A New Communication Method Using Natural Language as a Computer Communication Protocol

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Abstract-**This paper proposes a new computer communication protocol based on natural language called 'language protocol', a new communication method using the protocol, and an interface enabling to connect any communication standard, called 'Language Application Programming Interface'. With the proposed methods, we show the possibility of providing flexible communication environment for any communication object and the validity of the proposed methods with a simulation example of the communication using language protocol.**

I. Introduction

With the spread of the Internet, it has become common to widely use computers connecting with the Internet. Moreover, not only a computer, but also software and home electronic products are getting common to be operated through the Internet. At this moment, the network communication among such machines and software is performed by communication protocols established based on a firm communication regulation each communication object has. However, it is a hard job to establish communication among the communication objects with such firm regulations and it shall cost a lot. In this work, we therefore propose a new communication protocol called 'language protocol' which has the same characteristics of natural language, an interface which performs to connect any communication standard each other, and a new communication method using the protocol and the interface. The reason for using natural language as a computer communication protocol is that natural language is the most flexible communication protocol in the world , besides, if every computer communication protocol is able to communicate with natural language, we would have a united communication protocol for all communication protocols. This leads us to avoid laborious job to establish computer communication standard among communication objects. We call this seamless communication environment 'communication barrier-free' in computing.

II. Semiotic Base

The resources delivered by a language protocol are the linguistic resources to interpret and produce a text. We compile this resources as a data base called a 'semiotic base.' The basic idea for the semiotic base was proposed by Halliday & Matthiessen [1]; they have proposed the idea for a 'meaning base' which is a data base of the linguistic system with a viewpoint of systemic functional linguistics [2]. We extend their idea and construct it in an electric form as a resource data base of the linguistic system which consists of four bases for context, meaning, lexico-grammar, expression, and two components: a situation depended word dictionary and corpus (see Fig. 1).

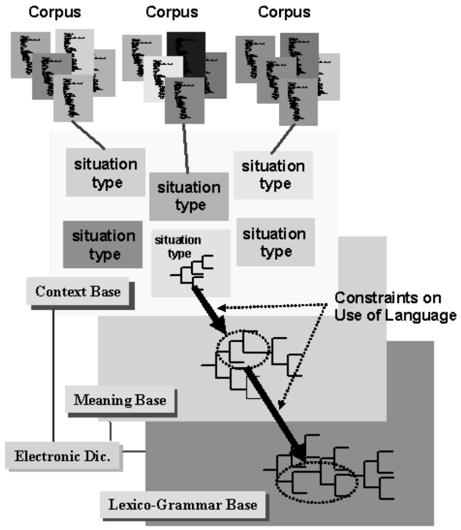


Figure 1: Overview of semiotic base

The contents of each base are systemized with the network called 'system network.' System network basically consists of selective choices of 'AND' or 'OR'. The contents of the context base are task-oriented knowledge, basic dialogue structure. All the information in the context base are classified as existing in a particular situation type based on three elements to characterize a situation type: 'field' of the use of language (what is happening), 'tenor' of the use of language (social relationship among communication participants), and 'mode' of the use of language (communication channel).

The meaning base consists of three parts: ideational, interaction, and textual parts. The resources of the ideational parts are the semantics of words and semantic roles for words. As for the interaction part, speech function is stored. As for the textual part, the resources for characterizing textuality such as cohesive relation, thematic information are stored. The contents of the lexico-grammar base are the resources for words and grammar. The contents of expression base are graphological resources. For example, in case of speech texts, phonological patterns are stored as its resources. There are constraints on the use of the resources among three bases. It corresponds to the same constraints on the use of language by humans in a particular social context.

III. Language Protocol

The basic idea for developing the language protocol is to develop natural language expression on the Internet. The protocol is designed as an application protocol running on TCP/IP so that it can access the resources provided by the current Internet protocols (see, Fig.2)[1].

It carries linguistic resources compiled in the semiotic base as the message contents which are suitable resources to communication objects. In other words, it provides tailor-made texts for any communication object such as people, electronic machines, etc., so that the communication objects can easily understand the given texts. The organization of the data delivered by language protocols reflects that of the semiotic base; which means it has strata in its organization and each stratum works together with the other strata to create the meaning of a text. Fig. 3 illustrates an example of a data part of language protocol in a packet.

