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STUDY ON INTELLIGENT DECISION SUPPORT SYSTEM OF RAILWAY EMPTY WAGON DISTRIBUTION IN CHINA

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Abstract: Railway in China is a very complicated and large scale network system. In 2002 the Ministry of Railway of China made a decision to develop a R&D project of Intelligent Decision Support System for the Railway Empty Wagons Distribution plan (REWD-IDSS). This paper, combining the practical R&D project of REWD-IDSS, adopts technological principles and methods of IDSS to develop analysis and research of detail on overall design, implementation method, and systematic prototype development, etc. It develops a goal system of tertiary management mode in which are included the Ministry of Railways, Railway Administration and Railway branch Administration, puts forward the principles proposed which obey decision-making process and performance law in real vacant adjusts plan management coordinate with supported decision-making in overall process of vacant adjusts etc, and selects a structure with parts of problem processing subsystem, database subsystem, model subsystem, knowledge subsystem, and human-computer interaction subsystem, etc.

Key words: Railway empty wagons distribution, Intelligent Decision Support System, System Prototype development

0. INTROUDUCTION

Railway in China is a very complicated and large scale network system with 12 railway administration, more than 50 railway branch administration, 70 thousand kilometers operation lines, near 6000 stations and more than 500 thousand wagons. It takes more than 70 percent of transportation turnover in freight all over the country. How to make a reasonable and scientific railway empty wagons distribution plan is a key subject to be resolved, according to the characteristic of the railway transportation in china. For this reason, in 2002 the Ministry of Railway of China made a decision to develop a R&D project of Intelligent Decision Support System for the Railway Empty Wagons Distribution plan(REWD-IDSS). This paper, combining the practical R&D project of REWD-IDSS, adopts technological principles and methods of IDSS to develop analysis and research of detail on overall design, implementation method,

and systematic prototype development, etc.

1. THE GENERAL DESIGN TARGET AND DEVELOPMENT PRINCIPLE OF REWD-IDSS

The general target, under the environment of TMIS information net work and FMOS data source, is to provide the Intelligent Decision Support System for the timely distribution of empty wagon and assurance of loading job being finished, meeting the needs of transport adequately to realize the efficient exercise of whole railway wagon in China. And to build up REWD-IDSS appropriating to the tertiary management mode for the Ministry of Railways, Railway Administration and Railway branch Administration. The system have the ability to produce plan for empty wagon distribution, to adjust plan of human-machine interaction, to manage and express the output of various information, and also to have the function counting and analyzing the main comprehensive evaluation index in each plan, such as the empty wagon walking-distance, the utilization ratio of empty wagon, bottleneck of route, discharge rate in intersection. All of this aiming at offering modernized tool for scientific decision in the plan and adjustment for the exercise of empty wagon.

The basic principles include obeying the rules both in decision-making process and performance law in real vacant adjusts plan management for tri-grade organization, coordinate between technical plan decision and the external environment condition system of TIMS&FMOS, supported decision-making in overall process of forecasting loading source, vacant adjustment, assignment of route-discharge, plan-working and evaluation of program, fully reflecting intellectual decision support, or reflecting that of system and policymaker integrating, etc.

2. DESIGN AND IMPLEMENT THE OVERALL STRUCTURE OF REWD-IDSS MODEL

2.1 The overall structure of REWD-IDSS model

REWD-IDSS system has picked up the presently mature construction of IDSSII, namely DSS & solution unit of problems & the model structure of Knowledge-base. See Figure 1 and 2.

2.2 Design And Implement The Subsystem Of Model Database

There are various models of REWD-IDSS, in accordance with real needs in constructing REWD-IDSS system, we mainly divide the model into mathematics model, data process model, diagram process model and intelligent process model, etc. Math model for the empty wagons distribution: Comprehensive optimal model and algorithm for macroscopic control of loading resource, wagons flow prediction model, empty wagons demand creation model, optimizing model and algorithm of Multi-objective for empty wagons distribution, optimizing model and algorithm of Multi-objective for empty wagons flow distribution. Data process model for the empty wagons distribution: Extraction and transform process model for original data of TMIS (Transportation Management Information System of Railways) and FMOS (Freight traffic Management Operation System of Railways), data process model for empty wagon walk-distance ratio, utilization ratio, work-load evaluation index and assignment index for route flux. Diagram process model: Process model for human-machine interchange graphic display

and planning report. Intelligent process model: Knowledge-restriction-based optimal model and algorithm for intelligent decision-making of empty wagons distribution, RGA-based optimal model and algorithm for intelligent flow assignment.

