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Information system interoperability maturity model

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ABSTRACT

Management of higher education (HE) cannot run if not yet have technological resources that can meet the needs of the campus community and stakeholders. The focus of this research was to look beyond the use of information systems (IS) of universities in Kopertis III Jakarta on the maturity level of data interoperability, software, communication, and physical IS. Using the Information System Interoperability Maturity Model (ISIMM), this study resulted in an average level of university located at level 3 (Collaborative) indicating the relationship between data was wider to facilitate IS, logical data model was shared and used in the data exchange process and no separation or the data sharing impacts on the easy exchange of information. The optimization of IS interoperability attributes (ease of access), develops ISIMM-based roadmap IS (planning), determines the main problem solving target (improvement), and improves the quality of IS based on importance level were some suggestions that university managers can make in order to advance IS.

1. Introduction

The development of information systems (IS) in the current era of globalization is the result of a digital revolution that changes people and organizations viewpoint within their lives and business sustainability towards information and communication technology (ICT). The digital revolution was provoked by numerous high-tech inventions in the '80s that signified as the beginning of the information age. A variety of digital forms of knowledge change everything, from habits to the mindset of people who are increasingly creative and then the knowledge is passed down, disseminated, and managed from generation to generation.

In terms of consumer expectations, cost reduction, sustainability, IS integration, and transparency is among the fourteen global supply chain system megatrend [1]. Those megatrends should always be taken into account by Higher Education (Universities) if they want to survive and obtain added value in the current information knowledge era since all knowledge can be easily obtained from both reliable and responsible sources even anonymously. The use of ICT in Higher Education has grown rapidly. It is not limited to creating and sending e-mails, but also as a means of sharing knowledge that has the aim of increasing the competitiveness of Higher Education [2]–[8].

College is an education institution which provides and organizes higher education. Meanwhile, Private College or University is a higher education institution which its organization is administered privately in the form of a legal institution which based on non-profit principle. Private College or University is commonly administered by foundations, associations, and other forms in accordance with the provisions of the legislation. Law Number 12 of 2012 Article 59 distinguishes higher education in six forms, namely universities, institutes, colleges, polytechnics, academies, and community academies. The University is a higher education that organizes academic education and

can administer vocational education at least 10% in various clusters of science and / or technology. University commonly can administer at least ten study programs and the number of permanent lecturers is at least 6 (six) people (Ministry of Research, Technology and Higher Education Decree Number: 2 / M / SE / lX / 20l6).

In higher education operations, the government requires the development of an integrated ICT-based service system as the main database which is expected to be integrated with the Higher Education Data Base (*PD Dikti*). It aims at providing data recording of *Tridharma* (Three Pillars of Higher Education comprising Education, Research and Community Service) activities and students in higher education. Furthermore, the data is available as a reference of decision making and accreditation (evaluation) (Ministry of Research, Technology and Higher Education Regulation Number 61 of 2016). Higher education which was registered at Higher Education Data Base up to January 2017 were 4,542 consisting of 415 State-owned Higher Education and 4,120 Private Higher Education or 90.71% Higher Education is privately administered. The percentage of Private Higher Education in Kopertis Region III is 7.33% of the total universities in Indonesia or 8.08% of all private universities in Indonesia.

Kopertis III Jakarta working area can be a picture of private universities with the highest number of Higher Education Institution Accreditation (AIPT) of Higher Education National Accreditation Agency (BAN-PT) amounted to 25 universities. Universities that already have 6 accredited achievements A, B accredited number 16, accredited C number 3 and not accredited or in the accreditation process totaling 32, meaning more than 50% of private universities have not been accredited by BAN-PT until January 2017.

The accreditation process of higher education refers to the Directorate General of Higher Education Data Base as the main database, thus all PTs should have an integrated database. There are many forms of integrated ICT-based service systems that can support Directorate General of Higher Education Data Base developed by the academic affair of the university. For instance, an academic information system which is developed by the university. Although each university has a different version of the academic information system, essentially the system is similar. It is connected through the internet, intranet, and extranet which serves as databases to track and record students' academic and administrative development and lecturers' activities. However, its interoperability has not yet tested.

