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Parallel Processing Implementation on Weather Monitoring System for Agriculture

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Abstract

Weather monitoring and forecasting are very important in agricultural sectors. There are several data need to be collected in real-time to support weather monitoring and forecasting systems, such as temperature, humidity, air pressure, wind speed, wind direction, and rainfall. The purpose of this research to develop a real-time weather monitoring system using a parallel computation approach and analyze the computational performance (i.e., speed up and efficiency) using the ARIMA model. The developed system wireless has been implemented on sensor networks (WSN) platform using Arduino and Raspberry Pi devices and web-based platform for weather visualization and monitoring. The experimental data used in our research work is a set of weather data acquired and collected from January until March 2017 in Bogor area. The result of this research is that the speed up of the using eight processors computation three times faster than using a single processor, with the efficiency of 50%.

Keywords*: Monitoring System, Networks, Parallel, Sensor, Weather*

1. Introduction

Weather is one of the environmental factors in the agricultural process. The weather is climate condition in an area when certain time interval. Climatic conditions are temperature, humidity, air pressure, wind direction, and rainfall. The weather change in a zone is quick, so it needs to monitor. The Monitoring system is one of the activities on precision farming [1].

Data collected activities in weather prediction activities need be conducted. Weather data collected activities can use Arduino and Raspberry Pi devices [2, 3] and Raspberry Pi devices [4]. Arduino is open-source devices for hardware prototype. Arduino can receive input from several sensors and provides commands to the motors. Arduino is low power consumption so can be used for a long time. Arduino programmed using the Arduino programming language for various purposes [5]. Raspberry Pi is a credit-card size of a mini computer device. Raspberry has BCM2835 ARM processor, and 256MB of RAM varies, 512MB and 1GB. Raspberry for any purposes use. For the community, education, home automation, industrial automation, and commercial product [6].

Wireless sensor networks (WSN) is one of the platforms on monitoring system and tracking system [7]. WSN has been used in the monitoring and tracking one of them in agriculture [2], [6], [8–10]. In WSN collecting data is main activity. Collecting data on WSN make produce of big data [11]. Data processing on big data on monitoring system used parallel processing [11–15]. Parallel processing uses multiple computers to solving problems. Objectives on parallel computing for shorten the processing time. Parallelization process by dividing the data into multiple memory or processors. The same or different computing can be processing in parallel computing [16].

Based on the background of the use of WSN in weather monitoring necessary for continuous observation. Processing of weather data using parallel computing to process data based on times. The purpose of this study was to perform system architecture design with WSN weather data collection, processing using parallel computing and parallel processing performance analysis on weather data.

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2. Research Method

This stage in this research design of the monitoring system, then monitoring phase, after monitoring phase design of parallel processing model. The next step of this research is parallel processing of weather data monitoring and evaluating parallel processing.

2.1. Weather Monitoring System Design

In this stages, data acquisition system design created based on WSN model. The selection of sensor for weather data collection such us temperature, humidity, air pressure, wind speed, wind direction, and rainfall. Every node of weather data acquisition based on Figure 1.

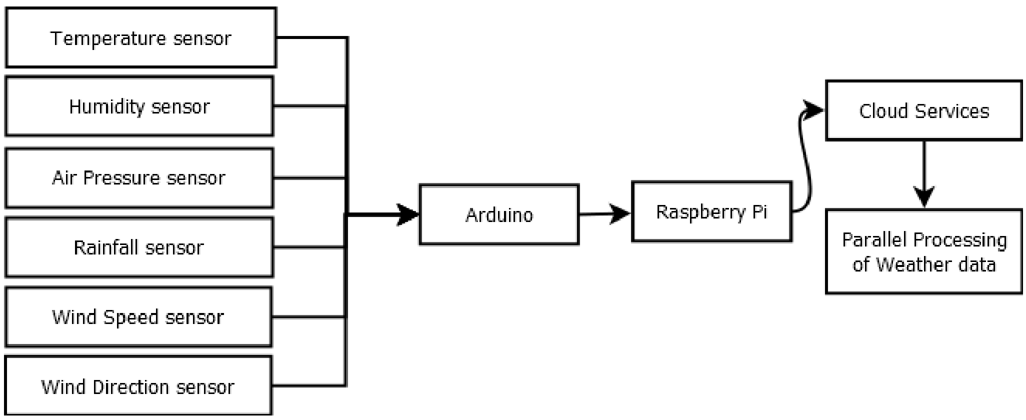

Figure 1. Weather monitoring system design

2.2. Implementation of Weather Monitoring System

At this stage, the testing of prototype and implemented of system design. System tested to know the system was running well and data received to the server for seconds, minutes, hours and days of data interval. Weather monitoring system implemented an agricultural field for a month. Weather acquisition sending data to could service databases and files services.

2.3. Data Processing and Design Parallel Processing of Weather Data

Weather observation data categorised of time series data, weather observation data depend on the time. The weather data stored in the time series and used to make predictions. The difference of time observation makes difference data observation. Model for analysis of time series data using autoregressive model (AR), moving average model (MA), Autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) [17]. Weather data processing with parallel processing for speed-up of processing. Processed of weather with the dividing of weather data categories in several processors [16].