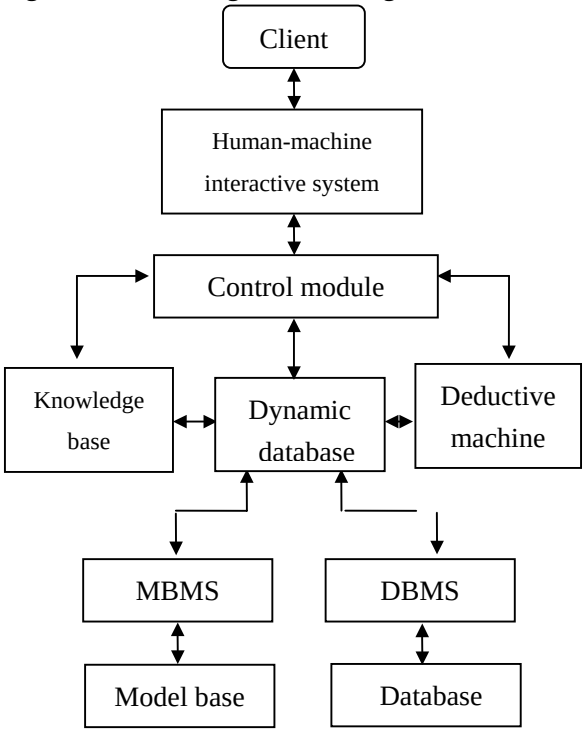

Figure 1 The overall structure of REWD-IDSS

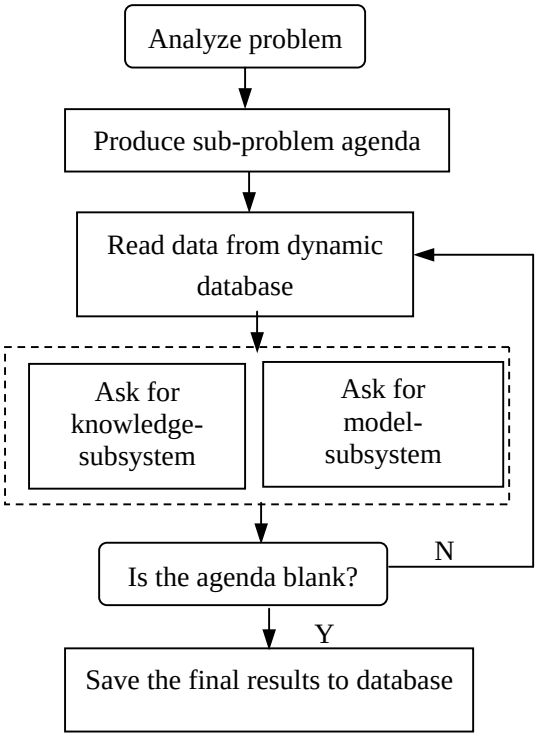

Figure 2 The control process of control module

Model database of REWD-IDSS has adopted the storage and design method of categorized unit model. Figure 3 shows the implemented structure of subsystem's model database.

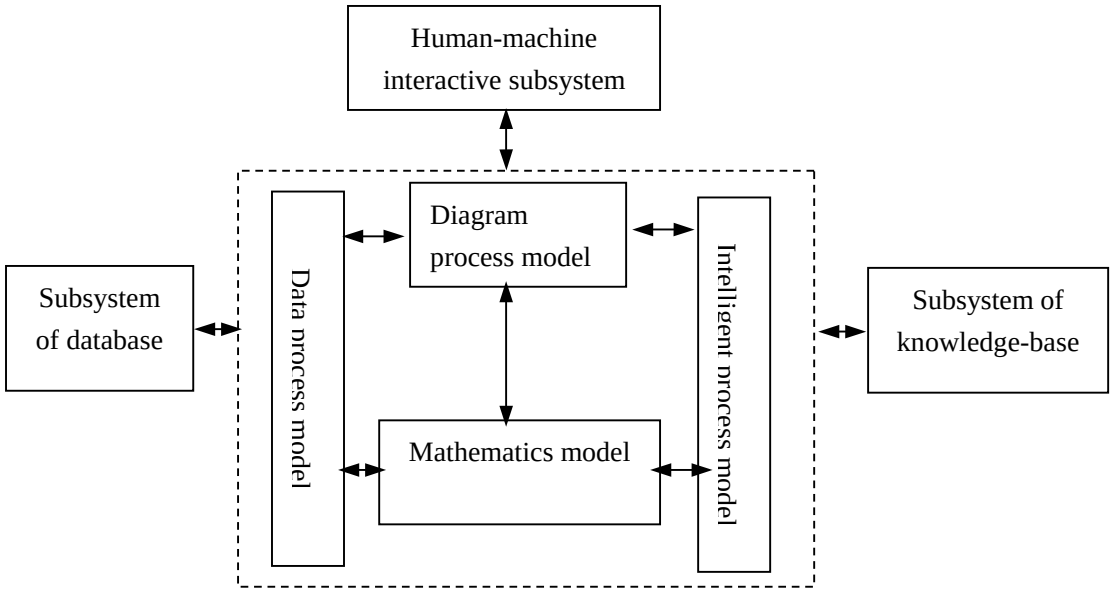

Figure 3 The implemented structure of model database subsystem of REWD-IDSS

The mathematics model in REWD-IDSS adopts the methods of programming (software model) and realizes with C++ or PASCAL so that we can take full advantage of the superiority in speed. The data handle model realized with Oracle database adopts the method of data structure. The intelligent model

adopts the methods of call process. The exiting model developed would be directed used.

2.3 Design and implement the subsystem of knowledge base

The arrangement of knowledge for empty wagon distribution is showed in Figure 4.The statement knowledge mainly include some concepts and facts, such as consignor, the Railway Transport Department, route, wagon, etc. The process knowledge mainly contain policy of domestic transport adjustment and various technical institution, various rules and control orders for empty wagon distribution, like replacement of wagon type, stand-by wagon, the exercise of decomposed wagon, the utilization of wagons for special purpose, demanding on not existing convection and junction, transport in the shortest route, which are relative to the organization of wagon flow. Besides there are also the rules for wagons flow incorporate calculate in section, the expert and precedent knowledge of empty wagon distribution.

