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Editors’ Introduction

WELCOME to the first issue of the Internetworking Indonesia Journal in 2013. This issue carries three papers from the 2nd IEEE Conference on Control, Systems & Industrial Informatics (ICCSII), which was held in Bandung, Indonesia in June 2013. The remaining two papers are the regular papers received by the IIJ.

The first paper covers a project on a client and server system that provides weather predictions to its end-user. As may be evident to the readership of the IIJ, a weather reporting and prediction system is valuable to many developing nations, particularly those with a considerable agrarian sector. The paper looks at the management of high-resolution weather data, with the aim of improving the dissemination of information. The paper proposes the use of a web-based data inquiry/access solution which is accessible via mobile devices. The implementation uses the numerical weather prediction model as the basis for obtaining high-resolution predictions. The project was implemented using open source software in order to reduce development costs.

The second paper reports work done at the Royal Institute of Technology (Department of Industrial Production) in Sweden. In broad terms the work seeks to include manufacturing information (typically stored in CAD/CAM systems) into Discrete Event Simulation, by using ISO 10303 Application Protocol 214 (STEP AP214). The aim of the work is among others to improve data management architectures for capturing, structuring, storing and exchanging process specifications.

The third paper reports on a project in Indonesia which seeks to make Intellectual Property (IP) information more accessible to mobile devices. This is due to the fact that the many islands in the country are not as yet connected to the Internet backbone of Indonesia. Hence, mobile phones and smartphones are the main client-side system available to the majority of people in Indonesia. The paper presents a number of interesting background data regarding the IPR applications received by the various branch offices of the Directorate General for IPR in Indonesia. In itself the paper represents an interesting snapshot of efforts to provide digital services to the public in Indonesia using the available technologies, in this case mobile devices.

Robotics is the topic of the fourth paper, which belongs in the regular section of this journal issue. A mobile robot is designed using an artificial neural network-based controller (or neurocontroller), which allows it to learn adaptively. The neurocontrollers of interest are those which evolve according to the determined genetic algorithm. Here the chromosome of each individual neurocontroller is defined to be the binary weights of the connections, while the fitness function is a simple rule for obstacle avoidance behavior. Prior to programming into the mobile robot, the best neurocontroller behavior is analyzed and selected through computer simulation. Although the chromosome is simple and only encodes the weight connections, the simulated evolution of the neurocontrollers has produced a neurocontroller that possess the obstacle avoidance behavior. The best neurocontroller simply controls the mobile robot to rotate left whenever the front and sides sensors detect an obstacle. Only after the obstacle is at the back of the mobile robot would it then move forward away from the obstacle. An important finding is that the three rear distance sensors are actually not important for the mobile robot to possess the obstacle-avoidance behavior.

The last paper in this journal issue reports on some problems and solutions pertaining to the roll-out of Wi-Fi services within a campus dormitory. The authors found that some user behavioral patterns affected the over performance of the Wi-Fi performance, and sought to develop some models to explain in greater clarity the problems faced.

Endra Joelianto (Guest Editor)  
Thomas Hardjono  
Budi Rahardjo  
Henri Uranus

The editors can be reached individually at the following email addresses. Endra Joelianto can be reached at ejoelianto@yahoo.com. Thomas Hardjono is at hardjono@mit.edu, Budi Rahardjo is at rahard@paume.itb.ac.id, Henri Uranus is at henri.uranus@uph.edu.

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Web-based Mobile Client and Server Grid Data Service for Accessing High Resolution Weather Information

Teddy Mantoro,1,2 Wido Hanggoro3 and Media A. Ayu4

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Abstract—The new era of forecast decision model was led by the usage of numerical weather prediction to ensure forecast accuracy. Weather information providers give accuracy, speed and appropriate information to different basic needs of the users. Unfortunately, service providers that meet those three criteria are still rare (especially in developing countries). A combination of PC-Cluster, NWP (Numerical Weather Prediction) and GDS (Grid Data Service) can be used as a low-cost solution in providing weather information which meets those three criteria. This paper presents a proof-of-concept web-based application using GrADS (Grid Analysis and Display System), GrADS Data Server, and GrADS interface to PHP. This was designed to give access to the weather online database to the server-side, which can then assist users from the mobile client in representing the weather prediction. Although the features of the resulting information service (Web Service, GDS and User defined data access) can already assist users in accessing weather information, improvements are still needed especially for delivering of high resolution weather information.

Index Terms—Grids data server, weather information, NWP, high resolution weather.

I. INTRODUCTION

With the increasing in the incidence of disasters caused by weather factors, there is public awareness of the need for weather information which is delivered fast, precise and accurate as absolutely indispensable. Weather information, in general and specific terms, given to certain sectors – such as agriculture and transportation – are also needed. In addition, the information provided should be easily and quickly accessible (i.e. mobile).

The accuracy of weather forecasts is strongly influenced by the spatial resolution of the information provided. So as to obtain accurate results, the forecasts should have a resolution that can describe the dynamics of the atmosphere in the region. This typically requires higher resolutions.

Nowadays, there are numerous options to obtain the weather information while mobile, either through websites or mobile weather applications which can be accessed via computers or mobile devices such as smartphones.

Although the forecast information provided needs to have good accuracy and delivered fast, the National Weather Office (NWO) is also required to provide information that can be easily understood by the general public.

In relation to the weather information, business process models used to describe weather analysis and forecasting has been evolving due to the presence of numerical weather prediction (NWP) [1]. Traditionally, weather information was read from the subjectivity of the forecaster’s analysis. Thus the accuracy of the prediction was, more or less, dependent on the skill and knowledge of each forecaster. New business processes minimize the human factor by using NWP as a weather analyst and examined the dissemination of weather information. This business process still uses forecasters to verify the NWP output and calculate the forecast uncertainty for decision-making [2].

In addition to the benefits of NWP methods, there are some variables that need to be considered, ensuring the accuracy of the weather information provided. Other methods that are used for weather predictions often have results that are less than the NWP expectations. Therefore, we need more improvements to increase the accuracy of the NWP model. Furthermore, according to Hawick [3], spatial environment datasets (especially with high resolution information) still has many challenging problems with regards to storage, access and processing.

NWP is used to get high resolution weather forecast. NWP is described as a collection of computer programming languages which is a numerical representation of the physical
and dynamic equations that occur in the atmosphere (represented in the spatial grids). Therefore, the calculation of physical and dynamic equations is complex and the number of spatial grids is huge. It can only be done with High Performance Computing (HPC).

This paper studies the management of high-resolution weather data to improve the dissemination of information through the development of a NWP web-based data inquiry. It also looks at obtaining high-resolution weather predictions using the NWP model and the configuration of hardware and software (Open Source), including access to the NWP output data with features for users who have differing weather information needs.

The remainder of this paper is organized as follows: Section 2 discusses some related works on weather data service. Section 3 discusses an overview of grid computing for weather information. Section 4 briefly presents the server side of web-based grid data service and the mobile client is discussed in Section 5. Section 6 presents the result and discusses the weather information service. Section 7 concludes the paper and outlines areas for future work.

II. RELATED WORK

Management of huge distributed and shared data resources efficiently within wide area networks has been a topic for both scientific research and commercial application for some time now [4]. The National Weather Services (NWS) in developing countries – which usually has poor Internet bandwidth, limited infrastructure and lack of human resources – faces a more significant problem. Hence, any proposed solution to solve the problem of the dissemination of weather information in developing countries should be low cost, adaptable and applicable.

Over the years scientists have developed many proposals to eliminate the gap for distributing the weather information (please refer to Table I). One of the most referenced systems is NOMADS (NOAA Operational Model Archive and Distribution System). It aims to build a public data center that can serve environmental datasets from NOAA and other organizations [5]. There are also plug-and-play applications such as DAPPER [6], THREDDS [7], and ERDDAP [8] that basically use OPeNDAP [9] as a protocol for delivering the huge amounts of data. For specific NWS purposes there are the KNMI (Koninklijk Nederlands Meteorologisch Instituut) Climate Explorer [10] and the ECMWF (European Centre for Medium-Range Weather Forecasts) MARS [11], while GrADS DODS [12] are the simplest applications that deliver GrADS readable format through online access.

In general there are three types of data access services on NOMADS server:

- Direct Client Access
- Live Access Server
- Data Portals

Due to its convenience level, NOMADS has become one of the more frequently accessed servers. Nevertheless the application of that system for most countries (especially developing countries) is hard to implement. We believe the simplest way is to adopt some of these systems and apply them as needed to the specific situation.

Fig. 1. The NOMADS Philosophy (redrawn and simplified from [13])

<table>
<thead>
<tr>
<th>Research Paper</th>
<th>Tools</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Real NOMADS Project:</td>
<td>OPeNDAP, CGI</td>
<td>GDS, pdisp and ftp2u application</td>
</tr>
<tr>
<td>Access to Operational Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data and Value Added Products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thematic Real-Time Environmental Distributed Data Services (THREDDS)</td>
<td>OPeNDAP, OGC, Web Coverage Service, NetCDF subset, HTTP file transfer services and XML</td>
<td>Web based server, Live Access server, INGRID and GDS</td>
</tr>
<tr>
<td>DAPPER: An OpenDAP Server for In-Situ Data</td>
<td>OPeNDAP, NetCDF, Java</td>
<td></td>
</tr>
<tr>
<td>Division’s Data Access Program</td>
<td>NetCDF Library,</td>
<td></td>
</tr>
<tr>
<td>ERDDAP-The Environmental Research</td>
<td>OPeNDAP, WCS, SOS, OBIS</td>
<td>Web based application handling many output format</td>
</tr>
<tr>
<td>Division’s Data Access DODS Server for In-Situ Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KNMI Climate Explorer: A Web-based Research Tool for</td>
<td>FORTRAN, CGI, GrADS, CDO,</td>
<td>Web based server including statistical analysis</td>
</tr>
<tr>
<td>High-Resolution Paleoclimatology</td>
<td>NCO, netCDF, Lapack dan Blas</td>
<td></td>
</tr>
<tr>
<td>MARS, ECMWF’s Meteorological Archive:</td>
<td>FORTRAN dan C, Java</td>
<td>MARS language and web based application</td>
</tr>
<tr>
<td>Experience in Managing a Large Archive</td>
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<td>The GrADS-DODS Server: An Open-Source Tool for</td>
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</tr>
<tr>
<td>Distributed Data Access and Analysis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OPeNDAP provides the most flexibility for the user to access and compute grid data compared to other services. GDS provides sample access for clients to be able to analyze the use of the OPeNDAP protocol. GDS can serve a variety of data that is recognized by the GrADS, like the formats
netCDF, HDF, GRIB WMO and BUFR WMO. Analysis tools that have been able to use OPENDAP data are: GrADS, Ferret, Matlab, IDL [14].

III. SYSTEM OVERVIEW

In grid computation, which needs intensive computation power such as in NWP, the resource required is dependent on the amount of computation to be performed. Weather predictions on a large area such as Indonesia, obviously needs a heavy duty computing machinery to deliver daily weather predictions on time as a part of the system decision support. Several projects related to the usage of PC Clusters have been established in many disciplines [15]. To get excellent output, cluster computing is used especially in monitoring its operations, in debugging, in failure detection and for performance optimizations [16]. One example is the use of parallel computing technology embedded in a distributed system, providing an ideal and practical solution for multi-site organizations and especially for government agencies who need to extract the best value from bulk geographic data in GIS systems [3].

System requirements needed to run the NWP is dependent on the amount of computation to be performed. As the number of grid points that are calculated increases, the workload of the computers will also increase. According to [17], the minimum computer equipment needed to run one of the NWP models WRFEMS (Weather Research and Forecasting Environmental Modeling System) is a premium-class computer with at least 4GB of physical memory. However, in actuality this depends on the amount of computation to be performed.

A. NWP Computation Model

The main problem encountered in running the NWP is the needs of computing processing. The use of PC-Clustering (a collection of several PCs connected through a network [1]) is one solution to obtain large computational grid data at low cost [19-20].

HPC architectures (such as multi-core, multi-processor HPC platforms with access to fast networks) have an influence on the overall performance of an application [21].

A network consisting of one cluster master node and the 4 client nodes are used to perform computations. The server has an Intel specification (R) Xeon (R) E5640 2.66GHz 24 processor and 16GB of memory use for each server. The network is connected with Fast-Gigabit Ethernet switches for data traffic to cope with rapid and large data access.

To apply a cluster system to this problem area, we also require software that can integrate the entire computing systems in the cluster to serve a job. One such software is MPI (Message Passing Interface), which is a platform in a distributed-memory parallel super computer, where a process can be run separately in a communication node and use the High-Performance Switch [22].

