Online monitoring for processes and condition of a machine using smart management card

I A V Damanik*, R D Rumbara and N Juhana
Balai Besar Logam dan Mesin, Jl. Sangkuriang No.12 Bandung
Email: damanik@kemenperin.go.id

Abstract. This work aims to propose a solution on online monitoring for machining in the manufacturing process through web service, so that all data usage and machine conditions are obtained and stored on the server as Big-Data. The methodology in this work is RFID-based sensors on machines with Card Management System (CMS). Machining data of each machines that are monitored through a self-made application, connected to the internet networking and can be accessed online from everywhere by using laptop or mobile devices. Those machine activities as data record, stored on the server as big data that further can be used as Big-Data analytic. The result will be a system model which is able to monitor all machines in real-time and online by using internet connectivity, and also to find out the current status of the machine whether available or not for a new process. In addition, we can also know the process of the work being done by the machine with the use of RFID Card. This real-time data are also used to prevent sudden engine damage by doing regular maintenance according to work-hour of machines and also to maintain the sustainability of the process to keep it on schedule.

1. Introduction
Information Technology (IT) is developing rapidly in the 20th century especially in Industry 4.0 which provides a lot of benefits and conveniences to industrial sector and provides short and long-term solutions in terms of increasing productivity. As new technologies are introduced that also backed up Digital Transformation (DT) in terms of using digital records and slowly reducing the use of paper, the machinery sector get benefits from its optimization as well. Modern machinery development today is very complex and relatively expensive, concerning the operation and the maintenance [1]. Operators and engineers must ensure that the machine is monitored properly so that damage does not occur to the engine. Current information and problem solving actions on production machines are needed quickly, to avoid both machine failures and decreased productivity [2]. The real fact on the process floor is delayed information about the machine problem. Hence, both engineers and supervisors will be unable to know the problem in advance; unless by checking the machine directly to the shop floor; and also could not fulfill the schedule. The supervisor would have difficulties in making the daily report of the machine. These problems require a monitoring system that capable of providing information in real-time and online. With internet connection, the information needed can be obtained quickly anywhere. Monitoring aims to provide information about the current status of an object with a certain time period. Generally, monitoring is carried out for specific purposes, for instance observation, examination, control and correction of all processes activities, as a basis for determining actions to be taken next. Also, documentation of machine operational data, such as what work is done, how long it needs to be done, and also to find out whether a process has been completed or is still in progress. These data are stored
in a database on the server. The database not only provides information about the condition of the machine online and in real time but can also provide trend data for taking preventive and corrective maintenance steps on a regular basis [3-7].

Another common and ubiquitous problem is that previous collecting data are still not available to be used as reference to a further analysis in determining the trends of a process and operating a machine. By 2020, data will have been generated, imitated, and consumed by users over 40 Zettabytes (or 40 trillion gigabytes) [8]. The unavailable collecting data and separated data at many points inflict an incorrect decision due to the lack of reference data. Industry 4.0 presence through the application of technologies such as Internet of Things (IoT), Cloud Computing, Cyber-Security, Big Data analytics provided a lot of progress in terms of production step-up capabilities and also lowering operational costs. One of the IoT item is Smart Management Card (SMC) so-called RFID system which has an important role in terms of online and real-time monitoring in Industry [9]. Radio-Frequency identification (RFID) systems known as powerfull method for many applications such as line production monitoring, the supply chain, public transportation, health industry, etc. [10-12].

This work aims to propose a solution on online monitoring for the machining process in the manufacturing process display through the web service. This solution result in all usage data and machine conditions are able to be obtained and are stored on the server as Big-Data. A number of data obtained by using an RFID system will be used as information through Big-Data, thus the management level can get real-time information to carry out further both analysis and results which become the basis to make up a decision on the machine such as maintenance and especially increasing machine productivity.

2. Materials and methods
RFID system is faster and does not make contact between the reader unit and tagged object compared to other types of identification methods recently [13]. All materials used in building a monitoring RFID system are obtained by assembling and using existing electronic components; making applications and systems by utilizing machines in the workshop from conventional to CNC and placing devices (hardware) consisting of electronic components and sensors in the machine and data communication is built with wireless method. Overall, the Smart Management System development is the use of RFID Card as the most important part of the type of card that can be both written and read by the system built, and the card is used to provide the code for each work, and also replace work cards that are usually used by operators.

