Information Technology Engineers Skill Standards

Technical Engineers (Database)

Contents

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1. Overview

1.1 Background of developing the “Information Technology Engineers Skill Standards”

At present, great hopes are placed on information technology as the sources of industry regeneration and new economic growth. This is because the roles of IT have been expanded from the tools for manufacturing cost reduction and service speedup to those for effective collaboration among enterprises and the creation of new industries. From now on, the rise or fall of an enterprise will be determined by quality of computerization investment. It is therefore an urgent matter to bring up engineers who construct advanced information systems and those who utilize them.

In view of this, the Central Academy of Information Technology has repeated a study on how to bring up, evaluate, and select good engineers who can show their practical ability on actual jobs. As a conclusion, the academy decided to establish the “information technology engineers skill standards” centering on the criteria to determine whether the required jobs can be performed adequately or not.

1.2 Significance and objective of developing the “Information Technology Engineers Skill Standards”

The results of surveys that the Central Academy of Information Technology has conducted on information processing engineers have suggested an important issue to be solved in the industrial world and by educational institutions such as schools. The issue is the establishment of the guidelines that clearly define what the industrial and educational worlds are expecting to get. While these guidelines need to define the level of knowledge, skills and capability to be equipped with by IT personnel (engineers) who do the actual jobs in the industrial world, they need to define the models of IT engineers who can be accepted internationally, and the ways how schools and other educational institutions should conduct education training on the basis of these models. One example of the guidelines is the “Skill Standard for IT Engineers” developed by the Northwest Center for Emerging Technologies (NWCET) as part of the establishment of “Skill Standards” by the US Department of Labor.

The “Information Technology Engineers Skill Standards” have been developed as a tool that solves the issue mentioned above, and apply to all the sections of the information technology engineers examinations as criteria to evaluate the skills of engineers who have been brought up. The application of this skill standard is significant for the industrial world in “recruiting human resources with the guaranteed ability to do actual jobs.” For educational institutions such as schools, this is significant for “understanding and confirming the knowledge, ability, and the achievement levels of the engineers required by enterprises.” For government agencies, this is significant for “grasping the technical level of the entire industrial world.”

1.3 Configuration of the "Information Technology Engineers Skill Standards"

The "Information Technology Engineers Skill Standards" is a tool that provides information about knowledge and skill needed to do jobs such as building, operational control, usage and evaluation of IT system in organizations such as corporations. It also provides indicators to determine the outcome of jobs. "Information Technology Engineers Examinations: Overview of the New System" and "Information Technology Engineers Examinations: Scope of Examinations" describe knowledge, technology (technical knowledge), and ability that information processing engineers need to have, and performance indicators (listed in 1), 2), and 3) below). The established skill standards describe these points more specifically by consulting actual jobs.

1) Roles and jobs
2) Expected technical levels
3) Scopes of examinations: examination in the morning and that in the afternoon
   (The above information can be downloaded to access http://www.jitec.jipdec.or.jp/.)

The "Information Technology Engineers Skill Standards" consists of three kinds of technical information described below. In this standard, individual skill standards are established for each examinees classified according to examination categories.

(1) Key activities

This chapter describes jobs that are keys unique to each examination categories. It describes the "roles and jobs" in 1) above more specifically.

(2) Skill criteria

This chapter describes what knowledge and skill should be used to do the key activities in (1) above, and also describe performance indicators to determine what outcome should be obtained. It describes "expected technical levels" in 2) above more specifically.

(3) Body of knowledge

This chapter systematically describes common knowledge independent of examination categories and knowledge needed to do the key activities in (1) above. This chapter also covers the "scopes of examinations" in 3) above.

1.4 Image of “technical engineers (Database)” and skill standards

This skill standard was prepared to apply the framework of the Information Technology Engineers Skill Standards to the “technical engineers (database).”

(1) Image of technical engineers (database)

In a typical mission critical database system development project, technical engineers (database) follow the work in planning, designing, construction, operation and management of the database. In these basic jobs, technical engineers are required to have the ability to implement the request analysis of the database system, prepare data models, design the physical database, design the distributed database, implement performance improvements and so forth.

Technical engineers (database) are also expected to take charge of database related technical support and construction of a data warehouse in the development of individual systems.

(2) Skill standards

The following skill standards apply to technical engineers (database):

1) IT common body of knowledge
2) Technical engineers (database)
   - Key activities, skill standards, practical body of knowledge, and core body of knowledge

2. Key Activities

Key activities in a mission critical database system development project refer to procedural items described concerning operations in the database system development phase, which is the basic job area for technical engineers (database). In this skill standard, the above job area is called a "database system development job process."

As shown in Figure 2-1, jobs in the database system development job process are broken down into five basic "activities."

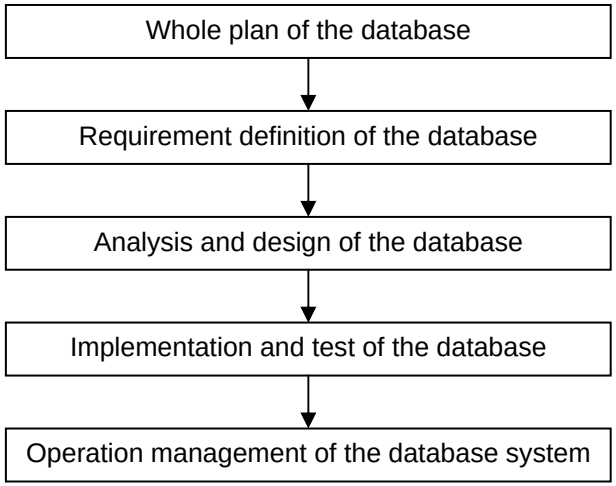

Figure 2-1 Database system development job process

Each activity is further broken down into detailed jobs called "tasks." This skill standard presents the database system development job process in the following format:

Activity	Task	Job outline
1. Act 1	1-1 Task 1	x x x x x x x x x x x x x x
	1-2 Task 2	x x x x x x x x x x x x
	1-3 Task 3	x x x x x x x x x x
2. Act 2	2-1 Task 1	x x x x x x x x x x x
	2-2 Task 2	x x x x x x x x x x x x x
	2-3 Task 3	x x x x x x x x x x x x x x
	2-4 Task 4	x x x x x x x x x x x x

Technical engineers (database) mainly take charge of the "whole plan of the database," "requirements of the database," "analysis and design of the database," "implementation and test of the database," and "operation management of the database" as shown in Figure 2-1. In these processes, technical engineers (database) exhibit the ability through tasks of "data analysis based on the user request," "data modeling," "database implementation," "recovery from failure," and "security management."

[Database system development job process]

Activity	Task	Job outline
1. Whole plan of the database	1-1 Database plan of the whole corporation	Set up both long range and short range database plans of the whole corporation taking the information strategy and the current status of the information systems of the whole corporation into consideration. Regarding the databases being developed and maintained individually, also plan global optimization for whole users of the corporation and consolidation of maintenance methods.
	1-2 Standardize data definition	Standardize coding scheme, definition method of data items, data consistency etc.
2. Requirement definition of the database	2-1 Survey current status and analyze issues	Conduct a survey on job processes and data, and consolidate request items through analysis of current issues and new needs. Based on the consolidated request items, determine the development of new applications and databases.
	2-2 Determine the work scope	Define the objective of database development and determine the work scope. Based on the work scope, develop a database project plan.
	2-3 Define the database requirements (initial requirements)	Define the database design requirements (data requirements and integrity requirements) and database operation management requirements (such as data access, performance, security and operations). And also review the requirement specification jointly with the database user and the application development engineer.
3. Analyze and design the database	3-1 Prepare conceptual data model	Prepare the conceptual data model based on the analysis of data requests in parallel with the designing of new applications. Furthermore, repeat the tune up and complete the model.
	3-2 Verify the conceptual data model	Verify the validity of the conceptual data model jointly with the user.
	3-3 Prepare logical data model	Convert the conceptual model to the logical data model (from ER chart to SQL table). In addition, implement the index design and the view design and unify the data through normalization.
	3-4 Verify the logical data model	Verify the validity of the logical data model. (Verification of validity of the items verified by conceptual modeling in logical modeling.)