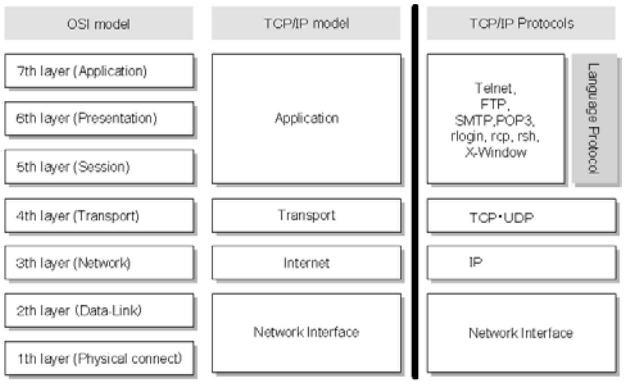
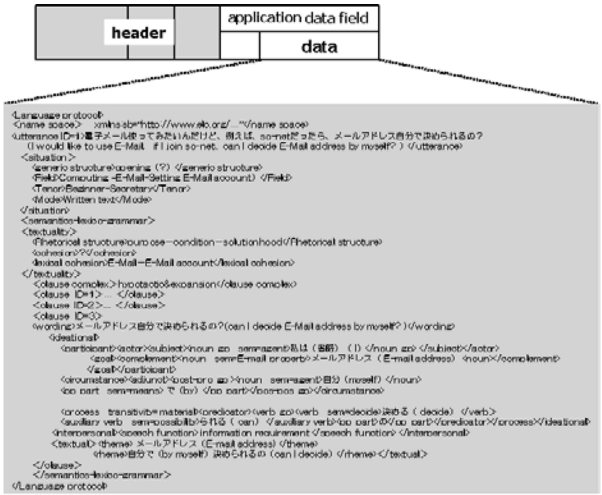


Figure 2: Status of language protocol in comparison with the OSI protocol model

The data part of a language protocol is compiled based on the result of the analysis of an input text with systemic functional linguistics. It consists of name space information for the tags used in the protocol, original wording of an input text, situational information, textual information (i.e., rhetorical structure, cohesive relation, coherence) of the wording, the information of semantics, and lexico-grammar with syntactic information.

A. Communication method

The ordinary computer communication requires that 100% the same interpretation has to be happened among communication objects, in order to establish communication among them. However, unlike computer communication, we human begins achieve communication without sharing 100% the same information. The reason for this is because human beings use natural language as communication protocol. Natural language is a flexible communication protocol in that everything of how the contents of the protocol are interpreted depends on a receiver. Therefore, even without sharing 100% the same information between a speaker and a hearer, the communication can be established. Fig. 4 shows the difference between computer communication style and human language communication style. The communication using the language protocol takes similar communication style as human language communication style.



```
<Language protocol>
<name space>   xmlns:sb="http://www.slb.org/…"</name space>
<utterance ID=1>電子メール使ってみたいんだけど、例えば、so-netだったら、メールアドレス自分で決められるの？
   (I would like to use E-Mail.  if I join so-net, can I decide E-Mail address by myself? ) </utterance>
  <situation>
    <generic structure>opening (?) </generic structure>
    <Field>Computing -E-Mail-Setting E-Mail account) </Field>
    <Tenor>Beginner-Secretary</Tenor>
    <Mode>Written text</Mode>
  </situation>
  <semantics-lexico-grammar>
  <textuality>
    <Rhetorical structure>purpose−condition−solutionhood</Rhetorical structure>
    <cohesion>?</cohesion>
    <lexical cohesion>E-Mail−E-Mail account</lexical cohesion>
  </textuality>
    <clause complex>hypotactic&expansion</clause complex>
    <clause ID=1>… </clause>
    <clause ID=2>… </clause>
    <clause ID=3>
    <wording>メールアドレス自分で決められるの?(can I decide E-Mail address by myself? )</wording>
       <ideational>
          <participant><actor><subject><noun gp   sem=agent>私は（省略） (I) </noun gp> </subject></actor>
                <goal><complement><noun   sem=E-mail property>メールアドレス（E-mail address) <noun></complement>
                </goal></participant>
          <circumstance><adjunct><post-pro gp ><noun   sem=agent>自分 (myself) </noun>
          <pp part   sem=means> で (by) </pp part></post-pos gp></circumstance>

          <process   transitivity=material><predicator><verb gp><verb   sem=decide>決める ( decide)   </verb>
          <auxiliary verb   sem=possibility>られる ( can)   </auxiliary verb><pp part>の</pp part></predicator></process></ideational>
        <interpersonal><speech function>information requirement </speech function> </interpersonal>
        <textual> <theme> メールアドレス (E-mail address) </theme>
                <rheme>自分で (by myself) 決められるの (can I decide) </rheme></textual>
    </clause>
    </semantics-lexico-grammar>
</Language protocol>
```