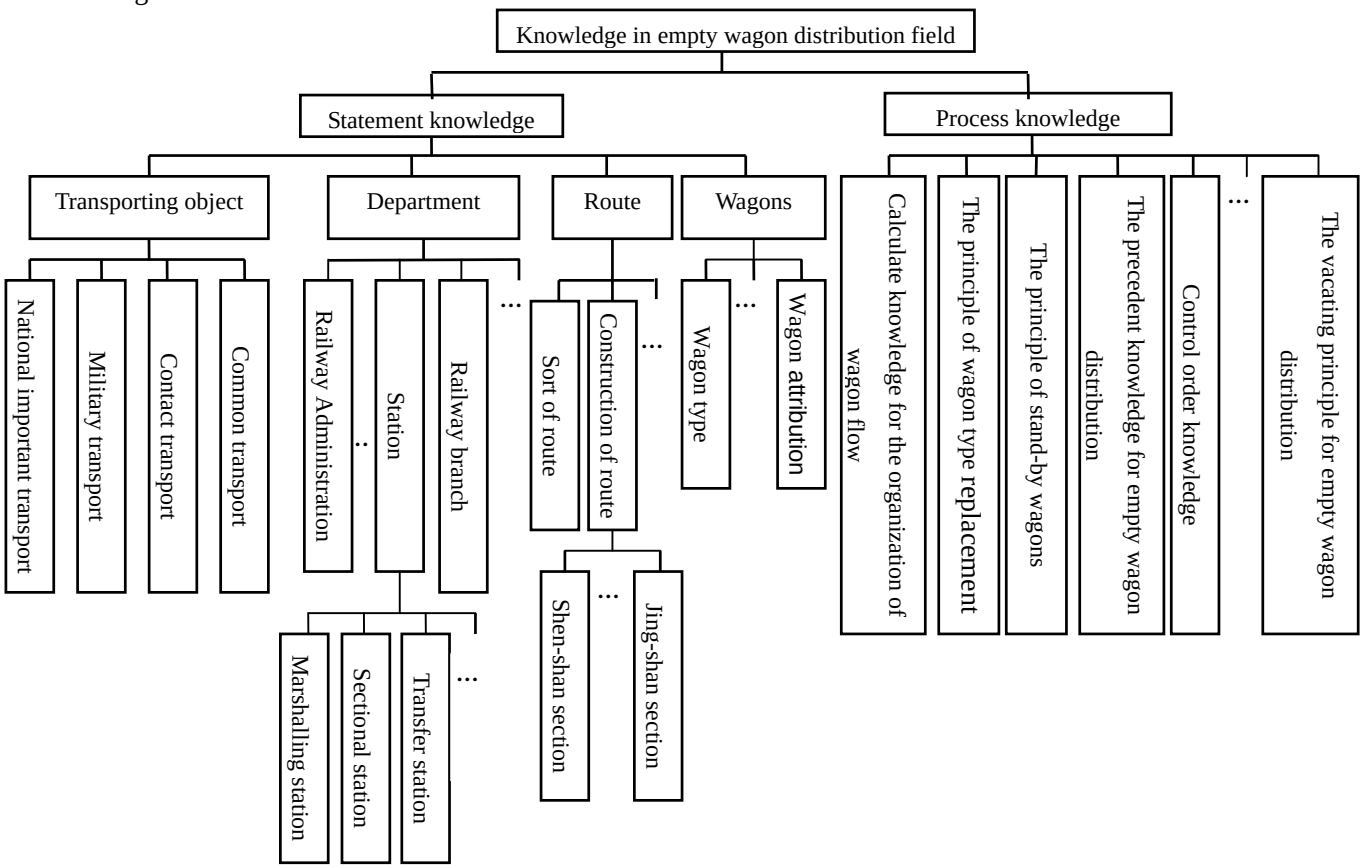

Figure 4 The knowledge of arrangement in empty wagon distribution field

The implementing structure of the subsystem of knowledge database for empty wagons is showed in Figure 5, which mainly includes the deductive mechanism, knowledge getting module and knowledge-base. By using the data, function model and knowledge, it can assist making decision intelligently for empty wagon distribution problem, with emphasis on the solution for semi-structural or nonstructural problems.

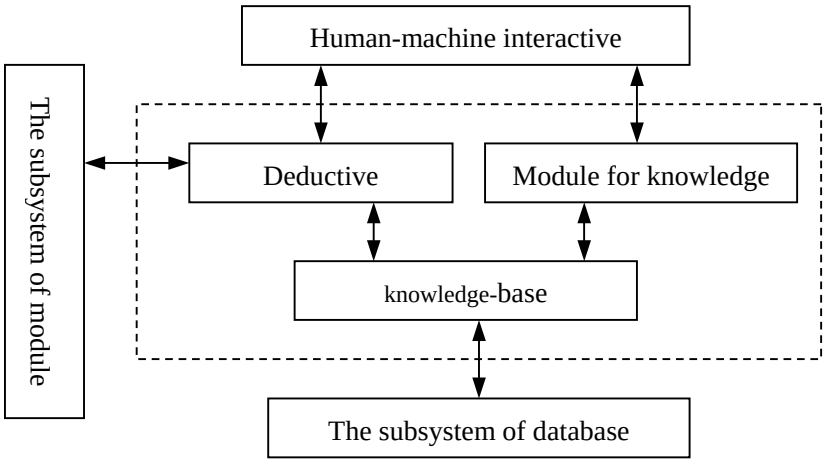

Figure 5 The implementing structure of knowledge-base's subsystem

The establish of REWD-IDSS knowledge repository is adopted the method of knowledge-base, and use the definition of C++ which may derive many sub class according to the category of station. The knowledge of station class with C++ is represented below:

REWD-IDSS

```
class station {                          //Definition of station
    protected:
        char Name [10];                   //Name of station
        char NameCode [3];                //Code of station
        char Manage1 [10];                //Railway Administration
        char Manage2 [10];                // Railway Branch Administration
        char Rank [1];                    //Rank of station
        char line [10]                    //Name of line
        int   number                      //Index Number of station
  public:
        Station ();                       //Constructor function
        ~Station ();                      //destructor function
        Assign ();                        //assign
        Read ();                          //read
        Display ();                       //display

         };
```

The Station class in the represented method is base class, whose member data has attribute such as the name, code, index number of station etc. The constructor function Station() initialize the new object, including the memory allocation, member assigned etc. The destructor ~Station() may clean memory and release object. The member function Assign(), Read(), Display() represent the operation of the object.

