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Strategi Efisiensi Energi dan Penyeimbangan Beban Kerja Layanan Cloud Computing Melalui Konsolidasi Mesin Virtual Dinamis

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Abstrak

Arsitektur data center di dalam cloud computing merupakan lingkungan yang heterogen dan terdistribusi, tersusun atas gugusan jaringan physical machine (PM) atau server dengan berbagai kapasitas sumber daya komputasi yang berbeda-beda di dalam PMnya. Kondisi permintaan (demand) dan ketersediaan (supply) pada layanan cloud yang fluktuatif tersebut membuat data center cloud harus dibuat elastis. Virtual Machine (VM) merupakan representasi dari ketersediaan sumber daya komputasi dinamis yang dapat dialokasikan dan direlokasikan sesuai dengan permintaan. VM yang berada di dalam data center cloud dapat dipindahkan dari satu PM ke PM lainnya menggunakan migrasi VM secara langsung (live VM migration) ataupun tidak langsung (off-line VM migration). Lingkungan cloud computing yang dinamis dan terdistribusi mengharuskan strategi pengambilan keputusan di dalam konsolidasi VM harus dibuat sedinamis mungkin atau bahkan adaptif dengan mempertimbangkan heterogenitas sumber daya virtual sesuai dengan layanan cloud computing yang disajikan. Sehingga, dalam penelitian ini diusulkan efisiensi energi sekaligus menjaga kinerja layanan cloud computing melalui penyeimbangan beban kerja dengan teknik migrasi VM yang terdapat pada prosedur konsolidasi VM dinamis. Strategi pengambilan keputusan pada prosedur konsolidasi virtual machine dinamis yang diusulkan, dapat meningkatkan kinerja layanan cloud computing sekaligus beban kerja physical machine menjadi seimbang karena keputusan pemilihan VM dan penempatan VM pada physical machine dipilih secara optimal melalui MADM. Konsumsi energi dari physical machine juga dapat di hemat dengan mematikannya karena statusnya idle.

Kata Kunci: Pusat Data, Komputasi Awan, Konsolidasi *Virtual Machine*, Penyeimbangan Beban, Efisiensi Energi.

Abstract

Data center architecture in cloud computing is a heterogeneous and distributed environment, made up of a cluster of physical machine (PM) networks or servers with different capacities of computing resources within their PM. Demand (demand) and availability (supply) conditions on the fluctuating cloud services make the cloud data center must be elastic. Virtual Machine (VM) is a representation of the availability of dynamic computing resources that can be allocated and relocated according to demand. VMs inside the cloud data center can be moved from one PM to another using live VM migration or off-line VM migration. A dynamic and distributed cloud computing environment requires that the decision-making strategy in VM consolidation must be made as dynamic as possible or even adaptive by considering the heterogeneity of virtual resources in accordance with the cloud computing services presented. Thus, in this study it is proposed that energy efficiency while maintaining the performance of cloud computing services through workload balancing with VM migration techniques contained in the dynamic VM consolidation procedure. The decision making strategy in the proposed dynamic virtual machine consolidation procedure can improve the performance of cloud computing services while the physical

machine workload becomes balanced because the decision of VM selection and VM placement on the physical machine are optimally selected through MADM. Energy consumption from physical machines can also be saved by turning it off because the status is idle.

***Keywords**: Data Center, Cloud Computing, Virtual Machine Consolidation, Load Balancing, Energy-Efficient.*

1. PENDAHULUAN

Arsitektur data center di dalam cloud computing merupakan lingkungan yang heterogen dan terdistribusi, tersusun atas gugusan jaringan physical machine (PM) atau server dengan berbagai kapasitas sumber daya komputasi yang berbeda-beda di dalam PMnya. Apabila kapasitas sumber daya komputasi yang disediakan oleh data center cloud lebih banyak daripada permintaan maka penyedia layanan cloud menderita kerugian akibat overhead biaya operasional (perawatan dan konsumsi daya) dan proses yang terjadi di data center cloud akan mengalami kekurangan pemanfaatan (underutilization). Sebaliknya, jika kapasitas sumber daya komputasi yang disediakan oleh data center cloud mengalami kekurangan akibat banyaknya permintaan, maka penyedia layanan akan kehilangan pendapatan akibat ditinggalkan oleh pelanggan dan proses yang terjadi di data center cloud akan mengalami kelebihan pemakaian (overutilization)[1][2]. Manajemen sumber daya komputasi yang tidak efektif dapat menyebabkan beban kerja menumpuk (workload hotspot) hanya di satu sisi sumber daya komputasi saja, sehingga utilisasinya menjadi tidak seimbang.

Di masa pandemi covid-19 yang mengharuskan 90% aktivitas normal dilakukan dari rumah menjadikan layanan cloud computing di serbu oleh pelanggan. Kemudahan yang ditawarkan oleh layanan cloud computing melalui model provisioning berdasarkan pemakaian membuat permintaan pelanggan terus meningkat. Berbagai macam layanan aplikasi berpindah ke platform cloud dengan tingkat kebutuhan sumber daya komputasi beraneka ragam yang juga mengakibatkan beban kerjanya semakin meningkat. Layanan cloud menjadi kebutuhan dan pelanggan menjadi ketergantungan yang membuat faktor ketersediaan menjadi sangat penting. Karakteristik pelanggan yang memanfaatkan momen waktu tertentu di dalam mengakses layanan cloud membuat jumlah pertukaran data melalui jaringan dan tersimpan di storage mengalami peningkatan yang juga dapat menyumbangkan masalah bottleneck.

Kondisi permintaan (demand) dan ketersediaan (supply) pada layanan cloud yang fluktuatif tersebut membuat data center cloud harus dibuat elastis. Teknologi yang memungkinkan untuk merealisasikan hal tersebut adalah virtualisasi. Virtual Machine (VM) merupakan representasi dari ketersediaan sumber daya komputasi dinamis yang dapat dialokasikan dan direlokasikan sesuai dengan permintaan. Virtualisasi juga dapat digunakan untuk menempatkan VM semaksimal mungkin pada seminimal mungkin Physical Machine (PM). Secara operasional hal tersebut dapat mengurangi kompleksitas dan menekan biaya perawatan dengan meminimalisir PM yang berjalan (running).

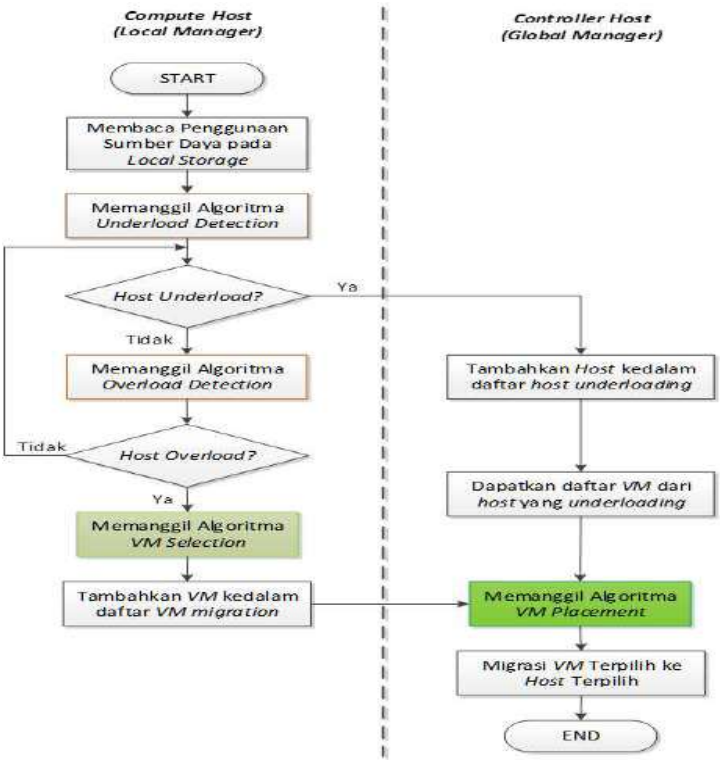
Permintaan layanan aplikasi yang beraneka ragam dapat menyebabkan VM dengan tingkat konsumsi sumber daya komputasi yang berbeda-beda misalnya CPU-intensive, Memory-intensive, Network-intensive dan Disk storage IO-intensive. Aplikasi pelanggan mungkin membutuhkan tingkat CPU yang tinggi dan memori yang rendah untuk menjalankanya ataupun kombinasi di antara sumber daya komputasi yang tersedia. PM pada data center cloud dapat memiliki sumber daya komputasi tertentu yang melimpah, tetapi sumber daya komputasi lainnya mengalami kekurangan. Akumulasi dari alokasi sumber daya komputasi pada VM yang tidak seimbang dapat menurunkan kinerja secara keseluruhan pada PM yang ada di data center cloud.

Hal tersebut berdampak pada beban kerja VM di dalam PM data center cloud menjadi tidak seimbang (load imbalance).

VM yang berada di dalam data center cloud dapat dipindahkan dari satu PM ke PM lainnya menggunakan migrasi VM secara langsung (live VM migration) ataupun tidak langsung (off-line VM migration). Live VM migration dilakukan di antara PM yang terdapat di dalam data center cloud ketika PM tersebut dalam keadaan hidup. Live VM migration dapat digunakan sebagai strategi konsolidasi untuk menyeimbangkan beban kerja di antara PM yang mendasari layanan cloud di atasnya, menghemat penggunaan daya data center cloud dengan menonaktifkan PM yang idle setelah VM di migrasikan dan memaksimalkan utilisasi dari VM itu sendiri dalam melayani akses permintaan dari pelanggan.

1.1 Konsolidasi Virtual Machine Dinamis

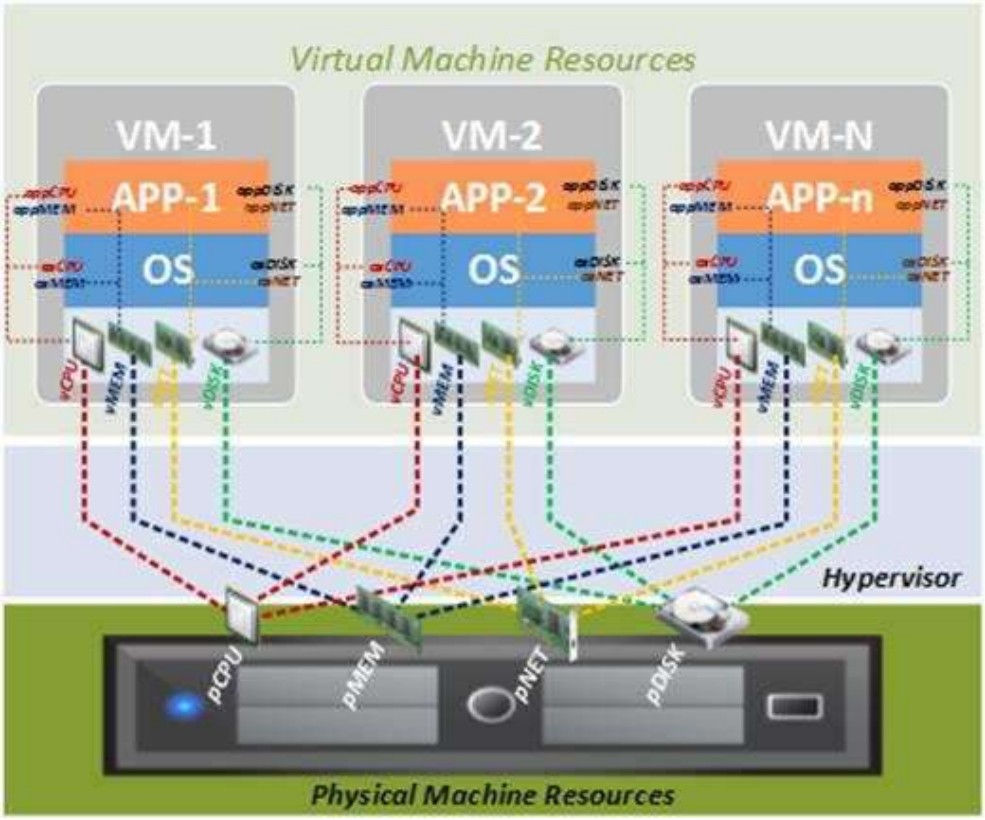
Secara garis besar [3][4] mengelompokkan strategi konsolidasi VM menjadi: konsolidasi VM statis dan konsolidasi VM dinamis. Konsolidasi VM tersebut dapat dilakukan dengan mempertimbangkan kapan, yang mana dan kemana VM harus dimigrasikan diantara PMnya atau host di dalam data center. Prosedur konsolidasi VM dinamis oleh [5][6][7] diuraikan ke dalam sub pengambilan keputusan yaitu host overloading detection, host underloading detection, VM selection dan VM Placement. Seperti pada gambar 1 host overloading detection dan host underloading detection digunakan untuk menentukan kapan suatu host mengalami overloaded ataupun underloaded. Dalam kondisi ini, satu atau lebih VM harus bermigrasi dari host tersebut. Keputusan VM mana yang harus dimigrasikan dari suatu host ke host lainnya akan dilakukan pada tahapan VM selection (pemilihan VM). VM placement (penempatan VM) akan memetakan kemana VM yang terpilih harus di migrasikan pada suatu host yang relatif underloaded dengan host lainnya.



Gambar 1. Prosedur Konsolidasi VM Dinamis

Di dalam prosedur konsolidasi VM dinamis, deteksi host yang overloading sering kali menjadi fokus utama guna mengurangi beban kerja yang dikaitkan dengan tujuan penghematan konsumsi energi yang ada di data center cloud[4]. Keputusan yang diambil dalam setiap prosedur konsolidasi VM dinamis didasarkan pada pendefinisian aturan yang diambil dari utilisasi sumber daya komputasi PM. Aturan yang ditetapkan biasanya menggunakan nilai yang cenderung konstan atau statis dengan mempertimbangkan bobot tertinggi dan terendah dari beban kerja yang menggunakan sumber daya komputasi, sehingga dapat dimungkinkan terjadinya overhead di dalam konsolidasi VM dinamis ketika memigrasikan VM. Overhead ini muncul sebagai akibat dari migrasi VM yang seharusnya tidak di perlukan atau VM yang seharusnya di migrasikan tetapi tidak dilakukan sebagai akibat dari penetapan policy dari host yang overloading dan underloading yang kurang sesuai. Deteksi host yang overload dan underload merupakan keputusan awal di dalam prosedur konsolidasi VM dinamis, jika keputusan awal tersebut tidak tepat maka akan mempengaruhi pengambilan keputusan pada langkah selanjutnya yaitu pemilihan VM yang akan di migrasikan dan penempatan VM yang terpilih pada host yang yang terpilih juga.

Utilisasi sumber daya cloud computing merupakan dasar yang dijadikan dalam pengambilan keputusan pada setiap prosedur konsolidasi VM dinamis. Sumber daya tersebut terdiri dari sumber daya fisik dan sumber daya virtual seperti yang ditunjukkan pada gambar 2.



Gambar 2. Sumber Daya Pada Cloud Computing

Sumber daya virtual memiliki keanekaragaman berkaitan dengan jenis aplikasi atau service yang dijalankan pada virtual machine. Variasi dari jenis aplikasi ini, akan menghasilkan workload dengan tingkat konsumsi sumber daya yang berbeda-berbeda. Selain itu, lingkungan cloud computing yang dinamis dan terdistribusi mengharuskan strategi pengambilan keputusan di dalam konsolidasi VM harus dibuat sedinamis mungkin atau bahkan adaptif dengan

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mempertimbangkan heterogenitas sumber daya virtual sesuai dengan layanan cloud computing yang disajikan. Sehingga tujuan efisiensi energi sekaligus menjaga kinerja layanan cloud computing melalui penyeimbangan beban kerja dengan teknik migrasi VM yang terdapat pada prosedur konsolidasi VM dinamis dapat terpenuhi. Pengambilan keputusan pada[1] rata-rata hanya menggunakan satu kriteria yaitu CPU sebagai parameter di dalam pengambilan keputusan pada prosedur konsolidasi VM. Sehingga, masih diperlukan usaha pengambilan keputusan pada setiap langkah konsolidasi VM dinamis yang mempertimbangkan beberapa kriteria sekaligus (tidak hanya satu kriteria) dari sumber daya cloud computing agar nantinya keputusannya lebih optimal.

1.2 Kriteria-kriteria Sumber Daya Cloud Computing

Sistem Cloud Computing pada dasarnya terdiri dari perangkat keras yang berupa physical machine seperti halnya komputer server dan perangkat lunak mesin virtual (virtual machine). Baik mesin fisik maupun virtual tentunya memiliki komponen sumber daya untuk pemrosesan, penyimpanan dan konektivitas. Komponen-komponen tersebut sangat berpengaruh terhadap pengambilan keputusan pada prosedur konsolidasi VM. Untuk tujuan efisiensi energi maupun peningkatan kinerja layanan cloud, parameter yang sering digunakan adalah processor saja seperti halnya pada [5] untuk diterapkan pada pengambilan keputusan hanya di salah satu prosedur konsolidasi VM. Padahal layanan cloud computing yang ditawarkan bervariasi jenisnya dengan tingkat konsumsi sumber daya yang berbeda-beda.

Oleh karena itu multi kriteria akan dijadikan sebagai pertimbangan dasar di dalam pengambilan keputusan pada prosedur konsolidasi VM. Pada PM kriteria-kriteria yang akan digunakan seperti pada pada tabel 1 berikut ini:

Tabel 1. Kriteria Physical Machine

Kriteria	Nama Atribut	Deskripsi
C1	$pCPU_u$ %	Prosentase penggunaan CPU PM
C2	$pRAM_u$ %	Prosentasi penggunaan RAM PM
C3	$pNET_u$ %	Prosentase penggunaan Network PM
C4	$pDISK_u$ %	Prosentase penggunaan *disk storage* PM
C5	$pDISK_{io}$ %	Prosentase *disk storage IO* PM
C6	pCPUc	Cadangan kapasitas CPU PM
C7	pRAMc	Cadangan kapasitas RAM PM
C8	pNETc	Cadangan kapasitas *bandwidth* PM
C9	pDISKc	Cadangan kapasitas *disk* PM
C10	VM	Jumlah VM pada PM

Kriteria pada tabel 1 dipetakan ke dalam jumlah physical machine yang akan digunakan seperti pada tabel 2.

Tabel 2. Pemetaan kriteria PM dengan PM yang digunakan

Alternatif	Atribut (kriteria)					
	pC1	pC2	pC3	pC4	pC5	pCn
PM 1	P1C1	P1C2	P1C3	P1C4	P1C5	P1Cn
PM 2	P2C1	P2C2	P2C3	P2C4	P2C5	P2Cn
PM 3	P3C1	P3C2	P3C3	P3C4	P3C5	P3Cn
PM 4	P4C1	P4C2	P4C3	P4C4	P4C5	P4Cn
PM 5	P5C1	P5C2	P5C3	P5C4	P5C5	P5Cn
PM m	PmC1	PmC2	PmC3	PmC4	PmC5	PmCn

Kriteria-kriteria physical machine tersebut akan digunakan dalam pengambilan keputusan Kriteria-kriteria physical machine tersebut akan digunakan dalam pengambilan keputusan pada prosedur konsolidasi VM di tahapan deteksi PM atau host yang overload dan underload serta penempatan VM agar lebih optimal.

Sedangkan pada *Virtual Machine* (VM) kriteria-kriterianya adalah sebagai berikut pada *Virtual Machine* (VM) kriteria-kriterianya adalah sebagai berikut:

Tabel 3. Kriteria Virtual Machine

Kriteria	Nama Atribut	Deskripsi
vC1	$vCPU_u$ %	Prosentase penggunaan CPU VM
vC2	$vRAM_u$ %	Prosentase penggunaan RAM VM
vC3	$vNET_u$ %	Prosentase penggunaan Network VM
vC4	$vDISK_u$ %	Prosentase penggunaan *disk storage* VM
vC5	$vDISK_{io}$ %	Prosentase aktivitas *disk storage IO* VM
vC6	vCPUc	Cadangan kapasitas CPU VM
vC7	vRAMc	Cadangan kapasitas RAM VM
vC8	vNETc	Cadangan kapasitas *net bandwidth* VM
vC9	vDISKc	Cadangan kapasistas *disk storage* VM
vC10	vAPPu	Konsumsi *resources* VM oleh APP

Kriteria pada tabel 3 dikombinasikan dengan jumlah virtual machine yang digunakan akan tampak seperti pada tabel 4.

Tabel 4. Pemetaan Kriteria VM dengan jumlah VM yang digunakan

Alternatif	Atribut (kriteria)					
	vC1	vC2	vC3	vC4	vC5	vCn
VM1	V1C1	V1C2	V1C3	V1C4	V1C5	V1Cn
VM2	V2C1	V2C2	V2C3	V2C4	V2C5	V2Cn
VM3	V3C1	V3C2	V3C3	V3C4	V3C5	V3Cn
VM4	V4C1	V4C2	V4C3	V4C4	V4C5	V4Cn
VMm	VmC1	VmC2	VmC3	VmC4	VmC5	VmCn

Kriteria-kriteria VM tersebut digunakan untuk pengambilan keputusan pada prosedur konsolidasi VM ketika tahapan pemilihan VM yang akan dimigrasikan agar lebih optimal.

