Solution Architecture Definition for "Mirroring of Virtual-labs at IITD"

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1 DOCUMENT NAME AND STATUS

Solution Architecture Definition

Mirroring of Virtual-labs at IITD
Lab Sources and VLEAD VMs

Document Status:	Draft
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2 DOCUMENT PURPOSE

The Solution Architecture Definition defines the overall architectural solution for the "Mirroring of Virtual-labs at IITD". The solution addresses the problem as documented

in the "VLEAD Mandate - Virtual Labs Integration: Deliverables, Resources and Budget 2012-06-02". The solution comprises a number of elements or components, which are partitioned into subsets for implementation. The primary audience of this document consists of IT and network architects.The primary purpose of this document is to communicate the essential elements of the overall solution so that operatational implications can be assessed and understood, and so that the design activities in Design & Build can proceed further. As such it tries to achieve the following:

- It provides visibility and exposure to other architects for peer review.
- It unambiguously defines the overall solution to the proposed requirements of the initiative.
- It provides a basis for assessment of the overall solution once implemented.
- It describes how the development and deployment of the solution can be phased if this is required to meet needs and or to meet technology constraints

3 PROJECT OVERVIEW AND STATUS

VLEAD (Virtual Labs Engineering and Architecture Division) team was setup in June 2012 as a central engineering team for integrating all the virtual-labs (around 180 in number) across all disciplines and institutes onto a common data-center (currently located at IIIT Hyderabad). Currently(as of 2013-08-15) around 86 lab sources are version-controlled and around 40 hosted out of IIIT data-centre. Hence, it becomes absolutely necessary to have atleast the sources mirrored at an additional location (identified as IIT Delhi) so as to ensure availability, reliability and faster recovery of **Virtual Labs** in case of unforeseen disasters or catastropes.

In very long term, the plan is to achieve live mirroring of all the lab content as well as to run **Virtual labs** out of multiple sites to ensure better availability, reliability and performance.

4 PROJECT SCOPE

The scope of this project is to have the sources of all the Virtual-labs mirrored at one of the servers at IIT Delhi. Additionally, other critical data on VLEAD VMs and containers are also planned to be mirrored as part of this initiative.

Table 1: Project Scope - Inclusions and Exclusions

Inclusions	Exclusions
Backup of Lab Sources	Live Mirroring of lab content and hosting
Backup of VMs and Containers	Mirroring of complete VLEAD Services
	Load-sharing between IIITH and IITD sites

5 PROJECT ROLES AND RESPONSIBILITIES

5.1 Key Stakeholders

Table 2: Key Stakeholders

AREA / POSITION	NAME	ROLE
Prime Stakeholders	Ranjan Bose	Principal Investigator (IIT Delhi)
	Venkatesh Choppella	Principal Investigator (IIIT Hyderabad)
Technology Stakeholders (IT, Vendors, Networks etc)	Chandan Gupta	Technical Manager (IIIT Hyderabad)
	Kuldeep Singh	Engineer (IIT Delhi)
	Suraj Ketan Samal	Engineer (IIIT Hyderabad)
	Technical Support	Technical Support (IIIT Hyderabad)

5.2 Escalation Levels

Table 3: Escalation Levels

Escalation Level	NAME	Email	CONTACT NUMBER
LEVEL 4	Ranjan Bose	rbose.iitd@gmail.com	+91-11-26591048
LEVEL 3	Venkatesh Choppella	venkatesh.choppella@iiit.ac.in	+91-965-2740281
LEVEL 2	Chandan Gupta	chandan@virtual-labs.ac.in	+91-970-3330781
LEVEL 2	Kuldeep Singh	kuldeep.002@gmail.com	+91-11-64674687
LEVEL 1	Suraj Ketan Samal	suraj@virtual-labs.ac.in	+91-868-6160862
LEVEL 0	Technical Support	engg@virtual-labs.ac.in	+91-40-66531592