The design and establish of REWD-IDSS deduction machine are depended on the mixed deduction method combing the positive and reverse deduction and the search strategy with prototype knowledge.

2.4 Design and implement subsystem of database

The implementing structure of database's subsystem for REWD-IDSS is showed in Figure 6. The database of REWD-IDSS is a two-graded database. All of the data from original database, generally, isn't input into the database of REWD-IDSS, however, we in accordance with real need input it. The original database is the large-size database of TMTS & FMOS system. There are great many of relative data documents, such as wagon, train, time table of train, exit of division-bureau, the amount of loaded

and unloaded wagons, the direction of loaded wagons and plans for demand on wagons.

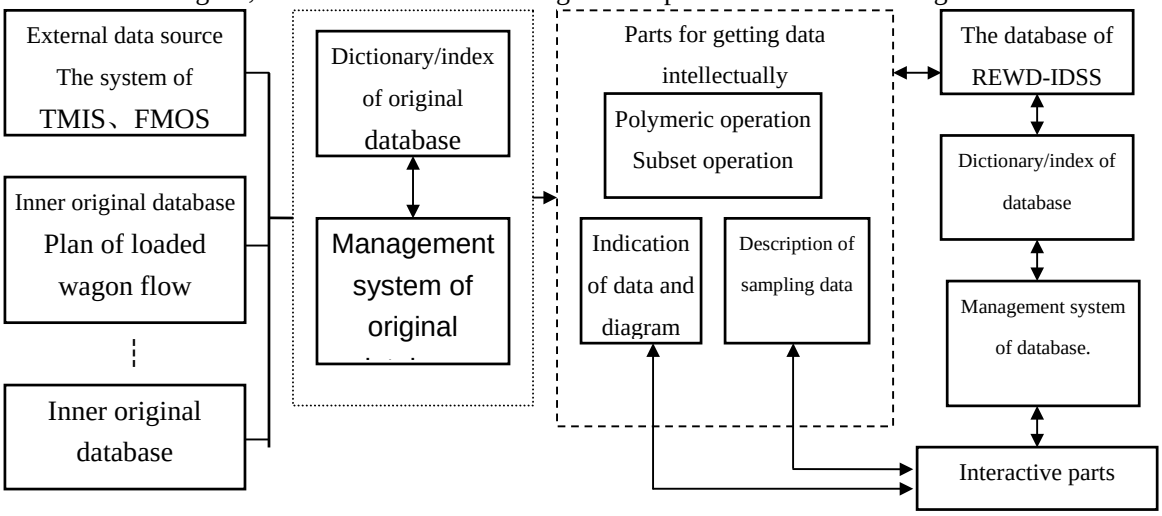

Figure 6 The implementing structure of database subsystem

The basic component part in implementing REWD-IDSS database is showed in Figure 7. Basic database reserves basic data which is directly input or intellectually got from TMIS&FMOS and from management information system for technical planning, meeting the needs of empty wagon distribution. Programmatic database reserves data including program automatic-produced, the middling results and program revised by customers. The reasoning database stores all kinds of dynamic data that are provided during the empty wagons distribution decision-making reasoning. The plan database saves the data which include auto-formed plan, the middle results and the user amending plan and so on. The reasoning database stores all kinds of dynamic data that are provided during the empty wagons distribution decision-making reasoning. Model-dictionary database save the management information of every model of the model database. Data-dictionary database is the set of general dictionaries for the empty wagons distribution such as ministry dictionary, administration dictionary, branch administration dictionary, station dictionary and so on.

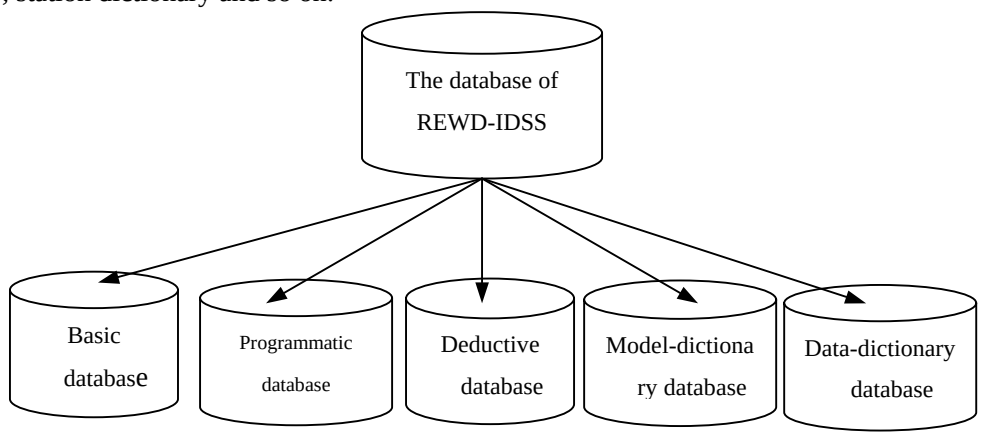

Figure 7 The basic component part of database

REWD-IDSS database's structure of table is below:

①Data structure of authorizing plan

```
ID              VARCHAR2(10)   primary key,   /*main key*/
Pyc_id          VARCHAR2(10),                 /*mark key*/
LWDW            VARCHAR2(15)   NOT NULL,      /*Department*/
```

```
 NYSLH          VARCHAR2(14)  NOT NULL,      /*date number*/
XH              VARCHAR2(1)   NOT NULL,      /*index number*/
FZ              VARCHAR2(3),                 /*starting station code*/
DZ              VARCHAR2(3),                 /*arriving station code */
CZ              VARCHAR2(1),                 /*category of car*/
PZCS            NUMBER,                      /*number of approving plan*/
PZDS            NUMBER,                      /*number of approving ton*/
PM              VARCHAR2(7),                 /*name*/
YSTZ            VARCHAR2(2),                 /*characteristic*/
FZHZZM          VARCHAR2(10),                /* starting station name */
DZHZZM          VARCHAR2(10),                /* arriving station name */
FJ              VARCHAR2(3),                 /* starting station code */
DJ              VARCHAR2(3),                 /* arriving station code */
FJM             VARCHAR2(12),                /*starting station name*/
DJM             VARCHAR2(12),                /*arriving station name*/
HZPM            VARCHAR2(20),                /*name of product*/
HZPL            VARCHAR2(20),                /*class of product*/
PZYCFH          VARCHAR2(11),                /*number of approve/
CLBZ            VARCHAR2(1),                 /*flag of car   */
FFJ             VARCHAR2(3),                 /*code of starting administration*/
DFJ             VARCHAR2(3),                 /* code of arriving administration */
RC              NUMBER,                      /*number of day*/
YS              NUMBER,                      /*left number*/
Yxxbz           VARCHAR2(1),                 /*null or 1：validate，0：invalidate */
Bz              VARCHAR2 (20)                /*remark*/
②Data structure of load and unload of station
ZDM             VARCHAR2(3),                 /*station code*/
HZZM            VARCHAR2(20),                /*station name*/
FJDM            VARCHAR2(3),                 /*branch administration code*/
LJDM            VARCHAR2(1),                 /*administration code*/
CZ              VARCHAR2(2),                 /*category of car*/
ZCS             NUMBER,                      /*load number*/
XCS             NUMBER,                      /*unload number*/
ZXC             NUMBER,                      /* last number*/
BZ              VARCHAR2(20)                 /*remark*/
③Data structure of load and unload of railway station
JM              VARCHAR2(6),                 /*administration name*/
CZ              VARCHAR2(6),                 /*category of car*/
ZCS             NUMBER(6),                   /*number of load*/
XCS             NUMBER(6),                   /*number of unload*/
ZXC             NUMBER(6)                    /*last number*/
④Data structure of table of empty car
ZDM             VARCHAR2(3),                 /*station code*/
```

```
HZZM        VARCHAR2(20),          /*station name*/
FJDM        VARCHAR2(3),           /*branch administration code*/
LJDM        VARCHAR2(1),           /* administration code */
CZ          VARCHAR2(2),           /*category of car*/
CS          NUMBER(6),             /*number of car*/
CRBZ        VARCHAR2(1),           /*flag*/
BZ          VARCHAR2(20)           /*remark*/
⑤Data structure of routing information of empty car
JLBH        VARCHAR2(7),           /*number of routing*/
FFJDM       VARCHAR2(3),           /*branch administration code*/
FZDM        VARCHAR2(3),           /*station code*/
FJDM        VARCHAR2(3),           /*administration code*/
DFJDM       VARCHAR2(3),           /* branch administration code */
DZDM        VARCHAR2(3),           /*station code*/
DJDM        VARCHAR2(3),           /* administration code */
BZ          VARCHAR2(20),          /*remark*/
QCLC        NUMBER(6),             /*total length*/
BS          VARCHAR2(1)            /*own car 0 car 1*/
⑥Data Structure of initial table
ZDM         VARCHAR2(3),           /*code*/
HZZM        VARCHAR2(20),          /*station name*/
FJDM        VARCHAR2(3),           /*branch administration code*/
LJM         VARCHAR2(1),           /*administration code*/
CZ          VARCHAR2(2),           /*category of car*/
CS          NUMBER(6) ,            /*number of number*/
CRBZ        VARCHAR2(1),           /*flag*/
BZ          VARCHAR2(20)           /*remark*/
```

2.5 Design and realization of the human-machine interactive subsystem

According to the basic demands of REWD-IDSS system construction, REWD-IDSS system will face three kinds of users. The first one is developer and maintainer who are mainly composed of computer technology persons. They update and maintain database, model database and knowledge database through the human-machine interactive subsystem (interface). The second is developer of model and algorithm tool with REWD-IDSS. They construct models of all units, simulate analysis of arithmetic, and amend parameter through the human-machine interactive subsystem (interface). The third one is final users who are main policy-makers of program workout for the empty wagons distribution in ministry, administration, branch administration. They do practice operation for the empty wagons distribution through the human-machine interactive subsystem (interface).

The configuration of realization of the human-machine interactive system for the REWD-IDSS is showed in the Figure 8. For ministry and administration, it was developed by the technology based on Web browser. For branch administration, there are two kinds of design methods of the human-machine interactive system for the REWD-IDSS. The first one is based on browser. The second one uses the interface design function of Delphi 6.0 and adopts the dialogue method that combines menu technology

and the function of input and output.