This system uses MPICH (Message Passing Interface Chameleon) for the optimization of the cluster without disturbing any other processes running on the same system [22]. In other words, the process can be done multiple ways and aimed only at specific nodes. However, for reasons of computational requirements, all nodes (including the master node) are used to process data.

B. Weather Data Acquisition

The environmental data, such as atmospheric variable, is highly dynamic. As such the data input needed to predict the weather should be recent information in order to maintain the rapid changes in any parameter predicted [23]. Brusch [24] used the latest environmental information that uses radar and satellite data to provide storm prediction information. Kang also achieved this using AWS data to gain daily weather information to predict plant diseases [25]. Despite this, the basic understanding of the NWP and the weather is still required [26].

C. Grid Analysis and Display System (GrADS) Data Server

The main reason for using this application is that GrADS was commonly used by forecasters worldwide and is able to read 5 dimensions of data; 4 of which are commonly used in regular dimensional weather data (latitude, longitude, altitude and time level) and one other dimension that is used for the ensemble [27].

GDS allows users to access, to manipulate and to display data in a GrADS format via the GDS (online data server). GDS uses a combination of GDS and OPENDAP (the Open source Project for a Network Data Access Protocol) software, formerly known as DODS (Distributed Oceanographic Data System), to produce open-source solutions of weather information data services [28].

To serve the needs of GDS access, a server with the same
PC-Cluster specifications was set-up, with two 8 TB Network Attached Storage (NAS) for data storage.

Figure 3 shows a flow diagram of a GDS, which requires implementation of Java servlet on the server side. The Jakarta Project’s Tomcat package serves as a servlet execution environment so that the data is accessible via the internet.

All configurations are handled by a server configuration file in XML format which also defines the data that we want to display. The configuration file also gives control over resource usage of the GDS server. An administrator can restrict the use of CPU and memory to a request for access by restricting the number of users and the maximum size of a subset of the data cache [30].

GDS provides a server that can manage and serve the weather data. The server can easily be used to share data with others and can be used internally to reduce the load on the network access [30].

IV. WEB-BASED SERVER

Although GDS has been able to deliver NWP data as an online-ready access product, typically not every user or forecaster has the ability to use it with certain applications, such as GrADS or MATLAB. It is also more time consuming to display any images or data extraction using that application with several codes needed, rather than accessing it under web-based service (user friendly application).

Improvements have been made to bypass the difficulties using GDS under a third party application, by using a PHP interface for GrADS. The PHP interface for GrADS is an alternative method of scripting GrADS that can take advantage of the unique capabilities of PHP [31].

A. Basic Features

This application simply delivers all of GrADS basic features into a web application. Users freely choose any settings to display value or images on certain locations or area by changing input values on the left side panel to display on the right side panel (saving images by using right click). Previously users needed to type a few lines of code to get the same output using a third party application. This application is also able to handle animated images by choosing a certain option provided. By choosing the latitude and longitude, users can easily pan their domain interest across Indonesia region.

The forecast information provided by the server is made available up to three days, within hourly time resolution with initial condition provided three days backwards. However, only basic weather parameters, such as precipitation, temperature and humidity at any certain pressure level are provided. To access more parameters, users can use the features of GDS.

Display features are divided into four groups based on how many varying dimensions are inserted. If there are no varying dimensions, the output panel will display the value of the parameter in a certain location, but if there is at least one varying dimension the output will be a graphic image (Figure 5). This web-based application is also capable of providing display output if there are four varying dimensions inserted that typical third applications, such as Grads, are not capable of doing.

GDS link was provided to check the availability of the data. The full list of metadata should be checked using this link. It is very useful to browse the data, especially for new users. It also has direct access to data location that can be accessed using third party applications.

B. Raw NetCDF Data Access

Sometimes users need more than images to analyze the atmosphere condition, therefore they need the raw data to
identify atmosphere phenomena or verify the model output with some observation data. Hence, we provide an access button to download the data (in the NetCDF format) that is easily modified by users using the menu panel. The full feature of this application is provided in Figure 4.

To decrease the size of the downloaded file the NetCDF file is compressed into a zip file, reducing the time required for the download.

V. MOBILE GRID DATA

To obtain the data grid, we used the Weather Research and Forecasting Environmental Modeling System (WRF EMS) software, which is one of the NWP models. According to Rozumalski [4], the WRF EMS is a complete NWP model and is simple to use with a basic knowledge of NWP and the weather data. Compare with other NWP models the WRF EMS is more intended for operational use of weather forecasts than a model intended for research purposes.

There are several steps to obtain estimates of the output data grid in the WRF EMS model. The details are presented in Figure 5.

![WRF EMS flow diagram](image)

The first step is setting up a domain or local area that we want to predict. In this case, the predictions were made for a resolution of 27 km area in Indonesia with the following specifications:

- Latitude: 19.47° to 27.71°
- Longitude: 79.97° to 169.74°
- Altitude (pressure level): 1013mb to 10mb
- Time steps: 1 – 73 hours

These specifications are required by the NWP models to prepare the data information such as the study area, topographic data, the soil type and land use.

NWP Data input is obtained from GFS (Global Forecast System) NOAA which has a spatial resolution of 0.5°. The data is downloaded each time a model needs to output a prediction. The results of processing these data will be data grid to be used as a source of weather information.

The total time needed from the HPC initial data preparation to obtain the output of the data grid is approximately 3 hours, using the HPC 5 nodes and a large output file about 2GB.

VI. RESULTS AND DISCUSSION

NWO, as a weather service provider, is usually thought to display information that is easily understood by users. Therefore, the information displayed is usually very diverse depending on the needs and knowledge of the users.

By using a combination of GDS, GrADS and GrADStoPHP software, we have built a web application that bridges the information needs of users with different requirements. The application of weather information is running in real-time online; as such it can be easily accessible. Moreover, simple computations of these data with the help of GDS can also be done.

To provide output data that is informative, we developed three (3) types of services that can provide information services to users who have different interests.

A. Web Service

This Web service is one of the most common types of service provided by any provider in the weather information. Data produced by NWP models will then be converted into the form of images/pictures and then uploaded into the website (Figure 6).

Predictions of some basic parameters such as rainfall,
temperature and humidity with different levels of user-accessible heights up to three days ahead with a range of hourly predictions.

A limitation of this type of service is that users can only view the parameters provided by the service providers, without the ability to modify the raw data.

B. GDS Access

To be able to modify the output data (e.g. display the parameters that are not displayed on the web service, perform data processing, displaying a particular domain, converting the data into another format, etc.) provided by a GDS, the information obtained is in a lot (62 parameters with different levels of altitude) because direct access to the raw data output of NWP models are possible.

Data access can be done using one of the data processing software using GrADS through port 8080. Therefore, users are required to use the data processing software, which can become obstacles for some users. Wide bandwidth is also required to access the large data.

---

**GrADS Data Server - top level - wrf - 27km**

**GrADS Data Server - directory for /wrf/27km : 8 entries**

1. 201205081200_indices: 201205081200_wrf_wrfout_d01.grb info dds dds
2. 201205151200_indices: 201205151200_wrf_wrfout_d01.grb info dds dds
3. 201205171200_indices: 201205171200_wrf_wrfout_d01.grb info dds dds
4. 201205181200_indices: 201205181200_wrf_wrfout_d01.grb info dds dds
5. 201205191200_indices: 201205191200_wrf_wrfout_d01.grb info dds dds
6. 201205211200_indices: 201205211200_wrf_wrfout_d01.grb info dds dds
7. 201205221200_indices: 201205221200_wrf_wrfout_d01.grb info dds dds

back to parent directory

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C. User Defined Data Access

User Defined Data Access is a web service that is used to overcome the obstacles encountered when accessing the web service and the GDS. In this feature, the user can freely choose the parameters they want to display without having to think about how to run weather data processing software.

An interactive web interface is used to allow users to select the desired parameters (example: Initial condition, latitude, longitude, time interval, the level of altitude and weather parameters). The resulting output can be either images or moving images such as those obtained at the web service access. All computation is done by the computer server so that the large bandwidth requirement to access the GDS can be overcome (e.g. when a lot of users are accessing simultaneously, and large transfer of data is required).

Accessing data using the User Defined Data Access is not as pleasant as using the GDS. But when compared with using a web service, data access using the User Defined Data Access is much better as the user does not have to think about how to deploy the weather data processing software (using the GDS). Therefore the User Defined Data Access can fill a needs-gap between a web service and the GDS.

Even with the advantages offered by each of these features, refinement and dissemination of the data is still required in order to provide appropriate information to the users.

D. GDS and User Defined Data Access Speed Comparison

WRF EMS data access speed in GDS server is analyzed by comparing data access using GDS (in this case client GrADS was used) and user defined data. The data access speed is calculated based on how fast data from GDS can be accessed using both techniques. Various air temperature data dimensions, i.e. time, latitude, longitude, and level, was used in analyzing the speed of these two techniques in accessing the data (see Table II).

Data access speed on user defined data is calculated based on the accumulation of the time required to process the data in the server and the time required by the client to download the data. Data access on GDS ignores the load burden caused by the high number of accesses by other users, and it was done not during the peak access time (done at night time).

<table>
<thead>
<tr>
<th>Datasets</th>
<th>Time</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Height Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data 1</td>
<td>Vary (1-25 hours)</td>
<td>Fix</td>
<td>Fix</td>
<td>Fix</td>
</tr>
<tr>
<td>Data 2</td>
<td>Vary (1-25 hours)</td>
<td>Vary (9°S to 5°S)</td>
<td>Fix</td>
<td>Fix</td>
</tr>
<tr>
<td>Data 3</td>
<td>Vary (1-25 hours)</td>
<td>Vary (105°E to 115°E)</td>
<td>Vary (1013 to 800 mb)</td>
<td>Fix</td>
</tr>
<tr>
<td>Data 4</td>
<td>Vary (1-25 hours)</td>
<td>Vary (9°S to 5°S)</td>
<td>Vary (105°E to 115°E)</td>
<td>Vary (1013 to 800 mb)</td>
</tr>
</tbody>
</table>

---

Fig. 7. GrADS data server screenshots

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C. User Defined Data Access

User Defined Data Access is a web service that is used to overcome the obstacles encountered when accessing the web service and the GDS. In this feature, the user can freely choose the parameters they want to display without having to think about how to run weather data processing software.

An interactive web interface is used to allow users to select the desired parameters (example: Initial condition, latitude, longitude, time interval, the level of altitude and weather parameters). The resulting output can be either images or moving images such as those obtained at the web service access. All computation is done by the computer server so that the large bandwidth requirement to access the GDS can be overcome (e.g. when a lot of users are accessing simultaneously, and large transfer of data is required).

Accessing data using the User Defined Data Access is not as pleasant as using the GDS. But when compared with using a web service, data access using the User Defined Data Access is much better as the user does not have to think about how to deploy the weather data processing software (using the GDS). Therefore the User Defined Data Access can fill a needs-gap between a web service and the GDS.

Even with the advantages offered by each of these features, refinement and dissemination of the data is still required in order to provide appropriate information to the users.

D. GDS and User Defined Data Access Speed Comparison

WRF EMS data access speed in GDS server is analyzed by comparing data access using GDS (in this case client GrADS was used) and user defined data. The data access speed is calculated based on how fast data from GDS can be accessed using both techniques. Various air temperature data dimensions, i.e. time, latitude, longitude, and level, was used in analyzing the speed of these two techniques in accessing the data (see Table II).

Data access speed on user defined data is calculated based on the accumulation of the time required to process the data in the server and the time required by the client to download the data. Data access on GDS ignores the load burden caused by the high number of accesses by other users, and it was done not during the peak access time (done at night time).

<table>
<thead>
<tr>
<th>Datasets</th>
<th>Time</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Height Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data 1</td>
<td>Vary (1-25 hours)</td>
<td>Fix</td>
<td>Fix</td>
<td>Fix</td>
</tr>
<tr>
<td>Data 2</td>
<td>Vary (1-25 hours)</td>
<td>Vary (9°S to 5°S)</td>
<td>Fix</td>
<td>Fix</td>
</tr>
<tr>
<td>Data 3</td>
<td>Vary (1-25 hours)</td>
<td>Vary (105°E to 115°E)</td>
<td>Vary (1013 to 800 mb)</td>
<td>Fix</td>
</tr>
<tr>
<td>Data 4</td>
<td>Vary (1-25 hours)</td>
<td>Vary (9°S to 5°S)</td>
<td>Vary (105°E to 115°E)</td>
<td>Vary (1013 to 800 mb)</td>
</tr>
</tbody>
</table>

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Table 2: Air Temperature Data Dimensions

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VII. CONCLUSION

This paper presents a weather information provider which provides accuracy, speed and appropriate information to different basic needs of the users. We propose the combination of PC-Clusters, NWP and GDS that can be used as a low-cost solution in providing weather information which meets those three criteria.

