JXTA Based P2P Healthcare and Hospital Management

3.1 INTRODUCTION

In today’s world it is very well recognized, that the public health requires a multi-talented approach with total involvement and professionalization to achieve quality with high reach to the rural people with cost effectiveness. Hence the total focus has been shifted to monitor the activities of doctors, nurses and other health professionals to serve better in the rural public health centres. This is a fast growing concern in this decade regarding monitoring activities of health professionals and medical care because majority of Indians are in villages where there is a need to provide them better health with quality service like in the cities with latest technologies.

The most advance medications and facilities are poised as a cutting edge for hospital management and clinical care. Considering the PHC’s (Public Health Canters), 40% of the doctors find difficult to cover-up all the out patients during their working hours. For rural it’s difficult to get their basic treatment at regular intervals because the facility provided by the PHC’s were unknown to them and also sometimes due to an obsessive administration.

We have identified from our survey that even though the government taken many steps to overcome these issues but failed due to lack of transport and infrastructure at PHC’s with good health professionals.

Nowadays telecom networks are everywhere and Mobile Phones are with everybody. So we have designed an architecture which helps to monitor the activities of the health professionals for improved delivery of service in rural areas.

3.2 HOSPITAL MANAGEMENT SHORTFALL

PHC is the best source to the village community for providing health services and solving health issues in case of emergencies. Many of the rural PHC’s could not succeed this due to irregular participation of health professionals and inadequate
functioning of existing equipment’s. It needs regular monitoring. One solution which is followed is observations through announced visits. The role of Village Home Nurse (VHN) who is a part of PHC is to handle pregnancy cases exclusively, which also needs monitoring. Much Percentage of villagers accessing to various PHC’s round the year for their health issues and are turning to city hospitals due to the shortfall of Experts/facilities. As the PHC’s are main source for the rural it need to function regularly with good management and the public need to be given high importance for securing their health.

The table below represents the percentage of villages that are provided with infrastructure and various services provided for patients in rural India

Table 3.1 Health Infrastructure in Rural India

<table>
<thead>
<tr>
<th>Infrastructure Service</th>
<th>% Villages</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHC’s</td>
<td>75.5</td>
</tr>
<tr>
<td>Sub Centre</td>
<td>57.5</td>
</tr>
<tr>
<td>Government Dispensary</td>
<td>73.9</td>
</tr>
<tr>
<td>Private Clinic</td>
<td>76.6</td>
</tr>
<tr>
<td>Private Hospital</td>
<td>78.6</td>
</tr>
</tbody>
</table>

*(Information Source: National Rural Health Mission (NRHM))*

3.2.1 STRATEGIES FOR DEVELOPMENT

The PHC will stand to gain a great deal if they adopt a system to monitor all the activities of health professionals like doctors, nurses and pharmacists for their regularity to take care of rural public healthcare and management aspects. This may gain high potential for long time consistent strategy.

JXTA on mobile devices for P2P service supports hospital management and health care. The objective of the proposed frame work is to provide regular and better services to the rural people through PHC’s without shortfall and with an efficient management. Experimental evaluations lead good performance when compared with the present conventional systems. This frame work is confined for mobile-constraint devices with JXTA peer-to-peer application.
3.3 HOSPITAL AND HEALTH CARE FRAMEWORK

Mobile JXTA network has a streaming technique with good quality and no delay of service. Permanent IP network used for streaming is different from mobile IP networks. Streaming and messaging works in real time and has the limitation over the storage space. The P2P message server holds all the information’s related to SMS and MMS that are concerned to the doctors and the patients. P2P information store holds the data related to the doctors. The added components such as presentation servers, caching server are used to provide additional services for improving the overall quality of services. New patients who enter in the peer group will register their mobile devices in the registration peers. The framework designed here is more efficient when compared to the existing systems (like announced visits)

![Figure 3.1: JXTA Hospital and Health Care Framework](image)

3.4 WORK STREAM

The workflow of the above mentioned architecture is as follows

**Step 1:** The Health Director (above the Deputy Director) combined with the Health Minister is responsible for framing new rules and conducts review
meetings monthly with all the DD’s (Deputy Director’s) to know the progress of their districts and also directs with new instructions.

**Step 2:** DD’s are responsible for each district that controls and implements the decisions of the directors with the help of BMO’s (Block medical officer) and gives directions to all the health professionals.