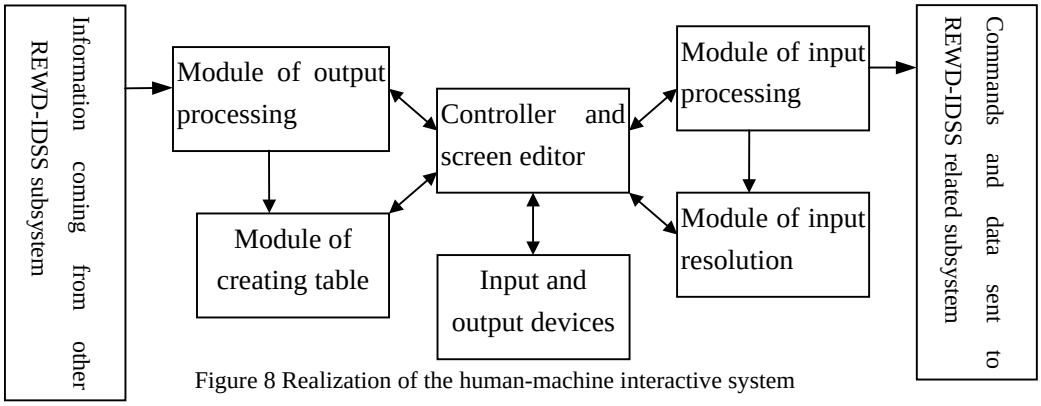

Figure 8 Realization of the human-machine interactive system

3. ANALYSIS OF THE DEVELOPMENT OF SYSTEMATIC PROTOTYPE OF THE REWD-IDSS

The TMIS system of China railway is based on the X.25 protocol, which connects the administration, branch administration, and department of railway. It has central Server , ORACLE data system, and 2200 information dots, which may provide exact and completed dynamic information in time including car, engine, container etc. FMOS system is based on the TMIS, which constituted unite shipper, unite station, branch administration, administration, and railway department, whose function is to sustain product management of freightage plan including data collected and car flow plan and data exchanged and finishing analysis and statistic.

REWD-IDSS system developed under the TMIS and FMOS is a DDS, whose function is sustain product manage of railway plan including establishing three grade plan of railway department, administration and branch administration and exchanging data and analyze plan etc.

REWD-IDSS system which is showed in the Figure 9 selects a system structure which is composed of client / server (C/S) and browser / server (B/S). The structure of C/S may use independent hardware and many kinds of different system platform. It offers open interfaces that make the expansion and maintenance of system easier and assure the security and integrality of data. The structure of B/S is convenient to the release of information and browse and download of the related departments. It may be used for the exchange of a lot of information that are demanded for the empty wagons distribution plan of all level.

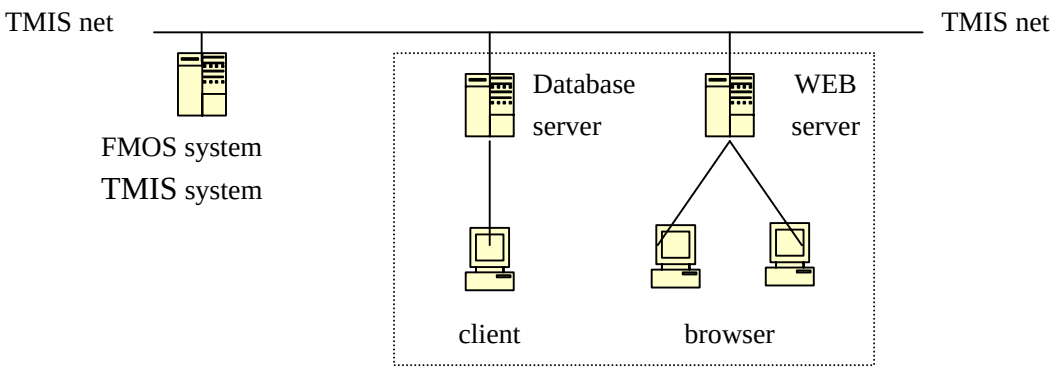

Figure 9 System structure of REWD-IDSS

3.1 Analysis Of Development Of The Empty Wagons Distribution Systematic Prototype Of Ministry Of Railways

The steps and contents of analyzing and developing in the empty wagons distribution systematic prototype of Ministry of Railways are showed in attached Figure 1.
The empty wagon distribution REWD-IDSS system use the mode of “evolution prototype development”, which make use of important technology:

The page structure of the empty wagons distribution system of Ministry of Railways is composed of sub-pages such as definition of center station, data maintenance , formation of initial plan, adjusting of the human-machine interactive system and function options such as exit and return. Design and realization of page is showed in attached Figure 2~ Figure 3.

3.2 Analysis Of Development Of The Empty Wagons Distribution Systematic Prototype Of Railway Branch Administration.

Analysis of development in systematic prototype is showed in attached Figure 4.There are main input and processing information such as route-basis information, wagons information, distribution section information, stand-by wagons information, control order information, wagons type replacement information, the empty wagons distribution plan delivered to dividing station by administration, workload plan and other index information.

The realization of branch system need establish database, rule information base and model base. The project is established as below: 1.intelligent attemperment order etc complicated problem; 2. imitating “empty wagon adjusted charm” and intelligent concluding balance flow; 3. making use of model and algorithm to realize network flow distribution and “window adjust” and “table modify” to realize project amending and explore to realize information exchange and plan distribution.
The interface of the human-machine interactive system for the REWD-IDSS includes nine functional options such as accepting the plan of Railway Administration, show of the plan of Railway Administration, definition of distribution section, creation of route, creation of plan, adjusting of the human-machine interactive system, output files from base, copying data, printing tables. Design and realization of page is showed in Figure 5~ Figure 8.

4. CONCLUSION

This paper combines the reality of the Chinese railway, does research on overall design, implementation methods of REWD-IDSS and the content of systematic prototype development. The research and development of systematic prototype has been finished, some research results have already been used, actual application system will be dropped into to use in 2006.