Activity	Task	Job outline
4. Implementation and test of the database	4-1 Select and install DBMS	Assume utilization of the relational database, select and install DBMS. The selection of DBMS is made from the candidate products of various vendors based on the established criteria, taking the budget, the objective of the database, required functions, performance and so forth into consideration. In addition, install the selected DBMS and confirm its operation, taking the consistency between existing mission critical information system and user's environment into consideration.
	4-2 Design the physical database	Implement the design of the physical database in the following sequence: (1) Analyze the characteristics of transaction and define precisely the requirements for the database utilization. (2) Define the physical environment of the platform, the physical requirements of the database such as file volume, response time, integrity, failure recovery and operation requirements. (3) Determine whether the architecture is a centralized or distributed type, taking the needs of data arrangement at business locations, the performance to access data, security and so forth into consideration. (4) Implement the design of the physical database taking the functions and the limitations of target DBMS into consideration. Also, calculate the required disk capacity and set the lock control method. (5) Implement the following work taking performance and maintainability into consideration: • Design of fields • Un-normalization of tables, selection of access path, selection of index • Performance adjustment through the trade-off of storage efficiency, access efficiency and computing process efficiency • Study of file access efficiency improvement through utilization of RAID if necessary • Improvement of application performance through the conformity of application development to the rules, optimum design of query and adjustment of access path (6) Determine the physical location of the database taking the alternate database, the distribution to multiple disks, the store sequence of data, measures against faults and so forth into consideration.
	4-3 Implementation	Implement the database into RDBMS in the following sequence: (1) Define the database in the following sequence: define database→define table→define index→define view→define access rights. (2) Extract the original data, convert data if necessary, and load the data into the database environment.

Activity	Task	Job outline
	4-4 Test and migration	Implement the test and migration of the database in the following sequence: (1) Make evaluation of performance, security, integrity and backup recovery through the database access test and confirm their adaptability to user requests. (2) Prepare the users manuals and the database operation management manuals, distribute and keep them in custody.
5. Operation management of the database system	5-1 Operational plan of database system	Develop an operational plan for the database system focusing on the following: (1) The operational system and the operational mode of the database system in normal time and abnormal time (2) The monitoring target and the monitoring mode of the database system (3) The management of performance, fault/recovery and security of the database system (4) The maintenance of the database system and preservation of data integrity
	5-2 Operation and maintenance of the database system	Implement operation and maintenance of the database system through the following jobs: (1) Collect and analyze the monitoring data and strive to discover problems. With a problem, provide the solution with the least hindrance to jobs. Continue monitoring in order to secure the performance guarantee and early response to the failure and security. (2) In accordance with the maintenance schedule, properly conduct the update following DBMS in the target environment, reconfiguration of the database, and grade-up of the database application. (3) Prepare and improve the database operation standard and obtain agreement on conformity to the standard. Furthermore, manage the status of conformity of the database application to the standard.
	5-3 Management of the database system	Manage the database system implementing the following jobs in order to maintain the data integrity, guarantee the performance and availability which users want, and develop a more appropriate capacity plan: (1) Confirm periodically the preservation of data integrity in accordance with the plan. (2) Maintain the data object physical structure in order to guarantee the database access without delay. (3) Monitor the execution status of backup and manage the implementation status of failure/recovery plan. (4) Provide users the advice and the education/training on security as well as monitoring the effect of the database security measures. (5) Prepare the audit materials in accordance with the database audit procedure, and explain it to the audit accurately.
	5-4 Performance tuning	(1) In order to fulfil the database access request without delay, grasp the hardware performance and the status of the access execution path, and manage and improve the performance. (2) Grasp the resource utilization status by the database application and conduct capacity management for the optimum utilization of resources.

Activity	Task	Job outline
	5-5 User support	Provide the following convenience for the effective use of the database and improvement of systems: (1) Provide the database application development environment and support the utilization. (2) Provide users with the database service to guarantee the accessibility that satisfy the request. (3) Provide appropriate user education and training considering the burden in terms of both time and money. (4) Collect and analyze users new requests and propose improvements. Also make an assessment of the database structure and develop a plan for system update so as to meet the new business environment.

3. Skill Criteria

The skill criteria correspond to tools (tables) that provide indicators to check the status of achievement of the database system development job process described in the key activities. With these criteria, it is determined whether technical engineers (database) have promoted a series of jobs successfully according to proper sequence and by using proper techniques, proper knowledge, and proper skill.

The skill criteria provide indicators to indicate what outcome needs to be obtained ("performance indicators") as a result of job execution for each "task" of each five activities. They also provide knowledge ("required knowledge") and skill ("required skill") required to do jobs.

[Technical engineers (database) skill criteria]

1. Whole plan of the database				
No.	**Task**	**Performance indicators**	**Required knowledge**	**Required skill**
1-1	Database plan of the whole corporation	• The database plan is based on a proper understanding of the corporate information strategy, and reflects the current utilization status of the information and the database with accuracy. • The individual situations pertaining to the utilization and maintenance of the database have been grasped accurately • Both long-range plan and short-range plans of the database have been explained and approved by database users and related persons.	• Knowledge about evaluation methods of information systems • Knowledge about problem analysis methods • Knowledge about database maintenance	• Ability to evaluate database utilization • Ability to evaluate database maintenance • Ability to operate and manage the database • Ability to think about information systems and the database from a global perspective • Ability to clearly explain the plan to database related persons
1-2	Standardization of the database definition	• The code definition rule has been established and approved by application development related persons. • The standard pertaining to the data definition has been explained to database development related persons and approved.	• Knowledge about code design • Knowledge about data designation • Knowledge about data items • Knowledge about integrity	• Ability to design codes • Ability to establish the rules of data standard • Ability to explain the standardization of code and data to application developers • Ability to understand different viewpoints and to persuade or adjust different opinions.

2. Requirement definition of the database

No.	Task	Performance indicators	Required knowledge	Required skill
2-1	Survey current status and analyze issues	• The survey information is correct and perfect. • Details of requests are reliable and reflect the present situation. • The proper methodology for capturing the source of information and requests. • Information has been collected using a standard interview technique adopted by the corporation. • Information is collected efficiently and continuously. • User requests have been analyzed properly, and persuasion has been performed with opposite requests. • The development of new applications and the database has been explained and approved by database users and related persons.	• Knowledge about the details of user jobs and terms • Knowledge about information collection methods • Knowledge about data analysis methods • Knowledge about problem analysis methods	• Ability to identify the major information source of the user's needs • Ability to implement information collection techniques and sequence • Ability to determine the required amount of information to be collected • Ability to analyze replies from individuals and groups • Ability to select and obtain collected information and to identify needs • Ability to put together and to summarize request information • Ability to let other people discuss important issues freely and to derive various solutions
2-2	Determine the work scope	• The aims and targets of the database project have been agreed on. • The work scope that satisfies the budget, quality, and delivery date requested by the user has been identified. • Resources that satisfy requested details can be assured and have been estimated • Risks have been analyzed, and proper measures against emergencies have been planned. • The work scope has been written in documents correctly, completely, and simply.	• Knowledge about system environment • Knowledge about system architecture, hardware, and software • Knowledge about database development • Knowledge about availability of system resources and the project delivery date • Knowledge about calculating man-hours • Knowledge about technical restrictions • Knowledge about risk analysis methods	• Ability to create documents on work scope for user requests clearly • Ability to discern the scale, scope and complexity of the project • Ability to negotiate with the requesting persons about the achievement criteria for the database project • Ability to calculate man-hours for each work item of the database project • Ability to survey, analyze, and compare marketed products and to determine applicability for the project • Ability to create documents on technical restrictions • Ability to think globally

