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HL7 Middleware Framework for Laboratory Notifications for Notifiable Diseases

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Abstract. LabSurv is an electronic notification system developed to support laboratories to directly notify the results of notifiable disease testing to public health services in New Zealand. A direct laboratory notification middleware framework was developed to manage the information flow between laboratories and public health services. The framework uses an HL7 messaging standard to receive the laboratory results and windows services to integrate the results with the cases of notifiable diseases within a national electronic surveillance system. This paper presents the system design and implementation details of direct laboratory notification system in LabSurv. It presents the HL7 messages structure implemented in the system. Finally, the performance of the system based on implemented framework is analysed and presented to evaluate the efficiency of our design.

Keywords. HL7, Laboratory Results, Public Health

Introduction

In New Zealand, medical practitioners have been required to report the cases of specified infectious diseases for over 100 years. Currently, 85 diseases are "notifiable" to a Medical Officer of Health in New Zealand [1]. Initially, the notifier was required to complete a specified form and send it by post to the local District Health Officer. Throughout the years, the delivery of this information has been systemised, in 2007, a secure web-based real time national disease surveillance system – EpiSurv – was deployed. EpiSurv enables Medical Officers of Health or other public health staff to record notifiable disease case details from clinicians in the national database and provides real time access to data for analysis at the national level [2]. EpiSurv is currently used by 20 Public Health Units (PHUs) throughout New Zealand, with 150 registered users. EpiSurv provides a robust and secure information management platform to deliver integrated and timely information to its stakeholders and end users.

In December 2007, new legislation for reporting of notifiable diseases by laboratories was enacted in New Zealand [3]. This new legislation required laboratories to report the results of tests for specified diseases directly to the Medical Officers of Health for that region. This legislation enhanced the current reporting by clinicians and provided comprehensive and timely information to Medical Officers of Health. In order to ensure information flow between laboratory systems and EpiSurv, an electronic reporting system – LabSurv – was developed as the technical backbone to support laboratories in notifying the data about communicable diseases [4]. LabSurv has been

in full service since March 2008. The application adapts the HL7 Radiology and Pathology Messaging standard for data exchange and a middleware framework to integrate data into EpiSurv allowing notifying laboratories to electronically transmit patient results to a Medical Officer of Health.

This paper presents the technical aspects of the HL7 middleware framework implemented for electronic data transfer of laboratory results within the surveillance system. The objective of this paper is to present technical solutions developed in New Zealand which could be applicable in surveillance systems of other countries or international networks. In the following sections we will describe the requirement, design, implementation and performance of our middleware framework.

1. System Requirements

The most important task of developing a health information system is to design the architecture for exchanging various medical information and data across systems. In the architecture design of LabSurv, several requirements have to be met while choosing and defining the standards to be used in our system. First, the system should be designed to be operated by laboratory staff and PHU staff. Hence, interfaces would be needed to exchange data electronically using existing national health information systems, laboratory information systems and EpiSurv. Second, the software architecture must be able to store the results in a solution, eliminating the need for users to manually enter data relating to the notification. Where appropriate, details from the electronic notification will be mapped into a case report form, avoiding the need for manual data entry. PHUs will be able to extract all data generated for their PHU for use in their local systems used to support their information needs for notifiable diseases. Third, new laboratory-reported cases are visible to local public health staff members who are then able to reconcile lab information with an existing notification for a patient. For example, if a corresponding physician report record does not already exist within the database a new case record is generated and allow a Medical Officer of Health to modify, close and delete the case. Finally, the national surveillance system i.e. EpiSurv would be the master source of the core data for notifiable diseases reflecting any change in the case status.

2. System Design and Implementation

To meet the above requirements, the end to end laboratory notification process is defined as follows:

Step 1. The clinician examines the patient, identifies the possibility of presenting symptoms of a notifiable disease.

Step 2. Sends patient to submit a sample for a laboratory test.

Step 3. The laboratory performs tests, if the criteria for notification are met then the laboratory generates and transmits an electronic message to LabSurv.

Step 4. LabSurv processes the message in real time and makes it available on EpiSurv as a notification to be viewed and actioned by the relevant Medical Officer of Health.

Step 5. The laboratory sends the test results in a report form back to the ordering clinician.