2.1. Front-end
The front-end scheme is a communication step that aims to register an RFID card in the database. The process that occurs in this section is how to attach identification code to the RFID card after it is registered on the writer device so that it can send a signal to the PC, as figure 1. Subsequently, the PC will send the status of card to the server (database) and the card is completely registered. When this card is attached to one of the readers on a machine, the reader will send a signal to the server about the existence of the card. The card identity contains the job information such as job number, Company name and date of collection.

2.2. Back-end
In contrast with the Front-end, the back-end system is when the RFID card is used in the workshop. As can be seen in figure 2, RFID cards that have been registered (front-end) will be used as marking to execute the machining process, so that all activities in each machines or job process will be transferred online; how long the duration of work, and still ongoing or completed.

The method is that a card must be swiped twice (first as ON sign and second as OFF sign). When this card is only once attached to the reader and is not re-attached again for the second time which indicating of a machining process is complete, then no other card will be recognized in the monitoring system although it is pasted on the machine.
2.3. **Smart card specification**

Smartcard Reader is a device that functions to read information stored on a smartcard as shown in figure 3. In its implementation, a smartcard reader will operate if detect the valid card according to the workflow setting that has been determined. The HF RFID standard including ISO/IEC 18000 standard is a reference for RFID tag specification [14]. Operators or users will be able to monitor all activity on the machine by online for all the time.

![Figure 1. Smart management system-front end.](image1)

![Figure 2. Smart Card Management System – Back end.](image2)
- Power module:
  This device is a module that functions to convert AC voltage to DC and provide power to the reader. This module consists of a power supply and DC to DC Step down to convert 220VAC to 12VDC and 5VDC.

- Reader module:
  Reader module is an antenna device smart card reader (card reader) that functions to connect the card with a computing system.

- Main control module:
  This module functions as a storage of logic data, memory, and work settings for reader devices (computing). This module consists of a computing unit, network module, and driver controller.

- Network module:
  This module is a communication interface module between the reader and external devices and applications. This module consists of 3 types of interfaces, among others, USB, Wifi, and Ethernet.

- Driver controller:
  This module functions as an I/O module that controls the push button system, indicator and fan.

- Lamp indicator:
  The lamp indicator functions as a work indicator of the smartcard reader.

- Fan:
  Fan is a device that functions to maintain the temperature of the smartcard reader.

- Push button:
  This module functions as input from the system to turn on and turn off the reader.

2.4. Database and server
All Activities data for number of machines that is monitored by using a Card Management System (RFID) will be stored in a database on the server. The database built is able to accommodate data with a duration of delivery to the server per 5 seconds for approximately 3 years period. Server’s setup depends a lot on how much and size each data will be stored.
Table 1. Hardware and other part specifications.

| Product         | Specification                                                                 |
|-----------------|-------------------------------------------------------------------------------|
| PC Server       | HPE ProLiant DL20 Gen9; Intel Xeon E3-1220v6 Quad Core; 16GB                  |
| HDD - Add on Server | Harddisk HPE 1.2TB SAS 10K                                                  |
| RAM - Add on Server | HPE DL20 8GB (1x8GB) Dual Rank x8 DDR4                                       |
| Routerboard     | 1U rackmount, 12x Gigabit Ethernet, 4xSFP cages, LCD 36 cores x 1.2GHz CPU, 4GB RAM |
| Module Transceiver Fiber Optic SFP | Konverter fiber (optic-RJ45) untuk Mikrobits SFP Transceiver (RJ45) |
| WD Cloud Kabel LAN | My Cloud EX2 Ultra Device; 4 TB; Ethernet cable; Kabel UTP Belden CAT 5 |
| PRW             | Data on                                                                      |

2.5. Server specifications

Server specifications in table 1 is selected based on the need for storing the RFID Smart Card system activities. Determining the specifications is very important to accommodate all data that will be accepted as a database that ultimately forms a Big Data Methods.

