



Agent-based Modeling of Human Work & Information Systems

A case for Human-Agent Interaction

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Outline

- Background
- Theoretical Stance
- Brahms
- Current Research
- Summary: Research Vision

Background

- '86: Eng. degree in Higher Informatics
 - Thesis: Applying KADS and Expert Systems to Social Security Law for the City of A'dam (de Hoog & Wielinga)
- '86 - '97: K.E. & K.R. and Expert Systems (Sema Group, IBM, NYNEX S&T)
- '92 - '97: Developed and applied Compendium together with Al Selvin (Ph.D. student at KMi)
- '92 - now: Development & application of Brahms
- '97 - '01: Ph.D. at SWI, UVA (de Hoog, Wielinga, Clancey)
 - Thesis: Modeling and Simulating Work Practice; Brahms: A multiagent modeling and simulation language for work system analysis and design.
- '98 - now: WSD&E group at NASA ARC

Work Systems Design & Evaluation Group

NASA ARC

- '98: Work Systems Design & Evaluation Group (1st members Clancey & Sierhuis)
- 2 ethnographers, 3 Brahms developers, 1 Brahms modeler, 1 Ph.D. student
- Current projects
 - MODAT: Mission Operations Modeling & Simulation (14 people)
 - Mobile Agents: Agent-based Workflow for Exploration (20+ people)
 - BrahmsVE: Bot-language for Virtual Worlds (5 people)
- Funding: NASA is like DARPA and NSF (things are changing)

Theoretical Stance

Philosophical Stance about Practice as Knowledge

*Technical Rationality to Reflection-in-Action,
Schön, D. A. (1982)*

- *Practice* is a valid form of knowledge
- *Practice* drives people's behavior and action
- We can objectify this knowledge in a Knowledge-Level Representation, just like CommonKADS objectifies problem-solving knowledge

Philosophical Stance about Practice as Knowledge

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Understanding Context

- Hermeneutics and Work Practice (Winograd & Flores)
 - Interpreting the world in order to act
- Situated Action Models (Suchman, Lave)
 - Moment-by-moment analysis of interaction between people, tools and environment in a particular situation (or setting).
 - Plans are *not* a mechanism for action, but resources created in activities (a rationalization of intention).
- Activity Theory (Vygotsky, Leont'ev, Nardi)
 - Group behavior is described in terms of an activity.
 - An activity is composed of a subject, object, its actions and operations.
 - Operations are learned activities and are primitive (i.e. not consciously decomposed into goals and sub-actions)
 - An activity creates and encompasses the context through its enactment of actions and operations of the people engaged, and the artifacts used.
- Distributed Cognition (Hutchins)
 - The study of representation of knowledge both inside people's heads and in the artifacts and systems they use, i.e. the total cognitive system (e.g. the pilots and the cockpit).
 - The focus is on the coordination within the total cognitive system (people and systems).

Work Practice

Definition:

- *situated activities of a group of people*
- *synchronously or asynchronously*
- *collaborating and communicating*
- *gaining experience*

Practice is “doing-in-action” (Suchman, '87)

“Collective learning results in practices.” (Wenger, '98)

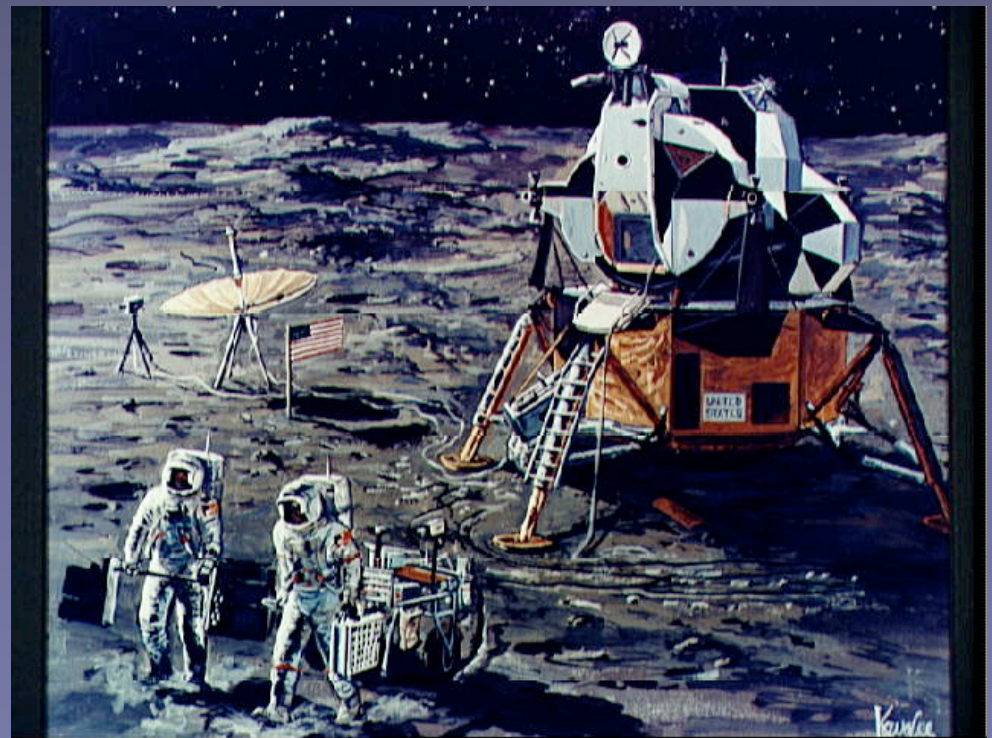
What is it that results?

Can it be described?

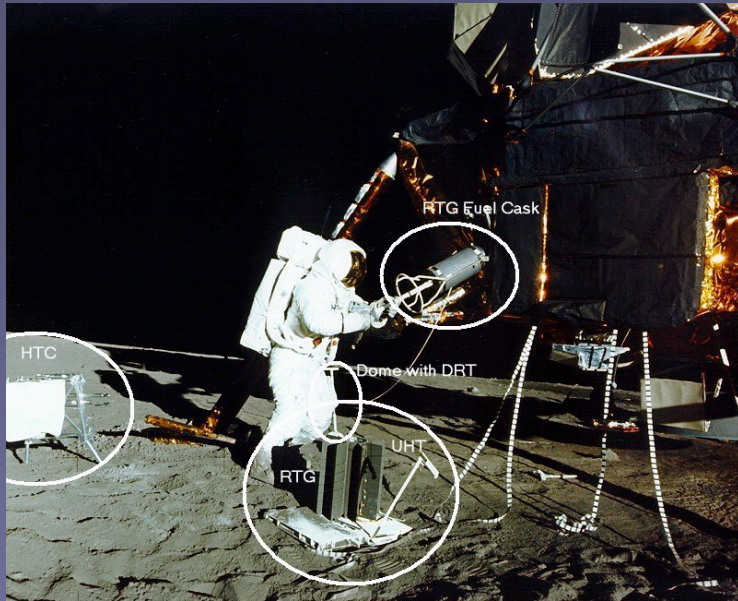
Can it be modeled?

