UNIFIED LANGUAGE SYSTEM FOR SOLVING PROBLEMS IN WORKPLACES - an INTEGRATED & INTERDISCIPLINARY STUDY -

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ABSTRACT (REQUIRED)

This paper describes analyzed working environment issues from statistics, ISO ergonomics standards and ecology of work theories in order to identify the requirements for the information system analysis and design, i.e., abstraction hierarchy with shift of languages, closed bottom up loop work system, etc.

These requirements are satisfied by a methodology called ULS (unified language system). As a base platform of Ecological Approach to Human Machine Systems, ULS is a theory with technique for translating business languages (manuals: natural language) into modeling language (systems language) i.e. DFDs (Data Flow Diagrams), ERDs (Entity Relationship Diagrams) and Mini-specs (Miniature specifications) which are ready to be fed to the programming language generation process.

Also, this study proposes successful integration of all the business systems related languages, i.e., natural/mathematical/logic languages, systems language and programming language in the form of unified language operating platform. It is concluded that the integration of business languages relying on ecological approach is promising to further enhance the worker oriented management systems theory and practice in the Web-based business world.

Keywords (Required)

System analysis and design, Computer Intelligence in Industrial Engineering, Information Systems, Unified Language System.

1 BACKGROUND

1.1 Statistics

The efficiency of business is based upon the accumulation of individual teamwork which should be synergetic. Therefore, team coordination and communication become important factors to design work systems. In many workplaces nowadays, however, the workers are treated with the stream from top to bottom directions as the open loop where they rarely express of their opinions and being stressed. Employees, therefore, become less loyal and motivated. Management as well are frustrated and they rely heavily on part timers who are not well-qualified. These caused, moreover, many problems and issues which should be taken care of immediately in terms of working environment. Significant issues are stated with statistics as following (Table.1).

Table 1. Employment Problems

(On all the companies and workers registered in Japan unless otherwise noted)

No.	Questionnaire	*Subjects*	Data	Source
1	*How many part timers working?*	***Company***	In 2007, non-regular employee (e.g. part time worker) occupied 30.1% of total employee in companies (more than 500 employees), increased by 6.6% comparing with year 2002.	**SB1**
2	*Why does your company increase part timers?*	***Company***	In 2006, companies with more than 1000 employees stated the reasons why they increased the number of non-regular employees as cost reduction (91.2%), reduction of training (56.2%), benefit of IT and manuals (41.7%)	**SL1**
3	*What kinds of skills are Required for employees?*	***Company***	2002 / 2007 / Dif. **Rationalization skill** 16.4 / 28.5 / **+12.1** Line job skill (general) 30.5 / 19.4 / **-11.1** Line job skill (assembly) 11.5 / 5.7 / **-5.8** Equip. maintenance skill 9.3 / 12.0 / +2.7 QA and testing skill 5.9 / 10.7 / +4.8	**SL2**
4	*The percentage of organized workers by in-house union?*	***Company***	Decreased steeply from 35.6% in 1955 to 18.1% in 2002	**MHLW1**
5	*Part time worker/ regular worker ratio*	***Company***	Japan 17.6% OECD 16.1% France 13.3% USA 12.6%	**OECD1**
6	*Years of service (average)*	***Company***	Japan 11.3 France 10.7 Germany 9.7 UK 7.8 USA 7.4	**OECD1**
7	*Loyalty to the company*	***Worker***	Higher than 3 years ago (16.2%), less (26.1%) and neither (51.7%).	**SL3**
8	*Reasons for less loyal to the company (unsatisfied with jobs)*	***Worker***	Not well paid (46.8%), evaluation system problem (35.6%), communication problem (24.2%), training and learning problem (21.1%), promotion problem 21.4%), etc.	**SL3**
9	*Reasons for less – incentive (than 3 years ago) for work*	***Worker***	Not well paid (43.4%), training and learning (career development) problem (32.6%), self realization and esteem problem (28.9%), social contribution problem (20.3%), etc.	**SL3**

No.	Questionnaire	*Subjects*	Data	Source
10	*Reasons of (first) resignation*	***Worker***	Male, tedium of work (35.8%), communication problem (20.9%), wage problem (19.3%), whereas female, 20.4%, 16.1% and 11.05, respectively.	**CO1**
11	*Which do you prefer free-time or high salary?*	***Worker***	Time 31.4% (1997) to 37.7% (2007), whereas high salary 49.2% (1997) to 44.7% (2007).	**CO2**
12	*Which do you prefer mental richness or physical richness?*	***Worker***	Mental 56.3% (1997) to 62.6% (2007), whereas physical 30.1% (1997) to 28.6 (200).	**CO2**

Source Indices:

SB1 "*Labour Force Survey2007*" **Statistic Bureau, Ministry of internal affaires and Communications**
SL1 "*Survey on Personnel strategy & the worker's consideration under diversified employment2006*" **Institute for Science of Labour**
SL2 "*The survey on workers' skill development and securing in manufacturing industries2008*" **Institute for Science of Labour**
SL3 "*The employee's consideration and problem of man-power management 2008*" **Institute for Science of Labour**
MHLW1 "*Labour Economics White Paper2008*"**Ministry of Health, Labour and Welfare**
OECD1 "*Employment Outlook2007*" **OECD**
CO1 "*Consciousness survey concerning the youth's social independence 2005*" **Cabinet Office, Government of Japan**
CO2 "*Public opinion poll concerning national life 2008*" **Cabinet Office, Government of Japan**

1.2 ISO6385 Focus Points

Most of the issues stated above concerning workplace difficulties, such as less loyalty and low motivation of workers, managements' frustration and shift to the part timers who are not well-qualified, etc. are derived from the relatively common idea that "workers are mechanisms." (see Figure1based on Saito(1998) which was originally an excerpt from the draft of ISO6385) ISO6385 stresses the importance of the shift from mechanical to environmental perspective in terms of workers in working environment (see Figure2 also an excerpt from the draft of ISO6385).

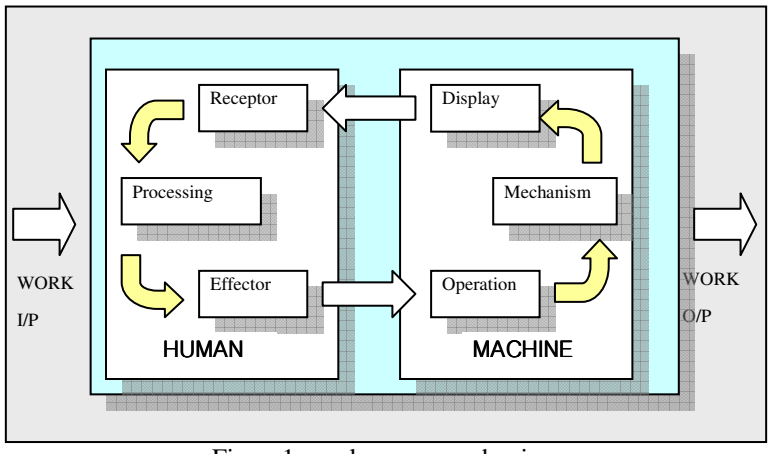

Figure1, worker as a mechanism

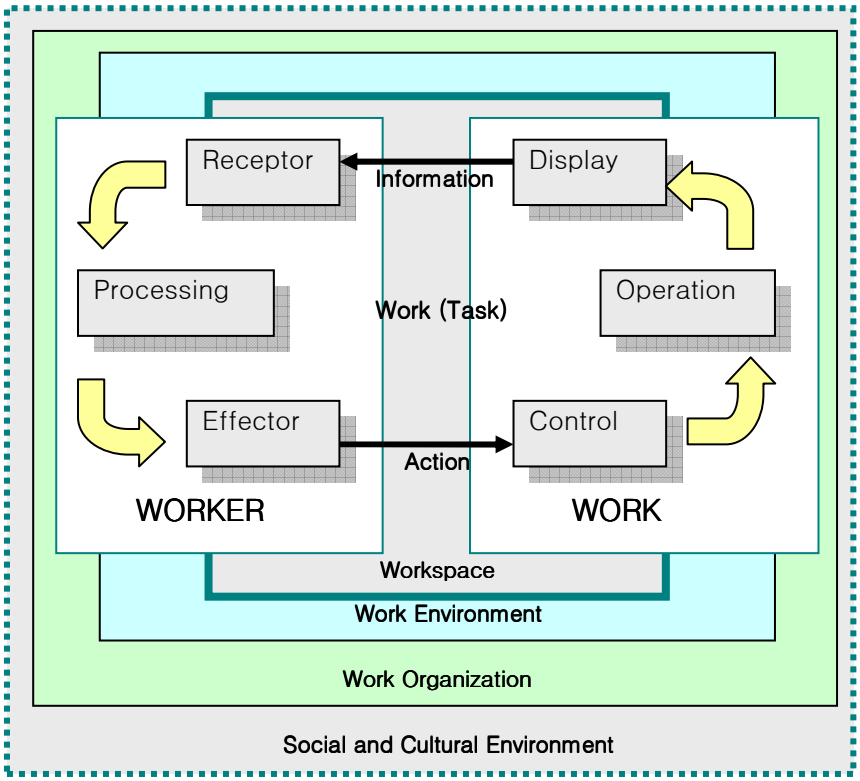

Figure2. worker as a system

ISO6385 also asserts points to be considered as follows:

1) Optimal working conditions: Imbalance between human ability and job demand should be eliminated by adjustments between "fitting the job to the worker" and "fitting the worker to the job" parameters (Figure3)