This paper also presents a solution for the server side to manage large weather information datasets using web-based application. By using GrADS, GDS, and GrADS interface to the PHP application, information was delivered for the users at a low-cost solution.

This approach was intended for internal users (forecasters) who know about the model output characteristic and...
information. It also provides an improvement in the form of a statistics feature that can download raw data in text format, and compile some data input from other NWP models.

As a case study, the prediction of weather information for a resolution of 27 km area in Indonesia was discussed. With the increasing number of smartphone users, an client-side application on smartphone devices (e.g. Android, iOS, Symbian, etc.) that can access the User Defined Data Access would be needed. This could be a promising direction for further development for mobile users who need to query specific weather information.

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Material Flow Data Representation and Integration Based on STEP

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Abstract—A fundamental requirement for executing Discrete Event Simulation (DES) is incorporating a data structure that represents process, product and resource information, and their interrelations. Further, the capability of integrating this data structure with other types of information such as geometry (e.g. for sizes of products or distances of transports) is of vital interest. Manufacturing information is normally not integrated but is heterogeneous and stored in different computer aided design (CAD) and computer aided manufacturing (CAM) applications in the factory plant. Therefore this paper aims to describe how to represent the main required operational data of a manufacturing system for DES by using ISO 10303 Application Protocol 214 (STEP AP214) in order to fulfill the mentioned characteristics of data and information. Stochastic properties of manufacturing resources and corresponding processes such as measured cycle time and disturbances information are represented using application module 1274 (ISO 10303-1274) that defines a particular schema for probability distribution representation. A test implementation of the mentioned data including a graphical user interface has been carried out to show the feasibility of the research approach.

Index Terms—Computer aided engineering, Computer integrated manufacturing, Information representation, Computer applications

I. INTRODUCTION

DIGITAL manufacturing is defined as a technology to process information to verify and optimize the manufacturing of products [1]. Discrete Event Simulation has shown a rigorous capability as a tool in the digital manufacturing context for the purpose of material flow analysis. However DES is rarely used in industry due to the ineffective and inefficient data management that is required for the DES implementation [2]. Extensive and time-consuming data preparation is one of the main reasons of this problem.

In addition, the required data for DES are heterogeneous and reside in different computer applications and databases. For instance, failure and disturbance data is stored in the databases of maintenance systems. Cycle times are defined by process planners and can be found in process planning applications, while geometrical data comes from CAD systems. Therefore, the representation of this data and information in an application and in a system-neutral format allows for easier data integration, for acceleration in the data preparation, and expedites updating DES models. This in turn prevents probable mistakes in data interpretation and facilitates data exchange among different computer applications.

There are a number of approaches that are able to develop data management architectures for capturing, structuring, storing and exchanging process specifications. Falkman [7] shows how process specifications represented as Petri Networks can be mapped to ISO 10303-214. This work represents process planning and conditions for process operation occurrences. However, the work does not focus on interrelated properties of processes, resources and products such as cycle times. Furthermore it does not specify the uncertainties embedded in the process such as the failure data Mean Time between Failure (MTBF) and Mean Time To Repair (MTTR).

Other research have been conducted on information modeling required for manufacturing processes, DES, online simulation, NC data and interlocking [8,9,10,11]. However, little has been investigated concerning the connection between information and DES models and integrating this information with other type of data.

There exist rich ontologies to represent manufacturing processes such as the Process Specification Language (PSL) [12], A Language for Process Specification (ALPS) [13], Core Plan Representation (CPR) [14], the <i-N-OVA> constraint model [15], the Visual Process Modeling Language (VPML) [16] and Petri Nets [17]. However since the aim of all ontologies is to represent knowledge of some domain (in this case manufacturing processes), integrating a specific ontology with other types of information is a laborious task. Moreover these approaches do not focus on shop floor data such as failure data. Boullone indicates how operational data such as measured cycle time, MTBF, MTTR and energy consumption can be generated by using generic data extracted from

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manufacturing databases [18]. They represent these operational data using the Core Manufacturing Simulation Data (CMSD) standard considering the stochastic processes properties. Riddick discusses representing geometrical or spatial aspects of manufacturing entities. However the CMSD standard does not rigorously cover all geometrical data and only focuses on simulation aspects such as boundary, placement and some other spatially-related aspects of the manufacturing entities [19]. Representations of this information using CMSD results in redundant data instantiation/conversion and waste of time since geometrical and spatial data already exist in CAD models and many Commercial CAD systems are able to translate them to the STandard for the Exchange of Product (STEP) model data that allows for interoperability. In the next section we discuss the necessity of integrating manufacturing processes with other types of information to support DES.

II. REQUIRED INFORMATION FOR MATERIAL FLOW AND PROCESS CONTROL

Required information for material flow representation and process control can be categorized as follows:

- **Product**: Product breakdown structure and its geometry data are used for DES. For instance, the diameter of a cylinder is necessary to be able to identify the required capacity of a conveyor which is used in a DES model.
- **Layout**: layout information such as general definitions of the boundary, placement and spatial relations of the manufacturing entities.
- **Manufacturing Resources**: their operational property such as the speed of a conveyor or energy consumption of a resource in different states.
- **Maintenance**: manufacturing resources availability information such as uptimes and downtimes.
- **Enterprise resource planning**: information about orders, production scheduling and production strategy.

Figure 1 illustrates the various domains and their corresponding information to build up a DES model.

III. PROBLEM STATEMENT

Data and information regarding products, processes and manufacturing systems are stored in different systems and databases throughout the factory, such as the Manufacturing Execution System (MES), the Enterprise resource Planning (ERP) and the PDM. This information is heterogeneous due to the lack of interoperability between the CAx commercial software and simulation software. Therefore capturing, structuring and representing this information requires harmonization of this heterogeneous information, and thus also providing the interoperability capability of these data.

This paper presents research on an information modeling schema for an integrated modeling of product, process and manufacturing system for the purpose of discrete event simulation. The schema is based on ISO 10303-214 International standard, namely the application protocol 214 (AP214). This schema has been implemented in a software platform that generates process specification using process schema represented in the CMSD standard, in layout systems, and product design. The presented schema and associated software can support DES, reconfiguration and optimization process in the shop floor.

IV. RESEARCH APPROACH

In this research ISO 10303 is utilized for the purpose of an integrated representation of product, process and manufacturing system. This standard has been chosen for this purpose in reference to the following essential characteristics:

1) **Extensibility**: the schema must be developed in a way that it can accommodate extensions of data in the overall data structure. This property is essential since during the life cycle of a manufacturing system and its reconfiguration new pieces of information might be needed. For instance, the distances that human operators walk can be important for the purpose of line balancing in manufacturing systems.

2) **Interoperability**: the data storage must be done in an application and system neutral format. Hence different software tools can use this information and perform analysis. Furthermore, data interoperability makes the communication of layout tools and simulation tools possible since important information of a DES comes from layout system such as distances among machines, stop times and so on.

3) **Multi granularity**: The schema must be designed to support different levels of analysis of data according to the required detail of information.

4) **Generic**: The schema must be generic to make it possible to be used for wide variety of manufacturing system.

5) **Integration**: it must be possible to model the product, process and manufacturing system as a whole. This feature is the main motivation for selecting the STEP standard since it has the potential to integrate different aspects of manufacturing entities, such as geometry, kinematics, process...
planning, and product routing. Hence different users can exploit their required data in their desired level of detail.

Entities represented in the suggested schema of this research deal with the product, process, and resources to model a manufacturing system and the interrelation of entities are highlighted in order to represent the product, process and resources as whole.

This research has focused on four (4) tasks and development of the software application:
1) Development of an integrated product, process and resources schema based on ISO 10303-214.
2) Mapping the process schema described in CMSD standard to STEP standard.
3) Develop computer application to translate data represented in CMSD (XML) to STEP 214 and validate it.
4) Develop a computer application for process specification translation from CMSD (XML) and integration with geometry of products and resources exporting form commercial CAD system in STEP format.

V. STANDARD FOR INFORMATION EXCHANGE

ISO 10303 STEP is an international standard that “provides a representation of product information along with the necessary mechanisms and definitions to enable product data to be exchanged” [3]. The term exchange should be interpreted as the exchange of data between computer systems in environments associated with the complete life-cycle of a product, including manufacturing. As an introduction to the STEP standard the following concepts will be explained:

- Application protocol (AP);
- Application reference model (ARM);
- Application interpreted model (AIM);
- Integrated resource (IR);
- The exchange/sharing mechanisms.

Application protocols (AP): define the scope, context, and information requirements for a particular application, e.g., the automotive industry (AP214), or the electrical design and installation (AP212). An application protocol is divided into two different representations of the information requirements: the application reference model (ARM) and the application interpreted model (AIM). In depth information on application protocols and STEP, in general, are available in [4]–[5].

ARM and AIM: The ARM is used to capture the information requirements using application-based terminology, whereas the AIM is used to represent the information requirements in application-neutral terminology. Thus, the ARM provides a model that is easy to interpret and understand for domain experts. In addition, the AIM provides a mechanism for interoperability between different application protocols. In this paper, the AIM model of AP214 is used.

AP214 is an application protocol developed to consider the requirements of automotive industry on information exchange. However, Scheller has shown that the generic structure of AP214 can be used to represent any type of mechanical product, including a manufacturing resource [6].

Implementation of the standard is supported by ISO 10303_22 SDAI (standard data Access Interface). SDAI is an abstract programming interface to access data models based on EXPRESS (ISO 10303-11). Express is a language that describes Information models in STEP. ISO 10303-27 specifies a Java binding to SDAI and is implemented in JSDAI, an open source development package produced by LKSoftWare GmbH.

VI. INTEGRATED SCHEMA FOR PRODUCT, PROCESS AND RESOURCE

A. Product, Resource Information Model

Figure 2 illustrates the product schema in a generic way in the AIM level of the ISO 10303_214 Standard. The product schema is generic; therefore it can represent both product and resource. The entities “Product”, “Product_definition_formation” and “product_definition” are used to represent a product in general regardless the aspects that must be represented such as geometry, structure, feature etc. However; for the purpose of representing a resource one need to use the entity “Product_definition_resource”.

The “Product_definition_resource” entity can be of type “Product_definition” and/or “Action resource”, and it specifies a machine or an instrument that is used to perform a process.

![Fig. 2. Product schema to represent product and manufacturing resource in ISO 10303_214](image-url)
the product. If the “Product” entity is a product that is to be manufactured, the Name attribute of the “product_related_product_category” must be instantiated as “part” and if it is a resource it must be instantiated as a “tool”.

Moreover, in AP214 each “product definition” entity and other related entities such as “product_definition_resource” must be connected with the entity “product_definition_context” and “Applied_organization_assignment”.

**B. Process Schema**

Figure 3 demonstrates the process schema in the AIM level of the ISO 10303_214 Standard. A “Process_plan” is a type of action that specifies the information necessary for manufacturing planning. The relation type specifies the meaning of the relationship. In the ARM level the following relation_type have been defined:

1. “Alternative”: The application object defines a relationship where the related Activity may be used alternatively instead of the relating Activity;
2. “Decomposition”: The application object defines a relationship where the related Activity is one of potentially more sub-activities into which the relating Activity is broken down.
3. “Derivation”: The application object defines a relationship where the related Activity is derived from the relating activity.
4. “Exclusiveness”: The application object defines a relationship where the relating and the related Activity shall not have any overlap in time of execution.
5. “Precedence”: The application object defines a relationship where the related Activity has higher priority than the relating Activity.
6. “Sequence”: The application object defines a relationship where the relating Activity shall be completed before the related Activity starts.
7. “Simultaneity”: The application object defines a relationship that establishes that both the relating and related Activity are considered as occurring during the same time period or shall be performed together in order to ensure consistency and enhance efficiency.

**C. Integrated Schema of Product, Process, Resource**

In order to represent the manufacturing system the product, process and resource information and their interrelationship must be represented as a whole schema. Figure 4 shows an integrated schema for a product and a resource that performs a process on the product.

The product entity #3 shows a resource and the product entity #4 shows a product to be manufactured. The entities “Product_process_plan” and “Process_product_association” are connected to the product #3 to specify the necessary information for process planning of the product. The entity “Product_process_plan” is connected to the entity “Action-relationship” to represent one manufacturing process. “Action-relationship” is connected to the “Action” entity that shows the relationship among actions (processes) such as sequence, parallel, alternative etc. sequence. Each “Action” is connected to the entity “Process_operation” that is the identification of a specific step in a process such as load, move, unload and so on. “Action” entity collects all information that is common for all occurrences of a particular process.
To represent the manufacturing processes that are performed with a resource, the “Product_definition_resource” entity is related by the entity “Action” and this action is already connected to the product schema as explained before. Hence, the relationship among product, process and resources can be established and represented. The product information includes ID, Name, Description, Life Cycle stage. The resource information includes ID, Name, Description, Category, and Operation.

