Cloud Computing for Maintenance Performance Improvement

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Abstract: *Cloud Computing is an emerging research area. It can be utilised for acquiring an effective and efficient information logistics. This paper uses cloud-based technology for the establishment of information logistics for railway system which requires information based on data from different data sources (e.g. railway maintenance, railway operation, and railway business data). In order to improve the performance of the maintenance process relevant data from various sources need to be acquired, filtered, fused, integrated, and analysed for decision making and to facilitate for example, diagnostics and prognostics decisions. The process of maintenance information provisioning is highly dependent on an appropriate information logistics. In this paper the authors have tried to study the improvement in the maintenance performance of railway operations in Sweden.*

Keywords: *eMaintenance, Cloud, RFID, railway.*

1. INTRODUCTION

An effective and efficient information logistics can be achieved through utilisation of various new and emerging technologies such as establishment of information logistics for railway system based on the use of cloud-based technologies. In 1999, Salesforce.com became the first site to deliver applications and software over the Internet and in 2007 Salesforce.com expanded its efforts, with Force.com (Salesforce 2012). Amazon stepped in, in 2002, with "Web Services" (AWS) and in 2006 introduced the Elastic Compute cloud (EC2) as a commercial web service (Amazon 2013). Until today, cloud computing is still an evolving paradigm. With cloud computing technology, data can be stored in cloud, and virtualization can support application execution in virtual machine according to customer and application requirement (Heuwinkel et al. 2003). The process of maintenance information provisioning is highly dependent on an appropriate information logistics. There are numerous views of what e-maintenance actually is, one important part is the application of information and communication technology (ICT) to achieve effective information logistics within the maintenance area (Koc and Lee, 2001; Tsang, 2002; Parida and Kumar, 2004; Iung and Crespo Marquez, 2006; Muller et al., 2008). Further, the development of ICT-based solutions should consider three essential aspects: architecture, infrastructure and content ontology (Karim 2008). Therefore, an effective and efficient information logistics aims to provide just-in-time information to the targeted users and optimization of the information supply process, i.e. making the right information available at the right time and at the right point of location (Heuwinkel et al. 2003; Haseloff 2005).

2. MAINTENANCE INFORMATION PROCESS AND CLOUD COMPUTING

A maintenance information system is needed to support an effective maintenance decision making process. This process consists of; data acquisition, to obtain relevant data and managing data contents; data transition, to communicate the collected data; data fusion, to compile data and information from different sources; data mining, to analyze data to extract information and knowledge; and information extraction and visualization, to support maintenance decision. However, development of demonstrator for Railway application faces number of challenges at each step of Maintenance Information Process. During the initial phase of data acquisition and transistion, the main challenge is the units and formats of data, which are stored at multiple data sources. When data is to be integrated then to identify common keys is a big challenge as there is mismatch in the attribute names. Further, the integration of these diverse datasets from the multiple sources is of different resolution, so to analyze this data is really a great challenge. In addition, the available data is scant so its not possible to generate work orders based on historical data. Due to diverse preferences of different stakeholders the visualization of data also varies.This paper is based on approach for establishment of information logistics for railway using cloud computing. Cloud computing is the use of computing resources (software and hardware) that are delivered as a service over the internet. The term cloud computing associates three levels of service: Software (Software as a Service or SaaS), the software platform (Platform as a Service, or PaaS) and the network infrastructure (Infrastructure as a Service, or IaaS).

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- *SaaS:* Cloud providers install and operate application software in the cloud and the cloud user can access the software over Internet.
- *PaaS:* At this level cloud providers deliver a computing platform typically including operating system, programming language execution environment, database, and web server. Application developers can develop and run their software solutions on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers.
- *IaaS:* The user rents a remote computer. The consumer does not manage or control the underlying cloud physical infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components.

