Attaining Computer Network Course outcomes through activities and statistical analysis of simulation results using SPSS tool

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Abstract— One of the important aspects of the outcome based Education (OBE) is the assessment of course outcomes (CO). As we have adopted the OBE framework for our programme, we have integrated the theory and laboratory course and conducted activities to achieve the course outcome of Computer Network course. As we know the tollgate courses have multiple prerequisite courses and to attain the course outcome the learning of these prerequisite courses can be applied in this course. The union of the attainment of the outcome sets of all the toll gate courses can be viewed as program outcome attainment. Fundamentally any tollgate course is progressive in the attainment of the outcomes. A Computer Network is one such toll gate course for computer science and engineering programme positioned during the sixth semester. The concepts of basic subjects like data structures, algorithms, object oriented programming, operating system are prerequisites which are used to solve a large problem.

The authors have attempted to measure the outcomes of this tollgate course through theory and laboratory activities. One activity on the client server computational overview was tried to address the issues related to fault tolerant systems. Other activity defined to understand the network behavior for given parameters to apply the statistical techniques for the simulated results.

Keywords— Tollgate; OBE; CO; Network; Statistics.

I. INTRODUCTION

The tollgate courses have multiple prerequisite courses and the outcome of these prerequisite courses can be verified in this course. The union of the attainment of the outcome sets of all the toll gate courses can be viewed as program outcome attainment. Fundamentally any tollgate course is progressive in the attainment of the outcomes. The tollgate courses try to apply the outcomes attained through prerequisite courses in a real time application. Noticeably the outcomes of the prerequisite course can be assessed in the toll gate course at the higher levels of the Bloom's taxonomy. The tollgate courses are fundamentally used to measure the learning for both stake holders (Students and the course instructors). The outcome attainment of the course can orient the direction of the program and helps to overcome the lapses of the curriculum.

OBE framework[1] direct us to define course outcomes which intern help to achieve Programme Outcome (PO).COs are the objectives/attributes, that each student should be able to or obtain at the time he or she is completing the particular course. Each course for the programme has its own set of COs. At the end of each course, the COs needs to be assessed and evaluated to check whether it has been attained or not. Here we have attempted to achieve the course outcome by defining the set of activities. A method to evaluate the achievement or attainment of the COs has been developed.

A Computer Network is such tollgate course for computer science and engineering discipline positioned during the sixth semester. The concepts of basic subjects like data structures, algorithms, object oriented programming, operating system are prerequisites which are used to solve a larger problem. The two layers of Computer Networks namely physical and data link layer have been already studied in a course called Data communication.

Computer Networks have been established as a part of any operating system. This concept can be only visualized and used by the programmer at application layer. Any application developed by engineer demands integration with a Computer Network. It becomes essential for a computer science engineering graduate to understand the fundamental concepts and the behavior of Computer Networks.

The Computer Network illustrates the concepts of inter-process communication, Remote procedure calls and fault tolerant computing that helps the students to understand the simulated behavior of the application under development.

The authors have attempted to measure the outcomes of this tollgate course through theory and laboratory activities. The client server computational overview also was tried to address the issues related to fault tolerant systems. The students were made to apply the statistical measurement techniques for the simulated results using **Statistical Package for the Social Sciences** (SPSS)[2] tool.

The paper is organized as follows, The Section II discusses the implementation of the activities, in Section III Assessment of the activities and section IV gives the conclusion.

II. IMPLEMENTATION

Here we have used the pedagogic practices in our teaching and learning process and we have adopted the OBE principles from American Accreditation Board of Engineering and Technology (ABET), where the course learning outcomes for each course need to be measured and used for continual quality improvement. OBE focuses on outcomes that are identified and measured. These outcome attributes, normally in form of knowledge, skill or attitude, which prepare the graduates for their professional practice. The outcomes are normally looked at 3 different levels, at course level (Course Outcomes), at programme level (Programme Outcomes), and at professional level (Programme Educational Objectives). In this paper we describe a method that is used to analyze or evaluate the attainment of specific course learning outcomes of course on Computer Networks. CO is the attribute that the students are expected to have after completing the course. The evaluation of whether CO is attained is essential in determining the student achieving in a particular course. The result of CO attainment will also be used to evaluate the attainment of Programme Outcomes . The outcome of analysis will be used to improve the teaching and learning experience in the particular course.

