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Analysis of 4G Network and Chat Applications to Smartphone Battery Life

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***Abstract*— this research aims to prove about the public perception of spendthrift of a smartphone battery life. Many people assume that their smartphone include wasteful with certain types of the use. In this study, the testing subject is the use of smartphones with a standard battery capacity ranging from 1500-2000 mAh, as well as the parameters of chat applications. Determination of the subject is done by establishing the list of event variables, which consists of 216 events contained in these parameters. The data was collected by doing observation directly in the field. Then, the collected data was processed and analyzed statistically by using the classification method with C4.5 algorithm. We also compared the results of manual calculations with WEKA tool and a simple application to test and evaluate the performance of the algorithm. The results showed that, the performance on manual calculation and simple application simulation generated a maximum accuracy of 100%. While, the WEKA get 93.06% accuracy value and experience a little error because there are some additional conditions performed on the calculation on the WEKA. This research contributes real to the science and add insight to the public that will have a true perception about the battery life of the smartphone.**

Keywords— Battery Life; Chat Application; 4G Network; Decision tree; C4.5 Algorithm

I. INTRODUCTION

The needs of the people regarding to browsing, chatting and even online games require a sufficient and stable internet network connection. The more often of the smartphone is connected to the internet then the battery power consumption will be more wasteful, because the smartphone antenna needs battery power to capture the signal of a cellular network. The use of internet on a smartphone depends on the used cellular network operators. In Indonesia, 4G network technology is already exist where the spread of the 4G network is not prevalent yet that cause unstable of the 4G network in some areas. The instability in the network certainly has an impact on the performance of the smartphone antenna, which will work harder [1].

One of the factors that influence the strength of the cellular network is the distance between Base Transceiver Station (BTS) to smartphone, weather and external factors such as electrical outage and the user location. Based on these factors, other information will be appeared that can be a great reference for network strength that is the number of signal bars on the smartphone [2], [3]. In addition to the strength of cellular networks, the number of applications that are used also affect the battery life of the smartphone, for example chat applications. Several popular chat applications nowadays are Whatsapp, LINE and BBM. By relying on smartphones that connect to the internet, the users can access chat applications anywhere and anytime. These chat applications have a fantastic number of PlayStore downloaders, BBM with 100 million downloaders, LINE with 500 million downloaders, and Whatsapp with 1 billion downloaders [4].

Initial hypothesis, more and more chat applications that are used then will impact on battery life of smartphone. Besides, chat applications are connected to the internet, there is also an outflow of data. The used data types are in multimedia such as text (chat), image, voice (call) and video (streaming), and also some promotional ads that appear [4]. This makes the data is quite large and certainly also make the smartphone antenna work harder, so that the battery life will be reduced. This hypothesis encourages authors to analyze the impact of smartphone battery life based on the 4G network strength parameters and the number of chat applications used. The generated information are expected to be able to provide insight to the people about the impact of the strength of the available 4G networks and chat applications that are used on smartphone to battery life, so people can be wiser in using smartphones and become more intelligent people.

In this study, we conducted a direct observation to obtain the real data about the network condition in certain areas with reference to the strength of 4G network. Several experiments are performed by using smartphone, then installing the chat applications and adjusted to the condition of the parameters to be searched. After obtaining the required data, then summarized it into a table for easy understanding. The classification method using decision tree C4.5 algorithm is applied as the reference of the data and the creation of the rule manually. In several case studies, the data combination are used to solve existing problems. Data mining is required to process the history data or basis data to be dataset used. The additional data are taken by actual interview or direct observation [5]. The resulted dataset are analyzed by doing simulations use tools (WEKA and developed simple application) as a comparison of the calculation results manually. The generated output will be in the form of information about the battery life of the smartphone with a variety of parameters provided [6].

