# An Institute Interaction with EMC Corporation for Enhanced Learning of Storage Area Network Course

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*Abstract*- **Information storage is a central pillar of information technology. To enhance student awareness about Information Storage Technology, Storage Area Network (SAN) course was introduced for undergraduate students at VII semester level in Information Science & Engineering curricula.SAN deals with storing, managing, and protecting Digital Information in Classic, Virtualized, and Cloud Environments. EMC's open curriculum, aimed at addressing the knowledge gap that exists in the IT industry in the area of information storage and emerging technologies. The Storage Area Network (SAN) / Information Storage and Management(ISM) course proposed by EMC Academic Alliance is designed and developed to enable students to achieve a comprehensive understanding of all the segments of storage technology. Here SAN course was designed by considering EMC Academic Alliance course contents and framed Course Learning Objectives. Course activity was dedicated for the study and presentation of white papers on EMC products related to the concepts which they have studied. Industry visit to EMC Corporation was organized to gain knowledge about current storage technologies and how storage concepts are implemented in Data Center. At the end of the course, an EMC Proven Professional Certification online exam was conducted in our college. Through this course we have mapped some of the program outcomes with ABET criteria.**

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*Keywords: SAN, ISM, EMC Corporation, EMC Proven Professional Certification, CIE, SEE.*

## I. INTRODUCTION

A large quantity of digital information is being created every moment by individual and corporate consumers of Information technology [1]. With the exponential growth of information and the development of sophisticated products and solutions, there is also a growing need for Information storage professionals, which motivated authors to include Storage Area Network course in the curriculum. In collaboration with EMC Academic Alliance we offered the SAN course which is designed and developed to enable students to achieve a comprehensive understanding of all the segments of storage technology. The SAN course fits into our curriculum at VII semester level as an elective to undergraduate students. As the course contains more of theoretical concepts, class activities were conducted taking case studies of EMC products .Continuous Internal Evaluation (CIE) activity was conducted where in students were assigned to study white papers on EMC Corporation products based on the concepts studied in

SAN course. An industry visit to EMC Corporation was organized to get the feel of how actually the concepts are implemented. At the end of the semester, EMC Proven Professional Certification for SAN course was conducted in our college. All these activities have helped students for better understanding of concepts. We could also address incremental complexity levels of Bloom's Taxonomy [2]. These new initiatives have resulted in enhanced learn-ability among students.

The organization of the paper is as follows, section II describes the literature survey. Section III discusses Course Design. Section IV explains Course implementation, section V describes assessment method. Section VI discusses course outcomes and observation. Section VII focuses on result analysis. We conclude the experiences of teaching the course in section VIII.

## II. LITERATURE SURVEY

Ed Van Sickle [3] has discussed about EMC Academic Alliance Program and Storage Technology Foundations course. Emerging challenges of data and information management have been described. Author has tried to build the partnership program with academia to prepare storage skilled leaders for the IT.

Vladan Jovanovic and et al [4] described the content, delivery and assessment mechanisms used for an undergraduate course on Networked Storage Technology. The course has been designed using EMC's vendor-neutral Storage Technology Fundamentals, which provides the detail review of how the course fits into the curricula and how it helps to achieve the 2008 ABET assessment requirements.

Novel and viable P2P-based model for efficient storage archival of business critical data is proposed by Ankur Gupta and et al [5]. P2P systems are characterized by heavy node transience. This model provides the redundant storage; reliability of the system in varying degree of node transience needs to be established using simulation.

Robert Spadling [6] has discussed various architectural considerations, components that satisfy various storage architectures and connectivity options for a networked storage environment.

## III. COURSE DESIGN

A course developed by an industry organization has been used as a basis for formulating the course in an Engineering curriculum. By aligning the academic curricula with industry practices & state of the art technology, a significant step can be taken to make the Engineering graduates "employable".

The SAN course is offered at VII semester level as an elective. The course curriculum design for the previous academic years is as follows:

In the academic year 2012-13, SAN course was designed using text book "Storage Network Explained "by Ulf Troppens , which explains the storage area network concepts based on solid technical foundations [10].

