BRAHMS: a multiagent modeling and simulation language for work system analysis and design

Maarten Sierhuis, Ph.D.
Senior Scientist
USRA/RIACS
NASA Ames Research Center
Moffett Field, CA
msierhuis@mail.arc.nasa.gov

August 6, 2002
The Rocket Science of HCC

What’s the Delta?

HUMAN

Coordinate multimodal concepts, values, practice

COMPUTER

Measure, classify, infer, depict, process
Research Question

• How can we model an organization’s work practice in such a way that we include people’s collaboration, “off-task” behaviors, multi-tasking, interrupted and resumed activities, informal interaction and geography?

• Objective is to find representations and techniques for analyzing and designing work systems (socio-technical systems) holistically and human-centered
Definition

The performance of collective situated activities of a group of people, collaborating, communicating, and gaining experience while performing these activities synchronously or asynchronously.
Work Practice Modeling

• **Groups & Agents**
  – work as activities
  – beliefs trigger work
  – bounded rationality is socially and culturally defined

• **Collaboration between Agents**
  – agents react to and interact with other agents
  – same time/same place
  – same time/different place
  – different time/same place
  – different time/different place
WPM cont’d

• **Tools & Artifacts**
  – tools used in activities
  – artifacts created in activities

• **Environment/Geography**
  – agents have a location
  – artifacts have a location
  – detecting real-world facts

• **Communication**
  – is situated
  – the means of communication depends on the situation (e.g. voice loop, f2f communication, telephone, faxing, e-mail)
  – impacts efficiency of work
Java-based

Java API

XML

Runs on PC’s, Mac, Unix, Linux ...

Agent-Oriented Language

Language Parser

Interactive Development Environment

Discrete-event Simulation Engine

End-user Simulation Displays

Simulation History Data Base

Brahms

© Maarten Sierhuis
Collaborative Modeling

Ethnographic Observation
Video Analysis
Conceptual Modeling
Brahms Modeling
Brahms Simulation

VR Model/AgentViewer

Work Practice Simulation

Human Activity System

Conceptual modelers

Observing work practice

Observing simulated work practice

Formal modeling of the WP

Simulation

 Formal static models

Brahms modelers
Design, Generate and Simulate

M1

Conceptual Model

Brahms Code Generation

Simulation/Visualization

M3/M4
Brahms Research
Projects at NASA

• Human-Robotic Teamwork
  – Teamwork & Work Practice onboard the ISS
  – Mobile Agents supporting of Mars Exploration

• Mars Habitat
  – Living and working on Mars

• ’03 Mars Exploration Rover
  – Use Brahms to model Mission Operations Work System at JPL
Mobile Agents

Runtime
- Models of People & Robots
- Intelligent Assistants
  - Agents for people & robots
- Software Agents
  - Dialog agent
  - Communication Agent
  - Proxy agent

Design Phase
- Simulated People & Robots
- Intelligent Assistants
- Software Agents (simulated)
- Software Systems (simulated)
<table>
<thead>
<tr>
<th>Agent Eva Dialog Agent</th>
<th>Agent Bob Agent</th>
<th>Agent BobProxy Agent</th>
<th>Agent EraProxy Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>wf: wf_waiting</strong></td>
<td><strong>wf: wf_waiting</strong></td>
<td><strong>wf: wf_waiting</strong></td>
<td><strong>wf: wf_waiting</strong></td>
</tr>
<tr>
<td><strong>pa: pa_waiting</strong></td>
<td><strong>pa: pa_waiting</strong></td>
<td><strong>pa: pa_waiting</strong></td>
<td><strong>pa: pa_waiting</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AtvBrahmsModel</th>
<th>AtvBrahmsModel</th>
<th>AtvBrahmsModel</th>
<th>AtvBrahmsModel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>wf: wf_waiting</strong></td>
<td><strong>wf: wf_waiting</strong></td>
<td><strong>wf: wf_waiting</strong></td>
<td><strong>wf: wf_waiting</strong></td>
</tr>
<tr>
<td><strong>pa: pa_waiting</strong></td>
<td><strong>pa: pa_waiting</strong></td>
<td><strong>pa: pa_waiting</strong></td>
<td><strong>pa: pa_waiting</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EraBrahmsModel</th>
<th>EraBrahmsModel</th>
<th>EraBrahmsModel</th>
<th>EraBrahmsModel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>wf: wf_waiting</strong></td>
<td><strong>wf: wf_waiting</strong></td>
<td><strong>wf: wf_waiting</strong></td>
<td><strong>wf: wf_waiting</strong></td>
</tr>
<tr>
<td><strong>pa: pa_waiting</strong></td>
<td><strong>pa: pa_waiting</strong></td>
<td><strong>pa: pa_waiting</strong></td>
<td><strong>pa: pa_waiting</strong></td>
</tr>
</tbody>
</table>
Mobile Agents Architecture
Simulation of MOS Work Process for MER MOS Design
Collaborative Design with MER MOS DT
### Mission Support Area