In the previous study [7], discussed about the effect analysis of 3G signals on smartphones that cause battery fast drop or lowbatt. Since smartphones are already widely circulated and

3G network technology comes in, people are using smartphones as a tool for browsing, chatting and some other media. Browsing and chatting applications require the speed of data packets to be comfortable when in use. However, there is one problem that has been experienced by the user when using his smartphone for browsing and chatting that is battery fast drop or lowbatt. This matter underlies the authors to analyze the impact of 4G network strength and applications that are used to battery life on the smartphone.

The purposes of this research are: (1) to know the implementation of the classification method using decision tree C4.5 algorithm to classify the battery life of smartphone, (2) to find out the battery life of smartphone with parameters the strength of 4G cellular network and the number of chat application used to battery life of smartphone, and 3) to know the performance comparison among manual calculation with result of the computation simulation and the developed simple application.

II. Research Methodology

A. Data Collection Method

Data collection methods as supporting the accuracy and quality of the data that will be used for this research are by conducting survey with direct observation and through literature study. The survey was conducted by observing 4G network to get data of the strength of 4G network based on different conditions and located around Semarang city. Data from chat applications parameters are added on the smartphone used. Surveys for some additional variables such as weather, location and network stability are also performed. The data will be the reference for the research process. Literature review aims to find the source of reference research derived from books, journals, or internet media associated with the conducted research.

B. Data Analysis Method

In this research, the used data analysis method is statistics technique. This is a data analysis method by collecting data or facts which then processed into data more concise, presented in the form of data tables, and analyzed the obtained rules from the specified data variables. Conclusions and decision making that is reasoned based on fact and analyzing done. In data analyzing, we use the help of a smartphone. It is used to collect the necessary data, because one of the specified parameters is the strength of 4G network, chat application and battery life on smartphone. Stages in analyzing initial data among others are:

1. Data Selection
   The data are taken with some variations of certain events. Data are obtained based on survey results that conducted in the field by using smartphone. The data are gathered by monitoring the activities of the smartphone with reference variables and events that have been predetermined. Each event is limited within 15 minutes.
2. Pre-Processing
   In this process, data grouping is done into training data and testing data based on the obtained data from the survey results. The data that has absolute value and the output results that have been known are grouped into training data, while the data that have the value but the output is not known then it will be grouped into the testing data [8], [9].
3. Transformation
   In the transformation stage, the data is processed into a table format into Microsoft Excel so that the data can be read more concisely and structured. The data table or dataset will be done classification process with decision tree C4.5 algorithm.

C. Proposed Method

The proposed method is to find the rules in overcoming the problems by using classification method and C4.5 algorithm. This method is selected because it has high accuracy values and can be used appropriately because the variables have many variations and make easy for calculation by means of weighting. Steps in performing calculation of classification method using decision tree C4.5 consist of:

1. Classification
   By using classification method and decision tree of C4.5 algorithm, the data will be processed into rules by checking the weights based on the output of each data. The weights will get the Gain values in each class and the Entropy value in each attribute [5], [8], [9].
2. Decision Tree
   Based on Gain and Entropy values, the obtained values will be transformed into a tree. A tree consists of several nodes or leaf nodes that continue to take root to the bottom. The initial node is obtained from the weighted Gain of the class that has the greatest Gain value [5], [9]. To continue the calculation of the node underneath, it is done re-calculation on attributes that have values or results are not uniform. The calculations continue to be repeated until the last leaf node is found and the value of all attributes is uniform.
3. Rule
   The composition of the resulted tree then is converted into a rule. The obtained rule is come from the certainty calculation and be a calculation reference of testing data or new data that has not been known yet their output.
4. Prediction
   A prediction or evaluation is required to know the number of errors in the classification process. Error is calculated from the amount of testing data output that is different from the training data output.