All courses of the programme would have their own course outcomes or also commonly known as CO. These COs are produced based on the requirement of the programme outcomes (PO). Each CO will be mapped to PO (the CO-PO) matrix. The PO will be then mapped to the programme educational objectives (PEO). Fig 1 shows an example of relationship between CO, PO and PEO.

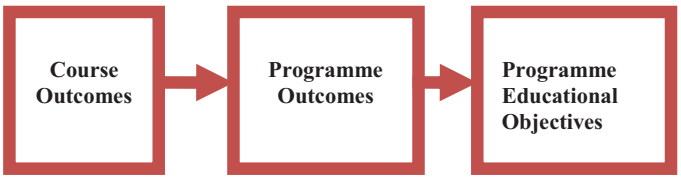

Fig1. An example of the relationship between CO, PO and PEO

The Prpgram Outcomes of Computer Science and Engineering deaprtment are listed below

a Ability to apply knowledge of math, science and engineering to provide computing solutions.

b Ability to analyze a problem and identify and define the computing requirements appropriate to its solution.

c Ability to design and implement a computer-based system, process, component, or program to meet desired needs

d Ability to function on multidisciplinary teams.

e Ability to identify, formulate problems and design, construct software systems of varying complexity.

f An understanding of professional and ethical responsibility.

g Ability to communicate effectively.

h Ability to understand the local and global impact of computing on individuals, organizations and society.

i Understand the need for life-long learning.

j Knowledge of contemporary issues.

k Ability to use tools and techniques necessary for computing practice.

l Ability to design & conduct experiments as well as analyze & interpret data

m Ability to manage process of carrying out projects and finance planning

The Course outcomes of computer Network theory and Computer Network laboratory are listed in section A and Section B.

A. The course outcomes for Computer Networks theory course are given below.

a) Analyze the components, processes involved in addressing and routing the data for a computer communication.

b) Analyze the relationship between various fields of a frame and their purpose in Computer Networks.

c) Interpret the protocols like TCP, UDP, FTP, SMTP and networks services used in the Computer Networks.

d) Demonstrate the behavior of client server computation or IPC as one of the component of the networks layer

B. The course outcomes of the Computer Network laboratory

1. Simulate the behaviour of a given network topology to produce a statistical inference with suitable justification for the setup.
2. Illustrate the proportional behavior of parameters like bandwidth, error rate, congestion etc. over the throughput of the Computer Network.
3. Predict the simulated behavior of scalable network in the form of mathematical model for maximum and minimum throughput
4. Simulate the protocol like ping, TCP/IP, UDP

The course outcome of theory course **d** and course outcomes of laboratory **1to 4** are tried to achieve through the set of activities and also we map the learning of the prerequisite courses through these activities.

C. *Activity on Interprocess Communication(IPC) in Theory:*

Study of network elements at various stages to demonstrate the behavior of client server computation or IPC as one of the component of the networks layer which addresses the course outcome **d** listed in Section A.

The attainment of course outcome d is accomplished with this activity on IPC, which is designed as follows,

1. **Each team is allocated with a problem statement:** The problem is based on the real time data management system which involves networks elements and IPC.

2. **What all to do?**
   - Study of the problem- Gathering the information.
   - Know about the entities involved and their owners.
   - Architecture of the system- Include Data flow diagram also.
   - Message formats and protocols used and communication model– remark on the possible protocol communication model.
   - Fault management and recovery Technique.

3. **How to present?**
   - ✓ Study the problem
     - Objective of the system
     - How does the system works
       - Entities involved
       - Operation and objective of the each entity
       - The connection or relation between entities
       - Complete business logic of the each entity
       - Layered diagram of the entities
   - ✓ Architectural diagram.
   - ✓ Communication model, protocols used, possible message formats.
   - ✓ Fault management and recovery techniques.

4. **Outcome of the activity on IPC**

Each team has done the study of the real time system and could come out with the entities involved, communication model, protocols used and even fault and recovery techniques, appropriate data structure are chosen and also applied the prerequisite concepts studied in the previous semesters. The problems assigned for the activity is given in Table I. the details pertaining to the activity done by the students are explained with an example below.