**Step 3:** Each block for a group of PHC will have a BMO. He controls the Doctors, Nurses, Village home nurse, Pharmacist and Health inspectors.

**Step 4:** Doctors and specialised doctors who are assisted by the nurses with the help of record peer group which hold all the information about the patients.

**Step 5:** Nurses inside the nurse peer group are responsible for front desk registration through the patient’s mobile device which also provides

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Figure 3.2 Work Flow for Hospital Management

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22
- Billing
- Human Resource Management
- Emergency Treatments
- Hospitality
- Safety of Patients.

**Step 6:** Patients data’s from wards, specialised wards, operation theatres are sent to the record peer group.

**Step 7:** Monitoring of all the health professionals can also be done through live streaming in the JXTA network.

**Step 8:** Streaming of videos can be done on both ends for monitoring and for sharing of patients records.

**Step 9:** Pharmacist in the Peer group is responsible for message delivery to the patient’s mobile device through SMS.

### 3.5 DUAL WEIGHT VECTOR QUANTIZATION ALGORITHM

There are wearable sensors that can measure *Body temperature, Pulse rate, Oxygen level in blood (SpO₂) and Blood Pressure*. These readings can be sent to patient’s mobile via wireless communication channels. This data can be messaged to Record peer group through JXTA framework. The record peer group can classify these set of readings as ‘normal’ or ‘critical’. **Dual Weight Learning Vector Quantization** is proved to have a low computational complexity.

![Figure 3.3. Dual Weight Vector Quantization Algorithm](image-url)
In the above figure X₁, X₂, X₃, X₄... Xₙ whose readings are obtained from the wearable sensors.

If we have n types of readings from the wearable sensors, we use n-dimensional training vector (x₁, x₂, x₃... xₙ). It is easy to get a set of such readings and corresponding outputs from patient records. Select some of these input vectors as reference vectors ‘W’. And the rest as training vectors ‘X’. Initialize importance vector λ (= 1/n) for each W, learning rates (α and ε) and maximum number of iterations.

If max numbers of iteration reached, Stop.

Else, Continue.

For an arbitrary training vector Xᵢ find nearest reference vector Wₘ using:

\[
\text{Distance between } X_i \text{ and } W_m = \sum_{j=1}^{n} \lambda_m^j (x_i^j - W_m^j)^2
\]

If Wₖ is the nearest reference vector, update:

\[
\begin{cases}
W_k = W_k + \alpha (X_i - W_k) & \text{if class}(X_i) = \text{Normal class}(W_k) \\
W_k = W_k - \alpha (X_i - W_k) & \text{if class}(Y_i) \neq \text{Critical class}(W_k)
\end{cases}
\]

Update importance vector λₖ as follows:

\[
\begin{cases}
\lambda_k^n = \lambda_k^n + \varepsilon \left( \frac{D}{N} \cdot d_k^n \right) & \text{if class}(Y_1) = \text{Normal Class (Wₖ)} \\
\lambda_k^n = \lambda_k^n - \varepsilon \left( \frac{D}{N} \cdot d_k^n \right) & \text{if class}(Y_2) \neq \text{Critical class}(W_k)
\end{cases}
\]

and \( \lambda_k^n = 0 \) if \( \lambda_k^n \leq \delta \)

where D = distance between Xᵢ and Wₖ,

Sensor measuring parameters and patients record peer group are shown in table 3.1 and 3.2

**Table 3.1 Sensor Measuring Parameters**

<table>
<thead>
<tr>
<th>Wearable Sensors</th>
<th>Parameters</th>
<th>Normal</th>
<th>Critical</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>AD590(omega)</em></td>
<td>Body Temperature(BT)</td>
<td>98.6</td>
<td>102</td>
</tr>
<tr>
<td><em>Piezoelectric Sensor</em></td>
<td>Pulse Rate(PR)</td>
<td>72/min</td>
<td>80/min</td>
</tr>
<tr>
<td><em>Pulse Optimizer</em></td>
<td>Oxygen Level in blood(OL)</td>
<td>80%</td>
<td>90%</td>
</tr>
<tr>
<td><em>SenSym SDX05D4</em></td>
<td>Blood Pressure(BP)</td>
<td>120/80</td>
<td>130/100</td>
</tr>
</tbody>
</table>
Table 3.2 Patients Data’s in Record Peer Group

