Healthcare activities from anywhere anytime

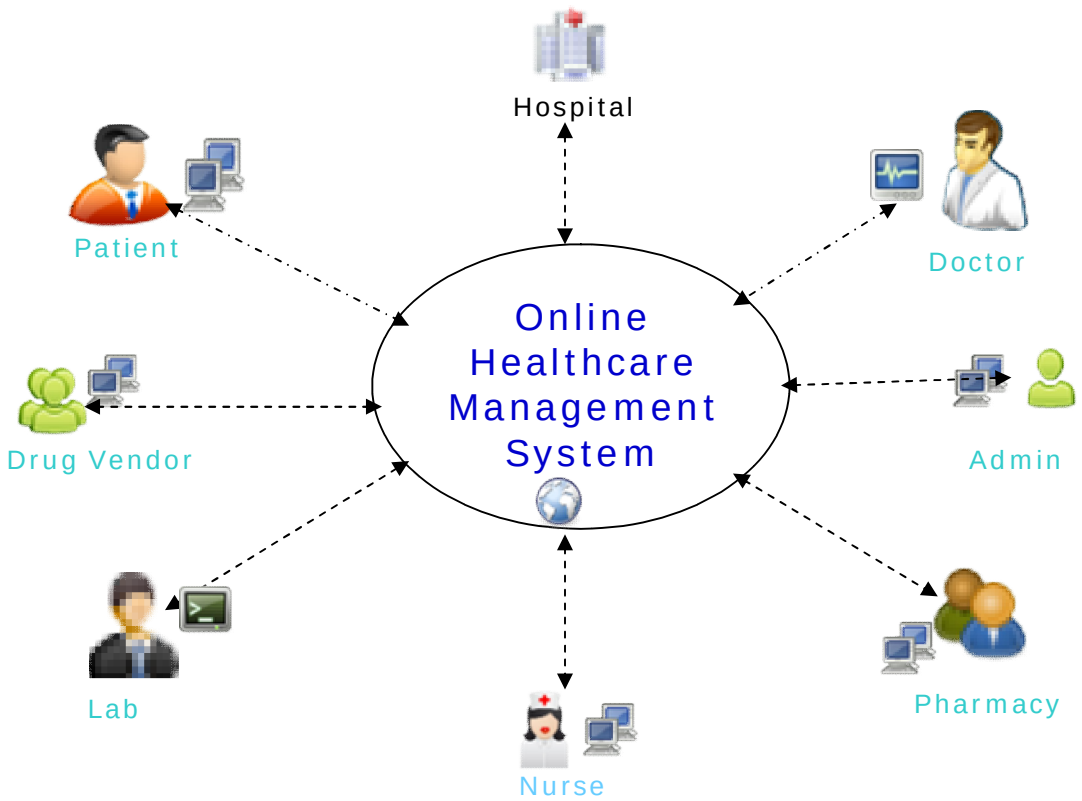
The deployment of OHMS™ in private cloud

1.0 Overview:

.OHMS™ is software as a service (SaaS) platform that enables the multiple users to login from anywhere and any device and execute healthcare activities in secure way. The vast majority of SaaS solutions are based on a multi-tenant architecture. With this model, a single version of the application, with a single configuration is used for all customers ("tenants"). To support scalability, the application is installed on multiple machines called horizontal scaling.

Users or Actors who are part of this system are Physician, Patients, Clinical Labs, Radiologist, Pharmacy, Drug Vendor, Patient Care (Nurse), Hospitals Admin etc

The following figure shows how each and every user is connected to the system and collaborates with each other.



User needs to register first to OHMS™ system and set username and credential. The system in turn generates unique ID called UHID which classifies user records by associating with it. In this system, users like physician, patients, or clinic initiate healthcare activities like creating event, schedule and electronic medical record. As this system is hosted in cloud, user's workspace consisting of records is within the boundary protected by cloud security. The medical records are kept in this protected region under the ownership of given user. The system provides user identity (authentication) based security and role based access control. The system provides features based on certain roles. Every Role has certain permissions on the record objects which are configurable by system administrator. For every record, there is an associated role corresponding to given record id and owner id with given permission set.

User can perform collaborative activities like sharing, referring, updating, deleting, notifying, tracking on Electronic Medical Records (EMR).

