Selection Of Microcontroller Type As An Implementation Of ANP (Analytical Network Process)

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***Abstract*— Practicum Material changes followed the development of microcontroller, also facilities and infrastructure that support the implementation of the practicum have to adjust to the latest type of microcontroller. The level of student's comprehension towards the type of microcontroller influenced the academic and curriculum developers to establish practicum material that is suitable to the syllabus. Curriculum developers will make an effective decision process to identify the factors that influence the selection of microcontrollers. These problems are modelled with Analytical Network Process (ANP). And the result is microcotroller type AT89S51/52 is better than the others.**

Keyword : Analytical Network Process, Decision Support System< Microcontroller.

I. INTRODUCTION

The academic and curriculum developers should set a practical matter in accordance with the syllabus. They must follow the development of microcontroller, facilities and infrastructure that support the implementation of the practicum. Needed an effective decision-making process to identify the factors that influence the selection of microcontrollers as well as deaspectine the effects and importance of these factors with each other from the view of decision makers. These problems are modeled by Analitycal Network Process (ANP). The academic developers analyze quantitative to assess the importance of related factors. Validation of weight calculation of each element in each of the nodes in the cluster using the software Super Decisions 1.6.0.

In this study, the method presented is a network model. The decision-making process is deaspectined through a comparison of technical data from each microcontroller and collecting data from student questionnaires as the subject of practicum. The advantages of this research is to apply the ANP method in deaspectining the type of microcontroller and implementation of software research decision-making systems that are useful and easy to use to aid decision making.

II. RESEARCH METHOD

In this study, steps taken on a chart as depicted in Figure 1. Step of this research is the development of decision-making process according to Simon in Turban (2005) by incorporating a step in the ANP as the first three steps.

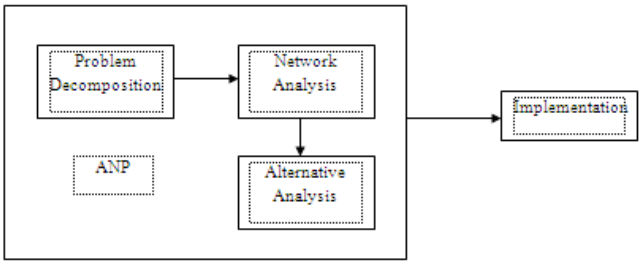

FIGURE 1. STEPS OF RESEARCH

A. Problem Decomposition

Network structure consisting of clusters and nodes. Network structure can be seen in Figure 5. Based on 6 clusters, namely: alternative, technical, programs, economically, users and industry. Clusters and nodes on the ANP method is assumed as follows:

1. Technical aspect

   Technical aspect is the ability of the microcontroller based on the specifications of the hardware (data sheet microcontroller) of each microcontroller type used in this study. Technical perspective include the nodes:

   - Operational Frequency
     The amount of the operational frequency is depend on the type of microcontroller. Frequency of operational functions in the regulation of the data readout speed and the speed of instruction execution. The operational frequency influence the level of power consumption required by the microcontroller.
   - Flash Memory

Flash memory is a type of memory to allocate lots of memory addresses to be erased and written in one programming operation. Flash memory is also used to store basic instructions microcontroller.

- Internal Memory
  Internal memory is RAM (Random Access Memory). RAM is used to store variables or data temporarily.
- Timer/Counter Mode
  Basically, the timer/counter is a set of binary counter which is connected directly to a microcontroller data channel, so the microcontroller can read the counter position, if necessary microcontroller can also change position of the counter.
- Read/Write
  Read/Write is the ability of the microcontroller to read and write commands. It works depends on the size of flash memory.

2. Programming aspect

Programming aspect is the ability of the microcontroller program in aspects programming language and auxiliary programs are used for a specific type of microcontroller. Programming aspects include the nodes as follows:

- Source Code
  Source code is a file contains the source files written by a programmer
- In-System Programming (ISP)
  ISP is a software used to upload programs that have been compiled into the microcontroller.
- Compiler Downloader
  Compiler downloader is a program that is used to change the file "asm" into the file "hex". Source code usually stored in a file with extension "asm". To be uploaded to the ISP into the microcontroller, then the "asm" file must be compiled into a "hex" file.