2-3	Define the database requirements (initial requirements)	• Requests for the design of the database are accurate and have been written in documents completely. • There is no inconsistency between users for the data access requests. • Performance evaluation criteria have been defined. • Performance requests have been written in documents correctly, completely and simply, and approved by related persons. • Database security requests have been defined based on the corporation's security policy. • The operation requirements of the database system has been defined as not being inconsistent with the database requests. • Database transition requirements have been defined. • Whole requests conform to the requests of whole database projects. • Whole compatibility and interdependency for requests have been confirmed. • Viewpoints of reviewing the requirement definition document have been presented to participants in review. • Review results have been written in documents. • All participants in review have understood and approved the database requirements.	• Knowledge about system development environment and system operation environment • Knowledge about the database and job integration • Knowledge about system functions and operation • Knowledge about design and operation of the database • Knowledge about analysis of data • Knowledge about identifying system performance requests • Knowledge about the corporation's security policy • Knowledge about assuring data integrity • Knowledge about data access control • Knowledge about the database system operation requirements • Knowledge about making progress of review • Knowledge about items and notes to be included in the database requirement definition documents	• Ability to translate user requests into database requirements • Ability to recognize conflicting requests and to present solutions • Ability to analyze correctness and consistency of information • Ability to apply effective technology to requests • Ability to understand distribution of data • Ability to evaluate performance evaluation criteria • Ability to grasp the attainability of performance evaluation criteria • Ability to propose how to secure the performance • Ability to reflect user security requests to the database system security requirements • Ability to reflect user operation requirements to the database system requests • Ability to describe important items clearly and accurately • Ability to select a communication method suitable for reviewing requirement definitions and to make progress of review effectively • Ability to evaluate opposite opinions properly

3. Analysis and design of the database

No.	Task	Performance indicators	Required knowledge	Required skill
3-1	Prepare the conceptual data model	• The conceptual data model has been defined correctly and completely and written in documents. • Entity, attribute, entity related, data restriction, and business rule have been identified correctly and completely and defined. • In the development process of the conceptual data model, communication between users and application development engineers has been contrived. • The conceptual data model is based on the data definition standard. • Business rule has been defined correctly and completely. • Business rule has been integrated in the data model.	• Knowledge about modeling technique • Knowledge about ER diagram • Knowledge about business rule • Knowledge about GUI	• Ability to analyze the information structure • Ability to apply user requests into the conceptual model • Ability to define entity attribute • Ability to confirm the consistency between the business process and data model • Ability to adjust the discrepancy among several conceptual models • Ability to recognize and solve the conflicting requests • Ability to develop easy to read documents for application development engineers and users of the conceptual data model
3-2	Verify the conceptual data model	• Consistency between the data model and the enterprise model has been secured. • Data model has been defined correctly and completely. • Data model is consistent with the database objective. • User's indication has been reflected in the data model. • The conformity between the data model and the business process has been maintained. • Conceptual data model has been explained to users and approved. • Data modeling process has been written in documents concisely and completely.	• Knowledge about enterprise model • Knowledge about business process	• Ability to grasp the primary concerns of user's • Ability to explain the data model to application development engineers and users and to get understanding • Ability to confirm the consistency between the enterprise model and the data model • Ability to recognize and solve conflicting requests • Ability to explain the change of the data model to persons concerned and to get consent • Ability to develop an easy to read document for application development engineers and users on data model

3-3	Prepare logical data model	• The relation table has been designed. • At least, a third of the normal form has been implemented. • View has been designed. • The integrity of reference has been secured.	• Knowledge about relational data model • Knowledge about relational data base • Knowledge about conversion rule from ER diagram to SQL table • Knowledge about design of view • Knowledge about normalization • Knowledge about integrity restriction • Knowledge about GUI	• Ability to convert from the ER data model to the relational model • Ability to implement normalization • Ability to indicate contradiction of the ER data model
3-4	Verify the logical data model	• Data model has been defined correctly and completely • Data modeling process has been documented concisely and completely	• Knowledge about enterprise model • Knowledge about business process	• Ability to verify data for accuracy and conformity to the objective of the project • Ability to develop easy to read documents for application developers on data model

4. Implementation and test of database

No.	Task	Performance indicators	Required knowledge	Required skill
4-1	Select and install DBMS	• The requests for DBMS has been written in documents. • Selection criteria has been established. • Installation environment has been approved by managers of the operation department. • Selected DBMS conforms to the database application and the characteristics of data and also corresponds to the objective of the database. • Selection process and reasons have been written in documents correctly and concisely including an alternate plan. • Selection process and reasons have been explained to users and application development engineers and approved. • An installation plan to the target environment has been written in documents. • Works in the installation process have been written in documents. • Release materials of DBMS have been prepared.	• Knowledge about collection methods of vendor information • Knowledge about selection criteria • Knowledge about existing environment and installation time environment • Knowledge about database application • Knowledge about design and implementation of the database • Knowledge about database performance • Knowledge about availability • Knowledge about system installation methods and system evaluation methods • Knowledge about test application and data	• Ability to understand, consolidate and summarize various requests for DBMS • Ability to understand the merits and problems of user groups • Ability to compare various viewpoints • Ability to evaluate vendor information • Ability to issue requests to vendors • Ability to negotiate with vendors • Ability to collect installation information of other companies • Ability to evaluate the conformity with the objective of the database project • Ability to select DBMS based on the study of trade-off in cost, function, performance, availability and so forth • Ability to understand opposite opinions • Ability to explain the selection process and reasons to related persons

4-2	Design physical database	(1) Confirmation of target physical environment • Hardware specifications of the target environment have been written in documents precisely, accurately and completely. • The performance of individual hardware elements have been confirmed. (2) Transaction analysis • Requirements of data utilization have been analyzed in detail and written in documents. • The critical process and the bottleneck process have been specified. • Requests have been analyzed properly and persuasion has been made to conflicting opinions. (3) Database detail requirements • The scale of the database file has been calculated both for the present and future. • The target performance of data access has been specified precisely. • The request of backup recovery has been defined in conformity with business requests. • The operation mode of the database system has been defined properly. • Request details are consistent with the target environment and have been written in documents completely. • Opinions of users and application development engineers have been reflected in the requirements.	• Knowledge about target environment • Knowledge about target DBMS • Knowledge about calculation method of data volume • Knowledge about analysis method of transaction • Knowledge about analysis method of critical area • Knowledge about corporate policy on data • Knowledge about corporate policy on backup recovery • Knowledge about operation management of the database system • Knowledge about the database access performance	• Ability to evaluate target performance • Ability to analyze transactions and define utilization requirements • Ability to analyze requests from a global perspective • Ability to prepare backup materials for the requirements definition and explain the reasons • Ability to analyze the request information and formulate into total requirements • Ability to analyze and think out the stable system utilization • Ability to define the database requirements in conformity with the database objectives • Ability to dig down the initial requirements of the database and develop the detailed system requirements • Ability to recognize conflicting requirements and to present solutions