2. METODOLOGI

Zimmerman (1991) dalam[8], pengambilan keputusan berdasarkan multi kriteria terdiri dari *Multi Attribute Decision Making (MADM)* dan *Multi Objective Decision Making (MODM)*. MADM digunakan untuk menyelesaikan permasalahan dalam ruang diskret dengan melakukan penilaian atau seleksi terhadap beberapa alternative dalam jumlah terbatas. Sedangkan MODM digunakan untuk menyelesaikan masalah-masalah pada ruang kontinyu seperti pada pemrograman matematika. MADM menyeleksi alternative terbaik dari sejumlah *alternative*, sedangkan MODM merancang alternative terbaik. Dari tipe datanya, multi kriteria pengambilan keputusan dibagi menjadi *deterministic*, stokastik atau *fuzzy*.

Medote MADM yang akan digunakan untuk menyelesaikan masalah pengambilan keputusan pada prosedur konsolidasi VM dinamis yang sesuai adalah *Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)*. Menurut hwang (1982), zeleny (1982) dalam [5], TOPSIS didasarkan pada konsep dimana alternatif terpilih yang terbaik tidak hanya memiliki jarak terpendek dari solusi ideal positif, namun juga memiliki jarak terpanjang dari solusi ideal negatif. Langkah-langkah penyelesaikan masalah menggunakan TOPSIS adalah:

1. Menghitung matriks keputusan.

$$D = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \dots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

2. Normalisasi matriks keputusan.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \; dengan \; i = 1, \dots, m \; dan \; j = 1, \dots, n \; , \quad (2)$$

3. Menentukan kriteria matriks pembobotan.

$$W = \begin{bmatrix} w_{11} & \cdots & 0 \\ \vdots & w_2 \dots & \vdots \\ 0 & \cdots & w_n \end{bmatrix} \quad (3)$$

4. Normalisasi pembobotan matriks keputusan.

$$v_{ij} = w_i r_{ij} = W \; x \; R, i = 1, \dots m, dan \; j = 1, \dots, n$$

dimana w_i adalah bobot dari kriteria j dan $\sum_{i=1}^{n} w_i$=1, (4)

5. Mendapatkan solusi ideal positif dan solusi ideal negative.

$$A^+ = \left\{\left(\max v_{ij} | j \in J\right), \left(\min v_{ij} | j \in j'\right) | i = 1,2, \dots, m\right\} = \left\{v_1^+, v_2^+, \dots, v_j^+, \dots, v_n^+\right\} \quad (5)$$

$$A^- = \left\{\left(\min v_{ij} | j \in J\right), \left(\max v_{ij} | j \in j'\right) | i = 1,2, \dots, m\right\} = \left\{v_1^-, v_2^-, \dots, v_j^-, \dots, v_n^-\right\} \quad (6)$$

6. Menentukan Euclidean Distance matriks berdimensi n.

$$d_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2} \; i = 1, \dots, m \quad (7)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2} \; i = 1, \dots, m \quad (8)$$

7. Menentukan jarak kedekatan relative dengan solusi ideal.

$$RC_i = \frac{d_i^-}{d_i^+ + d_i^-} \; dengan \; i = 1,\dots, \text{m} \; , \quad (9)$$

8. Perengkingan alternatif ditinjau dari kedekatan relative dengan solusi ideal.

2.1 Penerapan TOPSIS Pada Prosesur Konsolidasi VM

Deteksi PM yang *underload* dilakukan jika nilai utilisasi dari masing-masing sumber daya kurang dari nilai ambang batas yang di tetapkan maka statusnya adalah underload. Implementasi dari algoritma *underload detection* adalah sebagai berikut:

Tabel 5. Algoritma *Underload Detection*

Input	: utlisasi sumber daya pada suatu host dan threshold
Output	: status underload
1	**if** host_resources_util <= threshold :
2	host underload

Deteksi PM yang *overload* merupakan kebalikan dari deteksi PM yang underload yaitu apabila nilai utilisasi dari masing-masing sumber daya yang di konsumsi oleh suatu host lebih dari nilai ambang batas yang di tetapkan maka statusnya adalah *overload*. Implementasi dari algoritma *overload detection* adalah sebagai berikut:

Tabel 6. Algoritma *Overload Detection*

Input	: utlisasi sumber daya pada suatu host dan threshold
Output	: status overload
1	**if** host_resources_util > threshold :
2	host overload

Pemilihan *Virtual Machine* (VM) dilakukan pada setiap kondisi dimana host mengalami status underload atau overload. Utilisasi dari sumber daya yang digunakan oleh VM akan di jadikan sebagai masukan untuk menentukan VM mana yang akan di pilih untuk di migrasikan. Pseudocode dari algoritma pemilihan VM yaitu:

Tabel 7. Algoritma Pemilihan VM

Input	: sumber daya vm, bobot, rules
Output	: kandidat vm yang akan di pindahkan
1	vm_res = [cpu, memory, disk_io, net_io]
2	matriks_d = numpy.array(vm_res)
3	matriks_r = topsis.trans_to_matriks_r(matriks_d)
4	matriks_v = topsis.trans_to_matriks_v(matriks_r, bobot)
5	solusi_ideal = topsis.trans_to_A(matiks_v, rules)
6	jarak_alternatif = topsis.trans_to_S(matriks_v, solusi_ideal)
7	preferensi = topsis.trans_to_C(jarak_alternatif)
8	preferensi_user = sorted(preferensi)
9	vm_uuids = preferensi_user

Untuk mendapatkan VM yang akan di migrasikan dari host yang mengalami underload atau overload, maka di terapkan pemilihan VM dengan menggunakan *Multi Attribute Decision Making (MADM)* berupa TOPSIS. Sebagai masukannya adalah utilisasi dari penggunaan sumber daya oleh vm yang kemudian di transformasikan kedalam bentuk matriks_d menggunakan modul *numpy* dari *python*. Seletah matriks_d di dapatkan, maka di jadikan sebagai masukan dari matriks_r. matriks_r ini di jadikan sebagai masukan untuk mendapatkan matriks_v dengan menambahkan bobot yang telah di tentukan. Solusi idela di dapatkan dengan memasukkan matriks_v dan menambahkan aturan apakah kriteria yang digunakan itu sebagai biaya atau keuntungan (*rules*). Pada TOPSIS, solusi_ideal yang di dapatkan masih di proses guna

mendapatkan jarak_alternatif dengan memasukkan matriks_v dan nilai solusi_ideal tersebut. Jarak_alternatif inilah yang akan digunakan sebagai masukkan untuk mendapatkan nilai preferensinya. Nilai preferensi_user merupakan hasil dari pengurutan nilai preferensi yang merupakan vm_uuids sebagai kandidat vm yang akan di pindahkan. vm_uuids ini di parsing ke global manager guna menentukan host yang akan di tuju untuk menempatkan vm tersebut.

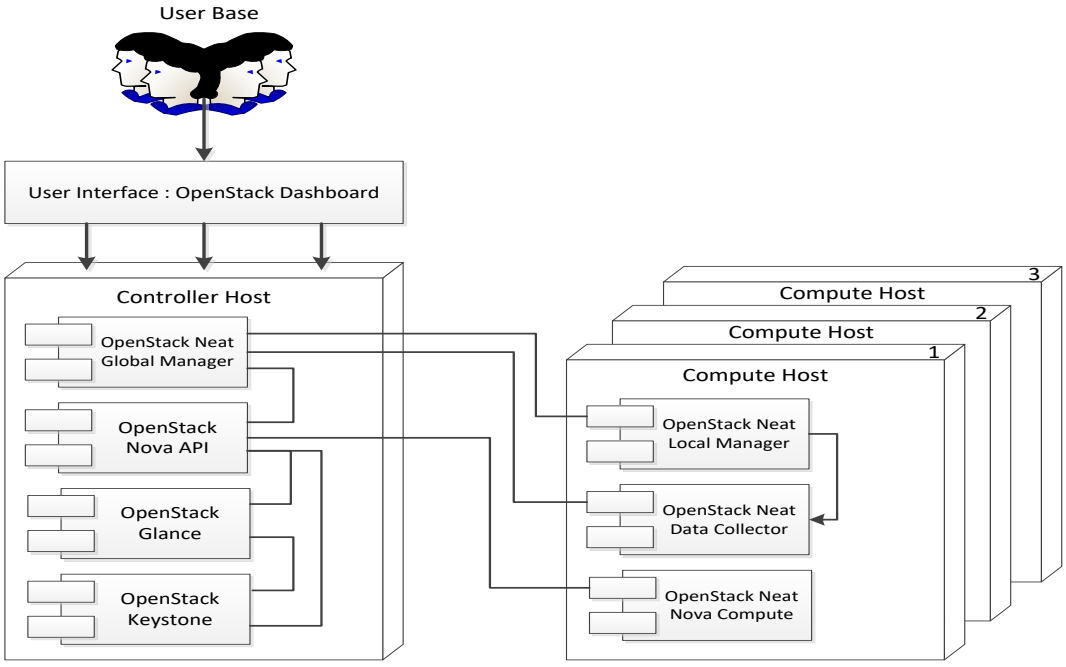
Penempatan VM yang terpilih pada dasarnya sama dengan prosedur pemilihan VM, hanya masukannya berdasarkan dari sumber daya yang digunakan oleh suatu host. Penempatan VM menghasilkan kandidat dari host yang akan di jadikan sebagai tujuan dari VM yang di migrasikan. Pseudocode dari algoritma penempatan VM adalah:

Tabel 8. Algoritma Penempatan VM

Input : sumber daya host, bobot, rules	
Output : kandidat host yang akan di tuju untuk migrasi vm	
1	vm_res = [cpu, memory, disk_io, net_io]
2	matriks_d = numpy.array(vm_res)
3	matriks_r = topsis.trans_to_matriks_r(matriks_d)
4	matriks_v = topsis.trans_to_matriks_v(matriks_r, bobot)
5	solusi_ideal = topsis.trans_to_A(matiks_v, rules)
6	jarak_alternatif = topsis.trans_to_S(matriks_v, solusi_ideal)
7	preferensi = topsis.trans_to_C(jarak_alternatif)
8	preferensi_user = sorted(preferensi)
9	vm_uuids = preferensi_user

2.2 Implementasi Sistem

Konsolidasi VM dinamis diimplementasikan kedalam lingkungan *cloud computing* secara riil menggunakan *OpenStack* dengan konsolidasi VM dinamis berbasis OpenStack-Neat [9][10] sesuai dengan topologi yang di tunjukkan pada gambar 3.



Gambar 3. Lingkungan *Cloud Computing* Berbasis OpenStack

Spesifikasi perangkat *controller host* yang di gunakan dalam di tunjukkan pada tabel 5.

Tabel 8. Spesifikasi *ControllerHhost* dan *User Base*

	Controller-host	***User-base***
Processor	Intel i3-2330M, 2 Core, 4 Threads, CPU @ 2.20 GHz	Intel i3-2330M, 2 Core, 4 Threads, CPU @ 2.20 GHz
RAM	4 GB	4 GB
Hardisk	500 GB	500 GB
Sistem Operasi	CentOS 6.5	Windows
Jumlah	1	1

Sedangkan spesifikasi perangkat *compute host* yang di gunakan di tunjukkan pada tabel 6.

Tabel 9. Spesifikasi *compute host*

Spesifikasi	***CPU-Intensive***	***MEM-Intensive***	***NET-Intensive***	***Disk-Intensive***
Hostname	*Compute-host2*	*Compute-host3*	*Compute-host4*	*Compute-host1*
Processor	Intel i3-2330M, 2 Core, 4 Threads, CPU @ 2.20 GHz	Intel i3-2330M, 2 Core, 4 Threads, CPU @ 2.20 GHz	Intel i3-2330M, 2 Core, 4 Threads, CPU @ 2.20 GHz	Intel i3-2330M, 2 Core, 4 Threads, CPU @ 2.20 GHz
RAM	4 GB	4 GB	4 GB	4 GB
Hardisk	500 GB	500 GB	500 GB	500 GB
Sistem Operasi	CentOS 6.5	CentOS 6.5	CentOS 6.5	CentOS 6.5
Jumlah	1	1	1	1

3. HASIL DAN PEMBAHASAN

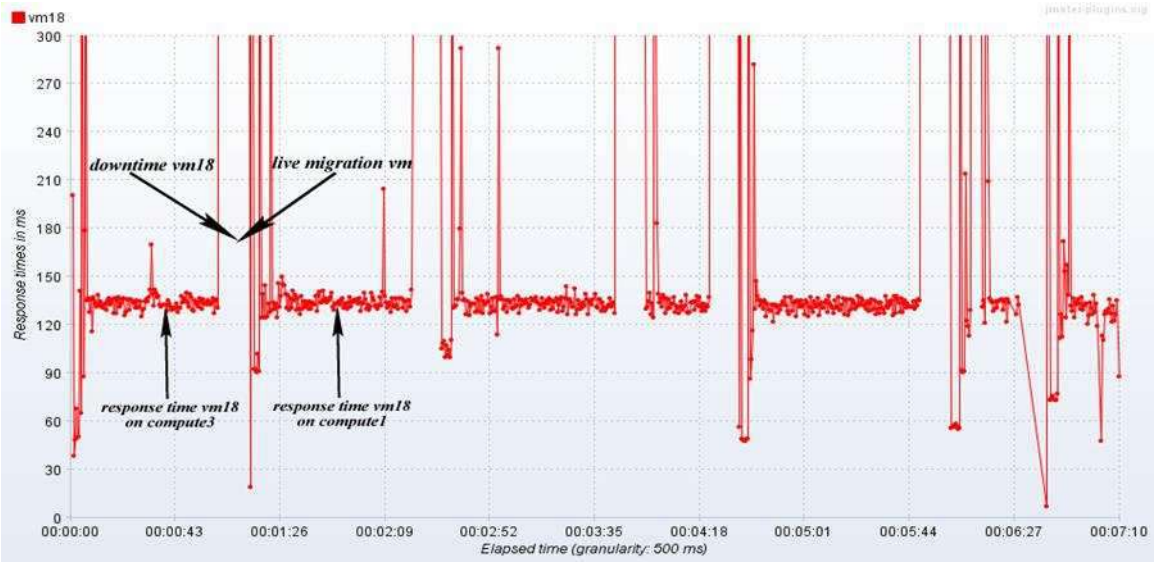
Hasil uji coba melalui pemberiaan peningkatan beban kerja secara periodik dengan waktu percobaan 300 detik guna mengetahui *workload* maksimum yang mampu diproses oleh suatu VM sesuai dengan layanannya. Pada *instance* VM selain layanan WEB (apache2+PHP5) ditambahkan layanan ServerAgent guna mendapatkan informasi tentang penggunaan sumber daya oleh VM. Hasil yang didapatkan dari hasil percobaan seperti pada Tabel 4.

Tabel 10. Hasil Uji Coba Pemberian *Workload* pada VM Selama 5 Menit

Percobaan	**Threads (Users)**	**Ramp-up (Sec)**	**Response Times (ms)**	**Throughput (Bytes/sec)**		**Latency (ms)**
				Bytes Recv	Bytes Sent	
1	1	1	5,3	6800000	6500	2,2
2	10	1	37,5	11195000	11830	15,8
3	20	1	76,5	11350000	11300	33,5
4	30	1	115,5	11500000	11450	52,2
5	35	1	139,5	11700000	11350	63,2
6	40	1	158,5	11450000	11250	74,4

Pada table menunjukkan penurunan *response times* selama percobaan ke-1 hingga ke-6. Untuk jumlah threads sebanyak 40, ServerAgent tidak dapat memberikan informasi tentang penggunaan sumber daya dari VM karena kekurangan jumlah CPU dan *service* secara otomatis mati. Sehingga jumlah *threads* maksimum yang mampu diproses oleh suatu vm selama 1 detik sebanyak 35 users.

Dengan meningkatkan beban kerja menjadi 35 *threads* dengan ramp-up 1 detik dan dilakukan selama periode waktu berulang. Penerapan prosedur konsoldiasi VM yang di usulkan tampak seperti pada gambar 4.



Gambar 4. *Response Time* pada *Live Migration* VM

Dari gambar 4 vm18 terpilih untuk dimigrasikan dan ketika menempati *compute3 response times* nya adalah 134 ms dan cenderung sama ketika menempati compute1 dan *compute2*. Vm18 cenderung mengalami peningkatan *response time* hingga 115 ms, ketika migrasi ke compute4 dikarenakan pada *compute4* cenderung *idle*. *Down time* ketika terjadi proses *live migration* vm18 di antara *compute node* adalah 13 detik.

4. KESIMPULAN

Strategi pengambilan keputusan pada prosedur konsolidasi *virtual machine* dinamis yang diusulkan, dapat meningkatkan kinerja layanan cloud computing. Hal ini dibuktikan dengan peningkatan response time dari 134 ms menjadi 115 ms ketika sebelum dan setelah proses migrasi *virtual machine*. Beban kerja physical machine menjadi seimbang karena keputusan pemilihan VM dan penempatan VM pada physical machine dipilih secara optimal melalui MADM. Hal tersebut dapat dilihat bahwa VM terpilih mengalami peningkatan response time ketika menempati compute node yang cenderung idle.

Konsumsi energi dari *physical machine* dapat di hemat dengan mematikannya karena statusnya idle sebagai akibat dari beban kerjanya menurun drastis setelah proses migrasi *virtual machine*. Selanjutnya masih terdapat potensi optimasi penyeimbangan beban kerja di lingkungan *cloud computing* misalnya dengan menggunakan *Artificial Intellegence* (AI) atupun *Machine Learning* (ML). Peluang efisiensi energi data center cloud juga masih terbuka guna menjawab sampai berapa persen penghematannya.

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Analisis Metode Identifikasi dan Verifikasi Kebutuhan Non Fungsional

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Abstrak

Kebutuhan non fungsional merupakan kebutuhan yang menggambarkan bagaimana sistem berkerja kedepannya. Dalam menentukan kebutuhan non fungsional tidaklah mudah, karena harus mengerti karakteristik dan batasan dari sistem. Terdapat beberapa permasalahan yang muncul ketika mengidentifikasikan kebutuhan non fungsional diantaranya ambiguitas, duplikasi, ketidakkonsistenan, definisi yang kurang, dan prioritas dari kebutuhan non fungsional yang kurang tepat. Oleh karena itu, diperlukannya cara untuk mengidentifikasi dan verifikasi kebutuhan non fungsional agar memudahkan dalam penentuan desain *software* untuk diimplementasikan oleh *developer*. *Paper review* ini melakukan analisis terhadap paper yang didapatkan dari database jurnal elektronik yaitu *ScienceDirect* dan IEEE dengan menggunakan kata kunci "*non-functional requirement*". Paper yang dianalisis dikelompokkan berdasarkan 5 tahun terakhir dan diklasifikasikan berdasarkan jenisnya, identifikasi atau verifikasi kebutuhan non fungsional. Hasilnya adalah metode yang sesuai untuk identifikasi dan verifikasi kebutuhan non fungsional. Metode yang sesuai untuk identifikasi kebutuhan non fungsional yaitu metode yang melakukan pengumpulan data kebutuhan terlebih dahulu. Sedangkan metode yang sesuai untuk verifikasi kebutuhan non fungsional yaitu pemodelan dan verifikasi kebutuhan non fungsional.

Kata Kunci: metode, identifikasi, verifikasi, kebutuhan non fungsional.

Abstract

Non-functional requirements are requirement that describe how the system works. Determining the non-functional requirements is not easy, because they must understand the characteristics and limitations of the system. There are several problems that arise when identifying non-functional requirement including ambiguity, duplication, inconsistency, lack of definition, and priorities that are not right. Therefore, the ways to identify and verify non-functional requirements is needed, in order to facilitate the determination of software design to be implemented by the developer. This review paper analyzes the paper obtained from electronic journal databases namely ScienceDirect and IEEE by using the keyword "non-functional requirements". The analyzed papers are grouped according to the last 5 years and are classified according to their type, identification or verification of non-functional requirements. The result is an appropriate method for identifying and verifying non-functional requirements. The method that is suitable for the identification of non-functional requirements is the method that collects the data needs first. While the appropriate method for verification of non-functional requirements is modeling and verification of non-functional needs.

Keywords*: method, identification, verification, non-functional, requirement.*

1. PENDAHULUAN

Analisis kebutuhan merupakan tahapan yang sangat penting dalam pembangunan perangkat lunak, dikarenakan pada tahapan ini apabila terjadi kekeliruan dalam menggambarkan kebutuhan

sistem bisa mengakibatkan gagalnya sebuah proyek pembangunan perangkat lunak [1]. Kebutuhan diklasifikasikan sebagai kebutuhan fungsional (FR) dan kebutuhan non fungsional (NFR) [2].