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

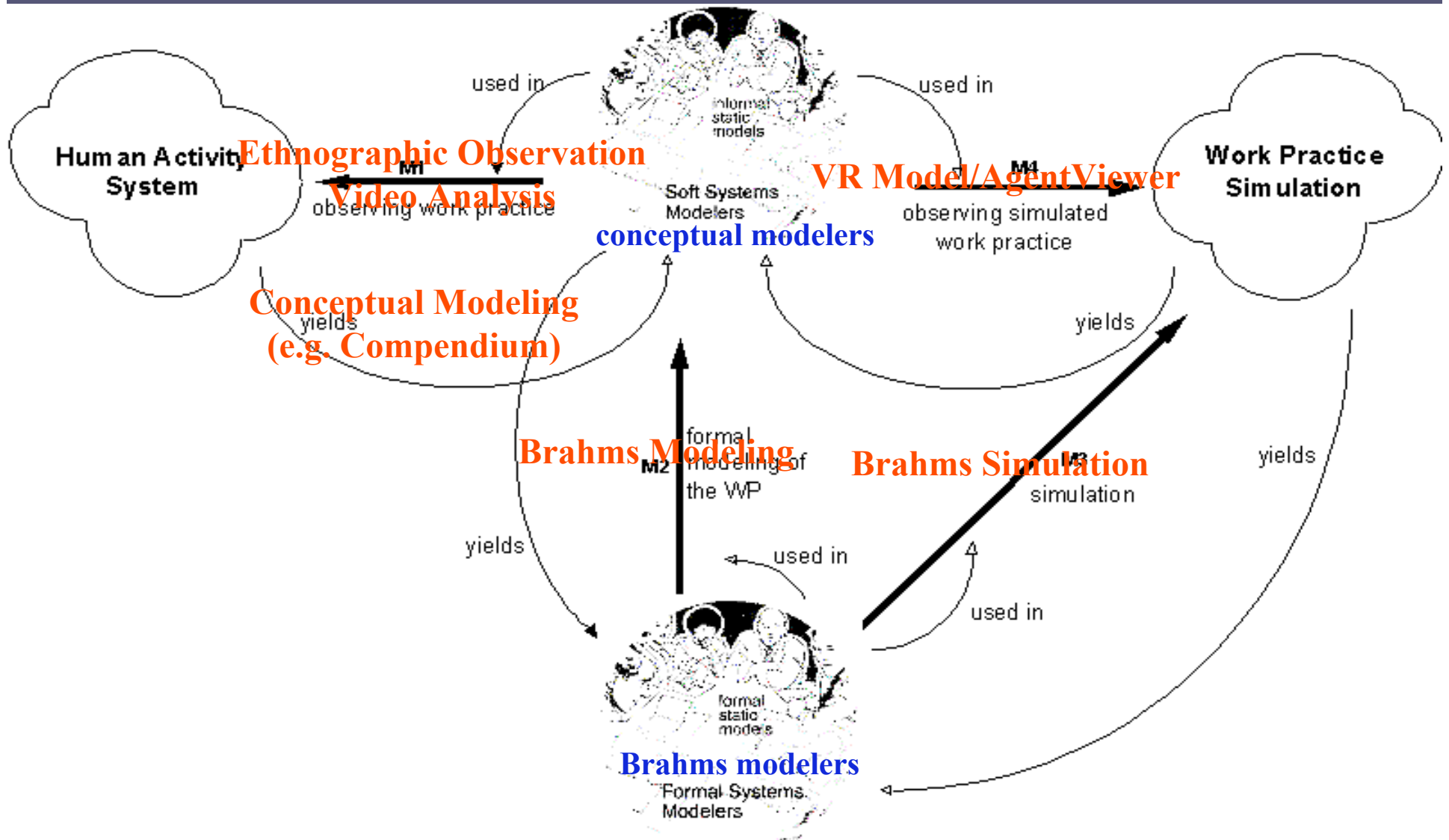


WPM cont'd



- **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

M&S-based Methodology



Brahms

Brahms Language Concepts

- Groups
- Agents

agent-based

- Classes
- Objects

object-based

- AreaDefs
- Areas
- Paths

geo-based

- Conceptual Classes
- Conceptual Objects

object flows

- Attributes (OA-V)
- Relations (ORO)
- Beliefs
- Facts

BDI

- Activities

activity-based/
subsumption

- Workframes
- Preconditions
- Consequences

rule-based

- Detectables

reactive

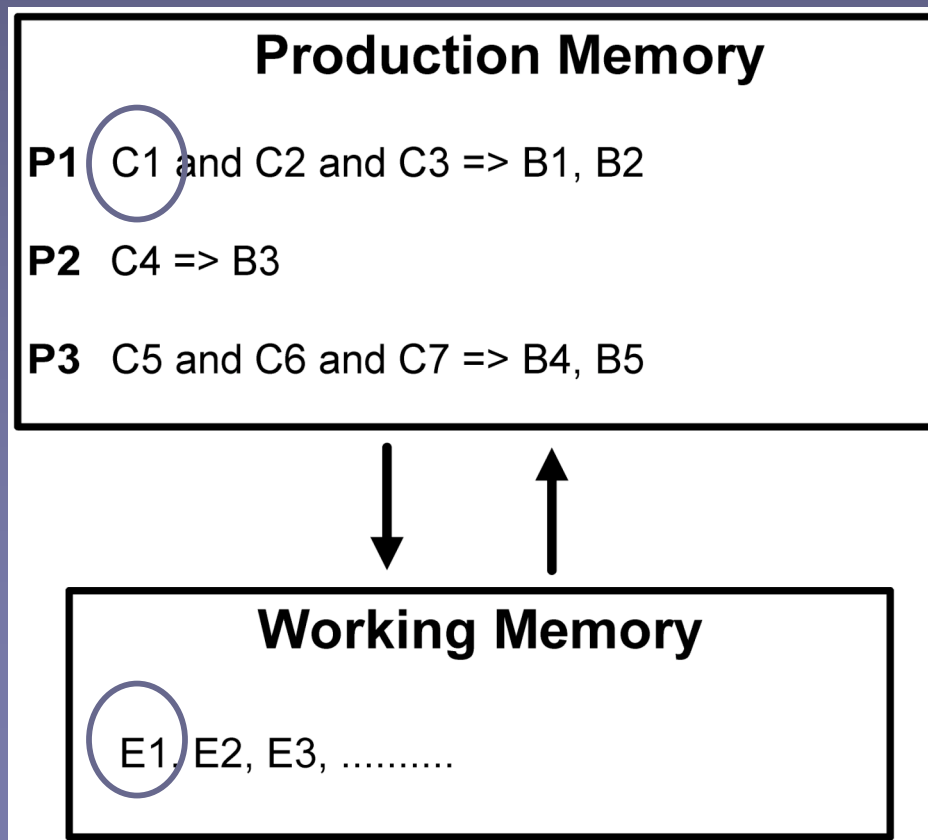
- Thoughtframes

inferences

Newell's Model of Cognition

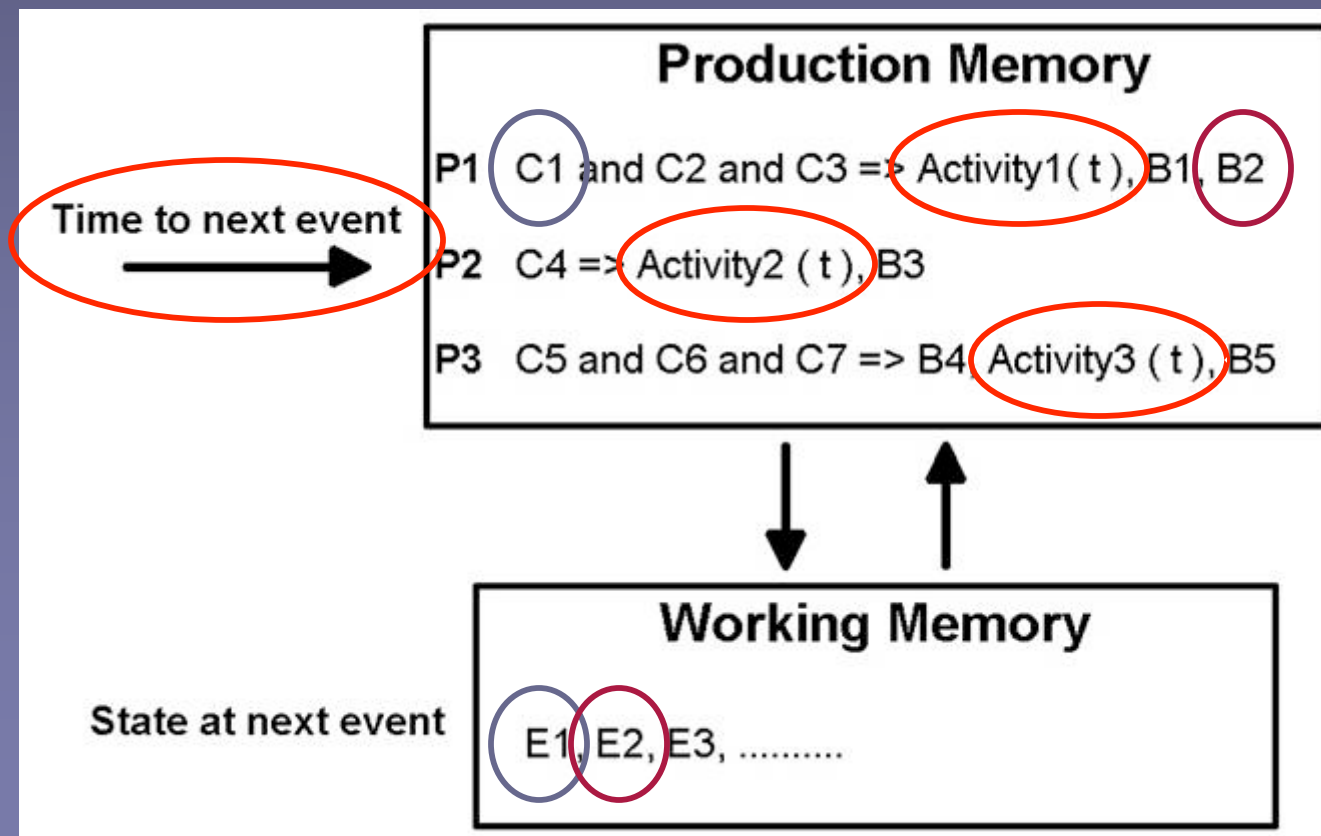
Production Rule System

Production Rules represent *Qualitative Relationships!!*

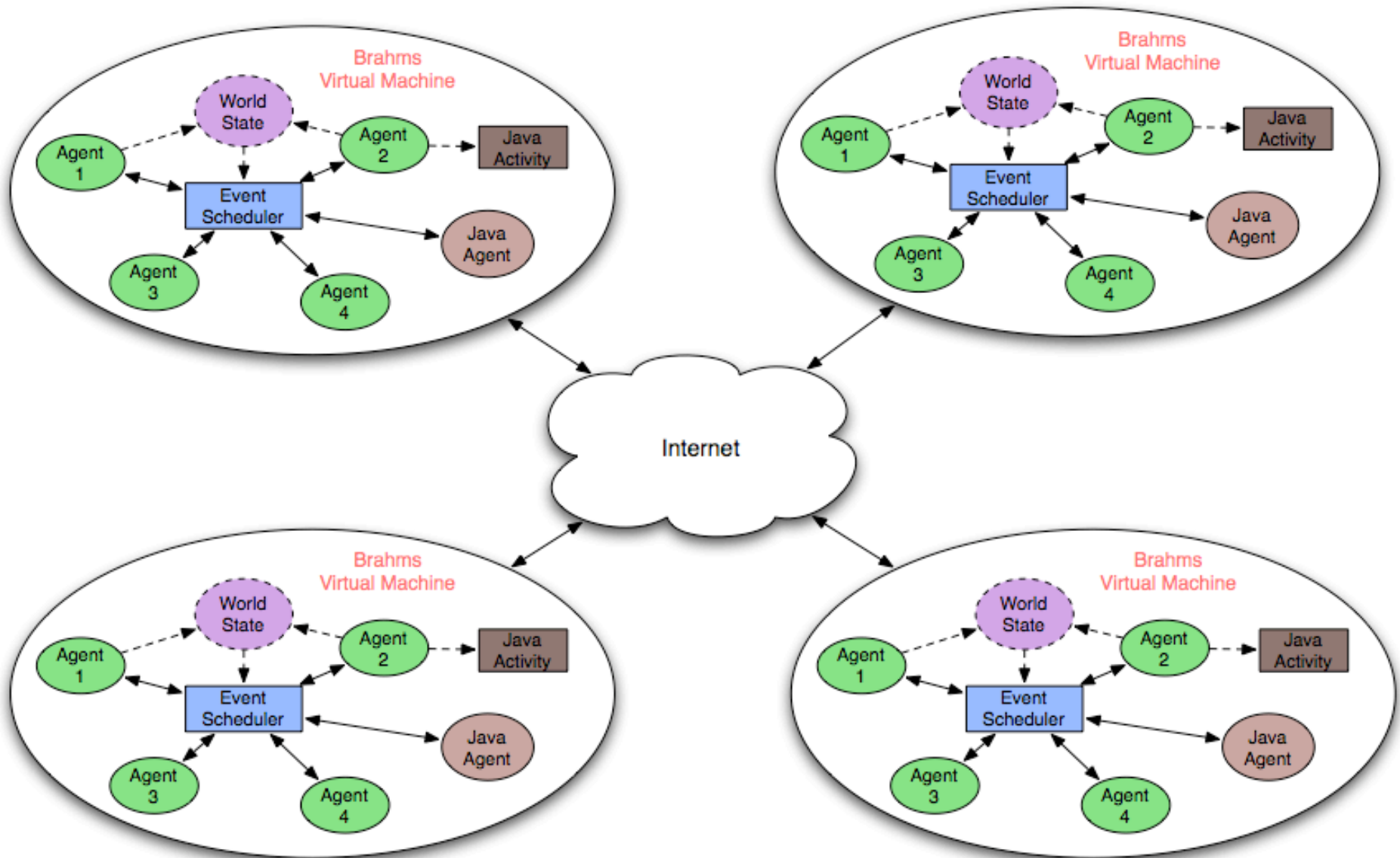


Symbolic Discrete Event BDI-like System

Situated-action Rules



Brahms: Distributed MAS

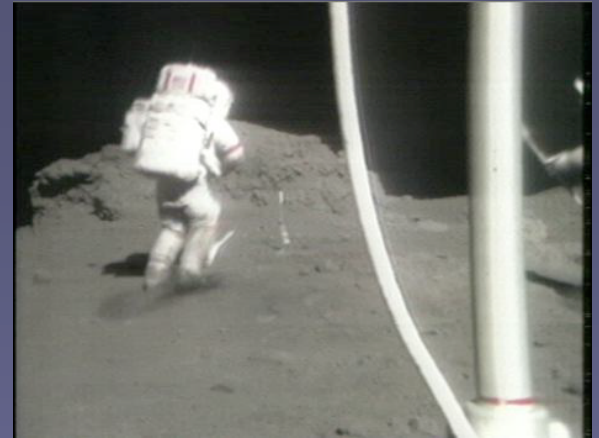


Current Research