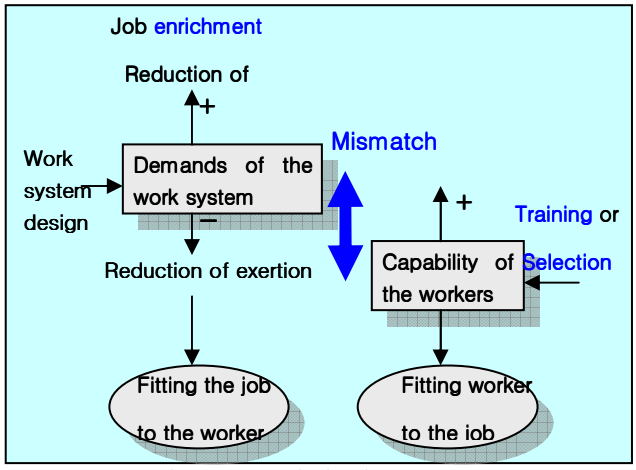

Figure 3. Optimization process

2) Workers' involvement in the systems development from design stage in the following terms:
1 task design: promote task performance
2 design of work space: postural stability and postural mobility
3 interface design: physical/mechanical & cognitive aspects
4 design of work environment: physical, chemical, biological conditions
5 job design: for work process design, job enlargement, job enrichment, voluntary job rotation
6 work organization: along with job design, managing tele-work

7 social and cultural environment

3) work system evaluation parameters in terms of:
1 health and well-being-physiological, psychological and subjective
2 safety-reliability, errors, unsafe behavior, near-miss
3 performance-quality, quantity

2 ECOLOGICAL SYSTEMS DESIGN (RASMUSSEN)

To solve problems stated above, Rasmussen asserted 3 layered human cognitive behavior, (i.e., skill-based, rule-based and knowledge-based, known as SRK) with 5 layered workplace abstraction hierarchy (i.e. purpose and values, flow of mass (energy, information, people, etc.), general work activities and functions, physical functions, physical form (space layout) (see Flach et al. 1995 in detail). Upper layers are the purpose of the lower layers(Figure 4ab). Lower layers are, in contrast, means of accomplishing the upper layers' ends. Thus the idea of Rasmussen can be characterized by two-axis layer system of "SRK" and" means-ends" hierarchy.