![Flowchart](image)

**Figure 4.** Work flow for online monitoring based Smart Management Card – RFID.

Online monitoring system begins with a machine identification activity to determine which machine will be used in the system as shown in figure 4. These activities intend to set out the topology of the system and make a networking plan for connectivity. Monitoring system is built based on web browser application by using local internet and collect all data in server. Electronic part fabrications (RFID writer and Reader) is adjusted to meet the needs of data captured to be delivered to the network. Then,
determining Hardware and Server specifications stage will be easily done by matching as needed. Since hardware and software are complete, both will be installed to the system until it is able to integrate the data. Connectivity testing for Online Monitoring are the last but not the least on this work.

3. Results and discussions
The means of the built-in online monitoring system is obtaining an integrated system from the use of a Card Management System (CMS) on a real-time machine condition that can be accessed online through an internet-based application.

3.1. RFID card management system

![RFID card management system flowchart](image)

**Figure 5.** RFID card management system flowchart.

Flowchart in figure 5 shows the stages how to use RFID Smart Management card in an online monitoring system for machine process. All stages cover the process begin with how to register the work order that obtained from marketing section at the beginning, get the number and register it to the system. Users
must ensure that the cards used are in good condition and still empty so it is possible to write some information into the RFID Card.

![RFID Card Reader Components](image)

**Figure 6.** Components of the RFID reader.

Caption in figure 6:
1. Power Module
2. Main control module
3. Indicator lamp
4. Power on button
5. Power off button
6. Smart card Reader

### 3.2. Dashboard for online monitoring using RFID card system

Both writer and reader send all information as database to a server. All information can be seen on the dashboard in real-time and online which can be accessed using electronic devices (laptop, PC, mobile devices) connected to the internet network. An online built system based on nodejs programming language on the web-server allows the user to monitor machine activities directly, and to find out work is being accomplished by the machine as well. RFID Card is designed to be more easily used. Firstly, user do the registration of Work Order “Surat Perintah Kerja” to database server which is usually in the form of a certain number made from the marketing department. In figure 7, the dashboard shows the registration is complete with SPK number, description, and the name of the consumer company. To ensure the SPK has been registered for the customer, just click on the list menu that shows that the SPK registration status. The application also provides information about the date of registering the work paper and the status of the work completed or still in progress.

The second step is determining how many worksheets are used to complete one SPK that has been previously registered as it can be seen in figure 8. The number of worksheets varies according to the needs and level of difficulties of a machine process. The number of worksheet is closely related to the number of RFID cards that will be used because it functions as a substitute for work cards in the form of paper that is commonly used. RFID Card serves as a marker on which machines the job will be carried
out and at the same time to replace work cards used by the operator to record machining activities (starting and ending in hours).

Next step, RFID card is written by swiping it to the writer devices so the identification data is entered into the card. RFID cards containing data are ready to be used by operators for the registration function on each machine.

When an object is going to be processed on machine A, then just look at the application whether machine A is being used for another job or in idle status. After deciding which machine is used for this process, the operator attaches the RFID card to the reader on the machine, and the machine begins to record all activities. RFID Cards used are that have been registered ones. So, if you use a card that has not been registered, the reader will not recognize the card and the data will not be sent to the server. Other indicators to know whether the RFID card has registered or not is three various colours of lamp indication. RFID reader will light on red if detect unregistered card while green indicates valid card.

The main dashboard as shown in figure 9 provides information about all machines status. The classification based on whether the machine is ready for use, being used, or in a damaged condition. Status information is presented in colour display that describes the description of each machine:

- Red = ready to use
- Green = in use
- Black = cannot be used (broken, dead or in maintenance)
The colour indicators provide machine information so that the process engineering can prepare the machine schedule according to the readiness of each tool and equipment. So, there are three main parts in this work:

- Part 1: Card Management System (CMS) Application and Smart Card reading module
- Part 2: Monitoring system Application, Smart Card Data Transmission Module and Database and Data Integration Module
- Part 3: Web Services and Data Integration Modules

These three main parts are combined to form an online monitoring of processes and conditions of a machine using a smart management card on an integrated web-based online.

3.3. Data security.
Most of the manufacturing industry is currently facing their own digital transformation by using automations as solutions to increase productivities at workshop. Online monitoring is one of obvious example for digital transformation implementation that has a very high risk in terms of cyber-attack. This puts the manufacturing industry at serious risk of cyber-attacks which have the potential to derail their operations due to the amount of data or company time lost.