The benefit of information system in the academic affairs of the university is to organize administrative issue during freshmen enrollment, academic data management, courses management, human resources management, and any executive decision-making process which can be conducted effectively and optimally [9]. Unfortunately, students only use information system provided to check for the grade, course schedule, and announcement however learning in an information system is way better [10]. In fact, the information system does not maximally organize which most databases of higher education do not satisfy high interoperability and do not align with the Higher Education Database. The information provided is not real-time data and users of the information system do not acquire recent information.

The formulation of the problems that arise in the management of the information system can be measured by evaluating the academic and non-academic information system of each university which is connected to the intranet, extranet, and internet networks. Model of information system interoperability maturity level (Information System Interoperability Maturity Model = ISIMM) is developed by Staden in which the ISIMM technical attributes have been tested on seven non-profit government organizations in Namibia, hence they can be used as a reference for organizational sustainability in optimization end-to-end non-profit organizations such as universities [11].

ISIMM provides a model to measure the level of information system interoperability maturity for cases such as: (1) Interoperability maturity and compliance with an information system in certain environmental conditions such as non-profit organizations; and (2) information interoperability and compliance maturity in pairs, groups, or clusters. The achievement of integrated ISIMM with Knowledge Management Maturity Model (KMMM) is the key to the progress of an organization's information exchange [11], therefore it is useful as an evaluation tool for leaders, technicians, and stakeholders to develop IS which has high interoperability. ISIMM defines the level of sophistication of interoperability that will be achieved by information system organizations. It focuses more on the technical aspects of interoperability in which the details allow the distribution of data designation in

an information system environment. Hence it can provide practical means to assess technical interoperability between information system pairs, groups, or clusters. In addition, it becomes a model for measuring the level of maturity or level of information system interoperability compliance which can be seen in Figure 1.

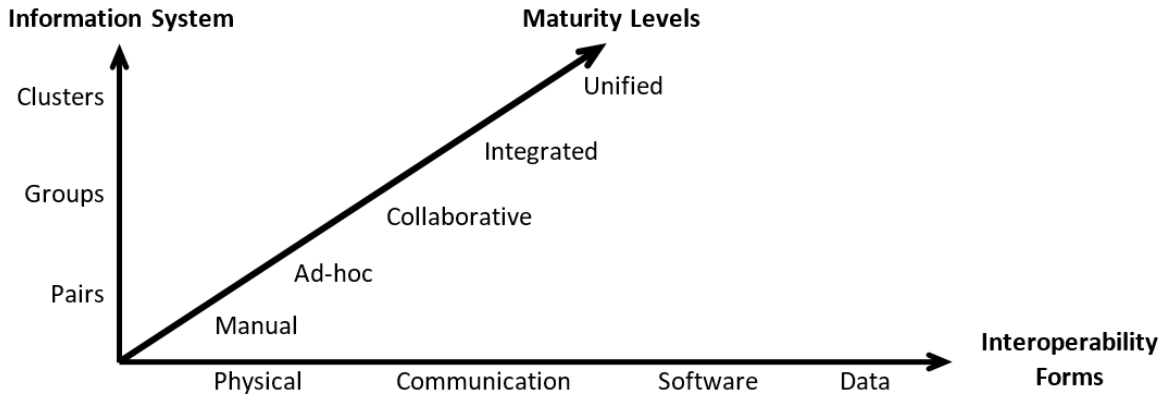

Fig. 1. Interoperability maturity level of information system.

