Real Time Emergency Care Monitoring using Data Stream Processing

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Abstract:
Emergency Medical Services plays a vital role in hospitals by providing critical care to the life threat patients. The practice of emergency medicine is naturally has intrinsic weaknesses vulnerable to mistakes. Any risk in such critical service will lead to serious issue. As a business solution to avoid risk in emergency care, we propose real time monitoring system using the hospital information. Almost 90% of the hospital with casualty use HMS / HIS for hospital management. The information stored in HMS database is our data source. Casualty related data available from hospital are acquired using stream or APIs to a centralized server. The data will be like admission details, emergency medicine and oxygen cylinder stocks, biomedical equipment status, etc. The acquired data are processed in real-time and also few were stored for later processing. The processed data are visualized in web dashboard for human monitoring. Also we provide automated alert mechanism to alert the risk through SMS/ Mail. The data from all the hospitals in a region or district or state should be acquired to central window in real time. As we are handling huge no of hospital data streams, we propose a scalable processing solution using data stream processing in big data technologies. As the data are monitoring related, they are mostly repetitive data and it will be junk data to store them database. We required scalable processing solution without storing them to data base. We use Spark along with Kafka to achieve scalable processing solution to handle any know of hospital data streams. Selectively few data required for historical analysis were stored in database for later analysis. Overall the whole solution assists centralized risk monitoring in emergency \ casualty department of hospitals. The existing public sector emergency service like 108 and 104 service Or group of private sectors which required centralized service may be the end users.

1. INTRODUCTION

1.1 EMERGENCY DEPARTMENT\ CASUALTY
An emergency department (ED), also known as an accident & emergency department (A&E), emergency room (ER), emergency ward (EW) or casualty department, is a medical treatment facility specializing in emergency medicine, the acute care of patients who present without prior appointment; either by their own means or by that of an ambulance. The emergency department is usually found in a hospital or other primary care center. Due to the unplanned nature of patient attendance, the department must provide initial treatment for a broad spectrum of illnesses and injuries, some of which may be life-threatening and require immediate attention. In some countries, emergency departments have become important entry points for those without other means of access to medical care. The emergency departments of most hospitals operate 24 hours a day, although staffing levels may be varied in an attempt to reflect patient volume.

1.2 SPECIAL FACILITIES, TRAINING, AND EQUIPMENT
An ED requires different equipment and different approaches than most other hospital divisions. Patients frequently arrive with unstable conditions, and so must be treated quickly. They may be unconscious, and information such as their medical history, allergies, and blood type may be unavailable. ED staff are trained to work quickly and effectively even with minimal information. ED staff must also interact efficiently with pre-hospital care providers such as EMTs, paramedics, and others who are occasionally based in an ED. The pre-hospital providers may use equipment unfamiliar to the average physician, but ED physicians must be expert in using (and safely removing) specialized equipment, since devices such as military anti-shock trousers (“MAST”) and traction splints require special procedures. Among other reasons, given that they must be able to handle specialized equipment, physicians can now specialize in emergency medicine, and EDs employ many such specialists. ED staff has much in common with ambulance and fire crews, combat medics, search and rescue teams, and disaster response teams. Often, joint training and practice drills are organized to improve the coordination of this complex response system. Busy EDs exchange a great deal of equipment with ambulance crews, and both must provide for replacing, returning, or reimbursing for costly items.

2. SYSTEM ANALYSIS

2.1 PROBLEM STATEMENT

2.1.1 RISK IN EMERGENCY CARE
Emergency Medicine by its nature has intrinsic weaknesses vulnerable to mistakes and dissatisfaction. Emergency departments operates 24 hours a day, seven days a week providing unrestricted access to patients with all types of injuries and illnesses at different degrees of severity. Patient attendance may be fluctuating, unpredictable and at times overwhelming. Patient conditions are usually acute and unexpected. Patients and accompanying persons are anxious and impatient. There is little patient rapport as this may be their first contact with the department. Critical decisions have to be made within the short patient stay in the department. This is especially taxing to the inexperienced staff. In some departments, rapid turnover of junior staff and inadequate senior super vision may further aggravate this risky situation.
2.1.2 OVERCROWDING

Emergency department overcrowding is when function of a department is hindered by an inability to treat all patients in an adequate manner. This is a common occurrence in emergency departments worldwide. Overcrowding causes inadequate patient care which leads to poorer patient outcomes.

Emergency department waiting times

Emergency department (ED) waiting times have a serious impact on patient mortality, morbidity with readmission in less than 30 days, length of stay, and patient satisfaction. A review of the literature bears out the logical premise that since the outcome of treatment for all diseases and injuries is time-sensitive, the sooner treatment is rendered, the better the outcome. Various studies reported significant associations between waiting times and higher mortality and morbidity among those who survived. It is clear from the literature that untimely hospital deaths and morbidity can be reduced by reductions in ED waiting times.

2.1.3 OPERATIONAL RISK

A hospital’s operational risks stem from the people, systems, and processes through which it operates. They can also include other classes of risk, such as fraud, legal risks, or physical or environmental risks. Operational risks for the ED can arise from issues with Facility, Privacy Equipment, Security, Safety Credentialing, Orientation, ED staff, Patient satisfaction, Consent, Telephone, Special patients, Discharge instructions, Specific problems and Test follow-up. During recent flood in Chennai, there was shortage of oxygen cylinders in hospitals. Even patient has gone in to risk due to unavailability of oxygen cylinders. In this case, the risk becomes higher due to increase of patients and shortage of resources. Lifesaving medicines should be kept enough to manage any patient crowd. During bus accidents, lots of patients get injured and they have to be reached to hospitals with enough to resource to handle the crowd.