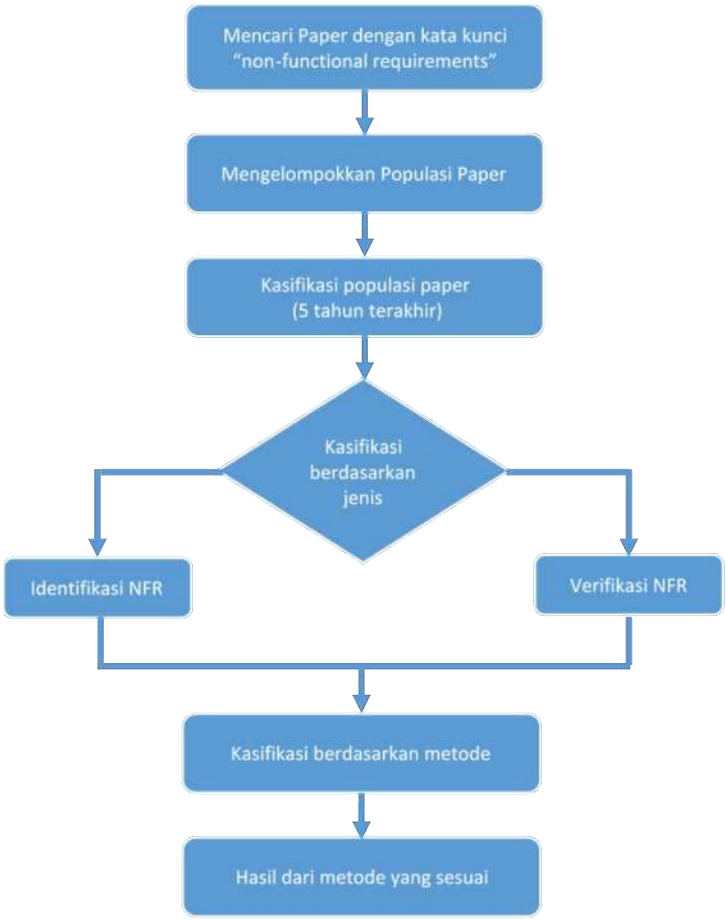
Kebutuhan non fungsional (NFR) dapat dianggap sebagai kriteria dari kualitas atau kinerja yang harus dipenuhi oleh sistem perangkat lunak dan ini merupakan elemen kunci yang harus ditangani selama proses pengembangan [3]. Kebutuhan non fungsional (NFR) biasanya dibedakan dari kebutuhan fungsional dengan pembeda yaitu bagaimana sistem harus melakukan sesuatu yang bertentangan dengan apa yang harus dilakukan sistem [4]. Sedangkan Kebutuhan fungsional adalah kebutuhan yang menggambarkan apa yang akan dilakukan oleh sistem. Analisis hasil statistik dari penelitian Feng-Lin Li menunjukkan bahwa kualitas menjadi kunci antara kebutuhan non fungsional dalam praktik Requirement Engineering dan banyak kebutuhan yang diidentifikasi sebagai NFR sebenarnya merupakan FR [5] . Penentuan kebutuhan fungsional cenderung lebih mudah diidentifikasikan dibandingkan dengan penentuan kebutuhan non-fungsional dikarenakan kebutuhan fungsional digambarkan dengan fungsi-fungsi sistem sedangkan kebutuhan non fungsional lebih kepada karakteristik dan batasan dari sistem [6] [7].

Pada perangkat lunak yang berkualitas, perlu mempertimbangkan kebutuhan fungional (FR) dan kebutuhan non fungsional (NFR), kurangnya memperhatikan NFR menjadi penyebab kegagalan untuk banyak proyek perangkat lunak [8]. Kebutuhan non fungsional (NFR) meggambarkan kendala penting pada pengembangan dan perilaku perangkat lunak, hal ini harus dipertimbangkan diawal, jika tidak akan menyebabkan beberapa masalah pada produk akhir seperi ketidakstabilan dan kualitas yang rendah [9]. Kebutuhan non fungsional (NFR) dapat mengatasi masalah penting dalam sistem perangkat lunak, dan sangat penting dalam keberhasilkan perangkat lunak [3]. Masalah NFR dalam suatu sistem mencerminkan kompleksitas sistem tersebut, secara sistematis NFR diselifiki untuk menentukan aspek yang mungkin menyebabkan konflik yang harus dideteksi sedini mungkin [3]. Terdapat banyak kebutuhan non fungsional (NFR) yang ambigu, tidak memuaskan, duplikasi, ketidakkonsistenan, tidak jelas, dan subjektif, menunjukkan perlunya meta-kualitas dalam penentuan NFR [5].

Identifikasi dan verifikasi kebutuhan non fungsional menjadi hal yang penting dalam software requirement karena dengan detailnya kebutuhan non fungsional yang diperoleh, akan memudahkan penentuan desain software dan mudah untuk diimplementasikan oleh developer. Sayangnya identifikasi dan verifikasi kebutuhan non fungsional bukanlah hal yang mudah. Dengan menggunakan tinjauan pustaka kami menganalisis jurnal-jurnal yang membahas mengenai kebutuhan non fungsional untuk mengetahui: (i) apa saja model yang digunkan untuk identifikasi kebutuhan non fungsional, (ii) apa saja model yang digunkan untuk verifikasi kebutuhan non fungsional, dan (iii) model apa yang paling banyak digunakan, baik untuk identifikasi maupun untuk verifikasi kebutuhan non fungsional.

2. METODOLOGI

Pada bagian ini akan dijelaskan tentang hal-hal yang dilakukan dalam penelitian ini. Paper ini merupakan jenis *paper summarize* yang dihasilkan dari penggabungan hasil beberapa paper lainnya. Metode penelitian dan penyusunan paper ini terutama berfokus pada metode pengumpulan paper. Langkah-langkah yang dilakukan dalam penelitian ini adalah mencari paper, memilih *paper, review paper,* dan identifikasi karakteristik teknik elisitasi. Alur metodologi penelitian diperlihatkan pada Gambar 1.



Gambar 1. Metodologi Penelitian

2.1 Mencari paper

Pada tahap ini dilakukan pencarian *paper* yang terkait dengan kebutuhan non fungsional. Untuk mendapatkan hasil *paper* yang terkait maka dilakukan dengan cara menggunakan kata kunci "*non-functional requirement*". Semua paper yang tersaring dari tahap ini akan dicatat dan dilakukan penyaringan kembali pada tahap selanjutnya.

2.2 Mengelompokkan populasi paper

Pada tahap ini dilakukan pengelompokan paper berdasarkan publikasinya dalam kurun waktu 5 tahun terakhir dan dikelompokkan berdasarkan tahun terbit *paper*. Populasi dimulai dari tahun 2014 hingga 2018.

2.3 Mengklasifikasikan paper per tahun

Berdasarkan hasil dari populasi pada tahap sebelumnya, dilakukan pengelompokan kembali *paper* setiap tahunnya. Pengelompokkan untuk mencari *paper* yang paling relevan dengan kebutuhan non-fungsional dengan menyaring berdasarkan judul publikasi yang terkait dengan "*non-functional requirements*". Untuk metode pengelompokkan populasi *paper* per tahun digunakan cara penyaringan data per-tahun, kemudian juga dilakukan pembandingan pencarian antara menggunakan command search dengan tanpa menggunakan *command search*. *Command search* adalah pencarian berdasarkan spesifik kata kunci dengan memberikan tanda kutip pada kata kunci pencarian *paper*. Dari proses ini menghasilkan jumlah paper yang akan dilakukan *review*.

2.4 Mengklasifikasikan paper berdasarkan jenisnya

Dalam pengklasifikasian paper, sesuai dengan tujuan dari review paper yang diajukan yakni mengetahui cara mengidentifikasikan dan memverifikasi kebutuhan non fungsional. Maka klasifikasi paper dapat dibagi menjadi dua yakni berdasarkan kelompok identifikasi kebutuhan non fungsional, verifikasi kebutuhan non fungsional. Pengelompokkan ini dilakukan dengan cara menganalisis paper yang sudah didapatkan pada tahap sebelumnya.

2.5 Mengklasifikasikan paper berdasarkan metodologi yang digunakan

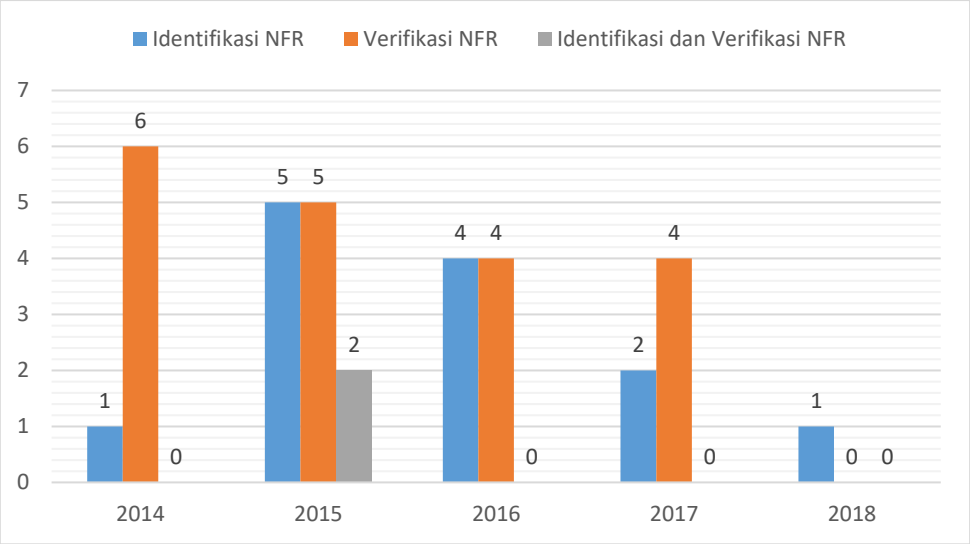
Setelah mengelompokkan paper berdasakan identifikasi dan verifikasi kebutuhan non-fungsional, maka dilakukan pengklasifikasian metode yang digunakan dalam paper tersebut. Klasifikasi metode ini bertujuan untuk mengetahui metode yang paling banyak digunakan oleh paper yang telah diperoleh. Metode tersebut dipilih untuk metode identifikasi dan verifikasi kebutuhan non fungsional yang paling sesuai, dan dijadikan sebagai hasil *review* paper ini.

3. HASIL DAN PEMBAHASAN

3.1 Hasil

Proses pencarian jurnal dimulai dengan pencarian jurnal pada database jurnal elektronik "*ScienceDirect*" dan "IEEE". Berdasarkan kata kunci "*Non-Functional Requirement*". Berdasarkan situs pencarian yakni *ScienceDirect* dan IEEE tanpa melakukan penyaringan tahun publikasi, didapatkan 1.501 paper pada ScienceDirect dan 1.272 paper pada IEEE. Kemudian proses berikutnya yakni mengelompokkan berdasarkan 5 tahun terakhir untuk tahun publikasinya. Hasil dari penyaringan yang ditunjukkan pada situs *ScienceDirect* terdapat 692 *paper* sedangkan pada IEEE terdapat 415 *paper*. Pengklasifikasian berdasarkan jenis mendapatkan sebanyak 34 paper, yang terdiri dari 8 paper dari *ScienceDirect* dan 26 *paper* dari IEEE. Hasil pengelompokan paper disajikan dalam bentuk grafik atau diagram yang berdasarkan topik pembahasan paper, metode yang digunakan, dan tahapan metodologi.

Pengelompokkan pertama didasarkan pada topik pembahasan. Terdapat tiga topik pada pengelompokan ini, yaitu identifikasi NFR, verifikasi NRP, dan keduanya. Setelah dilakukannya analisis didapatkan hasil bahwa paper yang membahas mengenai verifikasi memiliki jumlah yang lebih banyak dibandingkan dengan paper yang membahas identifikasi (Lihat Gambar 2).



Gambar 2. Pengelompokkan Paper Berdasarkan Topik Pembahasan

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Paper yang membahas identifikasi kebutuhan non fungsinal berjumlah 13 paper, sedangkan paper yang membahas verifikasi kebutuhan non fungsinal sejumlah 19 paper, dan terdapat 2 paper yang membahas keduanya.

Pengelompokkan kedua didasarkan pada metode yang digunakan. Berdasarkan hasil review, terdapat banyak metode yang digunakan untuk melakukan identifikasi dan verifikasi kebutuhan non fungsional. Metode-metode tersebut dapat dikelompokkan seperti pada Tabel 1. Dapat dilihat bahwa pengelompokkan berdasarkan metode menghasilkan 14 metode identifikasi NFR dan 20 metode untuk verifikasi NFR. *General Architecture for Text Learning* (GATE) dan *Java Annotation Patterns Engine* (JAPE) merupakan metode identifikasi NFR yang digunakan dalam dua paper. Sedangkan untuk metode verifikasi, NFR *modeling* and *verification* adalah model yang digunakan pada 2 paper. Sementara itu, model yang lainnya, baik identifikasi maupun verifikasi hanya digunakan pada 1 jurnal.

Table 1. Pengelompokan Paper Berdasarkan Metode

Identifikasi		**Verifikasi**	
Metode	**Jumlah**	**Metode**	**Jumlah**
Ontological Interpretation	1	*NERV (NFR Elicitation, Reasoning and Validating) Methodology*	1
Prosedur Multi-step	1	*Model Driven Engineering Techniques menggunakan RELAX*	1
NORMAP dan NERV methodologi	1	*HAM (Hybrid Assessment Method)*	1
NFR analysis Approach	1	*NFR Interdependency Framework (NFRIF)*	1
Modelling Method	1	*Fuzzy-Bayesian Network*	1
Latent Dirichlet Allocation (LDA) untuk modeling NFR	1	*NFR modeling and verification*	2
Model-based development	1	*Tool chain*	1
General Architecture for Text Learning (GATE) dan Java Annotation Patterns Engine (JAPE)	2	*DIVISE (DIscovery and Visual Interactive web Service Engine)*	1
Supervised Machine Learning. Support Vector Machine and Naïve Bayes Algorithms	1	*Multi-stages Prosedur*	1
Hybrid menggunakan traditional dan agile methodologies	1	*NFR Framework*	1
JIT (Just-in-time) Requirement. Teknik untuk modeling NFR menggunakan Latent Dirichlet Allocation (LDA)	1	*IVEA (Indicator Optimization and rules violation controlling evolutionary algorithm)*	1
HAZard and OPerability study (HAZOP)	1	*Ontological Formalisation and Automation SIG (Softgoal Interdependency Graph*	1
NERV (NFR Elicitation, Reasoning and Validating) Methodology	1	*RDS (Requirement Description Schema)*	1
Model Driven Engineering Techniques menggunakan RELAX	1	*CDNFRE (Conflict Detector in Non Functional Requirements) menggunakan ontology*	1
		cost-value proritization technique	1

(Multi Criteria Decision Analysis) MCDA-based method	1
Extending the Requirement Frame Model	1
Model Drive Software Engineering (MDSE)	1
NFR prioritization	1
NFR Design and Rational (NDR) Framework.	1

Hasil pengelompokkan yang didasarkan pada metode yang digunakan masih terlalu luas untuk menjawab rumusan masalah yang diajukan. Oleh karenanya, pengelompokkan ketiga dilakukan dengan dasar tahapan dari masing-masing metode. Pada metode identifikasi NFR, melakukan pengumpulan data kebutuhan terlebih dahulu merupakan tahapan yang paling banyak digunakan dalam model yang ditemukan. Tahapan tersebut digunakan pada beberapa model, yakni ontologi [5], semantik [10], *Optical Character Recognition* (OCR) [11], *analysis approach* [12], *Machine Learning* [6] dan terakhir menggunakan NERV [8]. Melalui metode tersebut, dilakukan analisis terhadap pengelompokan yang telah dihasilkan, dan kemudian dihasilkan NFR yang berkualitas. Hasil pengelompokan metode identifikasi kebutuhan non fungsional secara keseluruhan dapat dilihat pada Tabel 2. Sedangkan untuk metode verifikasi NFR, NFR *modeling* and *verification* merupakan tahapan yang paling banyak digunakan. Kebutuhan non fungsional yang sudah ada dimodelkan dengan pendekatan tertentu untuk selanjutnya dilakukan proses verifikasi. Metode ini digunakan oleh lima paper dengan pendekatan yang bebeda namun memiliki tahapan yang hampir sama. Metode yang menggunakan tahapan tersebut adalah NFR *modeling* and *verification* [7], NFR *modeling* [13], (*Multi Criteria Decision Analysis*) *MCDA-based method* [14], *Model Driven Engineering Techniques* menggunakan RELAX [15], dan *Model Drive Software Engineering* (MDSE) [16].

3.2 Pembahasan

Dalam lima tahun terakhir pembahasan mengenai kebutuhan non fungsional menjadi topik yang cukup banyak dilakukan oleh para peneliti dan praktisi yakni terdapat 34 paper yang membahas kebutuhan non fungsional. Dari paper yang didapatkan, dapat dikelompokkan dalam identifikasi kebutuhan non fungsional dan verifikasi kebutuhan non fungsional.

Berdasarkan pengelompokkan tersebut terdapat 15 metode yang digunakan dalam identifikasi kebutuhan non fungsional. Sedangkan untuk verifikasi kebutuhan non fungsional terdapat 21 metode seperti yang ditunjukkan pada Tabel 1. Berdasarkan hasil tersebut dapat dilihat bahwa pembahasan terkait verifikasi kebutuhan non fungsional lebih banyak diteliti. Hal ini dikarenakan permasalahan dalam *requirement engineering* adalah sulitnya menentukan kebutuhan non fungsional [5], terabaikannya kebutuhan non fungsional pada tahapan *requirement engineering* [11] [2] [8], dan kesalahan penafsiran dalam penerapan kebutuhan non fungsional pada sistem [17]. Literatur menunjukkan bahwa fungsi adalah fokus utama dalam proses *Agile*. Sementara kebutuhan non-fungsional (NFR) diabaikan atau tidak jelas [8]. Padahal kebutuhan non-fungsional (NFR), seperti reusabilitas, lebih lanjut memainkan peran penting dalam perangkat lunak dan rekayasa sistem [2]. Memodelkan NFR adalah metode yang efisien untuk analisis dan desain segala system [13]. Disisi lain, verifikasi desain model bisa mengurangi resiko pembangunan atas kualitas produk yang rendah [7]. Selain itu, harus ada cara untuk

memverifikasi kebutuhan ini sedini mungkin, bahkan sebelum pengembangan sistem ini dimulai [15]. Berdasarkan beberapa alasan tersebut, memodelkan kebutuhan non fungsional menjadi metode yang kebanyakan dilakukan oleh para peneliti.

Tantangan lain untuk verifikasi kebutuhan adalah keterbatasan biaya dan waktu, seorang developer harus memutuskan kebutuhan mana yang mengarah kepada kepuasan pemangku kepentingan. Untuk mengatasi permasalahan ini diperlukan prioritas terhadap kebutuhan [18]. NFRs sering bergantung satu sama lain dan hubungan mereka dapat mempengaruhi kualitas perangkat lunak. NFR cenderung konflik, mengganggu dan bertentangan satu sama lain. Sulit untuk menangani interdependensi karena kebutuhan bisa sangat kompleks [19]. Dari beberapa tantangan tersebut beberapa peneliti mengajukan metode prioritas NFR dan deteksi konflik untuk mengatasinya.

Akan tetapi dari alasan-alasan diatas bukan berarti bahwa proses identifikasi menjadi hal yang tidak penting dalam penentuan kebutuhan non fungsional. Sebagai asumsi meskipun kebutuhan tersebut secara explisit tidak didefinisikan, kebutuhan non fungsional cenderung tertanam dalam kebutuhan fungsional [10]. Secara umum, tujuan yang diperoleh dari para pemangku kepentingan tidak jelas, ambigu, ideal, dll [5]. Secara eksplisit mengidentifikasi NFR pada awal proses perangkat lunak sangat penting untuk membuat keputusan desain awal, dan kemudian untuk mengevaluasi alternatif arsitektur untuk sistem [10]. Dalam Rekayasa Perangkat Lunak, kebutuhan Fungsional (FRs) lebih diutamakan dan kebutuhan Non-Fungsional (NFR) diabaikan hingga tahap akhir pengembangan perangkat lunak. Pengembang perangkat lunak lebih memperhatikan kebutuhan fungsional perangkat lunak yang memenuhi kebutuhan bisnis, dan NFR seperti kinerja, kegunaan, keandalan, keamanan, dan skalabilitas biasanya ditangani kemudian selama fase pengujian sistem [11]. Hal-hal tersebut cukup memberikan alasan bahwa identifikasi kebutuhan non fungsional juga penting dilakukan pada saat melakukan *Requiremnet Enginering.* Tetapi metode apakah yang paling tepat untuk menentukan kebutuhan non fungsional. Metode dengan tahapan awal pengumpulan semua kebutuhan baik kebutuhan fungsional maupun kebutuhan non fungsional merupakan metode yang paling banyak dilakukan. Dikarenakan pengumpulan kebutuhan juga merupakan fase awal dari proses *Requiremnet Enginering*.

