Annals of University of Craiova, Math. Comp. Sci. Ser.
Volume 36(2), 2009, Pages 1–12
ISSN: 1223-6934

VoSys is able to communicate by e-mail with the user

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Abstract. VoSys is a software product designed to process knowledge represented by inheritance. This product was obtained in several stages. The first version of VoSys used a Graphical User Interface for the communication user-system. Other subsequent versions introduced the use of communication in natural languages and the voice processing such that both the input sentence and the output sentence are spoken sentences ([9], [10]). In this paper we add a new feature to VoSys: the system is able now to communicate by e-mail with the user. We generated an email account on an e-mail server. The user sends its interrogation by a letter to this address. VoSys can read this letter and computes the answer. The language of communication user-VoSys is modeled by a Recursive Transition Network. The implementation is obtained in Java and Prolog. To manage the communication by e-mail the package JavaMail API 1.4.1 was used. Some bidirectional connection Java-Prolog manages the connection between modules ([12]). The main aspects of the implementation are exemplified. The last part of the paper presents an example of interrogation and the corresponding answer given by VoSys. The ideas presented in this paper can be viewed as a facet of a remote interrogation of a knowledge base.

2000 Mathematics Subject Classification. Primary 68T30, Secondary 68T35, 68T50.
Key words and phrases. Inheritance, Object, Attribute, POP3, SMTP, RTN, GUI, Java, Prolog.

1. Introduction

A mathematical model of knowledge representation by inheritance was initiated in [7] and [8]. These ideas were developed in [9], where the components for an inheritance based knowledge system are defined. Moreover, based on several elements of the lattice theory, the computability properties of the answer function for such systems were studied. A possible implementation in Java and Prolog of such systems was developed as follows:

- A graphical user interface (GUI) was used for the communication user-system ([10]. The system can be interrogated by selecting an object Ob and an attribute Attr in GUI. The value Ans(Ob,Attr) of the answer mapping is computed. The result is displayed in some window of GUI by a sentence in a natural language.
- The use of speech technology to answer at the interrogation for such systems was also presented in [10]. The system obtained by this implementation was named VoSys (**Vo**ice **Sys**tem). The Speech Processing ([6]) comprises two sides: *Speech Synthesis* and *Speech Recognition*. The Speech Synthesis produces synthetic speech from text. It is often referred to as *text-to-speech* technology (TTS). The converse process is given by Speech Recognition: from the spoken sentence this component determines what has been said. In other words, it processes audio input containing speech by converting it to text.
- The elements of voice recognition were added to VoSys and these aspects were presented in [11], where the following aspects were treated:

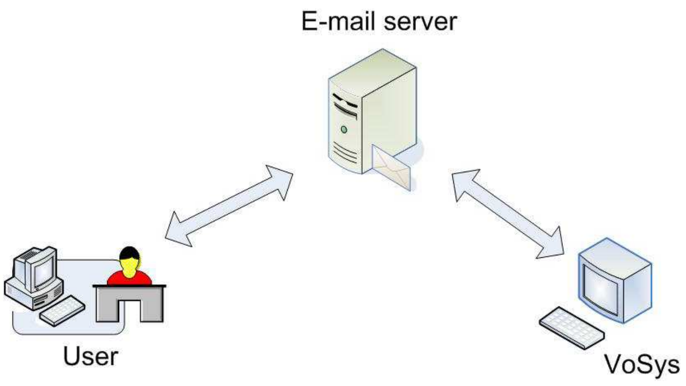


FIGURE 1. Communication user-VoSys

- The use of Recursive Transition Networks ([1], [4], [5]) to describe the syntax of the spoken sentences given at interrogation.
- The extraction of the semantics from the input sentence. This process takes into account the fact that using an inheritance knowledge base, any interrogation specifies an object and an attribute. Consequently, from the input sentence we extract these two entities.
- The architecture of the proposed system is presented.

In order to implement the system the following technologies were used:

– $jdk1.5.0\_02$, $Java\ Speech\ API$, $Sphinx4.01$;
– the language $Prolog$ and a bidirectional connection Java-Prolog (the product $JIProlog\ v3.0.2-8$ of Ugo Chirico, [12]);
– an auxiliary software, $Apache\ Ant$ and XML, to allocate the resources for speech technology.

Until now VoSys used three kinds of communications user-system:

- **Text to Text** communication: the interrogation and the answer are given by text using GUI;
- **Text to Voice** communication: interrogation by text, the answer by voice and text;
- **Voice to Text** communication: interrogation by voice, the answer by voice and text.

