Electric Elves: Dynamic Team Formation and Crisis Response in Complex Organizations

Milind Tambe

David Pynadath

Motivation

- Future organizations will be highly *agentized*
  - *Information gathering, planning, execution monitoring*
  - *Controlling resources, e.g., communication devices*
  - *Proxies for humans*
- All entities, including humans, will be agentized
- Dynamic teaming of agents will enable organizations to:
  - *Act coherently and robustly to attain their goals*
  - *React swiftly to crises and adapt dynamically to events*
- Results applicable to all organizations (e.g., military, civilian disaster response, corporations, universities, research institutes…)

Motivating Example: A Critical Demo in Rome, NY

- *Requires a team to be rapidly assembled, including people to fly to Rome and to support the demo at ISI. The right equipment must be shipped or rented, travel scheduled and the entire plan monitored*
- Plan demo in Rome:
  - Schedule & execute a meeting to finalize the team going to Rome
  - Plan travel arrangements for participants
  - Plan and execute the shipping of equipment
- Monitor and repair plan during execution:
  - A team member may become ill & require a replacement
  - A delayed flight may require notifications & meeting reschedules
  - Delayed equipment may require us to arrange rentals

Scope of the Research

- Dynamic team formation
- Persistent 24/7 teams
- Coordination and monitoring of teams
- Agents include humans in addition to machines
- Scale up in terms of complexity, number, and heterogeneity of agents
- Rapid incorporation of new agents
- Widespread substitutability of agents