4. KESIMPULAN

Berdasarkan pada hasil *literatur review*, diperoleh beberapa kesimpulan diantaranya bahwa pada penelitian ini terdapat 14 model untuk identifikasi kebutuhan non fungsional berdasarkan 15 paper yang ditemukan. Sedangkan pada verifikasi, terdapat 20 model untuk verifikasi kebutuhan non fungsional berdasarkan 21 paper yang ditemukan. Pada tahapan yang paling banyak digunakan pada metode identifikasi kebutuhan non fungsional adalah melakukan pengumpulan data kebutuhan terlebih dahulu berdasarkan 6 paper. Sedangkan pada tahapan yang paling banyak digunakan untuk metode verifikasi kebutuhan non fungsional adalah NFR *modeling* and *verification* berdasarkan 5 paper.

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Change Management Strategies to Implement A Fingerprint Based Attendance System in Information Systems Department Using ADKAR Model

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Abstract

Information Systems Department has used fingerprints as a student attendance system. But its implementation is briefly, because there are still technical and non-technical problems in the system. Unfortunately, at this time, the fingerprint is only left installed in each classroom and the manual attendance system is reused. It can be seen that the unsuccessful project management is caused by problems in changing from the manual system to the fingerprint system. Based on the ploblems, Information Systems Department of ITS requires change management strategies to implement this system. The planning of change management strategy is initiated by analyzing the gap between the business processes of manual attendance system and of the fingerprint-based attendance system. The goal of this gap analysis is to identify the changes and the impacts which then let to an identification to the solution. The solution will be an input for the development of change management strategy using the perspectives of Awareness, Desire, Knowledge, Ability, Reinforcement (ADKAR) model. The strategy is then mapped according to Prosci's state of change. The result from this research is a change management roadmap of the fingerprint system's implementation. This roadmap contains three states of change, which covering current, transition, and future.

Keywords*: strategy, change management, fingerprint, ADKAR*

1. INTRODUCTION

Information Systems Department is an organization that has implemented fingerprints as an attendance information system for students. This system is expected to be able to solve problems related to student attendance when a manual attendance system is used. The problem that often occurs is that students often deceive attendance by leaving their signatures to their classmates so that data on manual attendance becomes invalid. Not only that, officers in the academic section also sometimes has difficulties and errors in recording attendance data[1].

Fingerprint-based attendance is an effective method for monitoring student attendance at college. Through this system, students cannot leave attendance with classmates so that cheating can be reduced. The attendance data recapitulation problem is also resolved by having a fingerprint that has been integrated with the attendance information system. The use of paper for attendance forms can also be reduced because the attendance process is carried out directly using the fingerprint installed in each class[1].

Information Systems Department has used fingerprints as a student attendance system. But its implementation is only a few time because there are still technical and non-technical problems in the system [2] . At this time, the fingerprint is only left installed in each classroom and the manual

attendance system is reused. Meanwhile, according to [2] technically the fingerprint was ready to be used and was integrated with the attendance information system. However, the data is not ready because not all students have registered. The implementation of this system still has many problems on the non-technical side such as the absence of policies, procedures, and problems for students whose fingerprints cannot be read by system.

Based on this phenomenon, it means that there are problems that cause the implementation of fingerprint-based attendance is unsuccessful. Study that conducted by M. Levinson [3] concluded that one of the main causes of failure of a project is the lack of implementation of the change management process, not only in IT but in the organization as a whole. Some examples of project cases that fail due to lack of change management include: (1) a system that is technically and economically feasible but is simply kept quiet and not used, (2) a system developed by the organization's internal team that is also technically and economically feasible but becomes debate in its implementation[4].

Many problems can arise when changes are made, where the most often arises is the rejection of the change itself [5]. Achmad Holil Noor Ali dkk[6] in his research concluded that successful change requires not only effective project management but also good change management. Change management is the application of a structured process and a set of tools to direct people towards changes to achieve the expected outcomes. The purpose of change is to improve the organization by changing how work is done[7]. This was achieved by developing a change management strategy[6]. ADKAR is a change management model that is able to identify why changes are made and helps to determine the steps needed to make a change successful [8]. ADKAR was chosen because it was focused on change at the individual and organizational level. This is different from other change management models which only focus on the organizational level. As stated, the success of change in the organization will be achieved if changes at the individual level are successfully carried out [8].

Based on this problem, Information systems Department requires a structured change management strategy in the implementation of fingerprint-based attendance information systems. Therefore, the main objective of this thesis research is to produce a change management roadmap based on the ADKAR model which is initialized from the analysis of gaps between business processes of current and future attendance activities. This roadmap is expected to help the implementation of fingerprint-based information systems smoothly.

2. RESEARCH METHODS

In order to develop a change management strategy, this research was carried out in four main steps. Firstly, exploration of current and future conditions of the absentee business process, second is gap analysis, third is formulation of change management strategies, and the last is validation the strategy. Details of the research methodology are presented in Figure 1.

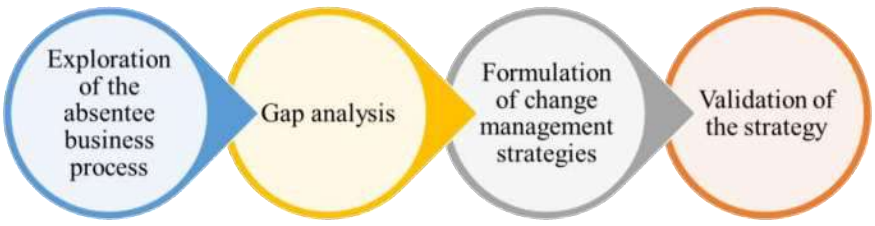

Figure 1. Research Method

Business process exploration is carried out with three activity, namely: document review, interview, and observation. Documents analyzed are documents related to the development of attendance information systems such as the requirement specification of fingerprint project, policy documents, and fingerprint implementation procedures. While the interviews were conducted directly with management, among them were the IS/IT Coordinator, academic staff, and head of department. This interview was conducted by asking number of questions related to the business process of student attendance activities. Through this method, the current and future conditions of the business attendance system will be obtained. Meanwhile, to find out the current condition of student attendance activities, researchers observe the student attendance process.

The second stage is gap analysis. There are three activities in this stage, namely identification of changes, identifying impacts, and identifying solutions. Changes are identified based on data that has been obtained previously. The results of the gap analysis will show any changes that occur in the components of the business process, both in terms of the process (activities), resources involved, and policy needs, organizational structure, and technology itself. The impact obtained from an IT application is commonly called value. The value is sometimes in the form of benefits that refer to increasing the efficiency of work processes that are applied in the organization and are gray so that it is often referred to as quasi benefits. Quasi benefits are usually analyzed by value linking, value acceleration, value restructuring, and innovation valuation. Furthermore, the solution is initialized to realize the impact that can be obtained from changes that occur using the OCM program, which includes leadership & sponsorship, governance and compliance, skill and competencies, performance management, organizational design and structure, incentive and rewards, communication, hiring and selection.

Utilizing the results of the gap analysis as well as all data and information obtained from the previous stages, a change management strategy and planning were begun. Change management strategies are prepared using the ADKAR model. Mapping the list of solutions to a list of change management strategies can be helped by mapping the activity or change management tools to the ADKAR element. Next, the list of strategies that have been obtained is then mapped into a state of change from the ADKAR model. This mapping is intended to develop a change management roadmap that accompanies the implementation of a fingerprint-based information system at this department. This change management roadmap will contain a list of strategies from the previous stages which are then organized into a state of change, i.e. current, transition and future for each strategy from each ADKAR element. The regulation of the arrangement is that the current state requires the Awareness and Desire elements of the ADKAR model, the transition state requires the Knowledge and Ability element, while the future state requires the Ability and Reinforcement elements.

The final stage is verification and validation of change management strategies. This process was carried out using interview techniques to conduct discussions with Information System Department management, including the IS/IT Coordinator, academic staff, and head of department to seek approval of the change management roadmap with the ADKAR model that was created.

3. RESEARCH RESULT AND DISCUSSION

3.1 The Current and Future condition of the attendance business process

The current condition of the attendance business process is the condition of the business process when attendance is done using a manual system. While future conditions refer to attendance business processes using the fingerprint system. The current condition is obtained

based on the results of interviews with Rio as academic staff and observations. The future conditions were obtained from the results of an interview with Mr. Radityo as IS/IT Coordinator in this department. The both conditions are seen from the 5 focus, namely: process (activity), organizational structure that has a related function, human resources who act as actors, policies, and technology used. The results of exploration of both conditions are presented in Table 1.

Table 1. The Current and Future Condition of Business Process

Focus	**Current Condition (*as is*)**	**Future Condition (*to be*)**
Process	1. preparation 2. taking attendance form 3. The attendance 4. returning attendance form 5. recapitulation	1. Fingerprint registration 2. preparation 3. taking attendance form 4. The attendance 5. returning attendance form 6. recapitulation
Organizational structure	Attendance activities is handled by: Academic unit	Attendance activities are handled by: 1. Academic unit 2. IT unit
Human resources	Actors who play a role in attendance activities are: 1. Academic staff 2. Lecturer 3. Students	Actors who play a role in attendance activities are: 1. Academic staff 2. Lecturer 3. Students 4. Fingerprint system
Policy	Policy of attendance activities: 1. Academic regulations for Chapter IX regarding academic activities article 25 paragraph 4 2. Policy the way of attendance process	Policy of attendance activities: 1. Academic regulations for Chapter IX regarding academic activities article 25 paragraph 4 2. Policy: rules of limiting time and place to be considered admissible 3. Procedures needed for the operation of a fingerprint-based attendance information system: a. Procedure when there is a power failure b. Procedure when there is damage to the tool c. Procedure when lecturing is not in class d. Procedure when the fingerprint is unreadable
Technology	The manual system uses paper as a medium for attendance	Fingerprint based attendance system, using fingerprint as a medium for attendance
Problems	Some problems with the manual attendance system: 1. The system cannot validate attendance data 2. The use of paper as a medium for recording attendance 3. Recording data is done manually	Some problems with the fingerprint attendance system: 1. there are students whose fingerprints cannot be read 2. doubts from some students and lecturers 4. the time for attendance with a fingerprint is quite long (about 15 minutes for one class). 5. attendance data transparency

Focus	Current Condition (*as is*)	Future Condition (*to be*)
		6. procedures for dealing with various risks besides returning to the manual system.

In addition to the explanation regarding the both conditions of the attendance process, this section also shows the problems that exist from each system. Problems with the manual system are the reason for the initiation of the application of the fingerprint system. As for the problems in the fingerprint attendance system will be considered in identifying solutions and change management strategies.

3.2 Gap Analysis

Based on the results of the analysis of business process attendance gaps between current conditions (as is) and conditions to come (to be) an example of change is obtained. The list of changes for all aspects is as follows:

a. There is a new sub-process, namely fingerprint registration
b. The attendance form used in class is only the lecturer teaching journal
c. There is one procedure for attendance.
d. The attendance method changed from requiring a signature to fingerprint scanning
e. Data is captured automatically
f. There is the responsibility of the IT department to manage the fingerprint system

The changes identified have several impacts such as the data accuracy, safer attendance data storage, reducing cases of cheating committed by students, there is clarity and uniformity of attendance procedures, and speeding up absenteeism recapitulation. The list of impacts is grouped into value concepts, namely: linking, acceleration, restructuring, and innovation valuation. Value linking is used to evaluate financially the combined impact of the performance improvement function and the permanent results of the separate function. Meanwhile, value acceleration is related to the comparison of acceleration in doing tasks using information technology with the previous one without using information technology. Value Restructuring is the value associated with changes in organizational restructuring related to the impact of information technology. While the value associated with creating new functions in the business domain is commonly called innovation valuation.

Changes and impacts that are identified need solutions to realize them. Solution initialization is carried out using the OCM program, which includes stakeholder analysis, change impact analysis, leadership & sponsorship, communication programs, key user programs, organizational alignment, work procedure alignment, end user training, and performance support. Some of the solutions identified include: the formulation of new duties and functions for the fingerprint registration guide, providing a fingerprint database storage, the existence of communication media to convey the reasons for change, communicating changes in attendance activities, new policies and procedures, and clarifying the position of IT section in the organizational structure.

3.3 Change Management Strategies

A summary of the strategies generated based on mapping the list of solutions to ADKAR elements is presented in Table 2.

Table 2. List of Change Management Strategies

Number	ADKAR's Element	Strategies
1	***Awareness*** *of the need for change*	1. Optimizing the role of superiors 2. Increased management support

Number	ADKAR's Element	Strategies
		3. Development of effective communication programs to convey the reasons for change
2	***Desire*** *to support and participate in the change*	Development of a conducive environment for change
3	***Knowledge*** *on how to change*	Development of education and training programs
4	***Ability*** *to implement new skills.*	1. Provide infrastructure needed 2. Development of a pilot program for implementing the fingerprint system 3. Formulation of new job desk 4. Making rules and procedures for attendance activities
5	***Reinforcement*** *to sustain the change.*	1. Optimizing the use of the fingerprint system 2. evaluate the application of the fingerprint system periodically

The strategies that were identified in each element were then arranged into a state of change from Prosci. Solutions on the element of awareness and desire enter the current state, solutions on the knowledge and ability elements enter the transition state, and the future state consists of strategies on the elements of ability and reinforcement. The structuring of the strategy results in a change management roadmap as presented in Figure 2.

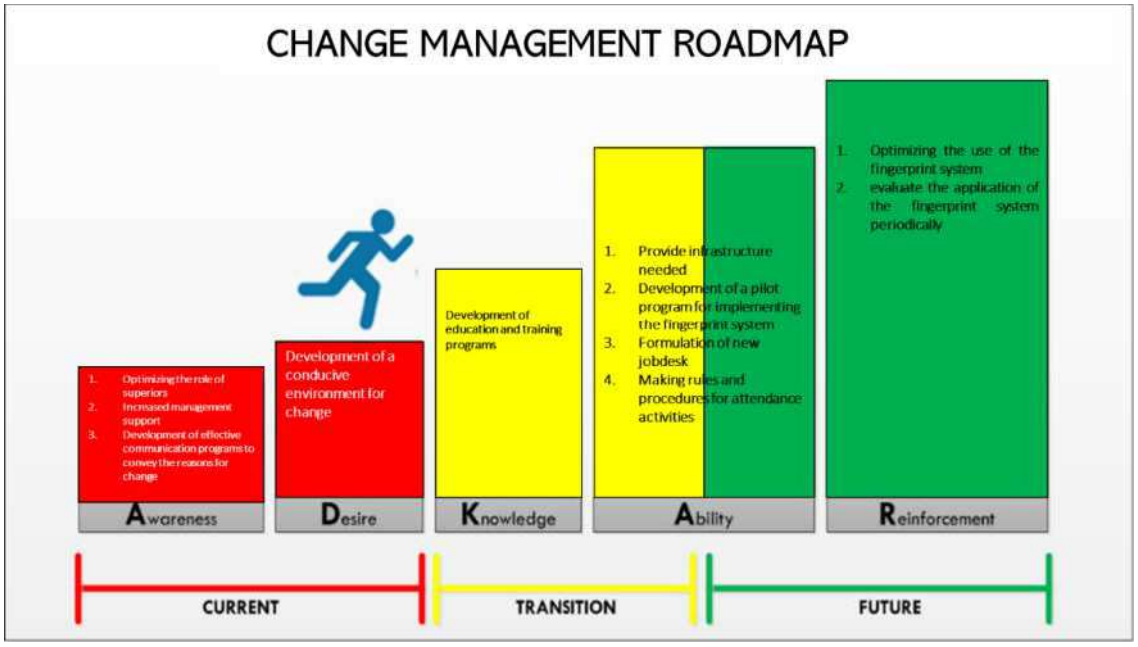

Figure 2. Change Management Roadmap

3.4 Validation of Change Management Strategies

The final stage in planning a change management strategy is verification and validation of results. This stage aims to find out whether the strategies proposed by researchers have included the problems and needs that are submitted by the management or not. This verification is carried out by researchers to the management, represented by Mr. Febriliyan Samopa as Head of Information Systems Department.

On this occasion, Mr. Febriliyan Samopa said that there must be alignment of business processes and technology applied to make changes to the attendance system. Other needs that are considered important by the Head department to be prepared for changing the attendance system from manual to fingerprint are as follows:

1. There are various risks that arise when applying fingerprints as a student attendance system
   Head of JSI-ITS stated that "risks such as power failure that might create alternate scenarios outside normal conditions are important. Therefore, the existence of these various risks raises the need to prepare treatment steps so that the attendance process continues".
2. When the system is ready, for fingerprint systems only need a Decree
   Head of Department stated that for the determination of the use of the fingerprint system, only need to make a decree. According to this as long as the system is ready, only by making a decree can the change in the use of the attendance system be carried out.

Next is the matching between things needed to change as stated by the Head of department with the change management strategy proposed by the researcher. First, there is a need to prepare steps for handling when alternate scenarios occur so that the attendance process continues. In the change management roadmap proposed by researchers there is one strategy, namely the formulation of rules and procedures for attendance activities. The purpose of this strategy is that in addition to preparing attendance procedures during normal conditions, several procedures in the event of alternate scenarios, which include attendance procedures when the power fails, equipment is broken, fingerprints are not read, and absenteeism in the classroom must be prepared. Not only that, the rules regarding the time provisions for recording absenteeism data and the limitation of time attendance to keep it said are also included in the proposed strategy. Second, a decree is needed for the use of fingerprints as a student attendance system. Although it is not explicitly stated by researchers that a decree is required for fingerprint use, but there is one point of strategy that has the same meaning. Strategies that cover these needs are on the element of awareness, optimizing the role of superiors. This strategy was initiated by the solution to the existence of policy encouragement or rules from the leadership related to the use of the fingerprint system for student attendance systems.

Based on the description above, it is known that the needs needed to change as conveyed by the head of department have been fulfilled in the change management strategy proposed by the researcher. In addition to covering the needs needed to change as conveyed by the Head of department, the strategy proposed by researchers also tries to cover other things needed to make changes. Starting from building awareness to change, creating a desire to participate and support change, to strengthening to safeguard change.

4. CONCLUSION

The results showed that the application of the fingerprint system brought changes, which included the addition of new sub processes, namely fingerprint enrollment, changes in attendance procedures, absence of data validation, attendance data recording was done automatically, and the authority of the IT department in managing the fingerprint system as attendance tool. Impacts based on several changes include data accuracy, reducing cases of cheating committed by students, clarity and uniformity in attendance procedures, and accelerating the recapitulation of attendance data. Based on the results of the gap analysis, a change management strategy for implementing a fingerprint system using the ADKAR model is optimizing the role of superiors, increasing management support, and developing effective communication programs to convey the reasons for change, developing a conducive change environment, developing education and training programs for users, providing the infrastructure needed, the development of a pilot program for implementing the fingerprint system, the formulation of new duties and functions,

and the formulation of rules and procedures for attendance activities, optimizing the use of the fingerprint system, and evaluation of the application of the fingerprint system periodically.

This research is only limited to the preparation of change management strategies with the result is change management roadmap. The preparation of this strategy does not yet include defining KPIs for each proposed strategy. In addition, in the preparation of this strategy, the management of the fingerprint system development project has not been too collaborative in it. Therefore, some further research that can be suggested is adding KPIs as a measure of success for each change management strategy and collaborative project management and change management in strategy development.

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Implementation of Nadhir Online Registration System in Badan Wakaf Indonesia Using Agile Development Methods

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Abstract

The Indonesian Waqf Board is an independent state institution formed under law number 41 of 2004 concerning endowments. At present, Nadhir registration service activities at the Indonesian Waqf Board are still carried out offline, which causes Nadhir registration service activities to be inefficient and take a long time. From the above problems the authors make research "Implementation of the Nadhir Online Registration System Using Agile Development Methods" which can help the Indonesian Waqf Board in nadhir registration activities in the Indonesian Waqf Board. This research uses agile development methods that focus on personal interactions, software functionality, collaboration with clients, responses to change. The results based on experiment are in the form of a website-based nadhir registration information system that features online registration, file upload, disposition, file verification, recommendations, approving and printing certificates that can help the process of registering Nadhir in Indonesian Waqf Board .System test results obtained from the usability variable of 82% so it can be concluded that the system is feasible to use.

Keywords*: Implementation, Information Systems, Online Registration, Nadhir, Indonesian Waqf Board*

1. INTRODUCTION

In the era of digital industry 4.0, the development of the internet has greatly increased with various innovations that focus on the internet of everything. This development is needed for innovations related to Islamic Charitable sources, especially waqf. Some studies, such as Muhammad Hakimi Bin Mohd Shafiai, 2014. which describe that Islamic Charitable Sources (zakat, waqf) very provide significant benefits and help the government to fight rural poverty [1]. Besides, in a study by Fahmi Medias, 2010. explain some of the benefits associated with waqf contain many positive aspects for the community including caring for the needs of the community such as programs contained in waqf institutions in Indonesia in providing benefits in terms of economic and social potential, helping to develop infrastructure in both worships, the world of education such as schools, health such as the construction of hospitals, housing for the community in the long term [2]. For example, the results of the management of waqf funds provide many great benefits, especially in the field of education and health under the management of the Indonesian Waqf Board [3], where waqf funds are intended for the general public because waqf assets cannot be sold or bequeathed.