5.3 Escalation Matrix

Below is the proposed response-time for various types of requests:

Table 4: Escalation Matrix

Escalation Level/Request Type	Urgent	Normal
LEVEL 0	2 hrs	2 days
LEVEL 1	4 hrs	5 days
LEVEL 2	6 hrs	10 days
LEVEL 3	1 day	15 days
LEVEL 4	3 days	25 days

Note:

- 'hrs' mean working hours and 'day' or 'days' mean working days
- 'response-time' means acknowledgement of the issue and work in progress on the same
- Below is the description of various Request Types:

Table 5: Request Types

Request Type	Description
Urgent	The complete solution or majority of the solution is affected. (Ex: Backups not happening any more due to some bug in the solution, Network Issues due to ISP down, power outage etc)
Normal	Minor bugs with little impact on the solution, change requests to the existing solution, and maintainance activities

6 SOLUTION ARCHITECTURE ASSUMPTIONS

Table 6: Solution Architecture Assumptions

Table 1.	Assumptions	
Number	Assumption	Description
ASS-01	Resources	Resources should be available at (IIITH and IITD) for setup and continuous support (trouble-shooting, fixing issues) throughout the duration of Virtual-Labs project
ASS-02	Infrastructure	Infrastructure at IIT Delhi will need to be setup within appropiate time-frames. It should be accessible from Virtual-labs datacenter,IIIT Hyderabad.
ASS-03	Data requirements	Data content and format for the mirroring-setup will not vary without agreement between VLEAD, IIIT Hyderabad and Virtual-labs,IIT Delhi teams.
ASS-04	Estimated Data	Labs Assumed =180, VMs Assumed = 55, Also, it doesnot include backups of individual VMs (one-vm-per lab model).
ASS-05	Change management	All subsequent changes to this interface will need to be signed off by all the prime Stakeholders and updated accordingly in this document.

7 SOLUTION OVERVIEW

7.1 Current Architecture Overview

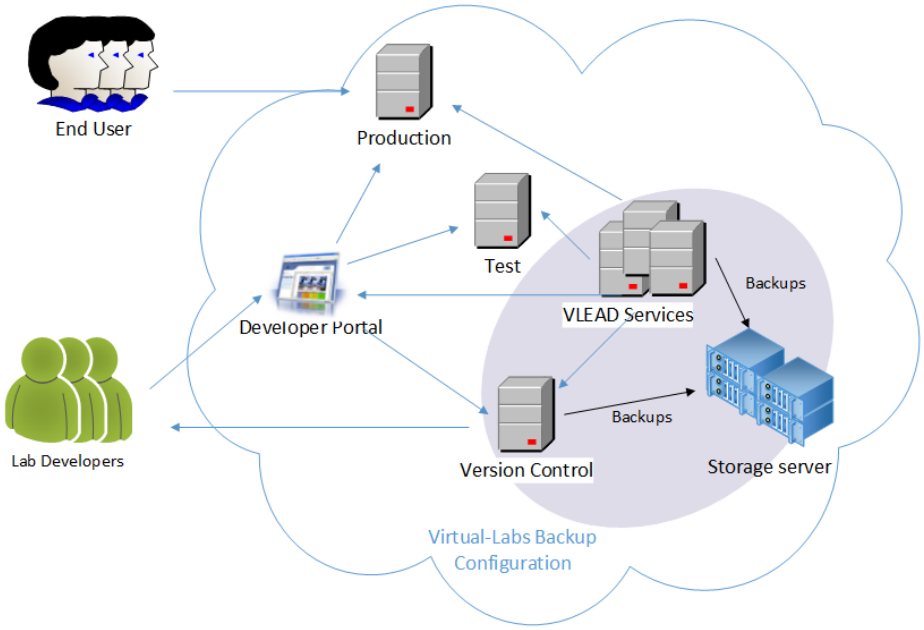

Figure 1: Current Architecture

Sources of all virtual-labs are stored in the version-control VM(*svn.virtual-labs.ac.in/bzr.virtual-labs.ac.in/git.virtual-labs.ac.in*) at Virtual Labs DataCenter, IIIT Hyderabad. These sources are uploaded (checked-in) and downloaded (checked-out) over HTTP and SSH publicly by different lab developers across all the institutes. This critical data is already backed-up on a storage server(SAN) located in the same data-center.