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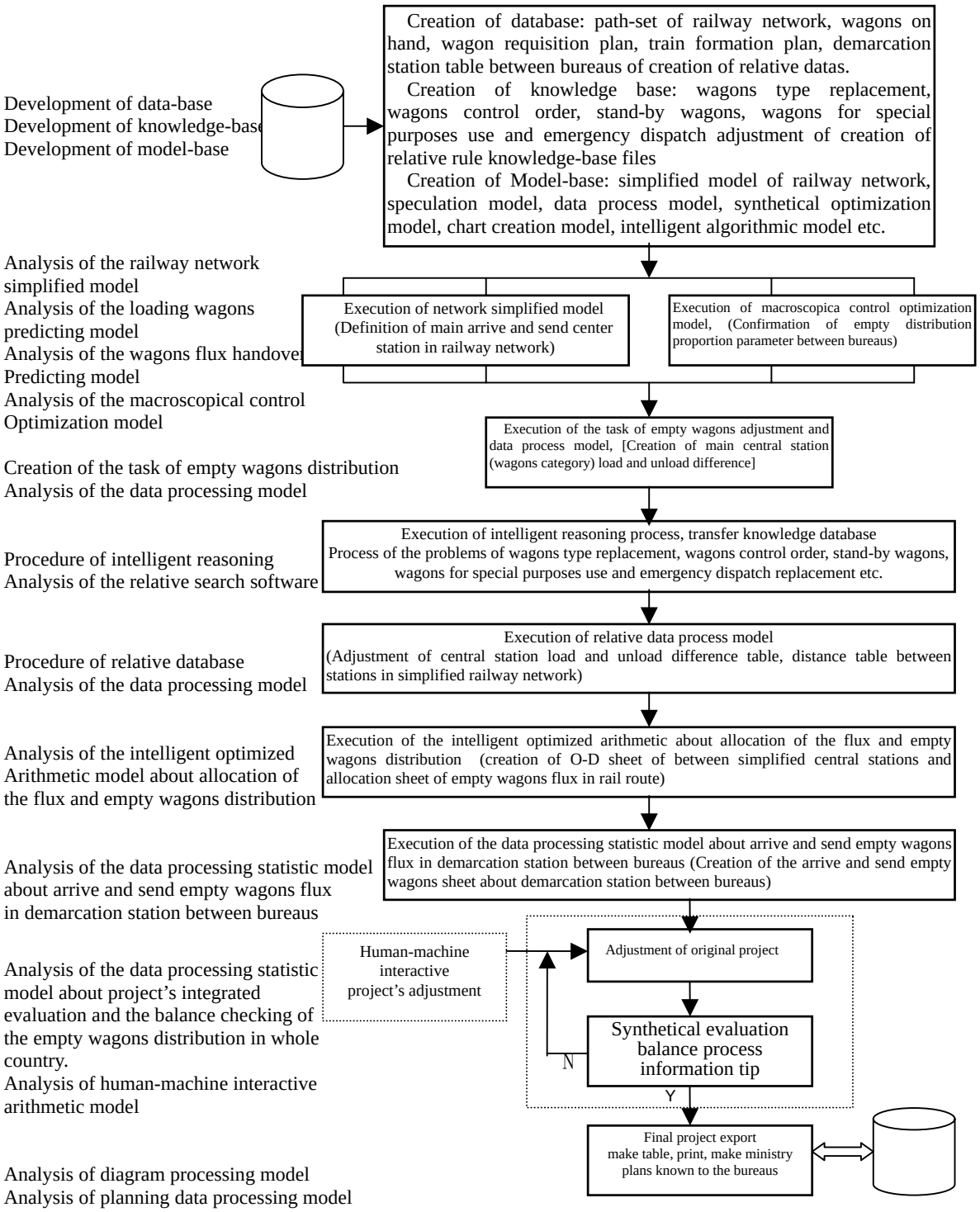
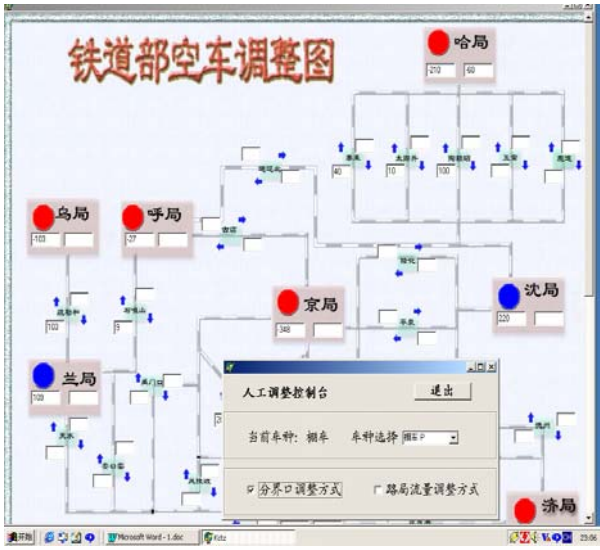
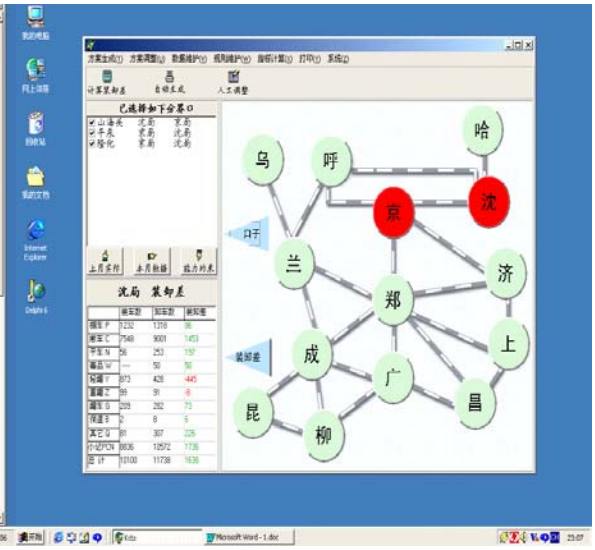