2.4. Parallel Processing Evaluation

Evaluating of parallel weather data processing with calculating the speedup and parallel efficiency. Speedup is a process for increasing the performance between two systems processing the same problem. Speedup (S_N) is a comparison between the serial of execution time (T_s) and parallel of execution time $\left(T_p\right)$ [16].

$$S_N = \frac{T_p}{T_s} \quad (1)$$

The ratio of the actual speedup to the theoretical speedup is the parallelization efficiency. Efficiency (E_N) from parallel processing using N processors using this formula [16].

$$E = \frac{S_N}{N} \quad (2)$$

3. Results and Analysis
3.1. Weather Monitoring System Design
These step of the design of system view in Figure 2. This system includes sensing node, WSN node, and Data Node. Sensing node is a set of sensors to sensing the weather condition. Weather data observation sent to WSN node for preprocessing of data than sending that. Data Node includes cloud-based file services, database services, and memory service.

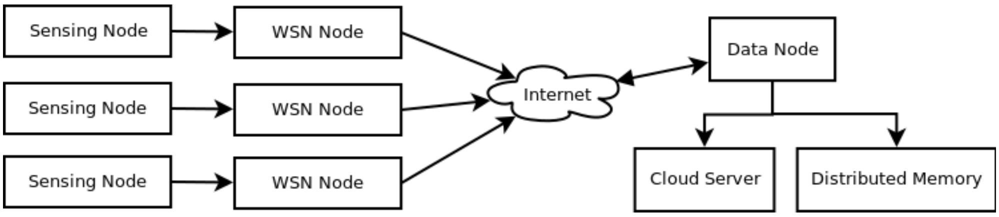

Figure 2. General architecture of weather monitoring system purposes

Environment data sensing using sensor and sending to WSN node. In WSN node processing of weather data with deletion of duplicate data and error of sensor reading data. Data from WSN node sending to data node using internet connection from provider. Data node include database services, and cloud file services. First design step of weather monitoring design is sensor selection for sensing temperature, sensing humidity, sensing air pressure, sensing wind speed, sensing wind direction, and sensing rainfall volume. The sensors used in this research show in Table 1.

Table 1. List sensor for weather data collection

Weather Parameter	Sensor	Unit
Temperature	DHT11	C
Humidity	DHT11	%
Air pressure	BMP180	hPa
Wind direction	Wind wave	degree
Wind speed	Anemometer	m/s
Rainfall	Rain bucket	mm

Programming design for weather monitoring system includes reading sensors, saving data to node WSN sensing, data cleaning, and sending of data. The sensing process of weather data views in Figure 3.

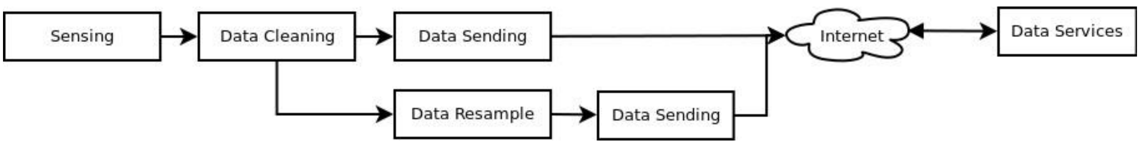

Figure 3. Data flow of weather monitoring system

Data acquisition from the sensor nodes produces and stored based on time series and save to comma delimited file (CSV), with this composition: Time of observation, date, wind direction, wind speed, rain volume, temperature, humidity, air pressure.

Data stored on WSN node includes raw data and clean data with preprocessing. Weather data collection was preprocessing with deletion of duplicate data entry. Storage consumption in every WSN node in Table 2. Storage use for every WSN around 1.25 GB every month, and mobile data use around 254.88 MB every node in the month for sync to cloud services.

Table 2. Estimated of Data storage consumption

Times	Data storage consumption Reading Sensor	Data storage consumption Preprocessed of data	Total storage consumption
1 second	400 B	100 B	500 B
1 minutes	24 KB	6 KB	30 KB
1 hours	1 450 KB	355 KB	1 805 KB
1 days	34 800 KB = 33.98 MB	8 700 KB = 8.5 MB	43 500 KB = 42.48 MB
1 month	1019.53 MB	254.88 MB	1274.41 MB = 1.25 GB

3.2. WSN Implementation

The stages of implementation system include weather monitoring place on specific location. Data collected from climate sensor every second. The flow of data on weather observations based Figure 3. Weather data preprocessing based on algorithm 1:

Algorithm 1: Weather data preprocessing

1. Read environmental data use sensor
2. Save data in CSV file.
3. Read CSV file
4. Row checking based on time series of data.
5. Deletion of duplicate data based on time series
6. Save to new CSV files
7. Sending data to cloud services and database service

Weather observation data synchronised to cloud-based services and send to the database server. List of data shows in https://github.com/dwisusanto29/weather/ based on date. Weather observation information view on a dashboard in page http://dwisusanto.web.id/dws/. Weather dashboard monitoring system displayed based on data observed type. Dashboard show based on daily temperature, daily air humidity, air pressure, daily rainfall and wind speed of weather data. These weather dashboard monitoring system in Figure 4.