With this digital era, a lot of information related to zakat, alms, and waqf is available through social media. However, public awareness and information related to procedural waqf are very

minimal in Indonesia. Lack of knowledge and learning media related to waqf is very much needed by Indonesian people because most people in Indonesia are Muslims. Even so, In Indonesia, the activity of waqf has increased tremendously in Muslim communities. Therefore, various innovations including waqf platforms are needed especially for administrative process problems that are often faced by Nadhir who want to register for the waqf administration process, which often takes a long time to process. Therefore, as a first step, a platform that can provide knowledge about waqf is even needed, it can even explain procedurally how the registration process to become Nadhir waqf, database management related to the management of waqf properties is very necessary for transparency of the process to the public, making it easier for the community to register from anywhere via the internet.

The Indonesian Waqf Board is an independent state institution formed under Law Number 41 of 2004 concerning Waqf. This institution was formed to develop and advance membership in Indonesia. Currently, nadhir registration activities at the Indonesian Waqf Board are still done manually. In the process of collecting files that have been sent which will be selected in the form of documents that require a long time to do file selection manually. The selection process must go through the interview stage which is conducted by coming to the Head Office so that it requires a large fee.

The main purpose of this problem is to assist the Indonesian Waqf Board in Nadhir registration activities. so, we create Implementation of Nadhir Online Registration System in Badan Wakaf Indonesia Using Agile Development Methods. Agile development methods have several models including extreme programming (XP), Scrums, Adaptive Software Development (ASD). The implementation of this Nadhir registration system which is the object of research found rapid changes so that it cannot directly meet the needs that must be met so the most suitable model used in this study is the agile system development model.

According to Pressman, 2010., Agile Development Methods is a software development methodology based on iterative development, in which the requirements and solutions for development through collaboration between organized team [4]. In Agile development, the process carried out has its characteristic and the same goal is to avoid processes that work based on time, document pressure and plan stages [5].

Nadhir is the person in charge of maintaining and managing waqf. Nadhir has an important position in representation so that the functioning of the waqf for mauquf ‘alaih is very dependent on nadhir waqf. In general, the ulama agree that the power of Nadhir waqf is only limited to the management of waqf to be used in accordance with the waqf objectives desired by the waqf. This proves that Nadhir is very necessary for waqf objects in achieving waqf goals [6].

An information system is a system that consists of a collection of system components, namely software, hardware, and brainware that processes information into an output that is useful for achieving a particular goal in an organization [7]. Information systems consist of five resources known as information system components [8]. The five resources are human, hardware, software, data, and network. These five components play a very important role in an information system. The use of information systems in the era of the internet of things is very necessary in the development of technology for example for the manufacture of platforms such as building smart trash web application platforms [9], Integrated Deep Learning Web Platforms [10], IoT platforms for Automated Water Quality Monitoring Systems [11] Therefore, a web platform for Nadhir registration is needed to simplify the registration and transparency of waqf activities.

2. RESEARCH METHODS

In this research, it is necessary to develop a system, so that users feel comfortable in running the system to be used. Development of computer-based information systems to solve organizational problems or take advantage of opportunities that arise. The research methodology carried out by the author is depicted in Figure 1.

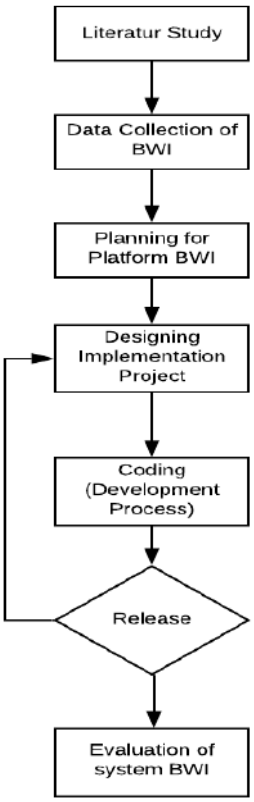

Figure 1. Research Methods

2.1 Literature Study

In this process, discussion is collected on journals, theses, and the internet to dig deeper into the initial idea. In addition, researchers are looking for references on Agile Development Methods.

2.2 Data Collection of BWI

At this stage the authors collect data to be used as the basis for the source of the problem or what is needed by the Indonesian waqf agency, data collection uses the interview method to ask details of the Indonesian waqf agency, which later the results of the interview will be attached to the research report.

2.3 Planning for Platform BWI

In this process, the process of designing a system is carried out, which is necessary to adjust, analyze the system requirements, which can be used according to user requirements. At this stage, we need an information system that can be built and easy to use according to user needs and can adapt to fast digital needs.

2.4 Designing Implementation Project

In this process, the authors make initial designs according to user requirements and translate them into visual UML diagrams such as use case diagrams, activity diagrams, and class diagrams.

The design is made by adding the required features in order to make it easier to use. In designing, the authors work with users to see the progress of the system.

2.5 Coding (Development Process)

In this process the writer performs a coding system (software coding) by the programmer in accordance with the designs that have been made previously. In the construction management information system development stage, programmers can make changes to the information system quickly as desired by the user.

2.6 Release

In this process, the authors conduct software testing which is carried out on an ongoing basis in accordance with customer needs by using the principles of agile development. So in the release stage, the authors provide the software testing results to the main stakeholders in order to evaluate the usefulness of the system whether or not it is in accordance with the needs of the user (user requirements).

2.7 Evaluation

In this process the authors evaluate the system as a whole. Evaluation is carried out based on a functionality test by providing a questionnaire that represents the usability aspects, namely efficiency, effectiveness, and satisfaction.

3. RESEARCH RESULT AND DISCUSSION

3.1 Data Collection and Analysis of Requirement System

The activity of Nadhir registration services at the Indonesian Waqf Board is carried out offline by means that prospective Nadhir must come to the office to be able to register as nadhirs and registration is still using the manual system. A candidate Nadhir provides registration documents and requirements in the form of hardcopy to the office then the files are received by the secretary to be given a letter number after which the files are disposable to the Nadhir division to check the completeness of the files and verify the data. Prospective Nadhir who pass the verification will be invited to conduct interviews while Nadhir candidates who do not pass the verification will be asked to double-check the files. After conducting interviews, the Nadhir division provides recommendations for the Nadhir candidates to the leadership. If the leadership approves, the candidate of Nadhir receives a certificate.

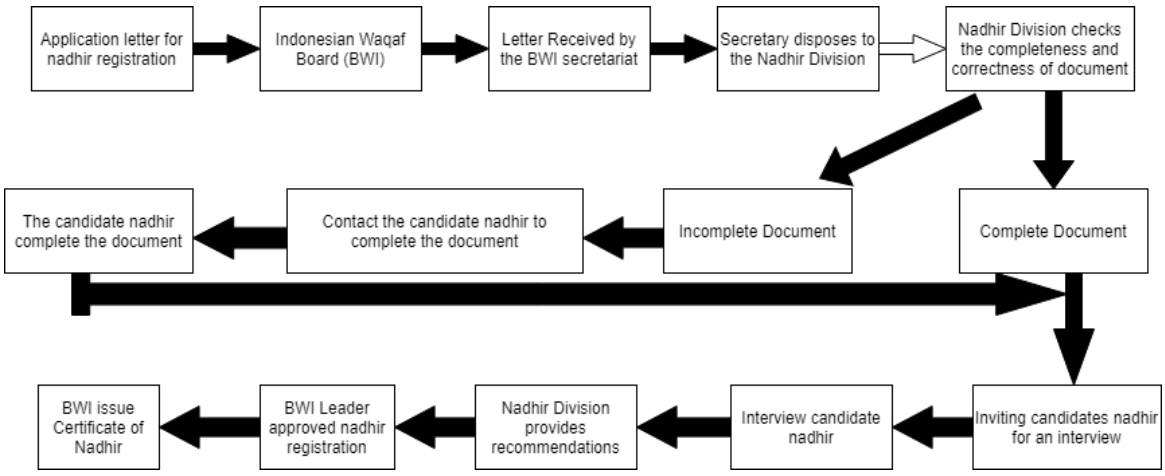

Figure 2. The activity of Nadhir Registration

3.1.1 Flowchart of the System

The right solution in solving the existing problem is changing the Nadhir registration system which runs manually with a computerized website information system which is expected to help the Nadhir registration activity to be faster. In general, the system to be developed is the registration process for Nadhir, submitting files and requirements online, each candidate for Nahdir has a separate account to carry out the registration process. The system can inform the final data, process data, and print certificates automatically. The system flow can be seen in Figure 2.

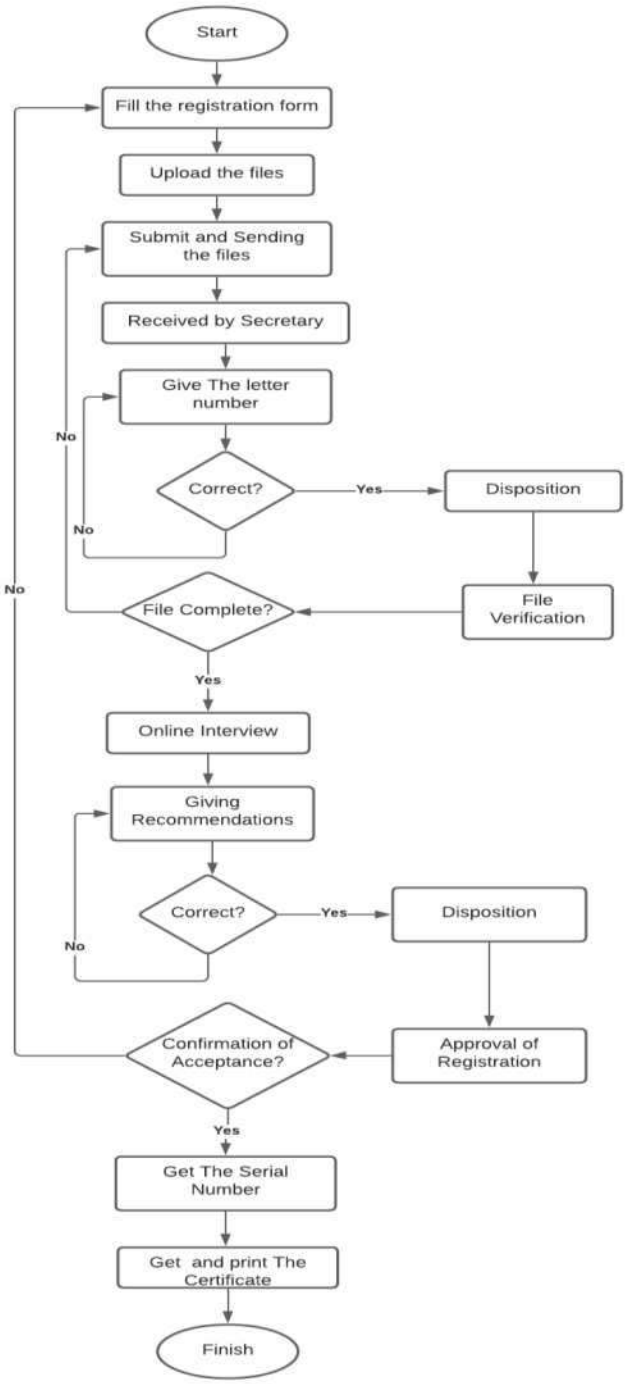

Figure 3. Flowchart of The System

3.1.2 Functional Requirements

a. General Requirements

1. Nadhir candidate can register and log in into the candidate information system registration.
2. Nadhir candidates can register new cash waqf.
3. Nadhir candidates complete the requirements in registration, requirements
4. Candidate Nadhir sends application for registration to BWI.
5. The BWI Secretariat accepts applications for registration from Candidates for Nadhir.
6. The BWI Secretariat dispositions applications for registration to the Division Nadhir.
7. Nadhir Division sees the completeness of the requirements that have been uploaded by Candidate Nadhir. If complete and appropriate, Nadhir Division schedule for an interview. If it's not complete, Nadhir Division return the application for registration to the Candidate Nadhir to be equipped.
8. Having determined the interview schedule, Nadhir Division conducts interviews with Candidate Nadhir by generating considerations from the interviews conducted.
9. After the interview, Nadhir Division provides recommendations during the meeting complete.
10. The results of the complete meeting of the leadership give approval / rejection of application for registration of Candidate Nadhir.
11. If approved, then Nadhir Candidate will get an eSet Certificate. If rejected, then nominee Nadhir must fix the shortcomings of the refusal.

b. Identification of Actor

Table 1. Identification of Actor

No	Actor	Description
1	Super Admin	Person who responsible for managing the overall system.
2	Candidate Nadhir	Person who accesses he system via internet to register as an online Nadhir
3	Secretary	Person who accesses the system to position registration files to the nadhir division
4	Nadhir Division	Person who access the system to verify the data and recommend a candidate of Nadhir.
5	Leader	Person who accesses the system to approve a candidate Nadhir to become as Nadhir.

3.1.3 Non-functional Requirements

a. Provides easy of the use for the Nadhir registration information system on each system features.
b. This registration system can be easily accessed on all windows, linux, OS X as Operating System.

3.2 System Design

3.2.1 Use Case Diagram

The use case diagram is a model for the behavior of the information system to be made. Use case describes an interaction between one or more actors with the information system to be created. In Figure 3, users can use the system after logging in.

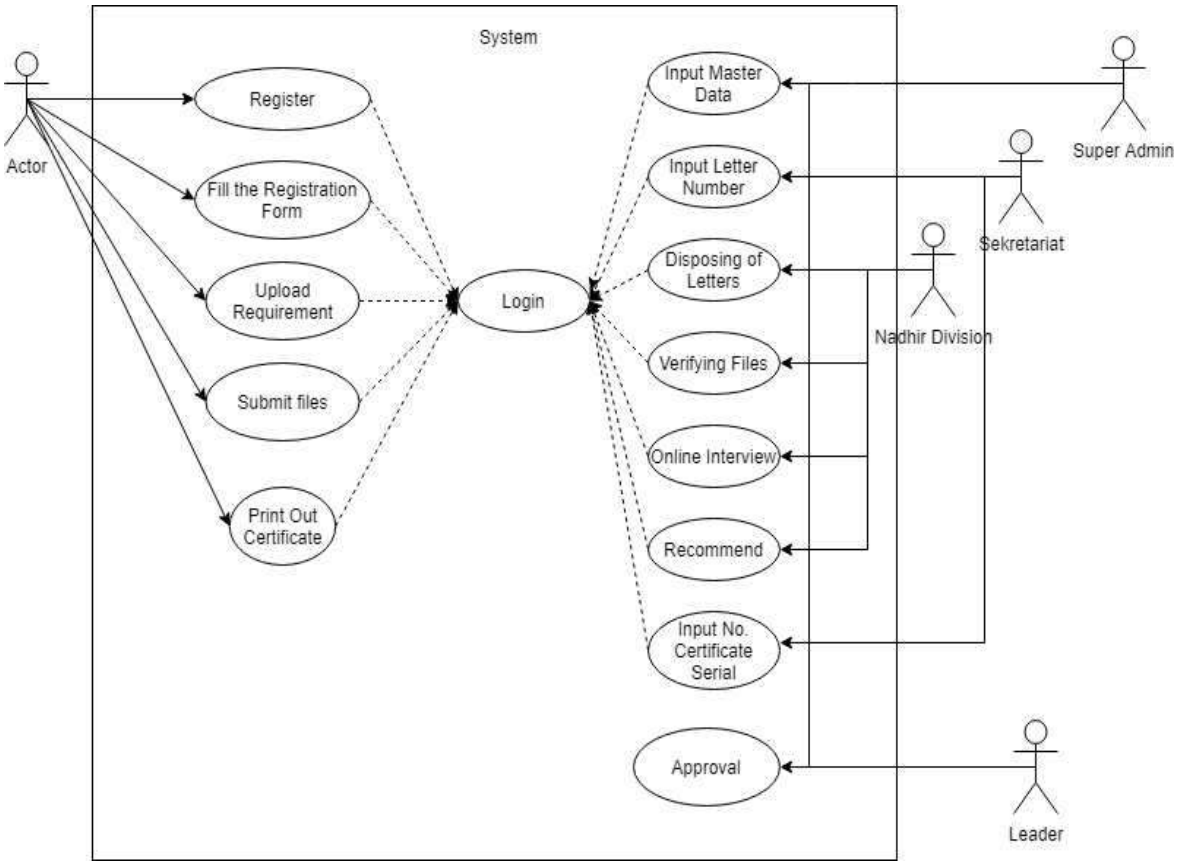

Figure 4. Use Case Diagram of Nadhir System Platform

3.2.2 Class Diagram

Class diagram is a diagram that shows the structural design of several existing classes of a system logically. Class diagrams describe the structure of the system in terms of defining classes that are made to build a system. Class has an attribute and method or operation. Attributes are variables owned by a class. Meanwhile, operations or methods are functions that belong to a class. Figure 5 is a class diagram of the Nadhir registration information system.

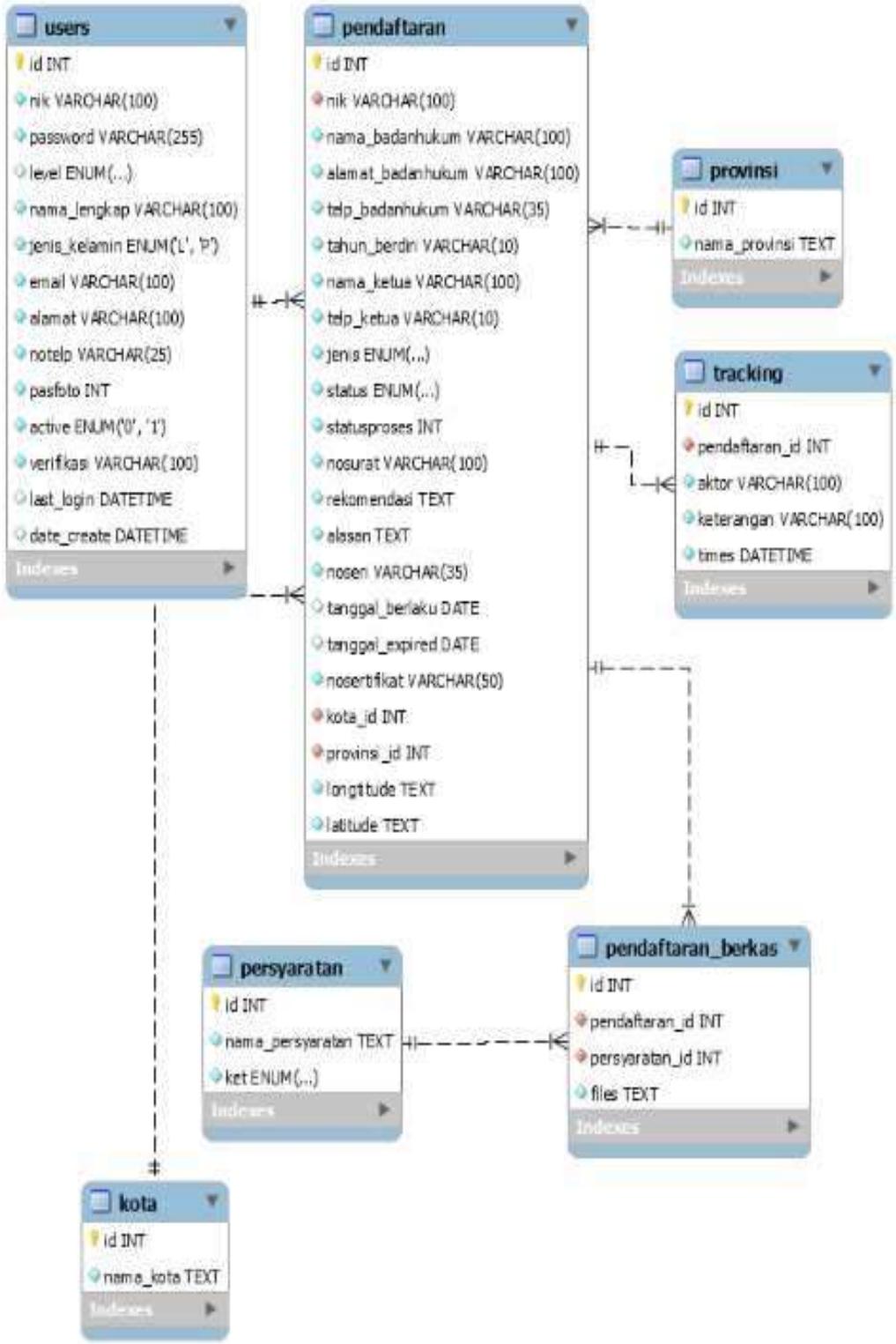

Figure 5. Class Diagram

3.3 Design Implementation

3.3.1. Register

The register page is a feature for registering an account to register waqf registration. In registering, users are required to fill out a form registration consisting of email, password, KTP no, cellphone number, and input Captcha code.

Figure 6. Register of E-Nadhir

3.3.2 System Login

The Login page is a feature to enter / log into the waqf registration system. In logging in, the user is required to fill in a login form consisting of a NIK, password.