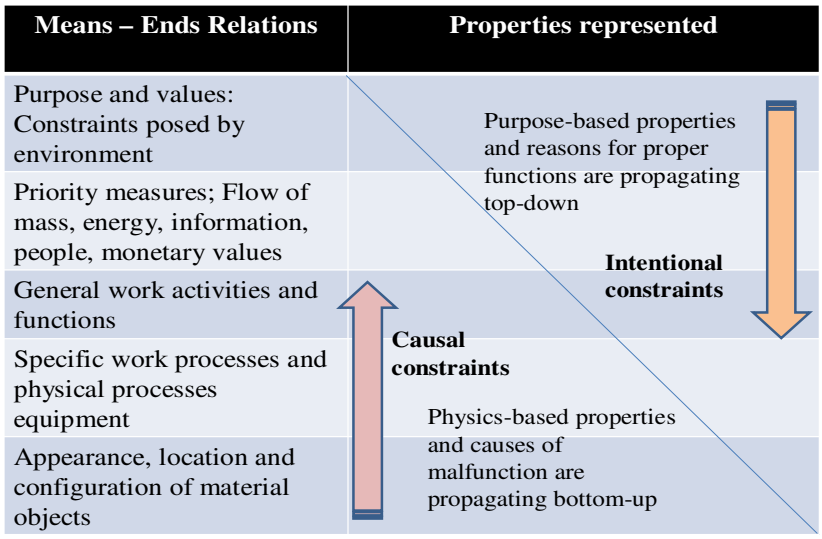

Figure 4a. Means-Ends Hierarchy

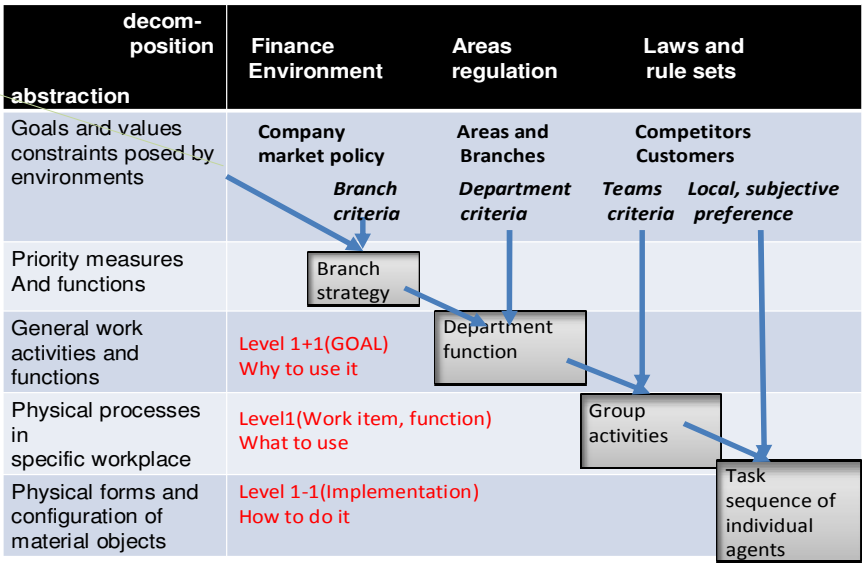

Figure 4b. Means-Ends Hierarchy

Each layer accompanies proper language, such as natural, logic, computer, physics and so on (Fig.5). All these are integrated into Ecological Interface Design (EID) diagram(Fig.6 from Flach et al. 1995). Therefore, it should be critical to relate natural language with systems analysis & design languages (systems languages: DFD, ERD, XML, OWL, UML, XTM, JAVA, C++, etc.) and other crucial languages (logic, mathematics, simulation and visual languages) for relating all layers described in these figures in order to define the algorithm which generates worker oriented systems analysis and design,