A new feature of VoSys is presented in this paper: VoSys is able to communicate by e-mail with the user. In order to accomplish this application we generated the email account syvo2008@gmail.com on www.gmail.com. The communication user-VoSys is depicted in Figure 1 and can be described by the following steps:

(1) The user sends an email to syvo2008@gmail.com containing the interrogation of the knowledge base. The knowledge base is located on the same computer as VoSys.
(2) VoSys is able to read the corresponding e-mail. The body text is extracted and each sentence is analyzed with respect to some grammar. The semantics of the sentence is extracted and the answer component of VoSys is used to generate an appropriate answer. If the letter of interrogation contains n input sentences then the answer given by VoSys contain also n output sentences.
(3) The address of sender is extracted and VoSys sends the answer back to the user.

2. The knowledge base

Our application uses several information from the fish world. We chosen the following classes of fishes:
(1) Chondrichthyes (shark, ray, skate);
(2) Osteichthyes (salmon, tuna, carp, seahorse, sturgeon)
(3) Agnatha (Lamprey, Hagfish)
and we described several features of these classes (fertilization, respiration, heart, body temperature, skeleton etc). As we proceeded in [10] and [11], the description of the knowledge base is given in Prolog. An object is a clause of the form

$$frame(name, [p_1, ..., p_n], [attr(a_1, v_1), ..., attr(a_k, v_k)]).$$

where *name* is the object name, the list $[p_1, ..., p_n]$ specifies its parents, $a_1, ..., a_k$ represent names of attribute and $v_1, ..., v_k$ give the values of these attributes.

The knowledge piece specifies two kind of knowledge:

- General information concerning the life of the fishes (what kind of fertilization is known for a given fish, what means internal/external fertilization etc);
- Particular information: "Peter is a fisherman. He is 35 years old. Peter is the owner of a fish shop. He sells salmon. John is a salesman. He is the brother of Peter. John is 32 years old. Susan is the wife of John."

Below we present a part of the knowledge base:

```
frame(general_fish,[],
                [attr(body_temperature,ectothermic),
                 attr(heart,'two chambered heart'),
                 attr(respiration,'gills used for respiration'),
                 attr(ears,'no external ears'),
                 attr(eye,'no eye lids'),attr(line,'lateral line')]).
frame(class1,[general_fish],[attr(skeleton,'made of cartilage')]).
frame(class2,[general_fish],[attr(skeleton,'made of bone')]).
frame(class3,[class1],[attr(fertilization,'external fertilization'),
                       attr(live,'marine and fresh water')]).
frame('Agnatha',[class3],[attr(jaws,'absence of jaws'),
                 attr(gill,'7 gills slits on each side of the head')]).
frame('Chondrichthyes',[class1],
                 [attr(fertilization,'internal fertilization'),
                  attr(live,'marine organisms only')]).
frame('Osteichthyes',[class3,class2],[attr(bladder,'swim bladder')]).
frame('Lamprey',['Agnatha'],[attr(picture,'lamprey.bmp')]).
frame('Hagfish',['Agnatha'],[attr(picture,'Hagfish.bmp')]).
frame(salmon,['Osteichthyes'],[attr(picture,'salmon.bmp')]).
frame(seahorse,['Osteichthyes'],[attr(picture,'seahorse.bmp')]).
frame(tuna,['Osteichthyes'],[attr(picture,'tuna.gif')]).
frame(carp,['Osteichthyes'],[attr(picture,'carp4.jpg')]).
frame(sturgeon,['Osteichthyes'],[attr(picture,'250px-Sturgeon2.jpg')]).
frame(shark,['Chondrichthyes'],[]).
frame(ray,['Chondrichthyes'],[]).
frame(skate,['Chondrichthyes'],[]).
frame('Peter',[],[attr(work,fisherman),attr(sell,salmon),attr(age,35),
                  attr(is_owner,'fish shop')]).
frame('John',['Peter'],[attr(work,salesman),
                        attr(is,'the brother of Peter'),
                        attr(age,32)]).
frame('Susan',[],[attr(is,'the wife of John')]).
```

3. Communication user-VoSys

The user writes its message to VoSys by means of a Recursive Transition Network. This grammar is represented on two levels. The first level is depicted in Figure 2. The second level is represented in Figure 3. The initial state of the diagram is $q1$ and the final state is $q4$. The message of the user contains several sentences. Each sentence is finished by a question mark or a dot. We observe that each sentence specifies some object name and some attribute name. From Figure 2 and Figure 3 we observe that the interrogation sentences can be of the following form:

```
Who is Susan?
I would like to know the age of John.
Where does a salmon live?
What kind of heart has a fish?
What skeleton has a salmon?
How old is John?
What kind of fertilization is known for salmon?
Is Peter an owner?
What heart has a salmon?
Who is John?
```

The extraction of the object names and the attribute names is implemented in Java. This module allows to verify also the syntax of the sentences.

