An Agent-based Simulation Model for Organizational Analysis

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Outline

- Introduction
- Organizational model
  - Organizational components
  - Interrelationships among organizational components
- Agent behaviors
  - Situational awareness
  - Task scheduling
  - Event handling
- Illustrative example
- Summary and future work

Introduction

- **Motivation**
  - Simulations based on computational organization theory
    - provide insights into the degree of match between tasks and organizational structure
    - identify bottlenecks
    - improve the quality and efficiency of an organization
  - Traditionally, organizational theory describes an organization at an aggregate level
    - provides general qualitative predictions about its overall behavior
- **Our contribution**
  - Define and implement a “micro” model of the structure and behavior of the components in an organization
    - work activities, groups of agents, and the organizational structure
  - Model information, expertise and knowledge as dynamic resources
    - can be acquired, and shared among agents
  - Implement the model by a discrete-event simulator, *Extend*™

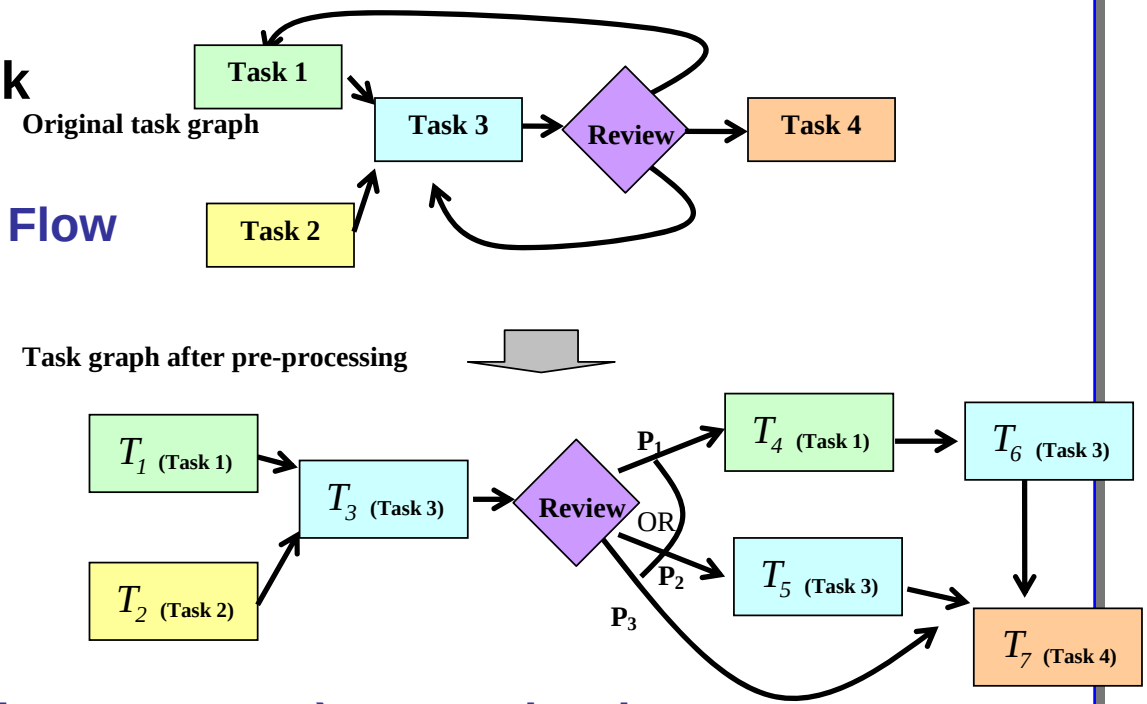
Organizational Components - 1

Resource

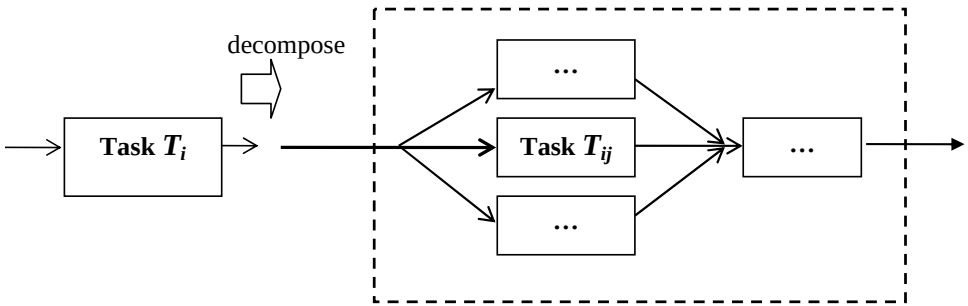
Identifier
Quantity
Transferability

Work

a) Task Flow



b) Task-subtask decomposition



c) Lowest level task characteristics

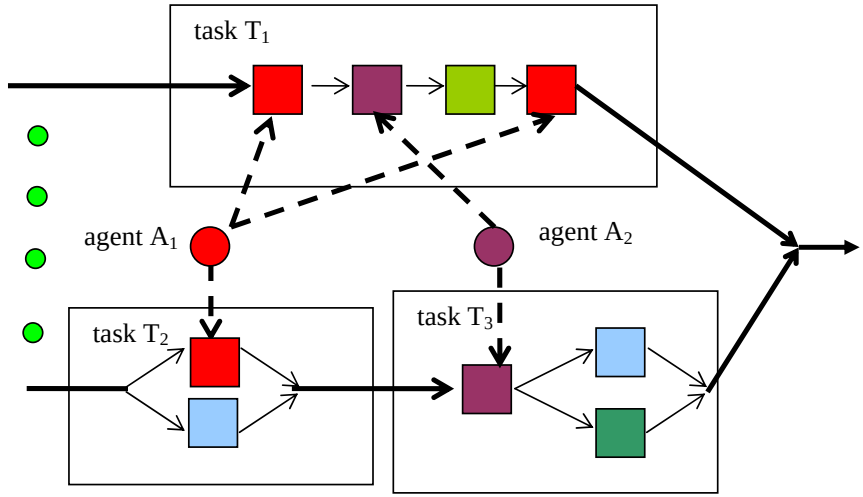
Required resources
Baseline processing time
Baseline unit workload
Resources to gain
Synchronization task set

Organizational Components - 2