EMC Corporation, the world leader in data storage, created the EMC Academic Alliance Program to educate students on storage and bridge the education gap that exists between industry and academia. EMC developed a Storage Technology Foundations course to teach students about the design of storage technologies. Therefore, author's redesigned SAN course during the academic year, 2013-14, which includes version 1 of SAN course into the curriculum proposed by EMC Academic Alliance with a goal of:

- Introducing real world case studies
- Industry visit
- Certification for enrolled students

Course content from ISM Version 1.0 [1] for the first time curriculum design is:

Part 1: Information Storage and Management for Today's World which covered information growth and challenges, define a storage system and its environment, review the evolution of storage technology, and introduce intelligent storage systems.

Part 2: Storage Options and Protocols cover the SCSI and Fibre channel architecture, direct-attached storage (DAS), storage area networks (SANs), network attached storage (NAS), Internet Protocol SAN (IP-SAN), content-addressed storage (CAS), and storage virtualization.

Part 3: Business Continuity, introduces business continuity, backup and recovery.

During the process of curriculum design in the academic year 2014-15, an upgradation of syllabus by EMC Academic Alliance motivated authors to refine the syllabus of the course with regard to technology. Therefore syllabus has been refined from ISM Version 2 .0 (SAN) which contains [8];

Part A: "Storage System" covering Information growth, challenges and evolution

Part B: "Storage Networking Technologies" covering FC-SAN, IP SAN and NAS.

Part C: "Backup, Archive, and Replication" covering business continuity, backup and recovery, de-duplication, data archiving, local and remote data replication.

Part D: "Cloud Computing" introducing cloud computing, including infrastructure framework.

Part E: "Securing and Managing Storage Infrastructure" covers storage security, storage infrastructure monitoring, management, including security and management.

## IV. COURSE IMPLEMENTATION

SAN course is developed to enable professionals and students to achieve a comprehensive understanding of all segments of storage technology. Following are the objectives of SAN course by EMC Academic Alliance Program

1. Describe storage technology solutions such as Storage Area Networks (SAN), Network Attached Storage (NAS), and Content Addressed Storage (CAS).
2. Understand and articulate the technologies and solutions available to support an IT Infrastructure including Business Continuity, Information Availability, Local and Remote Replication, Backup and Recovery and Disaster Recovery needs of businesses.
3. Understand the key tasks in successfully managing and monitoring a data storage infrastructure:

Considering these objectives, authors have set the following Course Learning Objectives (CLO).

1. Describe the different storage system architectures like SAN, NAS and IP SAN.
2. Evaluate disk performance using various data protection techniques.
3. Explain the management of storage infrastructure related to different storage virtualization techniques.
4. Choose appropriate storage technology solutions for business continuity and protecting database against data loss.
5. Explore current advancements in Storage Area Network.

These CLOs were framed to meet the current storage technology trends of the IT industry. EMC Product case studies assisted to address higher level of blooms taxonomy. Activities helped to enhance student's knowledge on current advancements in SAN and improved their presentation and communication skills. The next sub section describes the course activities used to implement these objectives.

### A. COURSE ACTIVITIES
The authors approach in teaching the course aimed at better understanding of the concepts and correlation with the industry implementation. Activities implemented by authors are as follows;

- EMC Case studies

EMC product case studies were discussed during class hours correlating theoretical concepts. Such case studies were also a part of Continuous Internal Evaluation (CIE) and Semester End Exam (SEE).

- EMC product white paper presentation

Group of two students were assigned to study and present EMC products white papers on the concepts they have studied. Sufficient time was given for preparation.

These activities lead to the better understanding of concepts from the application point of view. All students were made to attend the presentations compulsory to ensure that they gain more knowledge on the concepts and opportunity was given for discussion. This helped the students to improve their presentation, communication skills and their confidence level.

- Industry visit to EMC Corporation

EMC Corporation Industry visit was organized with the help of TEQIP II sponsor of our college. It was a one day visit; we took around 30 students who were interested and scored well in CIE. Schedule was given by EMC Corporation. The employee in charge took us to view the Research Lab. We were allowed to go through each part of the Lab; they explained the implementation and functioning of SAN, fibre cables, RAID, NAS, virtualization and cloud setup. The students were able to correlate the concepts they studied and their implementation in data centre. It gave a good exposure to students.

They have provided an opportunity to have an interactive session with CEO of EMC Corporation, they discussed with students about upcoming technologies on storage and big data, how to improve thinking ability and job opportunities in the next 5 years down the lane.