- Level 1 - Manual, No connection among information system. Data sharing remains conventional such as flash disk, CD. Zip, Drive, and etc.
- Level 2 - Ad-Hoc, Data sharing is done by using simple electronic means and data sharing between the units or organization is not standardized. Application and database are separated and are not shared between the unit or organization.
- Level 3 - Collaborative, The relationship between data is broader to facilitate information system. Basic level collaboration takes place through program distribution between independent applications. Logical data models are divided and used in the process of data exchange which has a common function in exchanging minimal data assignments then applications and databases are separated but the data is not shared.
- Level 4 - Integrated, Data sharing is arranged for multiple databases and exchanged between applications independently using domain-based sharing models. Collaboration used is already at a sophisticated level and service integration systems can already be implemented between organizations or units.
- Level 5 - Unified, Data and applications can be distributed between organizations or units without obstacle. Collaboration at the organizational level can operate continuously through the logic server system. Data has command interpretations and is based on models commonly used in sophisticated (systematic) exchange modes. The full back office system becomes a unified system. In the data processing up to confirmation is done automatically with a high level of security [11].

The definition of interoperability according to the Indonesian Dictionary (KBBI) is the ability of various types of computers, applications, operating systems, and networks to exchange information in a useful and meaningful way. The definition of interoperability is specifically related to the performance of an information system. An information system is the capacity of a product or system whose interface is fully expressed to interact and function with other products or systems, now or in the future, without restrictions on access or implementation [12].

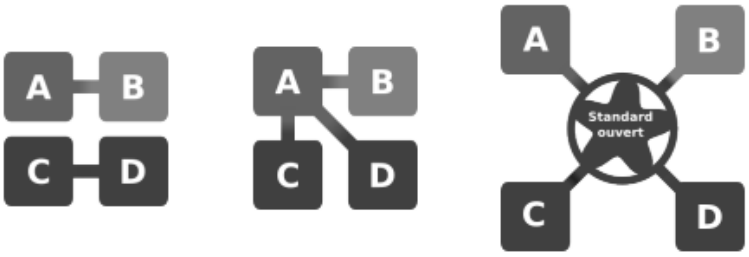

Fig. 2. Interoperability degree.

Standardization of protocol and system interoperability technology are the key to openness. In the context of business, education, or other high-level networks in higher education, the principles of openness and standardization are implemented with attitudes and gestures that indicate openness so that agreement on cooperation protocols and guarantees of implementation in the field can be facilitated centrally [13]. There are three stages in the formation of value creation network in academic sphere namely, facist, logical, and social.

Table 1. The Formation of Value Creation Network Stages

Aspect	Stage 1	Stage 2	Stage 3
	Facist	***Logical***	***Social***
Compliance	Network interconnection infrastructure and electronic content development	Content management and interoperability between content processing applications	Value creation process based on social interaction
Requirement	The local fascist network is ready: The material or substance that will be digitized is available	Content management applications already exist; Mastery of cross-application interoperability technology	The creation process at the local level has been running; Motivational similarities ; and the economies of scale need for the values generated by the network has been fulfilled

2. Method

This study took five universities in Kopertis III Jakarta and started from February to June 2017. The data processing was ended in August 2017. It employed descriptive design with a case study approach in private universities which focus on ISIMM level. It employed observation method on the official page of universities, Higher Education Database, National Accreditation Agency for Higher Education, and Kopertis III Jakarta. Next, an in-depth interview and close-ended questionnaire to the university's board of director, person in charge, and information system builder was conducted. From the identification, it obtained data that can classify problems encountered by the university which is worth evaluating. The snowball method was applied to respondents who completed ISIM instrument questionnaires, this method was used the limited insight of the researcher regarding the builder or person in charge of ICT or the developer of information system in each university. Therefore, by asking directly to the boards of the director is expected to deliver an appropriate recommendation to ICT and information system developer of the university.

ISIMM was used to measure the level of mastery of a university's information system in developing an ICT-based information system. The four layers of interoperability developed by Staden, became the main reference, namely data conditions, software, communication systems, and physical devices used [11]. It measured the level of interoperability in pairs, groups, and clusters. Thus, the university's information system can be classified in the levels of maturity explained above i.e. manual, ad-hoc, collaborative, integrated, or unified.

