Internet of Things (IoT) For Galactic Cosmic Ray Application Over Astronomical Observatory in Near Future: A Review Study

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Abstract. Galactic Cosmic Ray (GCR) it’s very harmful for human life. The Ultra high Neutrino radiation GCR energy from outside galaxy were intimidated Earth and Environmental. The measurement GCR energy using neuron monitor is successful to capture Ultra-high Neutron and Gamma ray, respectively. During Fourth Industrial Revolution (4IR), the current neutron monitor was expanded into Internet of Things (IoT) system to obtain Ultra-high Neutron and Gamma ray in near future. Thus, in this study aimed to develop conceptual study of Neutron Monitor with IoT system over Astronomical Observatory. The result shows Neutron Monitor with IoT system need to deploy in Equator and Antarctic region due to Gamma ray distribution. Here, Neutron Monitor data with IoT system were applied to analyse Natural Hazard potential with predictor from GCR flux parameter. By using auto send status from IoT system, Natural Hazard potential will be updated per-hour into stakeholder (e.g. hospital, Astronautics, and meteorology service). Thus, a disaster victim from Natural Hazard potential caused by Ultra-high Neutron and Gamma ray will be minimized using IoT system during evacuation process in near future.

Keywords: Galactic Cosmic Rays Application (GCR), Internet of Things (IoT), and Natural Hazard.

1. Introduction

Space radiation is composed by heavier charged particle, neutron, and electron up to $10^{20}$ eV. During several years the space radiation are increased especially Galactic Cosmic Ray (GCR) flux due to inversion earth magnetic field [1]. A massive GCR flux it’s very harmful for human life e.g. communication technology, human health, and space exploration (satellite radiation dose) [2]. Many researchers have been studied to observe GCR flux using neutron monitor over Astronomical observatory [3]. The observation system from neutron monitor has been recorded and shared using File Transfer Protocol (FTP) technology [4]. However, the FTP technology has disadvantages based on service and transfer speed of the data. Thus, this study aimed to design Internet of Thing (IoT) for GCR application based a review study to increased service and transfer speed of the data observation. During Fourth Industrial Revolution (4IR), the Internet of Thing (IoT) have a function to increased...
service and transfer speed of the data observation using cloud system [5]. The cloud system was applied in many applications including prediction and forecasting natural hazard disaster [6]. The preliminary study about GCR distribution particle energy using GEANT4 application was successful studied [7]. Here, the GCR flux assessment was calculated over four stations during Solar Particle Event (SPE) from ground-based station on 14 July 2000 and 28 October 2003, respectively. However, in this study the average error of GCR simulation less than 3%. Thus, the soft sensor modeling using Artificial Neural Network (ANN) for GCR application was proposed to estimate average error for simulation GEANT4 over previous study [8]. The estimation result using ANN was improved GCR average error $\pm 3\%$ to $\pm 1\%$ on November 2001 to December 2012 over two ground-based stations (Forth Smith and Inuvik). However, the training data to estimate GCR result using ANN need processing time due to observation data. Thus, the cloud system (including storage and processing data) were proposed to improve processing time over training data using ANN [9]. The integrated system on Internet of Things (IoT) was suggested to integrated communication system and processing data in cloud computing [10]. Based on previous study, the integrated system cloud computing and IoT it’s powerful to develop forecast, prediction, and nowcasting in many application especially for GCR flux parameter over astronomical observatory in near future.

2. Methodology

2.1. Cloud Computing

In order to explain the understanding cloud computing system, we compare with two adopted system e.g. Cluster and Grid Computing. The assessment Cloud, Cluster, and Grid computing based on characteristics is showed in Table 1 [11]. Here, the characteristics between Cloud, Cluster, and Grid system are described in seven parameters. The seven parameters are assessed based technical aspect and service to develop system.