**Fig. 5.** Representing MTBF and measured cycle time as properties of an “Action” that is performed by a resource on a product

**D. Schema to Represent Failure Data and Measured Cycle Time**

The most widely used failure information in discrete event simulation is MTBF and MTTR. MTBF is often in practice seen as a kind of total performance measure of a resource which performs many different operations on various products. Thus it might be difficult in practice to relate the MTBF to a specific combination of operation-product. Still, theoretically the MTBF is a kind of time which characterizes how the resource performs. Thus the time between failures is a property of an activity which in turn is related to both resource and the product that is being processed.

MTBF and MTTR can be represented by “Product-property” schema (ISO 10303-41) and “Process-property” (10303-49) schemas.

Figure 5 demonstrates an example of representing a property of a resource-process. The “Action entity “is connected to a “Process_operation” entity that is a manufacturing process. The “Action” is connected to the “Action_property” entity property that can be MTBF. “Action_property” entity is connected to the “Action_property_representation “entity that is used to represent the desired property. Measured cycle time is a cycle time that has been measured in the shop floor for example by executing stop-watch method. This property can be represented with the same schema. Moreover the cycle time that is identified through the process planning activity can also be represented in the same way. However if measured cycle time is stochastic, its corresponding distribution is represented using AM 1274 that is explained in next section. Figure 5 shows the schema for representation of MTBF as a property of an action that is performed by a certain resource and produces a particular product.

**Fig. 6.** Schema for probability distribution using AM 1274 ISO 10303

**E. Schema of Probability Distribution**

Failure information such as MTBF and MTTR are intrinsically sporadic and not deterministic. Therefore they are described using probability density functions (PDF). These functions are mathematical functions whose main parameters are Mean and Standard Deviation. Another example is measured cycle time since the nominal cycle time changes after a while due to the resource degradation. Application Module 1274 is an information model within the ISO 10303 standard that is dedicated to represent probability distribution. This part of ISO 10303 specifies an application module for the representation of probability distribution. Probability distribution provides the basic capability needed to mathematically describe a probability distribution. It does not provide a means to exchange the formulæ used in the calculation of probabilities, such as the cumulative distribution function or the density function. However, in the case of well-known distributions, such as the Normal (or Gaussian) distribution, it does provide the ability to record the parameters of the distribution. It also allows for empirically derived distributions.
Figure 6 illustrates a MTBF representation that follows Normal distribution with mean that follows Normal distribution with mean 125 and Standard deviation 5.

Figure 7 illustrates an example of energy consumption as a property of a resource.

F. Representation of Energy consumption of manufacturing resources

Energy consumption analysis has been the subject of interest for DES to increase the ecological sustainability in production systems. Skoogh shows that the variability of energy consumptions in different statues of the machine (Idle, busy, standby) are low [20]. Therefore this research represents the energy consumption data in a deterministic way by using “Product_property-definition” schema (10303-41), representation schema” (10303-43) and “Measure schema” ISO 10303-41.

Table 1 shows some examples regarding the mapping table. The entities used in CMSD to represent a manufacturing system and properties for a DES model are described in [2].

Table 1. Example of mapping CMSD to STEP AP214

<table>
<thead>
<tr>
<th>No</th>
<th>Concept</th>
<th>Entity in CMSD</th>
<th>Entity in STEP(AIM) level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Product</td>
<td>&lt;ProductDefinition&gt;</td>
<td>Process_product_definition Association Process_process_plan</td>
</tr>
<tr>
<td>2</td>
<td>Product</td>
<td>&lt;Product&gt;</td>
<td>Product_product_plan</td>
</tr>
</tbody>
</table>

G. Map CMSD TO STEP

GDM (Generic Data Management) tool is a software application developed by Chalmers University which extracts the generic data regarding cycle time and failures form the available databases in the plant, draw the histogram, execute the probability distribution fitting, and publish the result in XML format based on CMSD standard [21]. The CMSD Information Model defines a data specification for exchange of manufacturing data in a manufacturing simulation environment. The specification provides a neutral data format for integrating manufacturing applications and simulation. However it does not cover specification of implementation methods and execution behavior of the manufacturing system.

In GDM the toll raw data, describing all necessary behavior on the shop floor, are manually extracted from off-line copies of two production databases, mainly using copy and paste functions. Moreover, filtering of irrelevant or incorrectly measured data was manually performed in MS Excel by simply identifying and deleting data points using process knowledge.

The computer application developed in this research extracts operational data from the output of GDM tool. Therefore a comparative study has been carried out to map the CMSD to STEP. The scope of data is limited to operation sequence, cycle time, failure data and energy consumption of resources in this research.

The main attributes of product, resource and processes that are considered in this schema are as follows:

- Product representation: unique ID, Name, Description, Life Cycle stage, Product process plan (a relation between product and processes).
- Resource representation: unique ID, Name, Description, Category, Operation.
- Representation of Stochastic operational characteristics of resources including Mean Time Between failure (MTBF) and Mean Time To Repair (MTTR).
- Deterministic representation of resource properties including Energy Consumption in different machine statues such as energy consumption busy, Standby, idle.
● Processes required for product manufacturing:
  ○ Stochastic representation of Measured Cycle time;
  ○ Product routing (describes the material flow: operation sequence, operation alternatives and synchronization of operations - whether parallel or in sequence).

VII. SYSTEM ARCHITECTURE OF THE DEVELOPED COMPUTER APPLICATION

This research includes development of one application for providing information for a Discrete Event Simulation Software tool. Figure 8 illustrates the system architecture of the developed computer application. This application is a STEP implementation based on the AP214 AIM schema. It was developed using the Java language because the STEP standard has a strong programming interfaces for Java. All data are represented with STEP part 21 that is the physical part of the standard. Other required data such as organizational data, technical information of a manufacturing resource (machine data card) can be extracted for other available databases or instantiated manually. The geometry data of a product or a resource are translated from any CAD system that is able to represent geometrical data rigorously in STEP format. After translation of operational data, these data are merged with geometry using the developed computer application. Now this repository of data and information can be used for extracting the desired information for the purposes of discrete event simulation. However, since one of the objectives of this test implementation is to export data to the ExtendSim software, the application extracts and converts the information to a text file that is recognizable for the ExtendSim software. This will be discussed below. In the design stage, the integration of three layers is considered: physical data, resources, and application. The resources are collected in a layer to link the application with physical data. Physical data is the data physically stored in the hard disk. The application layer contains the developed programs.

VIII. CASE STUDY

This case study considers a manufacturing encompassing five manufacturing resources, one product and 5 processes. The purpose of the simulation is the calculation of throughput and energy consumption. Each resource includes energy data in three different states: busy, idle and standby. Each process-resource has MTBF, MTTR, measured cycle time, and nominal cycle time. The MTBF, MTTR and measured Cycle time are imported to the application in CMSD format (XML) and other information is extracted from other databases or set up manually. A graphical user interface was developed for end users. With this interface end users only need to identify the path of the CMSD file, the desired location for the STEP file and the database of the ExtendSim software. Finally by clicking the convert buttons the files will be converted in less than one minute.

Figure 9 demonstrates the flow of data translation and integration using the developed computer application. First manufacturing process specification in XML format is translated to STEP. In this step other organizational information is added as well. In second step this information is integrated with geometrical information. The geometrical data come from CAD systems. Finally three pieces of information including cycle time, MTBF and MTTR are exported to a readable text format for ExtendSIM simulation software.

Figure 10 illustrates the graphical interface and the various file formats during the conversion process. As mentioned before some geometrical data of a resource and product are used for DES as well. For instance, the capacity of a straight roller conveyor is the result of the length of the conveyor divided by the diameter of a semi finished product. Therefore the developed computer application merges the operational data with geometrical data of resources or products.

The geometry of a resource or a product is imported from commercial CAD systems. When merging geometry and process schemas, the header, data section and entities “product” and Product_definition_formation” are duplicated. As such the application eliminates the extra entities, and combines geometrical data and process data, etc.

The “Product_definition-formation” is the entity that collects all product representation aspects and exists in geometry, technical data, and property schema. Therefore the computer application searches products with the same ID, keeps one “Product_definition_representation”, eliminates the rest and conducts the necessary relationships among the remaining “product_definition_representation” entity and the other entities that were connected with “Product-definition-representation” in other schemas.
Fig. 9. Flow of data translation and integration

Fig. 10. Graphical interface of data translation and integration
IX. CONCLUSION

This research focuses on representing material flow data and information in a system neutral format by utilizing the STEP standard. Moreover, it shows the feasibility of integrating this data with other kinds of information such as geometry and technical data such as machine data card. This makes the exchange of data among different CAX and simulation applications less erroneous and more efficient. Moreover storing operational data in a system neutral repository decouples the information and the simulation model thus making one model reusable for other similar cases or making it easier to redo the simulation whenever information is updated. Further, to exemplify and verify the approach a computer application was developed to convert operational data from CMSD (XML) to STEP, integrating it with geometrical information from CAD systems and finally converting the data to a readable format for ExtendSIM simulation software.

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Navid Shariatzadeh has a M.Sc. in Mechanical Engineering. He is working towards a Ph.D. degree at the Department of Production Engineering, KTH (Royal Institute of Technology), Stockholm, Sweden, in the field of information modeling and management within the manufacturing area. His research has been conducted in collaboration with industrial partners such as Scania, AB Volvo and Volvo Car.
Intellectual Property Right Dissemination Service Based On Mobile User Location in Indonesia

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Abstract—Intellectual Property Rights (IPR) system is an important economic element which supports economic development through the creation of innovative environments and the enhancement of competitiveness of a nation. As a member of the World Trade Organization (WTO), Indonesia conducted major amendments to its patent laws, trademark laws and copyright laws in 1997 in accordance with the TRIPS Agreement. Later on, an industrial design law, a trade secret law, and a semiconductor-integrated circuit law were established in 2000. The patent laws and the trademark laws were amended in 2001, while the copyright laws were amended in 2002. The Directorate General of Intellectual Property Rights (DGIPR) is a government office under the Ministry of Law and Human Rights of the Republic of Indonesia which is responsible for the registration and protection of intellectual property, including patents, trademarks, copyright, industrial designs, layout designs of integrated circuits and trade secrets. The DGIPR is also responsible for disseminating information on intellectual property (IP). Indonesia is one of the largest archipelago countries in the world and which has 33 provinces. Currently many people residing in these provinces find it difficult to obtain IP related information, such as: flagship trademarks, patent research or geographical indication of product from a province. At the same time there is currently no application or system in Indonesia that provides IP-based mobile information services. The aim of this study is to develop a system that disseminates the IPR information based on location of the IPR for mobile users. This system is also being integrated with social networks such as Facebook and twitter.

Index Terms—Intellectual Property, Mobile User, Location Awareness

I. INTRODUCTION

Intellectual Property Rights are generic terms of exclusive rights given to the results gained by a person’s original intellectual activities and to the intellectual property signs used for business activities. They signify the intangible rights that own economic value. In the convention establishing the World Intellectual Property Organization (WIPO) – which acts as the central organization for international protection of IP and the expert organization of the United Nations – IP rights are defined as follows: "Intellectual property shall include the rights relating to literary, artistic and scientific works, inventions in all fields of human endeavor, scientific discoveries, industrial designs, trademarks, service marks, and commercial names and designations, protection against unfair competition, and all other rights resulting from intellectual activity in the industrial, scientific, literary or artistic fields" [1].

Realizing the important role of the DGIPR in Indonesia, we furthermore understand that its service performance may have significant impact on Indonesia’s economy. With the utilization of an IPR system, the economic development stemming from and relating to intellectual property can be improved in a sustainable manner. The IPR system certainly requires administration/management which is effective, efficient, transparent, accountable, and supported by adequate information technology tools, such as an IPR automation system. The existence of a proper automated system is intended to ensure an optimal management of IPR as a national asset. Such a system is also deemed very urgently needed in order to support economic development and R&D (research and development) activities in this era of knowledge and creativity-based economies (knowledge and creativity economic base) [2].

Today mobile devices are changing the way people work and communicate. Most of the innovative devices today offer the opportunity to access the users’ location information using a programmable API. Another interesting aspect is the rapid development of mobile operating systems such as the Android, BlackBerry OS, iOS and the Windows Phone which combined...
has a rising market share from year to year. Currently, the Android operating system can be considered as one of the fastest growing of mobile operating systems in the market. For this reason, the current study will use Android as its development platform.

In addition to mobile device, today social networks like Facebook and Twitter have become a significant medium for the dissemination of information. The information submitted by a user will be read by possibly thousands of other users. Other users can then further share the information they receive. Thus, sending information through social networks is one of the most effective ways for rapid dissemination. As of this writing Facebook and Twitter are the best known social networks, each growing rapidly with millions of users respectively.