		(4) Architecture design • The requests at each user location have been grasped. • The performance, availability and security have been examined thoroughly. • In case of distributed architecture, the following have to be examined; - data distribution strategy, query optimization, transaction management, and recovery from failure - Transparency of distributed DB and autonomy of individual location • The decision process of architecture and reasons have been explained to users and approved. (5) Conversion to target DBMS • The requirements at the physical database level have been defined completely. • A survey has been conducted on the functions and restrictions of the target DBMS. • The data access has been presented by types. • Data design at field level has been written in documents. • The data volume has been calculated properly. • The level of lock and type of lock have been selected. • Communication with users has been made.	• Knowledge about data life cycle (generate, distribute, process, discard) • Knowledge about the needs for data processing at user's location • Knowledge about the distributed system and the distributed database • Knowledge about c/s (client server) systems • Knowledge about the advantage and disadvantage of centralized or distributed databases • Knowledge about network architecture • Knowledge about target DBMS • Knowledge about selection of data type • Knowledge about data compression • Knowledge about data integrity • Knowledge about design of physical record • Knowledge about calculation methods of data volume • Knowledge about lock of data	• Ability to determine the architecture and prepare documents • Ability to analyze the scheme of information and data • Ability to translate user's requests into architecture design • Ability to consolidate and summarize various requests • Ability to identify technical issues and propose solutions • Ability to explain the decision process of the architecture and their reasons to related persons • Ability to design distributed data • Ability to understand logical data model • Ability to think out stability of systems • Ability to dig down the limit of target DBMS • Ability to calculate required disk space
		(6) Performance design • Performance requests at user level have been defined in system level requirements. • The study for access path selection has been made. • Considering performance, the adjustment on the data model normalization has been made. • The study for selection of index has been made. • Communication with users has been conducted.	• Knowledge about target DBMS • Knowledge about selection of access path • Knowledge about adjustment method of normalization • Knowledge about selection of index • Knowledge about allocation of disk space	• Ability to think out the stability of system • Ability to dig down the limit of target DBMS

		(7) Physical allocation of data • At determination of the physical allocation of the database, alternate database, distribution of disks, and storage sequence have been studied and written in documents. • Knowledge about data utilization characteristics (8) Security design • The design has been made to satisfy the corporate security policy and user requests for security	• Knowledge about dual configuration of disk • Knowledge about how to secure the database security • Knowledge about access control	• Ability to analyze the concentration of data access • Ability to design a distributed data area and distributed log area • Ability to evaluate the operation efficiency of the database • Ability to correlate the security requirement and access control • Ability to grant privilege appropriately
4-3	Implementation	• The definition has been made in accordance with the database definition sequence, and the process has been written in documents. • The original data of the data object has been collected or generated in conformity with corporate rules. • The conversion to target data format has been made and the information concerned has been written in documents. • The data converted to the use specification has been loaded in target environments	• Knowledge about the database definition through SQL • Knowledge about the design method of the data object • Knowledge about data conversion	• Ability to implement or direct the definition of the database on target DBMS • Ability to collect original data and convert them to target data format • Ability to check data models and database items

4-4	Test and migration	• The corporate test criteria and the procedure have been written in documents. • The test application and data have been created in consistent with the aims and scope of the database. • The test has been conducted in accordance with the test criteria and delivery has been completed. • All results in the test have been written in documents without omission • Both user manuals and operation manager manuals have been prepared correctly and completely. • Documents have been distributed and kept in custody in accordance with the corporate standard procedure. • Manuals have been changed or revised if necessary and the notice has been provided to related persons.	• Knowledge about the test method of the database • Knowledge about utilization of the test tool • Knowledge about the procedure when anything unusual is detected • Knowledge about the benchmark test • Knowledge about how to keep documents in custody and maintain them	• Ability to prepare test data • Ability to detect abnormal status • Ability to take counter measures against abnormal situation in cooperation with other engineers • Ability to indicate defects of the database and assess the influence to users • Ability to explain to related persons accurately if the defect with significant influence to users has been detected • Ability to prepare easy to read manuals completely and accurately

5. Operation management of the database system

No.	Task	Performance indicators	Required knowledge	Required skill
5-1	Operational plan of the database system	• The database operation plans consistent with the database implementation in terms of the aim and the scope for both long range and short range have been developed and written in documents. • The monitoring criteria in accordance with user's requests has been established and approved by users. • The policy for collection of monitoring data has been written in documents. • The monitoring plan has been explained to the administration and understood. • The enhancement plan of hardware, especially disks has been written in documents. • The system operation time, the maintenance schedule and the backup schedule have been established and written in documents. • The data security measures has been established and written in documents. • The database maintenance policy has been established and written in documents. • The user support policy has been established and written in documents. • The operation management policy has been explained to users and approved.	• Knowledge about the monitoring method • Knowledge about the monitoring tool • Knowledge about hardware maintenance • Knowledge about the additional installation of hardware • Knowledge about backup recovery • Knowledge about system monitoring • Knowledge about securing performance • Knowledge about data integrity • Knowledge about data security	• Ability to formulate the system management policy taking budget into consideration • Ability to explain the operation management policy to users and to get understanding • Ability to understand the importance of monitoring • Ability to enumerate abnormal situation • Ability to think out the stable system operation • Ability to propose countermeasures against abnormal situation • Ability to make the installation plan of additional resources

5-2	Operation and maintenance of the database system	• Monitoring data have been collected without delay and analyzed without omission. • The system halt time has been minimized. • Abnormal status has been grasped properly and written in documents. • Abnormal status has been reported to the staff in charge of operation management and the appropriate countermeasures against abnormal condition have been taken. • The whole countermeasures against unsuitable status of database system have been written in documents. • The necessary standards have been properly established and the necessity to conform with them has been explained. • The status has been improved through the conformity with the standards. • The application engineers have been urged to conform to the standards. • The maintenance of database applications has been made properly. • The standards have been written in documents and updated if necessary.	• Knowledge about the collection method of monitoring data • Knowledge about utilization of monitoring tools • Knowledge about the analysis method of monitoring data • Knowledge about OS(Operating System) • Knowledge about the effect by software update • Knowledge about database applications • Knowledge about establishment of standards	• The ability to analyze monitoring data • The ability to describe precisely and correctly the analyzed details in documents • The ability to take appropriate measures at detection of abnormal conditions • The ability to determine appropriate time for software update. • The ability to establish an utilization rule for a new application. • The ability to monitor the status of conformity with the standards and to promote the improvement. • The ability to prepare the document of standards • The ability to explain that the deviation from the standards may cause the degradation of performance and maintainability • The ability to determine to abolish the standards which no longer corresponds to the actual status.
5-3	Management of the database system	(1) Preservation of integrity • The plan to preserve the integrity has been set up. • The defect of integrity was detected and the countermeasures have been taken and the details have been described in documents. (2) Preservation of physical structure of data object • There is no response lag to degrade the database efficiency • The countermeasures against the fragmentation of the database are implemented at any time. • The physical structure of data has been updated in accordance with user's requests.	• Knowledge about data model • Knowledge about database application	• The ability to analyze the report of query • The ability to analyze user's requests, implement a solution, and evaluate the effect.

