

From (2), (4) and (6) the current, voltage and power can be estimated. To evaluate the current, voltage and power, the resistance is used from (5).

The Principle method used for power distribution system

The above mentioned three regions from the substation component can receive the power only within the allotted ranges. Due to any circumstances, if there is any overflow of power distribution occurred; those powers will be shifted to the base station computer. From here the power can be distributed properly to the particular regions. This may most likely arise only when there is a temporary shutdown in any of the individual region.

Distribution of power in agriculture, residential and commercial regions

The value obtained from the voltage calculations in all the three different regions, can be able to evaluate the power values as shown in Table 3. Figure 3 shows

Table 3 -Voltage, Resistance and Power Values for Agriculture, Residential and Commercial Regions

Region	Voltage(V)	Resistance(Ω)	Power(W)
Agriculture	719	10	510.4
	360	10	648.0
	900	20	405.0
	663	20	145.8
	454	30	681.0
	677	30	304.6
Commercial	242	10	580.8
	819	10	663.8
	612	20	183.6
	163.3	10	266.1
	900	20	405.0
	112.0	10	125.5
Residential	698	10	481.6
	441	20	970.2
	502	20	125.5
	122.4	10	149.3
	381	20	723.9
	112.5	10	126.0

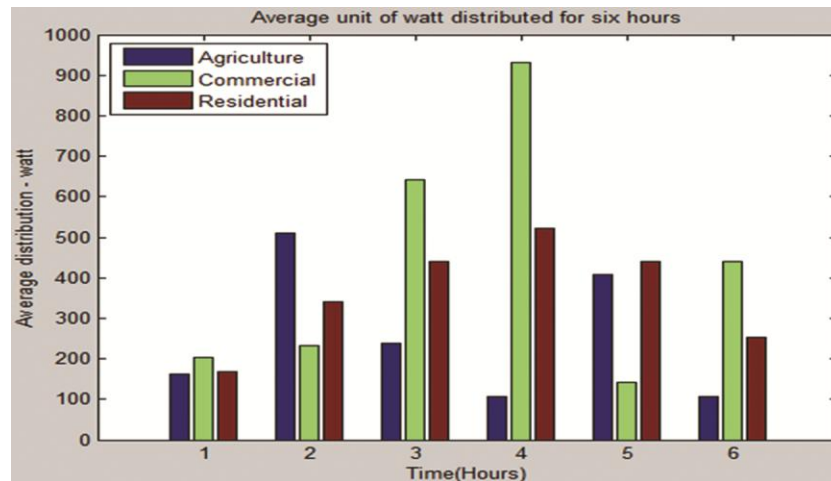


Fig.3- Average Power distributed in residential, commercial and agriculture regions for the first six hours time interval

the average power distributed in all the three regions for the first six hours. It shows the consumption of power is more in commercial region in the 4th hour than compared to the other two regions. The same principles can be extended for the remaining time intervals and obtain the amount of power distributed for any time periods.

Conclusion

The object oriented model is used for the estimation of power distributed to the substation components. The use object oriented method provides better solution than the non object oriented methods for the estimation of power that is distributed to the substation components. The use of object concepts provides flexibility, reusability and maintainability for the evaluation of power distribution system. Ohm's law is used for the power calculations. UML is used to represent the power distribution system in a structural form. The softwares starUML and mat lab is used here, for the efficient distribution of power from the substation components. This method can be extended to find the distribution of power in various time slots and for the distribution of power between various substations to reduce the excess workload of feeders.

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