Additionally, there is also critical data belonging to services provided by VLEAD (*eg. ldap, developer-portal, ns, mail*) which is used by Virtual-labs community and VLEAD internally. This data is across different Virtual machines setup at Virtual Labs DataCenter, IIIT Hyderabad. Selected file-systems from all these VMs is already backed-up on the same storage server(SAN) in the existing data-center.

7.2 Proposed Architecture Overview

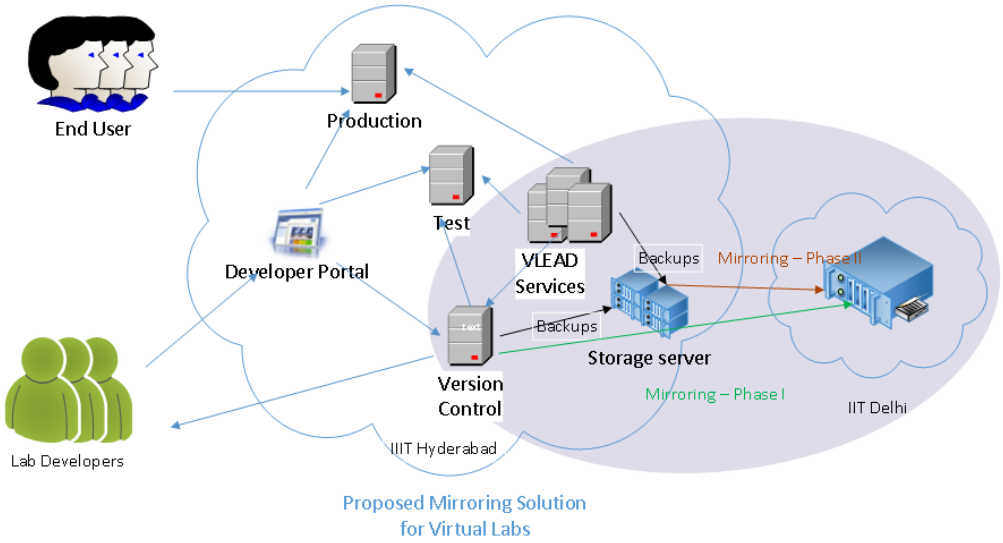

Figure 2: Proposed Architecture

- All the critical data(as described above) at IIIT DataCenter will be mirrored at an offsite location(IIT, Delhi) using a mechanism that syncs data overnight at a specified time everyday.
- In Phase-I, a overnight cronjob would be scheduled at the IIIT data-center to push all the virtual-lab sources from version-control server to the mirrored location at IITD.
- In Phase-II, the cronjob would be modified to additionally backup VLEAD service VMs from the storage server(SAN) to mirrored location at IITD.

7.3 Architectural Decisions

Here are a summary of significant decisions and the rationale behind the decisions used to derive the solution. This table represents a single decision and each decision in a table format.