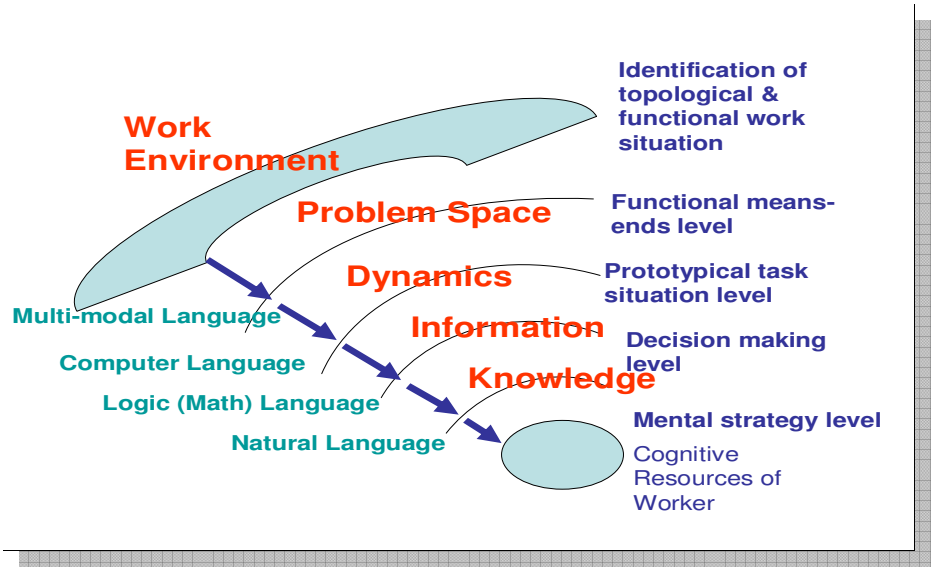

Figure 5. Language Shift

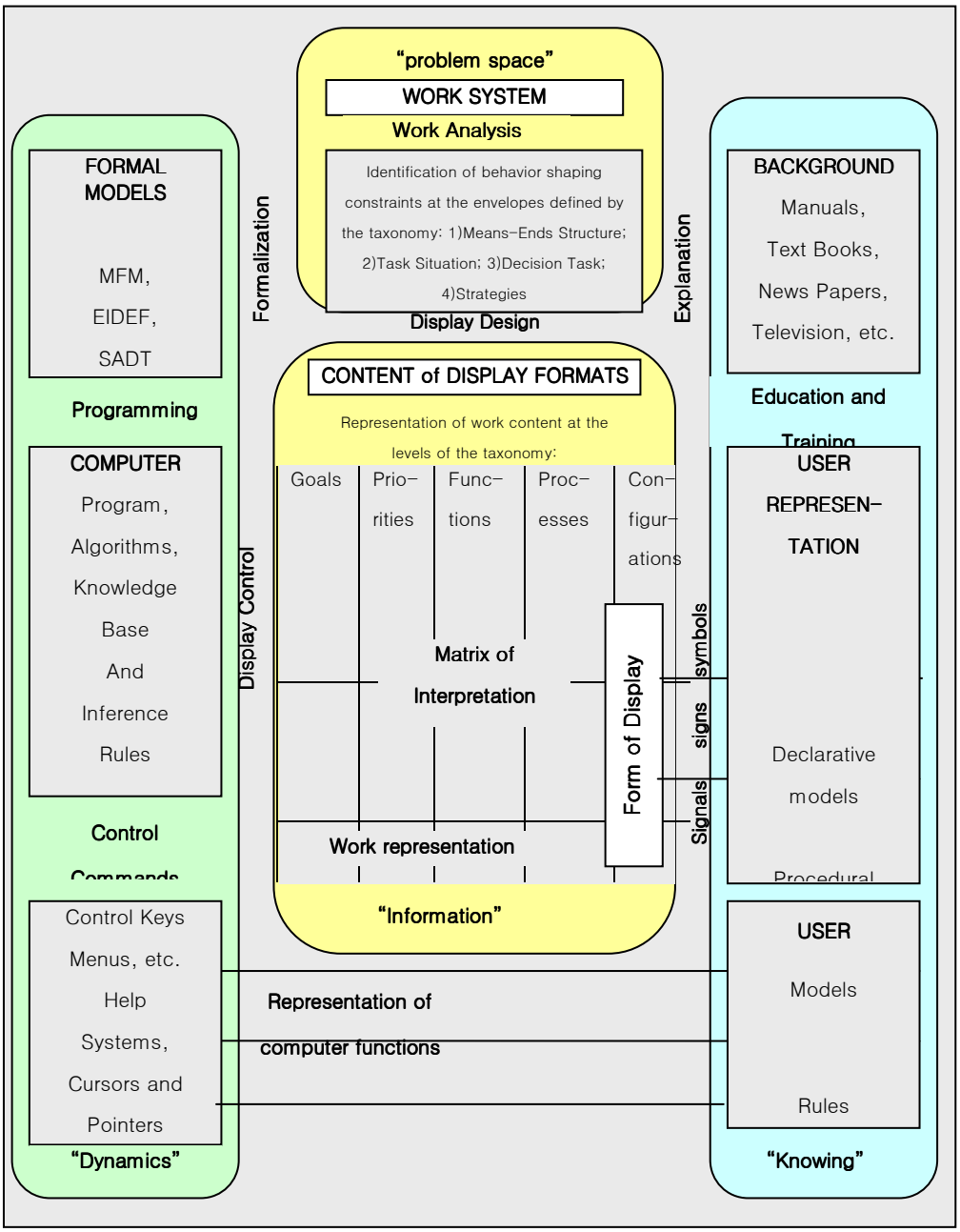

Figure 6. Ecological Interface Design (EID) diagram

3 REALIZATION OF ECOLOGICAL SYSTEMS DESIGN AS UNIFIED LANGUAGE SYSTEM (ULS)

The previous chapter tried to describe the importance of ecological approach in order to solve the current problems in workplaces. Especially, it should be important to analyze workplaces in hierarchical fashion with language shift in relation to closed-loop feedback loop of abstraction, so that make workers more motivated. To realize this process, it should be critical to relate natural language with systems analysis & design languages (systems languages: DFD, ERD, XML, OWL, UML, XTM, JAVA, C++, etc.) and other crucial languages (logic, mathematics, simulation and visual languages) in order to define the algorithm which generates systems analysis and design notations. All these ideas and goals are materialized as ULS (unified system). This chapter clarifies the EID related language system as followings.

3.1 Natural Language/ Systems modeling Language Conversion

First, ULS analyzes natural language, i.e., business manuals, in order to produce some important system modeling languages – DFD, ERD, Mini-specs etc. A well-known conversion process is the process of conversion in general "machine translation," which is divided into three processes: *analysis, transformation,* and *generation*. This process can be applied to a Natural-Systems modeling languages conversion process such as analysis process, structured inter-language process and systems language generation process. To carry out the above steps, basic technologies have been invented. These are: *structured inter-language*, "***modified"*** *Case Theory*, and *authentification*. Before explaining these technologies, this paper will briefly discuss some of the basic ideas including ***Surface structure*** (Chomsky 1965: the sentence which is actually used. This paper defines it as a sentence with some redundant elements which can be deleted), ***Deep structure*** (Chomsky 1965: the underlying well-formed sentences) **,** ***Transformation*** **and** ***generation*** (the structuring and refining of actual sentences in order to acquire their deep structures and write them in the form of an inter-language called *structured inter-language* which contains sufficient elements for full semantic interpretation). Afterwards, the deep structure stated in the inter-language is converted again into the surface structure in reverse in terms of the systems language. The basic theory of analysis and conversion utilizing the structured inter-language is the ***modified*** *Case Theory* based on C.Fillmore's *Case Theory* (Fillmore 1966).

The language conversion cycle(Figure 7), "manuals' life cycle," is especially applied for confirming multicultural business procedures. Exchanging business procedures written in structured inter-languages both English and Japanese (deep structure) must be much more effective and precise than exchanging directly between the original natural language manuals (surface structure).