Figure 7. System Login of E-Nadhir

3.3.3 Requirement Master

The Requirement Master, including list of requirements, add requirements, edit requirements, and remove the requirements.

a. List of Requirements, Requirements list page is a page that contains a list of requirements.

Figure 8. List Requirements

b. Add Requirements

If the candidate Nadhir want to add requirements press the add button, then fill out the requirement form which consists of the name of the requirement and information.

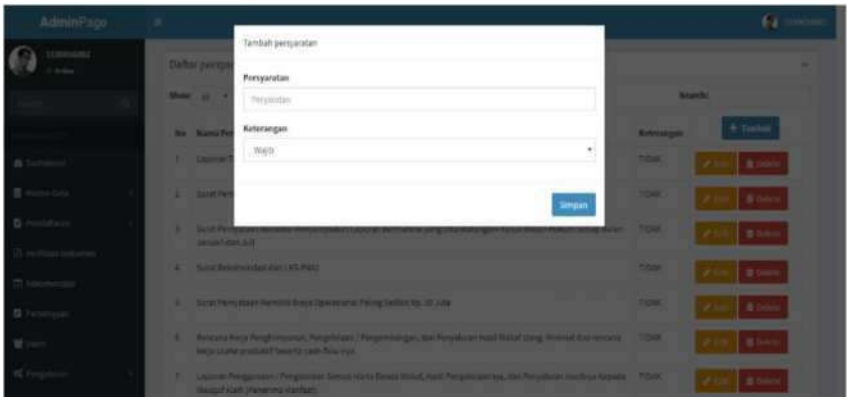

Figure 9. Add Requirements

c. Edit Requirements

If the candidate Nadhir want to change the requirements, press the edit button, then fill in the requirement edit form which consists of the name of the requirement and a description

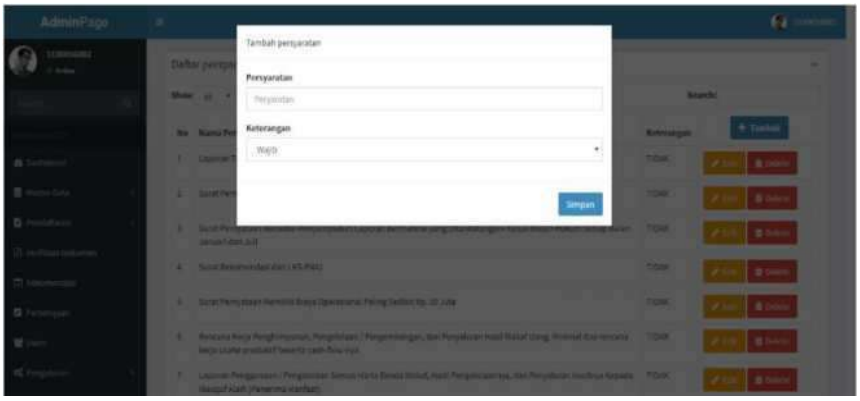

Figure 10. Edit Requirements

d. Remove Requirements

If the candidate Nadhir want to delete requirements, then click the delete button and the data will be deleted

Figure 11. Remove Requirements

3.3.4 Registration

The Registration including registration list, add registration, edit registration, clear registration, upload files, sending files, input letter number, file verification, recommendation, approval, print certificate, and show the map location of the approval Nadhir.

a. Registration list, The registration list page is a page that contains a list Nadhir registration.

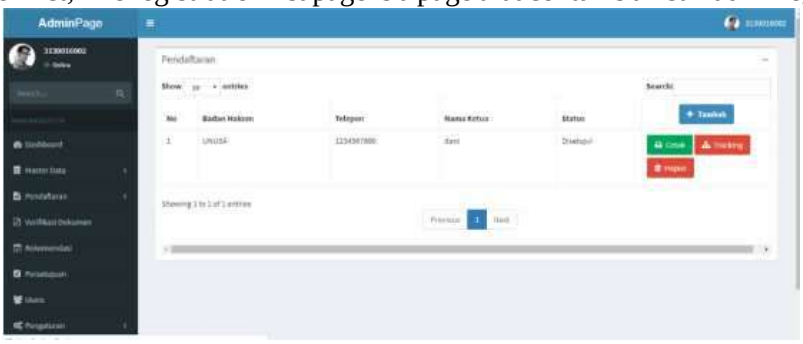

Figure 12. Registration list

b. Add Requirements

If the candidate Nadhir want to add a new registration, press the add button, then fill out the registration form consisting of the name of the legal entity, address, telephone number, year of establishment, longitude, latitude, name of the chairman, cellphone number, province, city.

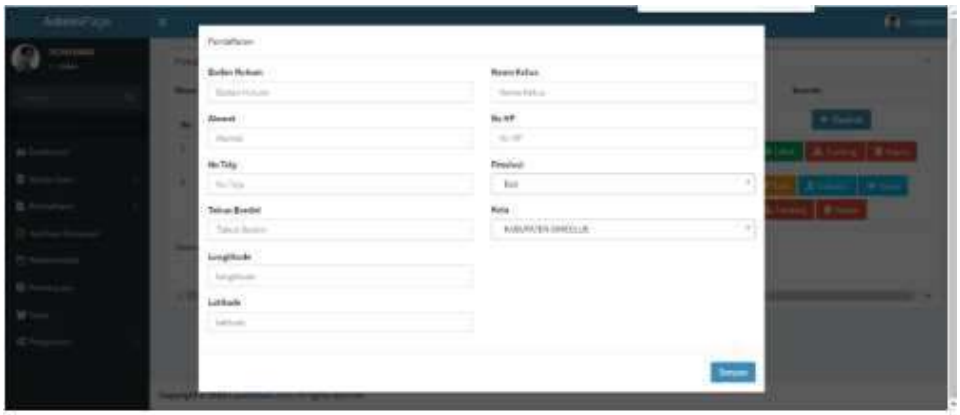

Figure 13. Add Registration

E-ISSN: 2621-4474, ISSN:2621-4458.

c. Edit Registration
If the candidate Nadhir wants to edit the new registration, press the edit button, then fill in the registration edit form consisting of the name of the legal entity, address, telephone number, year of establishment, longtitude, latitude, name of the chairman, cellphone number, province, city.

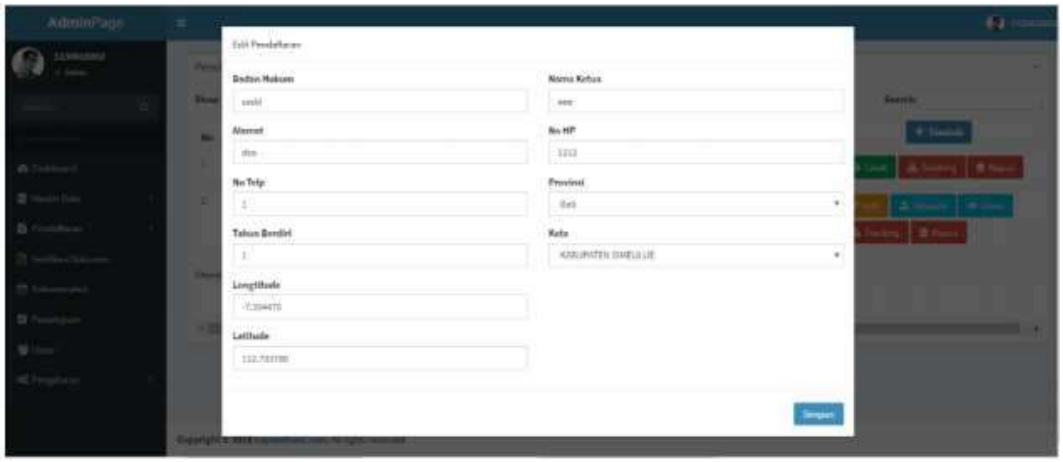

Figure 14. Edit Registration

d. Clear Registration
If the candidate Nadhir want to delete registration, click the delete button and the data will be deleted.

e. Upload Files
If the candidate Nadhir wants to upload the new registration file, press the upload button, then fill in the registration file upload form consisting of the file name and file uploads.

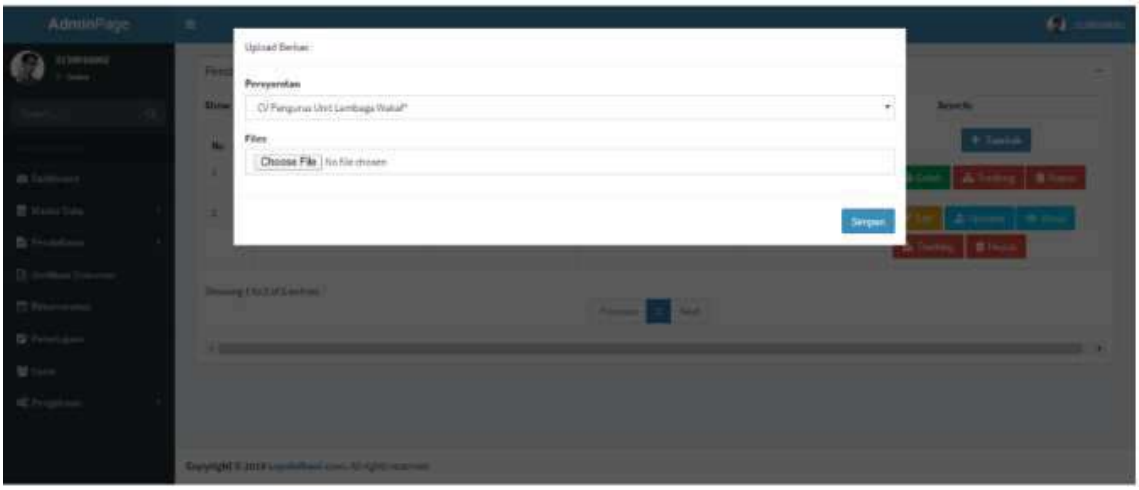

Figure 15. Upload File

f. Sending Files
Send registration files by clicking the submit button.

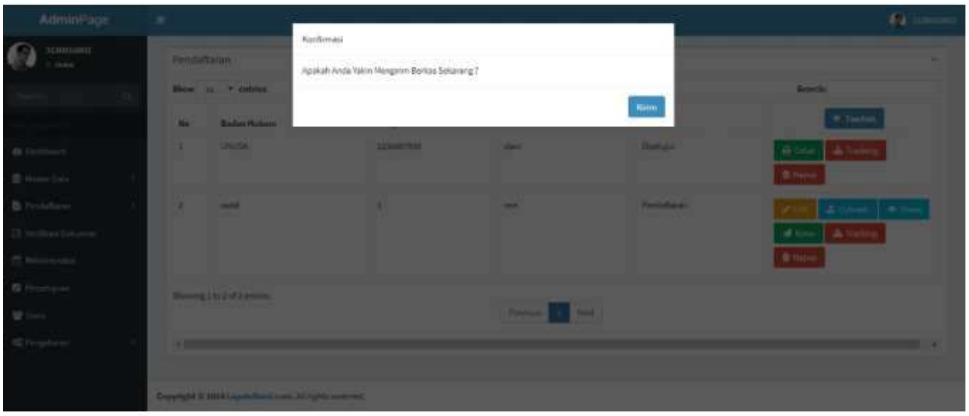

Figure 16. Sending Files

g. Input letter Number
After the file is sent the file is assigned a letter number by clicking the letter no. Button then filling out the letter no. Form then saved.

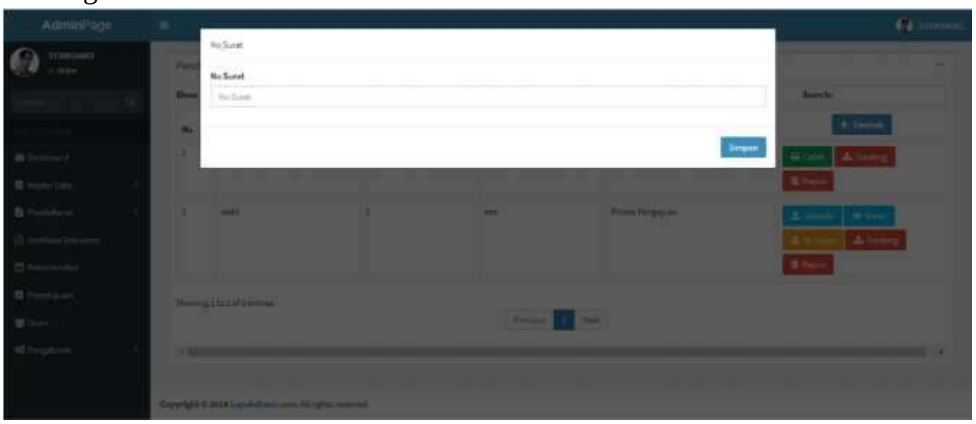

Figure 17. Input The Letter Number

h. File Verification
Verify the file by clicking the verification button

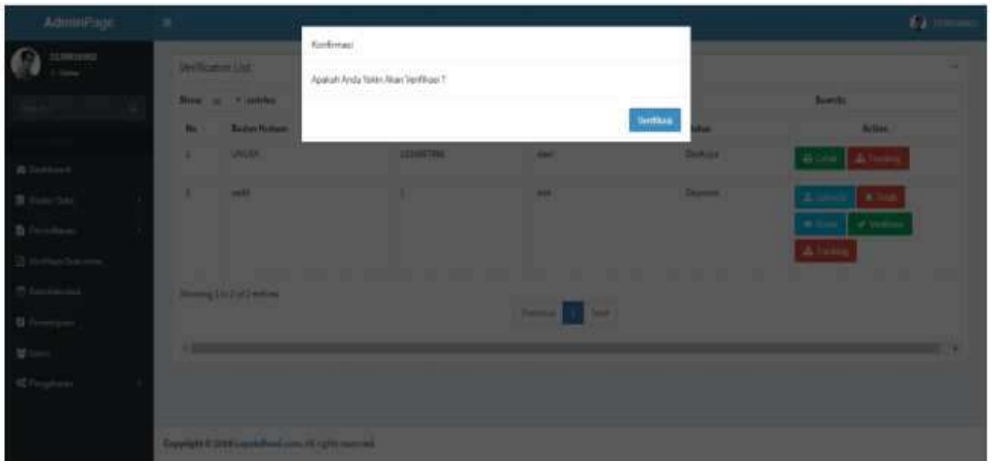

Figure 18. File Verification

i. Recommendation
Click the recommendation button, then fill out the recommendation form, then save it.

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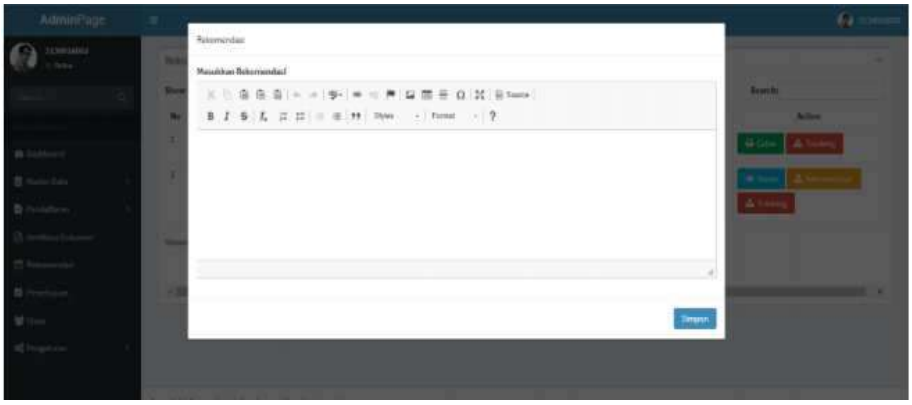

Figure 19. Recommendation

j. Approval
Click the approval button "Setuju" to accept the registration

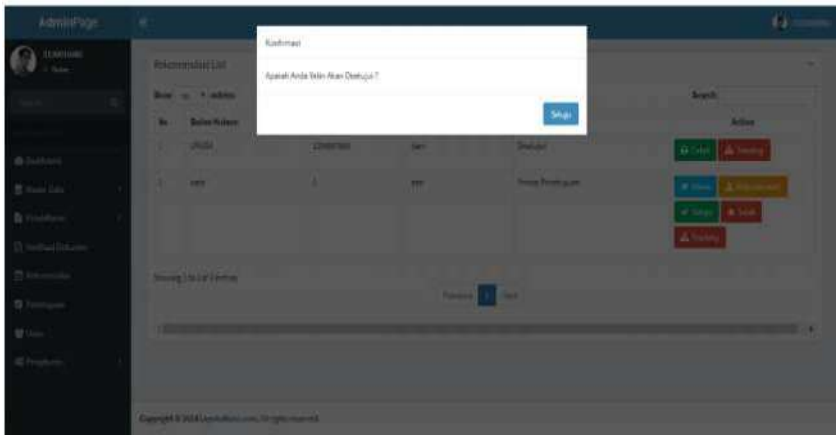

Figure 20. Approval

k. Print Certificate
Click Print certificate, then the certificate can be printed

Figure 21. Print Certificate

l. Nadhir Data Location
The data report page shown the page that contains the map data of the Nadhir location that has been approved by the leadership

Figure 22. Nadhir Data Location

3.4 Agile Implementation in System Development

In the process of developing a Nadhir registration information system using Agile Development Methods to facilitate system development to achieve the results desired by the Indonesian Waqf Board. Agile implementation in the System Development Stage can be shown in Table 4.15

Table 2. Agile Implementation in System Development

No	E-Nadhir	Stage	Result Description
1	Planning	1	Presenting the results of interviews with the Indonesian waqf board coordinator
2	Design Analysis		Present the results of use cases and activity diagrams
3	System Development		Shows the results of the system display design, shows what menus are in the system
4	Testing		There are corrections to add the information page / company profile feature
5	Design Analysis	2	Shows the results of adding the revised use case information page / company profile such as add serial number and print the certificate in time
6	System Development		Shows the display page information / company profile such as add serial number and print the certificate in time
7	Testing		There are corrections to add the final data report feature in the form of maps
8	Design Analysis	3	Shows the results of adding the revised use case information page / company profile such as add data report with the maps
9	System Development		Shows the display page information / company profile such as add data report with the maps
10	Testing		There is no other need correction and the system can be used.

3.5 Blackbox testing and Usability testing of E- Nadhir

E-Nadhir application using blackbox testing and usability testing. The results show that every button and transition of the system in each page run appropriately. The results of black box testing of E-Nadhir applications are presented in detail in Table 3 and The result of usability testing can be shown in Table 4.

Table 3. The result of blackbox testing

Page	Testing Button	Status
Homepage	View	(√) Succeed ( ) Failed
	Edit	(√) Succeed ( ) Failed
Registration Account	Register	(√) Succeed ( ) Failed
	Verification	(√) Succeed ( ) Failed
Login	Verification	(√) Succeed ( ) Failed
Data Master	View	(√) Succeed ( ) Failed
	Add	(√) Succeed ( ) Failed
	Edit	(√) Succeed ( ) Failed
	Delete	(√) Succeed ( ) Failed
Registration Nadhir	View	(√) Succeed ( ) Failed
	Add	(√) Succeed ( ) Failed
	Edit	(√) Succeed ( ) Failed
	Delete	(√) Succeed ( ) Failed
Input Letter Number	View	(√) Succeed ( ) Failed
	Edit	(√) Succeed ( ) Failed
Disposition Files	View	(√) Succeed ( ) Failed
	Edit	(√) Succeed ( ) Failed
Verification Files	View	(√) Succeed ( ) Failed
	Edit	(√) Succeed ( ) Failed
Rekomendation	View	(√) Succeed ( ) Failed
	Edit	(√) Succeed ( ) Failed
Approval	View	(√) Succeed ( ) Failed
	Edit	(√) Succeed ( ) Failed
Print Certificate	View	(√) Succeed ( ) Failed
	Edit	(√) Succeed ( ) Failed
	Print out	(√) Succeed ( ) Failed
Data Laporan Nadhir	View	(√) Succeed ( ) Failed
Notification Error if registration nadhir not complete	View	(√) Succeed ( ) Failed

After completing all existing blackbox testing, the next step is Usability testing by distribute questionnaires to administrators, secretaries, Nadhir divisions, leaders and Nadhir candidates containing 18 statements that represent the three aspects of usability, namely efficiency, effectiveness and satisfaction [12]. Users fill out questionnaires that have distributed based on their experiences (what they saw and tried) when doing blackbox testing.

Table 4. The Result of Usability Testing

	Usability Question																		Total
R	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
R1	4	4	4	4	4	3	3	3	3	3	4	4	4	3	3	3	3	3	62
R2	5	4	5	4	4	4	4	4	4	4	5	4	5	5	5	4	4	5	79
R3	5	4	4	4	5	5	5	4	4	5	5	4	4	5	5	5	4	5	82
R4	4	4	4	4	5	4	4	5	5	5	5	4	4	4	4	4	4	4	77
R5	4	4	4	4	5	3	4	4	4	4	5	3	4	4	4	4	5	4	71
Total																			371
Average																			74.2
Procentage																			82%

Based on the results of the evaluation, the Nadhir registration information system got an overall score of 371 with an overall average of 74.2 and an overall percentage of 82% so that the management information system in all aspects of the variables can be said to be very feasible for the Nadhir registration information system in the Indonesian waqf body.