D. Conceptual Framework

In this study, we have formulated a necessary conceptual framework for the basis of where the research will proceed. This stems from the problems that existed to the end of the research in the form of information that is useful for the people and extensive knowledge. The conceptual framework of this study can be divided into six discussion as in Fig. 1 below:

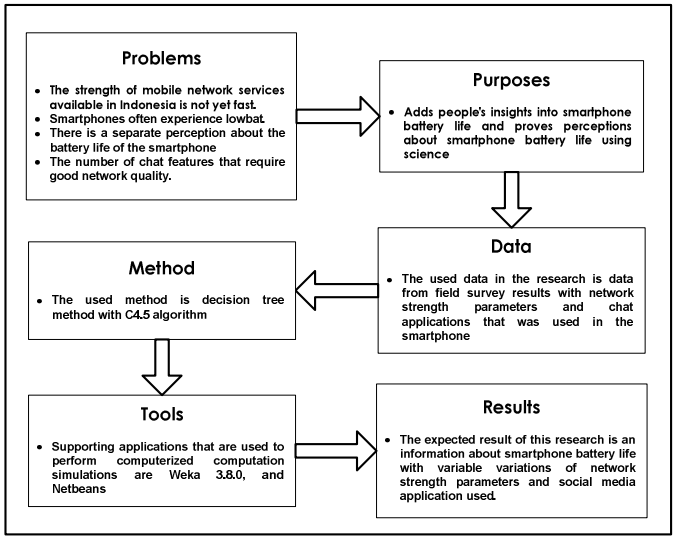

Fig. 1. Conceptual Framework.

This research is expected have benefits both for the people and science. The prospective researchers can have reference for the related research. This research is also expected to contribute in science with applied a method if data that have artificial intelligence value. The research results are expected to provide benefits to the people, especially in terms of smartphone use, so that people become wiser in using smartphones and understand a little basic mobile network.

E. Experiment and Testing Method

The conducted experiments are to simulate the calculation results that have been done by using Weka 3.8.0. This application will give several options to manipulate the output such as the number of errors, the number of nodes that are displayed and many other options that are useful for experiment. This research also conduct the tests using a developed simple application that was made by authors. The developed application was designed using the Netbeans to make coding in Java programming language [6], [10], [11]. The calculation results of simulation are used to know the comparison results of manual calculation with computerized calculation and also calculation come from developed simple program. To find out the evaluation of the classification model performance, it based on the number of dataset records that are predicted correctly and incorrectly in the classification model used containing the comparison of testing data with training data results.

III. RESULT AND DISCUSSION

A. Data Requirement Analysis

Analysis of data needs or data selection is done to determine the data or attributes that are used to determine the decision variables that can be shown in the TABLE I below.

TABLE I. ASSESSMENT CRITERIA

No.	Attributee	Criteria
1	Bar Signal	1-2 Bar 2-3 Bar 3-4 Bar
2	Weather	Sunny Cloudy Rainy
3	Location	Indoor Outdoor
4	User Type	Passive Active
5	Number of Applications	1 2 3
6	Stability	Yes No

The conducted surveys are to obtain data of the battery life attributes that has wasteful and saving criterias. It is based on the variation of predefined data of the variable criteria. This survey is done by utilizing smartphone using variable variations of data and done within 15 minutes. The survey results can be shown in the TABLE II below.

