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Graph Theoretic Modelling and Analysis of CIM Database: A Case Study

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Abstract: ***In this paper we are studying the effect of database in the CIM system using graph theoretical approach. The permanent function developed using various subsystems and there interactions is used tocalculate the numerical value of the system showing all its characteristic features and any change in the value of any of the subsystem or there interactions lead to change in the value of the permanent function of the system. This change helps in determining whether the system has moved towards better or worse.***

1. Introduction

CIM has a basic concept, to format a mutual database to clench the majority part of information essential to ride a manufacturing company. CIM concept has drastically progressed now. The expansions of the factories future prospective, architectures all should now accumulate the introduction of this new technology for the production flexibility and also for the changes in social attributes in an organisation.

M. Anwarul (1992) presented the importance of a CIMs database. The definition of CIM is formal connection of all manufacturing operations from the product start and primary marketing analysis through the design and manufacturing with digital techniques that provide consistency and availability of data to each operation on time. The basic method to the CIM concept is physical and logical integration of design, manufacturing and support systems.

The selection of CIM database is done using Analytic Hierarchy Process (AHP). Basic, general and technical criteria are the classes of hierarchical selection criteria.

The points concluded from the CIM data models are as follows:
1) There is dissimilarity between various subsystems data. Alphanumeric data is mainly for business system and geometric and graphic for CAD systems.
2) The sharing of design data is done by various subsystems like CAPP, MRPII and FMS. Interactive Graphic Exchange System (IGES) works as an efficient data conversion tool as design data is not directly recognisable and has to be converted into a recognisable format.

For CAD systems, the data should be dynamically created and deleted for the process. It should also provide information about the tools, equipment capacities etc. Any change in design or data requirement should be automatically updated in the process plan without any constraint.

Geometric data from the CAD is converted in alphanumeric data for MRPII to be used in bill-of-materials (BOM). MRPII database should be updated of any change in the inputs from the CAD and CAPP.

The data characteristics for a common CIM system are as follows:
1) Heterogeneous types of data must be taken care by the CIM database.
2) Integrity constraints and validity checks must be present.
3) Enormous volume of data is required by CAD/CAPP.
4) Sharing of main system data among subsystems should be there.
5) Database has to be made steady at all times by propagating changes in one part to the other part.
6) Apprising must be proficient and fast in order to provide the data as required in real time.
7) Complex objects should be supported by the system.
8) Independence of data must be there for every item.
9) Required data by any system should be instantaneously available for easy access of the operations.
10) The access to the system should be flexible as processing equipment has to support real time operation.
11) Reliability and availability of data should be there for real time operations.
12) Redundancy should be least to avoid any inconsistency in data during real time operations.
13) Same data should not be updated simultaneously by more than one user.

The database requirements meeting these criteria are summarized in figure 1.