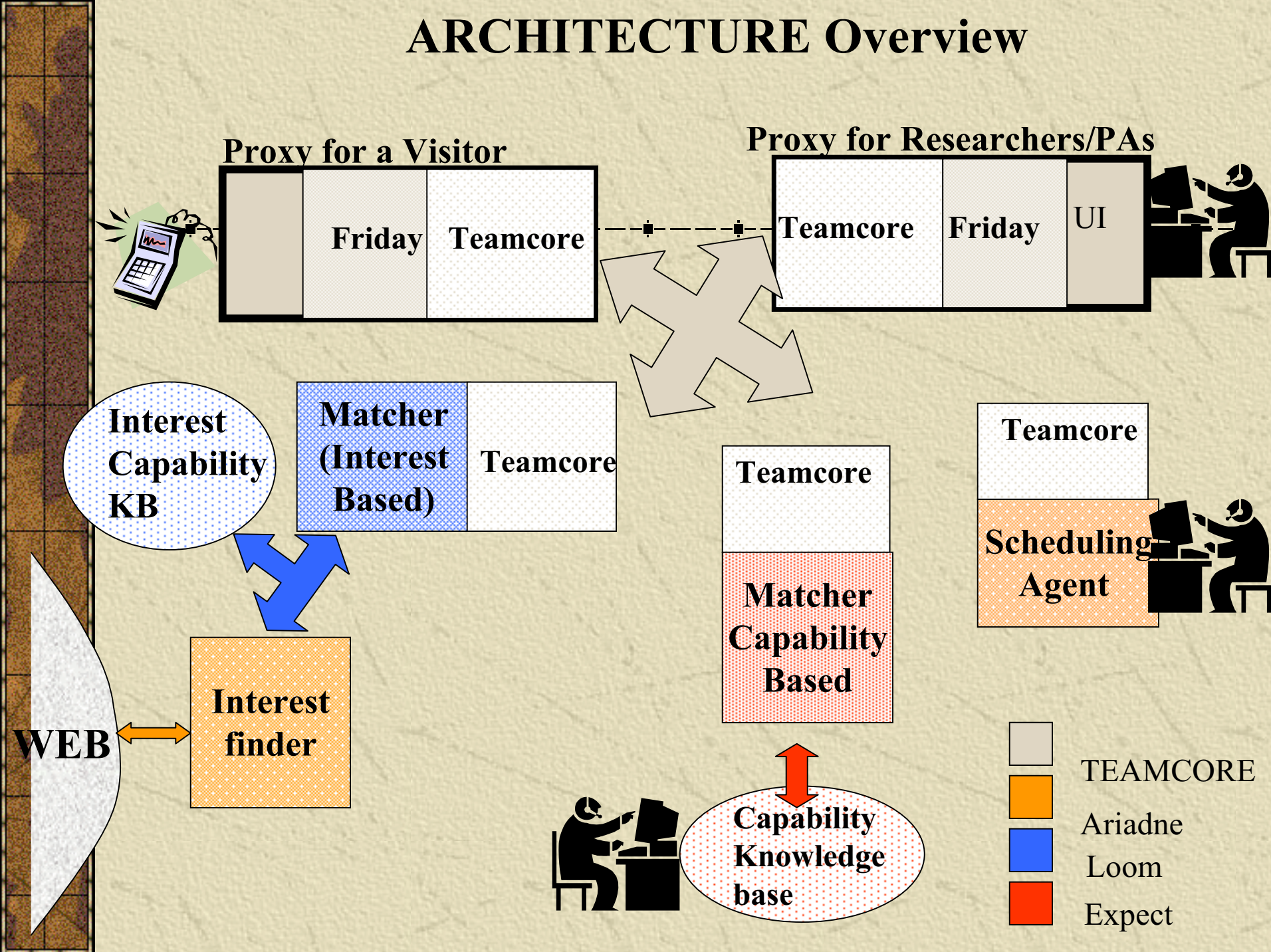
Scope of the Resulting System

- Support “deployment” of teams for short-term actions
- Involve both people and computers
- Team is fully agentized with proxies for people
- Supports dynamic integration of agents created by others

Detail

- Predefined templates for deployments
- Mixed initiative, distributed plan refinement process
- Includes selection of team members and computing resources
- Monitor deployment of both humans and computers
- Coordinate response to a crisis