Figure 3: Example of the data part of a language protocol

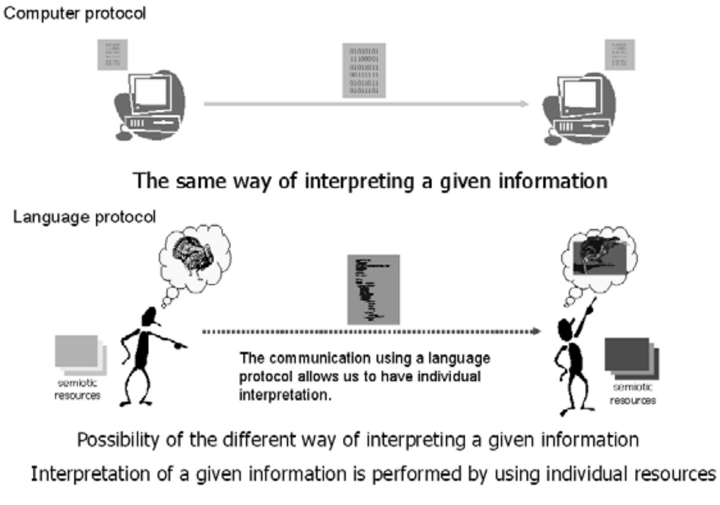

Computer protocol
The same way of interpreting a given information
Language protocol
semiotic resources
The communication using a language protocol allows us to have individual interpretation.
semiotic resources
Possibility of the different way of interpreting a given information
Interpretation of a given information is performed by using individual resources

Figure 4: Communication style using language protocol

The communication using language protocol is achieved with two processes: the pre-process and the post-process. At the pre-process, an agent called a client's secretary agent analyzes the input text, given by a client, with the client's semiotic base, and then produces a language protocol based on the result of its analysis. A language proto-

[1] The language protocol is now being developed so as to be one of application protocols on TCP/IP, however, at this moment, the development has started from designing the message format of the protocol. The message format is carried by http protocol as well as agent communication languages.