1. Work Practice Modeling & Simulation
MER Mission Operations
2. Human Activity Behavior and Gestures
Generation in VW Systems
MARS Crew Suit Donning
3. Human-Agent Systems
Mobile Agents Project

Collaborative Planetary Science

- Teamwork
- Collaborative decision-making
- Man or machine science?
- Apollo missions
- MER mission
- Human mission to Mars (MDRS '03)



Work Practice Modeling & Simulation

The diagram illustrates the system architecture for the Mars Exploration Rover (MER) mission, showing the flow of data and commands between Mars and Earth.

Mars Side:

- Orbiter:** Communicates with the Lander and the Earth-based Deep Space Network (DSN) via UHF at 256 Kbps.
- Lander:** Communicates with the Athena Rover and the Earth-based DSN via UHF at 256 Kbps.
- Athena Rover:** Communicates with the Lander via UHF at 256 Kbps and with the Earth-based DSN via S-Band at 12 Kbps or 1 Mbps.

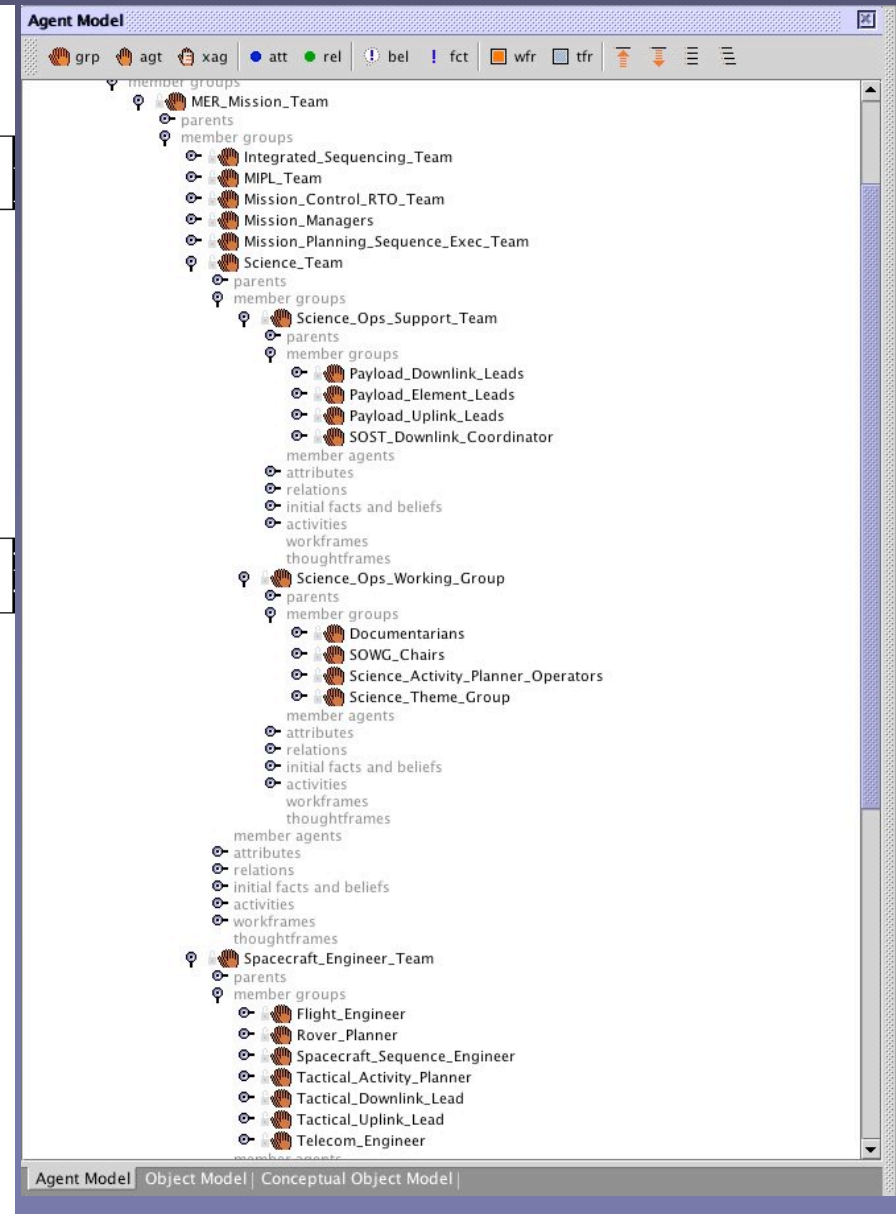
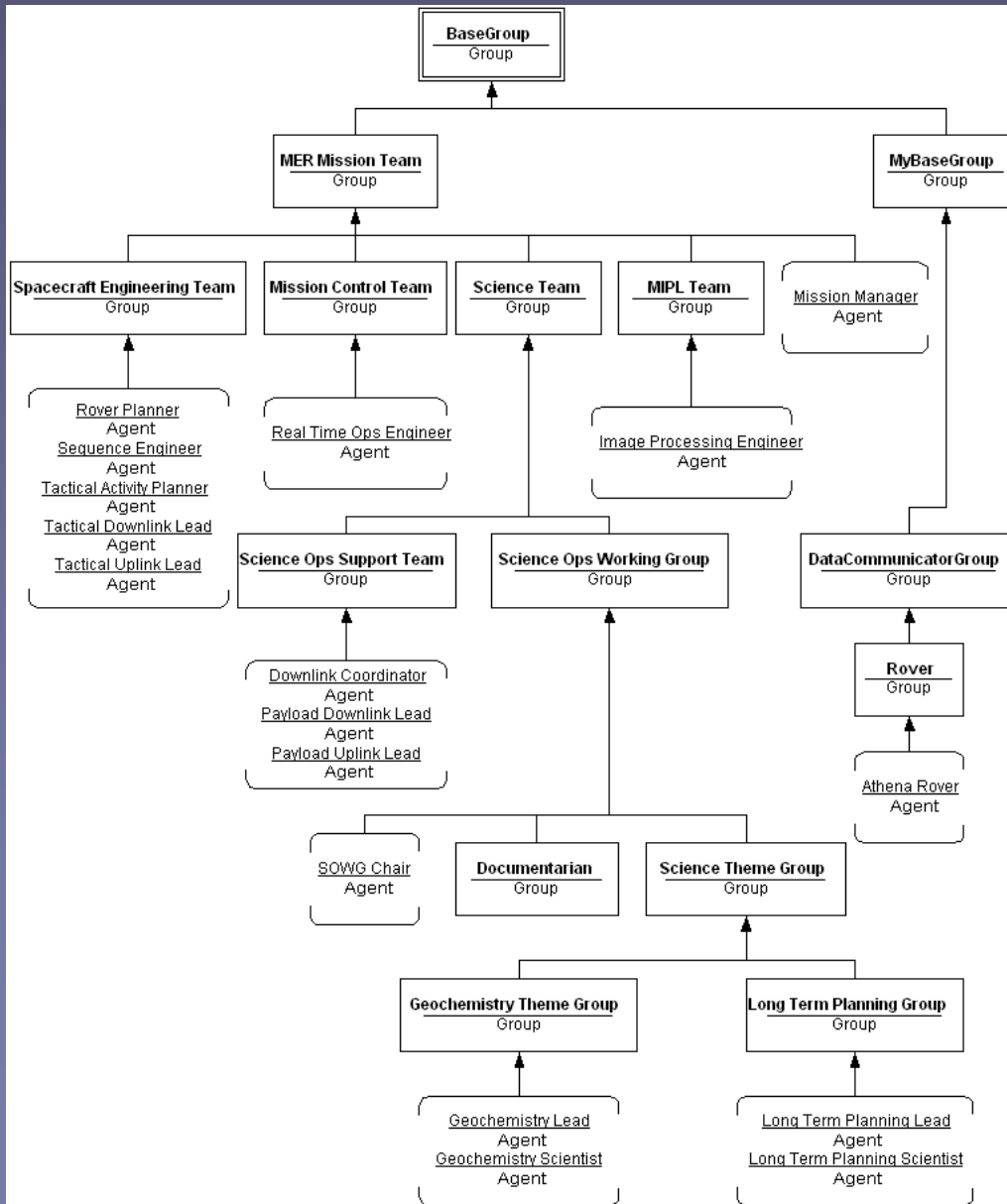
Earth Side:

- Deep Space Network (DSN):** Receives data from the Mars vehicles and transmits commands back to them.
- Data Acquisition & Command Subsystem:** Acts as the central hub for receiving data from the DSN and distributing it to the various Earth-based teams and subsystems.
- Mission Control Real Time Operations Team:** Monitors the mission and provides real-time support.
- Spacecraft Engineering Team:** Manages the spacecraft's health and performance.
- Science Team:** Includes the Science Operations Working Group, Integrated Sequencing Team, and Science Operations Support Team, all working together to plan and execute the science mission.
- Data Mgmt & Archival Subsystem:** Stores and manages the data received from the Mars vehicles.
- Engineering Analysis Subsystem:** Analyzes the data received from the Mars vehicles.
- Science Activity Planning & Sequencing Subsystem:** Plans and sequences the science activities.

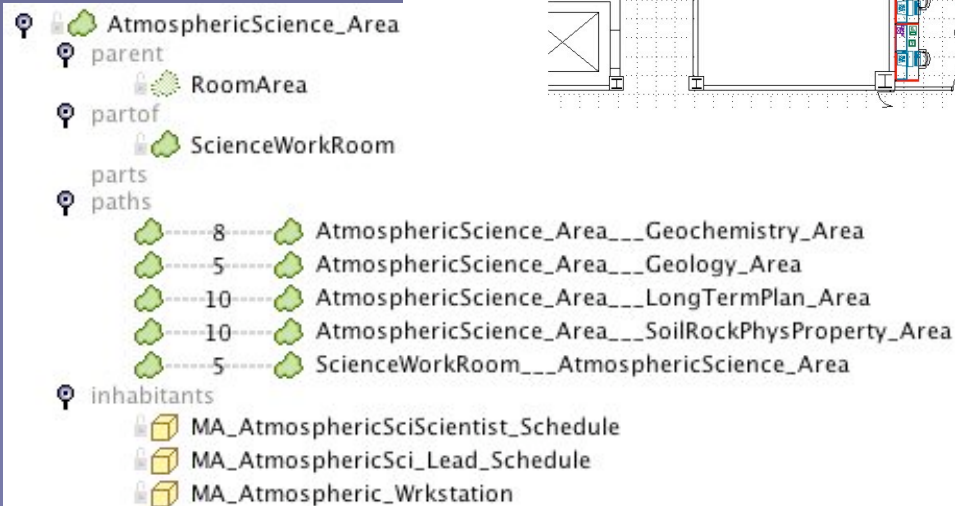
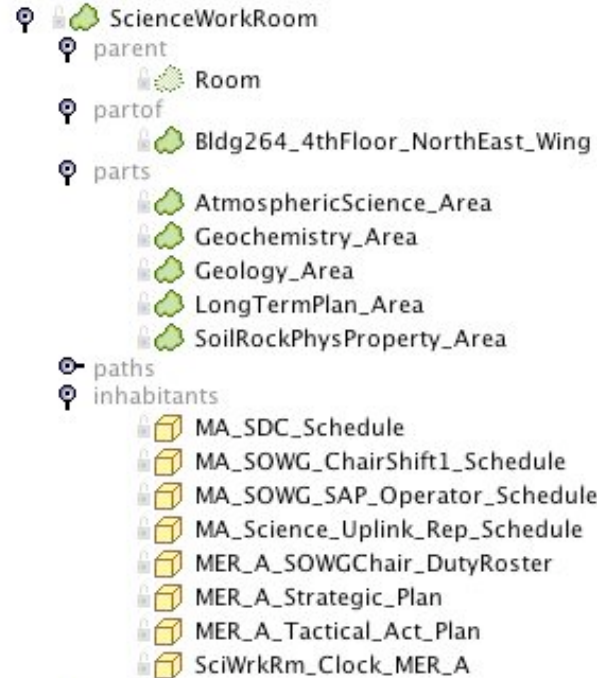
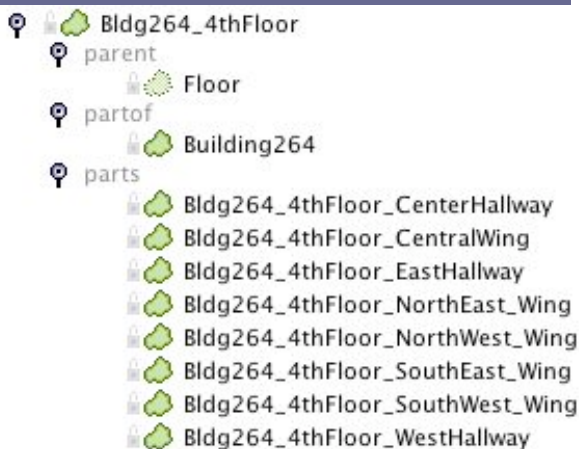
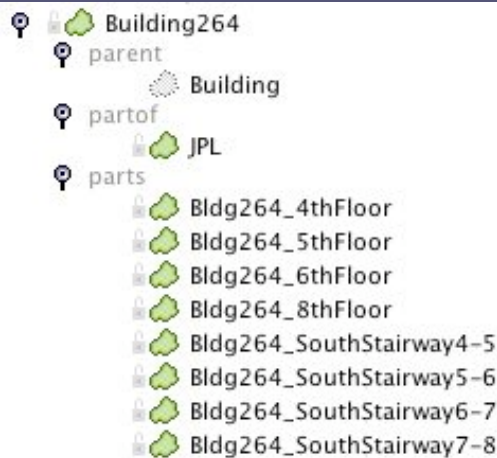
Location: The Earth-based teams and subsystems are located at NASA JPL Pasadena, CA.

- Organization Structure and Roles
- Work procedures and activities for roles
- Mission Operations Systems
- Mission data flow
 - From Downlink to Uplink to Downlink of science data
 - Creation, flow and use of intermediate data products
 - Communication between people, and between people and systems
- Science decision making and planning
- Uplink command sequence generation
- Space vehicle
 - Command execution
 - Science Payload
 - Science data capture
 - Data downlink
- NOT included at the moment?
 - Operation and health maintenance of both vehicle and payload