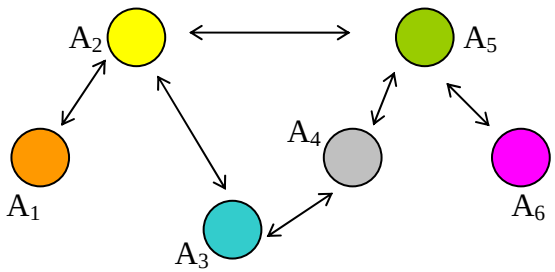
- **Agent**

Resources
Maximum unit workload
Task Assignment

- **Organization**
  - **Assignment of agents to tasks**



  - **Communication channels among agents**



Interrelationships among organizational components

Modeling assumptions

- **A** relative degree of congruence exists between each pair of organizational components

- Basic hypothesis of the model is: *the greater the total degree of congruence among the various components, the more effective the organization will be*

Performance measures

- Mission completion time
- Mission quality and qualities of individual tasks
- Workload distribution among agents
- Communication and coordination load of individual agents and the organization

Modeling Agent Behavior: Situational Awareness

Situational Awareness

- **At any time, an agent knows the status of all its own tasks:**
  - Status of a lowest-level task can be any one of the following:

a) Not ready,

b) Ready,

c) Scheduled,

d) Working,

e) Completed

Modeling Agent Behavior : Task Scheduling

Task Scheduling

For each ready task, the agent shall:

1) estimate its projected processing time, workload,
   - based on agent's resource capabilities and the task requirements

2) select task which has the earliest projected finish time and the projected workload is acceptable based on agent's current workload

3) communicate with other agent (s) who own the necessary transferable resources

4) if it is a task requiring synchronization
   - initiate synchronization message (s) with proposed start time
   - otherwise, start the task when all the resources are available