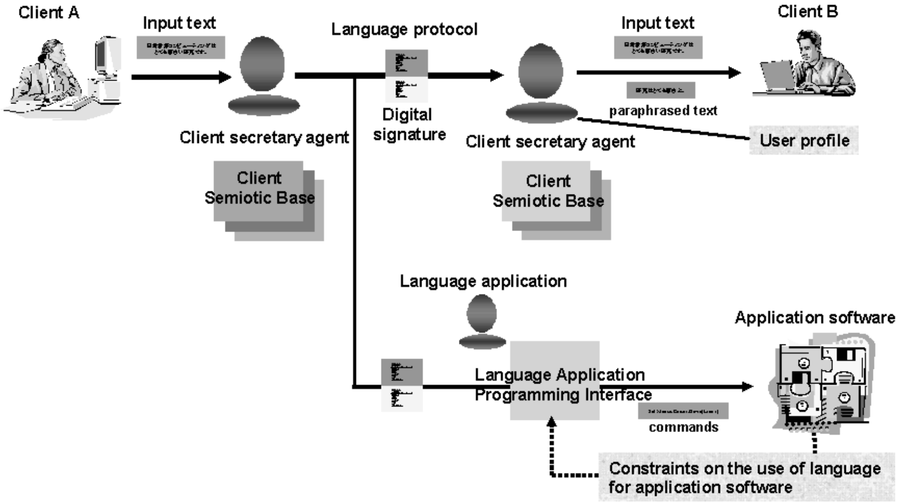


Figure 5: Communication style using language protocol

col consists of two texts annotated with the tags provided by a semiotic base; one is the original input text and the other is the paraphrased original text so that a receiver of the protocol can easily understand the protocol contents. A generated language protocol is sent to communication objects with the digital signature of a sender. At the post-process, the receiver's secretary agent understands the contents of the language protocol and can convert it into a text for the receiver's needs based on the receiver's profile information.

By locating clients' secretary agents between the clients, the agents support and expand the possibility of clients' communication. In case of communicating with application software, application software are wrapped using an agent wrapper so as to send, receive and respond to a language protocol[2].

To sum up, the communication method using language protocol is the communication that a tailor-made text is produced at the sender's side and a receiver is allowed to re-interpret the given tailor-made text for the receiver's needs.

B. Language application programming interface

In order to establish communication between the different communication standards, it is required to develop an interface which can communicate those standards. Furthermore, if a large number of the communication standards is required to communicate each other, we have to develop an interface for each standard. This shall cost a huge sum of money. However, if we develop an interface which can communicate any communication standard via natural language so as natural language works as a common medium for any communication standard, it would reduce the cost required to establish a new communication standard between the firm regulations. We call this interface 'Language Application Programming Interface (henceforth, LAPI).' LAPI leads to provide the communication barrier-free environment. Fig. 6 shows an image of how LAPI works to communicate the different standards via natural language.

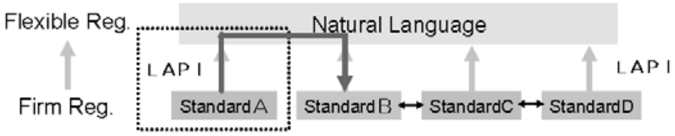


Figure 6: Communication-free via natural language

C. Development of LAPI

In this section, we show how application software can communicate with LAPI as an example of using LAPI. In the example, LAPI works to connect input natural language information, i.e., a language protocol, with the internal expressions of operating the application software, i.e., commands or program. LAPI is developed as having two basic functions; (i) one is the function to be able to directly connect different communication standards via the common natural language expressions describing the different internal expressions of the standards. We call this function the 'function 1' of LAPI. (ii) The other function is the one to indirectly connect the different communication standards via the semantic operation of natural language. We call this function the 'function 2' of LAPI. The function 2 works when the function 1 is unavailable. As for the function 2, it is not guaranteed that the communication among communication objects will be perfectly established with 100% ratio, however, it regards of value to be somehow able to connect the different communication standards.

Fig.7 shows the overview of the LAPI functions.

As for the development of the function 1, the basic idea of this function depends on the fact that even though the internal expression of application software is different, the same natural language expression can be used for describing the internal expression. Therefore, we firstly

[2] In this work, we call application software, wrapped by an agent wrapper which can understand a language protocol, 'language application.'

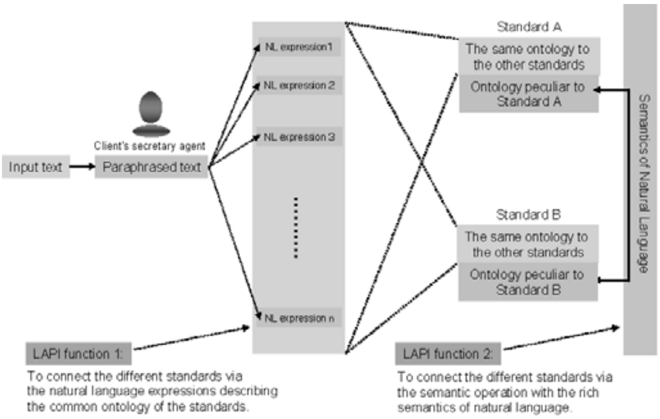
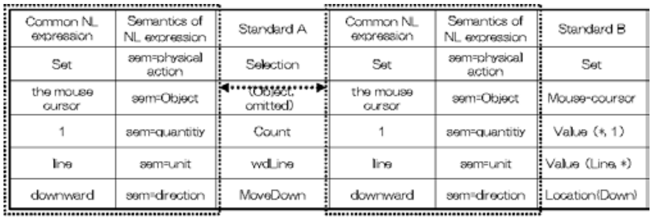