Table 7: Architectural Decisions

Subject Area	Area of Concern
Architectural Desicion	AD-001 Backup principle
Issue or Problem	Which backup/restore tool should be used ?
Assumptions	
Motivation	- Data sizes are huge, hence need to have a mechanism to send incremental data rather than sending all the data everytime. - Backup/Restore process should be recoverable, so that in case of failure, it can start from the place it failed. - Backup/Restore process should work seamlessly with a subset of data without any additional efforts. - Transfer of data over public network should be secure and encrypted. - Should be scalable (atleast up to the estimated specifications). - Should complete within stipulated time-frames and not interfere with system's normal operations. - Should be automated requiring as less manual intervention as possible. - Backup tool should preserve the user/group/timestamp attributes. - Data needs to be pushed rather than pulled to enable VLEAD team to monitor the backup/restore process. - Should send data with parallel/simultaneous connections and in compressed format.
Options	Rsync, SCP (Secure Copy), Rsnapshot(uses rsync), Clonezilla (works at image level)
Decision	'rsync' tool to be used and scheduled on crontab. Data will be pushed from the source to the destination.
Justification	Rsync seems to closely satisfy all the requirements as mentioned earlier: - SCP cant be used in an incremental fashion and doesnot preserve filesystem attributes. - Rsnapshot is a good tool but applicable when it runs on destination and pulls data from source. - Clonezilla or other Imaging tools work at disk/filesystem level and not applicable in complete or partial backup/restore of directories.
Implications	'rsync' tool should be available on both the systems and an SSH account on the mirror-system is required
Derived requirements	Rsync should be installed on both source and destination systems.
Related Decisions	

Table 8: Architectural Decisions

Subject Area	Area of Concern
Architectural Decision	AD-002 Mirrored Platform Specifications
Issue or Problem	Which hardware/OS/softwares should be used for the target mirror destination and what should be its specifications ?
Assumptions	
Motivation	- Existing lab sources are versioned on linux platforms(open source). Hence mirrored location should also be Linux based so as to make the backup/restore process simpler. - Destination platform should be reliable, available and provide optimum performance. - Mirrored location should be operational remotely (aleast from IIIT Hyderabad). - Server should be accessible from Virtual-labs network, IIIT Hyderabad.
Options	
Decision	- Standard Platform (Multi-core Intel Xeon Series Processor) - Atleast 16GB of RAM - Atleast 1TB of available space after (RAID) - Redundant power backup - RAID Configured for reliability and optimum performance. - Multiple network interfaces (if possible). - An SSH account is required for maintainance purposes. - Rsync tool is required and should run on a port accessible form Virtual-labs network.
Justification	Decisions made according to items required in the Motivation section
Implications	
Derived requirements	
Related Decisions	

7.4 Architectural Issues

Table 9: Key Architectural Issues

Issue Identifier	Area(s) Impacted	Description	Status
ISS 01	Backup Data	Version control is currently in a different network (10.4.7.x) and needs to be migrated to (10.4.12.x) network before the solution is implemented.	Closed
ISS - 02	Security	Data on mirrored-location can be accessible to anyone having physical access to the system as it is a file-system backup.	Open
ISS - 03	Backup Tool	Rsync has problem with higher file-sizes (>2GB)	Open
ISS - 04	Network Bandwidth	Overall link bandwidth might not be reliable and intermittently slow. We should probably investigate use of a dedicated service line from IIIT Hyderabad to IITD based on the cost and future scope/plan	Open

7.5 Architectural Risks

Table 10: Key Architectural Risks

Risk [AR]	Description
AR - 01	Mirroring speed has an upper-limit equal to the network latencies of ISPs and hence the solution cannot be scaled infinitely.
AR - 02	Security is compromised as data travels using different ISPs over public network

8 SOLUTION DESCRIPTION

8.1 Functional Model

- The backup would be scheduled at 8:00PM overnight everyday.

- In case of a failure, the backup process would be configured to retry a maximum of three times after a gap of 15 minutes between each trial.

8.2 Re-use of Components

- Pre-existing rsnapshot backup/restore scripts and configurations developed for backups to the local storage(SAN) server at IIITH will be used as a baseline and will be re-used to implement the solution.

8.3 Information and Data Characterstics

8.3.1 Data Types

- All lab sources data to be mirrored are in repositories in the form of unix directories and flat-files.
- Databases would be dumped into flat(.sql) files and then backed-up as flat-files.