TABLE I. PROBLEM STATEMENTS FOR THE ACTIVITY ON INTERPROCESS COMMUNICATION

	Problem Statement
1	Censes in India
2	Aadhar information Gathering
3	State date of birth and death registration
4	IRCTC ticket booking
5	IRCTC ticket cancellation
6	Land registration records
7	Clearance certificate for land
8	Vehicle registration
9	CET counseling
10	Migration certificate
11	NSE
12	BSE
13	Banking - DMAT account
14	Results acquisition in a university
15	ATM
16	Putting up a civil suit in the court

Example: IRCTC Network Analysis

Problem Statement: —Analysis of the Data Communication and Network Infrastructure of the IRCTC online Reservation and Cancellation system. In specific with Cancellation of e-ticket".

Objective of the System.

- ✓ User can perform the Reservation/Cancellation of tickets through irctc.co.in.
- ✓ The passengers' request for reservation, cancellation and modification of journey are handled by the system through requisition slips.
- ✓ Major outputs generated by the system are Reservation cum-journey tickets, cancellation/Modification tickets, Reservation Charts and Daily Terminal Cash Summary.
- ✓ The system is also capable of generating different types of Management Information System (MIS) Reports.

Entities: Customer, Internet, IRCTC, PRS, Payment Gateway, Master/Visa Organization, Card Issuing Bank.

Architecture diagram:

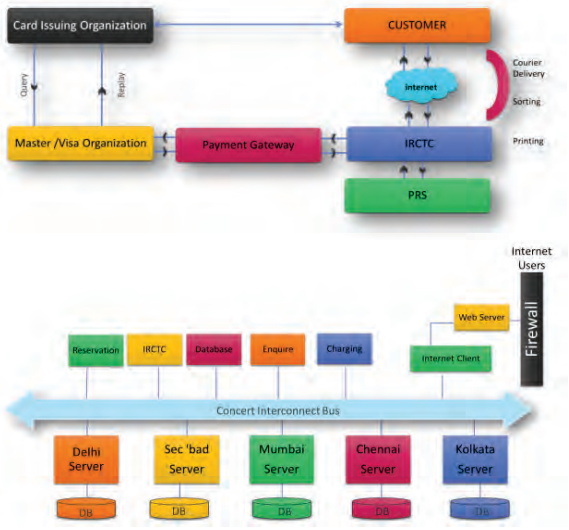

Fig2. Architecture and Working model

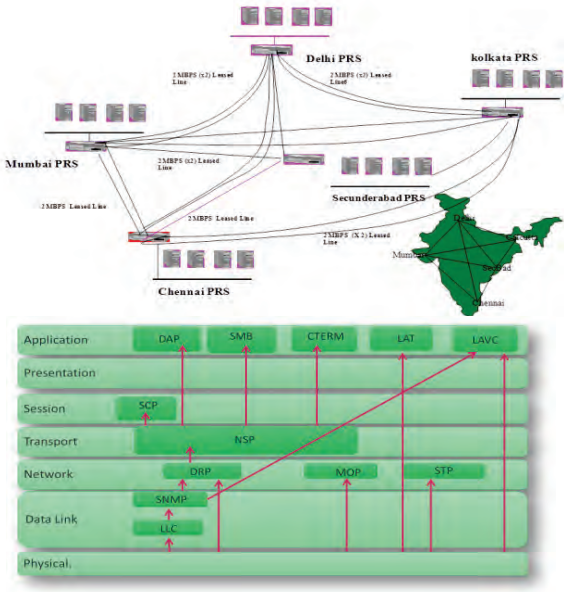

Fig 3. Network topology and Communication model and Protocols

The Fig 2. Shows the architecture of the IRCTC online Reservation and Cancellation system [3] and also it shows the working model of the IRCTC system. Fig 3. Shows the network topology and communication model and the interaction between the different layers.

D. Activity on NS2 simulation in Laboratory:

To address the outcome, **"Illustrate the proportional behavior of parameters like bandwidth, error rate, congestion etc. over the throughput of the Computer Network."(Course outcome 2 listed in section B),** we have designed the activity on simulation using NS2. Here we expect the student to simulate the network topology and calculate the performance parameters like throughput, Round trip time (RTT). Further students need to perform the statistical analysis to find the regression coefficient and establish null hypothesis.