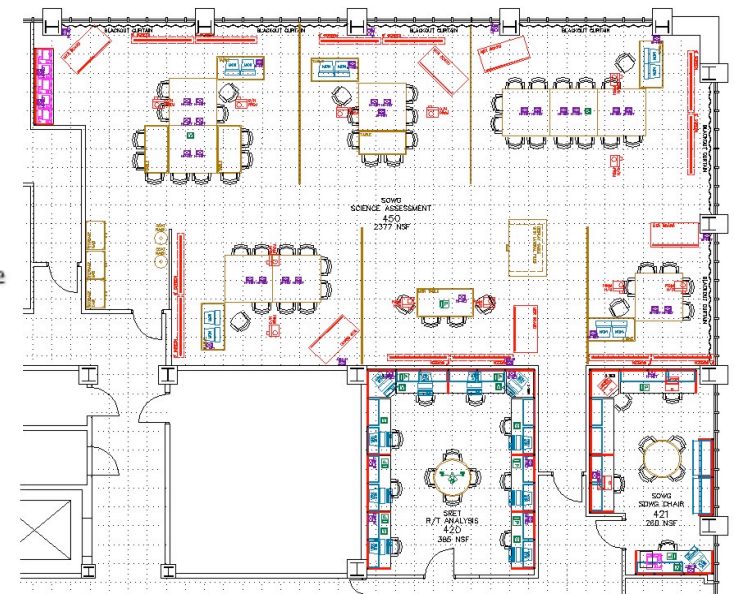
MER Agent Model



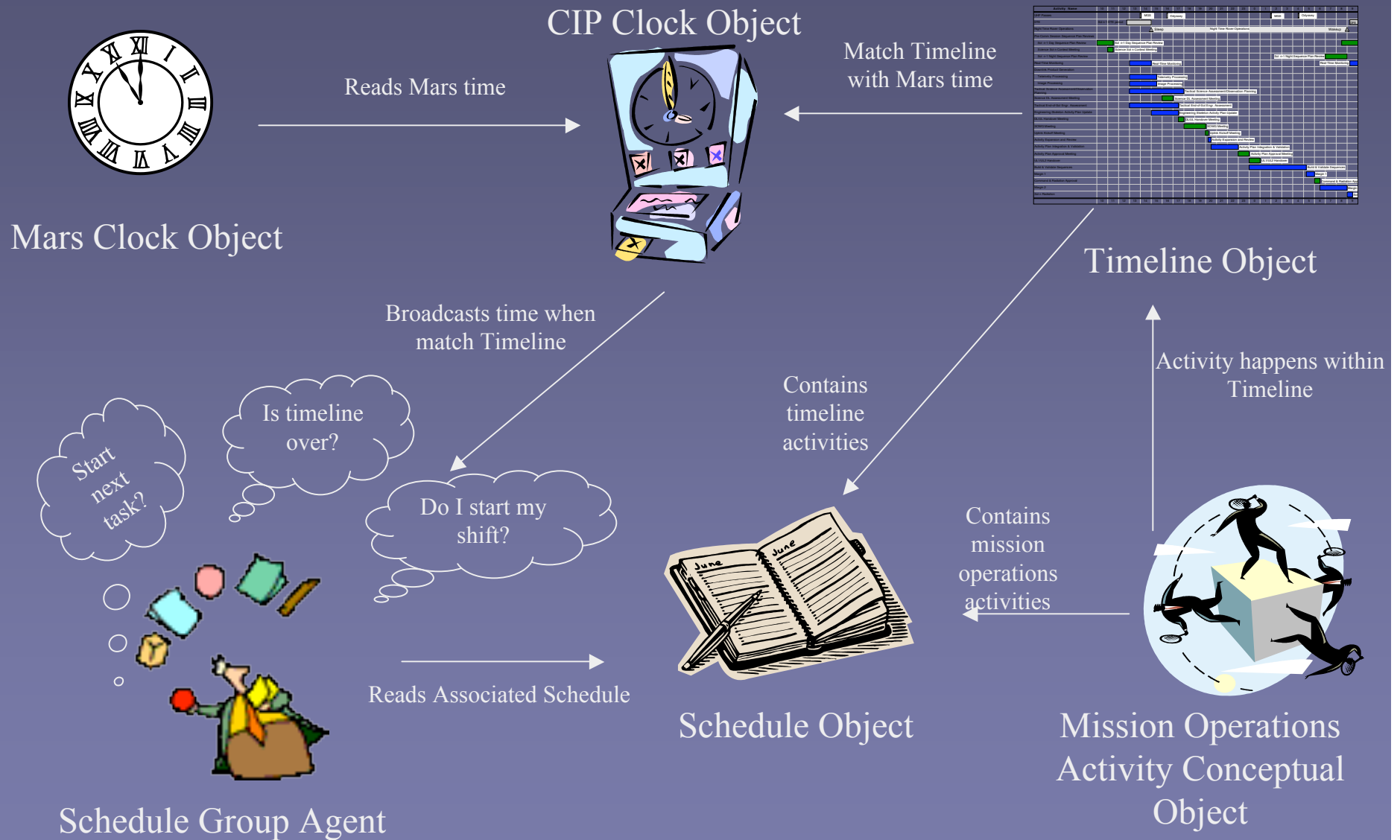
MER Facilities (Geography)



B264 4th (North East Wing)



Clock, Schedule and Agents



Conference Room...	...	Bl...	Bldg264 South Stair...	Bldg 264 South Stairway 4-5	...	B...	Sequence Development Room (B264 Floor 4 South East Quad)
01/17/2004 08:17:40 PM	08:18:20 PM	08:19:00 PM	08:19:40 PM	08:20:20 PM	08:21:00 PM	08:21:40 PM	
agent Tactical Uplink Lead (MER A) Shift 1							
wf: SOWG...	wf: Move_To_Timeline_Activity_Location				wf...	wf: Uplink_Kickoff_Meeting	
ca: SOWG ...	ca: Move To Area				pa...	ca: Uplink Kickoff Meeting	
wf: Listen_T...	...	wf...	wf: B264_SouthStai...	wf: B264_SouthStairs4-5_to_B...	...	wf: Roll_Call	wf: Understand_Activity_Requests
pa: Listening	...	m...	mv: Moving To Loca...	mv: Moving To Location	...	b... pa: Takin...	b... pa: Understanding Activity Requests

Uplink Meeting between TUL, TAP & PUL

Conference Room...	Bldg264 South Stairway 5-6	Bldg 264 South Sta...	B2...	B...	Sequence Development Room (B264 Floor 4 South East Quad)
01/17/2004 08:17:40 PM	08:18:20 PM	08:19:00 PM	08:19:40 PM	08:20:20 PM	08:21:00 PM	08:21:40 PM	
agent Tactical Activity Planner (MER A)							
wf: Move_To_Timeline_Activity_Location				wf....	wf...	wf: Uplink_Kickoff_Meeting	
ca: Move To Area				p...	p...	ca: Uplink Kickoff Meeting	
...	...	wf: B264_SouthStairs5-6_...	wf: B264_SouthSL...	wf...	...	wf: Convert_RML_To_APF	
...	...	mv: Moving To Location	mv: Moving To Lo...	m...	...	cw: Specify Run R...	ca: Waiting for Data
						wf: Wait_For_Data	
						pa: Waiting For Data	

Chin Seah's notes from Port 6, Oct 21 '03

7:30pm (Activity Refinement & Constraint Editing)

The PULs start arriving and sit along the walls in front of their respective workstations. TUL start taking roll call of which PULs are present. He mentions that the PULs for APXS payload are still missing. TUL identifies which workstations are available in the room and mentions the ones that are not working. TUL confirms with the TAP that the RML file, generated from SAP, has been split and the split files have been placed in the SOWG directory. TUL tries to confirm that all PULs know how to find the file.

wf: S							
ca: SOWG ...	ca: Move To Area				pa...	ca: Uplink Kickoff Meeting	

Human Activity Behavior and Gestures Generation in VR Systems

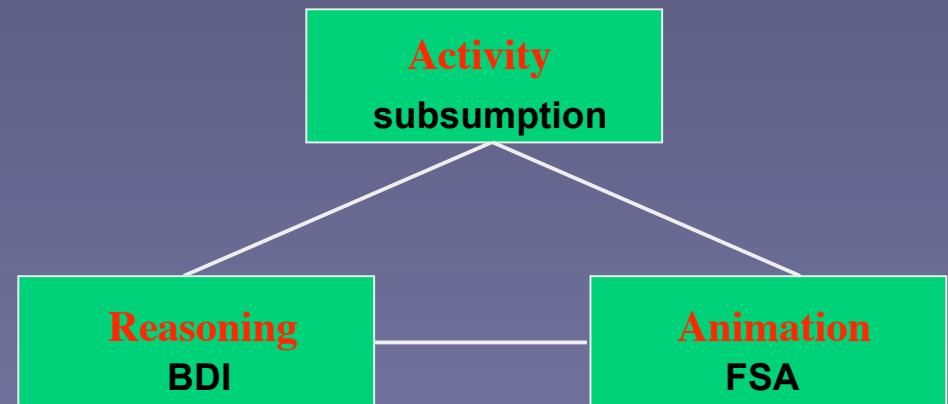


Behavioral components for autonomous avatars

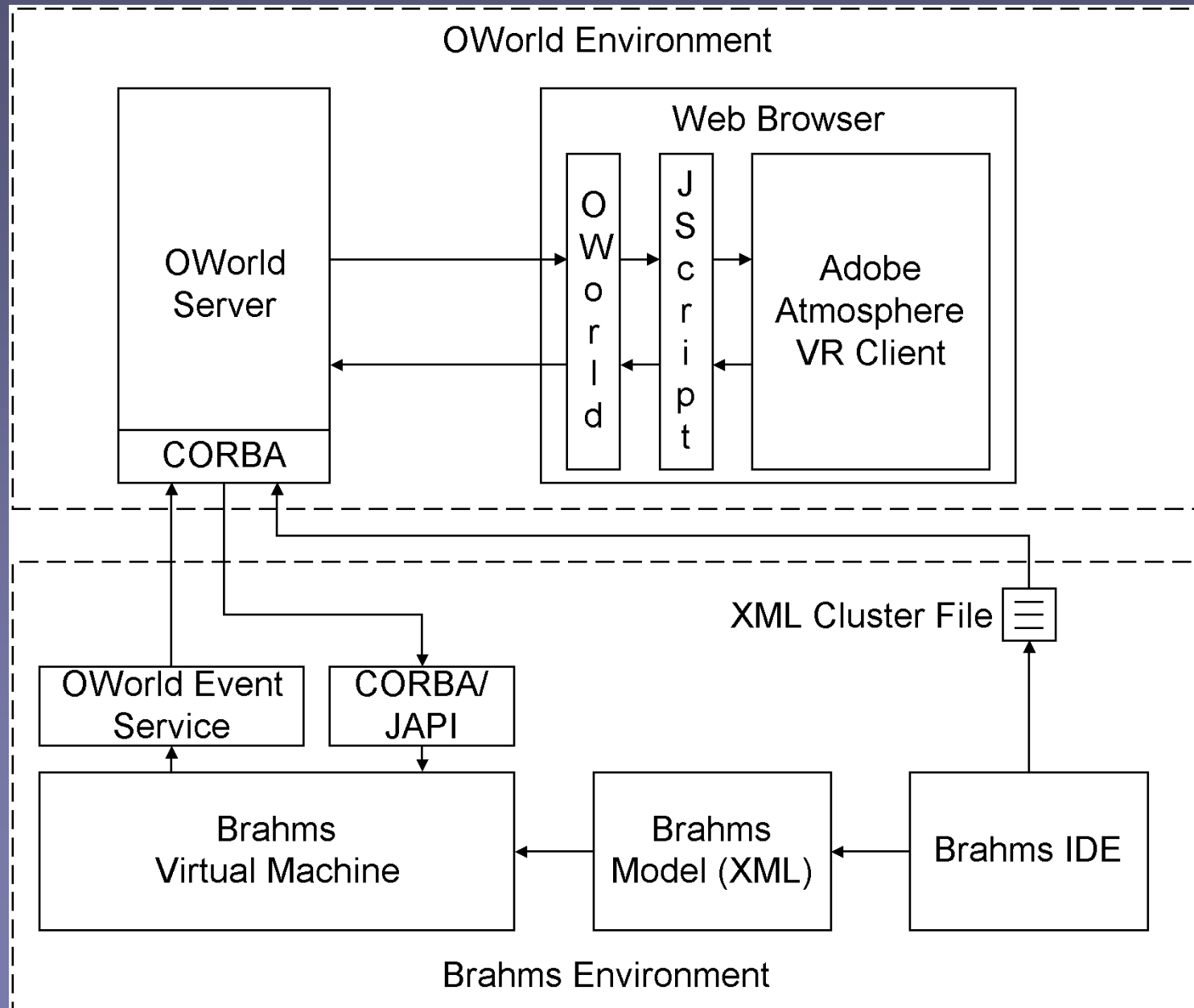
Madsen & Granum (2001)