3. RAILWAY EMAINTENANCE CLOUD – A CASE STUDY

Today railways are adopting IT systems for rail maintenance. Organizations running railways need to plan for routine maintenance and deal with unforeseen breakdowns to ensure that trains are operational. In addition, to track goods wagons both on its own network and those of other networks, trains with no RFID (Radio Frequency Identification) tags, public safety issues and penalty clauses for late running and it is obvious that getting maintenance right is a key issue. Trains infrequently suffer a complete and unexpected breakdown but if left unfixed for too long may precipitate a breakdown. The idea of developing railway cloud is to make the maintenance team know the issue as soon as the train driver learns about it, or even before so that decision can be taken to fix the problem. Therefore, to solve the problem, RFID technology has been used. RFID is a technology for wireless communication between a reader and a transponder/tag. This technology permits the transfer of data to the most diverse objects without the need for physical contact and uses intelligent barcodes to track items which are used in many industries. In figure 1, data is acquired through RFID Reader and send to database for the analysis, better understanding and interpreting the data. This collected data is acquired by Railway eMaintenance Cloud and then filtered, fused, integrated, and analysed to facilitate for example, diagnostics and prognostics for cost effective maintenance planning and adapted for visualization and presentation as per the need of various stakeholders. Therefore, it helps to provide greater control of the train carriages, making it easier to plan resources. Improved data collection will allow stakeholders to plan proactive maintenance and give infrastructure managers a basis for non-disruptive track maintenance.

Thus, figure 1 shows how the data is acquired from the RFID Reader and send to local database through wired network and then accessed by eMaintenance cloud through internet where it is filtered, integrated, and analysed to facilitate cost effective maintenance planning and adapted for visualization and presentation as per the need of various stakeholders. Further, railway eMaintenance cloud database consists of Wheel Profile data and Forces data for decision making. The results are presented in grids and graphs.For any specific train we can show the forces data and the wheel profile data in the form of grids as well as graphs for any range of axles.

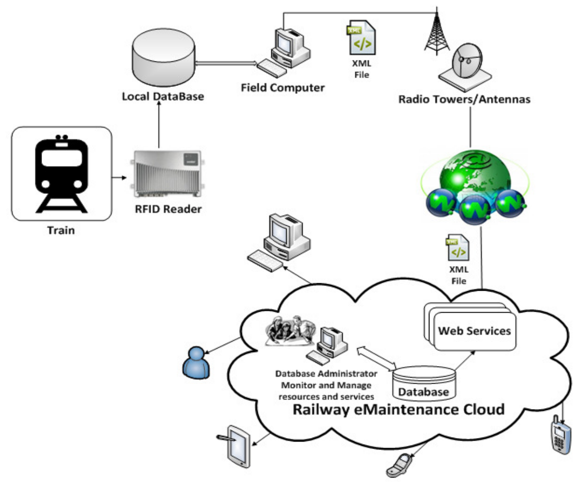
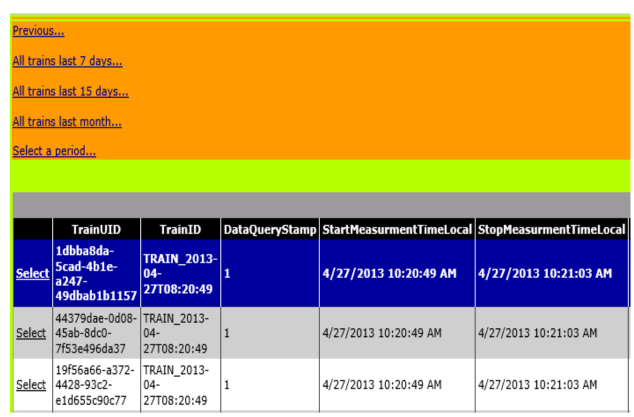


Fig. 1 Railway eMaintenance Cloud Architecture

4. RESULTS AND DISCUSSIONS

The demonstrator for the eMaintenance railway Cloud shows analysed data of trains in the form of grids and charts as shown in figures 2-7. It shows the historical data related to different trains passed through way-side measurement stations. Depending upon the periods, like last 7days, last 15 days, last month or any specific periods we can show data related to trains in the form of grids. The screen shot of demonstrator for the eMaintenance railway Cloud is shown in figure 2.



Previous...

All trains last 7 days...

All trains last 15 days...

All trains last month...

Select a period...