The answer given by VoSys is obtained as follows:

- For a given name of object and some attribute name, the value of the corresponding attribute is computed by an inference engine written in Prolog.
- The above computations are performed for each sentences of the user message. As a consequence, if the message contains n sentences then n such values $v_1, \ldots, v_n$ are obtained.
- The general answer of VoSys is obtained by means of the values $v_1, \ldots, v_n$, which are combined by a procedure written in Java. The partial answer, representing the answer to some sentence of the letter, is obtained by a module written in Prolog. We exemplify here a part of this module, with the mention that the predicate `displ` is interrogated:

```
displa(X,'sell',Y,Z):-
     concat_atom([X,' sells ',Y],Z).

displa(X,'work',Y,Z):-
     concat_atom([X,' is a ',Y],Z).

displa(X,'live',Y,Z):-
     concat_atom(['The ',X,' lives in ',Y],Z).

displa(X,'age',Y,Z):-
     concat_atom([X,' is ',Y,' years old'],Z).
```

```
    displa(X,'skeleton',Y,Z):-
         concat_atom(['The ',X,' has a skeleton ',Y],Z).

    displa(X,'heart',Y,Z):-
         concat_atom(['A ',X,' has a ',Y],Z).

    displa(X,'is_owner',Y,Z):-proper_name(X),X='Peter',
         concat_atom(['Yes, ',X,' is the owner of a ',Y],Z).

    displa(X,'is_owner',_,Z):-proper_name(X),
         concat_atom(['No, ',X,' is not an owner'],Z).

    displa(X,'fertilization','external fertilization',Z):-
         concat_atom([ 'For ',X,' is known the external fertilization.
         This is a form of fertilization '],A),
         concat_atom([A,'in which a sperm cell is united with an egg
         cell external to the bodies of the '],B),
         concat_atom([B,'reproducing individuals'],Z).

    displa(X,'fertilization','internal fertilization',Z):-
         concat_atom([ 'For ',X,' is known the internal fertilization.
         This is a form of fertilization '],A),
         concat_atom([A,'that takes place inside the female
         after insemination '],B),
         concat_atom([B,'through copulation.'],Z).

    proper_name('Peter').
    proper_name('John').
    proper_name('Susan').

    displ(X,A,Y,Z):-displa(X,A,Y,Z),!.
```

The communication user-VoSys by e-mail was implemented by means of JavaMail API 1.4.1. This communication is based on two protocols: POP (Post Office Protocol) and SMTP (Simple Mail Transfer Protocol). We generated an email account on GMAIL server. According to the specifications of this server the following settings were used to read the e-mail:

```
String host = "pop.gmail.com";
String user = "syvo2008@gmail.com";
String password = "xxxxxxxxxxxx";
String port = "995";
Properties props = new Properties();
props.put("mail.pop3.host", host);
props.put("mail.pop3.user", user);
props.put("mail.pop3.port", port);
props.put("mail.pop3.starttls.enable","true");
props.put("mail.pop3.auth", "true");
props.put("mail.pop3.socketFactory.port", port);
```