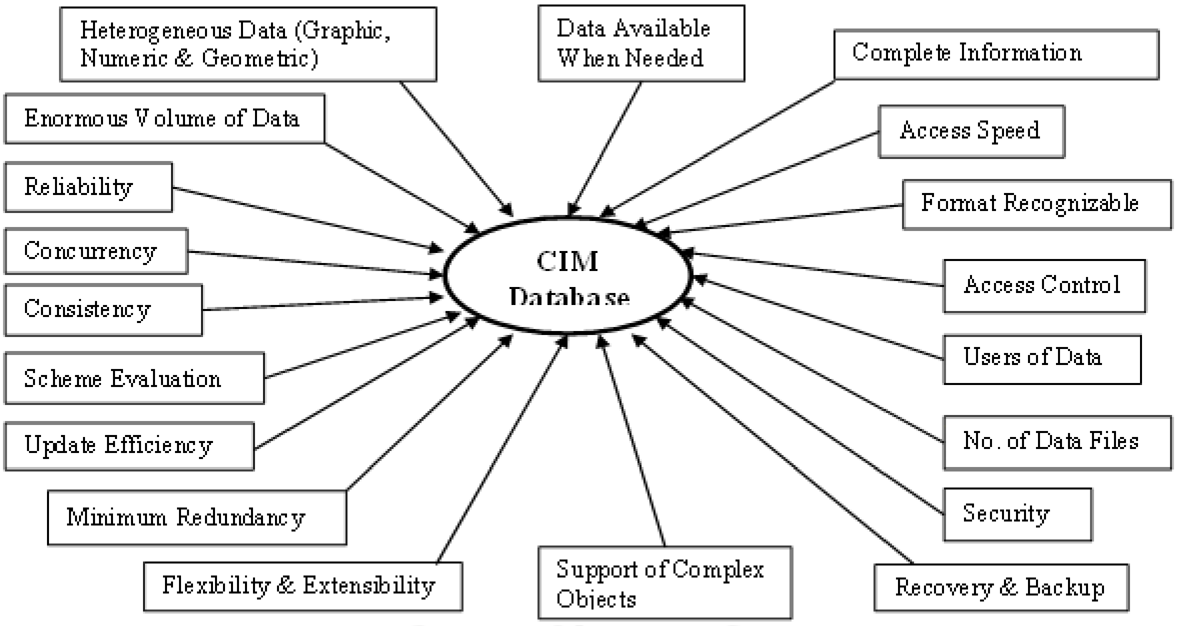


Figure 1: CIM database requirements

The process of selection is showed in figure 2 and hierarchy model in figure 3. The selection process begins with the analysis of database requirement. Using AHP, each alternative is viewed and the decision is thoroughly examined. The AHP model presented in figure 3. It represents the defined model of selection which emphasise on the three categories and the sub factors of each category.

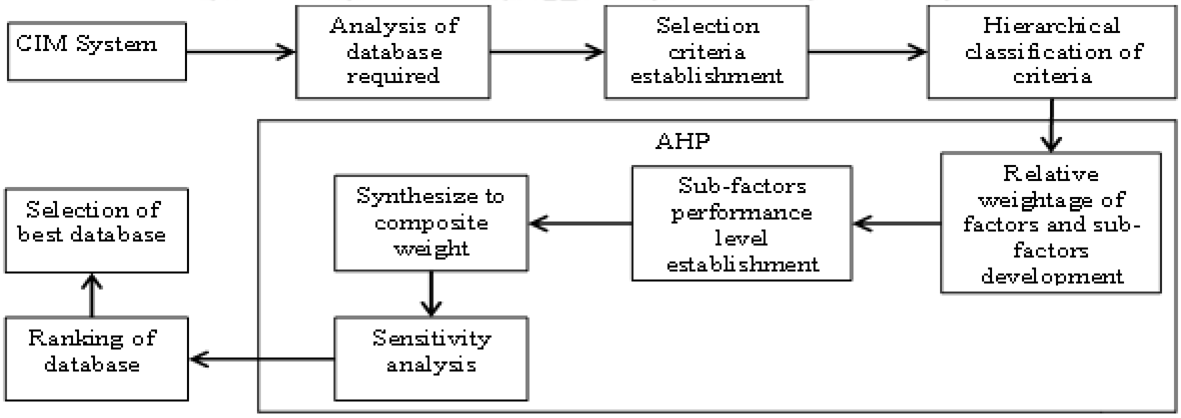
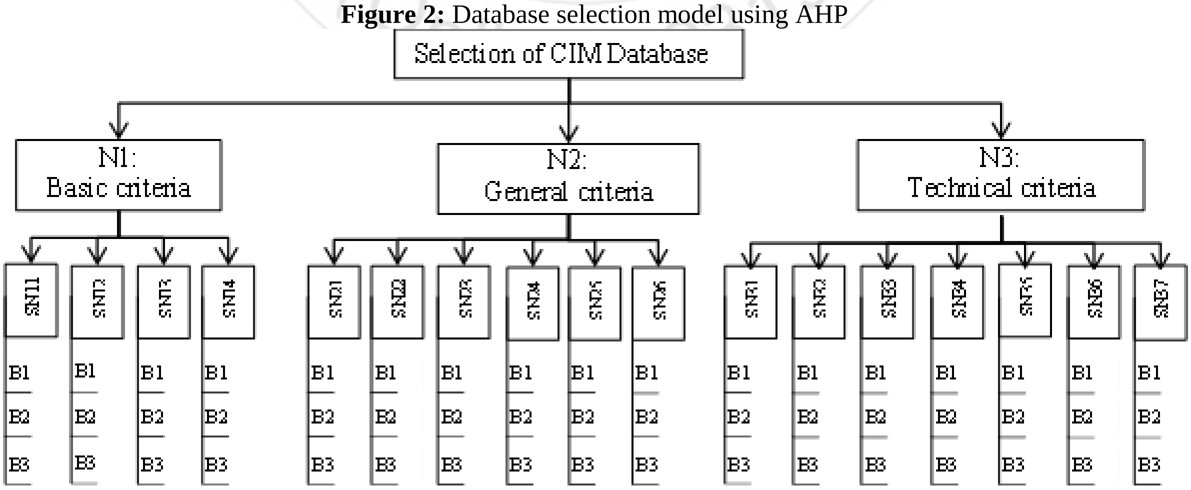