4. CONCLUSION

Based on the results and discussion above, it can be concluded that the E- Nadhir registration information system is designed with the Mysql database and in the process of developing this Nadhir registration information system, it uses the agile development method to facilitate the development of the system to achieve the desired results by the Indonesian waqf agency.This registration information system application has an attractive and simple design to make it easier for users to use the system. The results based on experiment are in the form of a website-based nadhir registration information system that features online registration, file upload, disposition, file verification, recommendations, approving and printing certificates that can help the process of registering nadhir in Indonesian Waqf Board. The system test results obtained from the usability variable of 82% so it can be concluded that the system is feasible to use.

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Image Classification with Shell Texture Feature Extraction Using Local Binary Pattern (LBP) Method

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Abstract

Classification procedure that is usually done manually by way of separation based on the texture of the shell shell. Classification is done by looking at objects based on inherent characteristics usually referred to as features / characteristics. Classification by hand can cause accuracy problems. In the image of the shells, texture characteristics are needed to distinguish one type of shell from another. The purpose of this study is to develop a texture feature extraction system for the classification of shell images. The input image is carried out preprocessing and segmenting to separate objects from the background and the image of the separated object is transformed into a grayscale image for the feature extraction process using the Local Binary Pattern method. Based on trials that have been done, the accuracy is quite good, the highest accuracy value occurs in shellfish blood cockles with RBF kernels. While the lowest accuracy is on testing the feather shell image where the accuracy value is 86.6% this result can show that the LBP method with SVM classification is quite reliable in calculating the accuracy for the classification process of shellfish types.

Keywords*: texture feature extraction, LBP, classification, shell image.*

1. INTRODUCTION

Indonesia is one of the countries that has the largest area of marine waters in the world. Geographically, the waters of Indonesia are located in tropical regions which are rich in various natural marine resources. Utilization of marine resources is not only done through capture, but also needs to be developed cultivation business. The existing fisheries sector is still exploring sea products, namely tuna, shrimp and seaweed, while various types of mollusks are not yet desirable to develop. One type of mollusk is a shell which is an abundant fishery product in the tropics and a good and inexpensive source of animal protein for the community [1]. Shellfish and foods from the sea are rich in amino acids and fatty acids. Shellfish can also be developed into one of the reliable export products. Therefore, making shells as an interesting object to be studied. Shellfish are marine animals that belong to a group of soft-bodied animals oyster family, flat and layered, and has a pair of shells that are connected by hinges so that it can be opened and closed. Each type of shell has a different shell texture and shape. Each shell of the shell has a characteristic pattern on the texture and shape of the shell. It is this style and shape that distinguishes one shell from another one[2]. Automatic separation (classification) can be done by utilizing computer technology, especially in image processing and for the classification can be solved using Support Vector Machine (SVM)[3][4]. One important part that can support the success of the classification process is the pattern recognition process. Pattern recognition process is carried out by extracting

features from existing patterns. The characteristic that is used to recognize the pattern of shells is the texture characteristics. Texture characteristics can describe the arrangement of intensities of a set of pixels that are next to an image. Therefore, the exact texture feature extraction method is needed in order to achieve high accuracy results in the classification process.

One method for extracting good texture features is Local Binary Pattern (LBP). LBP is a simple but quite efficient method in representing texture characteristics[5]. LBP is a gray-scale invariant or unaffected method for uneven lighting in an image, because LBP describes the texture locally to support the local contrast measure from an image[6]. In addition, LBP only consists of a few neighboring pixels with uncomplicated operations. Local Binary Pattern (LBP) is a texture analysis method that uses statistical and structural models. LBP analyzes the texture locally in the spatial domain, by comparing the intensity of the pixels between the central pixels and the neighboring pixels at a certain radius. So that gradient information can be obtained to represent edges, points, and other local features of an image. Next, a histogram is arranged to determine the distribution of the gradient values. With this simple calculation method, making LBP quite reliable on images that have different lighting [7].

Local Binary Pattern (LBP) is a texture analysis method that uses statistical and structural models. Many researcher using LBP for pedestrian detection[8], medical image analysis[9], car detection[10], license plate number detection[11], music genre classification[12] and facial expression recognition[13] but others researcher also using it for texture feature extraction and classification such as Jie Sima et all [14]applied extended Contrast LBP by using the extracted feature including sign feature, energy feature, and the center pixel feature by constructing the histogram based in the feature of the sign energy center pixel before and also combine it with chi-square distance and the nearest neighbor classifier to perform texture classification. . LBP analyzes the texture locally in the spatial domain, by comparing the intensity of the pixels between the central pixels and the neighboring pixels at a certain radius. So that gradient information can be obtained to represent edges, points, and other local features of an image. With this simple calculation method, making LBP quite reliable on images that have different lighting[5]. LBP steps in extracting features are:

1. For each pixel, the LBP value is calculated by comparing the intensity of the pixel between the intensity of the central pixel with the intensity of its neighboring pixels at a certain radius, as shown in Figure 1. The intensity of the central pixel becomes the thresholding to arrange the LBP value in each pixel of the image.

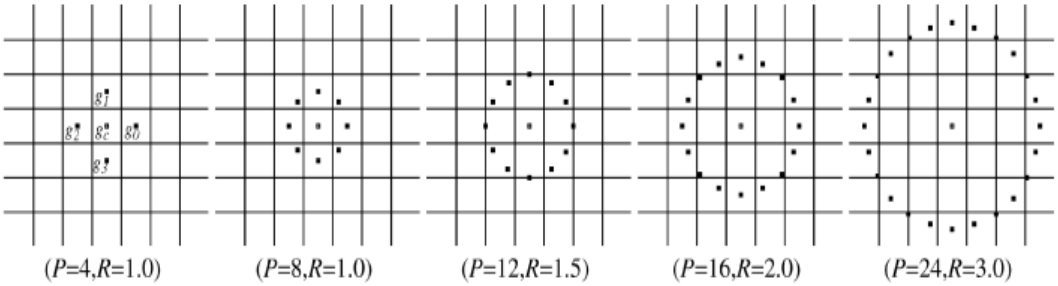

Figure 1. Local Binary Pattern Operator

2. If the value of the intensity of the central pixel is greater than the value of the intensity of the neighboring pixels, the binary transformation value for the central pixel is one. Conversely, if the value of the intensity of the central pixel is smaller than the value of

the intensity of the neighboring pixel, the binary transformation value for the central pixel is zero, as shown in Figure 2 (b).

3. The binary values of the neighboring pixels are arranged, as shown in Figure 2 (c)
4. The arrangement of the binary value is converted to a decimal value, by multiplying the binary value by its weight, as shown in Figure 2 (c) and Figure 2 (d).
5. Mathematically, LBP calculations can be written based on Equation (1).

$$LBP_{P,R} = \sum_{p=0}^{P-1} s(I_{p,R} - I_c)2^P \quad (1)$$

Where,

$$s(x) = \begin{cases} 1, & x \geq 0 \\ 0, & x < 0 \end{cases} \quad (2)$$

P is the number of neighbors, R is the radius between the center and neighbor, $LBP_{P,R}$ is the decimal value of the conversion binary value, I_c is the intensity value of the central pixel, $I_{p,R}$ is the intensity value of neighboring pixels p

$(p = 0,1, \dots, (P-1))$ with radius R. Whereas $s(x)$ is a thresholding function.

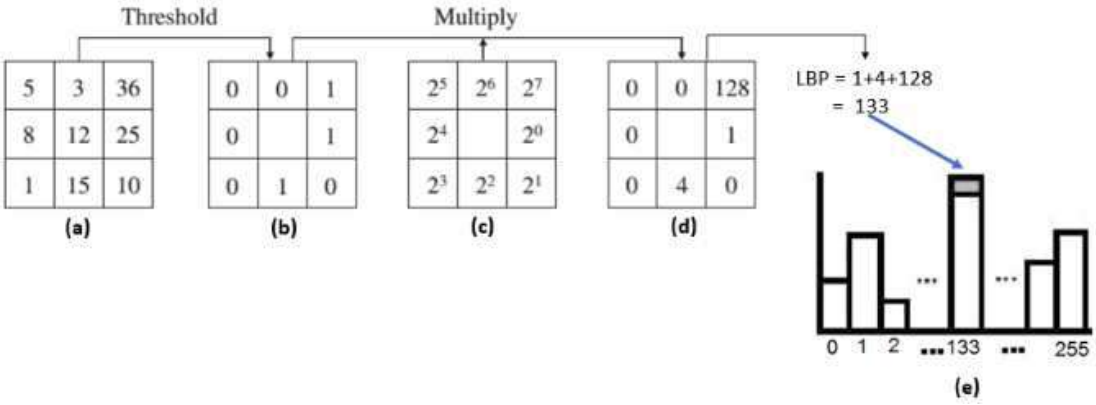

Figure 2. Illustration of LBP Process
(a) Original image. (b) The result of comparison with the thresholding function. (c) Weight. (d) Results of multiplication with weights. (e) Histogram of LBP features.

6. A histogram is arranged, as shown in Figure 2.5 (e). Mathematically, a histogram can be defined by Equation (2.3).

$$H_j = \sum_{x,y}^{L-1} \begin{matrix} I(x,y) = j, \\ j = 0,1, \dots, n-1 \end{matrix} \quad (3)$$

H_j is the histogram value at the j intensity, $I(x,y)$ is the intensity value at the pixel coordinates (x,y), L is the measure of the number of pixels in an image, and n is the maximum value of intensity.

2. RESEARCH METHODS

The design of this study, there are several things that need to be considered, this research explained how to extract shell texture characteristics on the image of a shell using the Local Binary Pattern (LBP) method. Broadly speaking, the flow of research can be observed in Figure 3.

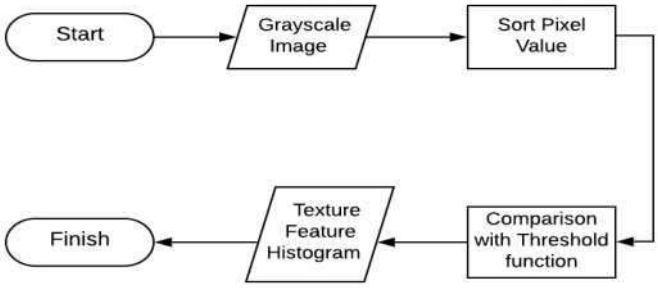

Figure 3. Extract Shell Texture Using Local Binary Pattern

At the analysis and design stage of an algorithm, an image before undergoing further processing needs to be done a preprocessing stage, which is a technique used to prepare an image in order to produce the desired output. The image that has gone through the preprocessing stage, then will go through the segmentation stage, namely the separation between the foreground and the object. In this study, the original image through the preprocessing stages is changing the original image in the form of an RGB image, then image processing is done by changing the RGB image into a grayscale image and then the canny edge, dilation and median filtering process is performed. The stages of the process are to get the shape of the edge of the shell (binary image) which will then be processed when extracting the shape features.

For the next stage, grayscale image through canny edge detection is used to get the edge of the object. The process of dilation and erosion is also used at this stage, then a skeleton process is used to represent the binary image of the object shell. In Figure 2. you can see the preprocessing and segmentation stages for each feature.

In the next stage, the implementation of algorithms against the designs that have been designed previously. The specifications of the hardware and software used consist of an Intel Core i3 2.20 GHz processor, 2.00 GB of memory capacity and a hard disk with a capacity of 500 GB. As for the software specifications used in the implementation of this research algorithm, namely Microsoft Excel and MATLAB R2013a by utilizing existing libraries.

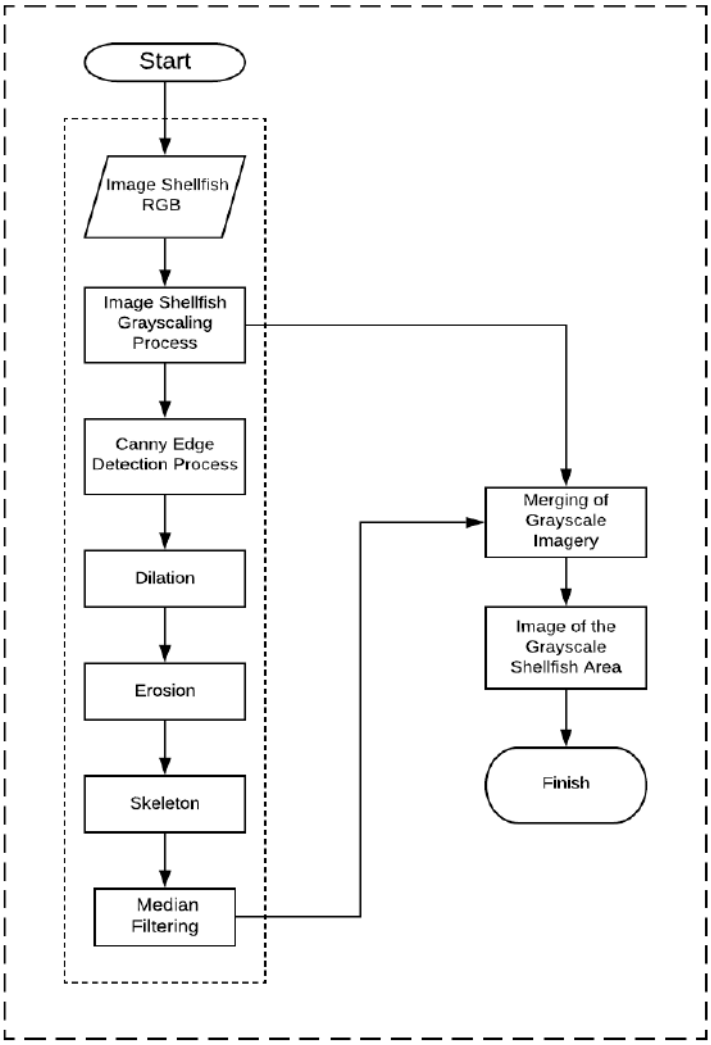

Figure 4. Pre-Process and Segmentation Stages

In the final stage to analyze data from the texture feature test results, it is expected that from the usury test analysis results will be obtained in accordance with the initial research objectives. For the process at the classification stage is done by using Support Vector Machine (SVM)[3][4]. Although in the beginning SVM was a classification for two classes, in its development SVM did not only classify two classes, but more than two classes (multiclass). The reason for using this classifier is because of its ability to generalize, its relatively easy implementation, and its ability to handle high-dimensional data. In the classification stage there are several kernel experiments performed namely linear kernel, Radial Basis Function (RBF) / Gaussian kernel and Polynomial kernel [3][4][15].

3. RESEARCH RESULT AND DISCUSSION

In this study the dataset used is a 300x225 RGB image. The number of datasets used as trial data is 60 images of clams consisting of 3 different classes / species, namely 20 images of blood shells, 20 images of sand shells, and 20 images of feather shells. Data collection was taken personally by researchers in the morning with good lighting. The shells used as a dataset are fresh consumption shells. An example of the dataset used is shown in Table 1.

Table 1. Dataset Sample Shellfish Description

No	Class	Images
1.	Shellfish Blood Cockles	
2.	Shellfish Sand Cockles	
3.	Shellfish fur Cockles	

In Figure 3. It is a preprocessing stage for obtaining the texture of the shells. Initially a conversion of an RGB image (a) into a grayscale image (b) was followed by the merging of a grayscale image (c) and a segmented binary image to get the object area of the shell (d). The final result of this stage of the proposal is the formation of an output image which will become the input image at the feature texture extraction stage by the LBP method.

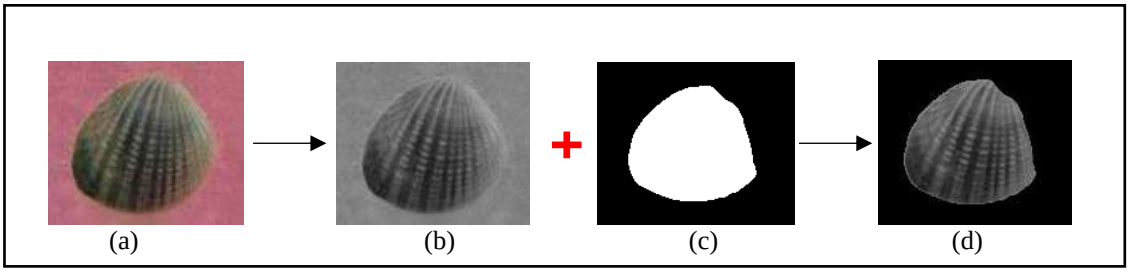

Figure 5. Preprocessing step to get the image of the texture of the shells

Then a test is performed on the feature testing using the LBP method. Get an average texture value with 256 texture histogram and 128 features.

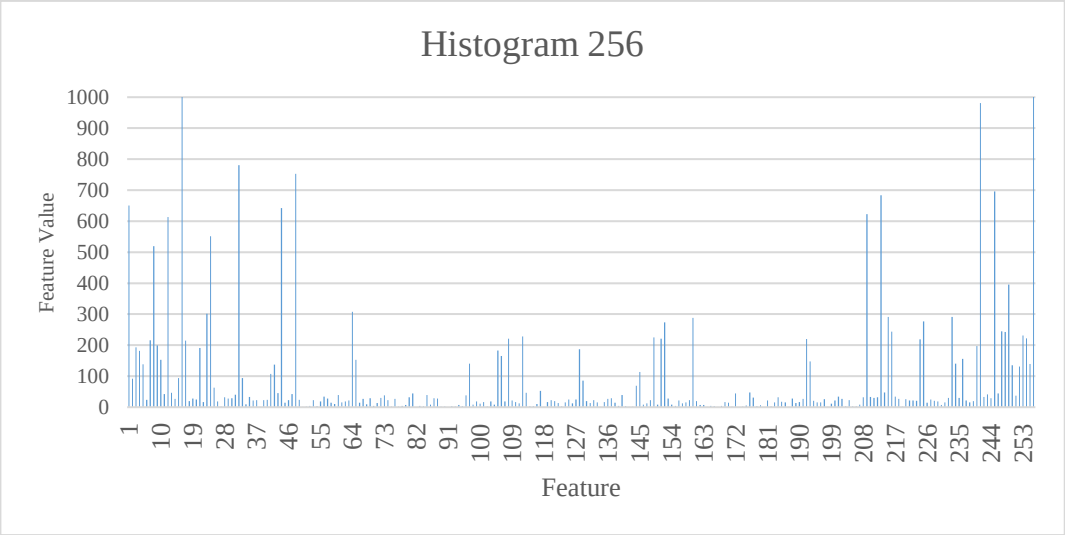

Figure 6. Histogram 256 Texture Characteristics

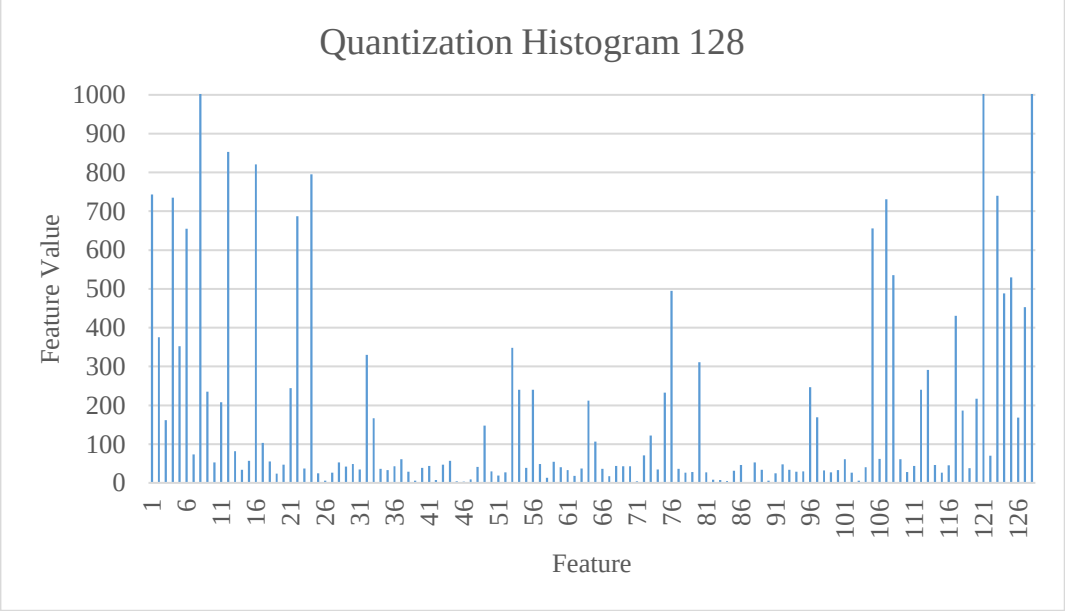

Figure 7. Texture Histogram 128 Characteristics

Next to test the texture feature classification results are performed with a quantization histogram along 128 and 256 features of the image of the shells in the existing dataset. In this research, we also classify using SVM, this research is carried out using linear SVM and the use of linear kernel and RBF kernel using parameter C. The C parameter in SVM is used to control the tradeoff between hyperplane margins and errors in classification. However, in this study, the parameter values of C = 1 and gamma = 0.1 were used. the use of functions in C and gamma to determine the validation value of accuracy where the performance measurement uses the percentage of classification accuracy. Accuracy can be written as a comparison between the correctly classified image and the whole image being tested. The accuracy calculation is calculated as follows:

Accuracy = (Number of test images identified as correct / number of images tested) x 100%

The parameters used in this experiment for linear kernels with parameter C = 1, while for RBF kernels the with C = 1 and gamma = 0.1. Model testing of training data is testing the previously trained images and stored in a model where the training data used is 3 shells and each shell uses 20 images. The results of model testing on training data can be seen in the following Table 1.

