Expert System with Forward Chaining Method to Estimated Cost of Small and Medium Building Development in Indonesia

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ABSTRACT

The most important part before carrying out the housing construction is to make an estimate of the Budget Plan (RAB).The Budget Plan has variations that vary depending on the type of building, land area, class of building, material to be used in the building. With so many variations, it takes a relatively long time to estimate costs to suit your needs. In this case, an information system for estimating the cost of development can be used practically .Therefore this study will discuss how to create an expert system to determine the estimated cost of development. The development of this system will be used by the Expert System approach .This system starts with determining the cost of using an *inference engine* as the center of decision making on the expert system combined with facts on the database with a *knowledge base* to get an answer. The method used as a reasoning process in an inference machine is a *forward chaining* method. The results to be achieved are a system that can facilitate the users *(users)* to get an estimate of the cost of building a house to live quickly, and easily that can be done anytime and anywhere without having to consult in advance with an Architectural Consultant services company.

Keyword: *Expert System, Forward Chaining*, *Estimated Cost, Cost for Building Development*

I. PRELIMINARY

PT. AAK is an Architectural Consultant service company that has experts in the field of building construction. The majority of information needs in the development sector are still in each of the experts in the form of Knowledge's tacit, especially in terms of the calculation and estimation of costs or estimates of development cost planning .One important phase before carrying out building construction is to determine the Budget Plan. The budget plan for costs varies greatly depending on the object of the construction. Besides that, it depends on the size of the land, the class of buildings and the material chosen for the building .Therefore, it takes a relatively long time to make a budget plan in the traditional way.

For keperlual above, the company usually holds meetings with clients with the aim of discussing the estimated costs required in building the building requested by the client. The meeting can occur for days between the company and the client until a cost match occurs. Furthermore, the company will submit an estimate of the cost of building construction (cost estimation) results of the discussion at the above meeting to the client. In this case the client often does not provide information or feedback (feed back) or a statement of approval of the estimated costs offered by the company. Even clients often do not continue the building process without informing the company (PT. KAA). The fact is that the company has spent a lot of time and money to arrive at the point of determining the estimated construction costs Amun there is no certainty of the client if the estimated cost of construction is offered it is consistent or still need further discussion.

From the above events there is the fact that not all clients can approve the estimated development costs offered by the company. So often the client disconnects unilaterally without notice to the company. This is a risk that often occurs and is a reasonable risk for the company. But there needs to be an effort to minimize these risks in order to prevent the possibility of time and costs being wasted.

Referring to the current condition of PT. AA K intends to apply technology in calculating estimated or estimated development costs to facilitate the company estimator in calculating budget estimates and is expected to facilitate clients to check or get an estimate of the cost of development without having to hold a meeting with experts.

From the discussion above, to provide solutions in accordance with current problems requires several ways and efforts .One of the media needed is to build an expert system to determine the estimated development costs offered by PT.AAK with forward chaining approach

II. THEORETICAL BASE

A. Expert system

The expert system or commonly referred to as the knowledge based system is a computer application that is intended to help decision making or problem solving in a specific field. This system works by using knowledge and analytical methods that have been defined in advance by experts in accordance with their respective fields of expertise. This system is called an expert system because its functions and roles are the same as an expert who must have knowledge, experience in solving a problem.

Expert systems are also an artificial intelligence technique that attempts to adopt human knowledge to computers, so that computers can solve problems as is usually done by experts. A good expert system is designed to solve certain problems by imitating the work of experts. With this expert system, a wampun people can solve real problems that can only be solved with the help of experts. For experts, this expert system will also help its activities as a very experienced assistant [1].

B. Estimation

Estimation is the whole process that requires and uses an estimator to produce an estimate of a parameter. (Harinaldi: 2005). The meaning of estimation is a measurement based on quantitative results or in other words, the level of accuracy can be measured by numbers (Tockey: 2004). The definition of estimation according to the Big Indonesian Dictionary is an estimate, judgment, or opinion.

Based on some of the above understanding shows that the estimation term can be used in general to express our estimates, judgments, or opinions about something.