Figure 2: Database selection model using AHP



B1: Network database B2: Relation database B3: Object oriented database
N1: Basic criteria N2: General database criteria N3: Technical criteria relative to CIM
SN11: Data is to available when needed
SN12: Data have to be complete, not fragmented
SN13: Data have to be recognizable format
SN14: The accessibility without intermediaries
SN21: Amount of data can be stored
SN22: Users of data
SN23: No. of files required
SN24: Access control
SN25: Security
SN26: Recovery & backup
SN31: Data type
SN32: Access speed
SN33: Access flexibility
SN34: Modularity and extensibility
SN35: Data integrity
SN36: Update efficiency
SN37: Support for complex objects

Figure 3: Hierarchical structure of CIM database selection model

2. Quantification of Factors and Their Interdependencies

The several factors which are affecting the CIMS are acknowledged and listed in table 3.1. Also the subsystems are presented in the same table.Using the table permanent functions presented in each of subsystem Per(P) is evaluated. For this process, the variable function is selected from the lowest order of the table. To avoid complication, an appropriate numeric value is to be allocated at both levels. The numeric value depends on weightage of the subsystem to the total system. The below table 1 suggests that the value which is interdependent of the computer integrated manufacturing system.

Table 1: Qualitative measure of CIMS subsystems and their interdependencies

S.No.	Qualitative measure of subsystem Si	Weightage
1	Excellent	6
2	Very good	5
3	Good	4
4	Average	3
5	Poor	2
6	Very poor	1
S.No.	Qualitative measure of interdependencies	Weightage
1	Strong interaction	4
2	Average interaction	3
3	Weak interaction	2
4	Very weak interaction	1

3. Selection of Database

For the selection of a CIM system three types of characteristics must be satisfied by a database:

A. Basic Criteria

Easy recovery of complete data information. Data format should be identifiable by all the subsystems for smooth sharing. Easy availability of data for real time operations.

Table 2: Paired comparison matrix of sub-criteria of basic criteria

	Data availability	Data completeness	Data format	Data accessibility
Data availability	1	2	2	3
Data completeness	1/2	1	1	2
Data format	1/2	1	1	2
Data accessibility	1/3	1/2	1/2	1

B. General Database Criteria

Applications in this criteria are common and are of same value. Recovery and backup, no. of users and amount of data are more important criteria than access control, no. of files required and security. This is because heterogeneous software and hardware share huge amount of data.

Table 3: Paired comparison matrix of sub-criteria of general criteria

	Amount of data	Users of the data	No. of files required	Access control	Security	Recovery & backup
Amount of data	1	1	3	2	2	2
Users of the data	1	1	3	2	2	2
No. of files required	1/3	1/3	1	1/2	1/2	1/2
Access control	1/2	1/2	2	1	1	1/2
Security	1/2	1/2	2	1	1	1/2
Recovery & backup	1/2	1/2	2	2	2	1

C. Technical criteria in the context of CIM

The CIM system holds the heterogeneous data types. Data type is of less importance as compared to the access speed for real-time operations. Access speed, extensibility and modularity are important for addition of new entities in the system. Update efficiency is important for reliability of system during real-time operations. Complex objects should be supported.

Table 4: Paired comparison matrix of sub-criteria of technical criteria

	Data type	Access speed	Access flexibility	Modularity and extensibility	Data integrity	Update efficiency	Support for complex objects.
Data type	1	1/3	1/2	1/3	2	1	1
Access speed	3	1	1/2	1	3	1	2
Access flexibility	2	2	1	1/2	2	1	2
Modularity and extensibility	3	1	2	1	3	1/2	2
Data integrity	1	1	2	1/3	1	1/3	1
Update efficiency	3	1	2	1	3	1	3
Support for complex objects.	1	1/2	1/2	1/2	1	1/3	1

4. Graph theoretic approach of the computer integrated manufacturing database

Diagraph for the technical database developed in fig 4.1.4 contains multinomial of AAA_i and m_{ij} terms. The permanent index can be developed by assigning the numerical values to the subsystems and their interactions. The score obtained will be the numerical value of the subsystem. For subsystem the permanent index of the sub-subsystems will be considered.