ISIMM analysis technique produces an integrated one information system with another information system, in this case is information system of Higher Education Database with private university information system, then the information system is used pairs, groups, or clusters that indicate the level or degree of maturity. The level of capacity can be distinguished according to the information system work field such as data, software, communication, and physical conditions which

can explain that the higher interoperability of information system, the less human intervention in the system. The range values for each maturity level are shown in the upper part of Table 2 (for example 1-4, 5-7, 8-10, 11-13, 14>) then the overall compliance rating is shown below the expected range value at the respective compliance level layers of interoperability (i.e., D, S, C, and P) are defined from Table 3. The functional compatibility of basic interoperability required for each attribute of each layer of interoperability is shown in Table 2 with "E" = Expected, " A "= Exceeds target (above), and" B "= Not according to target (below).

Table 2. ISIMM Matrix and Functional Compatibility

Code	Interoperability Layers and Attributes	Level of Interoperability				
		Manual	***Ad-hoc***	***Collaborative***	***Integrated***	***Unified***
		(1–4)	*(5–7)*	*(8–10)*	*(11–13)*	*(14>)*
		(2)	*(6)*	*(9)*	*(12)*	*(15)*
D	Data Interoperability	1	2	4	5	5
1	Common data presentation format	E	E	E	E	E
2	Share meta-Content			E	E	E
3	Common Data Model			E	E	E
4	Data Security		E	E	E	E
5	Shared data				E	E
S	Software Interoperability	1	2	3	5	8
6	N-Tier Common Interoperability				E	E
7	Data Exchange Services	E	E	E	E	E
8	Directory Services					E
9	Common Naming Services					E
10	Discovery Services			E	E	E
11	Common Workflow Services					E
12	Security Management Services		E	E	E	E
13	Share Application				E	E
C	Communication Interoperability	0	1	1	1	1
14	Common Communication Protocols		E	E	E	E
P	Physical Interoperability	0	1	1	1	1
15	Share Communication Network		E	E	E	E

Table 3. ISIMM Grading Matrix Example

Code	Interoperability Layers and Attributes	Interoperability Capability
D	Data Interoperability	2
1	Common data presentation format	√
2	Share meta-Content (Data about data contents)	-
3	Common Data Model	-
4	Data Security: Ownership, Rights, and Auditing	√
5	Shared data	-
S	Software Interoperability	4
6	N-Tier Common Interoperability Architecture	√
7	Data Exchange Services	√
8	Directory Services	-
9	Common Naming Services	-
10	Discovery Services	√
11	Common Workflow Services	-
12	Security Management Services	√
13	Share Application	-
C	Communication Interoperability	1
14	Common Communication Protocols	√
P	Physical Interoperability	1
15	Share Communication Network	√
	Total Rating	8

√ = done

– = not yet

The stages of ISIMM analysis techniques were determining the target level of private university information system interoperability in short-term, medium-term, and long-term. The second step was to use data in Table 3 as recent grading instrument for pairs, groups, and clusters which in the end it completed Table 2 for each technical mastery. After determining recent condition and defining the desired circumstance, roadmap to achieve goal settled in the first step was developed.

3. Result and Discussion

Information system achievement on the maturity level of interoperability is the achievement of MP within the organization [11]. Therefore, MP management advancement within an organization is reflected in the maturity level of the information system interoperability. The information system in the five universities studied is sufficient, however it was found that there is a minor obstacle when accessing A1, A2, and A4 university information system. Furthermore, information and knowledge obtained from digital libraries, repositories, academic information systems, e-learning services, evaluation of teaching and learning processes, research and students' creativity project (PKM), and Higher Education Database are beneficial to improve services at the university since it is in accordance with the standards and results expected from the information system service except for e-learning services at A2 University.

In terms of ease of access, the boards of director assumed that it was still difficult to access the MP or information system portal of the university, especially the Universities A1, A2 and A4. University entities should log in to different information system since the account is not integrated into one system. In terms of benefits and expectations, information system services have a high level of benefits and meet the expectations of users. There4fore, the information obtained is in accordance with the expectation of obtaining the information. Only at the University A2 e-learning service that is still not in line with expectations due to difficult access or due to technical problems are shown at Table 4.

