# A Collaborative Activity for Evaluating HAT-COM: Human-Agent Teamwork Communication Model (Demonstration)

Nader Hanna, Deborah Richards
Department of Computing, Macquarie University
NSW, 2109, Australia
T: +61298509567 F: +61298509551
{nader.hanna, deborah.richards}@mq.edu.au

## ABSTRACT
Communication between collaborating virtual agents and humans is a challenging activity as it can take many forms and requires situation awareness, planning and replanning. In this paper we present the Human-Agent Teamwork Communication (HAT-COM) model and scenario that have been integrated into a collaborative virtual learning environment for evaluation purposes.

## Categories and Subject Descriptors
I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence – *intelligent agents, multiagent systems.*

## General Terms
Design and Human Factors.

## Keywords
Human-Agent Communication Model, multimodal Communication, Human-Agent Collaboration.

## 1. INTRODUCTION
Working in teams can be an effective way of getting tasks done and also add to the enjoyment of the activity. However, humans are often not so willing or able to collaborate. To make our existing virtual learning environment (VLE) more interactive and engaging and to help students learn how to collaborate, we have designed and implemented an authentic collaborative task to be done by a human and virtual agent working together. Ferguson and Allen [1] state that true human-agent collaborative behaviour requires an agent to possess a number of capabilities, including communication. Communication is one of the main challenges in agent-human collaboration research [1]. While much research involving agent-agent communication exists, few present a communication model. Models that do exist only concern communication between agents (e.g.[3]), a sketch of a spoken negotiation model [4] or non-verbal communication [2].

To address these gaps, this demonstration paper presents our model that establishes communication between a human and agent in a real-time collaborative environment. The proposed Human-Agent Teamwork Communication (HAT-COM) model has the advantage of two-way communication involving human-agent teamwork and offers two-channel communication that combines verbal and non-verbal communication, similar to human-like communication in real-time collaborative situations. To test how well the model supports human-agent communication in order to achieve together an objective in a virtual world, we have extended a VLE designed for secondary science students.

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## 2. HAT-COM ARCHITECTURE
The proposed model is shown in Fig. 1. This communication model is connected with an agent planner and includes both verbal communication (i.e. textual communication) and non-verbal communication (i.e. behavioural communication). Other communication forms could be handled via preprocessing and appropriate input/output devices and technology, e.g. voice recognition and translation of oral communication into text or use of an eye tracker for eye gaze into actions/behaviours. Interaction involves alternating between textual and behavioural communication. That is to say, the human will send a text request to the agent, and the agent will reply with acceptance or rejection depending on its plan. The agent may also send a text request to the human user asking for help to achieve the task. The human user may reply with acceptance or rejection. The rejection of the agent's request by the human user will lead the agent to modify its plan to the new state of the task. Behavioural communication is also handled in an alternating fashion and relies on the agent planning process. As part of behavioural communication, the agent has to monitor the surrounding environment and observe the actions of the human teammate and continuously adapt his plan to the changes.

## 3. SCENARIO AND TECHNOLOGY USED
The VLE we extended represents an ecosystem on an imaginary island with a mission to the learners to draw a conclusion why the fictitious animals, known as Yernt, are dying out. This collaborative scenario is a task where both the human user and virtual agent, David the ecologist, collaborate to achieve a shared goal: to capture a Yernt so that David can study it more closely. We felt this task was an authentic collaborative activity as in the real world it is much easier to capture an animal if there is someone to help you. The activity also provides a sense of urgency to motivate efficient communication.

To trap the animal, both the learner and the agent should take alternating turns to build a fence around the animal by selecting one region out of eight regions forming an octagon around the animal (see Fig. 2). In the beginning, the human will select one region. After choosing one region, the two possible selections will be the two neighbouring regions. In his turn, the virtual agent will observe: his environment; human action (non-verbal communication); any request from the human (verbal communication) and finally form his plan to take the decision about the next step.