Modeling Agent Behavior: Event Handling

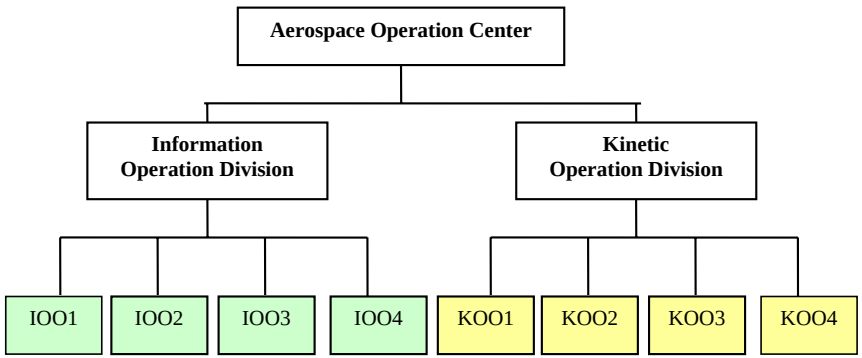
Event handling procedure of an agent

- when a task owned by an agent is completed, update:
  - task status
  - resource status
  - workload record
- when an agent receives transfer request for a resource
  - transfers the resource as requested
- when an agent receives a synchronization request
  - checks its availability at the requested time
  - if available, it acknowledges the synchronization message
  - else proposes a time which is the earliest available
  - sends a synchronization return message to the originator

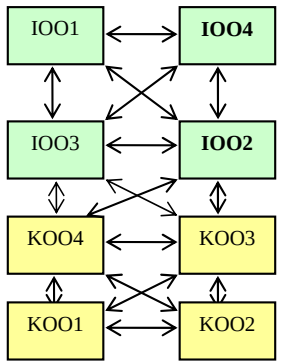
Illustrative Example

Air Operations Center (AOC)

