The Internet of Things, Big Data, Machine Learning, and the Lift & Escalator Industry

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Abstract. New technologies such as the Internet of Things, Big Data, Cloud Computing and Machine Learning have the potential to radically change the Lift and Escalator Industry. This is particularly true in the areas of lift and escalator maintenance, product development, and quality. Lift and escalator maintenance has evolved over the years. The various forms of maintenance have included breakdown maintenance, preventive maintenance, usage based maintenance, condition based maintenance, and task based maintenance. Using the Internet of Things, Cloud Computing, Big Data, and Machine Learning, a new form of maintenance, Data Driven Maintenance, has arrived. Data Driven Maintenance provides benefits to building owners, building managers, lift and escalator passengers, and lift companies. What these new technologies are and how they apply to the lift industry is explained. Additionally, several real world applications of these technologies on lifts are detailed.

1 INTRODUCTION

Lifts and escalators are installed once, modernized as often as every 10 to 20 years, but are maintained for their entire lives. The lifts in the Woolworth Building in New York City, an early high-rise, were installed in 1914. The lifts were modernized for the fourth time in 2010 and the lifts are now currently in service and being maintained.

Maintenance is a major source of revenue and profits for the lift industry. The Internet of Things (IoT) has the ability to change the lift industry's maintenance business model.

2 THE INTERNET OF THINGS

The term "Internet of Things" was coined by British entrepreneur Kevin Ashton in 1999 [1]. Today there are approximately three billion (3,000,000,000) internet users. Most are humans exchanging information over the internet [2]. In 5 years, 30 to 50 billion physical objects, things, will be connected to the internet. These things also referred to as machines, will be communicating with other machines such as computers. This form of communication is referred to as Machine to Machine (M2M) communication. M2M can utilize Plain Old Telephone System (POTS) lines, Cellular communication, Ethernet connections, Wi-Fi, or many other forms of electronic communication, not all of which exist today.

3 BIG DATA

Big Data is a term with many meanings. Initially it referred to data sets that were too large or too complex for traditional software and computers to process in a reasonable amount of time. However, today Big Data has also come to mean the use of predictive analytics to extract value from data regardless of the quantity of data [3].

The processing of Big Data requires large amounts of processing power, power not found in desktop computers. Big Data is processed by from tens to thousands of servers using massively parallel software. Not all organizations have large server farms at their disposal and so must find alternative sources of processing power such as Cloud Computing.

4 CLOUD COMPUTING

Cloud computing is the opposite of On Premises computing.

With On Premises computing all the hardware and software is owned by the operator. If a business needs 100 servers to run its business, it must buy 100 servers, build an air conditioned facility to house the servers, and provide electrical power and communication support for those servers. Additionally, the operator must provide the support necessary to keep the facility operational.

If an additional 25 servers are required one day a week for data analytics then an additional facility with 25 servers must be built and operated.

The On Premises model has both a Capital Equipment Expense component and an Operational Expense component. Everything is outsourced with Cloud computing. The operator only pays for the computing and data storage on a pay as you go basis. If the operator needs 100 servers during the day, 25 servers at night and 125 servers when running data analytics, then the Cloud provider will provide only the servers required. The number of connected servers can change dynamically based on need. The Cloud computing model has no Capital Expense component. Cloud computing is purely an Operational Expense model [4].

The Cloud provider can do this because he is providing services globally. The server farm may be located in Ireland whereas one of his clients may be located in China, another in Europe, and yet another in North America. His clients are using the same Cloud servers at different times of the 24 hour day.

Cloud providers usually have server farms in several locations where data is backed up. If a natural disaster such an earthquake or tornado were to strike one facility, the parallel facility would continue to operate without any interruption perceived by the user.

It should be noted that most businesses have a mix of On Premises and Cloud computing.

5 MACHINE LEARNING & DATA MINING

Machine Learning evolved from Artificial Intelligence (AI). The goal of AI is to develop computers and software that mimic human intelligence. One of the goals of AI is learning. Machine Learning (ML) involves making predictions based on properties learned from data [5].

ML is sometimes confused with Data Mining. The goal of Data Mining is to discover previously unknown properties in a set of data.

While both ML and Data Mining are useful in the lift industry, it is this author’s opinion that ML will yield more tangible results more quickly than data mining.

There are many tools that can be used for ML. One of the more common approaches is known as Classification and Regression Trees (CART) [6]. These trees are decision trees that learn from what has occurred in the past and use that knowledge to make predictions about future outcomes. Newly developed software based on CART makes the analysis of data possible by trained practitioners who are not necessarily Data Scientists.