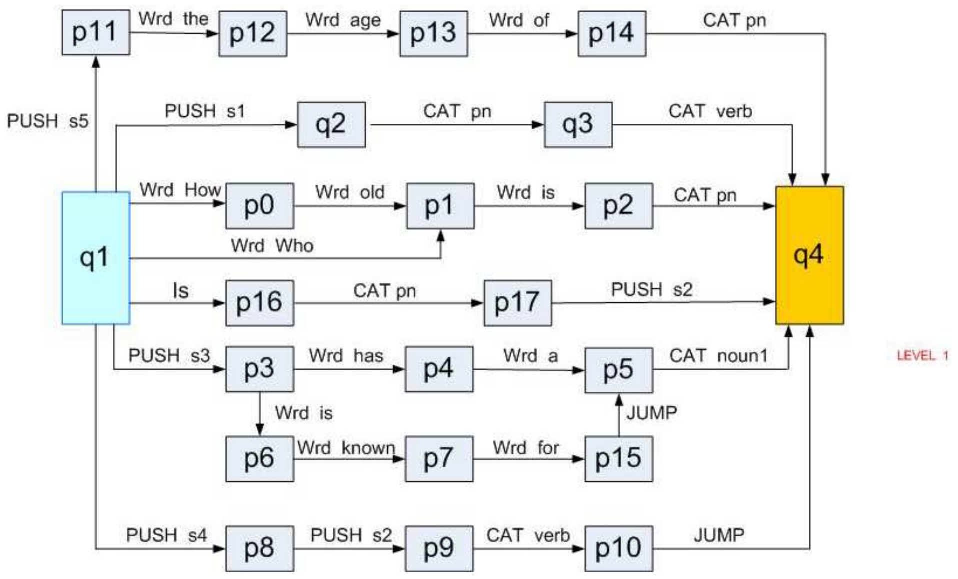


FIGURE 2. The first level of the grammar

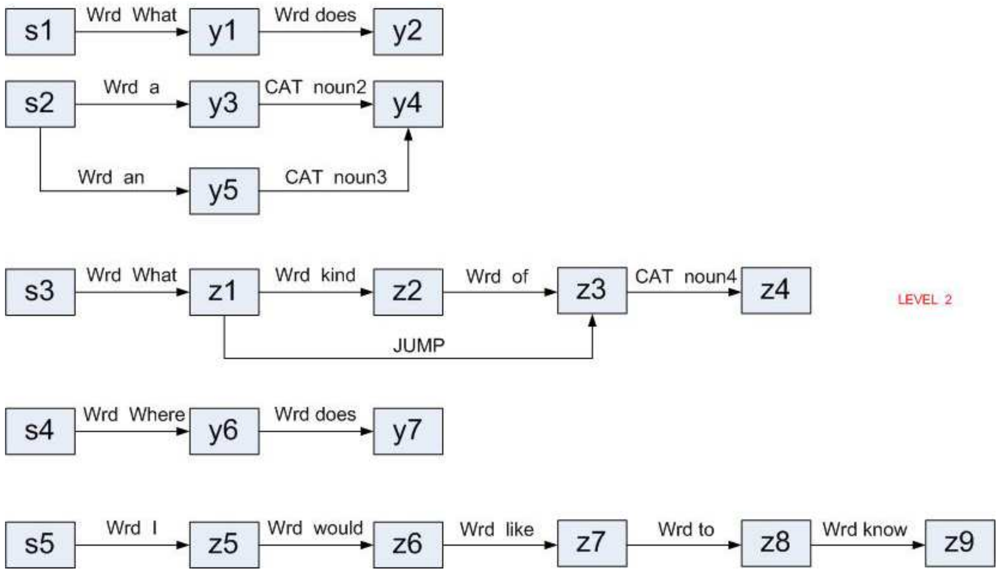


FIGURE 3. The second level of the grammar

```
props.put("mail.pop3.socketFactory.class",
          "javax.net.ssl.SSLSocketFactory");
props.put("mail.pop3.socketFactory.fallback", "false");
```

Now some session is opened, the connection with the server is performed, the INBOX folder is opened and the address of the sender is obtained:

```
Session session = Session.getInstance(props,
              new javax.mail.Authenticator()
{protected PasswordAuthentication getPasswordAuthentication()
{ return new PasswordAuthentication("syvo2008","xxxxxxxxxxxx"); }
});
Store store = session.getStore("pop3");
store.connect(host, user, password);
// Get folder
Folder folder = store.getFolder("INBOX");
folder.open(Folder.READ_WRITE);
Message message1[] = folder.getMessages();
nr_scrisori=message1.length;

if(nr_scrisori > 0)  {
// Get directory
Message message = folder.getMessage(1);
InternetAddress from=null;
Address[] froms = message.getFrom();
from = (InternetAddress)froms[0];
sender = from.getAddress();
```

Moreover, the message written by the user is processed:

```
Part messagePart=message;
      Object content=messagePart.getContent();
    if(content instanceof Multipart)
        {messagePart=((Multipart)content).getBodyPart(0);
         my_outs2.println("[ Multipart Message ]");}
      // -- Get the content type --
      String contentType=messagePart.getContentType();
email_Text1="";
if (contentType.startsWith("text/plain") ||
     contentType.startsWith("text/html"))
    {InputStream is = messagePart.getInputStream();
     BufferedReader reader=
             new BufferedReader(new InputStreamReader(is));
     String thisLine=reader.readLine();

     while (thisLine != null){
             resultText1=thisLine;
             email_Text1=email_Text1+resultText1;
             thisLine=reader.readLine();
                              }   //end while
                                                  }  //end if
```