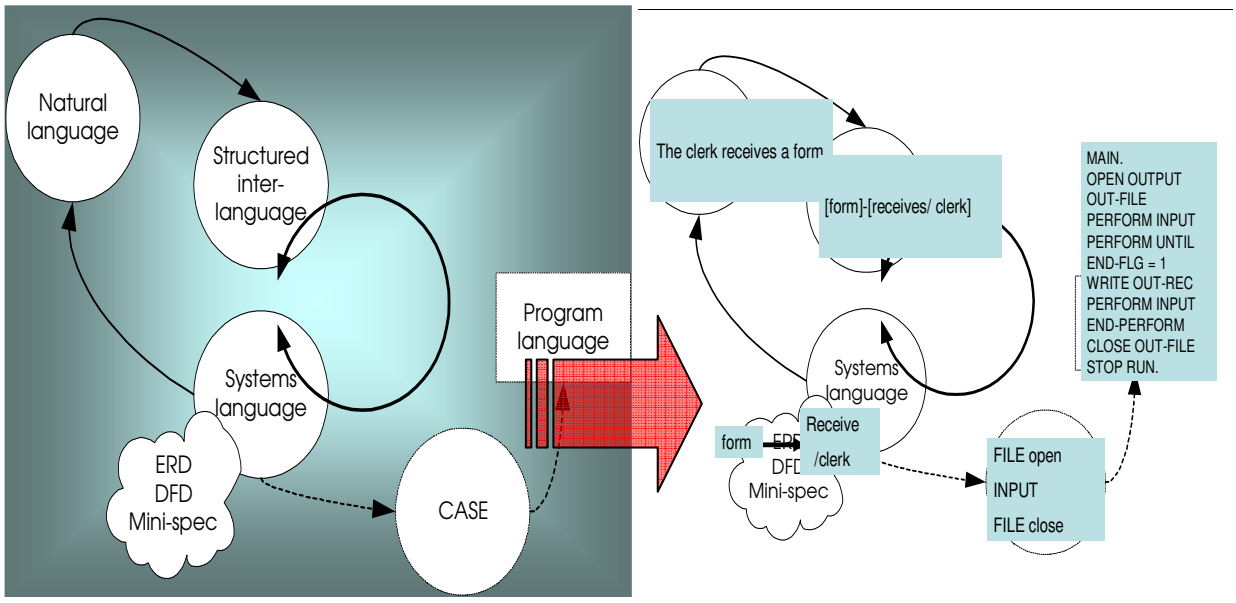

Figure 7. Manuals' Life Cycle

Followings are sample sentences (both natural and structured inter-language) and a systems language representation (DFD diagram) which is directly translated from the inter-language.

Natural language sentences (business manual):

1_0. Customer sends order to ordering dept., which prepares order acceptance memo to order acceptance memo file.

1_1. Customer sends order to ordering dept., which replies concerning order acceptance decision to customer.

1_2. Want information provides want slip for ordering dept., which replies concerning order acceptance decision to customer.

1_3. Commodity control clerk sends want slip to ordering dept., which changes want slip for want information.

1_4. Customer ledger provides customer information for ordering clerk, who prepares sales voucher for shipping clerk.

1_5. Commodity ledger provides commodity information for ordering clerk, who prepares sales voucher for shipping clerk.

1_6. Order acceptance memo file provides order acceptance memo for ordering clerk, who prepares sales voucher for shipping clerk.

1_7. Order acceptance memo file provides order acceptance memo for ordering clerk, who preserves sales voucher for sales voucher stub file.

Structured inter-language:

1_0. : [customer]-order-(prepares order acceptance memo| ordering dept.)-order acceptance memo-[order acceptance memo file]

(detailed language conversion process)

Input sentence

Customer sends order to ordering dept.,
which prepares order acceptance memo
to order acceptance memo file.

Grammatical relation analysis

Customer (ACTOR1) sends (verb1) order (OBJECT1) to ordering dept (LOCATION1:TO).,
which (ACTOR2) prepares (verb2) order acceptance memo (OBJECT2)
to order acceptance memo file (LOCATION2:TO).

1_1. : [customer]-order-(replies|ordering dept.)-order acceptance decision-[customer]

1_2. : [want information]-want slip-(replies|ordering dept.)-order acceptance decision-[customer]
(want information: shortage information, want slip: notice of shortage)

1_3. : [commodity control clerk] -want slip-(changes| ordering dept.) -want slip-[want information]

1_4. : [customer ledger]-customer information- (prepares sales voucher| ordering clerk) -sales voucher-[shipping clerk]

1_5. : [commodity ledger] -commodity information- (prepares sales voucher| ordering clerk) -sales voucher -[shipping clerk]

1_6. : [order acceptance memo file]-order acceptance memo-(prepares sales voucher| ordering clerk)-sales voucher-[shipping clerk]

1_7. : [order acceptance memo file]-order acceptance memo-(preserves| ordering clerk)-sales voucher-[sales voucher stub file]