2.1. System Architecture

A middleware framework was designed to implement the end to end laboratory notification process and to meet the requirements as outlined in section 1. Figure 1 provides a high level overview of the direct laboratory notification (DLN) architecture in LabSurv designed to receive and update the notification data in EpiSurv. In this architecture, a laboratory receives a test request and undertakes the tests requested. If a lab result is positive for a notifiable disease, the laboratory information system sends a notification message in HL7 format to LabSurv. The message broker receives the valid message, passes the message to direct laboratory notification middleware in LabSurv and send a message acknowledgement back to the laboratory information system. The role of the message broker is to manage laboratory notification messages to ensure they meet the minimum data set standard and securely passed between the laboratory and the LabSurv. In DLN middleware, the HL7 handler module consist of two windows services, a message receiver and a message parser. The message receiver service receives the message and stores the raw message in the message store and passes the message copy to parsing module. The parsing module is implemented using Java Composite Application Platform which parses the required information from HL7 message and stores the notification information in the Notification database. A matching module attaches the notification information to a corresponding case in EpiSurv if it already exists, based on a match of key patient identifiers or creates a new case from information contained in the notification. The Medical officer of health accesses new notifications through the 'notifications module' on EpiSurv via a web browser at their PHU.

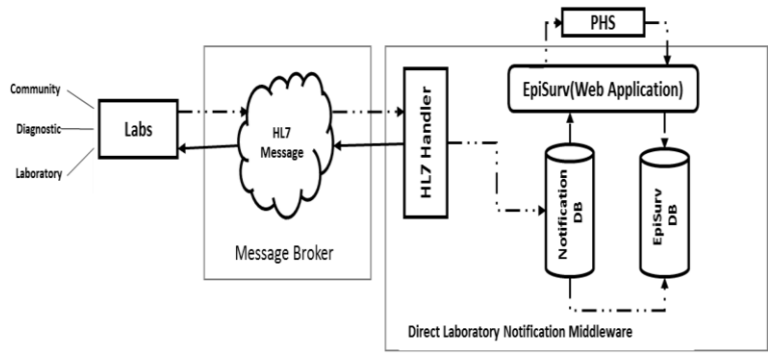

Figure 1. Direct Laboratory Notification Architecture in LabSurv.

2.2. HL7 Message Specifications

Message specifications have been developed based on information requirements for disease notification. This information includes demographic information for the patient, relevant clinical information and test results. Two types of messages are included. One is ORU laboratory results message, which is used for receiving notification from laboratory systems and other is ACK response message, which is used to send the

acknowledgement or rejection to message sender. Table 1 shows the segments of ORU and ACK messages.

In ORU laboratory results message, PID segment is used to include patient identification such as National Health Index number. PV1 is used to convey notification number. The OBR segment is used to record the details of sample, testing ordering clinician and the reporting public health unit. The OBX segment is used to record the disease notification type and test results. A specific LOINC code is used to identify the OBX segment that contains the disease notification type. The NTE segment is used to record any comment in free text format. The MSA segment is used only in version 2.1 message to send the acknowledgement response. The receiver only process MSH, PID, PV1, OBR, OBX and NTE segments and discards other segments, if any. In ACK response message structure, MSH is the message header, MSA is the acknowledgement section and ERR is the error code in case of any error occurred.

Table 1. HL7 message types and their segments in DLN.

ORU laboratory results message		**ACK response message**	
Segment Name	*Description*	*Segment Name*	*Description*
MSH	Message Header	MSH	Message Header
MSA	Message Acknowledgement	MSA	Message Acknowledgement
PID	Patient Identification	ERR	Error
PV1	Patient visit		
OBR	Order detail		
OBX	Observation/result		
NTE	Notes and comments on results information		

These messages comply with NZ Health Information Standards Organisation, HISO, standards [5]. Currently, 33 laboratory sites are sending notifications compliant with HISO HL7 standard v2.4 and one complies with v2.1.

3. Performance Analysis

This section presents an analysis of system usage in the process of attaching laboratory notification to case. We collected the HL7 messages received by the DLN middleware framework between January and December 2014. Table 2 shows the monthly statistical analysis of total laboratory notifications created in EpiSurv by the DLN system. “Not a New Case” represents that a case is present in EpiSurv at the time of notification being created. “New Case” represent that the cases have been initially created from direct laboratory notification. “Confirmed” represent that the case created by DLN was confirmed by Medical Officer of Health and “Not a Case” means that the created case was found to be an invalid case after further investigations by Medical Officer of Health. A total of 17962 notifications were received from which 7946 new cases of

notifiable diseases were created. Out of these new cases 6162 cases were confirmed by Medical Officer of Health. 10016 notifications are attached to existing cases, providing laboratory results for case management and public health action.

Table 2. Direct Laboratory Notification Statistics for 2014.