TABLE II. SURVEY RESULTS

No	Signal Bar	Weather	Loc.	User Type	Apps	Stable	Batt. Life
1	1-2	sunny	outdoor	Passive	1	no	4%
2	1-2	cloudy	outdoor	Passive	1	no	5%
3	1-2	rainy	outdoor	Passive	1	no	4%
4	1-2	sunny	indoor	Passive	1	no	6%
5	1-2	cloudy	indoor	Passive	1	no	8%
6	1-2	rainy	indoor	Passive	1	no	4%
…	**…**	…	…	…	…	…	…
49	1-2	sunny	outdoor	Passive	2	yes	5%
50	1-2	cloudy	outdoor	Passive	2	yes	5%
51	1-2	rainy	outdoor	Passive	2	yes	4%
…	**…**	…	…	…	…	…	…
67	1-2	sunny	outdoor	Active	3	yes	4%
68	1-2	cloudy	outdoor	Active	3	yes	7%
69	1-2	rainy	outdoor	Active	3	yes	7%
73	2-3	sunny	outdoor	Active	1	no	3%
74	2-3	cloudy	outdoor	Active	1	no	4%
75	2-3	rainy	outdoor	Active	1	no	3%
…	**…**	…	…	…	…	…	…
94	2-3	sunny	indoor	Active	2	no	5%
95	2-3	cloudy	indoor	Active	2	no	6%
96	2-3	rainy	indoor	Active	2	no	4%
…	**…**	…	…	…	…	…	…
139	2-3	sunny	outdoor	Active	3	yes	3%
140	2-3	cloudy	outdoor	Active	3	yes	6%
141	2-3	rainy	outdoor	Active	3	yes	6%
…	**…**	…	…	…	…	…	…
145	3-4	sunny	outdoor	Passive	1	no	2%
146	3-4	cloudy	outdoor	Passive	1	no	3%
147	3-4	rainy	outdoor	Passive	1	no	2%
…	**…**	…	…	…	…	…	…
187	3-4	sunny	outdoor	Passive	1	yes	2%
188	3-4	cloudy	outdoor	Passive	1	yes	3%
189	3-4	rainy	outdoor	Passive	1	yes	4%
…	**…**	…	…	…	…	…	…
214	3-4	sunny	indoor	Passive	3	yes	1%
215	3-4	cloudy	indoor	Passive	3	yes	3%
216	3-4	rainy	indoor	Passive	3	yes	2%

Based on the survey results, calculation average is counted accordance with procentage of reduced battery life. We do not show all the data but we make conclusion that can be shown in TABLE III below.

TABLE III. CALCULATION OF BATTERY LIFE LIMIT

	Signal Bar 1-2	Signal Bar 2-3	Signal Bar 3-4	Total
Summary	400%	315%	211%	926%
Average				4,29

Based on the calculation results obtained value 4.29 which becomes the size limit that is < 4.29 value is classified into Battery Life Saving and value > 4.29 is classified into Battery Life Wasteful.

B. Classification Method Using Decision Tree

To change the obtained data into an information in the form rules, it is performed calculation using decision tree C4.5 algorithm. The result of node calculation is represented by the calculation table of the initial node where in the initial node calculation table obtained values that become the answer to the problem that is the impact of network strength and chat application to battery life of the smartphone.

The C4.5 algorithm calculation steps are generally: (a) defining the attribute as its root, (b) making a branch on each value, (c) divide case into branch and (d) repeat each branch until all the cases on the branch have the same class. Here is a formula for determining Entropy [5], [10], [12], [13], [14]:

$$\text{Entropy}\ (S) = \sum_{i=1}^{k} -\text{pi} * \log_2 pi \qquad (1)$$

Where:

S is a special set
k is the number of partitions on S
pi is a probability derived from Sum (Yes) or Sum (No) divided by a special total.

After doing the calculation of entropy, then the next step is to do the gain calculation. Here is the gain calculation:

$$Gain\ (A) = Entropi\ (S) - \sum_{i=1}^{k} \frac{|S_i|}{|S|} x\ Entropi(S_i) \qquad (2)$$

Where:

|Si| is number of cases on partition to i
|S| is number of cases on S

Based on the the calculations result, we obtained the best attribute for the initial node that is the signal bar attribute with the highest gain value 0.313294. The next step is to calculate entropy and gain returns by assigning the selected attribute criteria such as the calculation of the variation variables on the criteria present in the attributes of signals bar 1-2, 2-3, and 3-4. In the preparation of the root of the decision tree, it needs to be considered is the value of the criteria. If the value of a kind then do not need to be calculated on the value. While if the value in the criteria is still varied then need to do the calculation again. The whole processes do not appear in this paper, this is caused to many repetitions for signal bar 2-3 and 3-4. Here is for example, the initial node calculation table can be seen on TABLE IV below.