Table 4. University MP Facility Condition

No	MP Condition towards IS	A1	A2	A3	A4	A5
1	Adequate IS Facility	√	√	√	√	√
2	Accessbility	-	-	√	-	√
3	Information and knowledge obtained from the following applications are useful for improving services at universities					
	a. Digital Library	√	√	√	√	√
	b. Repository	√	√	√	√	√
	c. Academic Information System	√	√	√	√	√
	d. E-learning	√	√	√	√	√
	e. Learning Teaching Evaluation Process	√	√	√	√	√
	f. Research and Students' Creativity Project Database	√	√	√	√	√
	g. Higher Education Database	√	√	√	√	√
4	a. The information and knowledge generated by the following application is as expected					
	b. Digital Library	√	√	√	√	√
	c. Repository	√	√	√	√	√
	d. Academic Information System	√	√	√	√	√
	e. E-learning	√	-	√	√	√
	f. Learning Teaching Evaluation Process	√	√	√	√	√
	g. Research and Students' Creativity Project Database	√	√	√	√	√
	h. Higher Education Database	√	√	√	√	√
Mean Percentage		93,75%	87,5%	100%	93,75%	100%

√ = done

– = not yet

The university information system which focuses on managing ICT-based *Tridharma* (Three Pillars of Higher Education comprising Education, Research and Community Service) as its facilities can be seen in the IS collaboration matrix. IS collaboration matrix is pairing each IS digital library, repository, academic information system, e-learning service, evaluation of teaching and learning process, research and students' creativity project database, and Higher Education Database using ISIM attributes so that each IS collaboration can be mapped as in Table 5.

Table 5. Collaboration Matrix of University IS

Information System	IS-1	IS-2	IS-3	IS-4	IS-5	IS-6
University A1						
IS-1						
IS-2	√					
IS-3	–	–				
IS-4	√	–	–			
IS-5	√	√	–	√		
IS-6	–	–	–	–	√	
University A2						
IS-1						
IS-2	√					
IS-3	–	–				
IS-4	√	–	–			
IS-5	√	√	–	√		
IS-6	–	–	√	–	√	
University A3						
IS-1						
IS-2	√					
IS-3	√	√				
IS-4	√	√	√			
IS-5	√	√	–	√		
IS-6	–	–	√	–	√	
University A4						
IS-1						
IS-2	√					
IS-3	–	–				
IS-4	√	√	–			
IS-5	√	√	√	√		
IS-6	–	–	√	–	√	
University A5						
IS-1						
IS-2	√					
IS-3	√	√				
IS-4	√	√	√			
IS-5	√	√	√	√		
IS-6	–	–	√	–	√	

√ = collaborated
– = not collaborated
IS-1 = Digital library
IS-2 = Repository
IS-3 = Academic
IS-4 = E-learning
IS-5 = Research and Students' Creativity Project Database
IS-6 = Higher Education Database

The information system of the digital library, repository, and e-learning service (e-learning, e-book, e-thesis, e-paper, and etc.) which is part of the learning system in the current condition collaborate with research and students' creativity project database so that the IS is connected to each other in each university.

Academic information system means percentage is the lowest internal information system collaboration, as much as 48%. Higher Education Database as an external information system in four universities obtained a similar percentage of 40%, while only A1 University obtained 20%. Research and students' creativity project database in A4 and A5 universities obtained the highest percentage of 88%. It means that the information system highly collaborates. Repositories and e-learning services obtained an average of 60% meaning that two of the five ISs that are paired do not have collaboration with Repositories or e-learning Services shown in Table 6.

Table 6. University IS Collaboration Percentage

University IS	Collaboration Percentage (%)					
	A1	***A2***	***A3***	***A4***	***A5***	***Mean***
Digital Library	60	60	80	60	80	68
Repository	40	40	80	60	80	60
Academic	0	20	80	40	100	48
E-learning	40	40	80	60	80	60
Research and Students' Creativity Project Database	80	80	80	100	100	88
Higher Education Database	20	40	40	40	40	36
University Mean	40	47	73	60	80	60

A5 University information system high collaboration level reaches an average of 80%, showing a high correlation between data and information between ISs, so that the use of the database becomes very massive. Whereas at the A1 University, the level of collaboration is below 50% or only 40%. It is caused by academic IS which is separately running or having its own database. Hence, it is not integrated with other IS and as a result, academic data used by other IS both internal and external are administered manually in data synchronization.