3. Economical Aspect

Economical aspects is an assessment based on market conditions of microcontroller. Economically subkriteria include the following:

- Market Price
  The market price is the price of IC component in microcontroller electronics stores. The purchase price is a major factor for consumers to purchase a product. If it's cheap and quality, then it will become the primary choice of consumers.
- Product Availability
  Stock of a product, usually affecting consumers in the selection of a product. Number of items will affect the price of the goods. If the amount of goods is a lot then the price will be cheaper, but if the amount of goods is limited then the price will be expensive.
- Product Reliability
  Reliability of products based on technical specifications of a product. There are some consumers who put a high technical specification as a consideration in the purchase of a product. They assumed product with high specification has a high reliability.
- Device Support
  A product that can not operate alone and should require other devices to function, then the supporting devices will also be hunted by the consumer. For the microcontroller, the devices are supporting a series downloader, data cable, jumper cables, and software.

4. User aspect

User aspect is an assessment of microcontrollers based on the ability of the user (in this case students), both in theory and in practice. Aspects of users include the nodes as follows:

- Level of Ease
  Level in aspects of ease of operation of the microcontroller processes both in aspects of software and hardware side.
- Level of Understanding
  Level of understanding in aspects of student ability to understand the theory of microcontrollers types. In addition is also the level of student ability in microcontroller working process.
- Level of Satisfaction
  If a student has understood the theory and practice, and easy to operate certain types of microcontrollers, it will usually always use this type of microcontroller to process further activities such as the final task. This is also meant the level of student satisfaction of a certain type of microcontroller.

5. Industrial Aspect

Aspects of the industrial world is the rating based on microcontroller applications in the industrial world. Industrialized world in aspects of covering the nodes as follows:

- Use
  The use of microcontrollers in the industrial world is meant either the use of certain types of microcontrollers in production processes and in products produced by the industry.
- Reliability

For the industry, the level of reliability is also focused on specifications of the microcontroller product. High technical specifications will increase production efficiency. In addition the use of reliability is measured in aspects of age, both in the production process as well as products generated by the industry.

III. NETWORK ANALYSIS

From the network structure in ANP method can be seen linkages between groups or clusters, or between the elements or nodes in a same group or the other group. A cluster is automatically connected to each other due to the relations among its member nodes. From Figure 2, the network structure can be expressed by the matrix shown in table 1.

Cluster	Alternative	Technical Aspect	Programming Aspect	Economical Aspect	User Aspect	Industrial Aspect
Alternative	0	1	1	1	1	1
Technical Aspect	1	1	0	1	0	0
Programming Aspect	1	0	1	0	0	0
Economical Aspect	0	0	0	0	1	0
User Aspect	0	1	1	0	0	0
Industrial Aspect	0	1	0	0	0	0

Matrix in table 1 shows that the element (node) that does not give effect to the other elements will give a zero value. The next step is to calculate the priorities in each group (cluster) is formed. Accordance with the payoff matrix representation of the network, then the elements or nodes that have a value one has particular value based on the calculation priority of inter-group. The calculation of the comparison of each group (cluster) are :

1. Comparative Analysis of Alternative Interest Cluster

   Pairwised comparison value and the priority weights of each group are connected to the alternative group can be seen in table 2.

TABLE 2. PAIRWISE COMPARISON OF ALTERNATIVE INTEREST CLUSTER

	Technical Aspect	Programming Aspect	Priority
Technical Aspect	1	2	0,666667
Programming Aspect	0,5	1	0,333333

Ratio Consistency = 0

From the analysis of the above, technical aspects is more important than programming aspects and the comparison matrix is consistent.

2. Comparative Analysis of Technical Aspects

   Comparative analysis of technical aspects of interest cluster pairwised comparison value and the priority weights of each group (clusters) connected with the technical aspect of the cluster can be seen in table 3. From the comparative analysis of interest groups in technical aspect of the user is the most important cluster than the other clusters and the comparison matrix is consistent.

TABLE 3. PAIRWISE COMPARISON OF TECHNICAL ASPECTS OF INTEREST CLUSTER

	Alternative	Technique	User	Industry	Priority
Alternative	1	0,2	0,142857	2	0,096309
Technique	5	1	0,333333	3	0,265637
User	7	3	1	5	0,557855
Industry	0,5	0,333333	0,2	1	0,080198

Consistency Ratio = 0,084689

3. Comparative Analysis of Cluster Interest from Programming Aspect

   Pairwised comparison value and the priority weights of each group (clusters) connected with the technical aspect of the cluster can be seen in Table 4.