C. Budget Plan.

Cost budget plan is a plan that is compiled to find out about the estimated (estimated) budget costs that must be spent on the work of a building. In calculating the cost budget plan can be done in two ways, namely:

1. **Temporary (rough) budget costs**

How to calculate the cost budget based only on the floor area of the building, class of buildings, number of floors and location of the building is located. This method is commonly used by BAPPENAS in determining the amount of DIPA for the procurement of state-owned buildings.

As a guideline in drafting a rough cost budget, the unit price per square meter (mk2) of floor area is used. Rough budget is used as a guide to the cost budget that is calculated carefully.

Although the name is a rough budget, the unit price of each m2 of floor area is not too different from the price calculated carefully.

2. **Meticulous budget costs**

How to calculate the cost budget by using the work unit price. The unit price of work is obtained based on material prices and work wages which are then calculated by one unit price analysis model (BOW, Mukomoko, A.Soedradjat S, SNI etc.) [6] .From the unit price and volume of work, the price of each type of work will be calculated by adding up the price of each type of work [7].

D. *Forward Chaining*

Forward Chaining Method is a search method or forward tracking technique that starts with existing information and combines rules to produce a conclusion or purpose. [4]

This advanced tracking is very good if it works with problems that begin with recording the initial information and want to achieve the final completion, because the entire process will be done sequentially forward. Here is a Forward Chaining diagram in general to produce a goal.

Forward chaining is an inference method that does reasoning from a problem to the solution. If the premise clause matches the situation (TRUE value), then the process will state the conclusion. Forward chaining is data-driven because inference begins with available information and new conclusions are obtained. If an application produces a tree that is wide and not deep, then use forward chaining.

Figure 1. Knowledge Base Rules

No	Aturan
R-1	IF A & B THEN C
R-2	IF C THEN D
R-3	IF A & E THEN F
R-4	IF A THEN G
R-5	IF F & G THEN D
R-6	IF G & E THEN H
R-7	IF C & H THEN I
R-8	IF I & A THEN J
R-9	IF G THEN J
R-10	IF J THEN K

III. SYSTEM ANALYSIS AND DESIGN

A. As-Is System Analysis

The implementation system for the estimated cost of development that is currently running at PT Arkade Adhi Kreasi can be described as follows, first the client contacts the company and then determines the time to hold the meeting. Then the parties from PT Arkade Adhi Kreasi and clients met to discuss development costs. Then the company asks the client about details of what kind of building will be built. And then after knowing the description of what kind of building will be built, the company calculates the costs manually and then submits detailed estimates or rough cost estimates. If both parties agree, an agreement is obtained to proceed to the next stage, namely the development planning stage.

B. Proposed Problem Solving

Based on the problems found in the current system, an alternative solution to problem solving was formulated, namely by building an expert system website to determine the estimated construction costs. With this, it is expected to be able to propose a new system by using alternative means of cost estimation systems that are still doing manual calculation into an internet-based computerized cost estimation system using UML's (Unified Modeling Language) method in determining development costs, thus providing more optimal, effective and efficient results. In this final project also uses the Forward Chaining Method as a reasoning for information in the knowledge base.

C. Forward Chaining Method Analisys

1. Requirements Analysis

Calculation of estimated development costs is a very complex problem. In this problem there are several variables that must be considered in order to produce an optimal total estimated cost of development. There are 5 important variables that must be considered in order to determine the optimal cost of development including the following:

a. Type of building
   The type of building is limited to 3 (three) houses, offices, supermarkets.
b. Building location
   The location of the building is one of the determining factors for "price per m2" because in each area the price of development "per m2" is different. (limited to 3 data)
c. Ownership
   Ownership is divided into 3 (three), namely personal / individual, corporate body, and government. This variable also affects the determination of "price per m2".
d. Building Class
   Ownership is divided into 3 (three), namely personal / individual, corporate body, and government. This variable also affects the determination of "price per m2".
e. Price per m2
   Is a *goal* in this *forward chaining* method .Price per m2 is the data that will be searched using the *forward chaining* method in this expert system.Then this data will be used in subsequent calculations.