	TrainUID	TrainID	DataQueryStamp	StartMeasurmentTimeLocal	StopMeasurmentTimeLocal
Select	1dbba8da-5cad-4b1e-a247-49dbab1b1157	TRAIN_2013-04-27T08:20:49	1	4/27/2013 10:20:49 AM	4/27/2013 10:21:03 AM
Select	44379dae-0d08-45ab-8dc0-7f53e496da37	TRAIN_2013-04-27T08:20:49	1	4/27/2013 10:20:49 AM	4/27/2013 10:21:03 AM
Select	19f56a66-a372-4428-93c2-e1d655c90c77	TRAIN_2013-04-27T08:20:49	1	4/27/2013 10:20:49 AM	4/27/2013 10:21:03 AM

Fig. 2 screen shot of demonstrator for the eMaintenance railway Cloud

This demonstrator for the eMaintenance railway cloud is implemented by using ASP.net as front-end and SQL Server 2012 as back-end. The results are presented in grids and graphs.For any specific train we can show the forces data and the wheel profile data.As an example the highlighted data in figure 2 shows a specific train for which the forces data and wheel profile data has been displayed. Thus, figure 3 and figure 4 shows the screen shots of forces data and wheel profile data for a specific train highlighted in figure 2 respectively.

Number of axles: 10

AxleUID	VehicleUID	ModDate	Provider	ResponsiblePersonName	Re
1cec560f-748b-4c4d-829a-a666f241ad45	4ae93f10-544e-4d96-9e2f-f0b813549ff2	5/18/2013 5:43:05 AM			
b11bf561-3cfb-4300-915f-af76d2c2641d	4ae93f10-544e-4d96-9e2f-f0b813549ff2	5/18/2013 5:43:05 AM			
29b63695-901a-43bb-9366-b558724f1957	4ae93f10-544e-4d96-9e2f-f0b813549ff2	5/18/2013 5:43:05 AM			
fb6e0dad-4d12-42a5-81d8-79b32f8dda4c	4ae93f10-544e-4d96-9e2f-f0b813549ff2	5/18/2013 5:43:05 AM			

Fig. 3: Screen shot of forces data for a specific train

Number of wheels: 20

ID	TrainID	CarSequenceNumber	CarInitial	CarNumber	CarOrientation	TrainSide	AxleSequence
2696420	35001	1				R	1
2696421	35001	1				L	1
2696422	35001	1				R	2
2696423	35001	1				L	2
2696424	35001	1				R	3
2696425	35001	1				L	3
2696426	35001	1				R	4
2696427	35001	1				L	4

Fig. 4 Screen shot of wheel profile data for a specific train

Forces data i.e. angle of attack, vertical force left, vertical mean force, vertical transients etc. for a specific train can also be analysed in the form of charts (figure 5). Further, the wheel profile data i.e. flange height, flange thickness, rim thickness tread hollow, diameter, flange slope for each left and right wheels for the specific axle of a train can be analyzed in the form of graph and one of the screen shots for the rim thickness parameter is reflected in figure 6 in the form of graph.