TABLE 4. PAIRWISE COMPARISON OF CLUSTER INTEREST FROM PROGRAMMING ASPECT

	Alternative	Program	User	Priority
Alternative	1	0,333333	0,142857	0,085324
Program	3	1	0,25	0,213238
User	7	4	1	0,701437

Consistency Ratio = 0,028083

Above analysis shows that cluster of user in aspects is the most important from other clusters and the comparison matrix is consistent.

4. Comparative Analysis of Cluster Interest from Economic Aspects

   Pairwised comparison value and the priority weights of each group (clusters) connected with economically cluster can be seen in Table 5. From the comparative analysis of the cluster interests from economical aspects show that cluster of technical point is the most important from other clusters and the comparison matrix is consistent.

TABLE 5. PAIRWISE COMPARISON OF CLUSTER INTEREST FROM ECONOMICAL ASPECTS.

	Alternative	Technique	Priority
Alternative	1	0,2	0,166667
Technique	5	1	0,833333

Consistency Ratio = 0

5. Comparative Analysis of Cluster Interest from User Aspects

Pairwised comparison value and the priority weights of each group (clusters) connected to the cluster in user aspects can be seen in Table 6.

TABLE 6. PAIRWISE COMPARISONS OF INTEREST SEFI CLUSTER USERS

	Alternative	Ekonomis	Priority
Alternative	1	0,333333	0,25
Ekonomic	3	1	0,75

Consistency Ratio = 0

The above analysis shows the clusters in users aspects is the most important than other clusters and the comparison matrix is consistent. The comparison of clusters result priority value. The values clusters are arranged in a matrix called the cluster matrix as shown in table 7.

TABLE 7. CLUSTER MATRIX

Cluster	Alternative	Technical Aspect	Programming Aspect	Economical Aspect	User Aspect	Industrial Aspect
Alternative	0	0,096309	0,085324	0,1666667	0,25	1
Technical Aspect	0,666667	0,265637	0	0,833333	0	0
Programming Aspect	0,333333	0	0,213238	0	0	0
Economical Aspect	0	0	0	0	0,75	0
User Aspect	0	0,557855	0,701437	0	0	0
Industrial Aspect	0	0,080198	0	0	0	0

The next step is calculation of the weight of inter-element (node) as follows:

- Pairwise Comparison of Node AT89S51/52 in Technical Aspects Value of pairwised comparison and priority weight of nodes of AT89S51/52 in user aspect cluster can be seen in table 8.

TABLE 8. PAIRWISE COMPARISONS OF AT89S51052 IN TECHNICAL ASPECTS CLUSTER

	Flash Memory	Internal Memory	Operational Frequency	Timer/ Counter	Read/Erase	Priority
Flash Memory	1	3	5	9	7	0,490622
Int.Memory	0,333333	1	3	9	7	0,286866
Op.Frequency	0,2	0,333333	1	5	3	0,127656
Timer/Counter	0,111111	0,111111	0,2	1	0,333333	0,032517
Read/Erase	0,142857	0,142857	0,333333	3	1	0,062338

Consistency Ratio = 0,060438

The above comparison shows that the operational frequency has highest priority compared with other nodes.

- Pairwise Comparison of Node AT90S1200, 68HC11, and ATMEGA8535 in technical aspects has same result with cluster node AT89S51/52 with the highest priority is operational frequency.
- Pairwise Comparison of Flash Memory in a Technical Aspects Cluster can be seen in table 9.

TABLE 9. PAIRWISE COMPARISONS OF FLASH MEMORY IN TECHNICAL ASPECTS CLUSTER

	Internal Memory	Operational Frequency	Read/Erase	Timer/Counter	Priority
Int.Memory	1	3	7	5	0,55789
Op.Frequency	0,333333	1	5	3	0,26334
Read/Erase	0,142857	0,2	1	0,333333	0,05689
Tim/Counter	0,2	0,333333	3	1	0,12187

Consistency Ratio = 0,0438

Pairwise comparison of flash memory node in technical aspects cluster is seen that internal memory has highest priority.

- Pairwised comparison of Internal Memory in technical aspects cluster has the same result with comparison of flash memory node in the technical aspects cluster above.
- Pairwised comparison of Operational Frequency in technical aspects cluster. Value of pairwised comparison and priority weight of technical aspects cluster can be seen in Table 10.

TABLE 10. PAIRWISED COMPARISONS OF OPERATIONAL FREQUENCY IN TECHNICAL ASPECTS CLUSTER

	Flash Memory	Internal Memory	Read/Erase	Timer/ Counter	Priority
Flash Memory	1	2	9	7	0,563455
Int.Memory	0,5	1	5	3	0,277643
Read/Erase	0,111111	0,2	1	0,333333	0,05123
Timer/Counter	0,142857	0,333333	3	1	0,107672

Consistency Ratio = 0,26223

Table 10 shows that flash memory has highest priority.