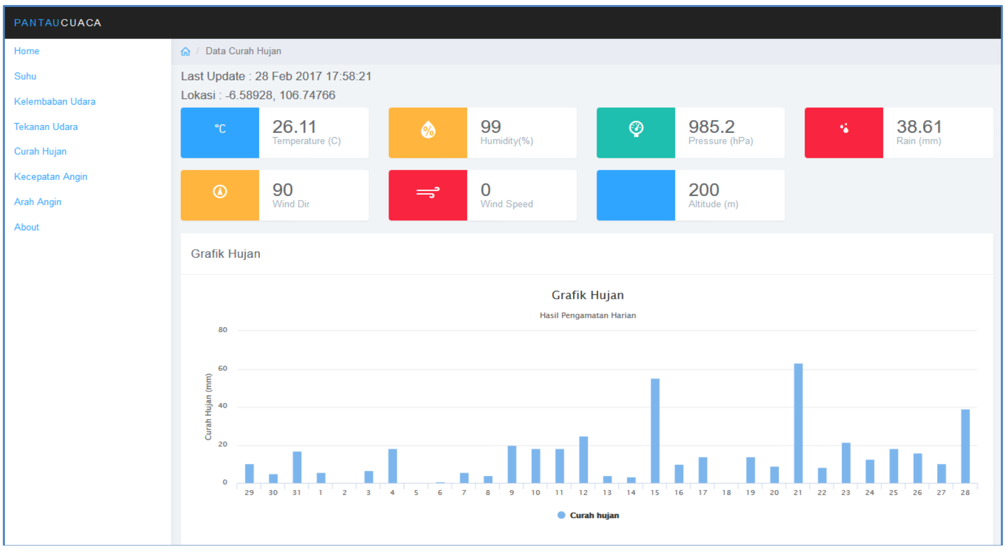

Figure 4. Weather monitoring dashboard

3.3. Parallelization Weather Data Processing

This research processing using serial and parallel processing. In parallel processing, the workload is divided into several processors using ARIMA models. The parallel processing of weather data flows view in Figure 5. The parallel processing performed on the computer with eight processors and 5500-row data. Parallel processing with divide based on data type: minimum temperature, maximum temperature, air pressure, humidity, daily rainfall, and solar.

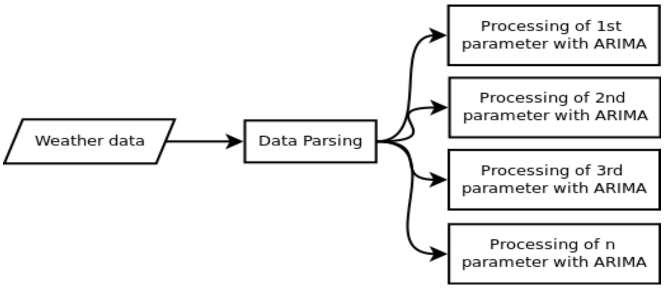

Figure 5. Parallelization of weather data

3.4. Evaluating of Parallel Processing

The increase in data processing speed informed in Figure 6. The use of processors/cores more than one can improve processing speed. 2-3 of processor usage increases almost two times, the use of 3 or 4 processors increase 2.5 times the processing time data. The use of 6, 7 and eight processors improve processing by three times the processing time compared with the use of one processor. Efficient use of the processor with speed more than two times.

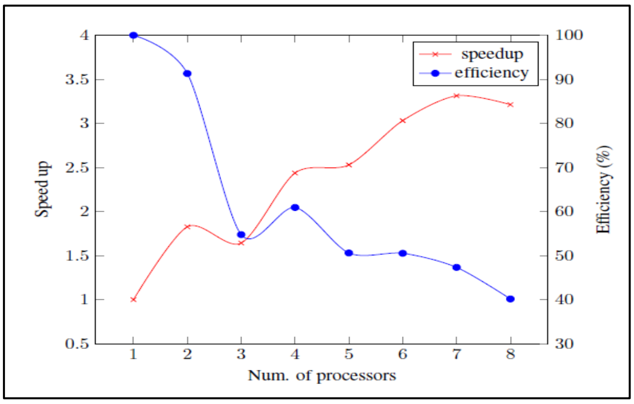

Figure 6. Speedup and efficiency of parallelization of weather data

4. Conclusion

The real-time weather monitoring system has developed and tested using parallel computation approach on ARIMA model. The parallelism strategy uses data partition model, where the collected weather data is partitioned and distributed to several processors for enabling parallel computation for increasing data processing speed up. The processed data include daily minimum temperature, daily maximum temperature, air pressure, wind speed, humidity, and daily rainfall. Each processor processes the same algorithm but different data. Processing using parallel computing to improve processing of weather data 2-3 times speedup. However, the efficiency of decreased as the speed up increased. For weather monitoring and forecasting purposes, computational speed up is far more critical than efficiency, especially when the availability of processor resources is not a primary constraint. The future improvement is to modify the ARIMA model algorithm that better fits with parallel computation conditions using functional segmentation strategy.

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