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Record Peer Group (Data’s)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAT 010</td>
<td>98.6(w₁₁) 72(w₁₂) 80(w₁₃) 120/80 (w₁₄)</td>
<td>NORMAL(Y1)</td>
</tr>
<tr>
<td>PAT 011</td>
<td>99.6(w₁₂₁) 79(w₁₂₂) 89(w₁₂₃) 120/80 (w₁₂₄)</td>
<td>CRITICAL(Y2)</td>
</tr>
<tr>
<td>PAT 012</td>
<td>98.6(w₁₃₁) 72(w₁₃₂) 80(w₁₃₃) 120/80 (w₁₃₄)</td>
<td>NORMAL(Y1)</td>
</tr>
<tr>
<td>PAT 013</td>
<td>98.6(w₁₄₁) 72(w₁₄₂) 80(w₁₄₃) 130/90 (w₁₄₄)</td>
<td>CRITICAL(Y2)</td>
</tr>
<tr>
<td>PAT 014</td>
<td>98.6(w₁₅₁) 72(w₁₅₂) 80(w₁₅₃) 120/80 (w₁₅₄)</td>
<td>NORMAL(Y1)</td>
</tr>
</tbody>
</table>

\[ X₁ \{ w₁₁, w₁₂, w₁₃, w₁₄ \} \rightarrow \text{Normal} \]
\[ X₂ \{ w₂₁, w₂₂, w₂₃, w₂₄ \} \rightarrow \text{Critical} \]
\[ d_k^n = \lambda_k^n(X₁^n - W_k^n)^2 \]
and \( \delta \) is predefined threshold such that \( 0 < \delta < 1/n \)

Once the sensor readings are classified, they are sent to nurse peer which is associated with the patient. The nurse can request information from BMO (M2) regarding availability of doctors as well as years of experience. If this output is critical, a highly experienced doctor can be informed. The nurse can immediately know if there is a serious condition with regard to the patient. An appropriate precaution can be taken in advance.

3.6 PEER GROUP ADVERTISEMENTS

Advertisement is imposing of hierarchy elements in the proposed system. Peer group advertisement is followed which describes peer group specific recourses service name, group id, service description, patient specification and service parameters. One sample advertisement is given below.

```xml
<?xml version="1.0"?>
<Doc Type=JXTA=Peer Group Advertisement (PGA) -> Patients>
<JXTA:PGA>
<GID>
Urn:JXTA:uuid-BCBCDEABBBAABAAABAAAAB000
</GID>
<MSID>
Urn:JXTA:uuid-BCBCDEABBBAABAAABAAAAB001
</MSID>
{Name>
Patients Peer Group
</Name>
<Desc>
Peer Group send messages to patients related to medical camps
</Desc>
</JXTA:PGA>
```

Figure 3.4 Sample Peer Group Advertisements
3.7 EXPERIMENTAL AND CONTROL SETUP

The existing system is analysed and directed based on the study. The factors considered in the experimental design are

- J2SE, JDK, Nodes (2.4GHz Intel P4, 1GB of RAM, linux 2.4.22)
- JXTA- Inst.exe peers via JDF (1 rdv peer and 2 edge peers)
- Fast data stream interface
- Pipe service, End Point service (Peer ID).
- One Control Server

3.7.1 OUTCOMES OF THE EXPERIMENT

<table>
<thead>
<tr>
<th>Health care</th>
<th>Mobile Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Aspects</td>
<td>Choice of platforms, Avoid systematic Errors</td>
</tr>
<tr>
<td>Budget</td>
<td>Low installation cost</td>
</tr>
</tbody>
</table>

3.8 QUALITY HOSPITAL MANAGEMENT SOLUTIONS

Simulation results produce 100% accurate results with following advantages

- Reduces 75% of operational cost
- 85% reduction of paperwork for storing daily reports.
- Customized workflow
- Follows up of rules.
- 60% improvement in patient care.
- Hospital centric online access.
- 80% reduction of monitoring flow time.

3.9 IMPLEMENTATION

A study in a rural public health center is considered for implementation. It consists of two phases they are

1. Monitoring the Hospital
2. Healthcare through Dual Vector Quantization Algorithm

Seven peer groups were created accordingly as shown in figure below. The figure also shows how to find peer groups and share files inside the peer groups which
makes the peers to Export and Import data’s within the peer group. Creating new
peer groups, joining and managing the peer groups has been mentioned.
Guidelines for new users on registration through the JXTA network have also
been mentioned.