- Pairwised comparison of Read/Write in technical aspects cluster. Value of pairwised comparison and priority weight of Read/Write in technical aspect cluster can be seen in table 11.

TABLE 11. PAIRWISE COMPARISONS OF READ/WRITE IN TECHNICAL ASPECTS CLUSTER

	Flash Memory	Internal Memory	Operational Frequency	Timer/ Counter	Priority
Flash Memory	1	2	5	7	0,520472
Int.Memory	0,5	1	3	5	0,297066
Op.Frequency	0,2	0,333333	1	3	0,124377
Timer/Counter	0,142857	0,2	0,333333	1	0,058084

Consistency Ratio = 0,02575

Table 11 shows that flash memory occupies the highest priority.

- Pairwised comparison of Timer/Counter in technical aspects cluster. Value of pairwised comparison and priority weight of Timer/Counter in technical aspects cluster can be seen in table 12.

TABLE 12. PAIRWISE COMPARISONS OF TIMER/ COUNTER IN TECHNICAL ASPETCS CLUSTER

	Flash Memory	Internal Memory	Operational Frequency	Read/Erase	Priority
Flash Memory	1	2	5	9	0,520015
Int.Memory	0,5	1	3	7	0,302003
Op.Frequency	0,2	0,333333	1	5	0,135572
Read/Erase	0,111111	0,142857	0,2	1	0,04241

Consistency Ratio = 0,044681

Table 12 shows that flash memory has highest priority.

- Pairwise Comparison of Source Code in Programming Aspect Cluster. Value of pairwised comparison and priority weight of source code in programming cluster can be seen in Table 13.

TABLE 13. PAIRWISE COMPARISONS OF SOURCE CODE IN PROGRAMMING ASPECT CLUSTER

	Downloader Compiler	In-System Programming	Priority
Downloader Compiler	1	0,333333	0,25
In-System Prog.	3	1	0,75

Consistency Ratio = 0

Table 13 shows that the In-System Programming has highest priority.

- Pairwise Comparison of In-System Programming in Programming Aspect Cluster. Value of pairwised comparison and priority weight of In-System Programming in programming aspect cluster can be seen in Table 14.

TABLE 14. PAIRWISE COMPARISONS OF IN-SYSTEM PROGRAMMING IN PROGRAMMING ASPECT CLUSTER

	Downloader Compiler	Source Code	Priority
Downloader Compiler	1	5	0,833333
Source Code	0,2	1	0,166667

Consistency Ratio = 0

Table 14 shows that the Source Code Program has highest priority.

- Pairwised Comparisons of Downloader Compiler in Programming Aspect Cluster. Value of pairwised comparison and priority weight of Downloader Compiler can be seen in Table 15.

TABLE 15. PAIRWISE COMPARISONS OF DOWNLOADER COMPILER IN PROGRAMMING ASPECTS

	ISP	Source Code	Priority
ISP	1	0,333333	0,25
Source Code	3	1	0,75

Consistency Ratio = 0

Table 15 shows that Source Code has highest priority.

- Pairwise Comparison in of Nodes in Alternative Aspect Cluster.
  Elements (nodes) connected with alternative have linkages so they have pairwised comparative value. From the calculation, the priorities of these nodes of the alternative can be seen in Table 16.

TABLE 16. NODE PRIORITY OF ALTERNATIVE

Elemen (*node*)	**Alternative-Alternative**				**Consistency Ratio**
	AT89S51/52	**AT90S1200**	**M68HC11**	**ATmega8535**	
Op. Frequency	0,118474	0,248778	0,55016	0,082588	0,03909
Flash Memory	0,208275	0,101044	0,642682	0,048	0,064448
Internal Memory	0,134062	0,053799	0,259473	0,552665	0,067539
Timer/Counter	0,124377	0,297066	0,520472	0,058084	0,02575
Read/Write	0,066493	0,294046	0,520866	0,118595	0,071208
Source Code	0,067962	0,323789	0,456019	0,152231	0,038811
In-System Program	0,116652	0,338899	0,478218	0,066232	0,082596
Downloader Comp.	0,116652	0,338899	0,478218	0,066232	0,082596
Market price	0,515922	0,249334	0,182415	0,052329	0,050184
Product availibility	0,511689	0,078018	0,237814	0,173479	0,038872
Product reliability	0,086711	0,142499	0,472951	0,297839	0,024104
Supporting instrument	0,320471	0,10545	0,403763	0,170316	0,053127
Level of Ease	0,470749	0,072604	0,192359	0,264288	0,051275
Level of Understanding	0,440705	0,074745	0,329181	0,155368	0,054936
Level of Satisfaction	0,435082	0,105633	0,309207	0,150078	0,045272
Utilizing	0,085801	0,129645	0,288701	0,495852	0,021114
Reliability	0,118474	0,082588	0,248778	0,55016	0,03909