How to conduct the activity:

- In each lab, six sub batches were made.
- Each sub batch has assigned a topology with network parameters.
- Each batch has to perform a simulation using Network simulator 2(NS2) tool independently by varying parameters like Bandwidth and packet size, asked to note down the corresponding RTT. Each of the sub batches has taken around the sixty readings.
- All the six sub batch readings were consolidated.
- Statistical techniques were applied to the consolidated readings using SPSS tool.
- Perform the null hypothesis.
- Infer the results.

Here we have a **sample assignment.**

Title: Analysis of the Network Topology

Objectives: The main objective of this experiment is to observe how the round trip time varies when different state variables are varied. The different state variables include bandwidth, packet size.

Topology:

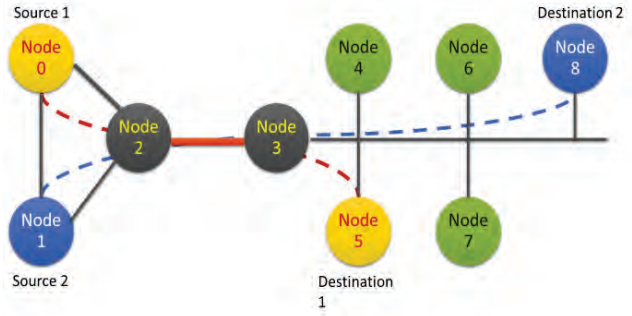

Fig 4. Network Topology

The outcome of the activity:

The team has simulated the topology shown in Fig 4. Each student team has done the statistical analysis of the simulated results using SPSS tool.

TABLE II: SAMPLE THROUGHPUT READINGS OF PACKET SIZE=5000

B.W	RTT
10	0.127485
11	0.098242
12	0.063977
13	0.063972
14	0.053387
15	0.040121
16	0.039358
17	0.039206
18	0.039151
19	0.038733
20	0.038488

The Table II shows the sample reading of the simulation for a given topology. Around 400 readings are collected from the entire batch and statistical techniques like correlation-test and Chi-square test are applied and analyzed using SPSS tool.

E. Statistical Analysis on the NS2 simulation activity:

- ***Correlation:***

Correlations indicate a predictive relationship that can be exploited in practice. Correlation coefficient value lies between -1 and +1. The closer the coefficient is to either -1 or +1, the stronger the correlation between the variables. Value of 0 implies no correlation. For example, Coefficient of Correlation = -0.09851518, indicates the strong correlation between the two parameters i.e. Bandwidth and RTT. Since it is +ve correlation, RTT increases with decrease in Bandwidth.

- ***T-test: (Paired t-test, 5% level of significance)***

A t-test's statistical significance indicates whether or not the difference between two data sets averages most likely reflects a ~~"r~~eal" difference in the population from which the data sets were sampled

H0: There is dependency between Bandwidth and RTT.
H1: Dependency does not exist between Bandwidth and RTT.
Degrees of freedom, v = n-1 = 120-1 = 119
If |t| > t (0.05) => H0 is rejected
If |t| < t (0.05) => H0 is accepted
For the experiment, 1.03585E-36< 1.6226
Hence, H0 is accepted. This implies that dependency exists between the two parameters i.e. Bandwidth and RTT.

- ***Chi-squared test:(5% level of significance)***

The chi-square test is a statistical test that can be used to determine whether observed frequencies are significantly different from expected frequencies.

H0: Bandwidth and RTT both have 50% contribution each, in determining the value of RTT.
H1: Bandwidth and RTT don't have 50% contribution, in determining the value of RTT.
Degrees of freedom, v = n-m = 120-2 = 118

If $|\chi^2| > \chi^2$ (0.05) => H0 is rejected
If $|\chi^2| < \chi^2$ (0.05) => H0 is accepted
For the experiment,
0.99978 < 110.898
Hence, H0 is accepted.
This implies that Bandwidth and RTT both have 50% contribution each, in determining the value of RTT.

- ***Conclusion of the activity: Students perspective***

The students appreciated the need of the statistical significance test and the conclusion drawn by them are,

i. The value of RTT is determined by the parameters Bandwidth and Packet size, both of which have 50% contribution each.
ii. As bandwidth increases, RTT decreases.
iii. As packet size increases, RTT increases.

