Chapter 4

Design of the MASICC

4.1 Agent communication of MASICC

The MAS is designed according to the requirements for effective diagnosis and delivering the treatment plans for young infant/child in the child-care setting described in section 3.2. It provides an interaction mechanism with the healthcare professional at a rural site and delivers diagnosed disease and suggests treatment plans as per the supplied sign-symptoms. The other functionality of MASICC is to select appropriate super specialist doctor, in case IPA fails to diagnose the disease. Figure 4.1 and Figure 4.2 illustrate the model using Interaction diagrams [81].

In Figure 4.1, the interaction that takes place between HCP at rural site with the patient and the UA is depicted. It also shows the communication that take place between UA and IPA. The HCP first gets itself registered with the IPA. IPA generates a unique identification number for each UA. The communication is designed to produce a result that contains information about the diagnosed disease; its severity level and the treatment plan. The treatment plan is to be administered on the patient by the HCP. This Figure also depicts the functionality of IPA, that is, the functions IPA perform.
Figure 4.1 Interaction diagram involving UA, IPA, HCP

In Figure 4.2, a special case is depicted. This special case corresponds to a situation when UA selects the 'others' as the main question. IPA responds back with a complete different set of sign-symptoms and finally IPA is responsible to select one of the SSA for communication. These Figures show that IPA is a fully automated agent.
MASICC : Sequence Diagram 2

Figure 4.2 Interaction diagram for a special case.

The next section describes the mathematical notation that is used to define the functional model of UA and IPA.
4.2 Summary of the notations

The following notation is used throughout the description of functionality of agents.

The set $S_{UA}$ specifies the agent assisting the rural HCPs.

$$S_{UA} = \{ua_1, ua_2, ..., ua_n\}$$

The agent at the urban area is called $IPA$. It interacts with all instances of $S_{UA}$ and also $S_{SSA}$. $S_{SSA}$ is a set that contains the super specialist agents, corresponding to one medical super specialization. Assume that there are $m$ super specialist agents then

$$S_{SSA} = \{ssa_1, ssa_2, ..., ssa_m\}$$

The main task of the HCP is to select the main question, out of given $k$ questions.

$$Q = \{q_1, q_2, ..., q_k\}$$

$$\forall i = 1, 2, ..., k-1$$

The $k^{th}$ question is a special question termed as 'others'.

Corresponding to each $q_i$, there is a set of sign-symptoms, say $s_j$.

$$S = \{s_1, s_2, ..., s_k\}$$

\text{where } s_j = \{\text{sym}p_{i1}, \text{sym}p_{i2}, ..., \text{sym}p_{it}\}

$$\forall j = 1, 2, ..., k$$

Similarly, corresponding to each set of sign-symptoms, we need a set $V$ that is defined as a set of values related to $s_j$.

$$V = \{val_1, val_2, ..., val\}$$

\text{where } val_r = \{v_1, v_2, ..., v_{rt}\}

$$\forall r = 1, 2, ..., t$$

The disease that is to be diagnosed is denoted as $D$ and its corresponding severity level is denoted as $SL$. $T$ specifies the treatment plan according to $D$ and $SL$. 
During a special case where, IPA sends a set of sign-symptoms, whose values are assumed to be

\[ V' = \{v'_1, v'_2, \ldots, v'_t\} \]

### 4.3 Functional model of agent in urban areas

**Definition 1:** We define a function \( \alpha : Q \rightarrow S \). The argument to this function is \( q_i \).

\[
\alpha(q_i) = s_j, \quad \text{where } s_j \in S \text{ and } q_i \in Q
\]

Eqn. 1

In other words, it accepts the main question posed by one of the UAs as input and returns a set of sign-symptoms \( s_i \) whose value(s) are to be filled by the UA.