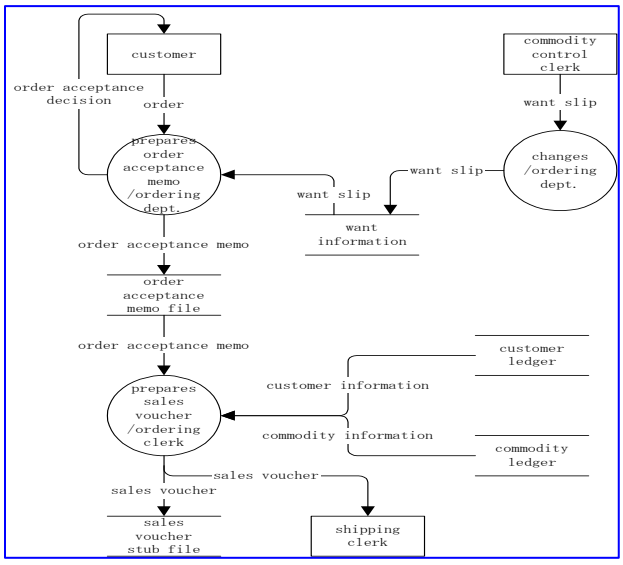

Figure 8. DFD

Next, ULS analyzes interviews, business manuals and job descriptions by abstracting significant nouns as entities with their relating verbs or action noun as relationships, and so on (parsing process). Following is a sample ULS view with parsing analysis and its results: significant entity as **database** and distinguished relationship as **enrollment**.

```
@UTF8 @Begin @Languages:  en @Participants:EMP Employee, COL Colin Investigator
@ID:  english|brown|EMP|||||Target_Employee||  @ID:  english|brown|COL|||||Investigator||
*COL:  Can you describe your job precisely?
*EMP:  Yes, I am in charge of CRM (customer relationship management)  operation, which consists of such parts as CustomerList, CustomerEnrollment and DataBase(ArrayList) .
*COL:  What is CustomerList operation?
```

```
*COL:  aux.v|Can pro|you v|describe pro:poss:det|your n|job adv:adj|precise-LY
*EMP:  adj|Yes pro|I v|be&1S prep|in n|charge prep|of n:prop|CRM n|customer n|relationship n|management n|operation pro:wh|which v|consist-3S prep|of qn|such n|part-PL prep|as n:prop|CustomerList n:prop|Customer**Enrollment** conj:coo|and n:prop|**DataBase**ArrayList .
*COL:  pro|What v|be&3S n:prop|CustomerList n|operation ?
```

3.2 XM-Language with Ontology

After parsing, i.e., clarifying entities and relationships, the "vital" entities and relationships are summarized to be translated into XML format. XML format can also be converted into XTM for ontological topic map description as shown below. The XML notation can also be converted into AI or Knowledge-base oriented languages (Lisp, C^{++}, etc.).

```
<?xml version="1.0" encoding="ISO-8859-1"?><topicMap xmlns="http://www.topicmaps.org/xtm/1.0/"
xmlns:xlink="http://www.w3.org/1999/xlink" xml:base="file:C:\tm4l\tm4l-bin-2.0.0\xtm\CRM.xtm">
  <topic id="x1obcgm67f-cc">
    <baseName>
      <baseNameString>database</baseNameString>
    </baseName>
  </topic>
  <topic id="x1obcgm67f-75">
    <baseName>
      <baseNameString>enrollment</baseNameString>
    </baseName>
```

3.3 OW-Language and UM-Language

Then the ontological topic map description automatically produces "Topic Maps" as shown in Figure 9 which is converted again into UML as Figure 10 for generating Java programs.

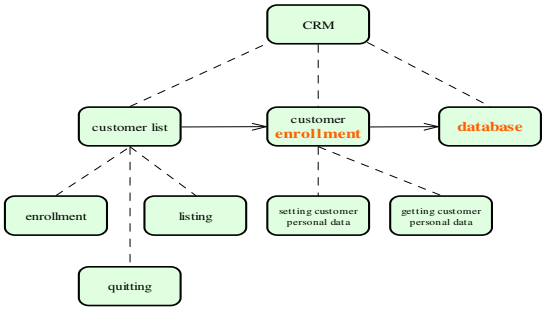

Figure 9. TopicMap

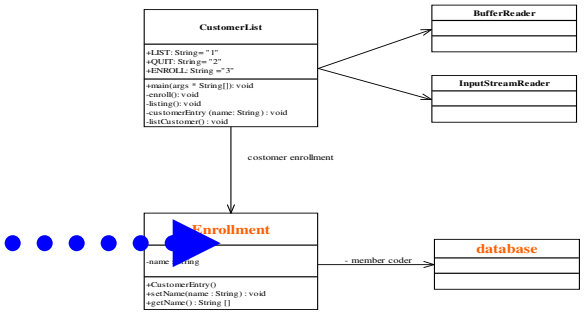

Figure 10. UML

3.4 Programming Language

As noted above, UML notation can logically generate JAVA code framework (Figure 11). After filling the frame, one could acquire Java program which realizes executable computer application (screen image: Figure 11).

```
import java.io.BufferedReader;
…
public class CustomerList {
   public static final String LIST = "1";
  …
   public static  Enrollment = new Enrollment();
   public static void main(String[] args) {
      enroll();
      … }
   private static void enroll() {
      while(true){
         try{…
            if(data.equals(QUIT)){
               break; }
```