The facilities owned by the entire universities, both academic and non-academic are sufficient. However, in A1, A2, and A3 universities, access to knowledge is obstructed. This is due to the development of a prototype which not all entities have an access to it or several entities have a different level of access. Digital libraries, repositories, and e-learning services which are part of the learning system which currently has collaboration with Research and Students' Creativity Project Database, so that inter ISs in each university are connected. The description of IS university collaboration at the interoperability maturity level IS shows the level of effectiveness of IS services in supporting the initiation, process and implementation as well as the sustainability of university management.

ISIMM's focus on IS interoperability is technically in the following areas: (1) Data Interoperability: showing the different software capabilities of heterogeneous IS to understand the syntactic and semantic meaning of data from different data models through the general use of the model data, data mapping, and data structures; (2) Software Interoperability: refers to different software capabilities used by organizations to work together in exchanging and sharing data by solving differences among them; (3) Communication Interoperability: shows the ability of the system to connect and communicate through public protocols; and (4) Physical Interoperability is the ability of different computers hardware, network devices, and peripherals to work in a connected way [11].

Table 7. University IS interoperability Percentage

Interoperability Layer	Percentage					Mean (%)
	A1	***A2***	***A3***	***A4***	***A5***	
Data	60	100	100	100	100	92
Software	62.5	75	100	75	100	82.5
Communication	100	100	100	100	100	100
Physical	100	100	100	100	100	100
Findings Percentage	80.63	93.75	100	93.75	100	93.63

The interoperability percentages of IS in University A1, A2, A3, A4, and A5, are 80.63%, 93.75%, 100%, 93.75%, and 100%. In Table 8 respectively, indicates that the total interoperability level of IS University A3 and A5 is very good. All systems are connected and already have a database system hence there is no repetition or duplication of data and all academic IS references, *Tridharma*, Repositories, KMS, etc. have only one source. All universities have high IS interoperability in communication interoperability (C) and physical (P) while the constraints on data interoperability (D) are only found in University A1. Then there is an obstacle in software interoperability (S) at University A1, A2, and A4 but overall the level of IS interoperability of the university has been very good, which is above 90%.

Analysis through pairing approach, Table 5 and 6 serve as the basis of examining IS collaboration in each university. The pairing analysis is presented as follows:

- Pairing 1 (P1)= Digital Library and Research and Students' Creativity Project Database
- Pairing 2 (P2)= Repository and Research and Students' Creativity Project Database
- Pairing 3 (P3)= Digital Library and Research and Repository
- Pairing 4 (P4)= Academic and Research and Students' Creativity Project Database
- Pairing 5 (P5)= Higher Education Database and Research and Students' Creativity Project Database
- Pairing 6 (P6)= E-learning and Research and Students' Creativity Project Database
- Pairing 7 (P7)= E-learning and Digital Library
- Pairing 8 (P8)= Higher Education Database and Academic

While the target of IS interoperability in each university is presented in Table 7 and IS pairing analysis is presented in the Table 8. From the results of ISIMM analysis on IS paired universities in Table 6, it can be explained that the average of interoperability on A1 University IS is 6 at 2E of Level 2 (Ad-hoc). It means that the level is low. Data and information sharing use simple electronic means and it is not standardized. In addition, the databases and applications are separated, particularly in P1, P2, P4, and P6. The manual approach is used in P5 and P6 since the internal system is not in accordance with the external system. The data transfer is used manual means such as flash disk. While P3 and P7 are higher at the level of 3: Collaborative.

At University A2, the average grade of IS pairing total rating is 8 at 3B of level 3. It is defined as collaborative below the target. It means that IS pairing at University A2 has an average interoperability which program distribution among application is administered independently. Also, application and database are separated and not divided. It is below the target since C and P obtained 0.8 in which at the level of 1B where P5 and P8 are manually administered. P2 and P7, meanwhile, at the high interoperability or in the level of 4 (integrated). Medium level or level of 3 are P4, P1, P2, and P6.