TABLE IV. INITIAL NODE CALCULATION

Node	Atributte	Criteria	Case	Saving	Wasteful	Entropy	Gain
1	Total		216	128	88	0.975119	
	Bar						0.313294
		1-2	72	18	54	0.811278	
		2-3	72	40	32	0.991076	
		3-4	72	70	2	0.183122	
	Weather						0.08305
		sunny	72	51	21	0.870864	
		cloudy	72	30	42	0.979869	
		rainy	72	47	45	0.825473	
	Location						0.002307
		Indoor	108	61	47	0.987844	
		Outdoor	108	67	41	0.95778	
	User Type						0.031255
		passive	108	75	33	0.887976	
		active	108	53	55	0.999753	
	No of Apps						0.01312
		1	72	47	25	0.931563	
		2	72	45	27	0.954434	
		3	72	36	36	1	
	Stable						0.000256
		yes	108	65	43	0.969857	
		no	108	63	45	0.979869	

From the initial node calculation table, the highest value of Gain is found in the signal bar. These results prove that the main factor that affects the battery life of the smartphone is the number of signal bars, followed by the weather, the type of application users chat and so on. In the preparation of the root of the decision tree that need to be considered is the value of the criteria, if the value of a kind then do not need to be calculated on the value. While if the value in the criteria is still varied then need to do the calculation again. After the decision tree is formed then it will be followed by the formation of rules that become the reference in determining the prediction results. The predicted results compared with the existing data are then evaluated using confusion matrix to determine the accuracy, precision and recall.

C. Designing Decision Tree

After getting the node from the weighting result, then the decision tree is made by taking the adjusting weighting condition, starting from top to bottom (root). Fig. 2 is the forming result of a decision tree with the initial node attribute signal bar 1-2 for representation of the formed decision tree in this paper. There are 51 nodes under the signal bar 1-2 which consists of attribute variations that have been adapted to the calculation conditions. Then, there are 57 node under the singnal bar 2-3 and 14 node under the signal bar 3-4. We do not show the decision tree under signal bar 2-3 and 3-4 in this paper. After the decision tree is formed, then the next step is to determine the rules that are used as a science that can be done for further implementation.