Location-awareness is a very important aspect of context-awareness in mobile computing systems [3]. The off-the-shelf availability and everyday use of a number of moderate-cost mobile devices such as tablets, PDAs, smart phones, handheld and laptop computers (all with pre-installed wireless and wired networking) with their associated location information leads us to focus our attention on context-aware computing that rests lightly on our everyday environment. Location awareness began as a matter of static user location. The notion has recently been extended to reflect movement.

Location-aware systems addresses the acquisition of coordinates in a grid, for example the use of distance metrics and range-based (lateration) algorithms, or at least distances to a reference point as, for example, discriminating presence at a certain choke point on a corridor or in a room of a building [4].

Having reviewed various aspects mentioned above, we believe it would be very useful and even necessary to develop a system that could provide IPR information with location awareness based on mobile devices. The system could use the Google maps API to determine the position of the user, so that the user can obtain the IPR information based on his/her position.

The remainder of this paper is organized as follows; section 2 discusses the related work; section 3 discusses the description of the IPR based location, and section 4 discusses pathway and position analysis. Section 5 provides the discussion and finally section 6 is the conclusion of the work.

II. RELATED WORK

A. Kingsbury Location Awareness System

The Kingsbury Location Awareness System or KLAS, is a prototype location based digital assistant for academic buildings at the University of New Hampshire campus, specifically the second floor of Kingsbury Hall [5]. The KLAS contains two main components, namely the location-awareness system and the user-interactive software. The location awareness system is comprised of a sensor network of IEEE 802.11 (Wi-Fi) access points. The software determines the user’s location through signal strengths of these access points. This will run in the background without any user-interaction. The user will interact with two main parts: a dynamic tour guide and an indoor mapping application. The user can access it by using a personal data assistant (PDA). The prevalence in today’s society of the IEEE 802.11 protocol is the reason it has been used for the basis of KLAS’s location determination. The IEEE 802.11 protocol defines a medium access control mechanism and physical access method to facilitate communication between two devices.

B. Travel Information Assistance

Services for mobile devices are gradually growing with more orientation towards user-location oriented services [6]. Mobile users nowadays are no longer satisfied with the old frameworks that render static and inappropriate services regardless of the user's location. Users require a service that provides intelligent suggestions and results that pertain to their locations, which are also of maximum usefulness and can be immediately utilized.

The study reported in [6] focuses on applying artificial intelligence principles, such as ontology, knowledge base and natural language processing, in building an intelligent mobile and Web service on Twitter, which is one of the biggest mobile-oriented network communities on Internet. The scope of the service is restricted to providing intelligent and personalized query results about restaurants and food for mobile users in Bangkok metropolis, Thailand. The system architecture has also been emphasized with the use of the emerging ontology in constituting the knowledge base in which the building of the ontology model would be instanced with real-value knowledge that would be continuously fed and queried by Twitter’s tweet messages.

C. Foursquare - Location Based Service

The service was created in 2009 by Dennis Crowley and Naveen Selvadurai [6]. Crowley had previously founded a similar project called Dodgeball as his graduate thesis project in the Interactive Telecommunications Program (ITP) at New York University. Google bought Dodgeball in 2005 and shut it down in 2009, replacing it with Google Latitude. Dodgeball user interactions were based on SMS technology, rather than an application.

Foursquare, stylized as foursquare, is a location-based social networking website for mobile devices, such as smartphones [11]. Users "check in" at venues using a mobile website, text messaging or a device-specific application by selecting from a list of venues from the application locates nearby. In many ways, Foursquare already reinvents what happens both before and after the check-in. Just look at how Jimmy Choo employed a pair of trainers to inspire a three-week frantic offline shoe hunt in London - with shoe sales jumping 30% around the time of the campaign - as proof of the concept. It’s the one campaign that Tristan Walker, Foursquare’s director of business development, speaks most highly of, even though the start-up didn’t directly participate.
in the sale. In this case, the LBS is implemented in e-commerce and/or e-marketing as discussed in [12, 13, 14].

D. Sharing Location within Social Groups

This study explores a distinct approach that draws from works on location-awareness and GSM positioning. ‘Connecto’ is an application that is always on [8]. It has location tagging and sharing applications that allows groups of friends to ‘tag’ locations using a standard Windows Mobile phone. Using GSM cell towers to position each phone, Connecto reports each user’s status and location to the group, supplementing the standard contacts view. In this way, Connecto supports the sharing of status and location in an unobtrusive manner, automatically communicating location and status without user involvement. Through sharing status and location, the system supported each groups’ ongoing repartee a site for social exchange, enjoyment and friendship.

III. IPR Based Location Framework
A. Intellectual Property Right

As mentioned earlier, an intellectual property right is an exclusive right. The justification of this proposition involves more than one theory. In the case of a patent right, typical theories involved might well include the theory of incentives for creation and the theory of compensation for public opening [9]. The former theory contends that denying an exclusive right to the creator of an invention that is physically unseizable and intangible would give rise to the possibility of a third party getting a “free ride” and would thereby diminish the incentive to create. Therefore, an exclusive right is granted to the creator so that she can preclude any third party’s unauthorized use of her invention and thus, personally make exclusive use of it. The latter theory asserts that an exclusive right is granted to the inventor as compensation for opening her invention to the public.

In both cases, it is expected that a patent right plays a major part in enabling exclusive use of an invention by virtue of its exclusivity. In the case of copyright, some people rely on the so-called theory of ownership based on mental labor, which says that ownership of a sort should be recognized for a product of mental labor, just as ownership over a tangible entity that is the product of physical labor is recognized. Naturally, this theory is premised on the exclusivity of such ownership.

In recent years, concurrent with the changes in economic circumstances – such as the advancement of globalization of economies – trade of articles other than products such as service trade has increased significantly. While an economy is proceeding with shifting an emphasis on service areas, the differences in the intellectual property system between countries is being questioned as one of the possible non-tariff barriers against the promotion of free trade. As a result, the need for the international harmonization of intellectual property systems has increasingly attracted attention.

Intellectual property systems are different in each country, where intellectual property rights take effect independently. The prevalence of counterfeit brand products and pirated CDs has recently brought about tremendous damages in trade, which has increased the number of international disputes related to intellectual property rights. The result of these problems has been an increase in the significance of the international protection of intellectual property rights and international harmonization of intellectual property systems.

Among the treaties administered by the WIPO are the following: the Paris Convention for the Protection of Industrial Property, the Berne Convention for the Protection of Literary and Artistic Works, the Rome Convention concerning protection of neighboring rights to literary works, Patent Cooperation Treaty (PCT), the Budapest Treaty on the International Recognition of the Deposit of Microorganisms, the Madrid Agreement concerning the protection of indication of source, Trademark Law Treaty, and the Treaty on Intellectual Property in Respect of Integrated Circuits (IPIC), and the Patent Law Treaty (PLT).

The work of [10] examines the enforcement of IP rights within a dynamic general equilibrium of framework, one in which the North invents new products and the South imitates them. A welfare evaluation of a policy of proper IPR is provided, by decomposing the welfare change into four items: (a) terms of trade; (b) production composition; (c) available products; and (d) inter-temporal allocation of consumption. The analysis proceeds in stages. It begins with an exogenous rate of innovation in order to focus on the first two elements. The following two components are added by endogenizing the rate of innovation [10].

In the absence of foreign intervention, proper investment of IPRs move the terms of trade against the South and bring about a reallocation of manufacturing towards higher priced Northern products, which harms the South. If the rate of innovation is responsive to this policy, the rate of innovation rises initially but declines subsequently. The initial acceleration of innovation is, however, insufficient to compensate Southern residents for its eventual decline. Consequently, the shift in the time pattern of available products also hurts the South. The last result may not be robust enough to model specifications, but it shows that endogenous innovation does not guarantee benefits to the South from tighter IPRs on account of the R&D investment response [10].

In the software industry, one of the factors behind the recognition of software-related patents was the transformation of a nation’s machine industry into an “information and knowledge” industry [15]. The practice of patenting began with the advent of the Industrial Revolution. While patents were initially issued for mechanical inventions, the scope was expanded to protect inventions in the chemical and electrical fields as well. In response to the information and knowledge industry boom of the 1990s, the scope was again expanded to cover software-related inventions.

Currently, information and telecommunications systems
produced by the information and knowledge industry serves a fundamental role in many other industries, and this role is expected to become increasingly important in coming years. Consequently, it is extremely important from a social perspective to adequately protect software-related inventions—the core components of these information and telecommunications systems—in an effort to promote the development of software and, ultimately, the development of the aforementioned systems. At the same time, however, there are those who point out that the exercise of software-related patent rights, which can potentially affect a wide range of information and telecommunications systems that are prevalent in society and industry, may actually hinder technological innovation.

The emergence of open source software and the heightened awareness of the importance of software interoperability drove discussions on how to strike a balance between the protection and utilization of software-related intellectual property rights. In June 2005 the METI organization formed a "Study Group on the Legal Protection of Software and Promotion of Innovation" to more closely examine the treatment of software-related intellectual property rights from the perspective of promoting innovation. In October of the same year, the Study Group released an interim report that summarized the issues at hand. Based on an analysis and organization of software characteristics, the Study Group proposed the elimination of any hindering effects that software patent protection might have on innovation.

The transition to free trade in the post-socialist economies offers promises & rewards. For example, the privatization of biomedical research offers both promises and risks [16]. Although it promises an increase in private investment, it also has the risk of creating an anti-commons through the proliferation of fragmented and overlapping IPR. An anti-common in biomedical research may be more likely to endure than in other areas of IP because of the high transaction costs of bargaining, due to heterogeneous interests among owners and due to cognitive biases of researchers. Privatization must be more carefully implemented if it is to serve the public goals of biomedical research. Decision makers should create regulation to ensure coherent boundaries of upstream patents and to minimize restrictive licensing practices that interfere with downstream product development. Otherwise, more upstream rights may lead paradoxically to fewer useful products for improving human health.

B. Distribution of IPR in Indonesia

In Indonesia, the distribution of IPR is managed by the DGIPR, which has 33 regional offices in the country. Since year 2003, IP applications can be filed not only at the DGIPR but also at regional offices. The DGIPR has an e-filing system that can be accessed from regional offices. The following table presents the number of applications through regional offices.

From Table I, it is evident that the Island of Java is the dominant source or origin of copyright and industrial design applications submitted to DGIPR. However, for trademark applications, a more even distribution can be seen from among Java and others provinces, such as Sumatera, Kalimantan, Sulawesi, and Bali. Patent applications mostly come from the DGIPR offices because most of the applicants need in-person representatives/consultants. There are also many applicants from outside of Jakarta or Tangerang that come directly to the DGIPR to apply for their IP. These applications can be classified based on applicants' residence address to determine the region of origin.

Table 1. Number of IPR Applications through Regional Offices in 2012

<table>
<thead>
<tr>
<th>Code</th>
<th>Regional Office</th>
<th>Copy Rights</th>
<th>Industrial Design Right</th>
<th>Trade Mark</th>
<th>Patent</th>
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<td>0</td>
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</tr>
<tr>
<td>04</td>
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<td>0</td>
<td>3</td>
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</tr>
<tr>
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<td>0</td>
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<tr>
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<td>Lampung</td>
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<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
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</tr>
<tr>
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<td>West Java</td>
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<td>3</td>
<td>256</td>
<td>0</td>
</tr>
<tr>
<td>09</td>
<td>Central Java</td>
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<td>West Papua</td>
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</tr>
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</table>
C. IPR Data Source

Currently the DGIPR has data concerning IPR applications for registration from both domestic and abroad. The following Table 2 presents the number of IPR applications that have been registered in the DGIPR.

The DGIPR classifies IP applications based on the original document from the 33 provinces. Each province has cities or regencies. For instance, the province of Bali is divided into 8 regencies (kabupaten) and 1 city (kota), which are: Jembrana Regency, Tabanan Regency, Badung Regency, Gianyar Regency, Klungkung Regency, Bangli Regency, Karangasem Regency, Buleleng Regency, and Denpasar City.