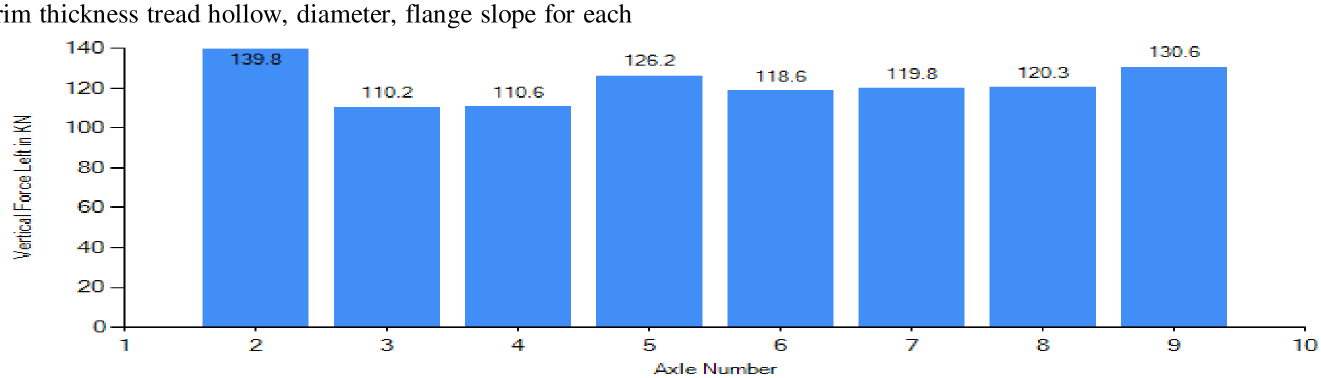


Fig. 5. Charts showing Forces data

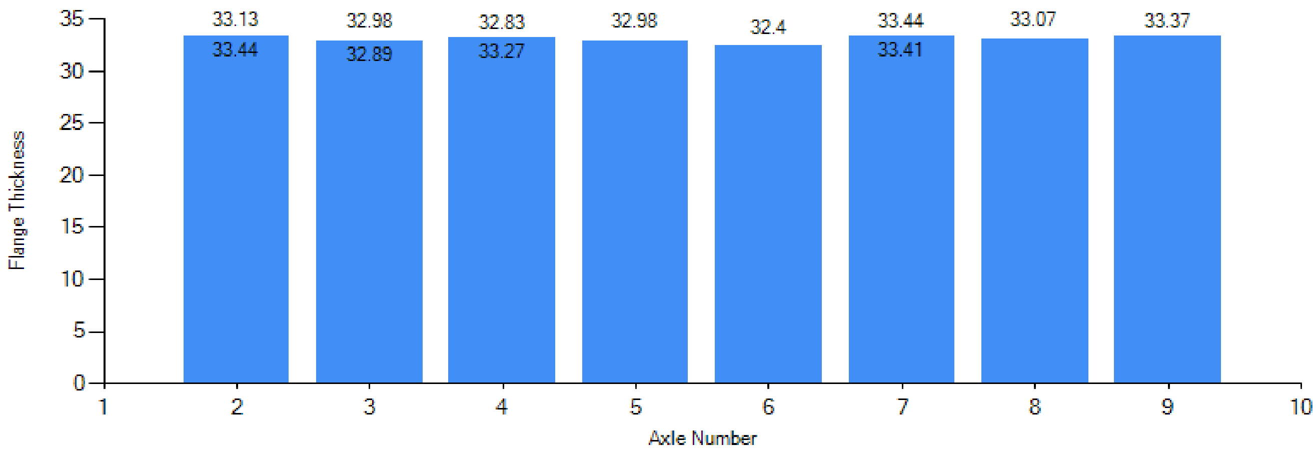
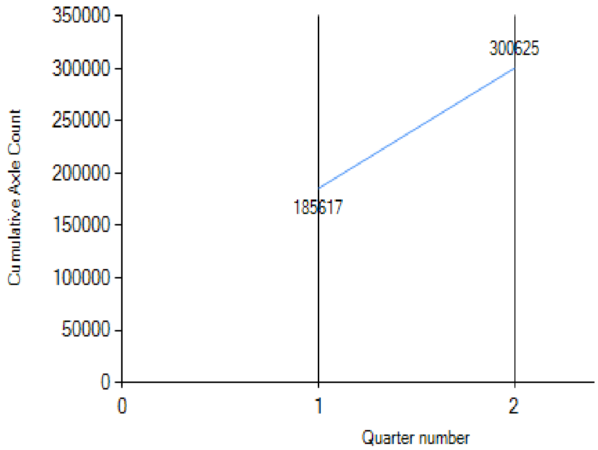
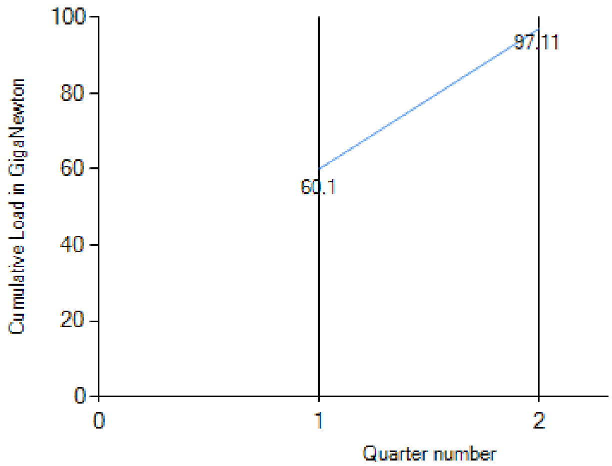


Fig. 6. Charts showing Wheel Profile data.