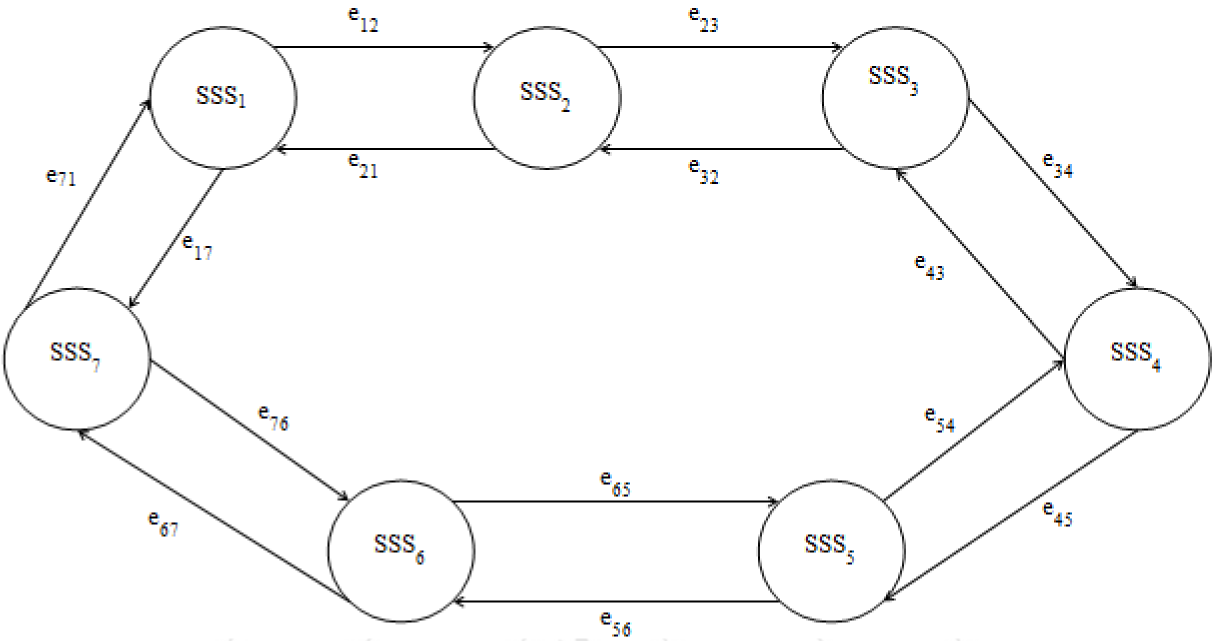


Figure 4: Diagraph for technical database sub-subsystem

where,

SSS_1: Data type
SSS_2: Access speed
SSS_3: Access flexibility
SSS_4: Modularity and extensibility
SSS_5: Data integrity
SSS_6: Update efficiency
SSS_7: Support for complex objects

5. The CIM database permanent matrix

Variable permanent matrix for the technical database sub-subsystem can be written as

$$Per(SS_3) = \begin{vmatrix} 2 & 1 & 1 & 1 & 3 & 2 & 2 \\ 4 & 2 & 1 & 2 & 4 & 2 & 3 \\ 3 & 3 & 2 & 1 & 3 & 2 & 3 \\ 4 & 2 & 3 & 2 & 4 & 1 & 3 \\ 2 & 2 & 3 & 1 & 2 & 1 & 2 \\ 4 & 2 & 3 & 2 & 4 & 2 & 4 \\ 2 & 1 & 1 & 1 & 2 & 1 & 2 \end{vmatrix} \quad (1)$$

The value of the permanent function of the technical database sub-subsystem $SS_3$is the permanent index of the matrices represented in eq. 1 which is equal to 1. Similarly the value of permanent function of other subsystems or sub-subsystems can be evaluated from the variable permanent matrices. Then for the structural graph of computer integrated manufacturing system shown in fig 3, permanent multinomial is developed in terms of S_i and e_{ij}. Variable permanent matrix shown in eq. 1 is to be developed. The values of the diagonal element of this matrix will be the permanent index calculated for the subsystem level and the value of the off diagonal elements will be judged. Then the determinant of eq. 1 will be the permanent index for computer integrated manufacturing system.

6. Conclusion

By solving the above matrix, a numerical value is obtained. This value tells us about the system characteristics. Now by varying any parameter, the subsystem and interactions values will be changed and the permanent matrix value will also be changed. The experts by comparing the changed value of the permanent matrix to the original value can determine whether the system will improve or not. The earlier processes available to see any change in the system by changing any parameters is to be done on the machine only which takes a lot of time and capital. But by using this technique we will be able to predict which way the system will go using numerical values provided by experts in the field without doing any physical process.

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