In order to send the answer the following settings were used:

```
String subject="SyVo";
String body=text_collect;
String recipients=sender;
String mailhost = "smtp.gmail.com";
Properties props_send = new Properties();
props_send.setProperty("mail.transport.protocol", "smtp");
props_send.setProperty("mail.smtp.host", mailhost);
props_send.put("mail.smtp.auth", "true");
props_send.put("mail.smtp.port", "465");
props_send.put("mail.smtp.socketFactory.port", "465");
props_send.put("mail.smtp.socketFactory.class",
"javax.net.ssl.SSLSocketFactory");
props_send.put("mail.smtp.socketFactory.fallback", "false");
props_send.setProperty("mail.smtp.quitwait", "false");
```

where `text_collect` contains the answer generated by VoSys.

Now the answer can be sent to user:

```
Session session_send = Session.getInstance(props_send,
new javax.mail.Authenticator()
{
protected PasswordAuthentication getPasswordAuthentication()

{ return new PasswordAuthentication("syvo2008","xxxxxxxxxxxx"); }
});
MimeMessage message_send = new MimeMessage(session_send);
message_send.setSender(new InternetAddress(sender));
message_send.setSubject(subject);
message_send.setContent(body, "text/plain");
if (recipients.indexOf(',') > 0)
message_send.setRecipients(Message.RecipientType.TO,
               InternetAddress.parse(recipients));
      else
       message_send.setRecipient(Message.RecipientType.TO,
                                   new InternetAddress(recipients));
Transport transport = null;
                transport = session_send.getTransport("smtp");
transport.send(message_send);
       transport.close();
```

4. Running the application

The Graphical User Interface of the application is shown in Figure 4. Some buttons of this figure are described in [9] and [10]. This interface is not viewed by the user, it is used only to describe the main steps of the application and for a step by step execution. A real application can use the principles described in this paper and will supervise permanently the email account. For each letter the application will prepare the answer and will sent this message to user.

The following buttons of the GUI are used for the interrogation by email of a knowledge base:

- `Read E-mail and compute`: read an e-mail, extract the semantics from each sentence and compute the values.
- `Generate Answer`: combines the values computed by the previous step and incorporate them into the general answer.
- `Answer by E-mail`: send the answer to user.

In Figure 5 we present an example of letter containing the following interrogation sentences:

```
Who is Susan? I would like to know the age of John. Where does
```