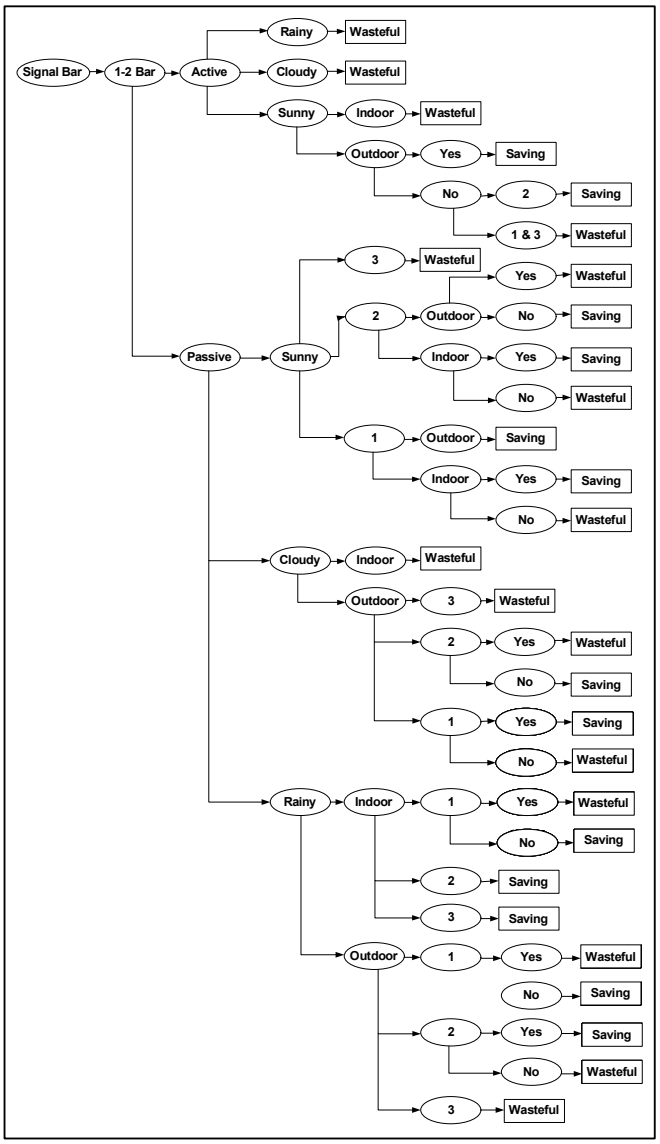

Fig. 2. Decision Tree for signal bar 1-2.

After the decision tree is formed then the next step is to determine the rules that are used as a science that can be done for further implementation. Several of the formed rules are as follow:

1. *R1= If Signal Bar = 1-2 ^ User Type = Active ^ Weather = Sunny ^ Location = Indoor then Battery Life = Wasteful*
2. *R2= If Bar Signal = 1-2 ^ User Type = Active ^ Weather = Sunny ^ Location = Outdoor ^ Stable = Yes then Battery Life = Save*
3. *R3= If Signal Bar = 1-2 ^ User Type = Active ^ Weather = Sunny ^ Location = Outdoor ^ Stable = No ^ Number of Applications = 2 then Battery Life = Save* and so forth.

There are 65 rules of the formed decision tree based on observations in the field.

D. Simulation Using WEKA

Experiments on WEKA tools are required to know and measure the strength of the used methods.

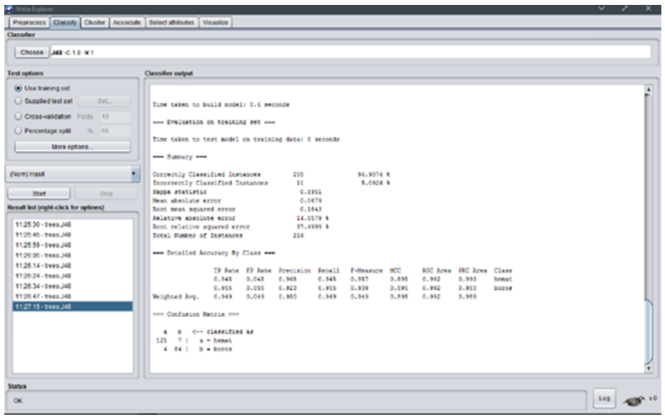

Fig. 3. Simulation the method using WEKA.

Fig. 3 is the result of the obtained calculations by using WEKA tools. The formed decision tree can be seen in the tools along with the accuracy, error and confusion matrix values.

E. Experiments Using a Developed Simple Application

Experiments are also performed using a developed simple application to calculate whether the application is eligible to be used by applying the rules of the decision tree well as shown in Fig. 4 below.