Table 2. Result of Training Data

Kernel	Parameter Kernel	Accuracy of training data
Linear	C=1	100%
RBF	C=1, ɣ = 0.1	100%

Model Testing against Test Data. Image testing aims to find shells that have not been recognized or classified. The classification model used to test the image of the shell that has not been recognized uses the best model from the validation results and training data testing. The test data used consisted of 3 shells with 10 images of each shell.

Table 3. Result of Training Data

Kernel	Number image test	The correct image recognition	Accuracy of training data
Linear	30	28	93.30%
RBF	30	28	93.30%

In the results of research conducted with the success rate of introduction of shells with different variations in virgin, sand and feather shells, a graph of the accuracy of the recognition success rate was obtained.

Table 4. Result Accuracy of Shellfish Image Testing

	Linear Kernel	RBF Kernel
Shelfish Blood	93.30%	100.00%
Shellfish Sand	90.00%	93.30%
Shellfish Fur	86.60%	86.60%

Where in the virgin shell test, the highest value was obtained where 93.3% was for linear kernels while 100% was for RBF kernels. In the sand shells, the values obtained were 90% for the linear kernel and 93.3% for the RBF kernel. Whereas for the feather shells, the value was 86.6% in the linear kernel or the RBF kernel.

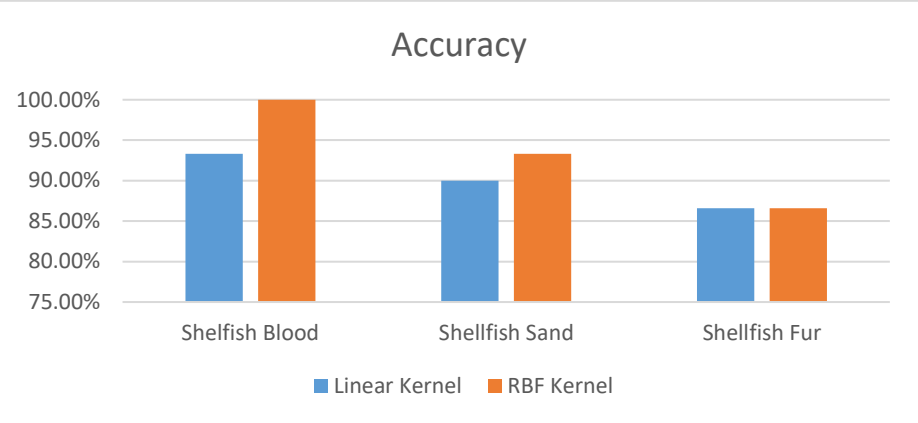

Figure 8. Accuracy of Shellfish Image Testing.

4. CONCLUSION

The results of the LBP (Local Binary Pattern) method are used to extract texture characteristics on the image of the shells obtained from the texture of the shells of the shells. The accuracy of classification obtained by using the SVM method gets a value that based on the results of the tests that have been carried out, the shellfish recognition system using LBP feature extraction has worked well on the use of C = 1 and gamma = 0.1 where the accuracy value for testing and training data gives 100% results and the accuracy value on testing test data is 93, 3%. Meanwhile, the highest accuracy value occurs in virgin shells with RBF kernels. While the lowest accuracy is on testing the feather shell image where the accuracy value is 86.6% this result can show that the LBP method is quite reliable in calculating the accuracy for the classification process of shellfish types.

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Agen Otonom Untuk Ketepatan Penembakan Pada Game Roket Berbasis Ant Colony Optimization

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Abstrak

Ant Colony Optimization (ACO) berbasis klasifikasi diterapkan pada game Rocket Tank untuk membantu karakter rocket dalam menembak target (tower) secara tepat. Pada paper ini, rocket berfungsi sebagai sarang semut dan tower sebagai sumber makanan. Agen semut dijalankan secara acak dan berjalan menemukan sumber makanan. Sumber makanan yang ditemukan didefinsikan sebagai target yang harus ditembak, dasar dari penentuan sumber makanan adalah jumlah bobot feromon yang terkumpul tanpa nilai jarak. Implementasi yang dilakukan pada paper ini adalah membandingkan penerapan ACO berbasis klasifikasi dalam melibatkan bobot feromon pada sumber makanan dengan ACO state-of-the art dengan hasil pada 100 kali iterasi adalah ACO berbasis klasifikasi mampu menembak secara tepat pada sasaran dibandingkan dengan ACO state-of-the art dengan peningkatan jumlah tembakan yang lebih banyak pada ACO berbasis klasifikasi dibandingkan ACO state-of-the art.

Kata Kunci: ant colony optimization, game, simulasi game, agen otomatis

Abstract

Classification-based Ant Colony Optimization (ACO) is applied to the Rocket Tank game to help rocket characters shoot targets (towers) accurately. In this paper, rockets function as ant nests and towers as a food source. The ant agent is run randomly and runs to find a food source. The food source found is defined as the target that must be shot, the basis for determining the source of food is the amount of pheromone weight collected regardless of distance value. The implementation carried out in this paper is to compare the application of classification-based ACO in involving pheromone weights at food sources with state-of-the-art ACO with the result that 100 iterations are classification-based ACOs being able to shoot precisely at the target compared to state-of-the-art ACO. the art with an increased number of shots fired on a classification-based ACO than a state-of-the art ACO.

Keywords*: ant colony optimization, game, game simulation, auto agent*

1. PENDAHULUAN

Game menjadi salah satu tren yang tinggi penelitian pada era ini. Pemanfaatan *game* tidak hanya untuk tujuan permainan semata, namun juga sebagai pemodelan, media bantu atau media pembelajaran, dan juga sebagai media untuk simulasi suatu kondisi. Realisasi dari pengembangan supaya lebih implementatif biasanya menerapkan kecerdasan buatan sebagai komponen internal game tersebut. Salah satu penerapan kecerdasan buatan di dalam game adalah metode *ant colony optimization* (ACO) dengan beberapa penerapan seperti *denoising*[1], sistem interaktif[2],

optimalisasi daratan pada sistem GIS[3]. Penerapan metode ini juga diterapkan di dalam game seperti tetris[4].

Penggunaan teknologi AI dan pembelajaran mesin dalam *game* semakin banyak digunakan, namun untuk game yang serius seperti game yang bergantung pada kemampuan *player* dalam pengembangan NPC cerdas seperti pada penelitian darmawan dkk [5] yang menitikberatkan pada pengembangan NPC cerdas yang dapat beradaptasi dengan gaya pemain dalam bermain game dimana NPC bisa berevolusi dengan perilaku adaptif seperti mengubah kecepatan dan tingkat kesehatan dengan melihat perilaku pemain. Namun, penggunaan yang menambah kekuatan teknologi AI dengan intuisi manusia dan kognisi manusia misalkan untuk memecahkan permasalahan yang kompleks misalkan masalah optimasi untuk mencari jalur yang terinspirasi koloni semut seperti penggunaan algoritma *Ant Colony Optimization* seperti pada *Improved modeling of intelligent tutoring systems using ant colony optimization*[6] dimana menggunakan perilaku semut dalam koloni semut buatan untuk menyelesaikan masalah pengoptimalan diskrit contohnya untuk pembelajaran *adaptive tutoring systems* menggunakan ACO. Penelitian ACO pada game lainnya misalkan pada penelitian Romero dan Ventura dkk yang menggunakan *artificial inteligent* dalam pencarian jalan misalkan untuk mengontrol NPC dalam menemukan jalur yang optimal melalui elemen *game*, pembelajaran *player* dan penilaian[7]. Namun penelitian lainnya, yang khusus menggunakan *ant colony optimization* dalam permainan game diantaranya michael d. kickmeier-Rust dkk dimana penggunaan algoritma ACO dipakai untuk mendukung adaptasi dalam *game* yang serius (kompleks)[8], penelitian G.Recio dkk[9] melakukan pengembangan kecerdasan swarm dengan pengoptimalkan *ant-colony-based framework* pada *video game* dimana kerangka kerja game diadaptasi untuk memungkinkan penerapan agen cerdas misalkan dalam permainan *Pac-Man*. Contoh penggunaan *Ant Colony Optimization* di game yang diaplikasikan untuk pencarian jarak pada games dapat ditemukan pada penelitian [10] dan [11].

Paper ini menjelaskan penerapan ACO pada game rocket tank, hal yang menjadi khas pada paper ini adalah penerapan metode ACO berbasis klasifikasi yang berbeda model dengan ACO *state-of-the art*. Fokus ACO berbasis klasifikasi adalah pada sumber makanan selain bobot perjalanan[1], hal ini berbeda dengan ACO *state-of-the-art* dimana ACO *state-of-the art* hanya berfokus pada bobot jalur perjalanan semut semata. Secara singkat, ACO berbasis klasifikasi menempatkan sumber makanan lebih dari satu lokasi dalam satu bidang sehingga setiap sumber makanan memiliki bobot feromon yang saling berbeda. Paper ini adalah catatan dari kegiatan penelitian dasar dari kegiatan pengembangan simulasi sistem geolokasi berbasis kecerdasan buatan. Pemilihan *game rocket* tank didasarkan pada kecocokan jenis data yang dipakai pada pengembangan sistem yang dikembangkan, pada paper ini seluruh karakter yaitu *tank* (penembak) dan *tower* (target) akan saling melakukan penyerangan secara otomatis tanpa control dari manusia.

2. METODOLOGI

Objek yang menjadi penerapan pada penelitian ini adalah *Game Rocket Tank* (Gambar 1). *Game Rocket tank* ini memiliki 1 pemain yang berupa objek *Tank. Tank* tersebut membawa roket di dalamnya. Pemain tersebut dapat bergerak ke segala arah (kanan kiri depan dan belakang). Selain itu terdapat juga beberapa objek yang menjadi target dalam permainan ini, ketika pemain menembakkan roket, maka objek yang menjadi target tersebut akan hilang ketika ditembak. Namun ketika pemain tidak menembakkan roket sama sekali, maka pemain tersebut akan hancur ditembak oleh objek yang menjadi target tersebut.

Gambar 1. Game Rocket Tank terdiri dari penembak (roket) dan sasaran (tower) yang saling menyerang

Skenario penelitian adalah penembakan otomatis oleh roket ke target yang dituju secara acak tujuan yang hendak ditembak. Supaya target yang disasar berhasil ditembak oleh roket, ACO diterapkan sebagai fitur pembantu roket untuk menentukan posisi target yang ditembak dan target yang menjadi sasaran pada saat itu. Sebagai ilustrasi, posisi roket dianalogikan sebagai sarang semut dan target yang dituju dianalogikan sebagai sumber makanan. Bobot paling optimal akan menjadi jarak sesuai untuk tembakan ke target.

Pada paper ini, ACO berbasis klasifikasi diterapkan pada *game Rocket Tank*. ACO berbasis klasifikasi merupakan metode ACO dengan pendekatan yang berbeda dengan ACO *state-of-the-art*, perbedaan ini terletak pada penilaian bobot tidak hanya terletak pada jalur yang dilewati semut, namun juga berfokus pada jumlah semut yang berada di lokasi sumber makanan. Untuk setiap iterasi nth, seekor agen semut berpindah dari satu *node* (koordinat sumbu x sebagai m dan y sebagai l matriks) ke *node* lain (koordinat sumbu y sebagai i dan z sebagai j matriks) secara acak.

$$p_{(l,m),(i,j)}^{(n)} = \frac{(\tau_{i,j}^{(n-1)})^{\alpha}(\varphi_{i,j})^{\beta}}{\sum_{i,j\in\Omega_{(l,m)}}(\tau_{i,j}^{(n-1)})^{\alpha}(\varphi_{i,j})^{\beta}} \quad (1)$$

$\tau_{i,j}^{(n-1)}$ adalah nilai feromon yang tersebar di setiap node, $\Omega_{(l,m)}$ merupakan node tetangga dari *node* (l,m), α dan β didefinsikan sebagai pengaruh dari matriks feromon dan matriks *heuristic*. *Update* feromon terdiri dari dua kondisi, yaitu: (a) *update* yang terjadi setelah semua agen semut bergerak

$$\tau_{i,j}^{(n-1)} = \begin{cases} (1-p).\tau_{i,j}^{(n-1)} + p.\Delta_{i,j}^{(k)} \\ \tau_{i,j}^{(n-1)} \end{cases} \quad (2)$$

Kriteria pertama ini adalah kondisi ketika seekor semut kth mengunjungi *(i,j)*, $\Delta_{i,j}^{(k)}$ ditentukan oleh matrik heuristik; dan (b) *update* yang terjadi setelah semua agen semut melakukan perpindahan

$$\tau^{(n)} = (1 - \psi) . \tau^{(n-1)} + \psi . \tau^{(0)} \quad (3)$$

ψ adalah koefisien feromon yang menyimpang. Klasifikasi pada peneltiian ini menggunakan *k-means* dengan K = 2.

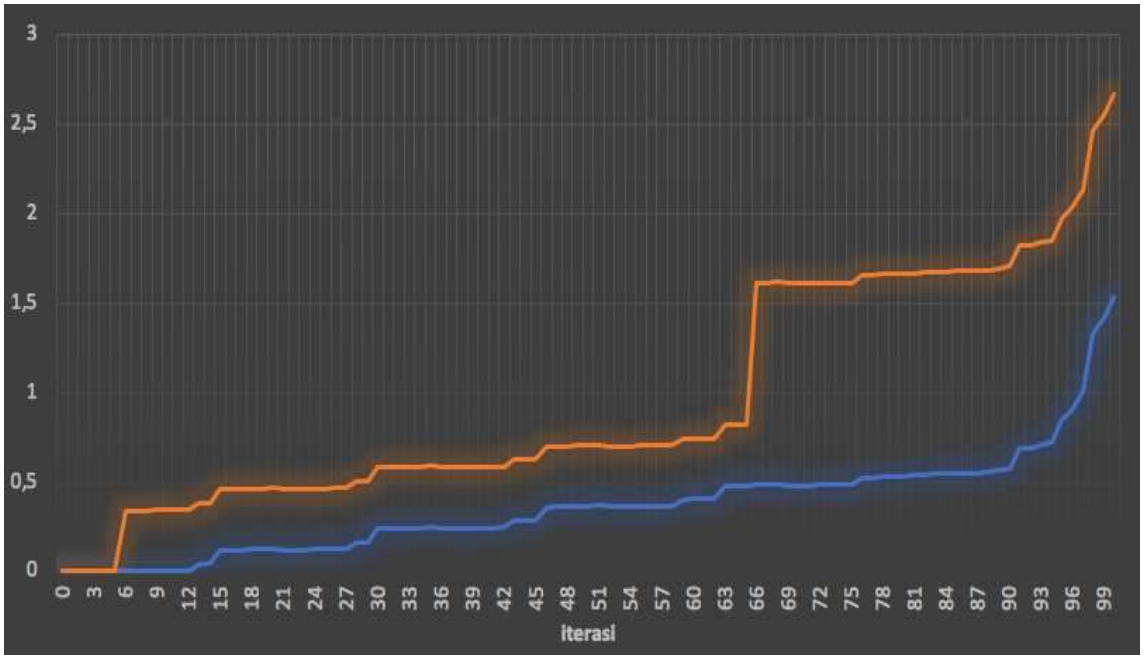
3. HASIL DAN PEMBAHASAN

Pada kegiatan ini, jumlah agen semut yang digunakan sejumlah 100 agen. Faktor feromon diatur sebesar $\propto = 1{,}5$. Secara umum, setiap target berhasil terdeteksi atau dengan kata lain agen-agen semut telah menemukan sumber-sumber makan (*tower* sebagai target) (Gambar 2). Gambar 3 menunjukkan serangan roket ke arah target sebagai hasil lokasi sumber makanan semut yang telah terdeteksi, serangan roket ternyata tidak selalu mengarah pada tower (sumber makanan) terdekat, beberapa percobaan menunjukkan tower secara acak terpilih untuk ditembak pertama kali sehingga dapat dijelaskan bahwa bobot sumber makanan yang diketahui pertama kali menajdi target serangan pertama.

Gambar 2. Sasaran yang terdeteksi

Gambar 3. Tembakan roket dari tank menuju target

Berdasarkan Gambar 4, penerapan *ACO state-of-the-art* dibandingkan dengan penerapan ACO berbasis klasifikasi, hasil dari penerapan ini menunjukkan bahwa dalam 100 iterasi, sebanyak 70 target berhasil tertembak dari penerapan *ACO state-of-the-art* dan 80 target berhasil tertembak dari penerapan ACO berbasis klasifikasi.



Gambar 4. Rata-rata dari akumulasi jumlah peluru roket yang jatuh ke posisi target dalam setiap iterasi (n x 10)

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4. KESIMPULAN

Penerapan ACO berbasis klasifikasi pada *game Rokcet Tank* memberikan hasil penembakan target yang lebih unggul dibandingkan penerapan ACO *state-of-the-art* melalui jumlah tembakan yang tepat sasaran ke lokasi target. Jumlah target juga berhasil terdeteksi melalui penerapan ACO berbasis klasifikasi ini. Berdasarkan kondisi ini, ACO berbasis klasifikasi mampu mendapatkan sumber makanan yang lebih tepat dibandingkan dengan ACO *state-of-the-art*. Namun, penerapan metode ini masih terbatas pada gerak *tank* yang masih diam sehingga perlu pengembangan teknis khusus untuk gerak dinamis pada tank. Selain itu, juga perlu pengembangan untuk penentuan target yang ditembak pertama kali dan berurutan target berikutnya.

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$$F = \sum_{i=1}^{n} \left(\frac{p_{CO_2}^{\text{data}} - p_{CO_2}^{\text{pers.}}}{p_{CO_2}^{\text{data}}} \right)^2 \qquad (1)$$

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This section describes the experimental design, tools, data collection methods, and types of controls. If research is carried out in nature, the author describes the research area, location, and also explains the work done. The general rule to keep in mind is that this section should be detailed and clear so that the reader has the basic knowledge and techniques to develop.

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Hasil dan pembahasan berisi data yang disajikan dengan tabel-tabel dan/atau gambar-gambar serta analisis pembahasannya.

Tabel dan gambar diberi nomor urut dan diberi judul. Contoh penyajian tabel dan gambar adalah sebagai berikut:

Tabel 1. (10 pt, *bold*) Contoh Penyajian Tabel (10 pt, awal kata dengan huruf besar kecuali kata sambung).

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1	Laju alir volumetrik arus-1, f_1 (cm^3/detik)	106
2	Laju alir volumetrik arus -2, f_2 (cm^3/detik)	71

3	Laju alir volumetrik arus -3, f_3 (cm^3/detik)	177
4	Konsentrasi arus-1, c_1 (gr/cm^3)	0

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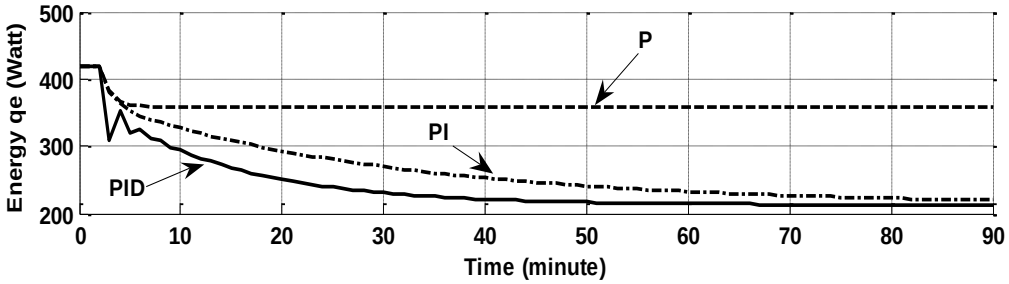
Gambar yang disajikan berwarna hitam-putih dengan kualitas gambar yang baik dan jelas. Jika terdapat lebih dari 1 gambar dalam satu judul, maka tiap-tiap gambar diberi kode (a), (b), (c), dst, dan keterangan tiap-tiap gambar dapat disajikan bersama judul gambar. Ukuran huruf untuk judul gambar 10 pt, nomor gambar *bold*, dan awal judul gambar berhuruf besar. Keterangan gambar dapat disajikan bersama judul gambar.



Gambar 1. Respons *loop* tertutup terhadap perubahan suhu arus-1 T_1 Energi pemanas listrik

The results of the research and discussion begin by presenting concise data with reviews use narrative text, tables, picture. Remember only the result is presented, there is no data interpretation or conclusion from the data in this section. Data collected in tables / images must be completed with narrative text and presented in an easy-to-understand form.

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