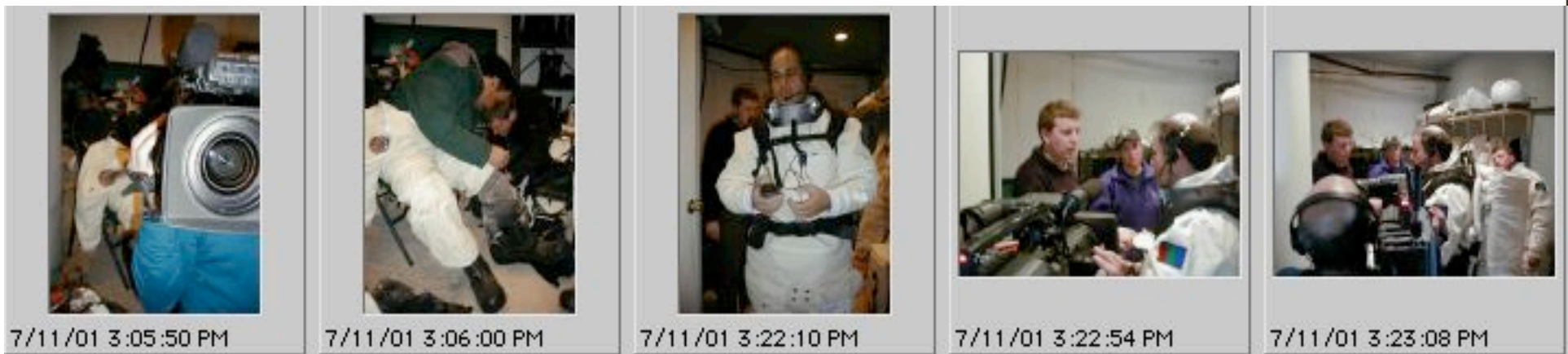
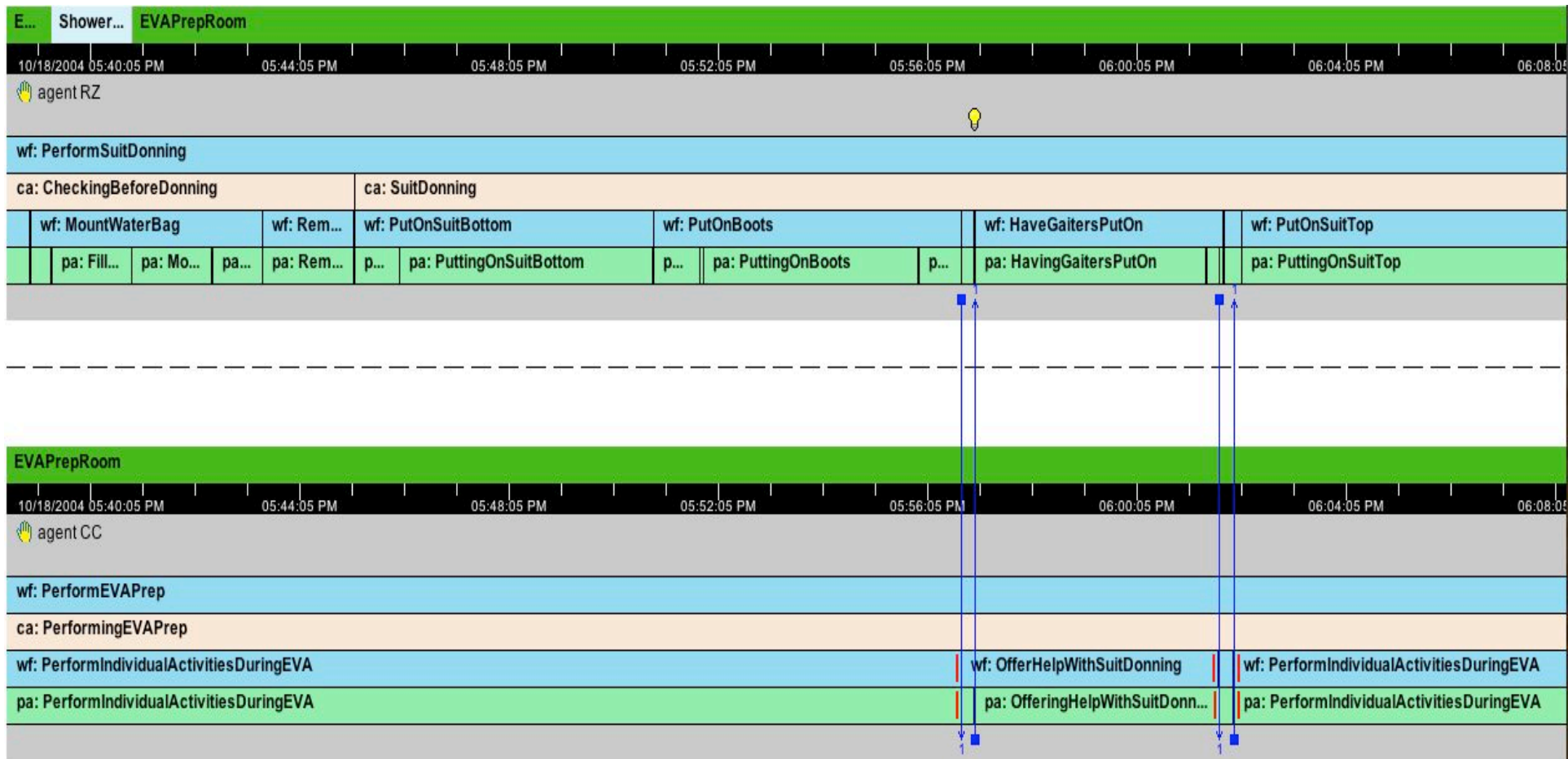
- Event-based Finite State Automaton (FSA) (ActiveWorlds, 2004), (Ogre, 2004)
- Behavior-based Reactive Architecture - subsumption architecture. Bouncy (Blumberg, 1996)
- Belief-Desire-Intention (BDI) agent architecture JAM (Huber, 1999)

Model of autonomous avatar or bot behavior

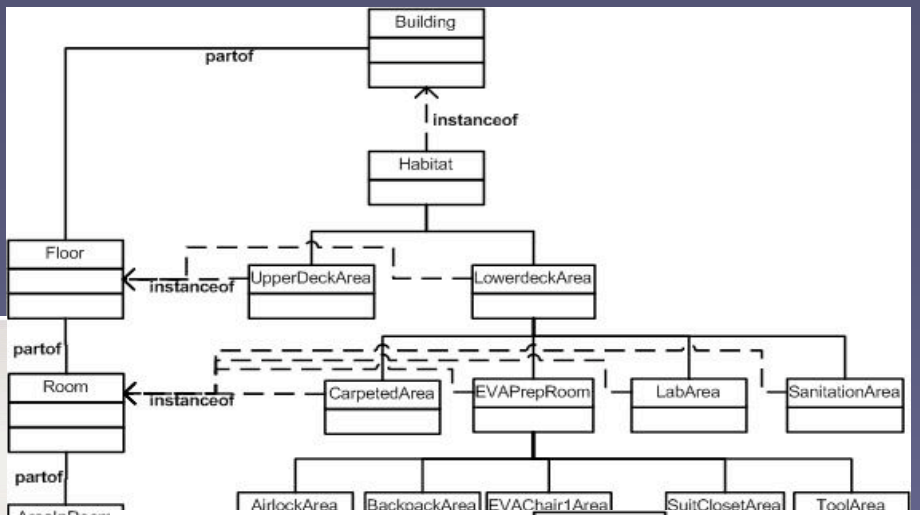


BrahmsVE Architecture

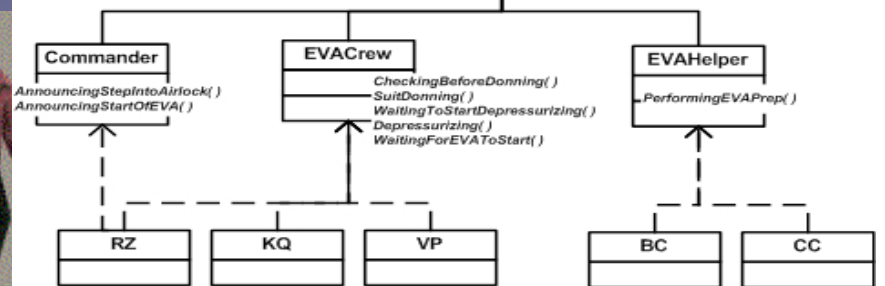




Virtual World Model



Behavioral Agent Model



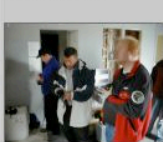
Avatar & Gesture Model

07110107.JPG



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07110108.JPG



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07110109.JPG



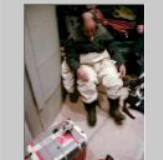
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07110112.JPG