In estimating construction costs, the 5 (five) criteria discussed earlier have the following priorities:
Priority 1: Building Type
Priority 2: Building Location
Priority 3: Ownership
Priority 4: Building Class
Priority 5: Price per m2

The rule-based *forward chaining* expert system requires knowledge and an inference engine to determine estimated development costs.This knowledge base contains the factors needed by the system. Whereas the inference engine is used to analyze the factors entered by the *user* so that a conclusion of the knowledge base needed by the system can be found, which consists of 5 (five) variables above.The data that becomes the system input is data on type of building, location of building, and ownership .While building class data is obtained from other calculations derived from *user input* data .These data are used by the system to determine the price per m2.

2. Knowledge Base

Knowledge base consists of two basic elements, namely facts and rules. In this case it is to enter the facts needed by the system. The facts found are types of buildings, location of buildings, ownership. From these facts, to determine the cost per m2 can be defined as follows:
$$A \wedge B \wedge C \wedge D \rightarrow E$$

Information:
To simplify the rules and facts above can be symbolized by:
A: Type of Building
B: Building Location
C: Ownership

D: Building Class
E: Price Per m2

Requires input data in the form of data on type of building, location of buildings, ownership, and class of buildings to determine the price per m2.

3. *Inference Engine*

The inference engine is a device for reasoning using existing knowledge such as procedures to match existing facts. Inference mechanism contains a mechanism of mindset and reasoning that is used to solve a problem, how the system can draw a conclusion based on the data entered by the *user* .Next the approach used to determine the cost per m2 by using *forward chaining* where the tracking is based on the input data and the conclusion will be made in the form of price per m2.

Based on the existing rules and facts, an *inference engine is* prepared where this *inference engine* provides the mechanism of the system reasoning function used by an expert as follows:

1. Mechanism for carrying out certain problems and then looking for conclusions or optimal results.
2. This machine will initiate blasting by matching the rules in the knowledge base with the facts in the database.

Following are the tracing stages with *match fire* inference *engine cycles procedures* by using *forward chaining* :
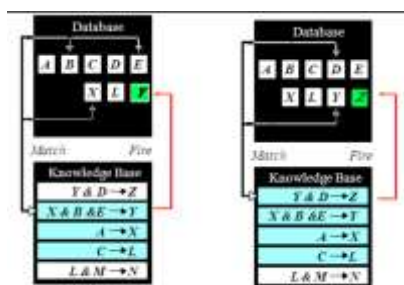
Requires data A, B, C and D from the database data so that it gets the E data, in the database there are found data A, B, C and D data *fired* and added to the database

4. REQUIREMENTS ANALYSIS RESULT

To produce an expert system to determine the estimated cost of development, it is necessary to make a complete and good knowledge base and rule base so that the information process runs well. Based on the results of the analysis, to determine the "cost per m2" the development required 4 variables, and 81 rules.

A. Production Rules

The following are some of the variables needed by the system to determine the "cost per m2" described in the tables below:

1. **Variable type of building**

Type of Building Variables	
Code	Type
JB1	Residential Home
JB2	Office
JB3	Mini Market

2. **Location Variables**

Location Variables	
Code	Location
L1	Jakarta
L2	Bogor
L3	Surabaya

3. **Ownership Variables**

Ownership Variables	
Code	Ownership
K1	Private
K2	Company
K3	Government

4. **Buildings Class Variables**

Building Class Variables	
Code	Class
KB1	Simple / Standard
KB2	Medium / Premium
KB3	Exclusive