1.1 Actors & Users

a) Physician
b) Patient
c) Radiologist
d) Clinical Labs
e) Pharmacy
f) Drug Vendor
g) Patient Care(Nurse)
h) Administrators

2.0 Information Exchange & Collaboration Workflow:

Collaboration could be between physician and patient, physician and clinical labs or pharmacy, physician and nurse etc. Each and every actor works on EMR at their stake. For example, patient can view the complaint, diagnosis or medications record created by owning physician. Similarly, clinical labs can view patient diagnosis record when diagnostic tests mentioned as part of diagnosis record, are requested to that lab. Patient clinical tests and radiological diagnostic image are uploaded so that referring physician and concerned patient can view that and delete whenever done. Physician also notifies the pharmacy by the patient medications record so that pharmacy can collaborate both with physician and concerned patient for the drug availability or its inventory purpose.

The following workflow is the most fundamental multi actor's workflow OHMS system supports.

2.1 Basic Workflow:

- Users register into the system
- Respective users log into system with username and credential
- Patient search doctor into the system over internet.

- Patient creates appointment with the required doctor.
- Doctor logs into system and confirms/cancels appointment
- Patient gets notified about this.
- Doctor keeps patient record (complaint to treatment) into the system.
- Doctor sends diagnostic test request to Clinical Labs.
- Clinical Lab logs into the system and checks test request.
- Clinical Lab schedules appointment with patient for sample collection and clinical tests.
- Clinical Lab uploads test results.
- Radiologist uploads image and updates his/her diagnosis (Radiology Information) to the referring doctor.
- Doctor sends prescription to pharmacy.
- Patient collects medicine from the pharmacy.
- Drug vendor publishes drugs to doctors.

2.2 Clinical Lab tests workflow

- Physician adds diagnosis record for a given complaint.
- Physician adds lab test and diagnostic imaging test to be done by clinical labs or radiologist
- Physician or Patient selects the registered clinical lab or radiologist in the same city and notifies about the diagnosis tests
- Clinical labs or radiologist logs into OHMS and checks the clinical test requests.
- Labs or Radiologist views the diagnosis record and adds pathology record or radiology image respectively after conducting the tests with patients.
- Clinical Test request status is automatically changed to “uploaded” and alert is sent to referring physician.
- Physician tracks the request in case of emergency and checks the test report as soon as the tracked request shows status of “uploaded”

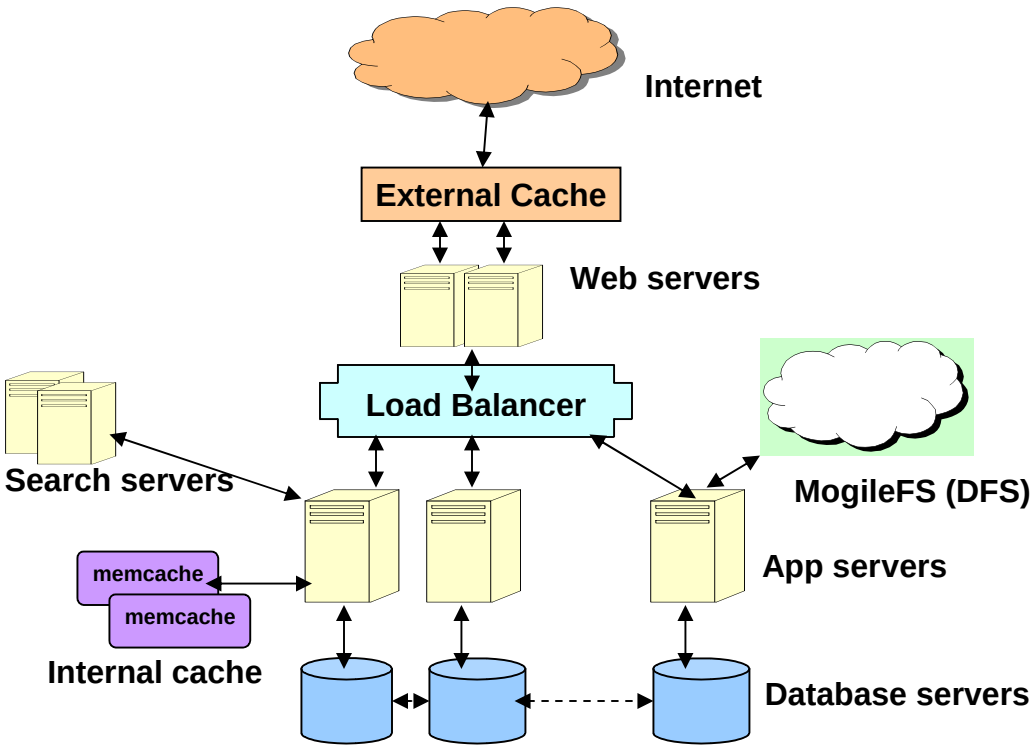
4.0 Security in collaboration:

Every user or actor has to login to the system to start accessing the OHMS over web from any where and any device. The user needs identity (username and credential) based authentication to get access to the system. As the software is hosted as service in private/public cloud, the system provides the time bound user session. After certain time of user remaining idle in session, the system forces user to login again so as to forbid un-authorized access by stealing the session cookie. Each record has owner and role associated with it. The system maintains certain categories of groups and corresponding roles based on the type of users associated with each group. For Example, Doctor Group has corresponding role which is owned by any doctor logging into system. Every role has certain permissions on each feature. The permissions are CRUD (Create, Read, Update

and Delete) type. Different Role may have different permissions on each feature being used by each group. The permissions are set by OHMS administrator.

We provide OHMS application both in private cloud as individual license and public cloud where individual is given subscription based usage.
In case of private cloud, the application will be hosted in the customer premise and administration will be handled by them. For application hosted in public cloud, the user will use the application as and when needed based on their yearly subscription. In this case, application and data will be maintained by OHMS Healthcare Pvt. Ltd in a secure data center. The following figure depicts the OHMS SaaS infrastructure and it's capability to service the customer's need.

OHMS SaaS infrastructure: (Public Cloud)



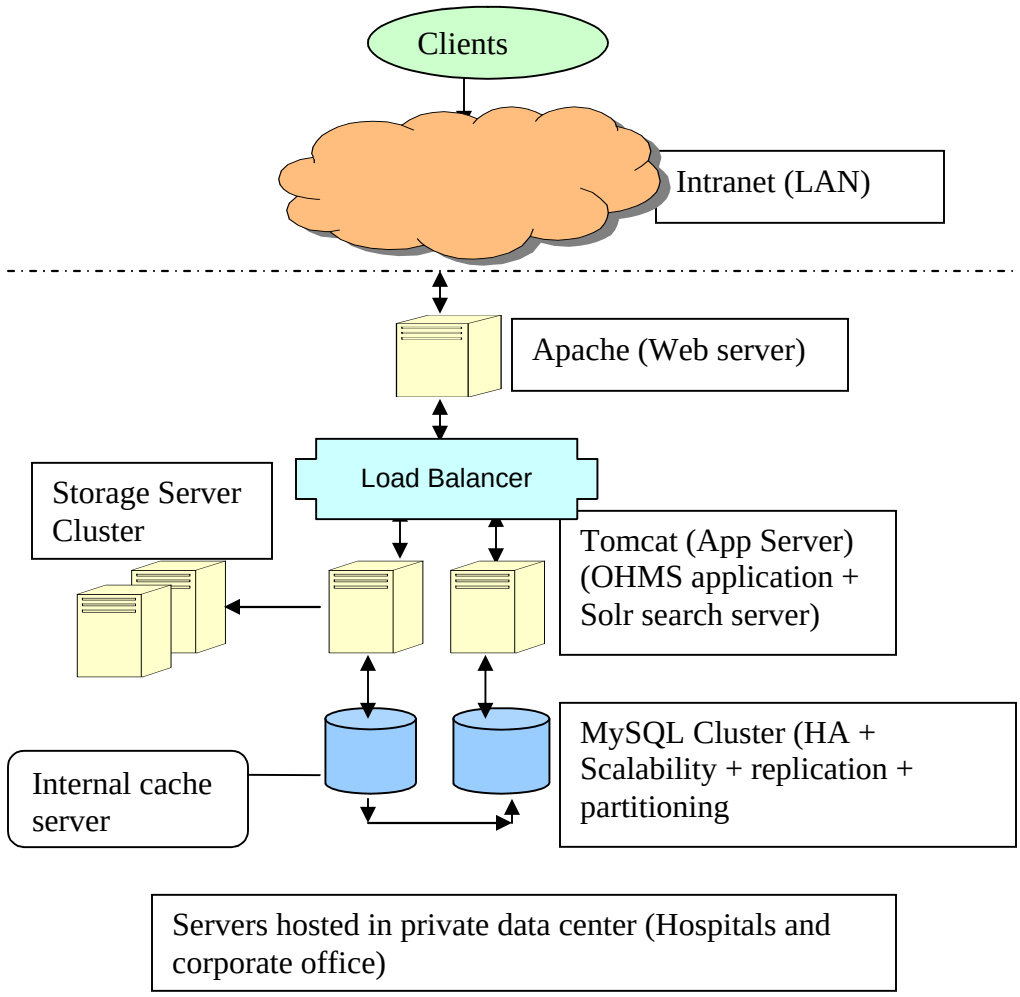
Data Centers:

The Web servers and App servers are running in Intel Xeon Quad core box with 16 GB RAM, 1TB SAS/SATA disk space. The OHMS application and search servers are

running in the App server Box. Internal caches are distributed among these boxes where RAM size is very high.

The MySQL clusters are formed with several instance of Server running in box with similar configuration. The Storage servers are running in Intel Xeon Quad core box with several TB of SAS/SATA disk spaces. The data centers can be scaled up to 100 of such hardware boxes base on the demand of concurrent user who accesses the OHMS application over Wide Area Network (Internet).

OHMS Deployment: (Private Cloud)



Deployment Configuration:

The private cloud is hosted in the company premises as a scaled down version of public cloud data centers. As shown in the above figure, there are a couple of hardware boxes which are sufficient to cater the limited number of users who access the OHMS application over LAN (intranet). In this case, there is one instance of Apache web server that load balances the multiple client requests to a couple of app servers (preferably 2 instance of Tomcat for number of users in the range of 200 – 400). The App servers connect to DB clusters consisting of a couple of hardware box. The Storage servers and internal cache servers are used in separate boxes.

The Hardware configuration (for users in the range of 200 – 500):

The Web servers and App servers are running in Intel Xeon Quad core box with 12 GB RAM, 1TB SAS/SATA disk space. The OHMS application and search servers are running in the App server Box. Internal caches are distributed among these boxes where RAM size is very high.
So, First box will have Apache web server, and load balancer into it. This could be simple Intel Core 2 duo box with 4 GB RAM (Ubuntu 10 32 bit OS).

Second and third box (Intel Xeon Quad Core with 12 GB RAM and 64 bit CentOS) will have Tomcat running into. These boxes will have internal cache server also running into it. In the same boxes, there will be two instances of MySQL server with cluster replications. The application OHMS and search and indexing servers will run out of these boxes.

Fourth box (Intel Xeon Quad Core with GB RAM and 64 bit CentOS) will have Storage servers (MogileFS distributed File System) running into. It will have several TB of SAS/SATA disk to handle PACS and other content management system. The some part of MogileFS can be installed in the first Box. Some internal cache servers can be distributed in this box so as to utilize the resource cost effectively.

The above configuration can be changed during installation and setup of private cloud based on capital expenditure budget.

Most scalable and performance driven web architecture:
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1. Web based, multi-layer, multi-tenant, SaaS based architecture. Many users can concurrently use the application over intranet and internet without having issue at all.
2. It supports all enterprise level RDBMS features (using MySQL) like master-master, master-slave replication, high availability in clusters, horizontal scalability of DB instances, horizontal partitioning of data on top of MySQL. It can support and host million’s patient records
3. Web server, application server layer are horizontally scalable. Based on the load or demand, server instances can simply be added with simple configurations.

4. The performance in every layer including application server layer and database layer is enhanced by distributed caching using internal cache servers called memcache.
5. Search of records is handled by dedicated cluster of search and indexing servers (using Apache Solr) in order to make data retrieval fast and independent of RDBMS search
6. To handle the growing demands of medical content (PACS and RIS), dedicated storage servers are hosted using distributed file system (MogileFS) where storage node can be dynamically scaled out.
7. The application deployment uses a lot of open source component, so that they can be customized and modified according to the needs of functionality, performance and scalability.
8. OHMS Application itself is vertically scalable, and all its subsystems are loosely coupled and event driven mostly. The data resides in shared database, so there is no security thread and risks in data transit unlike system based on HL7 protocol. The computing of application happens in the central servers of data center thereby reducing cost of end device or client.