8.3.2 Current and Estimated Data Size

Table 11: Current and Estimated Data Size

Slno		Criteria	Current	Estimated	Comment
1	Labs	Total number	86	180	
		Min Size	1.2MB	1.2MB	
		Max Size	25G	25G	
		Average Size	1.02GB	1.02GB	
		Total Size	88GB	185GB	Estimated based on average size
		Incremental size(per day)	1GB	1.5GB	
2	VMs/Containers	Total number	29	53	
		Average Size	5.28GB	5.28GB	
		Total Size	153GB	280GB	Estimated based on average size
		Incremental size(per day)	1GB	1.5GB	

8.3.3 Data Security

- The mirrored data is not compressed or encrypted and will have the same file-system structure as on the source file-system. This is required as in our use-case, partial restore of the data will be required mostly where a specific lab or VM data

is required to be restored. Hence, it is **required** that the mirrored system be kept in a secured area where data cannot be compromised.

8.4 Infrastructure Model

8.4.1 Source(IIIT Hyderabad Datacenter)

- No additional infrastructure is required at IIITH Datacenter for this solution

8.4.2 Target(IIT Delhi DataCenter)

- Following are required specifications of the target system where the mirrored data is required to be kept:
  - Standard Rack mounted Server(Multi-core Intel Xeon Series Processor)
  - Linux based OS (CentOS preferred)
  - 16GB of RAM
  - 2TB of available space after (RAID)
  - Redundant power backup
  - RAID Configured for reliability and optimum performance.
  - Multiple network interfaces (if possible).
- Proposed system:
  - **IBM System x3650 M4**
  - http://www-03.ibm.com/systems/in/x/hardware/rack/x3650m4/index.html

8.5 Integration and Network Model

- A dedicated 2Mbps link is proposed for the mirroring system at IITD

8.6 Security Architecture

- This section describes the security controls that will be incorporated into the solution.

8.6.1 Network Security

- No special security features will be implemented as part of this solution apart from any features that already exist or are provided by the tools used as part of the solution.
  - Using rsync server, the target mirror will be configured to accept connections only form source and will reject connections from any other hosts.
  - Only required ports will be made open on the source and target systems.

8.6.2 System Security

- No additional system security solutions would be implemented. The source and target systems will be secured by default options provided by Linux Operating system (PAM, SSH Key-based/password authentication, IPtable Firewalls)

8.6.3 Application Security

This will not be applicable as the mirrored-location will be dedicated for this solution and no additional applications will be allowed to be running out of the system.

No special application level authentication/authorization will be implemented. Authentication and authorization will work at system level and covered by system security.

8.6.4 Operational Security

For operational purposes, the mirrored-system super-user credentials will be only shared amoung ?? **(To be discussed)**

8.7 Privacy

No specific measures are proposed to be implemented as part of the solution to cater to safeguard private data. This is a risk which is mitigated by having security at system level and physical level.

8.8 Performance

The performance of the system would greaterly depend on the network speed of the ISP at both source(IIIT Hyderabad) and mirrored location(IITD) and hence a small analysis was done to estimate the required network link-speed and scheduled duration of backup