At University A3, P7, P1, P2, P3, and P4 are at the level of 4 (integrated). It is considered having high interoperability. Then, P6 reached the level of 3 or at the collaborative stage. While P5 and P8 are at the same level as University A1 and A2. Overall, University A3 is at a collaborative level in accordance with the target.

Having almost similar level with University A1, University A4 reaches 7.1 total rating and is at the level of 2 (ad-hoc) which obtained D and S average value higher, 2.8 and 2.9. However, IS interoperability of P7, P3, P4, P1, P2, and P6 are at the level of 3 or collaborative.

At University A5, the total score is 9.6 or at the level of 3 (collaborative) above the target. P3 and P7 are the highest with the score of 13 (level 4A), followed by P1 and P2 with the score of 12 (level 4E), P6 with the score of 11 (level 4B), P4 with the score of 10 (level 3A), and P5 and P8 which are similar to University A1.

Table 8. Maturity Level and Interoperability of University IS

Interoperability Layers	Interoperability Level and Grade								Mean
	P1	***P2***	***P3***	***P4***	***P5***	***P6***	***P7***	***P8***	
University A1									
Data	2A 2	2A 2	3E 3	2E 1	1E 2	2E 2	3E 3	1E 2	2E 2.1
Software	3E 3	3E 3	3A 4	3E 3	1B 0	2E 3	2B 3	1B 0	2E 2.4
Communication	2E 1	2E 1	3E 1	2E 1	1B 0	2E 1	3E 1	1B 0	1B 0.8
Physical	2E 1	2E 1	3E 1	2E 1	1B 0	2E 1	3E 1	1B 0	1B 0.8
Total Rating	2A 7	2A 7	3E 9	2E 6	1E 2	2A 7	3B 8	1E 2	2E 6
University A2									
Data	3E 4	3E 4	3E 4	3E 4	2E 2	3E 4	4B 4	2E 2	2A 3.5
Software	3E 3	3E 3	4A 6	4B 4	1B 0	3B 3	4E 5	1B 0	3E 3
Communication	3E 1	3E 1	4E 1	3E 1	1E 0	3E 1	4E 1	1E 0	1B 0.8
Physical	3E 1	3E 1	4E 1	3E 1	1E 0	3E 1	4E 1	1E 0	1B 0.8
Total Rating	3E 9	3E 9	4E 12	3A 10	1E 2	3E 9	4B 11	1E 2	3B 8
University A3									
Data	3E 4	4E 5	3E 4	4E 4	2E 2	2A 3	4E 4	2E 2	2A 3.5
Software	4E 5	4E 5	4A 6	4E 5	1B 0	4E 5	5B 7	1B 0	3A 4.1
Communication	4E 1	4E 1	4E 1	4E 1	1E 0	3E 1	4E 1	1E 0	1B 0.8
Physical	4E 1	4E 1	4E 1	4E 1	1E 0	3E 1	4E 1	1E 0	1B 0.8
Total Rating	4B 11	4E 12	4E 12	4B 11	1E 2	3A 10	4A 13	1E 2	3E 9.1
University A4									
Data	3B 3	3B 3	3B 3	3B 3	2E 2	3B 3	3B 3	2E 2	2A 2.8
Software	3E 3	3E 3	4E 5	3E 4	1E 0	3E 3	4E 5	1E 0	2A 2.9
Communication	3E 1	3E 1	3E 1	3E 1	1E 0	3E 1	3E 1	1E 0	1B 0.8
Physical	3E 1	3E 1	3E 1	3E 1	1E 0	3E 1	3E 1	1E 0	1B 0.8
Total Rating	3B 8	3B 8	3A 10	3E 9	1E 2	3B 8	3A 10	1E 2	2A 7.1
University A5									
Data	4E 5	4E 5	4E 5	2A 3	2E 2	3E 4	3E 4	2E 2	3B 3.8
Software	4E 5	4E 5	4A 6	4E 5	1B 1	4E 5	5B 7	1E 1	4B 4.4
Communication	4E 1	4E 1	4E 1	3E 1	1E 0	3E 1	4E 1	1E 0	1E 0.8
Physical	4E 1	4E 1	4E 1	3E 1	1E 0	3E 1	4E 1	1E 0	1E 0.8
Total Rating	4E 12	4E 12	4A 13	3A 10	1A 3	4B 11	4A 13	1A 3	3A 9.6