Input text
Client's secretary agent
Paraphrased text
NL expression1
NL expression 2
NL expression 3
NL expression n
Standard A
The same ontology to the other standards
Ontology peculiar to Standard A
Standard B
The same ontology to the other standards
Ontology peculiar to Standard B
Semantics of Natural Language
LAPI function 1:
To connect the different standards via the natural language expressions describing the common ontology of the standards.
LAPI function 2:
To connect the different standards via the semantic operation with the rich semantics of natural language.

Figure 7: Overview of two main functions of LAPI

extract common ontology on objects and methods shared by different application software, and secondly describe them with natural language expressions. Then, we obtain the correspondence relation between the common natural language expressions and the different standards (i.e., internal expressions) of application software. The communication between the different standards of application software is achieved through the semantic correspondence of the common natural language expressions. For example of this, here we assume that a common natural language expression, "Set the mouse cursor 1 line downward." describing the internal expression of two different application software (Appli. A and Appli. B) as follows:

Common NL: "Set the mouse cursor 1 line downward."
Appli. A: Selection.MoveDown Unit:=wdLine,Count:=1
Appli. B: Set Mouse-cursor.Location(Down).Value(Line,1)

These different standards can communicate through the same semantics of the common natural language assigned to the different internal expressions of the application standards (see, Fig. 8).



Common NL expression	Semantics of NL expression	Standard A	Common NL expression	Semantics of NL expression	Standard B
Set	sem=physical action	Selection	Set	sem=physical action	Set
the mouse cursor	sem=Object	(Object, omitted)	the mouse cursor	sem=Object	Mouse-coursor
1	sem=quantitiy	Count	1	sem=quantitiy	Value (*, 1)
line	sem=unit	wdLine	line	sem=unit	Value (Line, *)
downward	sem=direction	MoveDown	downward	sem=direction	Location(Down)

Figure 8: An example of the communication between different standards

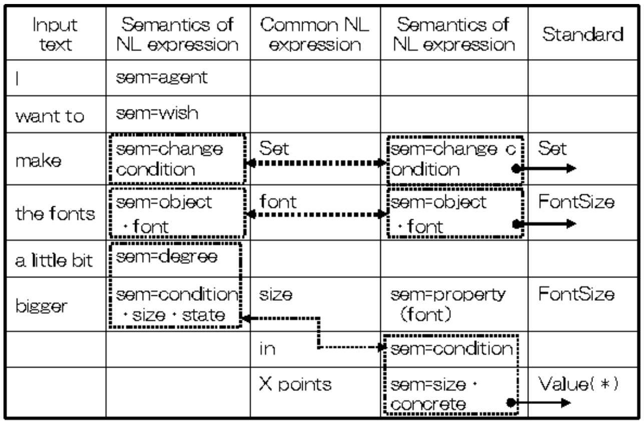
IV. Simulation

Fig. 9 shows an example of a simulation of the communication method using a language protocol. In Fig. 9, the wording given by a client is paraphrased by the client's secretary agent so that the wording will be easily understood by the communication target. And then, the client secretary agent compiles the result of the paraphrased wording into the format of a language protocol and sends it to a language application. The language application understands the protocol by connecting it with its knowledge, that is, the natural language expressions describing the internal expression of the application (natural language expressions listed in the column of 'LAPI NL expressions' in Fig. 9), and then performs actions to operate the application. There are two main types to connect a language protocol received from a client secretary with the natural language expressions for LAPI. They are the types that language application (a) can and (b) cannot directly connect the protocol with its natural language expressions for LAPI.

In the following, we shall show an example for the two cases:(a) and (b).

In case of (a)

This is the case that an input language protocol can be directly connected with the natural language for LAPI. By matching the semantic relation between the input language protocol and the natural language for LAPI, the input protocol can be connected with the action to control the application software (see, Fig.10).