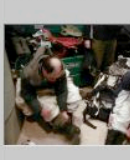
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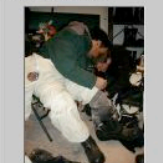
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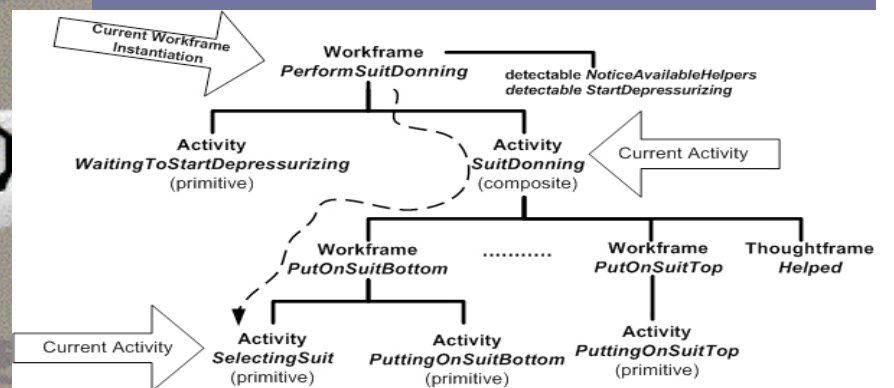


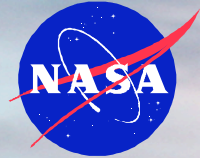
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Mobile Agents

Architecture for supporting *Human-Agent Systems*

Mars Desert
Research Station
Near Hanksville, Utah

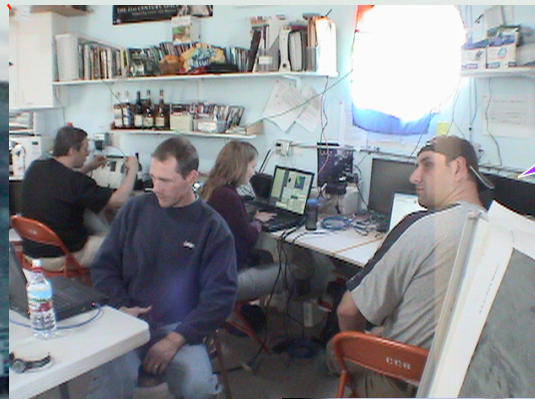
The Satellite Dish
back to Earth's
internet