Attached Figure 1 Simulation analysis flow Figure of REWD-IDSS



Attached Figure 2 The Human-Machine Interface of REWD-IDSS



Attached Figure 3 Information of Ministry Plan

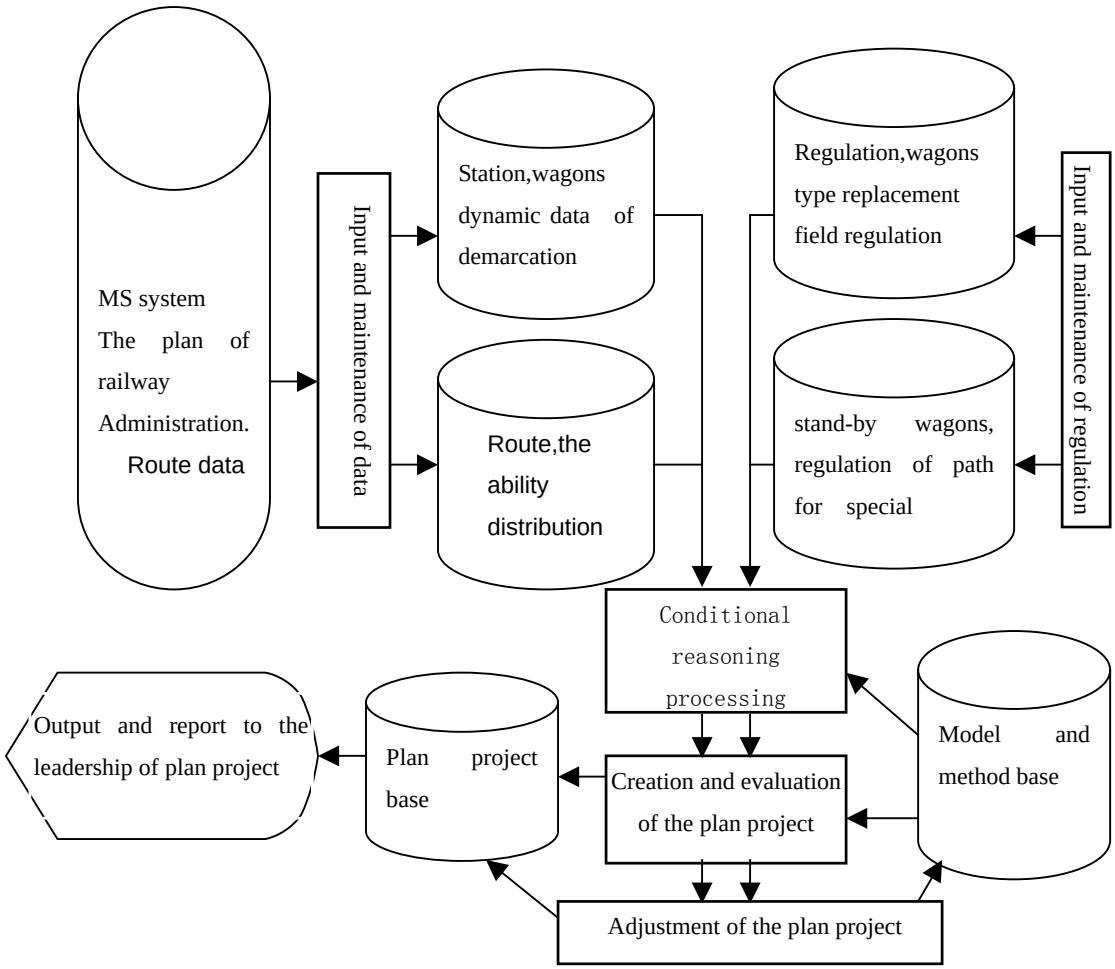
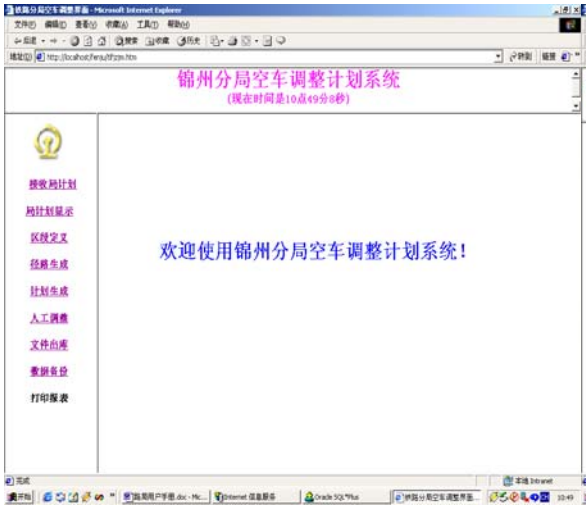


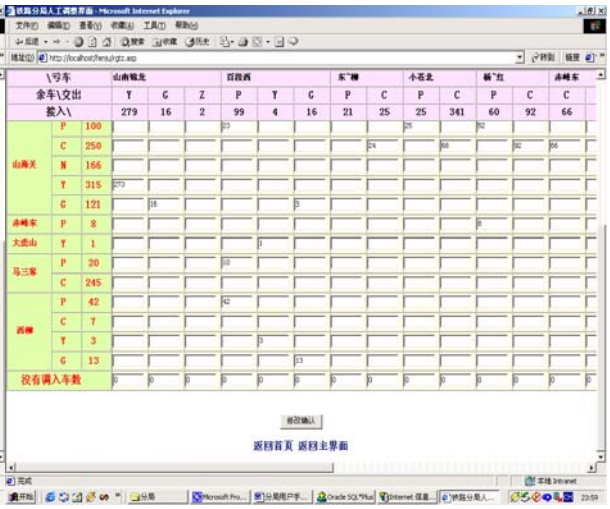
Figure 4 Flow Figure of analysis of the development systematic prototype of the Railway branch Administration.



Attached Figure5 Interface of Empty Wagon Adjust of Branch Administration

Attached Figure 6 Interface of Definition

Attached Figure 7 Interface of Plan Adjust Administration



Attached Figure 8 Interface of Information of Branch of Branch Administration