Figure 10. Java program code

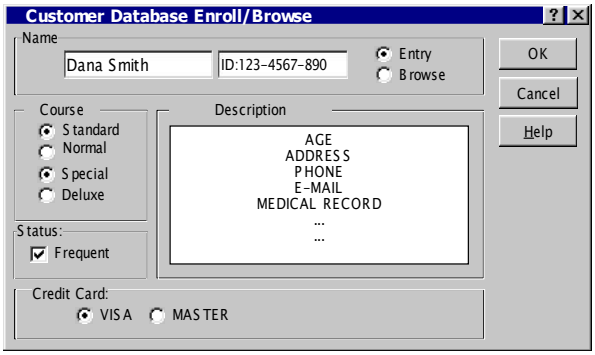

Figure 11.Ascreenshot of the Java program

3.5 Simulation Language

As those descriptions, notations and diagrams explained above are well-formed, they are formalized and formulated easily, i.e., one could conveniently convert XML and OWL, TM description into simulation languages. For example, nouns and verbs are roughly translated into stocks and flows variables respectively in simulation language. For the "customer enrollment case" stated above, the result of ULS conversion is again automatically translated into a notation, in our case, a general purpose system dynamics simulator formula, as following.

```
customer(t) = customer(t - dt) + (new_customer) * dt
INITIAL customer = 10
new_customer=enrollment_rate*customer*potential_customer_r
ate
potential_customer_rate          =          (potential_customer-
customer)/potential_customer
enrollment_rate = 0.15
potential_customer = 10000
```

(1)

The formula above is compatible with standard mathematical notations as (2) and (3). Based on the system dynamics simulation formula, the simulator also creates system dynamics diagram with its logistic curve representation which is exactly the same as the solution of (2) and (3). (Figures 12)
x: customer population, a, b: constants, $K=a/b$, $C=1-K/x^0$ (x^0 is initial customer population)

$$x' = ax(1-bx) \qquad (2)$$

$$x(t) = \frac{K}{1-Ce^{-at}} \qquad (3)$$

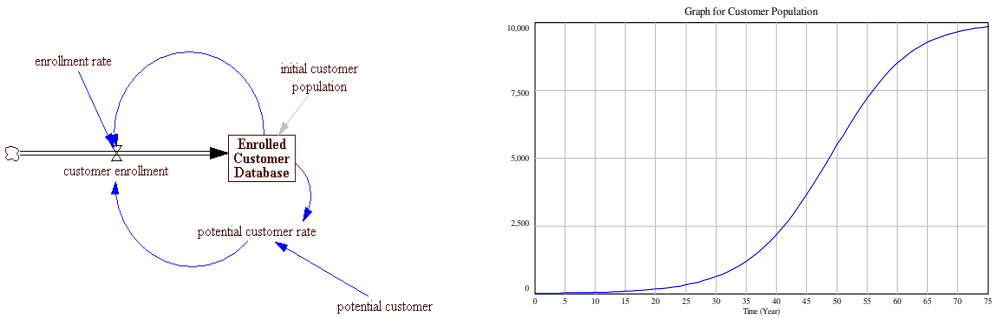

Figure 12. System Dynamics Diagram with its result

4. CONCLUSION

First, this paper analyzed working environment issues from statistics, ISO ergonomics standards and ecology of work theories in order to identify the requirements for the current work system analysis and design, i.e., abstraction hierarchy with shift of languages, closed bottom up loop work system, etc.

Second, these requirements are supposed to be satisfied by a methodology called unified Language system (ULS).With ULS algorithm, the natural language descriptions i.e., business manuals, company regulations, job descriptions and so on, were successfully converted into systems languages which were ready to be fed to the programming language generation process.

Finally, this study successfully integrated all the business systems related languages, i.e., natural /mathematical /logic languages, systems language and programming language in the form of ULS operating platform. It is concluded that the integration of business languages relying on ecological approach is promising to further enhance the worker oriented management systems theory and practice in the Web-based business world. As this study focus mainly on abstraction and language shift process, further research should be performed in terms of other crucial areas of ISO requirements such as closed-loop feedback improvement system.

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