The EVA Astronaut



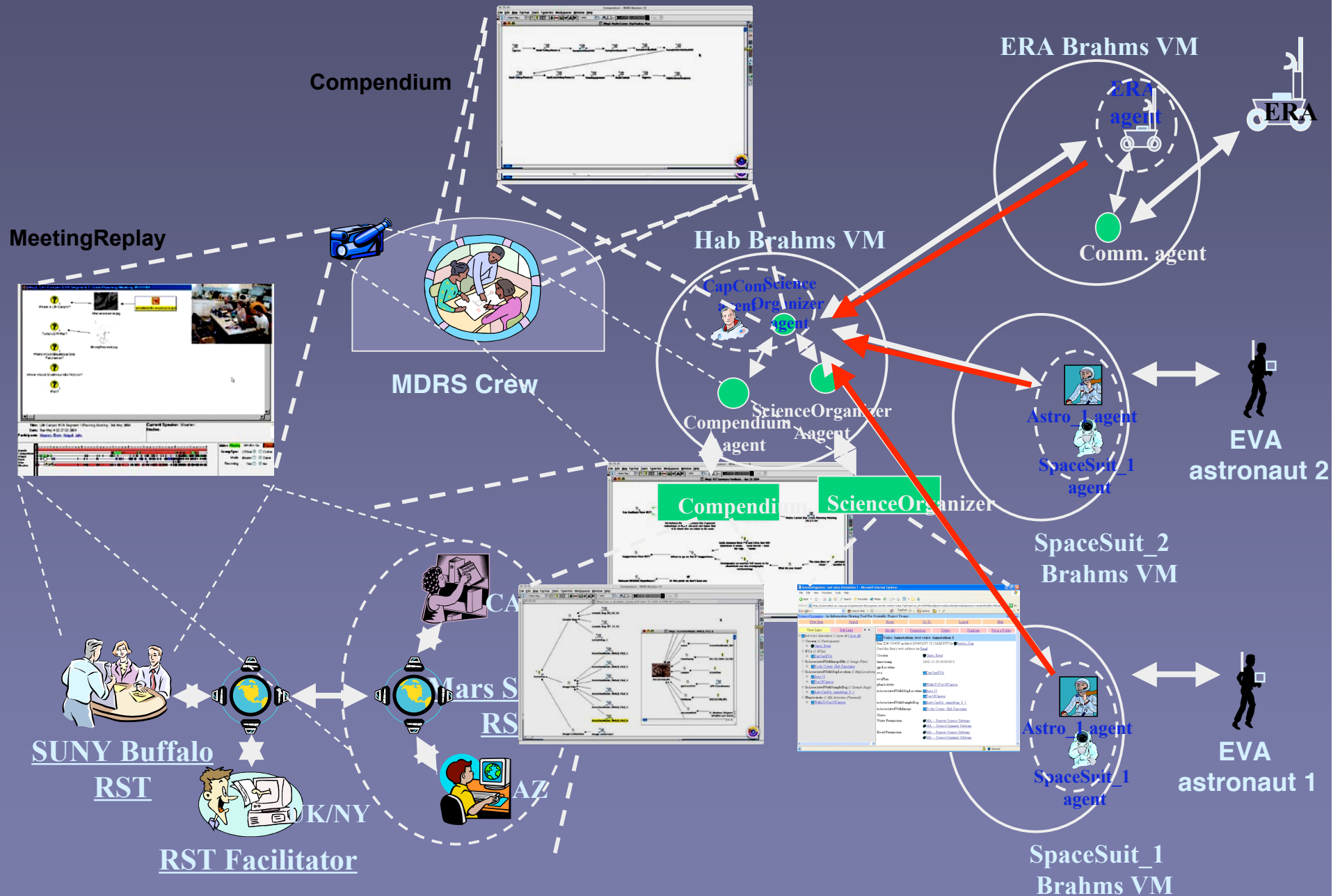
HabCom
and
Hab Robot Operator



The EVA
Robotic Assistant

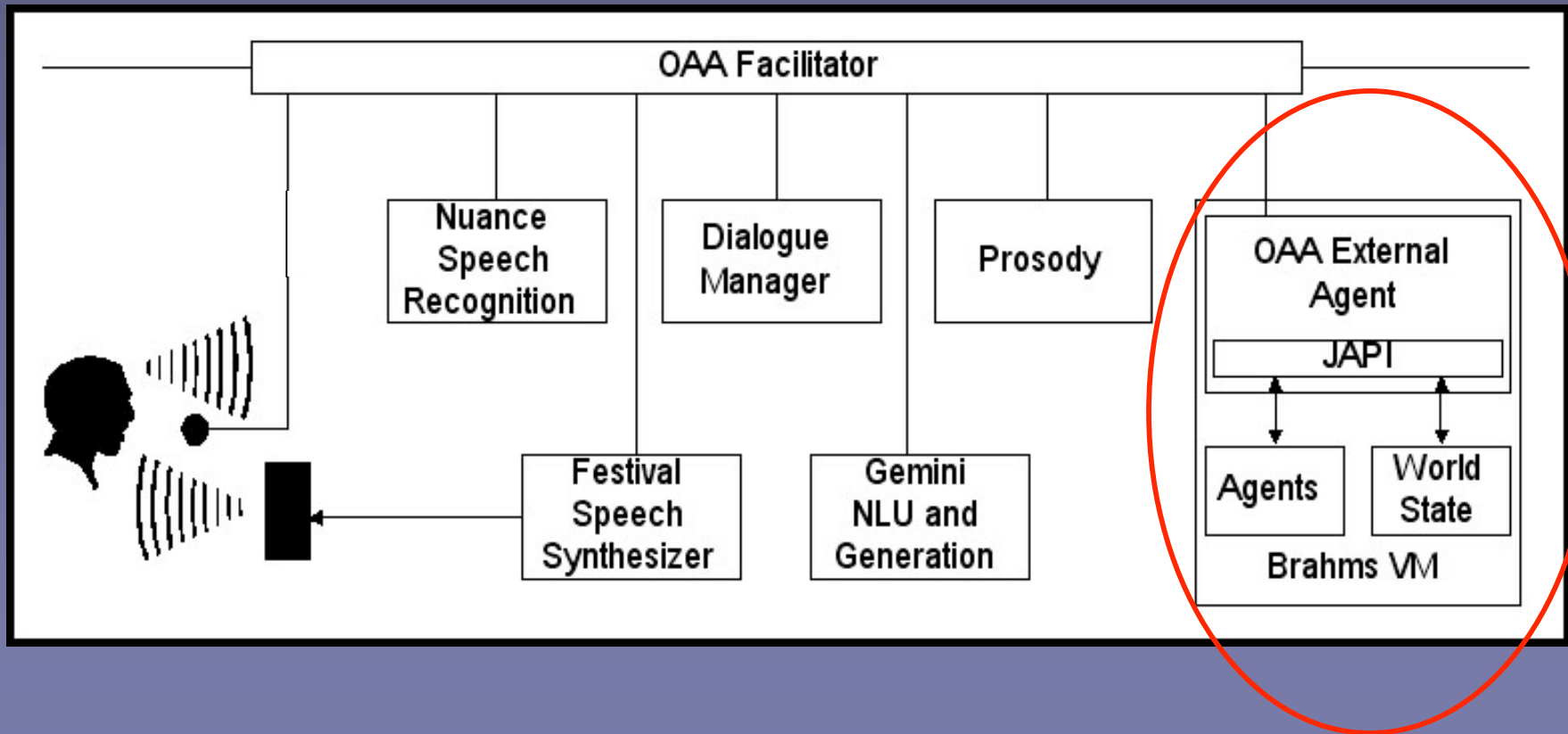


Collaborative Planetary Science



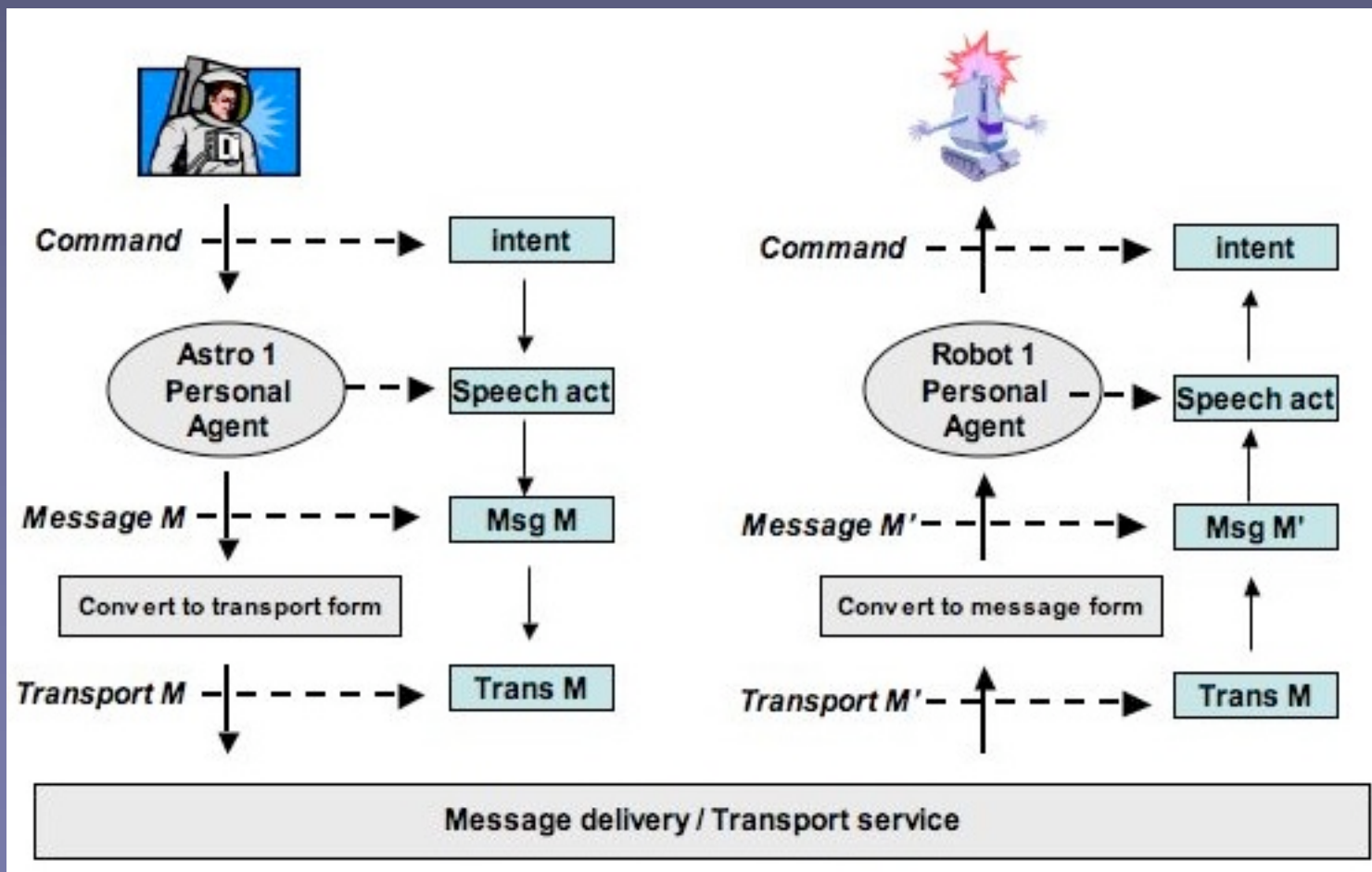
Speech Dialog Agent

$H \Rightarrow A$

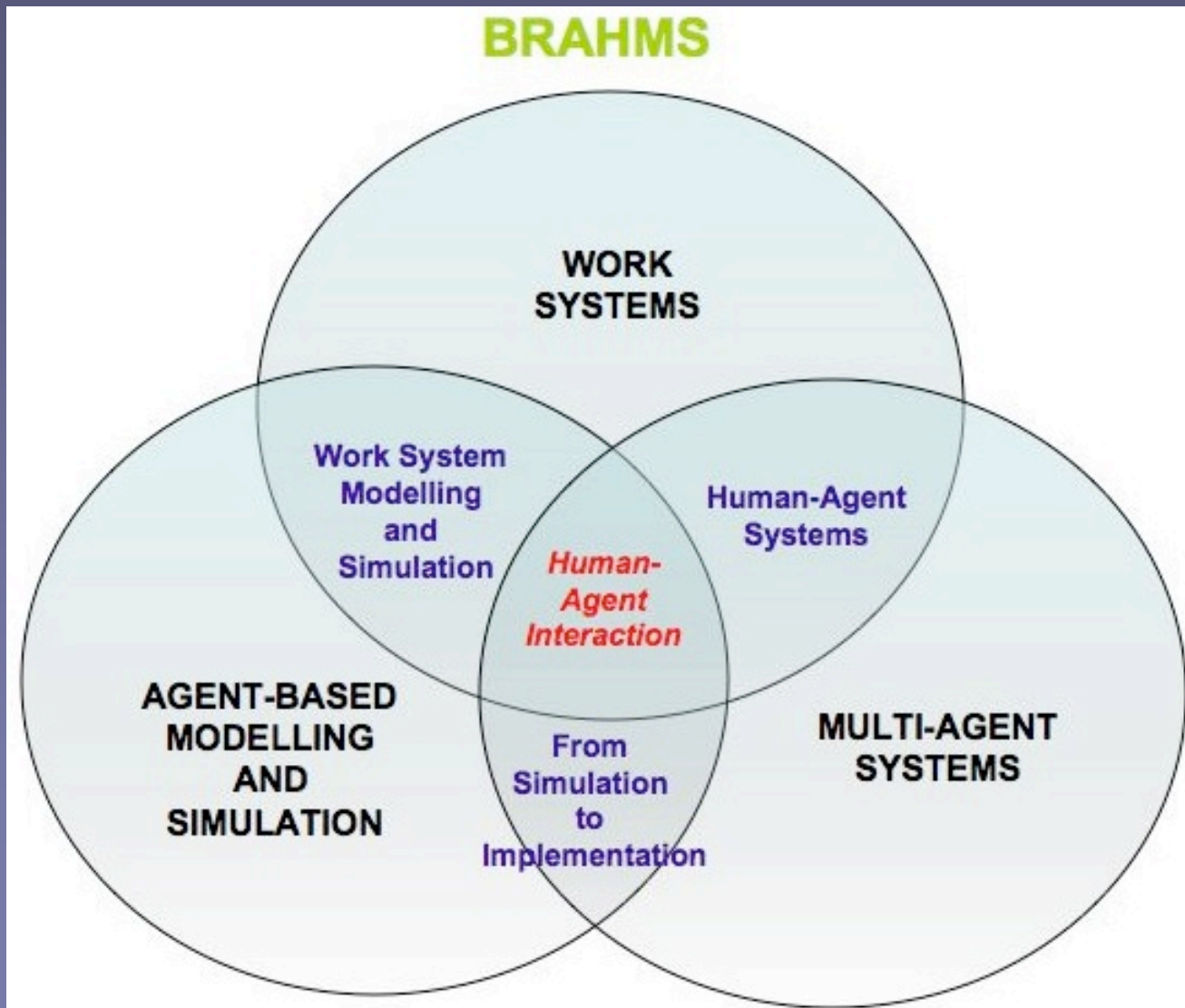


Human-Agent Communication

$H \Rightarrow A$ and $A \Rightarrow A$



Summary: Research Vision



Thank You!!

Some references

Theory

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BrahmsVE

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Mobile Agents

- Clancey, W. J., M. Sierhuis, et al. (2005). Automating CapCom Using Mobile Agents and Robotic Assistants. 1st Space Exploration Conference, Orlando, FL, Available as AIAA Meeting Papers on Disc [CD-ROM]: Reston, VA, and as an Advanced Knowledge Technologies Project ePrint [<http://eprints.aktors.org/375>].