This online monitoring applications equipped by local-server that built with such a suitable language programming. Using local-server can prevent your data from being stolen even though the risk of data loss may still occur. Moreover, this application provide a large data storage spaces so the user be able to back-up their data every time depend on how long the programmer set the system send data to the storage. The more data sent, the greater the storage allocation needed.

4. Conclusion
Machining process activities can be monitored in real-time and online by using internet connectivity which is displayed on a dashboard, including the status of the machine; ready for use, in use or damaged. The RFID Card Management system is able to replace paper as a working paper communication media as well as being a job tracing media on each machine in the workshop. The RFID system also provides detailed information on the length of working time on each machine which is displayed in dashboard that can be monitored online. All RFID system reading data results are stored in the server as work data that will be used as Big-data.

Acknowledgments
In completing this paper, the author would like to thank the authority of the Metal Industry Development Center (MIDC/BBLM) for providing funding and other laboratory facilities in the implementation of
this project. We also would like to thank the head of MIDC for allowing us to do research there, and specifically for the teammates: Anugrah Erick, Sony, Ali Firmanysah, Nana Juhana, Agus S, and Sandy Sitorus who always struggle together. The author will never be able to solve this without all of your guidance.

References
[1] Roy R, Stark R, Tracht K, Takata S, and Mori M 2016 “Continuous maintenance and the future – Foundations and technological challenges,” CIRP Ann. - Manuf. Technol., 65(2) 667–88
[2] Guo R and Jin Y 2019 “Phase Identification and Online Monitoring for the Uneven Batch Processes,” IEEE Access, vol. 7, pp. 81351–63
[3] Yew H T, Ng M F, Ping S Z, Chung S K, Chekima A, and Darghan J A 2020 “IoT Based Real-Time Remote Patient Monitoring System,” Proc. - 2020 16th IEEE Int. Colloq. Signal Process. its Appl. CSPA 2020, no. Cspa, 176–9
[4] Wang L, Yan Y, Hu Y and Qian X 2013 Intelligent condition monitoring of rotating machinery through electrostatic sensing and signal analysis IEEE Int. Conf. Smart Instrumentation, Meas. Appl. ICSIMA 2013 pp 26–7
[5] Juliasari N, Hartanto E D and Mulyati S 2016 Monitoring Suhu dan Kelembaban pada Mesin Pembentukan Embrio Telur Ayam Berbasis Mikrokontroler Arduino UNO J. TICOM 4(3) 109–13
[6] Zhang Y and Ruan J 2018 Large-scale machinery monitoring system based on the visual reality Proc. 2018 IEEE 3rd Adv. Inf. Technol. Electron. Autom. Control Conf. IAEAC 2018, pp 863–67
[7] Zhang P, Li J, Yang T and Huang S 2012 Flexible and smart online monitoring and fault diagnosis system for rotating machinery Proc.2012 Int. Conf. Comput. Distrib. Control Intell. Environ. Monit pp 343–47
[8] Sivarajah U, Kamal M M, Irani Z and Weerakkody V 2017 Critical analysis of Big Data challenges and analytical methods J. Bus. Res. 70 263–86
[9] Nayyar A and Kumar A 2019 A Roadmap to Industry 4.0: Smart Production, Sharp Business and Sustainable Development Mourad Amer, International Experts for Research Enrichment and Knowledge Exchange (IEREK), Cairo, Egypt p 89
[10] Han S, Lim H S and Lee J M 2007 An efficient localization scheme for a differential-driving mobile robot based on RFID system IEEE Trans. Ind. Electron 54(6) 3362–69
[11] Glidden R, Bockorick C and Cooper S 2004 Design of ultra-low-cost UHF RFID tags for supply chain applications IEEE Commun. Mag 42(8) 140–51
[12] Meillere S, Barthelemy H and Martin M 2006 13.56 MHz CMOS transceiver for RFID applications Analog Integr. Circuits Signal Process 49(3) 249–56
[13] Hwang Y S and Lin H C 2009 A new CMOS analog front end for RFID tags IEEE Trans. Ind. Electron 56(7) 2299–2307
[14] ISO/IEC 18000-3 2001 Information Technology-Radio Frequency Identification for Item Management—Part 3: Physical Layer, Anti Collision System and Protocol Values at 13.56 MHz.