		(3) Backup recovery management • The backup recovery has been planned and approved by operation managers. • The back up recovery has been implemented periodically. • The measures to make the system halt time minimum have been described in documents. (4) Management of requests for physical resources • The physical resources have been defined correctly and completely and described in documents. • The resources have been used appropriately and the requests for performance have been satisfied. • The issues on the use of resources have been grasped accurately and proper measures have been taken. • The trend analysis of requests for the resources has been made and written in documents. (5) Measures against the database audit • Appropriate materials have been prepared for the database audit. • In accordance with the recommendation made by a system audit officer, appropriate improvement measures have been presented. • Through the implementation of improvement measures, the defects have been rectified.	• Knowledge about system environment • Knowledge about backup recovery • Knowledge about the limitation of physical resources • Knowledge about capacity • Knowledge about the measurement method of resource utilization status • Knowledge about database applications • Knowledge about system audit • Knowledge about database audit procedure	• Ability to explain backup status to users and to get understanding • Ability to measure the utilization of resources • Ability to grasp the usage trend of resources accurately • Ability to forecast the expansion of resources usage • Ability to judge the necessity to enhance the resources • Ability to identify the abnormal usage of resources • Ability to explain the operation management status of the system to a system audit officer accurately • Ability to understand the audit criteria and to take countermeasures to the audit
5-4	Performance tuning	• Performance plan has been described in documents. • In order to improve performance, data models and DBMS parameters have been modified properly. • The causes of performance degradation and the improvement measures have been described in documents. • Tuning is not limited to specific users. • In the process of performance tuning, communications have been made with users at any time, and the tuning has been approved by users.	• Knowledge about performance design • Knowledge about table design • Knowledge about index design • Knowledge about physical allocation • Knowledge about disk access • Knowledge about performance improvement examples	• Ability to identify the reasons of performance degradation • Ability to apply past improvement examples as a performance tuning measures • Ability to ascertain that no negative impact resulted by the implementation of tuning • Ability to judge the necessity to enhance the device

5-5	User support	(1) Offering of database development environment and support for utilization • The database application development standard has been established and informed to the persons concerned. • The support for the utilization of development environment has been provided effectively. • The development environment has been written in documents correctly and concisely. (2) Offering of database utilization environment • The data model has been changed without hindrance on the users job operation. • Sufficient tests have been conducted for the change of the database system. • The improvement of utilization efficiency has been proposed. (3) Development and implementation of users education and training plan • A plan of education and training corresponding properly to the users skill level has been developed and written in documents. • The environment to satisfy the requests of user education and training has been designed and prepared. • The continuous education, training and support to users have been provided. • The training schedule has been set at the time of the highest preference in user requests. (4) A survey for the additional users requests • Additional requests have corresponded to the change of user needs • Additional requests have been written in documents and compared with the current specifications. • The new transaction needs have been identified and included. • The requests have been analyzed continuously and appropriate proposals have been made.	• Knowledge about DBMS • Knowledge about OS • Knowledge about the database applications • Knowledge about the development of the database • Knowledge about user applications • Knowledge about the operation of software by users • Knowledge about how to put forward the users training • Knowledge about collection of the requested information • Knowledge about how to analyze the request items	• Ability to establish or revise the development standards of the database and the database application • Ability to get to grips with the improvement of convenience of database application development engineers in concrete form • Ability to minimize the users impact caused by the change of data models • Ability to develop a plan to provide education, training and support, depending on users capability in the operation of software • Ability to evaluate users skill and reflect the results in the details of training • Ability to analyze users training process • Ability to analyze users needs for training and to take countermeasures • Ability to represent users needs into system technology requirements • Ability to make an appropriate explanation against an erroneous user's requests

4. Body of Knowledge

In the body of knowledge for technical engineers (database), the knowledge, which is needed to perform the key activities described in the preceding chapter successfully and to solve various problems is divided into groups according to technical and problem-solving concepts, and is classified in a hierarchical structure. Hereupon, the various problems may include the diversification and complexity of needs, the increase of operation management costs, and how to cope with the emerging technology.

The body of knowledge required for technical engineers (database) consists of the following two kinds:

1) IT common body of knowledge
2) Practical body of knowledge and core body of knowledge for technical engineers (database)

The "IT common body of knowledge" in 1) is not limited to technical engineers (database), but it is necessary for examinees of all examination categories. It is therefore provided in a separate volume. For details, refer to the "Information Technology Engineers Skill Standards: IT Common Body of Knowledge."

By consulting "Information Technology Engineers Examinations: Scope of Examinations," we can know that technical engineers (database) are tested for knowledge at the following technical level in five fields of the IT common body of knowledge:

"II. Computer Systems (level II)"
"III. System development and operation (level II)"
"V. Database technology (level III)"
"VI. Security (level II)"
"VII. Standardization (level II)"

In 2) "Practical body of knowledge and core body of knowledge for technical engineers (database)," knowledge included in "practical body of knowledge" is classified into four fields: "B Development and management of the database system" which is the most important field for technical engineers (database) to exhibit their capability, "C Important technology for development of the database system" where the problem-solving capability is required, "D Peripheral technology of the database," and "E Related technology trend." In "the core body of knowledge," the theories required for technical engineers (database) in constructing the mission critical database systems by RDBMS are selected and arranged in "A Outline of database system."

[Practical body of knowledge and core body of knowledge for technical engineers (database)]

Knowledge field	Major classification	Intermediate classification	Minor classification
A. Outline of database system			
	1. Outline of relational database system (RDB) utilization		
		1.1 Basic structure of RDB system	
			1.1.1 System catalog (information on cataloging the relational table)
			1.1.2 Relational table
			1.1.3 Data dictionary (Information for contents of each table and alteration career)
			1.1.4 Database language
			1.1.5 Data life cycle
		1.2 Related persons in construction of RDB system and their roles	
			1.2.1 Data administrators
			1.2.2 Data modeling engineers
			1.2.3 Database design and construction engineers
			1.2.4 Database operation engineers
			1.2.5 Database administrators
	2. Basic functions of relational database management system (RDBMS)		
		2.1 System catalog preservation function	
			2.1.1 Self description for database
			2.1.2 System catalog preservation method (via DDL)
		2.2 Retrieval and store functions of relational table	
		2.3 Interpretation function of requests for database utilization (SQL)	
			2.3.1 Interactive mode utilization (QBE, command line)
			2.3.2 Utilization by programs (general-purpose language, database language)
		2.4 Recording function of database utilization	
		2.5 Database backup/recovery function	
		2.6 Integrity preservation function	
	3. Relation model		
		3.1 Relational modeling technology	
			3.1.1 What can be made by relational model
			3.1.2 What relational model will do?
		3.2 Relational model elements	
			3.2.1 Relation (table)
			3.2.2 Attribute (column, field)
			3.2.3 Tuple (row, record)
			3.2.4 Domain
			3.2.5 Degree
			3.2.6 Cardinality
			3.2.7 Relational key (main, super, candidate, external)

		3.3 Integrity (conformity) rule	
			3.3.1 Entity integrity 3.3.2 Referential integrity 3.3.3 Domain integrity 3.3.4 User defined integrity
		3.4 Normalization	
			3.4.1 The meaning of normalizationv 3.4.2 The advantage of normalization 3.4.3 The functional dependence and use of key in normal form 3.4.4 Normal form description methods: first normal form - third normal form, Voice.cod normal form, fourth normal form, fifth normal form)
		3.5 Relationship in relational model	
			one-to-one relation, one-to-many relation, many-to-many relation
		3.6 Data manipulation	
			3.6.1 Relation algebra (union, difference, product, cartesian product, selection, projection, join, quotient) 3.6.2 Relational operation (Tuple-oriented, Domain-oriented)
		3.7 View	
			3.7.1 The meaning of view in relational model
		3.8 RDBMS implementation rule	
			3.8.1 Basic rule 3.8.2 Structural rule 3.8.3 Integrity rule 3.8.4 Data manipulation rule 3.8.5 Data independence rule