Table 3.4 Nurses Send Patients Records to Doctors

<table>
<thead>
<tr>
<th>Nurse Peer Group</th>
<th>Patient ID</th>
<th>BT</th>
<th>PR</th>
<th>OL</th>
<th>BP</th>
<th>Doctors Peer Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse 1</td>
<td>PAT 011</td>
<td>99.6 (w₁₁)</td>
<td>79 (w₁₂)</td>
<td>89 (w₁₃)</td>
<td>120/80 (w₁₄)</td>
<td>Critical</td>
</tr>
<tr>
<td>Nurse 2</td>
<td>PAT 010</td>
<td>98.6 (w₁₂)</td>
<td>72 (w₁₃)</td>
<td>80 (w₁₄)</td>
<td>120/80 (w₁₄)</td>
<td>Normal</td>
</tr>
</tbody>
</table>

Figure 3.5 Patient Registration Through Mobile Device
Figure 3.6 Patients Health Conditions Sent

Figure 3.7 Authentication to Monitor Health Professionals
Figure 3.8 Peer Groups (Create, Join, Manage, Share)

Figure 3.9 Doctors, Nurses, Patients Graph Galore
Figure 3.10  DD Peer group Monitoring Health Professionals Galore

Figure 3.11 Prescription form sent to patients mobile
3.10 COMPARATIVE STUDY

Table 3.5 Existing Hospital management VS JXTA Management

<table>
<thead>
<tr>
<th>Concerns with Existing Hospital Management Solutions</th>
<th>Advantages of JXTA Hospital Management System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitability with unique practices</td>
<td>Enhanced practice, acceptance by the patients</td>
</tr>
<tr>
<td>Predetermined features with lot of challenges in customization.</td>
<td>Fully customized according to the requirements.</td>
</tr>
<tr>
<td>Requires higher cost for Implementation</td>
<td>Distributed cost</td>
</tr>
<tr>
<td>Tough in Interfacing</td>
<td>Interfaces can be designed with existing systems. Separate network for file sharing.</td>
</tr>
<tr>
<td>Web based solutions requires web pages</td>
<td>Enhanced practice, acceptance by the patients</td>
</tr>
</tbody>
</table>

3.11 PERFORMANCE MEASURE

The Experimentation is performed from Dec 2010 to Dec 2011 using JXTA network in a rural public health centre (Anaicut, TamilNadu, India). We selected all the peer groups for streaming applications and file transfer within the peer groups. The control server monitors the activities of doctors and nurses, sends control messages to doctors through BMO (Block Medical Officer) and BMO’s through DD’s

Table 3.6 Quarterly Evaluation for different peer groups

<table>
<thead>
<tr>
<th>Month</th>
<th>No of Patients</th>
<th>Referred/Record Peer Group</th>
<th>External Peer Group</th>
<th>New Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 10 –Mar 11</td>
<td>120</td>
<td>70</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Apr 11 –Jul 11</td>
<td>230</td>
<td>120</td>
<td>62</td>
<td>40</td>
</tr>
<tr>
<td>Aug 11 –Dec 11</td>
<td>150</td>
<td>110</td>
<td>13</td>
<td>40</td>
</tr>
</tbody>
</table>

The above table represents peer group construction as a quarterly evaluation is done for managing the rural hospital through JXTA network. 500 patients were
monitored and 300 patients were referred to doctors whose status were obtained from Record Peer Group, 100 patients to specialized doctors and 100 to new users respectively.

During this evaluation, based on the requirements we have considered 500 users which include (new users, Record peer group, External peer group).

The proposed system reduces the distribution cost, saves time for sending reports and monitors the health professionals.

![Figure 3.12: Exploring P2P File Transfer in Hospital Environment](image)

Simulations produce accurate results from customized work flow and produce hospital centric access where patients care has produced a drastic improvement.

![Figure 3.13: Quality Improvement Quarterly](image)
3.12 CONCLUSION

The framework provides a structured solution to control and monitor the rural hospitals through mobile streaming supported by the JXTA network. It uses wearable sensors to measure Body Temperature, Pulse rate, Oxygen level in blood, Blood Pressure and sends to nurses who in turn refer to doctors. The hospital and healthcare framework is developed mainly for file sharing, mobile streaming for monitoring and controlling, Advertisements within the peer groups that supports the JXTA network. The enhanced study results in knowledge mining and cloud based M-health management technology comparing to the traditional system.