**Agent Tactical Downlink Lead**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Task Description</th>
<th>Priority</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/29/2002</td>
<td>1:30 PM</td>
<td>Tactical End Of Sol Engr Assessment</td>
<td>0</td>
<td>Busy</td>
</tr>
<tr>
<td></td>
<td>2:10 PM</td>
<td>start_Tactical_Downlink_Report</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2:50 PM</td>
<td>write_Rover_Health</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3:30 PM</td>
<td>reviewing Report</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4:10 PM</td>
<td>Reading Engr Activity Plan Update</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4:50 PM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Agent SOWG Chair**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Task Description</th>
<th>Priority</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/29/2002</td>
<td>1:30 PM</td>
<td>start_Shift_temp</td>
<td>0</td>
<td>Not Available Yet</td>
</tr>
<tr>
<td></td>
<td>2:10 PM</td>
<td>science_Assess_Observe_Plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2:50 PM</td>
<td>relate_Current_To_Strategic</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3:30 PM</td>
<td>move_To_Location</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4:10 PM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4:50 PM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Creation of new science plans (boundary objects) and communicating to others
<table>
<thead>
<tr>
<th>Scie Bldg</th>
<th>Bldg B South Stairway X-Y</th>
<th>Bldg B South Stairway Y-Z</th>
<th>Bldg</th>
</tr>
</thead>
</table>

Agent SOWG Chair

Walking Takes Time!!!!

Walking from Science Room to Conference Room

<table>
<thead>
<tr>
<th>Scie Bldg</th>
<th>Bldg B South Stairway X-Y</th>
<th>Bldg B South Stairway Y-Z</th>
<th>Bldg</th>
</tr>
</thead>
</table>

Agent Geochemistry Theme Group Lead

<table>
<thead>
<tr>
<th>Scie Bldg</th>
<th>Bldg B South Stairway X-Y</th>
<th>Bldg B South Stairway Y-Z</th>
<th>Bldg</th>
</tr>
</thead>
</table>

Agent Long Term Planning Theme Group Lead
ISS Project Goals

- **External goals**
  - *artifact* to study and understand work practices and teamwork onboard ISS
  - *model* to be used in:
    - *planning*. ISS Mission planning and procedure development
    - *execution*. HCI: Autonomous Intelligent Software or Robotic Agents (e.g. PSA, Robonaut) in support of teamwork.

- **Internal goals**
  - Explore use of Brahms in representing manned space missions
  - Study Brahms as an ABSS (Davidsson, 2002)
Modeling the ISS crew with Brahms

• Data
  • Videos, pictures, interviews
  • JSC manuals, procedures
  • Timelines, schedules
  • On-orbit and post-orbit debriefs
  • MOD servers

• Work practice data analysis
• Conceptual modeling
• Brahms model and simulation
Morning Activities ISS Exp 2, May 7, 2001