- EMC Proven Professional Certification

After the course completion, we conducted EMC Proven Professional Certification for all 60 students online in our college campus. Date and time slot was given by EMC Corporation. The exam was on ISM version 2.0 where the student had studied ISM version 1.0. Therefore the version 2.0 syllabus was given to the students well in advance for preparation.

## V.ASSESMENT METHOD

As our institution is an autonomous college, the assessment is split-up into two parts as CIE and SEE. In CIE student is assessed throughout the semester and SEE was conducted at the end of the semester through written exam.

Assessment is done as part of continuous evaluation. Out of 100 marks, weightage given to CIE was 50% and for SEE 50%. Real time case studies were assessed in SEE and CIE. 10% weightage was given for an activity to assess their understanding, communication and presentation skills. More

time was consumed for activity as there were 60 students' presentations. Industry visit and EMC Proven Professional Certification had no weightage since it was an opportunity given to students to assess themselves.

The proposed SAN curriculum design aims to attain the program outcomes [9] described in Table 1.

Table 1: Assessment of Pos mapped to CLO's

| POs | PO description | CLO's Addressed |
|---|---|---|
| a | An ability to apply knowledge of mathematics, computer science and engineering. | 1,2,3,4,5 |
| g | An ability to effectively communicate technical information in oral, presentation, and in writing. | 5 |
| h | Students will have the broad education necessary to understand the impact of computer engineering solutions in a global/societal context. | 5 |
| i | Recognition of the need for an ability to engage in lifelong learning. | 5 |
| j | Knowledge of contemporary issues. | 4,5 |

## VI.COURSE OUTCOMES AND OBSERVATIONS

This section summarizes the outcomes of different activities for effective teaching of SAN course.

1. Author's approach of discussing real time scenarios helped students to answer better during their CIE and SEE. Sample case study illustrated below discusses the real time scenario ;

**Business Profile:**
A mid-sized publishing house has a centralized IT department located in San Francisco, CA, connected to 3 branch offices on the west coast. Recent analysis of the storage environment suggests that they are getting poor performance in their storage infrastructure.

**Current Situation/Issue:**
The company's current infrastructure consists of several storage arrays direct-attached to a heterogeneous mix of 90 servers. All servers are dual-attached to the arrays for reliability and redundancy.

Since each storage device has 32 connectivity ports, each could support a maximum of 16 servers. The company sees the 32-ports as a limitation. Each storage device has the disk capacity to support more than 16 servers. However, there was no way to add a 17th server to make use of that capacity and support future growth.

**Proposal:**
How would you suggest that the company restructure their environment? List the advantages and disadvantages of your proposed solution. (Note: You will need to justify your choice based on scalability, performance, and availability of the new solution).

**Solution:**

- 90 servers are available. All servers are dual-attached to the arrays for reliability and redundancy
- It means **Mirroring technique** is used where each storage device has 32 connectivity ports, each could support a maximum of 16 servers.
- Company requires more ports and each storage device has the disk capacity to support more than 16 servers.
- So company can restructure their environment by implementing **parity technique** for reliability and redundancy instead of mirroring.
- **Scalability**: As the number of ports will be more than 16, more servers can be connected.
- **Performance**: Storage capacity utilization will increase due to more ports.
- **Availability**: Availability, reliability, redundancy of data will be good when servers are connected with multiple ports

2. Activity on EMC products paper presentation has resulted in better understanding of concepts. It has increased the presentation, communication skill, team work and the student's confidence. Table 2 lists few white papers presented by students. There were 30 papers given to 60 students.

Table 2: Sample List of White papers

| Techniques | Paper |
|---|---|
| RAID | DELL/EMC CX SERIES Initial Configuration |
| RAID, Replication, Availability | EMC CLARiiON High Availibility (HA) |
| Replication | EMC Centera Replication |
| Mirroring, Recovery and Storage Management | EMC CLARiiON SnapView and MirrorView for Oracle Database 10g Automatic Storage Management |
| Network architecture | EMC Clariion Storage |
| Big Data | EMC From Storage to Big Data |
| Mirroring | EMC Mirror view Cluster Enabler |
| Business Intelligence | Configuring EMC CLARiiON for SAS Business Intelligence Platforms |

3. Industry visit gave an opportunity to view implementation of theoretical concepts and interaction with industry people.

4. EMC Proven Professional Certification exam has provided an exposure about certification exams for the students. 70% was the cutoff for the exam, out of 60 students, 20 to 25 students were in the range of 60 to 65%.