Knowledge field	Major classification	Intermediate classification	Minor classification
B. Development and management of the database system			
	1. Preparation for designing of the database		
		1.1 Data model classification	
			1.1.1 Conceptual data model (ER model) 1.1.2 Logical data model (relational model, network model, hierarchical model)
		1.2 RDBMS functions	

			1.2.1 Database definition function 1.2.2 Data manipulation function 1.2.3 Transaction support function 1.2.4 Simultaneous execution control function 1.2.5 Recovery function 1.2.6 Security function 1.2.7 Integrity management function 1.2.8 Database management function 1.2.9 Utility function (performance measurement and tuning, data load/unload) 1.2.10 Application development support function (stored procedure, trigger)

		1.3 System catalogs	
			1.3.1 The meaning of system catalogs 1.3.2 The contents of system catalogs 1.3.3 A data dictionary 1.3.4 Meta data
		1.4 Information resource dictionary systems (IRDS)	
			1.4.1 The meaning of IRDS (the necessity of IRDS, data dictionary/directory and IRDS) 1.4.2 Standardization of IRDS
		1.5 Information resource management (IRM)	
			1.5.1 The importance of information resource management 1.5.2 Information resource management and enterprise model 1.5.3 Information resource management and data resource management
		1.6 Repository	
			1.6.1 The role of repository 1.6.2 The functions and characteristics of repository 1.6.3 CASE tools and repository 1.6.4 The role of technical engineers (database) in repository management
	2. Whole plan of the database		
		2.1 Database plan of the whole corporation	
			2.1.1 The information utilization strategy of whole corporation (in accordance with the computerization plan and the information plan of whole corporation, the long range DB plan, the short range DB plan) 2.1.2 Securing the optimization as a whole (the balance of whole systems, the global optimization, and the consolidation of maintenance)
		2.2 Standardization of the data definition	
			2.2.1 Code design rules 2.2.2 The consistency of data, the definition of data items (data name, the meaning and role of data, domain, data representation forms, data constraints, and data dictionary)
	3. Requirement definition of the database		
		3.1 The survey of current status and the analysis of issues	
			3.1.1 The survey and analysis of current status (data tables of current systems, the usage of each relation, off-line operations, and requests for database utilization) 3.2.2 The analysis of issues
		3.2 Determination of the work scope	
		3.3 Design requirements of the database (requirements definition documents: initial stage)	
			3.3.1 Data requirements (types of data (numeric values, characters, graphic forms, image, voice), data size and volume) 3.3.2 Integrity requirements
		3.4 Operation management requirements of the database (requirements definition documents: initial stage)	

			3.4.1 Data access requirements 3.4.2 Performance requirements 3.4.3 Security requirements 3.4.4 Platforms requirements 3.4.5 Operation requirements (monitoring plan, operational environment)

	4. Preparation of conceptual data model		
		4.1 The concept of ER model	
			4.1.1 Entity (type, instance, strong entity, weak entity) 4.1.2 Attribute (simple attribute, complex attribute, singlevalued attribute, mulitvalued attribute, derivation attribute, candidate key, main key, and complex key) 4.1.3 Relation (types, attribute, free degree) 4.1.4 Data constraints (Identifier constraint, form constraint, reference constraint, existence constraint, multi-level constraint, derivation constraint, relation constraint, update constraint, and process sequence constraint) 4.1.5 Generalization 4.1.6 Specialization 4.1.7 Super-type 4.1.8 Sub-type 4.1.9 Business rule 4.1.10 Notation of ER model
		4.2 Approach of data analysis/modeling	
			4.2.1 Top-down approach 4.2.2 Bottom-up approach 4.2.3 Mixed approach
		4.3 Conceptual data modeling (including design of new application)	
			4.3.1 Identification of entity, identification of key, identification of entity related 4.3.2 Identification of business rule 4.3.3 Validation of consistency between data model and business process
		4.4 Verification of conceptual data models jointly with users	
	5. Preparation of logical data models		
		5.1 Conversion to logical data models	
			5.1.1 Conversion from conceptual data model to logical data model (conversion rules) 5.1.2 Extraction of relations from logical data models 5.1.3 Designing of basic index 5.1.4 Designing of view 5.1.5 Normalization 5.1.6 Defining the constraints of integrity
		5.2 Verification of logical data models	
	6. Selection and installation of DBMS		
		6.1 Determination of type of the database (RDBMS, OODBMS)	
		6.2 Selection of DBMS	
			6.2.1 Documentation of necessary items for selection (linkage to application systems, functions, performance, security, space efficiency) 6.2.2 Making a list of candidate products for selection 6.2.3 Preparation of product rating criteria and a score table
		6.3 Installation of DBMS	

	7. Designing the physical database (designing physical structure in advance to the implementation to target DBMS)		
		7.1 Verification of physical environment (main memory, CPU, disk I/O, network)	
		7.2 Transaction analysis	
			7.2.1 Utilization requirements (data volume, utilization of data (frequency of transaction occurrence, transaction operation, sequence, concurrent access, view) 7.2.2 Specifying the critical process (mission critical systems, information systems) 7.2.3 Specifying the bottleneck process (number of access, frequency of update, access path)
		7.3 Database design requirements (requirements definition document: middle stage)	
			7.3.1 Physical requirements (DB file size, update log file size, growth of file) 7.3.2 Operation requirements (throughput, response time, integrity, backup/recovery, operation form)
		7.4 DBMS functions and constraints	
			7.4.1 DBMS functions (data compression, I/O method between AP, exclusive control unit, and recovery method) 7.4.2 Available data structure (structured type DB, two-dimensional table, and nested relation) 7.4.3 Limitation (number of table, number of item, record length, number of record, and number of index)
		7.5 Designing the architecture	
			7.5.1 Selection of centralization or distribution 7.5.2 Centralized database 7.5.3 Distributed database
		7.6 Converting to target DBMS	
			7.6.1 Field design (data type selection, data compaction, and data integrity) 7.6.2 Selection of access path 7.6.3 Unnormalization 7.6.4 Selection and use of index (index creation (main key, clustering, secondary key), use time of index) 7.6.5 Calculation of required disk space volume (Space (catalog, table, index, log file, and work file), (trade-off of performance and required space)
		7.7 Lock	
			7.7.1 Locking level (database, table, block/page, record, and field) 7.7.2 Types of lock (sharing, exclusive use)

		7.8 Performance adjustment	
			7.8.1 Efficiency improvement trade-off (memory efficiency, access efficiency, CPU time, file access by concurrent processing (RAID processing))
			7.8.2 Application performance adjustment (optimum design of query, access path adjustment, full implementation of conformity with application development rules)
			7.8.3 Physical allocation of data (1) Disk space allocation (block size, extent, free space, data segment, index segment, temporary segment, rollback segment) (2) Determination of alternate database (3) Distribution to multiple disks (4) Examination of sequence of the stored data
		7.9 Designing security	
			7.9.1 Addition of users and groups, and granting of role and privilege
	8. Implementation to RDBMS and test		
		8.1 Defining database (Create Database, Create Tablespace)	
		8.2 Defining table (Create Table)	
		8.3 Defining view (Create View)	
		8.4 Defining index (make RDB to select the access path in order to speed up the access: Create Index)	
		8.5 Defining the authorization (GRANT ON TABLE)	
		8.6 Loading the data	
			8.6.1 Migration of data (data extraction, data conversion) 8.6.2 Loading the data
		8.7 Test and evaluation	
			8.7.1 Database test and evaluation 8.7.2 Performance adjustment 8.7.3 Verification of security and integrity 8.7.4 Verification of backup and recovery 8.7.5 Access to database
		8.8 Preparation of user manuals and DBMS operation manager manuals	