| Characteristics                      | Clusters                        | Grids                                      | Clouds                                      |
|--------------------------------------|---------------------------------|--------------------------------------------|---------------------------------------------|
| Population                           | Commodity computers             | High-end computers (servers, clusters)     | Commodity computers and high-end servers and network attached storage |
| Size/scalability                     | 100s                            | 1000s                                      | 100s to 1000s                               |
| Node Operating System (OS)           | One of the standard Oss (Linux, Windows) | Any standard OS (dominated by Unix)       | A hypervisor (VM) on which multiple Oss run |
| Ownership                            | Single                          | Multiple                                   | Single                                     |
| Interconnection network speed        | Dedicated, high-end with low latency and high bandwidth Traditional login/password-based. Medium level of privacy – depends on user privileges. | Mostly Internet with high latency and low bandwidth Public or private key pair-based authentication and mapping a user to an account. Limited support for privacy. | Dedicated, high-end with low latency and high bandwidth Each user/application is provided with a virtual machine. High security/privacy is guaranteed. Support for setting per-file access control list (ACL). |
| Security/privacy                     |                                 |                                            |                                            |
| Discovery                            | Membership services             | Centralized indexing and centralized info services | Membership services |
| Service negotiation                  | Limited                         | Yes, SLA based                            | Yes, SLA based                             |
As can be seen in Table 1, the cloud computing platform have similar characteristics from both cluster and grid. The advantages of cloud computing are integrated with web service interface with visualization and supported application service. Thus, the mechanism service of cloud computing is provided without reference to the infrastructure on which these are hosted [11]. In current architecture ground-based station of GCR observation, the File Transfer Protocol (FTP) was used as a portal to get the data. However, the FTP system has disadvantages due to access mode, cost, and security compared by cloud system.

2.2. Ground Base GCR Observation
In order to improve the quality and processing data over ground base GCR observation, we explain the current observation system using Neutron monitor. Here, Neutron monitors are ground-based recorders of cosmic rays. Cosmic rays are highly energetic charged particles (predominantly protons, together with heavier nuclei of atoms, but also electrons and gamma rays) originating in the galaxy and traveling through interstellar space. The nuclear active components of the secondaries are detected by a neutron monitor (see Figure 1).

![Neutron Monitor](image)

**Figure 1.** The current architecture observation system using Neutron Monitor over ground-based station in correlation analysis case study

As can be seen in Figure 1, the current system to observe GCR flux parameter were developed in several years ago. The highest cost issues to observe GCR flux parameter using Neutron monitor including monitoring system is very expensive. Moreover, the maintenance cost on monitoring system to guaranteed the life time over sensor, electronics, and communication system (server and storage). Thus, to reduce development cost issues and maintenance cost, the Internet of Things (IoT) was proposed in future system. The IoT system with cloud computing will be reduce maintenance server and storage cost in near future.

2.3. Internet of Things (IoT) System
During Fourth Industrial Revolution (4IR), the Internet of Thing (IoT) have capability to reduce maintenance cost and processing time over observation data. In this study, IoT will be improve current architecture observation system using Neutron Monitor over ground-based station. IoT and cloud system it’s powerful to process observation data also broadcast the GCR observation result (intensity) over ground-based station after calculation process. Figure 2 shows flowchart of IoT mechanism and cloud computing over calculation process also validation process.
As can be seen in Figure 2, the future concept of observation GCR flux was designed using Neutron monitor over ground based station. Here, the preparation step collect GCR flux parameter using neutron monitor and recorded to cloud storage service while the IoT system will be manage whole of the system. In order to obtain the result, IoT proposed to cloud system to calculate GCR flux (get data observation) from cloud storage. The GCR flux data was selected to train and testing data, respectively. After the analysis/estimation/prediction of GCR flux obtained, the Root Mean Square Error (RMSE) and Variance Accounted For (VAF) are calculated to obtain performance model over statistic assessment to obtain model accuracy. Before the statistic assesment result obtained (RMSE and VAF), the analysis/estimation/prediction result must be validated by using data observation (observation). If the result status is invalid, all the data will be analyze to obtain good value. The advantages this application is reduced time process and budget limitation.