- Pairwised Comparison of Flash Memory Node in Users Aspect Cluster.
  Value of pairwised comparison and priority weight of Flash Memory nodes in user aspects cluster can be seen in Table 17.

TABLE 17. PAIRWISE COMPARISONS OF FLASH MEMORY IN A USER ASPECTS CLUSTER

	Easy level	Satisfaction level	Understanding level	Priority
Easy level	1	5	3	0,633346
Satisfaction level	0,2	1	0,333333	0,106156
Understanding level	0,333333	3	1	0,260498

Consistency Ratio = 0,033375

Table 17 shows that Easy level has highest priority.

- Pairwise Comparisons of Internal Memory, Operational Frequency, Read/Write and Timer/Counter, Compiler Downloader, In-System Programming, Source Code in user aspect cluster have the same results with pairwised comparison of Flash Memory in Users Aspect Cluster with Easy level has priority level.
- Pairwise Comparisons of easy level node in Economic Aspects Cluster. Value of pairwised comparison and priority weight of Flash Memory node in users aspect can be seen in Table 18. Comparison of easy level in economically aspect cluster shows that market price has highest priority.

TABLE 18. PAIRWISE COMPARISONS OF EASY LEVEL IN ECONOMIC ASPECTS CLUSTER

	Market price	Product reliability	Product availibility	Supporting instrument	Priotitas
Market price	1	5	2	3	0,472951
Product reliability	0,2	1	0,333333	0,5	0,086711
Product availibility	0,5	3	1	3	0,297839
Supporting instrument	0,333333	2	0,333333	1	0,142499

Consistency Ratio = 0,024104

- Pairwise Comparison of Satisfaction Levels node in the cluster Economic aspect has same result with the level of convenience in aspects of economic clusters.
- Pairwise Comparison of Flash Memory in Industry aspects Cluster Node. Value of pairwised comparison and weighting of priority Flash memory node in the cluster of industry aspects can be seen in Table 19.

TABLE 19. PAIRWISE COMPARISON OF FLASH MEMORY IN INDUSTRY ASPECTS CLUSTER

	Reliability	Utilizing	Priority
Reliability	1	3	0,75
Utilizing	0,3	1	0,25

Consistency Ratio = 0

From the comparison of nodes in the cluster in aspects of Flash Memory Industry shows that reliability has the highest priority.

The next step is by putting some weight in each node into a matrix containing all elements (node) so that formed matrix dimension is huge that is called supermatrix. Premilinary matrix formed is named unweighted supermatrix. The result can be seen in figure 3.

The supermatrix is made so that all elements listed in the column can be added and the result is 1 (one). The result of computation can be seen in figure 4.

Weighted supermatrix is quaded until it yields a matrix that has the same value listed lines by lines. In this case limit supermatrix is resulted from unweighted supermatrix into 16 quad. The result of limit supermatrix can be seen in figure 5.

IV. ALTERNATIVE ANALYSIS

Networking analysis yields limit supermatrix that has the same value listed in the same column. From limit supermatrix line we can get a value that is a value for each node for the networking. Analytical Network Process. For the nodes that are alternative cluster we can get alternatives from Analytical Network Process

I. AT89S51/52 = 0.1049
II. ATMEGA8535 = 0.0620
III. M68HC11 = 0.0530
IV. AT90S1200 = 0.0385

From above alternative priority we can get AT89S51/52 that is the highest priority.

V. CONCLUSION

There are some points that can be drawn from the analysis and discussion in this research, namely:

1. In the ANP method, the component (the name of ANP level) is not arranged orderly but is linked in pairs in accordance with the influence.
2. Decision support system determines microcontroller type that is able to give the best rank from usage criteria that are used to determine microcontroller type. The computation of ANP method resulted microcontroller alternative type AT89S51/51 which takes the highest priority and can be used as a consideration for decision maker in order that it will be used in Practical System of Microprocessor and Microrpocessor.

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