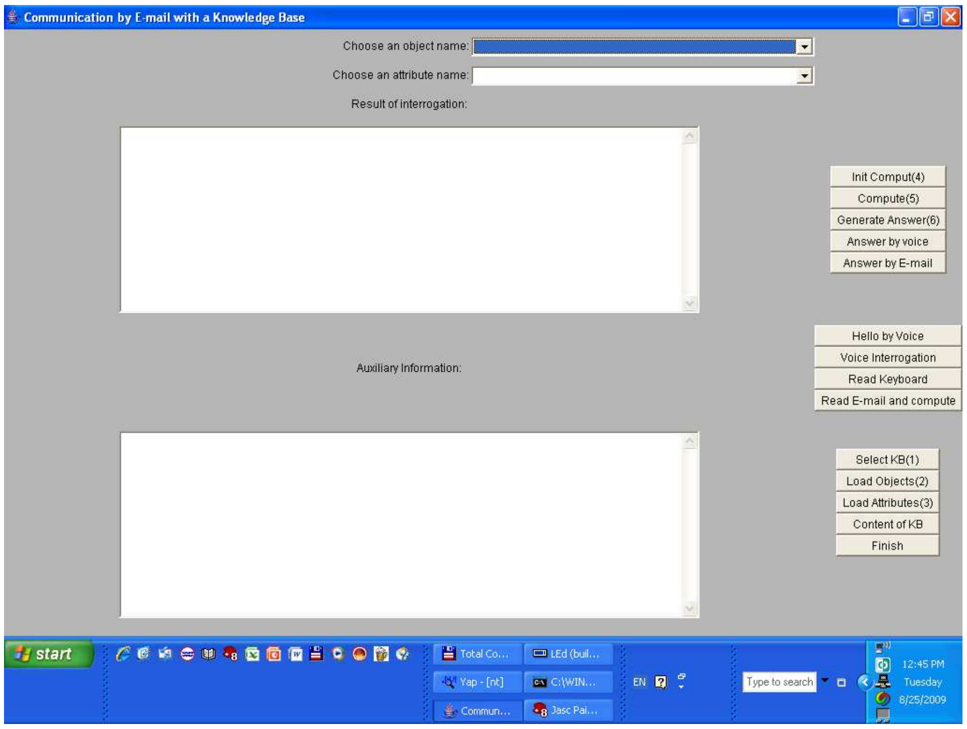


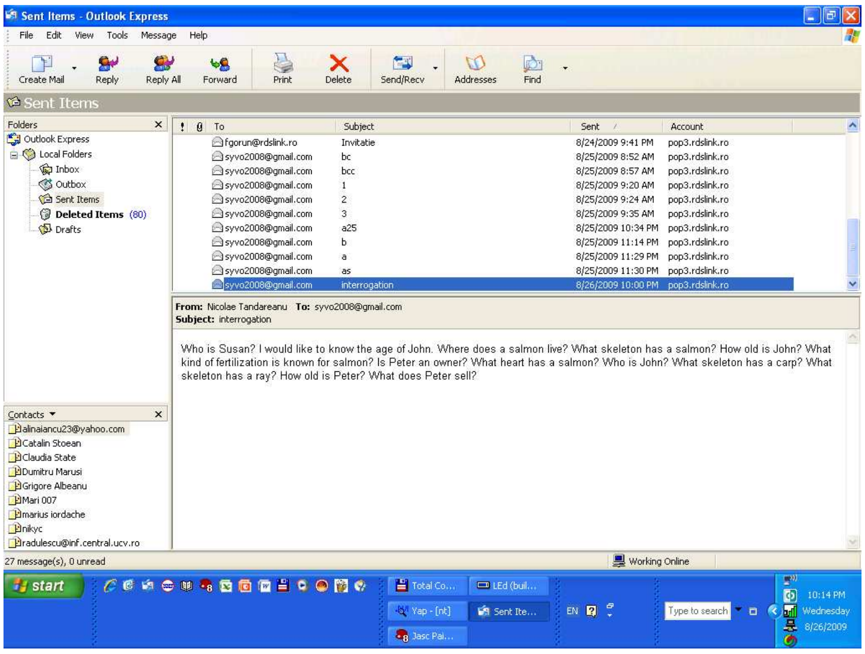
FIGURE 4. Graphical User Interface of VoSys

```
a salmon live? What skeleton has a salmon? How old is John?
What kind of fertilization is known for salmon? Is Peter an
owner? What heart has a salmon? Who is John? What skeleton
has a carp? What skeleton has a ray? How old is Peter? What
does Peter sell?
```

The answer of VoSys is shown in Figure 6 and this is the following:

```
Susan is the wife of John. John is 32 years old. The salmon lives
in marine and fresh water. The salmon has a skeleton made of bone.
John is 32 years old. For salmon is known the external fertilization.
This is a form of fertilization in which a sperm cell is united with
an egg cell external to the bodies of the reproducing individuals.
Yes, Peter is the owner of a fish shop. A salmon has a two chambered
heart.John is the brother of Peter.The carp has a skeleton made of
bone. The ray has a skeleton made of cartilage.Peter is 35 years old.
Peter sells salmon.
```

Remark 4.1. *The letter of interrogation given in Figure 5 contains the following two equivalent sentences:*
(1) *I would like to know the age of John.*
(2) *How old is John?*
In Figure 6 we observe that these sentences have the same answer:

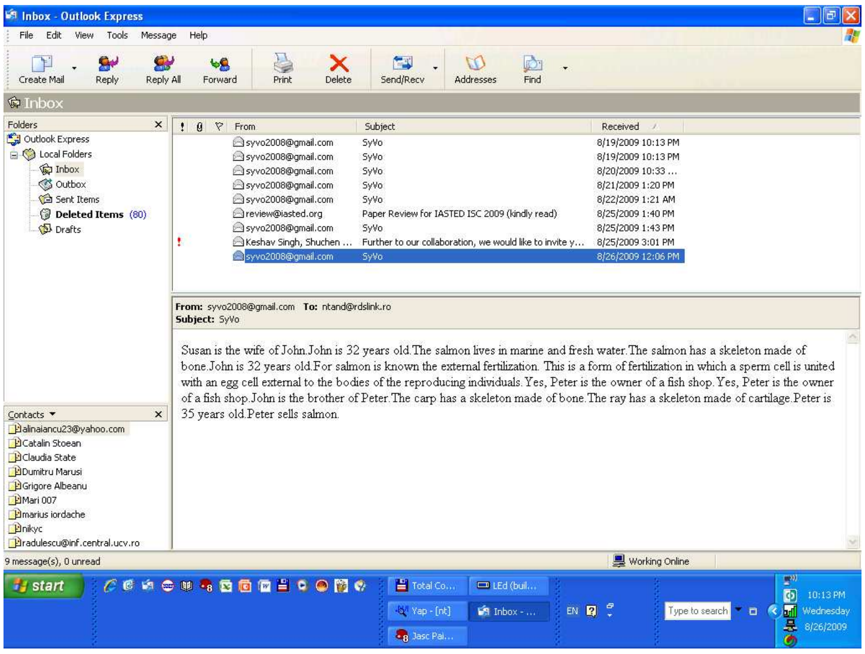


To	Subject	Sent	Account
fgorun@rdslink.ro	Invitatie	8/24/2009 9:41 PM	pop3.rdslink.ro
syvo2008@gmail.com	bc	8/25/2009 8:52 AM	pop3.rdslink.ro
syvo2008@gmail.com	bcc	8/25/2009 8:57 AM	pop3.rdslink.ro
syvo2008@gmail.com	1	8/25/2009 9:20 AM	pop3.rdslink.ro
syvo2008@gmail.com	2	8/25/2009 9:24 AM	pop3.rdslink.ro
syvo2008@gmail.com	3	8/25/2009 9:35 AM	pop3.rdslink.ro
syvo2008@gmail.com	a25	8/25/2009 10:34 PM	pop3.rdslink.ro
syvo2008@gmail.com	b	8/25/2009 11:14 PM	pop3.rdslink.ro
syvo2008@gmail.com	a	8/25/2009 11:29 PM	pop3.rdslink.ro
syvo2008@gmail.com	as	8/25/2009 11:30 PM	pop3.rdslink.ro
syvo2008@gmail.com	interrogation	8/26/2009 10:00 PM	pop3.rdslink.ro

From: Nicolae Tandareanu **To:** syvo2008@gmail.com
Subject: interrogation

Who is Susan? I would like to know the age of John. Where does a salmon live? What skeleton has a salmon? How old is John? What kind of fertilization is known for salmon? Is Peter an owner? What heart has a salmon? Who is John? What skeleton has a carp? What skeleton has a ray? How old is Peter? What does Peter sell?