3. Result and Discussion
In order to obtain the fastest processing GCR observation over ground base station with low cost architecture, we analyse the whole of the system into part system. The current architecture GCR monitoring system using Neutron monitor has combined with FTP and transfer data (storage service). However, the processing observation data (e.g. estimation, prediction, forecast, etc.) were processed in the outside of observation system due to traffic transfer data on server. Thus, the processing GCR data need additional cost, storage system, and time to calculate observation parameter. During Fourth Industrial Revolution (4IR), the big data observation can be handled by cloud system to calculate observation parameter without additional cost, storage system, and time (see figure 3).
As can be seen in Figure 3, the future architecture observation system using Neutron Monitor over ground base station are handled by cloud system. Here, FTP and processing observation data (e.g. estimation, prediction, forecast, etc.) are located inside cloud storage and cloud computing, respectively. The cloud computing was reduced maintenance and service cost due to handle by one cloud system. Moreover, the cloud system is very secure and fast to transfer data also processing observation data.

In order to obtain the low-cost system and processing time over observation data, the IoT system were proposed to manage and running the program called supervisory system. In this study, the supervisory system (including cloud and IoT system) are used to process observation data without lack of data and wasting the time. The new architecture of GCR observation using supervisory system were implemented over instrumentation building in Lampung Astronomical Observatory (LAO) formerly OAIL ITERA in near future. Figure 4 shows the new concept architecture supervisory system to monitor GCR flux parameter using Neutron monitor over Lampung Astronomical Observatory (LAO), Indonesia.

![Figure 4](image)

**Figure 4.** The new concept architecture supervisory system to monitor GCR flux parameter using Neutron monitor over Lampung Astronomical Observatory (LAO), Indonesia

As can be seen in Figure 4, the future architecture observation system using Neutron Monitor has been developed over Lampung Astronomical Observatory (LAO), Indonesia in near future. The advantages of supervisory system are auto update (calculation status) based on estimation or prediction model from GCR flux parameter. The IoT system were updated each of the calculation GCR flux parameter to airlines, national space service, and astronomical observatory network also stakeholder who use GCR flux parameter due to natural hazard protection in communication technology. Finally, the integrated cloud and IoT system was successful to design ground-based station over astronomical observatory in near future.

4. **Conclusion**

The review study in Internet of Things (IoT) for Galactic Cosmic Ray Application Over Astronomical Observatory successful studied. The replacement FTP system and processing mechanism to cloud system is reducing maintenance cost and service over Astronomical Observatory especially in the LAO, Indonesia. The cloud system and IoT has integrated called supervisory system to manage and processing the GCR observation data. Furthermore, the auto update system (calculation GCR flux) from IoT status are useful for airlines, national space service, and astronomical observatory network.
also stakeholder. Based on review study, the supervisory system using IoT and cloud computing have advantages compared by current system of GCR observation. Thus, based on the result we successful study new concept architecture supervisory system to monitor GCR flux parameter using Neutron monitor over astronomical observatory.

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References
[1] Tinsley B A 1996 Journal of Geophysical Research: Atmospheres 101 29714.
[2] Hellweg C E and Baumstark-Khan C 2007 Naturwissenschaften 94 526.
[3] Mishev A L, Kocharov L G, and Usoskin I G 2014 Journal of Geophysical Research: Space Physics 119 679.
[4] Steigies C, Thomann M, Rother O, Wimmer-Schweingruber R, and Heber B 2007 In Proc. 30th ICRC.
[5] Hashem I A T, Yaqoob I, Anuar N B, Mokhtar S, Gani A, and Khan S U 2015 Information Systems 47 115.
[6] Goswami S, Chakraborty S, Ghosh S, Chakrabarti A, and Chakraborty B 2018 Ain Shams Engineering Journal 9 378.
[7] Sihver L, Matthiä D, Koi T, and Mancusi D 2008 New Journal of Physics 10 105019.
[8] Suparta W and Putro W S 2014 Journal of Physics: Conference Series 495 012038.
[9] Suparta W and Putro W S 2014 Journal of Physics: Conference Series 539 012021.
[10] Wang C, Bi Z, and Da Xu L 2014 IEEE Transactions on Industrial Informatics 10 1434.
[11] Buyya R, Yeo C S, Venugopal S, Broberg J, and Brandic I 2009 Future Generation computer systems 25 616.