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Social Internet of Industrial Things for Industrial and Manufacturing Assets ⋆

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Abstract: The IoT (Internet of Things) concept is being widely discussed as the major approach towards the next industry revolution - Industry 4.0. As the value of data generated in social networks has been increasingly recognised, the integration of Social Media and the IoT is witnessed in areas such as product-design, traffic routing, etc.. However, its potential in improving system-level performance in production plants has rarely been explored. This paper discusses the feasibility of improving system-level performance in industrial production plants by integrating social network into the IoT concept. We proposed the concept of SIoIT (Social Internet of Industrial Things) which enables the cooperation between assets by sharing status data and optimal operation and maintenance decision-making via analysis of these data. We also identified the building blocks of SIoIT and characteristics of one of its important components - Social Assets. Related existing work is studied and future work towards the actual implementation of SIoIT is then discussed.

Keywords: Internet of Things, Social Media, asset management, condition-based maintenance, decision support, system performance optimisation

1. INTRODUCTION

The importance of asset management has gradually been recognised by the world of manufacturing. Effective asset management is key to reducing the total cost of asset ownership while improving machine availability, guaranteeing security, and increasing productivity.

Condition-based maintenance, as a major element in asset management, has gained popularity over traditional corrective maintenance and preventative maintenance, especially for high-capital equipment. Despite its advantage over conventional maintenance strategies, current condition-based maintenance suffers from the following drawbacks. First, the maintenance task is targeted at individual assets, rather than the interconnected fleet of assets utilised in manufacturing. The fact that many manufacturers outsource the maintenance and management of equipment to their respective OEMs (original equipment manufacturer) is contradictory to the end-users' predominant goal – system-level performance optimisation. Since no single organisation has total visibility over the entire system, system-level optimisation can never be achieved. Second, most maintenance policies are restricted solely to the decision making of maintenance, without considering the interaction between operation and maintenance strategies, where by an appropriate operation action may have a positive impact on maintenance plans (e.g., decreasing the load for a downstream machine whose condition is deteriorating, thus providing more time for maintenance preparations). Third, even if data is shared between different assets, there is still a great reliance upon human experts to analyse the data, spot latent problems, and propose solutions, in turn dragging down system efficiency. However, a potential solution to these problems is likely to emerge from current trends in technology advances. The notion of SIoT (Social Internet of Things), which results from integrating Social Media into the IoT (Internet of Things), has been increasingly witnessed in application areas such as product-design and traffic routing. It can be reasonably considered as a tool of support for the manufacturing world.

This work attempts to explore the possibility of applying SIoT to industry to develop an industrial system performance management infrastructure allowing for machine data sharing and analytics to support asset and operations management.

In section 2 a more detailed description of the emerging trends of integrating the IoT and Social Media, as well as its recent applications will be presented. Section 3 discusses possible applications of the IoT and Social Media in industry, along with its potential advantages. The concepts of SIoIT (Social Internet of Industrial Things) and Social Assets are also presented in this section. Subsequently, section 4 defines the characteristics of Social Assets, while section 5 outlines the building blocks for SIoIT. A literature review of existing work is provided in Section 6, followed by a discussion on future work in Section 7, and a concluding section.

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2. SOCIAL MEDIA AND THE IOT

The term IoT was first coined in 1999 by The Auto-ID Labs, within the context of supply chain management enabled by RFID (radio-frequency identifications) technology. However, its current definition has been extended to include a dynamic global network infrastructure with self-configuring capabilities, where physical and virtual things have identities, physical attributes, and virtual personalities, use intelligent interfaces, and are seamlessly integrated into the information network (Kranenburg, 2006). Vast amounts of data are generated and shared across the IoT which with the support of Social Media, has been widely used in the consumer world to benchmark and optimise the product quality and customer experience. For instance, companies like Garmin and Nike provide platforms for consumers to share and compare exercise data collected via GPS-enabled wristbands and smartphones.