B. **Rules Table (*Rule*)**
   Below are the rules used in determining development costs.

Figure.2 Rule of Determining Development Cost

NO	ATURAN (Rule)
R1	IF JB1 and L1 and K1 and KB1 then 2.500.000
R2	IF JB1 and L1 and K1 and KB2 then 3.500.000
R3	IF JB1 and L1 and K1 and KB3 then 5.000.000
R4	IF JB1 and L1 and K2 and KB1 then 3.000.000
R5	IF JB1 and L1 and K2 and KB2 then 4.000.000
R6	IF JB1 and L1 and K2 and KB3 then 5.500.000
R7	IF JB1 and L1 and K3 and KB1 then 3.600.000
R8	IF JB1 and L1 and K3 and KB2 then 4.250.000
R9	IF JB1 and L1 and K3 and KB3 then 5.700.000
R10	IF JB1 and L2 and K1 and KB1 then 2.000.000
R11	IF JB1 and L2 and K1 and KB2 then 3.150.000
R12	IF JB1 and L2 and K1 and KB3 then 4.550.000
R13	IF JB1 and L2 and K2 and KB1 then 2.700.000
R14	IF JB1 and L2 and K2 and KB2 then 3.900.000
R15	IF JB1 and L2 and K2 and KB3 then 5.200.000
R16	IF JB1 and L2 and K3 and KB1 then 3.200.000
R17	IF JB1 and L2 and K3 and KB2 then 4.600.000
R18	IF JB1 and L2 and K3 and KB3 then 5.300.000
R19	IF JB1 and L3 and K1 and KB1 then 2.400.000
R20	IF JB1 and L3 and K1 and KB2 then 3.400.000
R21	IF JB1 and L3 and K1 and KB3 then 4.800.000

R22	IF JB1 and L3 and K2 and KB1 then 2.800.000	R52	IF JB2 and L3 and K3 and KB1 then 6.000.000
R23	IF JB1 and L3 and K2 and KB2 then 3.900.000	R53	IF JB2 and L3 and K3 and KB2 then 7.150.000
R24	IF JB1 and L3 and K2 and KB3 then 5.300.000	R54	IF JB2 and L3 and K3 and KB3 then 8.135.000
R25	IF JB1 and L3 and K3 and KB1 then 3.300.000	R55	IF JB3 and L1 and K1 and KB1 then 3.200.000
R26	IF JB1 and L3 and K3 and KB2 then 4.800.000	R56	IF JB3 and L1 and K1 and KB2 then 4.800.000
R27	IF JB1 and L3 and K3 and KB3 then 5.450.000	R57	IF JB3 and L1 and K1 and KB3 then 5.600.000
R28	IF JB2 and L1 and K1 and KB1 then 4.500.000	R58	IF JB3 and L1 and K2 and KB1 then 4.300.000
R29	IF JB2 and L1 and K1 and KB2 then 5.350.000	R59	IF JB3 and L1 and K2 and KB2 then 5.800.000
R30	IF JB2 and L1 and K1 and KB3 then 6.000.000	R60	IF JB3 and L1 and K2 and KB3 then 6.600.000
R31	IF JB2 and L1 and K2 and KB1 then 5.300.000	R61	IF JB3 and L1 and K3 and KB1 then 5.200.000
R32	IF JB2 and L1 and K2 and KB2 then 6.200.000	R62	IF JB3 and L1 and K3 and KB2 then 6.800.000
R33	IF JB2 and L1 and K2 and KB3 then 7.100.000	R63	IF JB3 and L1 and K3 and KB3 then 7.600.000
R34	IF JB2 and L1 and K3 and KB1 then 6.000.000	R64	IF JB3 and L2 and K1 and KB1 then 3.000.000
R35	IF JB2 and L1 and K3 and KB2 then 7.160.000	R65	IF JB3 and L2 and K1 and KB2 then 4.500.000
R36	IF JB2 and L1 and K3 and KB3 then 8.750.000	R66	IF JB3 and L2 and K1 and KB3 then 5.400.000
R37	IF JB2 and L2 and K1 and KB1 then 4.000.000	R67	IF JB3 and L2 and K2 and KB1 then 4.000.000
R38	IF JB2 and L2 and K1 and KB2 then 5.000.000	R68	IF JB3 and L2 and K2 and KB2 then 5.000.000
R39	IF JB2 and L2 and K1 and KB3 then 5.900.000	R69	IF JB3 and L2 and K2 and KB3 then 6.000.000
R40	IF JB2 and L2 and K2 and KB1 then 5.100.000	R70	IF JB3 and L2 and K3 and KB1 then 4.700.000
R41	IF JB2 and L2 and K2 and KB2 then 6.000.000	R71	IF JB3 and L2 and K3 and KB2 then 6.300.000
R42	IF JB2 and L2 and K2 and KB3 then 7.000.000	R72	IF JB3 and L2 and K3 and KB3 then 7.100.000
R43	IF JB2 and L2 and K3 and KB1 then 5.750.000	R73	IF JB3 and L3 and K1 and KB1 then 3.100.000
R44	IF JB2 and L2 and K3 and KB2 then 7.000.000	R74	IF JB3 and L3 and K1 and KB2 then 4.800.000
R45	IF JB2 and L2 and K3 and KB3 then 8.500.000	R75	IF JB3 and L3 and K1 and KB3 then 5.600.000
R46	IF JB2 and L3 and K1 and KB1 then 4.200.000	R76	IF JB3 and L3 and K2 and KB1 then 4.250.000
R47	IF JB2 and L3 and K1 and KB2 then 5.200.000	R77	IF JB3 and L3 and K2 and KB2 then 5.200.000
R48	IF JB2 and L3 and K1 and KB3 then 6.100.000	R78	IF JB3 and L3 and K2 and KB3 then 6.200.000
R49	IF JB2 and L3 and K2 and KB1 then 5.250.000	R79	IF JB3 and L3 and K3 and KB1 then 4.890.000
R50	IF JB2 and L3 and K2 and KB2 then 6.170.000	R80	IF JB3 and L3 and K3 and KB2 then 6.500.000
R51	IF JB2 and L3 and K2 and KB3 then 7.500.000	R81	IF JB3 and L3 and K3 and KB3 then 7.700.000