**Definition 2:** We define a function \( \beta \). It accepts main question \( q_i \), set of corresponding sign-symptoms \( s_i \) and their respective values filled by the UA.

\[
\beta(q_i, s_i, v_k) = (d_r, s_l) \\
\text{where } 2^{|s_i|} \text{ denotes the normal power set of sets } \{s_j, v_k\}, \text{i.e. set of all possible subsets.}
\]

Eqn. 2

This function returns a tuple containing the diagnosed disease and its severity level.

**Definition 3:** A function \( \gamma \) is defined. The inputs to this function are the diagnosed disease and the severity level generated by the function \( \beta \) defined above.

\[
\gamma(d_r, s_l) = R \\
\text{where } R \ni (d_r, s_l, t_{p^*})
\]

Eqn. 3
Design of the MASICC

It returns a comprehensive report \( R \) that consists, denoted as ‘\( \mathcal{R} \)’, of the diagnosed disease, its severity level and the treatment plans. \( tp \), denotes one or more required treatment plan.

**Definition 4:** We define a function \( \alpha' \), a variant of function \( \alpha \). It accepts the question \( q_k \), a special case of main questions termed as ‘others’.

\[
\alpha'(q_k) = s' \tag{Eqn. 4}
\]

where \( s' \) is a special set of sign-symptoms

The function returns a special set of sign-symptoms, designed for \( q_k \) only.

**Definition 5:** Another function, termed as \( \phi \). It accepts a vector \( V' \), i.e. values corresponding to the \( s' \).

\[
\phi(v') = SSA' \tag{Eqn. 5}
\]

where \( SSA' \) is the most appropriate agent

It invokes one of the following three decision making mechanisms to select \( SSA' \):

a) Bayesian Network based decision making
b) Back Propagation Neural Network based decision making, or
c) Probabilistic Neural Network based decision making.

The selected \( SSA \) is to be contacted for consultation.

**Definition 6:** We define a function \( \eta \). The input to this function is \( SSA' \) i.e. the output of the function \( \phi \). It is responsible to inform the selected \( SSA' \) about the \( UA^* \) who sought help.

\[
\eta : \text{Inform} \{ UA^* \leftrightarrow SSA' \} \tag{Eqn. 6}
\]

Figure 4.3 (a) depicts the functional model during normal course of diagnosis followed by UA and IPA. Figure 4.3 (b) summarizes a special case, where IPA selects SSA for consultation. The next section describes the tasks that are performed by UA.
Figure 4.3 (a & b): Summary of the functional model
4.4 Functional model of the agent in rural areas

In this section, the functionalities, which are performed by UA, are defined in terms of tasks.

**Task T1: Invoke_regstr**

During initial phase of the communication between UA and IPA, *Invoke_regstr* is activated to register the HCP. A unique identification is generated by IPA and is passed to UA. UA in turn passes this information to the corresponding HCP.

**Task T2: Invoke_α**

*Invoke_α* is a two stage task.

Stage 1: During this stage, it interacts with the HCP and receives the main question.

Stage 2: In this phase, the received question is sent to the IPA by invoking function ‘α’ defined earlier. The main question is used by ‘α’ as an argument.

**Task T3: Receive_sign-symptoms**

Corresponding to the main question, IPA sends a set of sign-symptoms whose values are to be observed by the HCP.

This is a two stage task. Firstly it receives the set of sign-symptoms and then it passes this to the HCP.

**Task T4: Invoke_β**

This is a two stage task.

Stage 1: During this stage, the values of sign-symptoms are received from the HCP. These values correspond to the set of sign-symptoms sent to HCP during T3.

Stage 2: The value vector is passed on to IPA and ‘β’ is invoked. The value vector becomes the argument of ‘β’.
**Task T5: Receive_report**

During this task, a comprehensive report is received. This report contains a tuple of:

- $d$: diagnosed disease,
- $s$: the severity level, and
- $t$: treatment plan(s).

This report is further passed on to HCP for action.

**Task T2': Invoke $\alpha'$**

$Invoke_\alpha'$ is a special task performed during a special circumstance. UA on receiving main question termed as 'others' invoke $\alpha'$ at IPA.