8.8.1 Performance Modelling

Analysis Model.png Analysis Model.bb

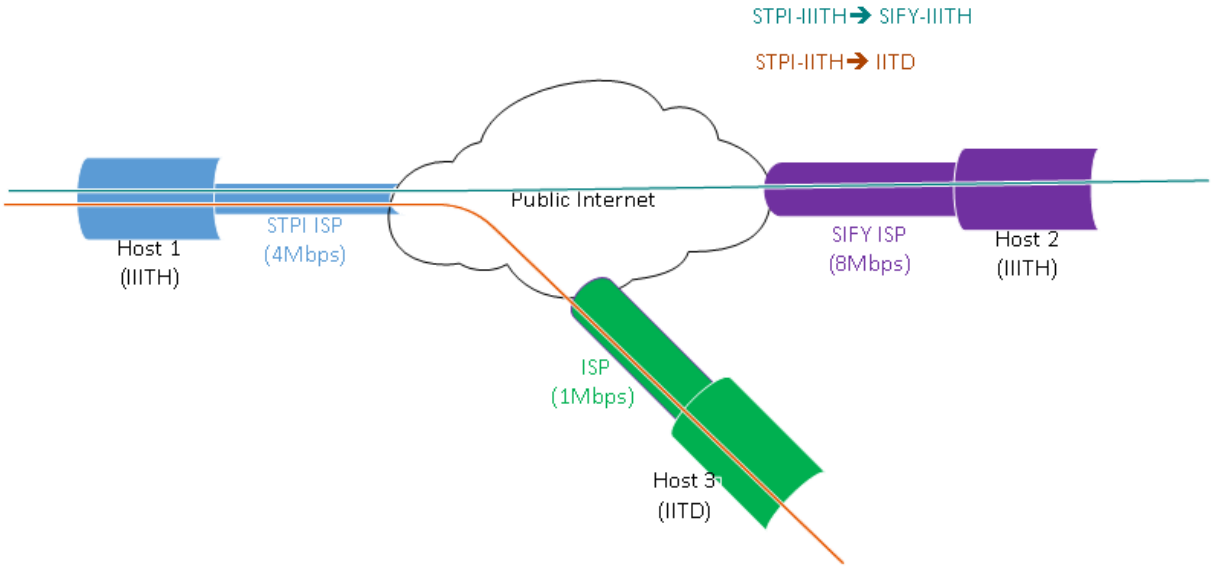

Figure 3: Performance Analysis Model

- Following two models were used to test and estimate the link-speed:
  - **STPI-IIITH to IITD**: Sample test-data was sent from one of the servers in IIITH on SIFY network to a test server located in IITD
  - **STPI-IIITH to SIFY-IIITH**: Sample test-data was sent from one of the servers at IIITH on SIFY network to another server on IIITH on STPI network

Table 12: Performance Modelling

Description	Source Upload speed (Mbps)	Destination Download speed (Mbps)	Average Size (GB)	Average Duration (Hrs)	Average Achieved Speed (Mbps)	Comments
STPI-IITH to IITD	4	1	1.38	4.61	0.73	
STPI-IITH to SIFY-IIITH	4	8	1.38	0.64	4.93	- STPI more reliable - Physical distance matters - Achieved bandwidth more because data gets compressed

Table 13: Performance Estimates

	Estimated Average Daily Size(GB)	Source Link-speed upload (Mbps)	Destination Link-speed download (Mbps)	Estimated Duration (Hrs)
Phase-I	1.5	4	2	2.5
Phase-II	3	4	2	5

8.9 Reliability and Availability

- The solution is required to be available all the time (24*7*365).
- Any outages at source or target mirror locations should be planned and notified apriori to that appropriate measures can be taken.
- Following would be implemented at platform and network level:
  - Hardware Level RAID Configuration would be used to ensure redundancy.
  - Multiple network ports on source and mirrored-system can be implemented.
  - Redundant power supply can ensure more availability.
- No measures at the application level will be implemented to ensure further reliability and availability.

8.10 Scalability

- The proposed solution is already planned to be scalable to the upper limits mentioned in the data characterstic specifications right from its inception and hence no specific scalability features would be implemented.

9 OPERATIONS

9.1 Monitoring

- The backup solution will be monitored manually once daily by the VLEAD Engineering team.

9.2 Alarms and Notifications

- No automated alarms will configured. Will be tackled on a reactive basis as per the escalation matrix.
- Email notifications will be configured to send the status or mirroring job everyday.

9.3 Reporting

- No Reporting mechanisms are implemented as part of this solution.

9.4 Capacity Planning

- Capacity planning for the entire solution is done in first stage itself and hence not required during operational phase of this project.

10 SOLUTION ACCEPTANCE CRITERIA

The solution should scalable for all the 180 labs and should be fast enough to run overnight and not affect normal operations of the systems and network.