5. Analysis of Calculation of total Estimated Development Cost
   Calculation of total development costs consists of several cost calculations, namely :

   A. Development costs
      Criteria:
      Total building area (obtained from the total building area for each floor)
      Price per m2 (adjusting from data on "building type", "building location", "ownership", and "building class" selected by the user.
      Calculation:
      "Total building area" x "price per m2" = "construction cost"
   B. Additional Facility Fees
      Swimming Pool Facilities
      1. Skimmer system
         Criteria:
         Swimming pool area (P x L x Depth)

Construction Costs = Rp. 3,000,000 x swimming pool area
Equipment costs = Rp. 19,500,000
The cost of filling water (tank) and initial treatment = Rp. 5,500,000
Calculation:
"Construction costs" + "equipment costs" + "water filling fees and initial treatment" = "pool fee for skimmer system facilities"

2. Overflow System
    Criteria:
    Swimming pool area (P x L x Depth)
    Volume (m3)
    Length (m) x Width (m)
    Long Gutter
    Depth x Width = gutter length (m)
    Construction Costs = Rp. 3,500,000 x swimming pool area
    Cost of balancing tanks, services, local ceramic finishing = Rp. 2,500,000 x Volume
    The cost of gutter = gutter length x 562,500
    Equipment costs = Rp. 19,500,000
    The cost of filling water (tank) and initial treatment = Rp. 5,500,000
    Calculation:
    "Construction costs" + "cost of balancing tanks" + "gutter costs" + "equipment costs" + "water filling costs and initial treatment" = "pool overflow system facility costs"

3. Full Overflow System
    Criteria:
    Swimming pool area (P x L x Depth)
    Volume (m3)
    Length (m) x Width (m)
    Long Gutter
    Depth x Width = gutter length (m)
    Construction Costs = Rp. 4,000,000 x swimming pool area

Cost of balancing tanks, services, ceramic finishing
local = Rp. 2,500,000 x Volume
The cost of gutter = gutter length x 562,500
Equipment costs = Rp. 23,400,000
The cost of filling water (tank) and initial treatment = Rp. 5,500,000
Calculation:
"Construction costs" + "cost of balancing tanks" + "gutter costs" + "equipment costs" + "water filling costs and initial treatment" = "pool overflow system facility costs"
Parking Area Facilities
Criteria:
Parking area
Price per m2
Calculation:
"Parking lot area" x "price per m2" = "parking fee"

C. *IMB Retribution Fee*
    Criteria:
    Development Costs
    Additional Facility Fees
    Calculation: ("Construction costs" + "additional facility costs) x 1.75% =" IMB Retribution fees.

D. **Total Development Costs**
    Criteria:
    Development Costs
    Additional Facility Fees
    IMB Retribution Fee
    Calculation:
    "Construction costs" + "additional facility costs x" IMB levy fees "=" total construction costs "

6. **Architectural Design of Building Construction Estimated Systems.**

Fiigure 3 Architecture of System

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