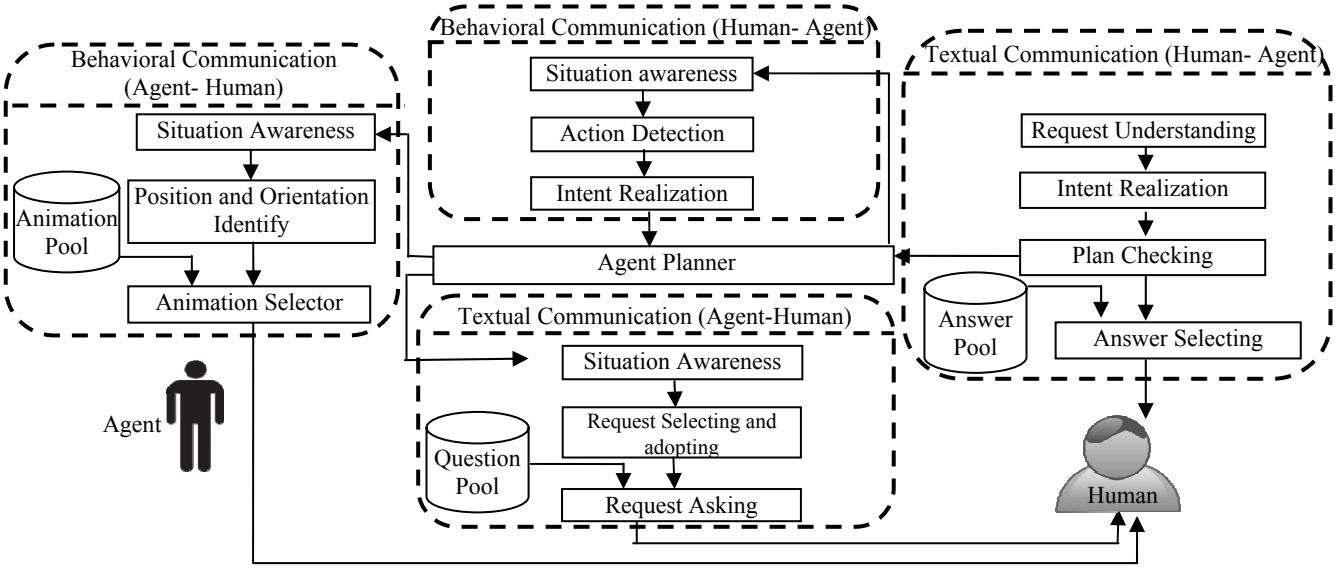


**Figure 1: Human-agent communication model**

Before the agent selects a region, he will verbally reply to the human's request. A fence will be built automatically between the two selected regions and the turn will go back to human. The human and agent keep taking turns and communicating until the fence is built around the animal. The system was designed using the Unity3D game engine, and the animation and agent reasoning were programmed using JavaScript language. The collaborative activity can be found at http://comp.mq.edu.au/~richards/AAMAS2013-demo/HAT-Com_Demo.html

**Figure 2: Snapshot from the collaborative environment**

## 4. EVALUATION

To verify the proposed model, an experiment was carried out with 66 participants enrolled in a second year undergraduate unit on animal behaviour. Data was collected by two means, the first one was automatic data logging to track both the human's and the agent's behaviours, messages and selections and to register any problems experienced by the participants. The second means was a survey that contained 10 Likert scale questions (strongly agree, agree, disagree and strongly disagree) to acquire the users' opinions about the agent's verbal and non-verbal communication and how it was relevant to the collaborative situation. Results demonstrated that 72.3 % thought the verbal communication was relevant to the collaborative situation, 78.1% thought the behavioural communication of the agent was relevant to the situation and the flow of action. Analysis of the log data revealed that the more the human and the agent communicate while carrying out the collaborative task, the more the human understood the agent's future intentions as reflected in the reduction of requests by the human to the agent to give the reason for the agent's requests.

## 5. CONCLUSION & FUTURE WORK

This paper describes an implemented collaboration activity to validate the HAT-COM model. Novelly, our proposed model enables two-way (between human and agent) and two-channel (verbal and non-verbal) communication between human and agent in a real-time collaborative task. Our system has shown promising results concerning the feedback of the human user to the communication process, as well the positive effect of communication built on the proposed model on the flow of action. Future studies will evaluate our latest version and a more complex scenario that includes multiple and alternative decision strategies.

## 6. References


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