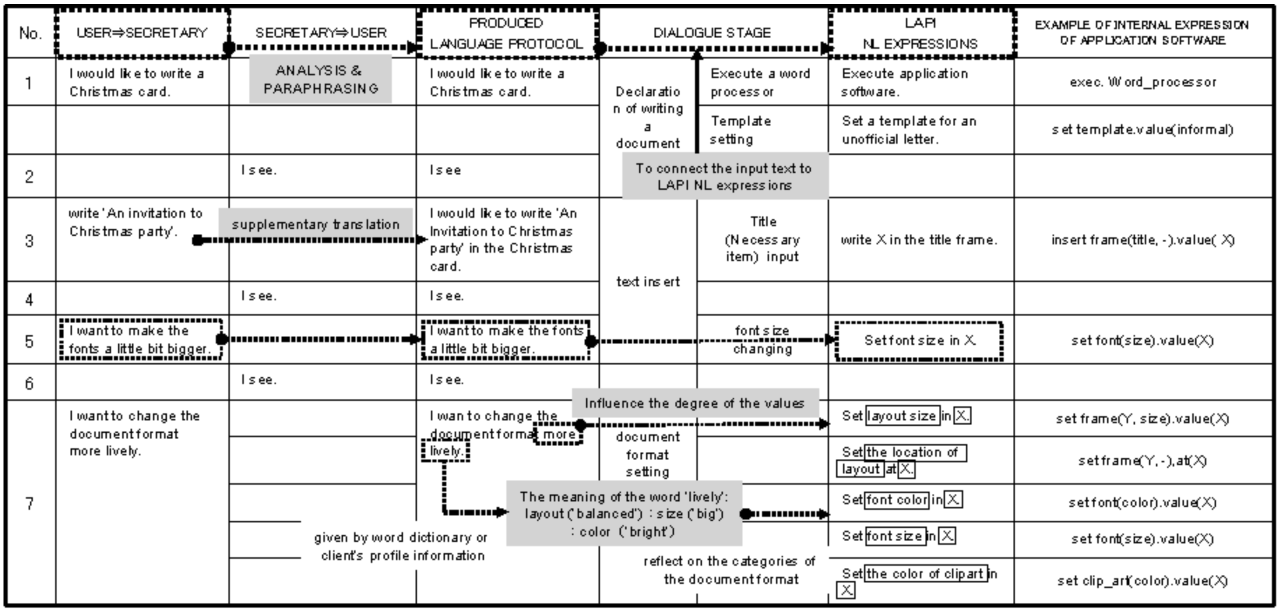
Input text	Semantics of NL expression	Common NL expression	Semantics of NL expression	Standard
I	sem=agent			
want to	sem=wish			
make	sem=change condition	Set	sem=change c ondition	Set
the fonts	sem=object ・font	font	sem=object ・font	FontSize
a little bit	sem=degree			
bigger	sem=condition ・size・state	size	sem=property (font)	FontSize
		in	sem=condition	
		X points	sem=size・concrete	Value(＊)

Figure 10: Correspondence between input language protocol and natural language for LAPI

In case of (b)

In this case, there are several patterns, but we deal with one of the patterns as shown in Fig. 11.

There is a word expressing the sensitivity, 'lively', in the dialogue shown in Fig 9. It is impossible to connect such a word with natural language for LAPI because the meaning of the given word, 'lively', is not easy to be identified. In this case, the client secretary agent searches the meaning of the word in the dictionary in the semiotic base or in the user-profiling information, and gives the definition for the word to the language application. Then, the language application understands the word with the natural language expressions for LAPI (see, Fig.11).