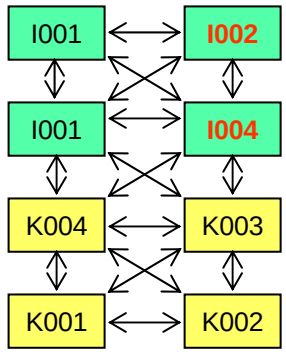
Organization



a) Organization Chart

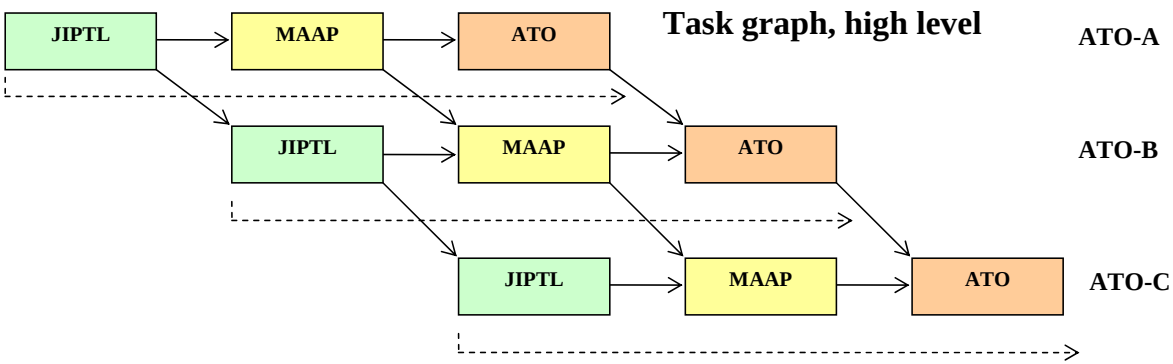


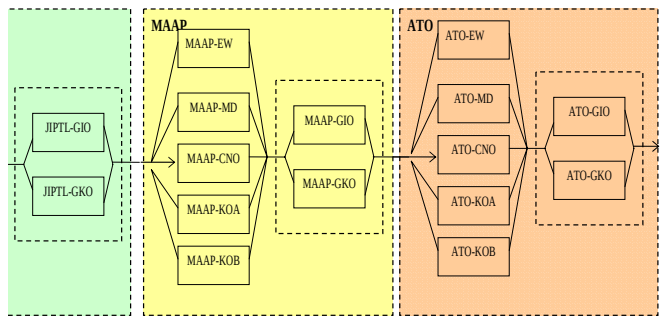
b) Communication Channels of ORG1



c) Communication Channels of ORG2

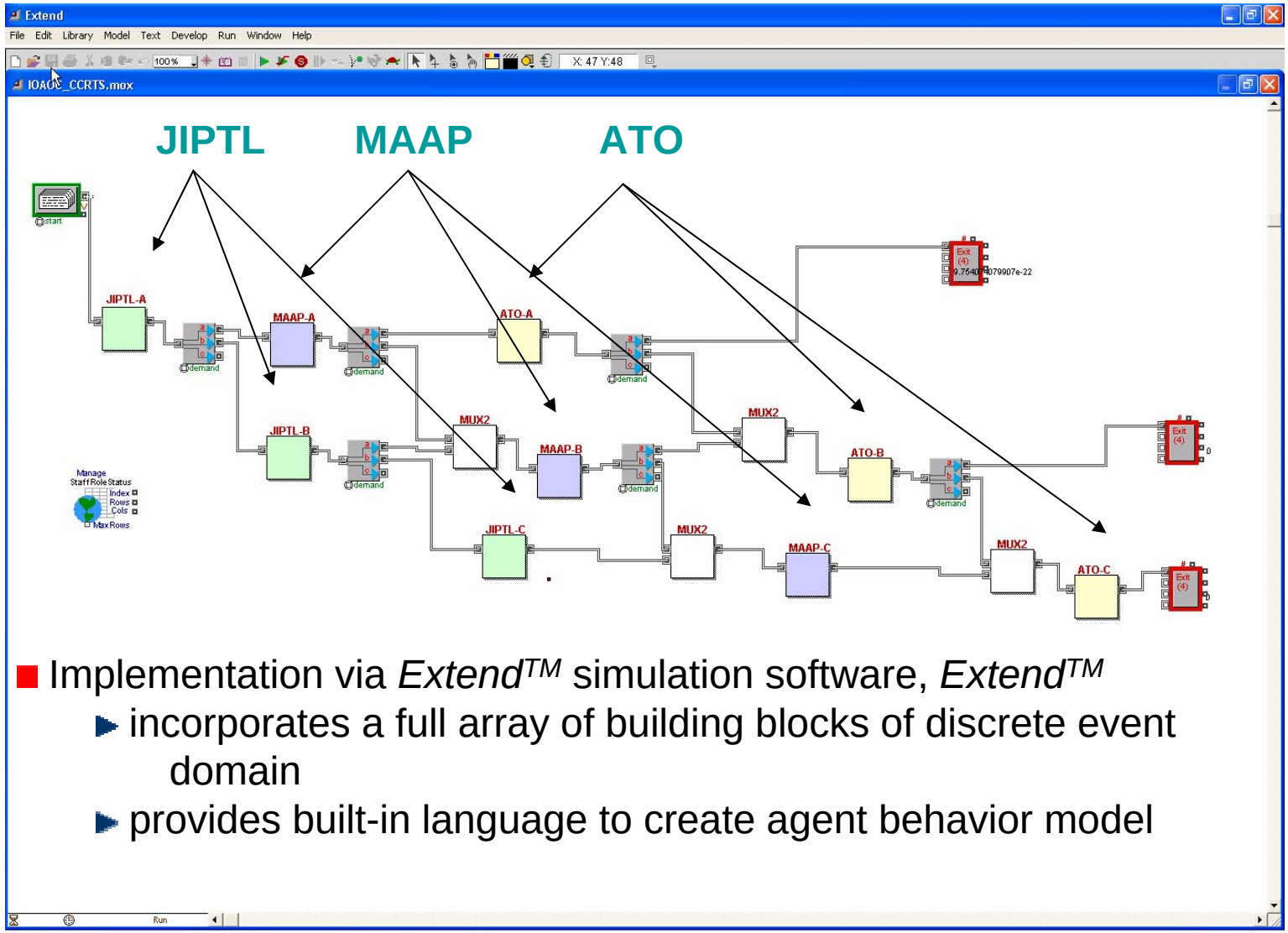
Task Graph





Task Graph, detailed

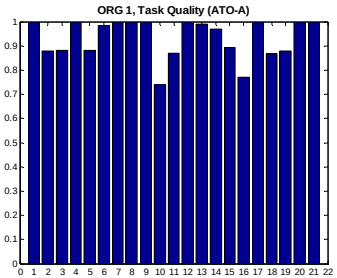
Simulation using *Extend*™

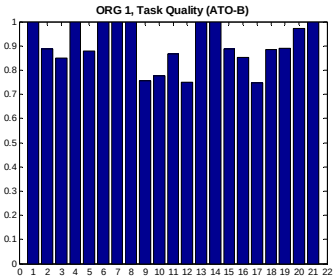


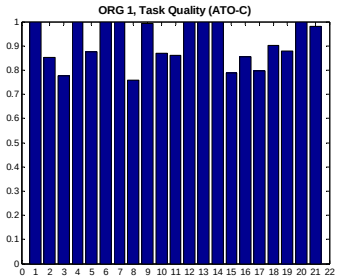
- Implementation via *Extend*™ simulation software, *Extend*™
  - incorporates a full array of building blocks of discrete event domain
  - provides built-in language to create agent behavior model