ARCHITECTURE Overview

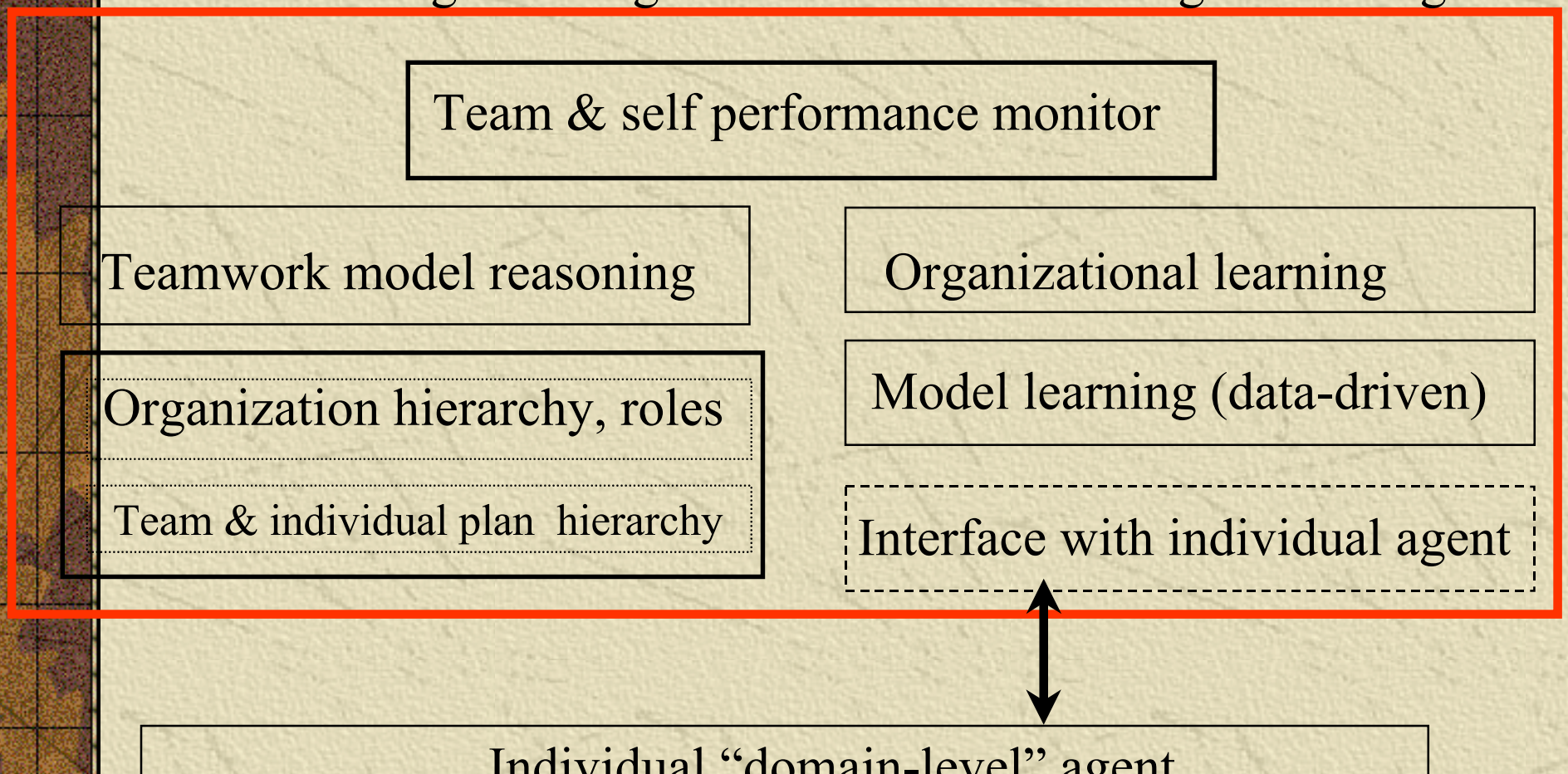


Current Focus: Agentizing One Research Group

- Mixed ~10 agent team, human & computers
  - *Proxy interface with humans, including PDA/GPS*
  - *Interface with matchmakers, information agents*
- Agent proxies running 24 hours, 7 days
  - *First such deployment of agents in a real organization*
- Interest-based & capability-based matchmakers
  - *Represent/reason about human interests & capabilities*
  - *Explain results to humans*
- Interest-finder agent
- Scheduling agent
- Interconnection among the agents, particularly via the Grid