III. ASSESSMENT

For every activity conducted in the theory and laboratory an assessment is carried out. Some of the course outcomes are assessed through minor and semester end exams. The Activity-1 on IPC conducted and Activity-2 on NS2 are assessed as part of Continuous Internal Evaluation (CIE). The Table III and IV show the scheme of evaluation for theory and Laboratory respectively.

TABLE III: CIE SCHEME IN THEORY

Assessment	Weightage in Marks
Minor Exam 1	**15**
Minor Exam 2	**15**
Quiz –I	**03**
Quiz -II	**02**
Group activity	**15**
Total	**50**

TABLE IV: STUDENTS ASSESSMENT THROUGH CIE (80%) + SEE (20%)

	Assessment	Weightage in Marks
Continuous Internal Evaluation (80%)	Demonstration	10
	Exercise	20
	Structured Query	50
Semester End Examination (20%)	Implementation of Structured Query based experiment.	20
	Total	**100**

A. Minor Exams

- Two minor exams were conducted; the question papers are prepared based on the learning objectives.
- Our objective was to test the writing and problem solving ability of a student.

B. Quiz

- Quiz-1 was conducted to test the prerequisite skills. Quiz-2 was conducted to assess the learning of the various layers of computer networks. The quiz question pattern was similar to the GATE Question paper pattern.

The assessment parameter for the activities discussed in Section C and D are shown the Table V and VI.

TABLE V: ASSESSMENT PARAMETERS ACTIVITY-1: IPC

Clarity of the given Problem (01)	System functionality (02)	Architecture diagram (01)	Communication model & message formats (02)	Individual contribution (01)

TABLE VI: ASSESSMENT PARAMETERS ACTIVITY-2: NS2 SIMULATION

TCL script (02)	Determine the performance parameters (02)	Analyze the trace results using SPSS (03)	Interpretation of the data (02)	Conclusion (01)

The activities carried out are helped to attain the course outcomes in turn to attain the Program Outcomes. The Table VII (For computer Networks Theory) and Table VIII (For Computer Networks lab).show the Mapping of course outcomes with Program Outcomes through the course articulation matrix.

TABLE VII: COURSE ARTICULATION MATRIX: MAPPING OF COURSE OUTCOMES TO PROGRAM OUTCOMES.(COMPUTER NETWORK THEORY COURSE)

Course Outcomes/ Program Outcomes	a	b	c	d	e	f	g	h	i	j	k	l	m
Analyze the components, processes involved in addressing and routing the data for a computer communication.	H	M								L			
Analyze the relationship between various fields of a frame and their purpose in Computer Networks.		M	M										
Interpret the protocols like TCP, UDP, FTP, SMTP and networks services used in the Computer Networks.		M			L								
Demonstrate the behavior of client server computation or IPC as one of the component of the networks layer	H	M	M										

TABLE VIII: COURSE ARTICULATION MATRIX: MAPPING OF COURSE OUTCOMES TO PROGRAM OUTCOMES. (COMPUTER NETWORK LABORATORY COURSE.)

Course Outcomes/ Program Outcomes	a	b	c	d	e	f	g	h	i	j	k	l	m
Demonstrate the behavior of client server computation or IPC as one of the components of the network's layer.		M								L		H	
Simulate the behavior of a given network topology to produce a statistical inference with suitable justification for the setup.	H				L							H	
Illustrate the proportional behavior of parameters like bandwidth, error rate, congestion etc. over the throughput of the computer network.	H				L							H	
Predict the simulated behavior of scalable network in the form of mathematical model for maximum and minimum throughput.	H				L							H	
Simulate the protocols like ping, TCP/IP, UDP.	M		H									H	

IV. CONCLUSION

The major focus in this work is to integrate the theory and laboratory course on Computer Networks to help the students in achieving better learning. The activities defined made them apply the prerequisite knowledge, to acquire in depth knowledge in the Computer Networks. Course outcome d is attained using the Activity-1 on IPC and the laboratory outcomes 1, 2 and 3 are attained through Activity-2 on NS2 simulation. . The activity -2 has made the students to understand the network behavior, dependency between various network parameters. It has also promoted the usage of SPSS tool in analyzing the large amount of data obtained by different sources.

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