Performance Collection

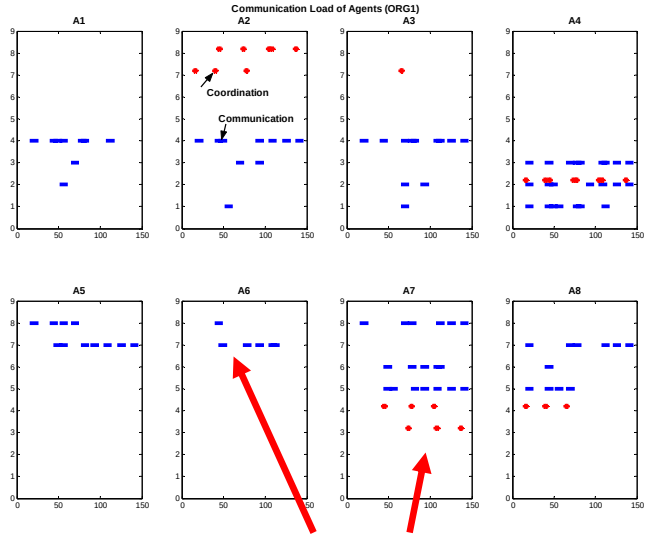
Performance Of Organization I



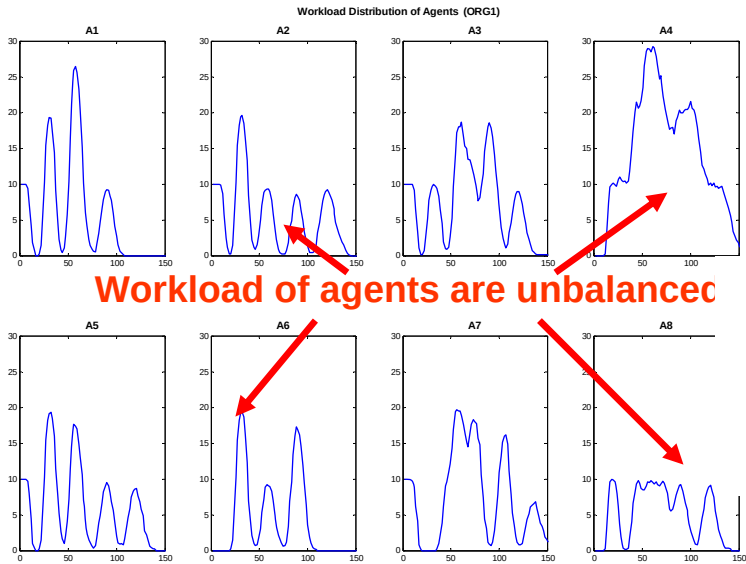




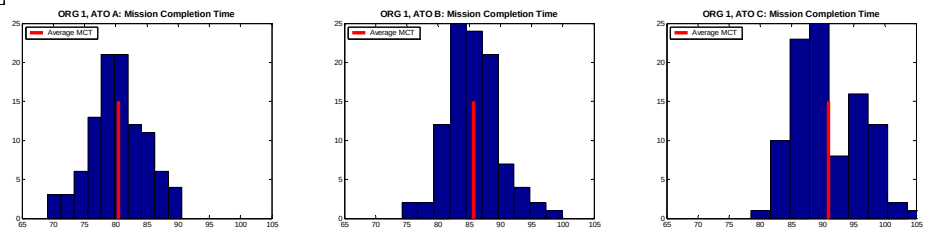
Some tasks are of low qualities



Communication load of agents are unbalanced



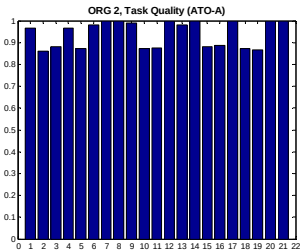
Workload of agents are unbalanced

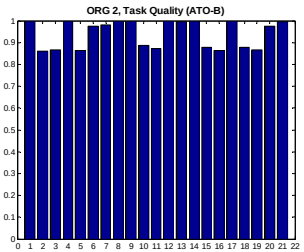


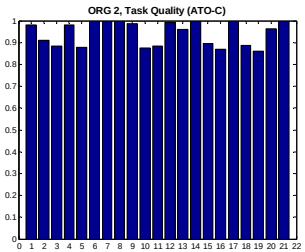
Mission completion time of each ATO is long