	9. Operation and management of database system		
		9.1 Operation plan of database system	
			9.1.1 Verification of operation policy (Operation criteria at normal time, operation criteria at abnormal time) 9.1.2 Determination of monitoring object and monitoring mode of database system 9.1.3 Database system management plan (Performance, failure/recovery, security, integrity, user education and training, and maintenance)
		9.2 Operation and maintenance of the database system	
			9.2.1 Collection and analysis of monitoring data (performance monitoring, failure monitoring, security monitoring) 9.2.2 Continuous activities for the stable operation 9.2.3 Database maintenance (database re-organization, review of security view and authentication, and maintenance of documents) 9.2.4 Statistics of database system operation (collection, analysis, and proposal of improvement measures) 9.2.5 Enlightenment about the conformity to the operation standards and improvement of standards 9.2.6 Correspondence to the database system audit
		9.3 Management of database system	
			9.3.1 Management of data dictionary and repository 9.3.2 Maintenance and management of data integrity (Integrity between records, reference integrity) 9.3.3 Management of database object physical structure (guarantee of data access without delay) 9.3.4 Backup and recovery (sequence, journal (audit trail), check point) 9.3.5 Deadlock management (centralized, distributed) 9.3.6 Concurrency control (sequencing possibility, locking, timestamp, optimistic approach) 9.3.7 Data security management (privacy, security, access control, view, authentication rules)
		9.4 Performance tuning	
			9.4.1 Coding check of SQL sentences 9.4.2 Review of table design 9.4.3 Improvement of index 9.4.4 Improvement of physical allocation 9.4.5 Enhancement of devices
		9.5 User support	
			9.5.1 Implementation of users education and training 9.5.2 Identification of requests after the operation

	10. SQL		
		10.1 Database language	
			10.1.1 The requirements of the database language 10.1.2 The types and characteristics of database language (data sub-language (data definition language, data manipulation language), host language, interactive language)
		10.2 Outline of SQL	
			10.2.1 Characteristics of SQL 10.2.2 The basic language element of SQL
		10.3 Database definition	
			10.3.1 Creation of database (CREATE DATABASE) 10.3.2 Creation of table (CREATE TABLE) 10.3.3 Creation of data integrity 10.3.4 Alteration of table definition (ALTER TABLE) 10.3.5 Separation of table (DROP TABLE) 10.3.6 Definition of index (CREATE INDEX) 10.3.7 Separation of index (DROP INDEX) 10.3.8 Definition of view (CREATE VIEW) 10.3.9 Separation of view (DROP VIEW) 10.3.10 Separation of index (DROP INDEX)
		10.4 Data manipulation	
			10.4.1 Process of single table 10.4.2 Process of multiple tables 10.4.3 Change data 10.4.4 Definition of data attribute (type: character, bit, numeric value, date, and interval)
		10.5 Integrity control	
			10.5.1 Definition of domain (CREATE DOMAIN) 10.5.2 Expression (CREATE ASSERTION)
		10.6 Trigger and procedure	
			10.6.1 Definition of trigger (CREATE TRIGGER)
		10.7 Type of SQL issue	
			10.7.1 Interactive SQL 10.7.2 Embedded SQL sentences 10.7.3 API
		10.8 Standardization of SQL	

Knowledge field	Major classification	Intermediate classification	Minor classification
C. The important technology in database system development			
	1. Distributed database		
		1.1 Distributed database concept	
			1.1.1 The meaning of distributed database (Requests for improvement, constraints, functional objective)
			1.1.2 The definition of distributed DBMS
			1.1.3 The characteristics of distributed DBMS
			1.1.4 The classification of distributed DBMS (Homogeneous distributed DBMS, Heterogeneous distributed DBMS)
			1.1.5 The distinctive functions of distributed DBMS
			1.1.6 The merits of distributed DBMS
			1.1.7 The demerits of distributed DBMS
			1.1.8 Date's 12 rules distributed DBMS
		1.2 Data distribution strategy	
			1.2.1 Fragmentation
			1.2.2 Allocation of data
			1.2.3 Distribution of data dictionary
		1.3 Distributed query processing	
			1.3.1 Fragmentation of query
			1.3.2 Data migration
			1.3.3 Optimization of query
		1.4 Distributed transaction management	
			1.4.1 Reliability
			1.4.2 Security
		1.5 Distributed database recovery	
			1.5.1 Faults in distributed environment
			1.5.2 The influence of fault to recovery
			1.5.3 2 phase commit (2PC)
			1.5.4 3 phase commit (3PC)
		1.6 Replication	
			1.6.1 Functions and advantages
			1.6.2 Timing (Synchronous replication, and asynchronous replication)
		1.7 Transparency of distributed DB	
			1.7.1 Location transparent
			1.7.2 Fragmentation transparent
			1.7.3 Replication transparent
			1.7.4 Transaction transparent
			1.7.5 Failure transparent
			1.7.6 Concurrency transparent
			1.7.7 Performance transparent
			1.7.8 DBMS transparent

	2. Database security		
		2.1 Understanding of security policy	
			2.1.1 Database security viewed from security policy
			2.1.2 Data security level (Most important, important, attention, option)
		2.2 Database security measures	
			2.2.1 Access controls to users (use of password, etc.)
			2.2.2 Access control by program (limitation of SQL commands included in programs)
			2.2.3 Control of table access (set up of user view, etc.)
			2.2.4 Access control to functions and operations (set up the authorization to use functions by target resources)
			2.2.5 Encryption/decoding of external storage data
	3. C/S systems and DBMS		
		3.1 Multi-users database environment	
			3.1.1 File server architecture
			3.1.2 C/S architecture (database server architecture, merits of C/S architecture, three tired architecture)
		3.2 Large scale database and parallel computing architecture	
			3.2.1 SMP (Symmetric MultiProcessing)
			3.2.2 MPP (Massively Parallel Processor architecture)
		3.3 The role of middleware	
		3.4 The issues of C/S for TE (DB)	
			3.4.1 Grasp of business needs accurately
			3.4.2 Analysis of architecture
			3.4.3 Realization of scalability
			3.4.4 The scope of service and support
			3.4.5 Provision of intelligence to database (stored procedure, trigger)
			3.4.6 Network analysis capability
			3.4.7 Total cost

Knowledge field	Major classification	Intermediate classification	Minor classification
D. The database peripheral technology	1. Data warehouse	1.1 The meaning of data warehouse	1.1.1 New type of query to database (New needs for utilization of database in information systems)
			1.1.2 Information resources to provide advantages in competition
			1.1.3 The limit of current database system and data warehouse
		1.2 The quality of data warehouse	
		1.3 OLTP and data warehouse	
		1.4 The configuration of data warehouse	
		1.5 The applications of data warehouse	1.5.1 Executive information system (EIS)
			1.5.2 Decision support system (DSS)
			1.5.3 Analysis work by atypical questions
		1.6 Basic concept of data warehouse (definition by Inmon & Hackthon in 1994)	1.6.1 Subject oriented
			1.6.2 Integrated
			1.6.3 Time variant
			1.6.4 Nonvolatile
		1.7 The architecture of data warehouse	1.7.1 Operational data and data for atypical inquiry
			1.7.2 Data warehouse and data mart
			1.7.3 The characteristics of meta data and the utilization
			1.7.4 Report generation tool
			1.7.5 Multidimensional database
			1.7.6 Online analytical processing (OLAP)
		1.8 Designing of data warehouse	1.8.1 Request analysis and request definition
			1.8.2 Modeling technology (star schema, snowflake schema, multidimensional modeling, and meta model)
			1.8.3 Generation of high level data model (high level ERD)
			1.8.4 Determination of the end user requested report
			1.8.5 Generation of logical data model
			1.8.6 Mapping from logical data models to physical data models
		1.9 Preparation of implementation	1.9.1 Estimate of disk storage capacity
			1.9.2 Determination of the processor
			1.9.3 Maintenance plan of meta data
			1.9.4 Distribution of data (location, split, replication)