**Task T3': Receive_special_sign-symptoms**

During this task, a special set of sign-symptoms corresponding to the main question 'others' are received and is passed on to the HCP. Rest of the functionality is same that of T3.

**Task T6: Invoke $\varphi$**

During this task, UA receives a set of values from HCP, corresponding to the set of sign-symptoms provided during task T3'. $\varphi$ is invoked at the IPA by providing this set of values as argument.

**Task T7: Invoke $\eta$**

UA invokes the function $\eta$ at IPA which informs it about the most appropriate SSA that is to be contacted. IPA is to decide about the SSA.

### 4.5 Application Scenario

The MASICC provides a clinical decision support to a HCP dealing with the child diseases at rural area. It is also designed to select the most appropriate medial specialist
Design of the MASICC for consultation. These two aspects of the MASICC are discussed with examples, given below:

**CASE 1 (Knowledge sharing between UA and IPA)**

A mother brings her one year old child with complaints of loose motions and fever. After observing the child health, if the rural health practitioner feels the need of assistance of a child specialist, he uses the graphical user interface of UA located at his site to pass the sign-symptoms and other observations to the IPA.

The IPA uses Eqn 1 to generate a set of related questions that indicate possible diseases like bacterial infection, viral disease, malaria, malnutrition or food allergy. In the second phase, UA supplies back the observed and measured values corresponding to the sign-symptoms generated earlier by IPA.

UA answers the questions like: checking for general danger signs (convulsions y/n; unconsciousness y/n) bloody diarrhea y/n; Sunken eyes y/n; able to drink y/n; stiff neck y/n; bulging fontanelle y/n etc. IPA uses Eqn 2 to decide the diagnosed disease and its severity level.

The presence/absence or values of some of the sign-symptoms need due importance. That is why, some sign-symptoms are given more priority than others. For example presence of ‘lethargy or unconsciousness’ is assigned higher priority than ‘sunken eyes’. This will help to classify the disease into very severe (requires urgent treatment & referral) or less severe (requires conservative treatment without referral) category.

The summary report that contains the diagnosed disease, its severity level and the treatment plan(s) is then sent back to UA, using Eqn 3, for actions to be taken by the HCP.

Figure 4.4 depicts a hypothetical case scenario of a child suffering from moderate dehydration. Refer section 5.1 for detailed sample cases for knowledge base.
### Application Scenario

<table>
<thead>
<tr>
<th>Main Question</th>
<th>Sign-Symptoms</th>
<th>Disease</th>
<th>Severity Level</th>
<th>Treatment</th>
</tr>
</thead>
</table>
| High frequency of stool | • From How Long days?  
• Is there Blood in stool?  
• Is the infant Lethargic or Unconscious?  
• Is the infant Restless or irritable?  
• Look for Sunken Eyes. | Some dehydration | Moderate | 1. If the infant has low weight or another severe classification:  
a) Refer urgently to the hospital with mother giving frequent sips of ORS on the way.  
OR  
2. If infant does not have low weight or any other severe classification Give fluid for severe dehydration. |

**Figure 4.4** Sample case of Disease Identification and Treatment Plan

#### CASE 2 (Knowledge sharing between UA and IPA and Decision making by IPA)

Assume that the HCP wishes to pose a different problem that is not listed as a main question. The HCP selects 'other' as main question. UA sends this information to IPA using Eqn 4. Later IPA sends back a list of sign-symptoms, which can be selected as input. For instance, the HCP finds the following three sign-symptoms in a patient:

a) Wheeze  
b) Pain in chest, and  
c) Abdominal distention
IPA receives this input using Eqn 5 and processes it to select one of the SSA. There are number of competing SSAs, but based on the inputs 'Pulmonologist Agent' needs to be selected to treat the patient who is suffering from chest related disease. This decision making process is very critical for effective communication among agents. The IPA is also responsible to inform UA about the selected SSA and SSA about the UA that invoked the 'other' case. This is performed using Eqn 6.

These two examples demonstrate the use of various equations that we defined in this chapter.