Table 2. Number of IPR Registered in the DGIPR

<table>
<thead>
<tr>
<th>Type of IPR</th>
<th>Number of Application</th>
<th>Number of Registered Application</th>
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<tr>
<td>Trademark</td>
<td>744,300</td>
<td>434,000</td>
</tr>
<tr>
<td>Industrial Design</td>
<td>44,700</td>
<td>24,000</td>
</tr>
<tr>
<td>Copyright</td>
<td>46,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Geographical Indication</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Trade Secret</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The current study gives the experimental query to the IPR database system on how to select the top 5 IPR types based on user location or user preferences. For instance, when a user is located in Denpasar, the query will give result as presented in Figure 1.

```sql
//query for trademark based on user location
select limit 5 trademark_title, owner, application_date
from dw_table
where cities like '%get_location%'
order by application_date

//query for trademark based on user query
select limit 5 trademark_title, owner, application_date
from dw_table
where trademark_title like '%get_title%' or
    owner like '%get_owner%
order by application_date

//query for trademark based on user query
select limit 5 trademark_title, owner, application_date
from dw_table
where cities like '%get_cities%' or
    owner like '%get_owner%
order by application_date
```

Fig. 1. Query based on location

From the query in Figure 1, the cities variable represents the location of the IP application originated. Creating an auxiliary table that contains the name of the city and the longitude and latitude location will assist in determining the user's location more effectively. In the DGIPR, each type of IPR has its own database with a mechanism to extract the data from data warehouses into a single database.

Figure 2 presents the ETL (Extraction, Transformation and Loading) process which will be done automatically using the Kettle Pentaho, which is an open-source software to handle the data warehouse. Pentaho has a scheduler that runs as it is configured. The Pentaho Data Integration delivers powerful ETL capabilities using an innovative, metadata-driven approach. The Pentaho Data Integration provides an intuitive, graphical, drag and drop design environment and became an alternative approach for this study for extraction, transformation and restore and loading process or as a data integration tools.

Fig. 2. An illustration of data warehouse processing in the DGIPR

Another approach that can be used is one based on a scheduler such as the cron job process. Cron enables schedule jobs (commands or shell scripts) to run periodically at certain times or dates so that availability of data for the system will be more adequate.

D. Location Sensing Technologies

A central problem in location aware computing is how to determine the physical location of a person or object [17]. Researchers in academia and industry have created numerous location sensing systems that differ with respect to accuracy, coverage, frequency of location updates, and cost of installation and maintenance.

There are many technologies for this purpose such as: Global Positioning System (GPS), Radio Frequency Identification (RFID), Infrared, Bluetooth, Wi-Fi, Mobile
Figure 3 shows the available location sensing technology based on location accuracy.

In Figure 3, horizontal span of each box shows the range of accuracy which the technology covers; the bottom boundary represents current deployment, while the top boundary shows predicted deployment over the next several years. To provide support for a variety of location-aware applications, researchers are working on techniques for fusing data from multiple sensors, on methods for representing location data, and on drawing high-level contextual information from location data.

Researchers are working on techniques for fusing data from multiple sensors, on methods for representing location data, and on drawing high-level contextual information from location data.

E. Model/Framework

In facilitating the development of the system prototype, in this study some open-source tools are used. The tools are as follows:

- Google API as engine to handle maps;
- Facebook and Twitter API for integrating application;
- Android SDK + Google API Add-On Plugin as backend application;
- MySQL/PostgreSQL as backend database;
- Java as programming language;
- Grails as application framework;
- Sun Glassfish as web server;
- Eclipse + Android plugin (ADT) as IDE;
- Kettle Pentaho for ETL tools in handling the data warehouse process.
- Handheld device (especially using Android OS).

The model/framework of the proposed Intellectual Property Rights (IPR) Information Systems is presented in Figure 4. The details of the framework are as follows:

- The IPR database is generated from the ETL (data warehouse) from each of the applications in the DGIPR.
- This process is done automatically using a batch script that is run in a schedule. Kettle Pentaho acts as the engine in processing the ETL process to extract data from the old sources into the new data warehouse.
- The application server will communicate (do some queries) with the IPR database based on the user’s location and will display a Google Map on the mobile device with the use of the Google API.
- The web application interface is intended to take over management of IPR information behind the scenes. So there are administrators to ensure the system’s service is running correctly.
- The system uses Google APIs Add-On for Android as an extension to the Android SDK development environment that helps develop applications for devices that include Google's set of custom applications, libraries, and services. A central feature of the add-on is the Maps external library, which helps to add powerful mapping capabilities to the Android application.
- The Android OS can automatically retrieve the longitude and latitude, and it can interpret results obtained in the form of maps with the help of the Google map API.
- The GSM Provider provides location-based services (LBS) services to obtain the location of the IPR. LBS represents a general class of computer program-level services used to include specific controls for location and time as one of features for IP location tracking.
- After the longitude and latitude location is captured, the system will display a map on the mobile device that consists of IPR information based on the user’s location.
- Realizing the importance of social networks today, the information obtained from this system can be disseminated through social networking such as Facebook or twitter through their API.
The following is the flowchart that describes how the system works (see Figure 5). Figure 5 shows that there are four areas in the flowchart. The areas are as follows:

- **Server**: it will handle the data warehouse process and it will communicate with external sources using API and will provide proper information to clients and administrators based on queries given.
- **External Sources**: it will work based on requests from web server. The information will be disseminated to other users that are connected through friend lists in Facebook or followers in Twitter.
- **Client**: it will communicate with Google Maps API in accessing maps and web server to obtain the IPR information. QoS depends on the quality of network services and the condition of server traffic.
- **Administrator**: it will monitor the whole system by communicating with the web server.

![Flowchart](image)

Fig. 5. Location-based IPR System Flowchart

IV. RESULTS AND DISCUSSION

The prototype for user’s location information based on IPR in the mobile device can be seen in Figure 6. The application will show the Google Map based on the user’s location based on GPS data, which include the IPR information. The map will also change when the user moves to a different location. If the user is in a building, then the detection of the user location will be based on LBS system of the GSM which has less precision from GPS.

This application needs support from a GSM provider through data access services. Data access speeds will affect the quality of application services. Faster access to data means better service is provided. Furthermore, the information gained can be disseminated through social networking.

The other consideration is the use of LBS services that is provided by telecommunication (GSM) providers. This approach has less accuracy than GPS in detecting user locations and there is a small charge for using this service according to the service provider.

Figure 7 presents the top ten IP application which is grouped by province and it was submitted without a consultant. It shows that location (province) is an important aspect in disseminating IP information. This figure presents a statistical test when the application is performed in three different cities in a province based on the success rate in obtaining IPR information. It also shows that there are a big potential of intellectual property from different provinces in Indonesia.

![Graph](image)

Fig. 6. IPR Information Application based on user location (GPS or LBS)

Fig. 7. A graph of the top ten IP application – grouped by province

In a small city, the accuracy of the location detection may bring to less accuracy. This is because the determination of the user location will first be converted from the longitude and latitude location of their city’s name. The results of these conversions may degrade the accuracy of detection of the
user’s location, as it assumes the city size is in closed curve form. However, in our future work we plan to create a geo-fence for each city to get more accuracy for the user location determination.

The following are the statistics of user polling based on user expectations to the common application features.

Figure 8 indicates that users expect the system to have more application features. For instance, the capability to search the IPR information based on keywords that they enter. Social media is also an important feature for disseminating the IPR information as such the current system may be extended to use keywords for searching purposes.

Fig. 8. Graphs of user expectation for the common application features

V. CONCLUSIONS

The objective of this paper is to provide an intellectual property information dissemination service based on the mobile user's location. The design is as follow: the public can find what trademarks are registered in a city they visited and what kind of product that available in that location based on those IPRs. The geographic location will indicate on what IPR is available in that location.

The detection of the user's location based on the GPS’s longitude and latitude often have constraints for indoor environment. Therefore, the method of location based service is considered to be used in indoor as this IPR system does not need high accuracy of prediction in determining user location. For further study, the combination of geolocation and geo-fencing approach can enrich the features provided to the users. In addition, the application is expected to perform searches based on keywords entered by the user. The user can explore more information in regard to the IPR information and it may relevant to the user profile. Another consideration is to extend the client side of the system to other platforms such as Blackberry, Apple iOS, and Windows Phone.

REFERENCES


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Adaptive Behavior of Evolutionary Neurocontroller for Obstacle Avoidance Mobile Robot

Aloysius Aldo Gani, Sofyan Tan and Meiliayana

Abstract—This research aims to analyze the adaptive behavior of an artificial neural network-based controller (neurocontroller) for an obstacle avoidance wheeled mobile robot. The neurocontroller of interest is the best of an ecosystem of neurocontrollers that evolved according to the genetic algorithm. The chromosome of each individual neurocontroller is simply the binary weights of the connections, and the fitness function is a simple rule for obstacle avoidance behavior. To limit the hardware requirements, the neurocontroller’s evolution is simulated in a computer, and the best neurocontroller behavior is analyzed in the simulation and in an actual mobile robot. Albeit a simple chromosome, the resulting best neurocontroller showed an obstacle avoidance behavior in both simulation and in the actual mobile robot, regardless of the positions of obstacles in the environment. The analysis of the chromosome after evolution also found that not all of the sensors are actually needed for the obstacle avoidance behavior.

Index Terms—Evolution, genetic algorithm, neural network, neurocontroller, reinforcement learning

I. INTRODUCTION

ANY computing systems are being modeled in the imitation of biological systems in nature for its adaptive behavior. In the context of robots, an adaptive behavior enables a robot to operate with minimum or no supervision by human in a changing environment. This behavior is important when the robot must operate in an environment that is unsafe for humans, an unclear or unknown environment, or one having limited communication link. Examples are the outer space and the deep sea.

Two popular algorithms modeling the biological epigenesis and phylogenesis are the artificial neural network (ANN) [1] and the evolutionary algorithm (EA) [2] respectively. The former models the connections of neuron in the brain, whereas the latter models the Darwin’s evolutionary theory. Generally the ANNs are trained in the supervised learning scheme using the back propagation algorithm. The supervised learning scheme requires a comprehensive training set to train the ANN. Such training set may be difficult or even impossible to be completely obtained. The more complex the behavior and environment, the more difficult it is to obtain the training set. Moreover, the back propagation algorithm is a gradient-based optimization algorithm, which is prone to be trapped in local optimum of the search space.

The evolutionary ANN in [3] and [4] offers an alternative for an intelligent neurocontroller (an ANN for control purpose). The algorithm involves the evolution of an ecosystem of neurocontrollers using the genetic algorithm. The chromosome of each neurocontroller is the string of all connection weights. Instead of training a single neurocontroller, many neurocontrollers compete for survival for several generations based on their fitness value. Instead of specifying all the reactions for all situations, as in the supervised learning, the fitness function measures the performance of each neurocontroller in accordance to the desired behavior. At each generation the neurocontrollers are subjected to elimination of the lowest fitness individuals, crossover between individuals, and random mutation. The evolution continues for generations until a neurocontroller with fitness value exceed a threshold value is found.

This approach of learning is categorized as the reinforcement learning where the neurocontroller is just given a set of general rules to achieve. The actual strategy to achieve that desired behavior is learned by the neurocontroller through interaction with the environment. Furthermore this learning algorithm is less prone of being trapped in the local optimum. This research is a variation of the evolutionary neurocontroller in [5] in which the proposed neurocontroller consisted of simply binary weights, hence the chromosome being binary. The proposed neurocontrollers are evolved in simulation, and the best neurocontroller is implemented in an actual mobile robot. Analysis of the adaptive behavior of the neurocontroller is carried out in the simulation and an actual mobile robot.

A. Related Works

The idea of neural network learning from its environment was introduced in [6]. It simulated an ecosystem of neurocontrollers that decide their next actions while learning to predict the future sensor reading during their lifetime. Many of the weight connections of each neurocontroller are trained...
using back-propagation to predict the next sensor reading during its lifetime, whereas some output weight connections for determining the next action are fixed. At the end of their lifetime the best neurocontrollers inherit their learned weight connections to their offspring which then undergo mutation. The paper emphasized that by learning to predict the next sensor reading, an ecosystem of neurocontrollers has a better chance of finding neurocontroller with the desired behavior. The paper only adopted the selection and mutation genetic operators, and it did not employ crossover operator. The evolutionary learning is further surveyed by [3] and [4] to discuss various combinations of neural networks and evolutionary algorithms, and various search operators. It shows that an evolutionary algorithm can be used to evolve not only the connection weights, but also the architecture and the learning rule of the neural network. Some applications of the evolutionary neurocontroller are demonstrated in [5] and [7-9] using a fixed learning rule or fixed architecture. The chromosome encodes the connection weights and the neuron thresholds of the neurocontroller as floating point numbers.

B. Methodology

Evolution of a population of neurocontrollers in hardware can be expensive and takes a very long time. Therefore it is more convenient to simulate the evolution in computer and then implement the best neurocontroller in the actual robot for evaluation. The simulation of the evolution requires modeling of the mobile robot, the environment, and the neurocontroller.

In this research, an actual mobile robot, the arena, and their models are constructed. The models are used to simulate the evolution in computer to find the best-performing neurocontroller after several generations. The best neurocontroller is then implemented in the microcontroller of the actual mobile robot to evaluate its behavior in the actual arena. The next subsections will describe the mobile robot, the arena, the neurocontroller, the evolution simulation, and the hardware implementation of the neurocontroller.