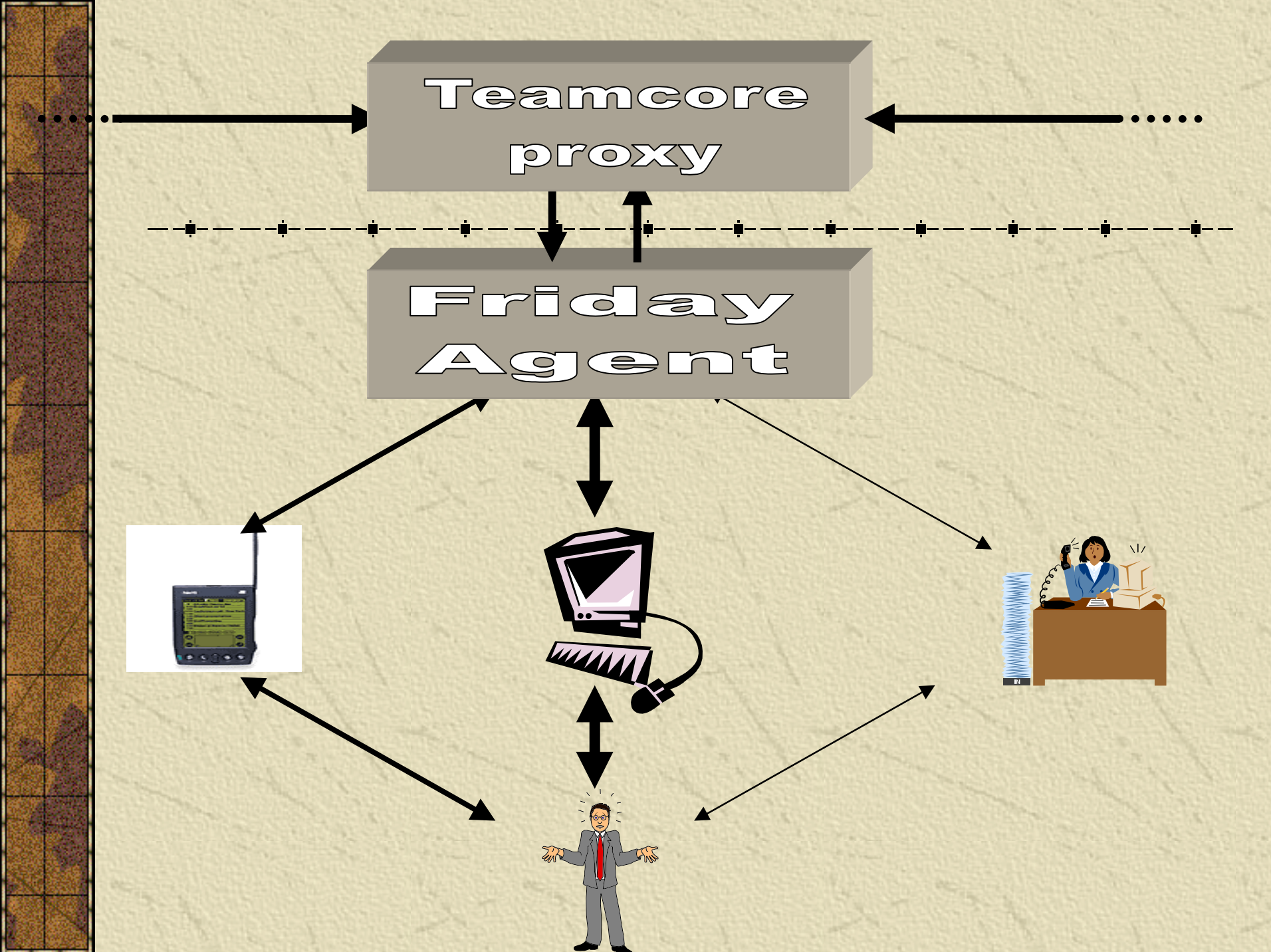
TEAMCORE Architecture

TEAMCORE Agent: Integrates teamwork reasoning & learning



Teamcore for Human Collaboration

- Teams: Research groups
- Team plans: Meetings, Hosting visitor
- Roles: presenter, participant, demonstrator
- Teamwork reasoning:
  - Coherent commitments
  - Monitoring: e.g., can user attend meeting?
  - Repair: e.g., presenter unable to attend


Teamcore proxy
Friday Agent

Adjustable Autonomy: On Being a Proxy for a Human User

- Agents automatically adjust level of autonomy
  - Consult human users when critical decisions
  - Must not always bother users
- Initial approach used decision-tree learning
  - C4.5 used to learn model of decision, autonomy
  - Performed well in experimental setup (91% accuracy)
  - Worked well initially in practice
  - Some important failures, e.g., cancellations, delays…
- Problems with initial approach, since:
  - Autonomous, No model of cost, require multiple action

Adjustable Autonomy: A new approach

- Problem cast as a Markov decision process (MDP)
- Explicit reasoning about cost & uncertainty
  - *Reason about a sequence of actions*
- Outcome: “Reasonable”, flexible behavior policies
  - *E.g., instead of immediate cancellation, the program may delay-5, ask, then cancel..*
- Initial results promising, but state space explosion

Results from Use of Elves

- Team “style” different from previous app.
  - multiple team plans
  - little communication needed
- Adjustable autonomy
  - C4.5 good mechanism for many decisions
  - but makes catastrophic mistakes in others
  - Use MDP model to consider costs of mistakes
- Social Awareness

Future Work: Agentized Organization

- Scale-up to ~100 agents (ISI's Intel Systems Division)
  - *Highly heterogeneous*
  - *Capable of dealing with changes in resources & personnel*
  - *Rapid incorporation of new agents*
  - *Industrial strength system*
- Versatile interfaces with humans for tasking
- Dynamic changes to team requirements and team members
- Automated team self-repair and learning
- Human organization norms: authorities, permissions etc
- Automatic agentizing of new data sources
- Dynamic & adaptive description of agent capabilities
- Ontology-based translation of messages….

Research Challenges

- Adjustable autonomy
- Dynamic team formation
- 24/7 system
- Coordination and monitoring