Table 3 describes outcomes of each activity carried out during the course.

Table 3: Activities and their outcomes

| Activity | Outcomes |
|---|---|
| EMC Case studies | <ul><li>Improved student's knowledge in understanding the concepts better.</li><li>Achieve lifelong learning.</li><li>Increase the Blooms taxonomy level in questions</li></ul> |
| EMC product paper presentation | <ul><li>Reading and understanding of technical white papers.</li><li>Gained acquaintance about how concepts are implemented in real time.</li><li>Improved communication and presentation skills and confidence level of students.</li><li>Accomplish lifelong learning.</li></ul> |
| Industry visit to EMC Corporaion | <ul><li>Exposure to industry working environment</li><li>Experienced the working of a data center with all the concepts studied.</li><li>Interaction with industry people and know the current and emerging technologies.</li></ul> |
| EMC Proven Professional Certification | <ul><li>Experienced the company exams</li></ul> |

A. STUDENT'S REACTION

Student's reactions at the end of the semester were;

- Students' appreciated EMC case studies used in classes, which helped them to understand concepts easily.
- Students cherished the EMC products white paper study, self learning and presentation
- Experience of industry visit was strongly appreciated as they were introduced to industry scenario.
- Good Opportunity provided to get certified for EMC Proven Professional Certification.
- Two students who undergone SAN course, placed in Microsoft are currently working in same stream.

B. EDUCATOR'S REACTION

At the end of the course educator's perceptions are as follows:

- There were more fruitful class discussions and higher learning curves.
- Improved the affinity between the instructor and all students in the class.
- There is an improvement of Blooms Taxonomy level in the assessment. Blooms Level 3 questions were increased in exams to strengthen the quality.
- If ISM version 2.0 was in the syllabus then it would be much easier for students for EMC Proven Professional Certification, which is incorporated in curriculum of 2014-15.

## VII. RESULT ANALYSIS

The Semester end exam results of two years (2012-2014) analysis are shown in Figure 1. In 2012-2013 there were no S grade students and peak is more for B grade and 1 student failed. During 2013-2014 result achieved was 100% because of pedagogical activities there is an improvement in the result. In 2013-2014 result 10 % of students have scored 'S' grade. Equally there is an improvement in 'A', 'B' and 'C" grades also. This course has been introduced during 2012-2013. So result analysis is done for two years data.



**Result analysis**

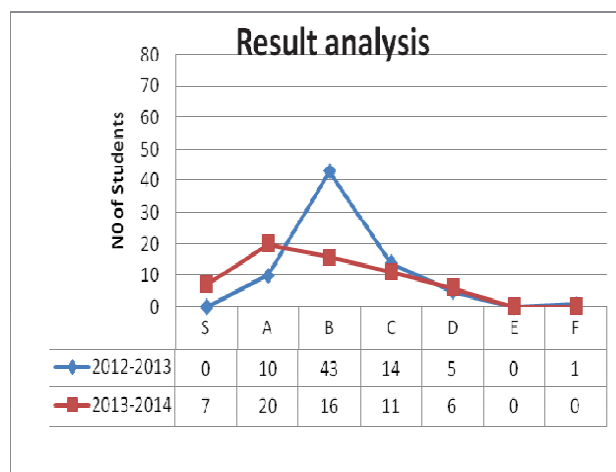| | S | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|
| 2012-2013 | 0 | 10 | 43 | 14 | 5 | 0 | 1 |
| 2013-2014 | 7 | 20 | 16 | 11 | 6 | 0 | 0 |

Figure -1: Result Analysis of SAN Course

## VIII. CONCLUSIONS

Storage technology is one of the nascent areas by making use of many hardware devices, networking protocols and storage management software. Human requirements are continuously changing over the years, to meet up with the new challenges innovations are very much essential. EMC's Storage Technology Foundations course covers "the big picture" including SAN, NAS, CAS, Back Up and Recovery, virtualization, cloud storage and array based replication. This paper describes the Storage Area Networks course objectives, implementation details ,assessment methods and ABET criteria mapping in the curriculum. This course will provide an opportunity to meet the needs of industry by providing students with an exposure in current storage technologies. Our colleges is having tie up with EMC Academic Alliance Program and uses the Storage Technology Foundations course to teach students and prepare them for the emerging challenges of data and information management. The goal of this partnership program is to prepare skilled storage leaders.

## ACKNOWLEDGEMENT

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