2.2 EXISTING SYSTEM STUDY

Currently we have a centralized emergency transport service like 108. But we don't have a centralized monitoring \ event handling to prevent risk in emergency care. When we say centralized monitoring, hospital data required for risk analysis has to accessible in a single window. Same data has to be processed in real time and analyzed for risk. Few chains of hospitals under single organization have centralized data processing. But they mostly deal with business data and uses traditional ETL. There is no centralized medical record data exists. Identifying, accessing, analyzing, controlling, minimizing and preventing risk are important. So the risk has to be identified earlier and alerted to prevent before it occurs. Also the processed data has to be visualized for human analysis and decision making.

2.3 BUSINESS ANALYSIS

2.3.1 DATA SOURCE

For monitoring any system first need is information about the system. In our case, we need the operation information of the emergency care department. In a hospital, the operational details were recorded in Hospital Management System and Electronic Medical Record. Mostly 90% of the hospital with casualty used HMS \ HIS with EMR to record operational and medical data.

2.3.2 HOSPITAL MANAGEMENT SYSTEM:

A hospital management system (HMS) is a computer or web based system that facilitates managing the functioning of the hospital or any medical set up. This system or software will help in making the whole functioning paperless. It integrates all the information regarding patients, doctors, staff, hospital administrative details etc. into one software. It has sections for various professionals that make up a hospital. The Hospital Information System (HIS) is a province-wide initiative designed to improve access to patient information through a central electronic information system. HIS’s goal is to streamline patient information flow and its accessibility for doctors and other health care providers. These changes in service will improve patient care quality and patient safety over time.

2.3.3 DATA RELATED TO EMERGENCY CARE

Among the various data recorded in the HMS, the following data related to emergency care.

- Admissions, Transfer and Discharge (ADT) details in casualty.
- Medicine stock in Emergency department
- Equipment details in Emergency Department
- Casualty Beds and its occupied details
- Doctors and Nurse duty schedule
- Case sheet, prescription and diagnostic orders recorded for emergency patient.

2.4 TECHNICAL ANALYSIS

Implementation centralized monitoring major part were data acquisition, data processing, data visualization and data based event management.

2.4.1 DATA ACQUISITION

In our case we need to acquire the data from various HMS database. Hospitals use different HMS provided from different providers. Each HMS has different data base and schema. It is not cost effective to develop different acquisition service for each HMS. Service provide for data acquisition should be configurable for different database and different DB schema.

2.4.2 DATA STREAMING

Data acquired from HMS database has to be collected in the centralized system. As it is critical system, we need to collect and send data frequently for real time monitoring. We need some effective data queuing mechanism to receive the data. The data queuing system should be scalable to support adding any no of hospitals as per the need. It is cluster based an should be distributed to meet the frequent data from large no of hospitals.

2.4.3 DATA PROCESSING

Data collected through has to be processed at real time. There are three ways to process the data,
1. **Data can be processed while data acquisition and send processed data to the centralized server.**
   **Cons:** When we do any processing mechanism we need to deploy in each hospitals. Practically it has huge management cost.

2. **Data can be processed in the web application server before visualizing.**
   **Cons:** As per the increase of huge data, scaling the web application required more resources and management. There is no possible way to scale particular processing logic.

3. **Data processing using Big Data.**
   When comes to Big data, we have two architecture,
   - **Too Late Architecture:**
     Assess of structured and semi-structured historical data are stored in Hadoop (Volume + Variety).
   - **Fast data architecture**
     Stream processing is used for fast data requirements (Velocity + Variety).

### 3.3 SYSTEM ARCHITECTURE

#### 3.3.1 BUSINESS PROPOSAL

Based on the study and analysis on existing system, we propose a centralized monitoring solution for all hospitals in region or district or a state to prevent risk in emergency care. Here are many standards and criteria for preventing risk in hospitals. Here we take only few of them in our project. They are,

- Monitoring and alerting unattended patient Or Time taken beyond NABH standard for Initial Assessment of Emergency patients. NABH- National Accreditation Board for Hospitals & Health care Providers
- Centralized Resource Monitoring like Life Saving drugs stock, Oxygen cylinders and Bio medical Equipment status.
- Bed Availability Monitoring
- Notifiable diseases monitoring like Dengue and Malaria. Report the same to government.

#### 3.3.2 TECHNICAL PROPOSAL

As the data are related to risk management, we can’t wait for end-of-day analytics to make decisions. Here the real time processing becomes basic need. Also when all hospitals are brought to single window, the data stream will be huge in both volume and velocity. So we go with big data processing by implementing hybrid architecture of both too late architecture and fast data architecture.

- Causality related data available from hospitals are acquired and streamed to centralized server using Acquisition service. The service has schema and configuration related to the DB & Kafka connection and its data acquiring queries.
- The acquired data which are not required to store were processed in real-time using Apache Spark with Apache Kafka
- The data which required historical analysis were stored to HBase for later processing.

- The processed data are visualized in web dashboard for monitoring using spring web socket.
- At the same time event based server provides alert mechanism to prevent risk using SMS and Mail API
4. CONCLUSION

The emergency care real time monitoring system is completely versatile in gathering any HMS database, scalable for handling any of no of hospital stream data, configurable to support any metrics calculation and responsive in fast computation. Beyond the four metric implementations, the system can be enhanced to collect and compute more metrics as per the user requirement. The system implemented both real time and later processing as an example. Similarly based on the metric, the data can be processed at real-time or save in DB for later processing. Also data collection can be improved bringing in IOT into the picture. For example, the ambulance location and its availability data can be collected using mobile app. Based on ambulance availability can be added to the metrics. Also geo location of the hospitals can be collected to find the nearest best hospitals. This helps in decision making for ambulance to reach appropriate hospital. The overall system assits the emergency care management in all possible ways to deliver timely service to the life threatening patients.

5. REFERENCES


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