Month	Not New Case	New Case (Confirmed, Not a Case)	Total Notifications
January	836	774 (606, 119)	1610
February	851	609 (482, 94)	1460
March	808	635 (489, 115)	1443
April	746	496 (394, 77)	1242
May	776	601 (463, 106)	1377
June	774	535 (404, 98)	1309
July	814	652 (463, 155)	1466
August	717	614 (487, 95)	1331
September	941	658 (508, 114)	1599
October	1090	819 (630, 136)	1909
November	800	782 (614, 129)	1582
December	863	771 (622, 134)	1634
Grand Total	10016	7946 (6162, 1372)	17962

Figure 2 shows the total number of notifiable disease cases identified and the total number of new confirmed cases created from direct laboratory notifications for each month in the year 2014, with a minimum of 48.18% and maximum of 55.95% new cases (with an average of 51.09%) created from the messages received directly by LabSurv during January to December 2014. The trend lines shows a linear relation between EpiSurv case count and the new confirmed cases created via LabSurv.

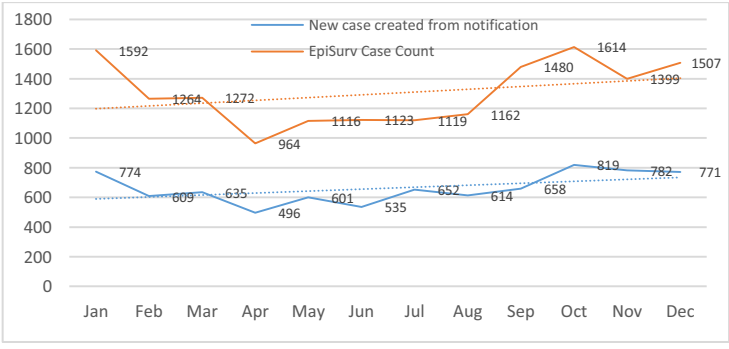

Figure 2. Trend of EpiSurv Cases and New Cases Created from Direct Laboratory Notifications.

Figure 3 shows the time taken between receiving the notification message by HL7 handler, parse the information and attach it to an existing case. Figure shows that, 26.8%, 60.9% and 75% of messages were processed in maximum of 10, 20 and 30 seconds respectively.

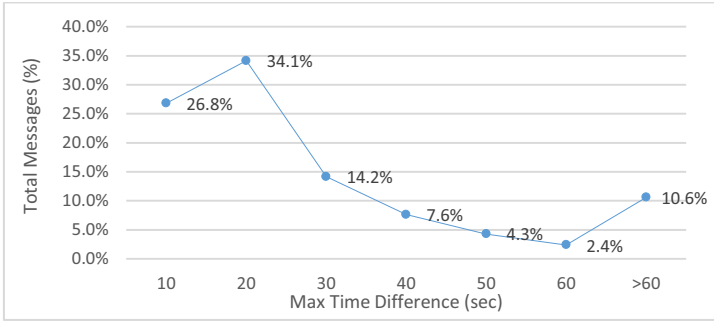

Figure 3. Time Taken by Messages to Process.

4. Discussion and Conclusion

In this paper, a middleware framework for transferring laboratory results to national electronic surveillance system using an HL7 standard and windows services is presented. The HL7 and windows service framework has provided an effective solution for the challenges of integrating various and heterogeneous information systems while developing a large scale health information system. The system is found to be an effective tool to be used in conjunction with the national reporting system and currently creating an average of 51% of notifiable disease cases automatically from the data collected from HL7 messages. 75% of messages were processed within 30 seconds of receipt from message broker providing a near-real time reporting of notifiable infectious disease of public health significance.

There are limitations in performance and use of LabSurv. In terms of performance, a time delay of more than 30 seconds is attributed to windows services which run in batch mode and resulting in a short delay of notification processing. This is being addressed by replacing the services and message broker to Orion Health Ltd.'s Rhapsody Integration Engine [6]. The system does not currently extract laboratory details for example pathogens and their subtypes from laboratory results and place it into EpiSurv case reports. This is primarily because the system is using HL7 version 2 which has limitations in defining data fields to encompass broad range of health information and vocabulary [7]. This may be addressed in future, but is dependent on changes in the way laboratories structure test results within the OBX segment, which could be largely dependent on the implementation of laboratory data standards. While the LabSurv system has been widely adopted, its use is not mandatory and not all Laboratories in the country send their notifications electronically, with community laboratory providers continuing to use alternative manual and bespoke methods of notification to local public health units. A programme of work is underway to work

with Laboratory Information System vendors to enable their system to send notifications electronically.

The current study is focused on the technical component of the system, therefore the system is evaluated to measure its efficiency in processing the notifications in a real time manner. LabSurv has also allowed laboratories and public health unit to adopt digital methods of information management, rather than the informal and fax based methods used previously. A further evaluation of the system with PHUs would be useful to measure its impact on public health.

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