II. THE MOBILE ROBOT AND THE ARENA

The mobile robot to be controlled is a wheeled mobile robot having two wheels and a caster to balance the robot. Each wheel has a diameter of 6.5 cm and it is driven by a DC motor that can rotate in forward and backward directions. The robot is 15 cm in length and 15 cm wide, and the two wheels are aligned to the back of the robot so that the turning radius of the robot is 13.5 cm from the center of the wheel axis. Details of the components arrangements and the photograph of the actual mobile robot are shown in Fig. 1. The placement of components in the mobile robot are arranged to impose the same load to the two wheels.

The robot is equipped with eight ultrasonic sensors distributed around the robot to ensure that the behavior of the neurocontroller will not be restricted by the lack of sensors in some directions. Four sensors are aligned to the forward, backward, left, and right directions of the mobile robot, while the other four covers the four corners of the mobile robot in order to eliminate blind spot, as shown in Fig. 1c. Each sensor can measure the distance to an object at 2 cm to 3 m.

III. THE NEUROCONTROLLER

Each neurocontroller is a single-layer perceptron consisted of eight input nodes and two output nodes. Each input node receives distance information from an ultrasonic sensor that measure the distance to the closest object. The two output
nodes control the speed of the two DC motors in a differential drive configuration. Configuration of the neurocontroller is depicted in Fig. 3.

The distance information from each sensor is converted to a single bit binary value by comparing the distance to a threshold of 16 cm. The threshold is chosen based on the response time of the sensor and the speed of the mobile robot. Therefore, the input value $S_i$ from sensor at node $i$ of the input layer is expressed as

$$S_i = \begin{cases} 0 & \text{dist}_i \leq 16 \\ 1 & \text{dist}_i > 16 \end{cases} \quad 1 \leq i \leq 8$$  \hspace{1cm} (1)

The weights $W_{ji}$ are single-bit binary values that model the connectivity of synapses from input node $i$ to output node $j$. The values of the weights are expressed as

$$W_{ji} = \{ 0, 1 \} \quad 1 \leq j \leq 2, \quad 1 \leq i \leq 8$$  \hspace{1cm} (2)

The output of the neural network $O_j$ is also a single-bit binary value that follow the following activation function

$$O_j = \begin{cases} 0 & \text{net}_j = 0 \\ 1 & \text{net}_j > 0 \end{cases} \quad 1 \leq j \leq 2, \quad \text{where } \text{net}_j = \sum_{i=1}^{8} W_{ji}S_i$$  \hspace{1cm} (3)

The activation function is a threshold function that instructs the wheel to rotate forward when the internal activity ($\text{net}_j$) of the neuron is zero and rotate backward when it is larger than zero. The $\text{net}_j$ cannot have a negative value since the inputs and weights are equal or larger than zero.

Combination the output value $O_j$ of the two nodes in the output layer produces four possible movements of the mobile robot, listed in Table 1.

![Image](image_url)

**Table I. Possible Movements of the Mobile Robot**

<table>
<thead>
<tr>
<th>Left Wheel ($O_2$)</th>
<th>Right Wheel ($O_1$)</th>
<th>Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>Forward</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>Rotate right</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>Rotate left</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Backward</td>
</tr>
</tbody>
</table>

IV. THE EVOLUTION OF THE NEUROCONTROLLER

Simulation of the evolution is performed in computer. The mobile robot kinematic is modeled according to the dimensions of the actual mobile robot, whereas the dynamic is assumed to be ideal, such as zero mass and zero friction.

Each sensor in the simulation is assumed to have zero angle of view, hence it only measures the distance of obstacle straight in front of the sensor. The actual sensors however have field of view of a few tens of degrees. The arena is modeled as a two dimension plane with line walls and square obstacles. The mobile robot velocity vectors can only be parallel to the plane. The arena’s walls and the obstacles are modeled as rigid static objects during evolution.

A. The Chromosomes

For each generation there are one hundred neurocontrollers which correspond to one hundred chromosomes. Each chromosome is consisted of 16 genes, which are all the weights in a neurocontroller, and as explained, these genes have binary value. The arrangement of weights in the chromosome is shown in Fig. 4a, where weights affecting the left and right wheels are arranged alternately. The corresponding placement of sensors is shown in Fig. 4b, where the arrow shows the direction of forward movement of the mobile robot.

B. The Fitness Function

Fitness function of the neurocontroller is designed to appreciate neurocontroller that stay away from obstacles (including walls), while consistently move forward or consistently move backward. Fitness of each individual neurocontroller at each generation is calculated according to

$$\text{fitness} = \frac{0.7 \sum_{k=1}^{1000} C_{1k} + 0.3 \sum_{k=1}^{1000} C_{2k}}{1000}$$  \hspace{1cm} (4)

Eq. 4 shows that at each generation the neurocontroller must control the simulated mobile robot for 1000 steps of movement. There are two sub-behaviors in the fitness function.
which are the obstacle avoidance sub-behavior and the straight movement sub-behavior, assessed as the $C_1$ and $C_2$ respectively. The two assessments are averaged so that the maximum fitness value is one, and weighted so that the $C_1$ assessment is much more dominant than the $C_2$ assessment. The main behavior of the mobile robot is obstacle avoidance, hence the larger weight of 0.7 for $C_1$. The smaller weight for $C_2$ makes it a lower priority assessment, such that in difficult conditions the robot may keep rotating or moving forward and backward alternately as long as it does not bump into obstacle.

The obstacle avoidance sub-behavior assessment is calculated according to

$$C_1_k = \begin{cases} 1 & D_k = 1 \\ 0 & D_k < 1 \end{cases} \quad 1 \leq k \leq 1000$$

where $D_k = \max(S_{1k}, \cdots, S_{8k})$. Whenever any sensor reports a distance of 16 cm or less from an object at step $k$, then $C_1_k$ has a value of zero, otherwise $C_1_k$ is one.

The straight movement sub-behavior assessment is calculated according to

$$C_2_k = \frac{(2O_{1k} - 1) + (2O_{2k} - 1)}{2}$$

Whenever the two outputs $O_{jk}$ are all ones or all zeros at a particular step $k$, then the magnitude of $C_2$ is at its maximum, otherwise $C_2$ is zero. $C_2_k$ is +1 when the robot is moving forward, and −1 when backward. Otherwise, when the robot is rotating left or right then $C_2_k$ is zero. Preservation of the sign in Eq. 6 ensures that neurocontroller that has a consistent forward or backward movement during a generation has a better fitness value when accumulated in Eq. 4.

C. The Genetic Algorithm

The simulated evolution lasts for 100 generations, starting with 100 neurocontrollers with random chromosomes. The square obstacles are sparsely placed at the beginning of the evolution and their positions are static throughout the evolution. The starting position of the mobile robot in each generation is alternating between four scattered starting positions to ensure adaptive behavior of the neurocontroller. At each generation neurocontrollers are running in the simulated arena in sequence, and at the end of the generation, after all neurocontroller has had their turn, the fitness values of all neurocontrollers are calculated. From one generation to the next generation there are elimination based on the neurocontroller’s fitness values, crossover, and random mutation of the neurocontrollers.

The elimination method used is the truncation method, where some of the neurocontrollers that have lower fitness values are eliminated and replaced with the same number of neurocontrollers with random chromosomes. The elimination rate in the simulation is 20%, which means that 20% lowest fitness neurocontrollers will be replaced with neurocontrollers with random chromosomes.

The resulting population of neurocontrollers will then go through the crossover process, using the one point crossover method. In the process, 24 randomly chosen pairs of parent neurocontrollers are exchanging part of their genomes/weights to form 24 new pairs of offspring neurocontrollers, which replace their parents.

Finally a random mutation is applied to the population of neurocontrollers. The mutation rate is 1%, where 16 out of 1600 genomes/weights in a population are flipped. The resulting population of neurocontrollers proceeds to the next generation, where their fitness will be calculated.

V. RESULTS AND DISCUSSION

Fig. 5 shows the simulator GUI along with the simulated arena at the left side of the screen. The GUI supports the initialization, evolution, and testing of the neurocontrollers.
In the simulated arena the last position of the mobile robot is pointed by the drawing of the mobile robot. The line behind the robot illustrates the past trajectory of the mobile robot, where the end of the line points to the starting position of the mobile robot. Square obstacles can be placed in any position inside the simulated arena.

In the first simulation evaluation, Fig. 5a, there is no other obstacle but the four walls at each side of the arena. Regardless of its initial position, the mobile robot developed the obstacle avoidance behavior. It can be seen from both evaluations that the mobile robot tends to move straight forward in order to increase its roaming distance. In the second simulation evaluation, Fig. 5b, obstacle avoidance behavior is also shown by the mobile robot when there are square obstacles inside the arena. The mobile robot rotates away from obstacles only when it is close to the obstacles. It is consistent with the thresholding function at the input layer and the fitness function. However it managed to develop moving forward behavior, differentiating the role of the front and rear sensors so that it will not rotate when only the rear sensors are obstructed. In both evaluations the mobile robot never move backward, this is because backward movement reduce the fitness obtained by forward movement, as described in Eq. 4 and 6.

To analyze more detail into the cause of the mentioned behaviors, we can look into the chromosome of the best neurocontroller in Fig. 6. It can be seen that the weights for sensor 4, 5, and 6 are all zero. These three sensors are the three rear sensors as shown in Fig. 4b. The evolution has founded that the three sensors are actually not important for the obstacle avoidance behavior, and they can be removed from the actual mobile robot without disrupting the obstacle avoidance behavior. The explanation is that the mobile robot does not have to move backward to avoid obstacle, it can always rotate away from obstacle.

Further inspection into the connections of the other five sensors shows that all connections to the right motor is zero and all connections to the left motor is one. The activation function in Eq. 3 and the programmed movements in Table 1 show that these values of weights will force the mobile robot to rotate left whenever any of the five sensors are obstructed. This behavior completes the previous analysis showing that the robot will always rotate left until no obstacle is obstructing any of the five sensors at the front and sides, and then continue with forward movement to move away from the obstacle.

One best neurocontroller found from the simulation with obstacles is evaluated in the actual mobile robot and arena shown in Fig. 2. The behavior of the best neurocontroller in the actual mobile robot in the arena is in accordance with the behavior in the simulation with some calibrations. The rotation speeds of the two wheels must be calibrated to assure that the robot’s movement is reasonably straight during forward or backward movement. The movement speed of the robot must not be too fast so that during a distance reading period the robot does not move too far. In the evaluation the actual straight movements speed is 5 cm per second.

The sequence of distance readings by the ultrasonic sensors must be controlled to minimize interference between the ultrasonic sensors, while minimizing delay between sensor readings. Furthermore the thresholds of the input neurons must be adjusted differently for different sensor directions. Front and rear sensors have larger threshold values compared to the side sensors in order to compensate the larger displacement of straight forward and backward movements.

VI. CONCLUSIONS

An approach of evolvable neurocontroller algorithm with binary weights is proposed and presented. The neurocontroller is a simple single layer perceptron with eight input neurons corresponds to eights distance sensors and two output neurons corresponds to two DC motors. The fitness function of the genetic algorithm is a simple rule to encourage obstacle avoidance sub-behavior and consistent straight movement sub-behavior.

Although the chromosome is simple and only encodes the weight connections, the simulated evolution of the neurocontrollers has produced a neurocontroller that possess the obstacle avoidance behavior. The best neurocontroller simply controls the mobile robot to rotate left whenever the front and sides sensors detect an obstacle. Only after the obstacle is at the back of the mobile robot then it moves straight forward away from the obstacle. The evolution also found that three rear distance sensors are not important for the mobile robot to have the obstacle avoidance behavior.

The best neurocontroller has been implemented to control an actual mobile robot producing equivalent obstacle avoidance behavior with some adjustments to the mobile robot and neurocontroller.

Future works of this research will involve evaluating the mobile robots for more types of environments such as labyrinth. Furthermore, expanding the research into swarm of neurocontrollers can provide more insights into the capability of evolutionary neural networks for swarm behaviors.

REFERENCES


Aloysius Aldo Gani obtained his bachelor degree in Computer Technology from Universitas Pelita Harapan, Tangerang, Indonesia in 2011, and Master of Science degree in Embedded System from Nanyang Technological University, Singapore in 2012. He is currently working as an embedded software engineer in Gemalto, Singapore. His research interests are embedded systems, artificial neural network and evolutionary computing.