The notion of incorporating social elements to the IoT has been around for approximately a decade, leading to the development of SIoT. One of the early ideas associated with SIoT is "Blogject", a neologism meaning "things that blog". An example was a flock of pigeons that were equipped with telematics for wireless communication, a GPS device for track tracing, and sensors to record the content of air pollutants (Bleecker, 2006) . The potential of combining social and technical networks has also been tested on service provision to both human users and technical systems. A use-case of a socio-technical network – The Cognitive Office, was reported, where Twitter was chosen as an example online social network for objects in a smart office to post events from selected sensors and listen for Tweets from other devices (Kranz et al., 2010). The exploitation of SIoT can also be found in traffic routing problems, such as opportunistic communication enabled by social networks in dynamic traffic networks (Schurgot et al., 2012).

3. SIOIT (SOCIAL INTERNET OF INDUSTRIAL THINGS)

Modern industrial assets are equipped with an array of sensors monitoring their condition and operational status, generating large amounts of data. The rise of data collection and analytics in SIoT has naturally progressed to discussions in the context of industrial plants – SIoIT. In SIoIT, intelligent machines with social properties, namely, Social Assets, share status information and cooperate via a social network to achieve a common goal - optimal system-level performance.

Several scenarios can be envisioned where SIoIT is likely to enhance system performance. With SIoIT, individual machines can provide status updates to the social network, thus sharing their condition and operation status with other machines that subscribe to the network. Consider a mining operation site that consists of a variety of capital-intensive equipment (e.g., trucks, loaders, crushers, and conveyors) manufactured by different companies but inter-connected through a social network. A crusher can decrease its speed to reduce downstream loads, thus helping the conveyor whose condition is excessively deteriorating at the current loading level (alternatively, the crusher can send a message to the human operator elaborating the problem and suggesting a possible solution, such as slowing the crusher down). In addition, assuming a truck has experienced a sudden break-down because of gear failure. This truck will be able to send a warning message to another truck at a remote site with gears from the same batch. Instead of passively waiting for instructions, machines actually actively participate in the production process.

The possibilities for machine learning and optimisation are significant in a world where machines in factories all over the world collect, update, and share status data via a social network. SIoIT enhances industrial data analysis and performance management at three levels – machine, production plant, and network levels. At the machine level, benchmarking data is available for manufacturers to analyse machine reliability and associate the root causes of differences in performance. At the production plant level, an overall visibility enabled by machines updating status to the social network will help manufacturers spot bottleneck in the system. Thus, system-level optimal reliability, productivity, and energy consumption can be achieved. In addition, intelligent machines are equipped with the ability to cooperate and learn from each other as a means to identify the best practice for problem solving. Understanding what and how other machines are doing makes it possible for machines to advise each other on collectively achieving production goals, as well as adjusting its own behaviour for a long-term optimal system cost-risk-performance balance. At the highest level, the network level, with more data generated and more machines taking part in the social network, comprehensive predictive analytics and learning will be realised, benefiting OEMs, designers, and service providers. Moreover, with intelligent machines looking after the system and themselves, spotting latent risks and executing solutions or suggesting solutions to human operators, the efficiency of maintenance is greatly increased.

In the future world of manufacturing, intelligent machines will communicate and cooperate with each other via a social network to accomplish production tasks, which very much resembles the human society.

4. CHARACTERISTICS OF SOCIAL ASSETS

The very first architectures of the IoT are based on the success of RFID technology. While this approach is ideal in tracking physical objects within a confined space, it is insufficient for more flexible and complex scenario requirements. This has led to an alternative architectural model – a loosely coupled, decentralised system of Smart Objects (Kosmatos et al., 2011). Smart Objects, which are autonomous physical/digital objects augmented with sensing, processing, and network capabilities, are categorised into activity-aware, policy-aware, and process-aware objects, and are believed to be building blocks for the IoT to cater functional needs (Kortuem et al., 2010). Similarly, what it takes for objects to be 'smart' still applies to the basic components for SIoIT in the manufacturing domain (i.e., machines or assets). However, it requires an additional requirement – apart from being 'smart', these components also need to be 'social'.