No.	USER⇒SECRETARY	SECRETARY⇒USER	PRODUCED LANGUAGE PROTOCOL	DIALOGUE STAGE		LAPI NL EXPRESSIONS	EXAMPLE OF INTERNAL EXPRESSION OF APPLICATION SOFTWARE
1	I would like to write a Christmas card.		I would like to write a Christmas card.	Declaration of writing a document	Execute a word processor	Execute application software.	exec. Word_processor
					Template setting	Set a template for an unofficial letter.	set template.value(informal)
2		I see.	I see				
3	write 'An invitation to Christmas party'.		I would like to write 'An Invitation to Christmas party' in the Christmas card.	text insert	Title (Necessary item) input	write X in the title frame.	insert frame(title, -).value(X)
4		I see.	I see.				
5	I want to make the fonts a little bit bigger.		I want to make the fonts a little bit bigger.		font size changing	Set font size in X.	set font(size).value(X)
6		I see.	I see.				
7	I want to change the document format more lively.		I wan to change the document format more lively.	document format setting		Set layout size in X.	set frame(Y, size).value(X)
						Set the location of layout at X.	set frame(Y, -),at(X)
						Set font color in X.	set font(color).value(X)
						Set font size in X.	set font(size).value(X)
						Set the color of clipart in X	set clip_art(color).value(X)

ANALYSIS & PARAPHRASING
To connect the input text to LAPI NL expressions
supplementary translation
Influence the degree of the values
The meaning of the word 'lively': layout ('balanced') : size ('big') : color ('bright')
given by word dictionary or client's profile information
reflect on the categories of the document format

Figure 9: Simulation of the communication using language protocol and LAPI

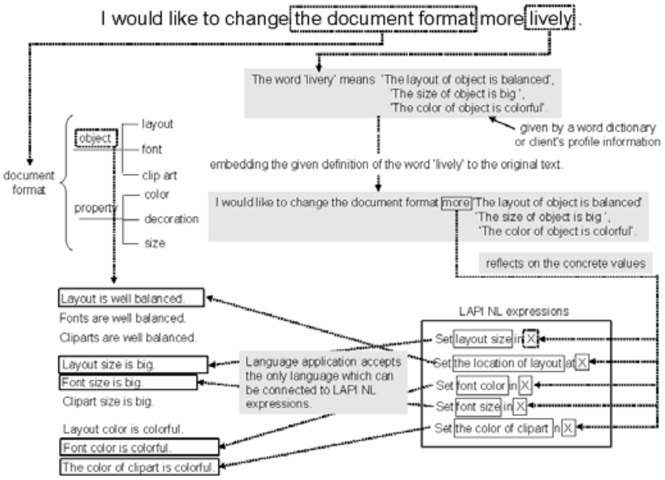

I would like to change the document format more lively.
The word 'livery' means 'The layout of object is balanced', 'The size of object is big', 'The color of object is colorful'.
given by a word dictionary or client's profile information
embedding the given definition of the word 'lively' to the original text.
I would like to change the document format more 'The layout of object is balanced' 'The size of object is big', 'The color of object is colorful'.
reflects on the concrete values
document format
object
layout
font
clip art
property
color
decoration
size
Layout is well balanced.
Fonts are well balanced.
Cliparts are well balanced.
Layout size is big.
Font size is big.
Clipart size is big.
Layout color is colorful.
Font color is colorful.
The color of clipart is colorful.
Language application accepts the only language which can be connected to LAPI NL expressions.
LAPI NL expressions
Set layout size in X
Set the location of layout at X
Set font color in X
Set font size in X
Set the color of clipart in X

Figure 11: Interpretation of the word 'lively' and its correspondence to the natural language for LAPI

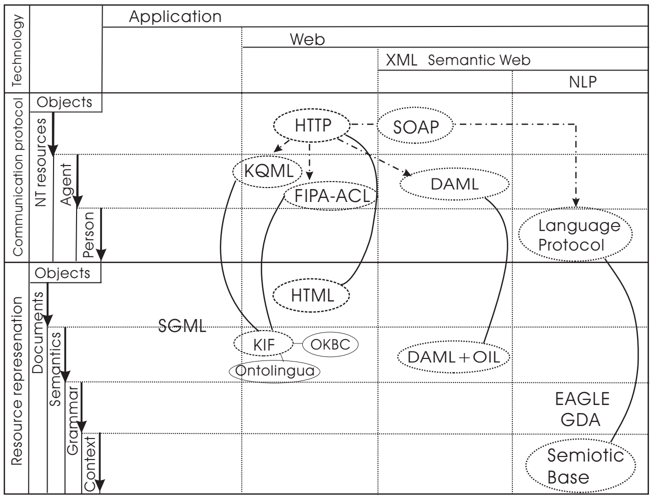


Figure 12: Comparison with the other protocols and their resources

A. Comparison with the other communication technologies

Fig. 12 shows the status of the language protocol and the semiotic base, compared to the other protocols and their resources.