Illustrative Example (4)
Organizational Change

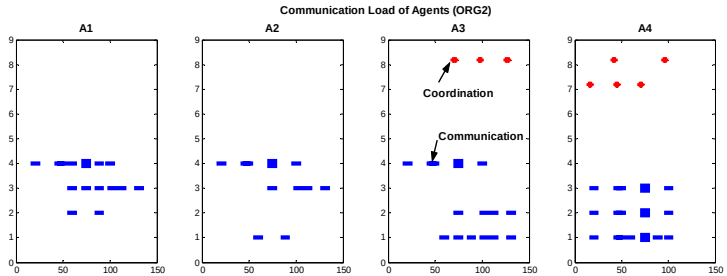
- **Performance Of Organization II**

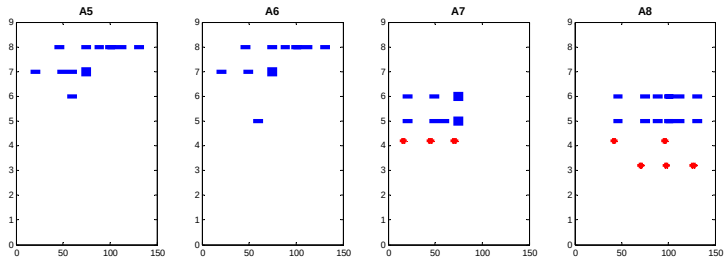




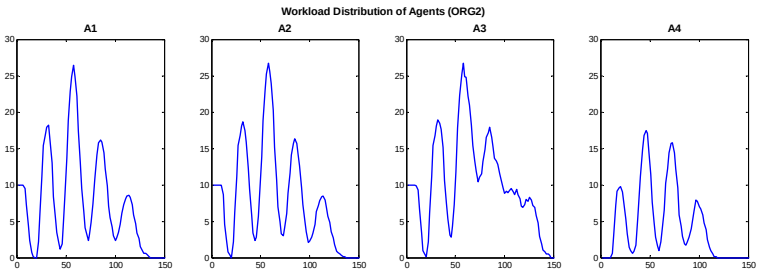


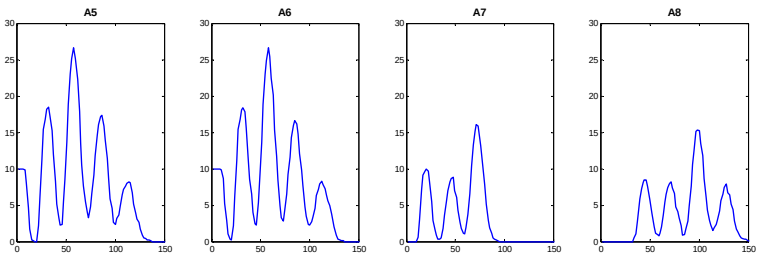
higher average task quality



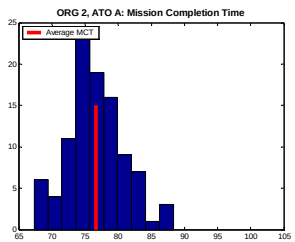


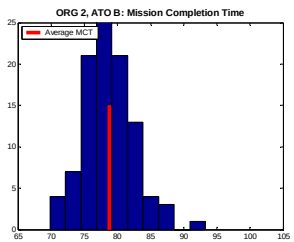
smaller average communication load,
and smaller communication load variance

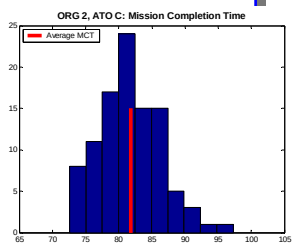




smaller average agent workload,
and smaller workload variance







shorter average mission completion time

Summary and Future Work

- **In summary, we**
  - proposed a modeling and simulation methodology for organizations involved in project-based missions
    - modeled information, expertise and knowledge as dynamic resources, which agents can acquire and share
    - modeled interacting components, hierarchical arrangement of agents
    - implemented the organizational model using *Extend*™ simulation package, a discrete event simulator
  - presented an example of an Air Operation Center (AOC)
    - to illustrate the potential of our modeling and simulation approach

- **In future work, we would consider**
  - more realistic and full-range of task interrelationships
  - sophisticated agent behavior model
  - impact of agent behavior on the task completion
  - Introducing information propagation error (ambiguity)

Questions?