Interoperability Maturity Level: Level 1 Manual, Level 2 Ad-hoc, Level 3 Collaborative, Level 4 Integrated, and Level 5 Unified.
Conformity Level in each Maturity: E = Expected, A = Exceeds target (above), and B = does not meet the target (below).

In the ISIMM, individual, pairs, and clusters analysis produce the level of IS interoperability maturity in each university. The average achievement of ISIMM in each university results from the average interoperability value in the ISIMM matrix and the functional suitability of the interoperability layer and it is described in Table 9.

Table 9. The Average of Maturity Level of University IS Interoperability

University	Maturity Level and Interoperability Value of Information System										Mean
	Individual	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*	*Cluster*	
A1	3A	2A	2A	3E	2E	1E	2A	3B	1E	3B	2E
	10	7	7	9	6	2	7	8	2	7	6.5
A2	4A	3E	3E	4E	3A	1E	3E	4B	1E	3E	3E
	13	9	9	12	10	2	9	11	2	8	8.5
A3	5A	4B	4E	4E	4B	1E	3A	4A	1E	4E	3A
	15	11	12	12	11	2	10	13	2	12.1	10.01
A4	4A	3B	3B	3A	3E	1E	3B	3A	1E	3E	3B
	13	8	8	10	9	2	8	10	2	9.3	7.93
A5	5A	4E	4E	4A	3A	1A	4B	4A	1A	5B	3A
	15	12	12	13	10	3	11	13	3	13.9	10.59

- ISIMM Pairing analysis: digital library and research and students' creativity project database (P1), repository and research and students' creativity project database (P2), digital library and repository (P3), academic and students' creativity project database (P4), Higher Education Database and students' creativity project database (P5), E-learning and students' creativity project database (P6), e-learning and digital library (P7), and Higher Education Database and academic (P8).
- Interoperability Maturity Level: Level 1 Manual, Level 2 Ad-hoc, Level 3 Collaborative, Level 4 Integrated, and Level 5 Unified.
- Compatibility level of each maturity level: "E" = Expected, " A "= Exceeds target (above), and" B "= does not meet the target (below).

In general, ISIMM level in pairs and clusters at the university are influenced by the external information system. It is described at a low level of interoperability at the Higher Education Database information system, because it still uses manual methods in data transfer which provides opportunities for input errors and data duplication. Then, at the internal level of university, good cooperation among databases is established, particularly at University A3 and A5. The two universities employ one database for the entire academic and non-academic necessities which require high interoperability. Mapping and determining the ISIM achievement targets of each IS makes it easier to solve interoperability problems that occur between IS. The increasing interoperability of IS in the ISIM attribute of the predetermined target gives an overview of the level of seriousness of the boards of director and academicians in developing IS-based MP.

4. Conclusion

Mapping the level of importance and expectation in the IS interoperability attribute provides an overview of the current university position and helps managers to determine the priority of MP development in the future. Kopertis III Jakarta can develop IS with high interoperability that is connected to the university database, thus it offers easy monitoring, assessment, and providing recommendations related to assistance and consultation on university capacity development.

The limited collaboration of external and internal IS only make the interoperability of all universities reached at the level of 3. Meanwhile, assessment on internal IS indicates that University A3 and A5 are at the level of 5, University A2 and A4 are at the level of 4, and University A1 is at the level of 3. Responding to the challenges of future of information system, it needs the recent, fast, resilient and large capacity to enhance the unified level of interoperability. Future research is expected to be more detailed in investigating ICT-based information system, particularly in the model and roadmap along with its financial arrangement. Thus, it can be explored comprehensively, in addition to being a reference for stakeholders in financing and cooperation planning.

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