11 IMPLEMENTATION AND MIGRATION

The solution is proposed to be implemented in two phases:

Table 14: Implementation Phases

Phase	Description	Dependencies
Phase-I	Mirroring of Labs	None
Phase-II	Mirroring of VMs and Disaster recovery testing	Phase-I

Detailed breakup and estimates of the subtasks can be found in "D10-mirror-sources.org" in VLEAD repository.

11.1 Efforts and Schedule(Phase-I)

Table 15: Schedule and Estimates - PhaseI

	Aug 2013	Sep 2013	Oct 2013
Deliverables	- Start Analysis - Tech-Specs	- Complete Analysis - Manual mirror setup at IITD	-Develop and install pilot scripts -Setup IITB mirror manually
Effort Estimates	80Hrs	80Hrs	80Hrs

	Nov 2013	Dec 2013	Jan 2013	Feb 2013	Mar 2013
Deliverables	- Deploy final scripts - Test and Fix issues - Documentation	X	X	X	X
Effort Estimates	80hrs	X	X	X	X

11.2 Efforts and Schedule(Phase-II)

	Schedule
Deliverables	Not yet planned
Effort Estimates	180 hrs

11.3 Migration Requirements

Since, the solution is built from scratch, no specific migration requirements are to be addressed

12 REFERENCES

Table 16: References

Document Number	Title	Location
	VLEAD Expert Committee Review - 25 July 2013 Presentation	<Vlead-Repo> /meetings-and-reviews /2013-07-25-expert-review /src/index.org
	VLEAD Engg Contract	<Vlead-Repo> /official-docs /2012-06-02-vlead-engg-contract.pdf
	Mirroring to IITD - Sub-tasks and Estimates	<Vlead-Repo> /plans//project-plan /grand-prix/estimates /D10-mirror-sources.org

13 DEFINITIONS

The following words, acronyms and abbreviations are referred to in this document.

Table 17: Definitions

Term	Definition
VLEAD	Virtual Labs Engineering and Architecture Divison
RAID	Redundant Array of Independent Disks
Engg	Engineering
IITD	Indian Institute of Technology, Delhi
IIIT	International Institute of Information Technology
VM	Virtual Machines
Containers	Light-weight Virtual machines
SAN	Storage Area Network
SSH	Secure Shell
HTTP	HyperText Transfer (or Transport) Protocol, the data transfer protocol used on the World Wide Web.

14 ATTACHMENTS

Document Number	Title

15 SIGN-OFF

The completion of the sign-off page is a testament by the signatories below that the following has been achieved or agreed:

- The document has been peer reviewed and all review-defects have been fixed
- The document is complete and accurate
- This document will be placed under configuration control

Table 18: Sign-Off

Reviewed Revision Number	0.2
Baseline Revision Number	
Baseline Date	
Author	Suraj Ketan Samal

Organisational Position	Professor, Dept. of Electrical Engineering, IIT Delhi	
Signature	<Attach e-mail approval or link to approval>	Date
Name	Ranjan Bose	Contact Number +91-11-2659104
Role	Principal Investigator, Virtual Labs Project	

Organisational Position	Associate Professor, IIIT Hyderabad	
Signature	<Attach e-mail approval or link to approval>	Date
Name	Venkatesh Choppella	Contact Number +91-965-274-0281
Role	Principal Investigator, VLEAD	

15.1 Major Comments

15.2 Documentation Location

Master Hard copy	Master Electronic
None	Stored in 'mirror' bzr repository on VLEAD server

16 DOCUMENT CONTROL SHEET

This section captures all changes made to the content of document. If you have any questions regarding this document or would like to suggest an improvement, contact:

Table 19: Contact for Enquiries

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Table 20: Record of Issues

Issue No	Issue Date	Nature of Amendment	Author
0.1	2013-08-21	Initial Draft	Suraj
0.2	2013-09-05	Updated with analysis and estimates	Suraj