		1.10 Data warehouse configuration	
			1.10.1 Extraction of data from source data 1.10.2 Conversion of data 1.10.3 Maintenance of data integrity
		1.11 Taking measures for the performance issue	
			1.11.1 Optimization of storage 1.11.2 Optimization of query
		1.12 Data warehouse management	
			1.12.1 Maintenance of data warehouse
	2. Online analytical processing (OLAP)		
		2.1 The meaning of online analytical processing	
			2.1.1 The merits of OLAP 2.1.2 The limitation of OLAP 2.1.3 The comparison of OLTP and OLAP (the difference of OLAP from a standard reporting tool)
		2.2 The multidimensional database (MDD)	
			2.2.1 Manipulation of multidimensional data
		2.3 Online analytical processing	
			2.3.1 Multidimensional OLAP and tool (MOLAP) 2.3.2 Relational OLAP and tool (ROLAP)
		2.4 Logic design of OLAP	
			2.4.1 Analysis of users requests and environment 2.4.2 Definition of cube, dimensions, hierarchy, and link 2.4.3 Define number of dimension 2.4.4 Define the aggregation method and the derivation method
	3. Data mining		
		3.1 The meaning of data mining	
			3.1.1 The advantage of data mining 3.1.2 The usage of data mining
		3.2 Data mining tools	
			3.2.1 The evaluation of the data mining vendors 3.2.2 The five categories of data mining tools (connection, sequence, classification, cluster, estimation)
		3.3 Data mining technique (discovery of rules, processing of signals, neural net, and fractal)	
		3.4 Data mining applications	

	4. Object oriented and database		
		4.1 Utilization of object oriented technology	
			4.1.1 Object oriented (Encapsulation (separation of package, abstract data type, class, interface), inheritance (single inheritance and multiple inheritance), polymorphism : overloading of methods, overriding and dynamic binding), object identification, relation and multiple level)
			4.1.2 Development of object oriented system. (spiral system development (repetition of analysis, design, implementation, and evaluation based on the same model), object oriented analysis and design (UML, OMT method, Booch method))
			4.1.3 Object oriented program language (C++, Java, and Smalltalk)
		4.2 Object oriented system development and database	
			4.2.1 Object oriented analysis based design and database design (data central design and object oriented design (in structured design: from data central design to object oriented design), ER chart and class chart (in data modeling technique: ER chart to class chart)
			4.2.2 Correspondence of object models and relational models (mapping table and class, addition of object identification data, representation by coupling of inheritance and aggregation)
			4.2.3 Program language and database (object oriented program language and SQL, making object in RDBMS flat and reconstruction)
			4.2.4 Merit of object oriented database management system (Affinity between object oriented models and program language)
	5. Internet and DBMS		
		5.1 Application service through Web	
			5.1.1 Dynamic Web page
			5.1.2 DBMS access from Web server (utilization of CGI, utilization of Web server extended API, utilization of Servlet and JSP)
			5.1.3 Three tiered architecture (three tiered system (Presentation tier, logic tier, data tier), encapsulation of data base access by application server (EJB, session management, transaction management))
			5.1.4 Utilization of XML
		5.2 Database access in Web application	
			5.2.1 Access to RDBMS by JDBC
			5.2.2 Access to OODBMS utilizing Java API of database
		5.3 The issues of Web application utilizing database	
			5.3.1 Session management (stateless HTTP protocol)
			5.3.2 Session termination not explicitly (timeout management, transaction termination)
			5.3.3 Authentication and security management (connection pooling, replication by multi database server)
			5.3.4 Performance improvement

Knowledge field	Major classification	Intermediate classification	Minor classification
E. The related technology trend			
	1. Object oriented database		
		1.1 The characteristics of Object oriented database management system (OODBMS)	
			1.1.1 Object oriented data model (object oriented data model (complex object, computational completeness, expandability), object model (model and class (class defines implementation)), object status (attribute and relation (property)), object behavior (manipulation), object model hierarchy (upper model and lower model, inheritance, class hierarchy)
			1.1.2 Persistence (Orthogonalization of persistence and model (one persistence to orthogonalize model, and the other persistence to subordinate to model), persistent object and temporary object (persistent extent, persistency with achievability), identification of persistent object (independence of position, value, and structure))
			1.1.3 Function as database management system (secondary storage management (clustering), concurrent processing (transaction and lock, deadlock, log and commit/abort, two phase commit, long time transaction, version management), failure recovery (dump and load, log rerun, replication), schema evolution)
		1.2 The architecture of OODBMS	
			1.2.1 OODBMS and programming language (integration of programming language and persistence (programming language binding (C++, Java, Smalltalk)), programming language and independent persistent object model manipulation language (object definition language, object query language)
			1.2.2 Store of manipulation in database (database schema and application schema)
		1.3 Standardization of OODBMS (ODMG 2.0)	
			1.3.1 ODMG object model
			1.3.2 ODL (Object Definition Language)
			1.3.3 OQL (Object Query Language)
		1.4 Comparison of OODBMS and RDBMS	
			1.4.1 Analysis based design and data model
			1.4.2 Application construction and performance
			1.4.3 Standardization trend

		1.5 OODBMS application area	
			1.5.1 CAD/CAM/CIM 1.5.2 Multimedia database 1.5.3 Document database 1.5.4 Knowledge database 1.5.5 GIS
		1.6 OODBMS products	
			1.6.1 The characteristics of typical products and the architecture
		1.7 The future trend of OODBMS	
			1.7.1 Consolidation with the object oriented system framework 1.7.2 The distributed database in Internet environment 1.7.3 The interoperability with RDBMS
	2. Object relational database		
		2.1 The characteristics of object relational database management system (ORDBMS)	
			2.1.1 The function of relational database 2.1.2 Expandable data type 2.1.3 The support of inheritance 2.1.4 Expanded query
		2.2 Standardization of ORDBMS (SQL3)	
			2.2.1 User defined type and user defined function 2.2.2 Inheritance and polymorphism 2.2.3 Inquiry 2.2.4 Object identification and reference type 2.2.5 Aggregate type 2.2.6 Trigger 2.2.7 Large object
		2.3 ORDBMS application area	
			2.3.1 Multimedia application
		2.4 The comparison of ORDBMS and OODBMS	
			2.4.1 Level of integration with programming language 2.4.2 SQL3 and OQL
		2.5 ORDBMS products	
			2.5.1 The characteristics of typical products and architecture

	3. ERP and database		
		3.1 ERP outline	
		3.2 Database of ERP	
			3.2.1 The difference between operational database and data model of ERP
			3.2.2 The difference between operational database and database of ERP
		3.3 Difference analysis between existing database and database of ERP	
	4. EC and database		
		4.1 EDI and database	
			4.1.1 Commodity database
			4.1.2 Customer database
			4.1.3 Standardization of EDI by XML
			4.1.4 Distribution innovation and database (ASP, SCM, CRM, and CRP)
		4.2 Electronic commerce and database	
			4.2.1 Commodity data catalog
			4.2.2 Commodity image information and network business

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