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Influences of Wireless Traffic toward WiFi Performance at BINUS Square - Jakarta

Rico Wijaya, Johan Muliadi Kerta, and Rinda Hedwig

Abstract—BINUS Square is a dormitory for students of Bina Nusantara University, Jakarta which provides Internet facility with wireless media. Since 2010, there have been many complaints on network performance such as slow connections or frequent break up of connections. Although the configuration and network capacity has been regularly fixed and upgraded, the complaints keep on repeating. The current study is formulated by using multiple case methodologies such as data retrieval by using SNMP polling tools, Access Point (AP) Monitoring, Syslog, and field measurements. It is noted that the distance factor, the number of users and signal strength do not influence the speed with an average of 4,769 Kbps for download and 874 Kbps for upload. However the roaming activity occurring in WLAN is equal to 30% of 10,418 roaming events, which in turn lead to the slow speed of the connections.

Index Terms—wireless traffic, access point monitoring, syslog, network analyzer, SNMP polling

I. INTRODUCTION

BINUS Square – Hall of Residence is a temporary residence for students of Bina Nusantara University which is occupied by 985 students. Since it was opened in 2010, the residence has been equipped with Internet access, a common facility offered by many education institutions [1-3] nowadays. Nevertheless, complaints of slow Internet access or break up of connections are greater than complaints for other facilities. This is because most students mainly access the Internet applications such as instant messaging, browsing and streaming for 24 hours. The characteristics of campus wireless network has been studied by Papadopouli [4] et. al., and Schwab and Bunt [5]. These provide the information about where, when, how much, and for what their wireless network is being used. Such information is important in evaluating design principles and planning for future network expansion.

Kortz and Essien [6] observed wireless network performance at Dartmouth College by implementing 3 different ways of Syslog recording: SNMP, polling and sniffer. In this implementation, a card switches access points (AP), identified by a ‘roams out to/ roams from’ message to a new AP. They also reported in their writing that they found that the roaming activity was as high as 40%, which will be compared later to BINUS square one. According to Geier [7], roaming process, even as low as 68ms, could interfere with the application layer. This is due to the hold off implementation in the network interface card (NIC), which is a wireless network interface card identified by MAC address, where data retransmission occurs during hold off period.

Using the same idea, this study was proposed to characterize residence’s wireless network so that the problem can be identified and solved.

The current study identified five ways to gather data: traffic monitoring through SNMP polling [8,9], syslog [10,11], network analyzer [12], AP monitoring [13] and field measurements. Pre-processing data based on Perl [14] was carried out before data gathering through syslog and AP monitoring. After data gathering, analysis was carried out by using descriptive statistics where a CDF graph was applied, and quantitative analysis approximation by means of double linear regression.

The proposed hypotheses are as follow:

Hypotheses 1
(H0) The number of users (X1) does not influence the download speed (Y1)
(H1) The number of users (X1) influences the download speed (Y1)

Hypotheses 2
(H0) Signal strength (X2) does not influence the download speed (Y1)
(H1) Signal strength (X2) influences the download speed (Y1)

Hypotheses 3
(H0) The distance between user and AP (X3) does not influence the download speed (Y1)
(H1) The distance between user and AP (X3) influences the download speed (Y1)

This research also uses cumulative distribution function graph so we could obtain the 50 percent median and 95 percent certain value. The sampling was done by taking 30 user rooms for t-test and variant analysis. Independent and dependent variables are shown in Table 1 while double regression model that is used in this research is 

\[ Y_1 = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 \]

<table>
<thead>
<tr>
<th>TABLE I.</th>
<th>INDEPENDENT AND DEPENDENT VARIABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent Variables</strong></td>
<td><strong>Dependent Variables</strong></td>
</tr>
<tr>
<td>Number of users (X1)</td>
<td>Download speed (Y1)</td>
</tr>
<tr>
<td>Signal strength/RSSI (X2)</td>
<td>Distance between user and AP (X3)</td>
</tr>
</tbody>
</table>
II. RESULTS AND DISCUSSION

The network profile of BINUS Square can be seen on figure 1 where the Proxy server was used as the Internet data cache in order to reduce the bandwidth usage for extranet access. Figure 2 shows the wireless LAN network topology with 1 Mikrotik gateway, 1 Mikrotik hotspot (router), 22 manageable Ethernet switches, a wireless controller and 163 AP that can be used for the Internet access. In this case, BINUS Square uses Ruckus Wireless as the access point.

The international bandwidth available in BINUS Square is 25Mbps (night time). The usage of international download bandwidth monitored since Nov 25th, 2011 until December 24th, 2011 showed that the maximum bandwidth of 78.82 Mbps was not above its maximum point of 80Mbps. The observation was also made for network traffic when the international bandwidth was set and the aggregate bandwidth was as high as 384Kbps and 80Mbps, respectively. It was found that the utilization of the bandwidth was never full for a long time. However, only a traffic peak was observed.

Figure 3 shows the activity between AP in the same WLAN and AP in different WLAN. It can be seen that the high roaming activity can cause instability of connections since network needed to update the IP address very frequently. This roaming occurred even though the users did not move locations. This was caused by an overlapping signal area with the same WLAN Service Set Identifier (SSID).

The graph of cumulative density function (CDF) of user number and Received Signal Strength Indicator (RSSI) can be seen in Figure 4. It shows that there was Internet activity on every floor, although some floors were not being occupied during the research period (16th to 18th floor). In this research, the measurement result was taken by taking signal data via wireless monitor and speed test. The statistical test using SPSS can be seen below.

Download Speed Model (Y1)

Table 2. Model Summary

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.284</td>
<td>.081</td>
<td>-.025</td>
<td>385.20821</td>
</tr>
</tbody>
</table>

Table 3. ANOVA

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Regression</td>
<td>539320.710</td>
<td>3</td>
<td>113106.903</td>
<td>.762</td>
<td>.525a</td>
</tr>
<tr>
<td>Residual</td>
<td>3858019.590</td>
<td>26</td>
<td>148385.369</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4197340.300</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), X3, X1, X2
b. Dependent Variable: Y1

Table 4. Coefficients

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Constant)</td>
<td>4613.954</td>
<td></td>
<td>9.564</td>
<td>.000</td>
</tr>
<tr>
<td>X1</td>
<td>36.620</td>
<td>.264</td>
<td>1.332</td>
<td>.194</td>
</tr>
<tr>
<td>X2</td>
<td>.019</td>
<td>.001</td>
<td>.004</td>
<td>.997</td>
</tr>
<tr>
<td>X3</td>
<td>-7.278</td>
<td>-.063</td>
<td>-.254</td>
<td>.802</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Y1
X1= number of user (user)
X2= signal strength/RSSI (%)
X3= Distance between user and AP (m)

Y1 = download speed (kbps)

Table 4 shows that the equation for double linear regression as is as follow:

Y1 = 4613.954 + 36.620 * X1 + 0.019 * X2 - 7.278 * X3

(1)

The partial hypotheses test on B1
1. \( H_0 : B_1 = 0 \) (X1 does not influence Y1)
2. \( H_a : B_1 \neq 0 \) (X1 influences Y1)
3. From t table, \( \alpha = 0.05, df = 26, t_{0.025(26)} = 2.056 \)
4. Since \( t_{0.025(26)} < t_{0.025(26)} = 2.056 \) then \( H_0 \) is accepted, which means \( X_1 \) does not influence \( Y_1 \)

The partial hypotheses test on B2
1. \( H_0 : B_2 = 0 \) (X2 does not influence Y1)
2. \( H_a : B_2 \neq 0 \) (X2 influences Y1)
3. From t table, \( \alpha = 0.05, df = 26, t_{0.025(26)} = 2.056 \)
4. Since \( t_{0.025(26)} < t_{0.025(26)} = 2.056 \) then \( H_0 \) is accepted, which means \( X_2 \) does not influence \( Y_1 \)

The partial hypotheses test on B3

Fig 1. Layer 3 network topology of BINUS Square.

Fig 2. Layer 2 network topology of BINUS Square per November 2010.
1. \( H_0 : B_3 = 0 \) (\( X_3 \) does not influence \( Y_1 \))
2. \( H_1 : B_3 \neq 0 \) (\( X_3 \) influences \( Y_1 \))
3. \( t_0 = -0.254 \)
4. Since \( t_0 = -0.254 < t_{0.025(26)} = 2.056 \) then \( H_0 \) is accepted, which means \( X_3 \) does not influence \( Y_1 \)

Third, since the AP coverage is reduced due to the small AP coverage area (assuming the second suggestion is applied), subsequently the placement of each AP should be rearranged in order to avoid blind spots. The SSID should be set differently from one floor to another floor.

From the partial test on \( B_1, B_2, \) and \( B_3 \) it can be concluded that the number of users, signal strength, and distance between users and the AP does not influence the download speed. It means that equation (1) cannot be applied to predict the download speed.

A network analyzer is used to find out the kinds of applications mostly used by users in the WiFi network. The data gathering is taken from Sangfor server. The data was collected for 13 days and it was found that there were 20,751,344 requests, as shown in Figure 5.

From all data analysis tested and observed we concluded that there was excessive roaming activity and that when users were connected to the network, they depended solely on Network Interface Card (NIC) [15] firmware in choosing the AP. Moreover, roaming also occurred due to overlapped channels. Knowing these issues, some solutions were proposed for BINUS Square to consider. First, BINUS Square should ask all users to update their NIC driver software either in their computer or other communication devices connected to the network. Users who have customizable NICs should set their NIC aggressiveness rate to the lowest level. Using this arrangement it is hoped that the excessive roaming can be reduced.

Second, we advised that BINUS Square rearrange their AP transmitting power, AP placements, and SSID arrangement. It is due to high transmitting powers that many channel overlapping has occurred. In order to reduce the roaming activity, the transmitting power should be set to the position in which the signal can be received by each user who stays in the same floor to as high as \( \geq 75 \)dBm. For the user who moves to different floors it is set to as low as \( \leq 75 \)dBm. By this arrangement the AP roaming from one floor to another can be neglected since the transmitting power is simply too low.

Kotz and Essien [6] also presented almost the same research for Dartmouth College. However there are differences, such as in terms of time used for observation where observation was taken only at a certain time (from Nov 20\(^{th}\), 2011 until Dec 24\(^{th}\), 2011 and from 19:00 to 22:00) while Kotz did it for a whole month. Both indicate that roaming is the main issue in this research. Unlike Dartmouth College, BINUS Square has a vertical area where most of the users stayed in their room and did not move from one room to another room. We also show that even though the users were not mobile, the activity of roaming remained heavy. An example of roaming from 14\(^{th}\) floor to 15\(^{th}\) floor within 1 second can be seen in Table 5.

During the observation, it was detected that the number of users connected to the APs was 1,119 (non unique user) with daily access up to 428 users. The biggest vendors that can be identified are Apple Computer Inc. (18.8%), Intel Corp. (17.1%), Hon Hai Precision Ind. Co. Ltd. (15.5%), AzureWave Technologies Inc. (8%), RIM (7.8%), LITE-ON Technology Corp. (6.4%), Samsung Electronics Co. Ltd. (4.5%), Askey Computer Corp. (4.4%), Quanta Microsystem Inc. (2.5%), and other 36 companies. It was also found that around 428 NIC cards were activated during the observation period since most of the students started to have the Internet access during campus hour.
Compared to Kotz [6], data collection of sessions did not include the ones which will be performed in the next experiment (for future report). This is due to the limit of data collection which needed a longer period of time compared to the one in this paper. However, in the result it can be see that roaming was indicated by ‘AP join’ activity either in a subnet or extra-subnet. This was recorded every 3 hours. The roaming activity in the card quite varied from 1 time to 165 times while the AP was active 24 hours a day. The traffic of AP can be seen in Figure 6 where heavy traffic only happened in the floors that were occupied with more students.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>User Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011/12/19</td>
<td>19:00:27</td>
<td>AP[C1501] radio [11b/g] detects User[00:1e:64:0c:83:40] in WLAN[Boarder@Binos Square] roams from AP[C1401]</td>
</tr>
<tr>
<td>2011/12/19</td>
<td>19:00:27</td>
<td>AP[C1401] radio [11b/g] detects User[00:1e:64:0c:83:40] in WLAN[Boarder@Binos Square] roams out to AP[C1501]</td>
</tr>
</tbody>
</table>

III. Conclusion

From this research we concluded that the excessive roaming activity is the main cause for the bad wireless connection in BINUS Square. Moreover, the roaming activity that comes from different WLANs can cause instability and frequently cut-off of the connection. The cause of low performance during download/upload is not yet certain since number of users, signal strength, and distance between user and the AP do not influence the speed performance. This is probably due to the bandwidth limitation that is applied for each user (5Mbps for download and 1Mbps for upload) as well as maximum number of users that can be connected to each AP (10 user per AP). However, there is no evidence in this research, and further investigation is necessary in the future to confirm this prediction. Such an investigation is currently being conducted for a future report.

REFERENCES


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