(a)



(b)

Fig. 7. Charts showing Cumulative Axle Count data (a) Charts showing Cumulative Load data (b)

Further, different wheel profile parameters with in threshold limit can be displayed and we can analyse how many wheels have crossed a certain threshold limit. Based on this analysed data decision can be taken.

Further, there are other applications in the demonstrator viz. cumulative axle count and cumulative load. The graphs for cumulative axle count (figure 7a) and cumulative load (figure 7b) are shown. The data can be represented as weekly, quarterly or yearly for both cumulative axle count and cumulative load. As an example, figure 7a shows cumulative axle count for quarters 1, 2 for the year 2013 and represents cumulative sum of number of total axles of different trains passed in respective months. In addition, figure 7b shows cumulative load i.e.vertical mean force in GigaNewton for quarters 1, 2 for the year 2013. With the help of analysed data the diagnostic decisions can be taken into place. Thus, this work is done as an approach to help efficient maintenance policies to be adopted for maintenance decision-making.

5. CONCLUSIONS AND FUTURE WORK

This paper is based on studying the improvement in the maintenance performance of railway using cloud technology. The information from different data sources has been integrated at eMaintenance railway Cloud for effective decision making and the work is implemented in the form of demonstrator. In order to enhance the performance of the maintenance process and achieve business effectiveness, relevant data from various data sources has been acquired, filtered, integrated, and analysed in the form of grids and charts to facilitate cost effective maintenance planning. Thus, the paper is based on the approach for establishment of information logistics for railway using cloud-based technologies to help efficient maintenance policies to be adopted for maintenance decision-making is limited at this stage, but in the near future the data can be utilised to generate workorders based on histotical data.

REFERENCES

Amazon. (2013). Amazon Elastic Compute Cloud (Amazon EC2). Available at: http://aws. Amazon.com/ec2/ (accessed 10.03.13).

Salesforce. (2012). A complete History of Cloud Computing. Available at: http:// www. salesforce.com/uk/social success /cloud-computing /the-complete-history-of-cloud-computing.jsp (accessed 09.04.13).

Iung, B. and Crespo Marquez, A.A. (2006). Editorial: special issue on eMaintenance. Journal of Computers in Industry, 57 (6), 473-606.

Heuwinkel, K., Deiters, W., Konigsmann, T. and Loffeler, T. (2003). Information logistics and wearable computing. Proceedings of the 23rd International Conference on Distributed Computing System, pp. 283– 288.

Koc, M. and Lee, J. (2001). A system framework for next-generation e-maintenance systems. Proceedings of the 2nd International Symposium on Environmentally Conscious Design and Inverse Manufacturing.

Muller, A., Marquez, A.C. and Iung, B. (2008). On the concept of e-maintenance: review and current research. Journal of Reliability Engineering and System Safety, 93 (8), 1165-1187.

Parida, A., Phanse, K. and Kumar, U. (2004). An integrated approach to design and development of emaintenance system. Proceedings of VETOMAC-3 and ACSIM-2004, 1141-1147.

Karim, R. (2008). A Service-Oriented Approach to eMaintenance of Complex Technical Systems. Doctoral Thesis, Luleå University of Technology, Sweden.

Haseloff, S. (2005). Context Awareness in Information Logistics. Doctoral Thesis, Elektrotechnik und Informatik der Technischen Universität Berlin, Berlin, Germany.

Tsang, A. (2002). Strategic dimension of maintenance management. Journal of Quality in Maintenance Engineering, 8 (1), 07-39.