6 DATA SCIENTISTS AND THE DATA SCIENCE TEAM

Data Scientists are the people who have a combination of business acumen and a knowledge of data analytics or statistics. Most data scientists have advanced degrees in science such as an MSc or a PhD. Thomas Davenport suggests that the combination of business, communication skills, and analytical skills may not be found in one individual [7]. He suggests that rather than try to find one person with all those skills, it may be necessary to form a Data Science Team.

If a data scientist is engaged solely in Data Mining, then no knowledge of the product being analyzed is required. If the Data Scientist is performing predictive analytics on a specific product such as a lift or escalator, then the scientist or data science team must have product knowledge. Such a person is known as a Domain Expert.

7 THE HISTORY OF LIFT AND ESCALATOR MAINTENANCE

The type of maintenance delivered by the lift industry has evolved over the years.

Initially only reactive (breakdown) maintenance was provided. When a lift stopped working a technician would be called to the site to return the lift to service.

The industry converted to preventative maintenance. The goal of this form of maintenance was to perform maintenance before a breakdown occurs and to increase the service life of a lift.

Remote monitoring of lifts and escalators appeared in the late 1980's. While remote monitoring would alert the lift company when a lift had a breakdown, it did not in and of itself reduce the number of breakdowns.

Usage based maintenance appeared in the lift industry in the late 1990's. The concept of this scheme was to adjust the quantity and timing of maintenance based upon usage. The concept was not truly new. Motor oil in automobiles has routinely been changed after a given number of kilometers of travel.

Condition based maintenance is simply providing maintenance based on the condition of a system or part. An example of this would be mounting an accelerometer and a temperature sensor on a critical bearing and monitoring the vibration frequencies, vibration amplitudes, and the bearing temperature. When a reading begins to leave the normal operating range, bearing maintenance or replacement can be scheduled.

Task based maintenance involves the generation of maintenance task lists based on the lift type usage and condition.

8 DATA DRIVEN MAINTENANCE

Data Driven Maintenance combines all the previously described maintenance types into one system. Data driven maintenance, while new to many industries including the lift and escalator industry, is quite mature in industries such as aviation [8].

Remote monitoring reports the usage and condition of the lift to the Cloud. Using Machine Learning, predictions are made of when and what must be maintained. These preemptive tasks are then communicated to the service technician from the Cloud. The service technician will then perform only those tasks which protect the customer's assets; their lifts or escalators.

The predictive nature of Data Driven Maintenance should be able to schedule maintenance tasks that will prevent breakdowns or increase the Mean Time Between Failure (MTBF). Additionally, when a pending failure is detected, Data Driven maintenance should be able to recommend a preemptive action that can be taken to eliminate a loss of continuity of service.

For example, if door motor current is monitored, an increase in current might, over time, indicate that additional door maintenance is required on the next visit. If a sudden increase in door motor current is detected it might indicate that a door was damaged, perhaps hit by a trolley, and a technician should be dispatched to correct the problem before a breakdown occurs.

Unscheduled breakdowns are expensive. They are much more expensive than preventative or preemptive maintenance. Data Driven Maintenance can reduce and hopefully eliminate unscheduled breakdowns. This will reduce maintenance costs and ultimately maintenance prices. Additionally, fewer breakdowns will increase customer satisfaction.

9 TIMING

When can Data Driven Maintenance be implemented? The technology for Data Driven Maintenance has existed for 10 or even 20 years. However, until recently, it was cost prohibitive.

Today we have very fast and very low cost computing. The cost of data storage is now a fraction of what it was just a few years ago. Low cost data storage has made Big Data economically feasible. The Internet is available almost everywhere in the world where lifts are located. Low cost wireless data communication is also available globally.

Cost and technology have reached a point in time where the economic benefits of Data Driven Maintenance can more than cover its costs and it comes with an improvement in customer satisfaction.

10 CONCLUSIONS

Data Driven Maintenance will change the way maintenance operations are conducted. More timely information about the performance of lifts will influence product development. If a new component has a higher or lower failure rate than the component it replaces, it will be detected more quickly.

If quality is defined by breakdowns per unit per year, then quality should improve.

Perhaps maintenance will be priced based on up-time.

Data analytics will also deliver unexpected results. Only time will determine how beneficial these results will be. However, it is logical to assume that these unexpected results will benefit both the lift industry, and more importantly, our customers.

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BIOGRAPHICAL DETAILS

Dr. Rory Smith is Visiting Professor in Lift Technology at the University of Northampton. He has over 46 years of lift Industry experience and has been awarded numerous patents.