In terms of communication technology, the agent communication language can be regarded as a similar technology to the language protocol. The data exchange formula in the agent communication languages, such as KQML [4] and FIPA-ACL [5], are designed based on speech act theory [6]. As their information exchange format, KIF [7] was developed, and the ontology representation technologies such as ontolingua [8] and DAML+OIL [9] are used to describe the contents of a message. In a viewpoint from natural language characteristics, those ontology representation can be regarded as describing the semantics of natural language.

Recently DAML [10] has been widely noticed, which is now being designed by taking account of the framework for Semantic Web [11]. Semantic Web is the framework that makes computers to understand the resources on the Web and use it at a Web-wide scale [12].

On the other hand, a number of projects whose goals are to produce the reusable natural language processing resources have been being promoted. The Expert Advisory Group on Language Engineering Standards (EAGLES) [13] is a project which aims to establish standards of a mark-up language to make reusable large-scale language resources for natural language processing (NLP). Global Document Annotation (GDA) [14] is the technology to establish tag sets to annotate the semantics and the grammatical structure of documents. By this technology, the applications become able to use NLP technologies to various degrees on the annotated documents using GDA tags.

Though these NLP based technologies are basically the ones which should not be compared to the ontology representation technologies, their characteristics to make natural language expressions used as message description is taken into the idea of the message description way of a language protocol.

Compared the semiotic base with the other resource representation, as for the resources of the agent communication language such as Ontolingua and DAML+OIL, their target for the resources corresponds to the semantics of natural language. They do not deal with situation and lexico-grammar of natural language as their communication resources, unlike the language protocol. As for EAGLES and GDA, they are not designed as communication resources used by a computer communication protocol.

Language protocol and semiotic base are located at the right side of the diagram shown in Fig. 12. We think that an ideal figure of communication protocol at which we finally reach must be a natural communication protocol, that is, natural language.

The basic framework for the communication method using the language protocol is developed based on the idea that we use a natural communication protocol which we have already had, that is, natural language, for any communication by any communication object. In this context, our proposed technology has many individuated techniques from the techniques of the other communication technologies.

Moreover, the proposed concept, 'communication barrier-free', can be thought of as similar idea to agent corporation methods. As some practical technologies which achieve this task, Bee-gent [15] technology, produced by Toshiba corporation, provides corporative operation and connection among similar and different application objects on the net. AgentPro [16], built by Fujitsu corporation, can support users to integrate the data by various application software based on user's request. Compared to these technologies, our proposed technologies are individuated in terms of achieving these tasks by using natural language as a communication medium.

V. Conclusions

In this paper, we have proposed a natural language based computer communication protocol, called 'language protocol', a new communication method using the protocol, and an interface enabling to connect any communication standard, called 'LAPI'. The communication method takes the similar communication style as we human beings do, and it realizes 'communication barrier-free' in which all communication object can communicate via natural language with LAPI.

Natural language is always thought of as unsuitable for being used as a communication protocol because it contains vagueness and ambiguous in itself. However, there are several advantageous and unique points with natural language, for example, only natural language can (i) provide various ways of interpreting information, (ii) report information by various wordings, (iii) transmit almost the same information – we do not have to share 100% the same information between speaker and listener in communication (image transmission by natural language), (iv) be a medium for multi-modal information, etc. Taking these characters of natural language into account, it must be necessary to have a different view for natural language in order to use for computer communication protocol.

Moreover, in order to make a computer have the intelligence produced by the linguistic activities such as humans thought with language, it might be necessary to change the computer communication protocol to natural language. Natural language is the only natural communication protocol which has produced human intelligence. The other artificial communication protocols have never ever produced such an intelligence. Though there are some unsolved technical problems in the framework of our computing, there are quite a few new ideas using natural language as a computational medium, which surpasses the conventional computer communication ideas.

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