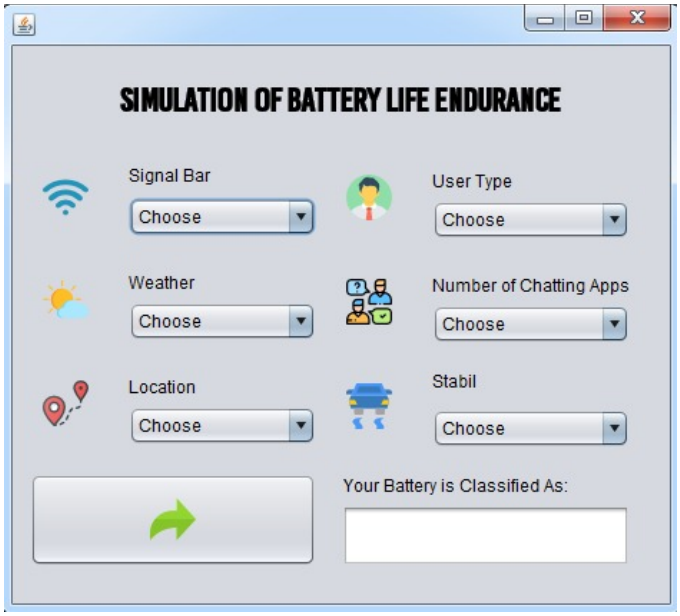

Fig. 4. Experiments using a simple application.

In Fig. 4, there are several options for assigning attribute values to each class. Attributes are filled with data testing. After all attributes in the class are filled, then the application will process with the rules that have been obtained and then produce the output of a wasteful or saving label for battery life of the smartphone.

F. Performance Evaluation

The performance evaluation of the classification model is based on the count of dataset records that are predicted correctly and incorrect using confusion matrix. It uses a table that contains the comparison results of the testing data with training data [12].

TABLE V. CONFUSION MATRIX

		Prediction	
		Class = 1	*Class* = 0
Actual	*Class* = 1	Z11	Z10
	Class = 0	Z01	Z00

Where:
Z11: Prediction is positive and actual data is positive
Z10: Prediction is negative and actual data is positive
Z01: Prediction is positive and actual data is negative
Z00: Prediction is negative and actual data is negative

$$Accuracy = \frac{Z11 + Z00}{Z11 + Z10 + Z01 + Z00} \quad (3)$$

While precision is a measure of the accuracy of a certain class that has been predicted.

$$Precision = \frac{Z11}{Z01 + Z11} \quad (4)$$

Recall is a percentage of data with a positive value whose predictive value is also positive.

$$Recall = \frac{Z11}{Z10 + Z11} \quad (5)$$

Based on the calculation done, the comparison table obtained which contains the accuracy, precision and recall values of each calculation as shown in TABLE V.

TABLE VI. PERFORMANNCE EVALUATION RESULTS

	Accuracy	**Precision**	**Recall**
Manually	100%	100%	100%
WEKA	94.91%	96.80%	94.53%
Simulation	100%	100%	100%

Based on TABLE VI, the result from manual and using simple application calculation get accuracy, precision and recall value 100%. We use manual calculation, WEKA and a developed simple application are to test the algorithm and to know the differences among them. Maximum results can be obtained because the calculation is almost completely done by researchers. While the results on the WEKA tools get smaller results because the WEKA when processing calculations to determine the node, the same values of the gain or entropy only left alone and given a value that is still mixed (not uniform) therefore the decision tree results on WEKA experience error.

IV. CONCLUSION AND FUTURE WORK

Based on the data analysis results using classification method with decision tree C4.5 that is applied to WEKA and developed application, it can be concluded as follows:

1. By applying the classification method using decision tree C4.5 to the research problem, after calculating the value of gain, entropy, forming a decision tree and determining the rules, the battery life can be classified become saving or wasteful easily.
2. In the calculation of the initial node, it can be seen that the main cause of smartphone battery life is the signal bar strength of the operator in the smartphone that has a gain of 0.313. Followed by several parameters in it that adjusted to the parameters that have been determined at the beginning node, where the weather 0.831, the location 0.023, the user type 0.313, the number of applications 0.131 and stable 0.0003.
3. This study get a comparative table data that contains the results of manual calculations, WEKA and developed simple application for experiment. Based on the comparison results among the calculations, we can conclude that the manual calculation and simple simulation applications have accuracy, precision and recall value of 100% while WEKA have accuracy value of 94.91%, precision 96.80% and recall 94.53%. (3)

In the research, we realize there are still some shortcomings that need to be done development and improvement such as: (1) objects of observation can be developed on some types of smartphones and (2) further research is needed to further detail what parameters affect the battery life of the smartphone.

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