FIGURE 5. A letter of interrogation

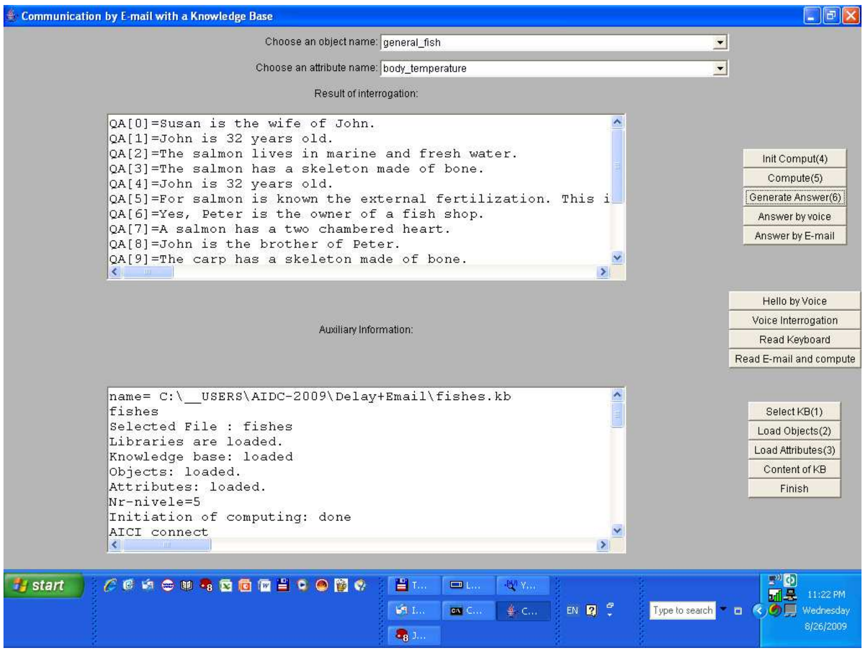


!	From	Subject	Received
	syvo2008@gmail.com	SyVo	8/19/2009 10:13 PM
	syvo2008@gmail.com	SyVo	8/19/2009 10:13 PM
	syvo2008@gmail.com	SyVo	8/20/2009 10:33 ...
	syvo2008@gmail.com	SyVo	8/21/2009 1:20 PM
	syvo2008@gmail.com	SyVo	8/22/2009 1:21 AM
	review@iasted.org	Paper Review for IASTED ISC 2009 (kindly read)	8/25/2009 1:40 PM
	syvo2008@gmail.com	SyVo	8/25/2009 1:43 PM
!	Keshav Singh, Shuchen ...	Further to our collaboration, we would like to invite y...	8/25/2009 3:01 PM
	syvo2008@gmail.com	SyVo	8/26/2009 12:06 PM

From: syvo2008@gmail.com **To:** ntand@rdslink.ro
Subject: SyVo

Susan is the wife of John.John is 32 years old.The salmon lives in marine and fresh water.The salmon has a skeleton made of bone.John is 32 years old.For salmon is known the external fertilization. This is a form of fertilization in which a sperm cell is united with an egg cell external to the bodies of the reproducing individuals. Yes, Peter is the owner of a fish shop. Yes, Peter is the owner of a fish shop.John is the brother of Peter.The carp has a skeleton made of bone.The ray has a skeleton made of cartilage.Peter is 35 years old.Peter sells salmon.

FIGURE 6. The answer sent to user



Choose an object name: general_fish

Choose an attribute name: body_temperature

Result of interrogation:

```
QA[0]=Susan is the wife of John.
QA[1]=John is 32 years old.
QA[2]=The salmon lives in marine and fresh water.
QA[3]=The salmon has a skeleton made of bone.
QA[4]=John is 32 years old.
QA[5]=For salmon is known the external fertilization. This i
QA[6]=Yes, Peter is the owner of a fish shop.
QA[7]=A salmon has a two chambered heart.
QA[8]=John is the brother of Peter.
QA[9]=The carp has a skeleton made of bone.
```

Auxiliary Information:

```
name= C:\__USERS\AIDC-2009\Delay+Email\fishes.kb
fishes
Selected File : fishes
Libraries are loaded.
Knowledge base: loaded
Objects: loaded.
Attributes: loaded.
Nr-nivele=5
Initiation of computing: done
AICI connect
```

FIGURE 7. The final state of GUI

John is 32 years old.

The final state of the GUI can be viewed in Figure 7, where in the first window we see the answer computed by VoSys for each sentence of the interrogation.

If we use the scrollbars then we see the following content of the first window:

```
QA[0]=Susan is the wife of John.
QA[1]=John is 32 years old.
QA[2]=The salmon lives in marine and fresh water.
QA[3]=The salmon has a skeleton made of bone.
QA[4]=John is 32 years old.
QA[5]=For salmon is known the external fertilization. This is a form of
fertilization in which a sperm cell is united with an egg cell external
to the bodies of the reproducing individuals.
QA[6]=Yes, Peter is the owner of a fish shop.
QA[7]=A salmon has a two chambered heart.
QA[8]=John is the brother of Peter.
QA[9]=The carp has a skeleton made of bone.
QA[10]=The ray has a skeleton made of cartilage.
QA[11]=Peter is 35 years old.
QA[12]=Peter sells salmon.
The answer is the following:
Susan is the wife of John. John is 32 years old. The salmon lives in
marine and fresh water. The salmon has a skeleton made of bone. John
is 32 years old. For salmon is known the external fertilization.
This is a form of fertilization in which a sperm cell is united with
an egg cell external to the bodies of the reproducing individuals.
```

```
Yes, Peter is the owner of a fish shop. A salmon has a two chambered
heart. John is the brother of Peter. The carp has a skeleton made of
bone. The ray has a skeleton made of cartilage. Peter is 35 years old.
Peter sells salmon.
```

5. Conclusion and future work

In this paper we describe a new feature of VoSys: the ability to communicate by e-mail with the user. This ability can be viewed as a facet of the remote interrogation of a knowledge base. VoSys can process knowledge bases that allow the inheritance, but the ideas presented in this paper can be used for other kinds of knowledge bases. The reader can observe that the knowledge base used by VoSys contains some pictures of the fishes. It is not difficult to introduce such a picture into the answer of VoSys. An improved version of our application can be obtained if several models presented in [2] and [3] are taken into consideration.

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