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Simulation-Based Systems Engineering (SBSE) of Intelligent Enterprises (IE)

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INCOSE-LA 2009 Mini-Conference

7 February 2009



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Simulation-Based Systems Engineering (SBSE) of Intelligent Enterprises (IE) John R. Clymer

- Biography
 - BS & MS Iowa State, PhD Arizona State
 - Employment with FORELL enterprises (Buena park, CA), Rockwell International (Anaheim, CA), Navy Fleet Analysis Center (Norco, CA), and General Electric Company (Phoenix, AZ)
 - Professor of EE (CSUF – 1982 to present)
 - Experience covers most phases of SE:
 - INCOSE Fellow
 - IEEE and INCOSE
- SBSE with artificial intelligence



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Presentation Topics

- OpEMCSS Blocks: Add On ExtendSim Library
 - Complex System Interactions
 - Context-Sensitive Systems (CSS)
 - Evolutionary Optimization of Inventory System Operation
- Intelligent Enterprises
 - Description of IE
 - OpEMCSS Model of IE
 - Features of IE Model
- Project Plan for IE Modeling and Analysis
- Other Continued IE Research
- Summary



OpEMCSS Blocks: Add On ExtendSim Library

- Blocks required to simulate interacting concurrent processes.
- Blocks required to do evolutionary optimization of the system design
 - Evolutionary algorithm block can optimize architecture component algorithms and methods used
 - Classifier System block optimizes system control decisions
- Blocks required to simulate motion and spatial interactions among a set of physical entities in the system and its environment.

Types of Complex System Interactions

- **Process Synchronization**
 - One or more process instances must wait while another process completes a task
- **Resource contention**
 - One or more process instances must wait while another process uses a resource
- **Communication and adaptation**
 - One process instance sends a message to another process instance that is then used to decide an action

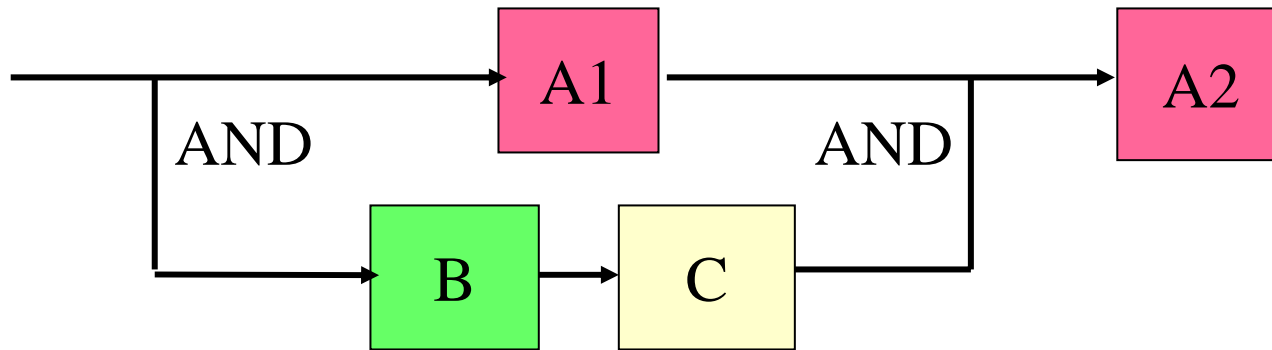


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Example Process to Study System Interactions



A job request arrives every N units of time

- Tasks A1 and A2 share resource A as noted by same color
- Task B exclusively uses resource B
- Task C exclusively uses resource C

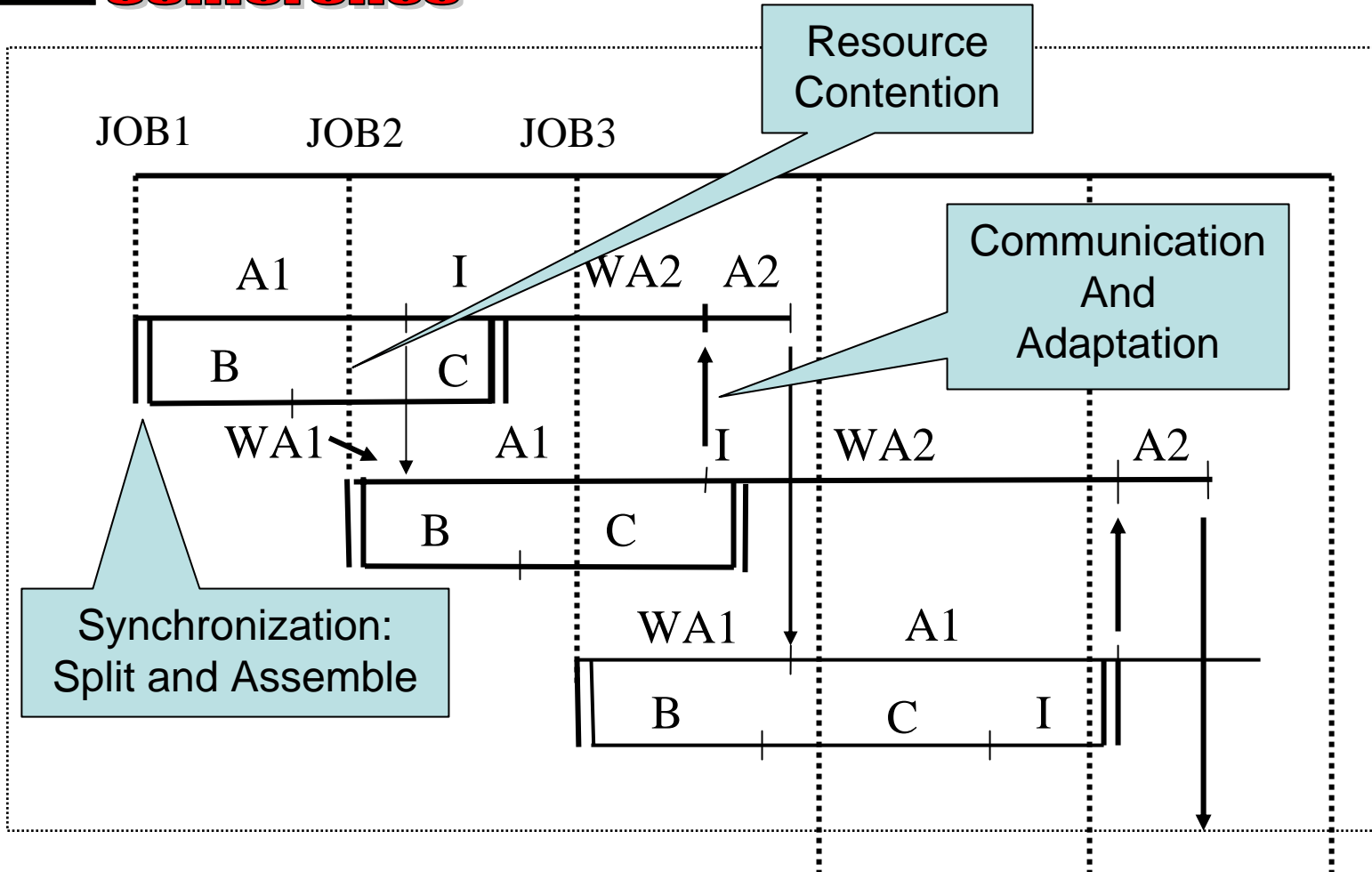


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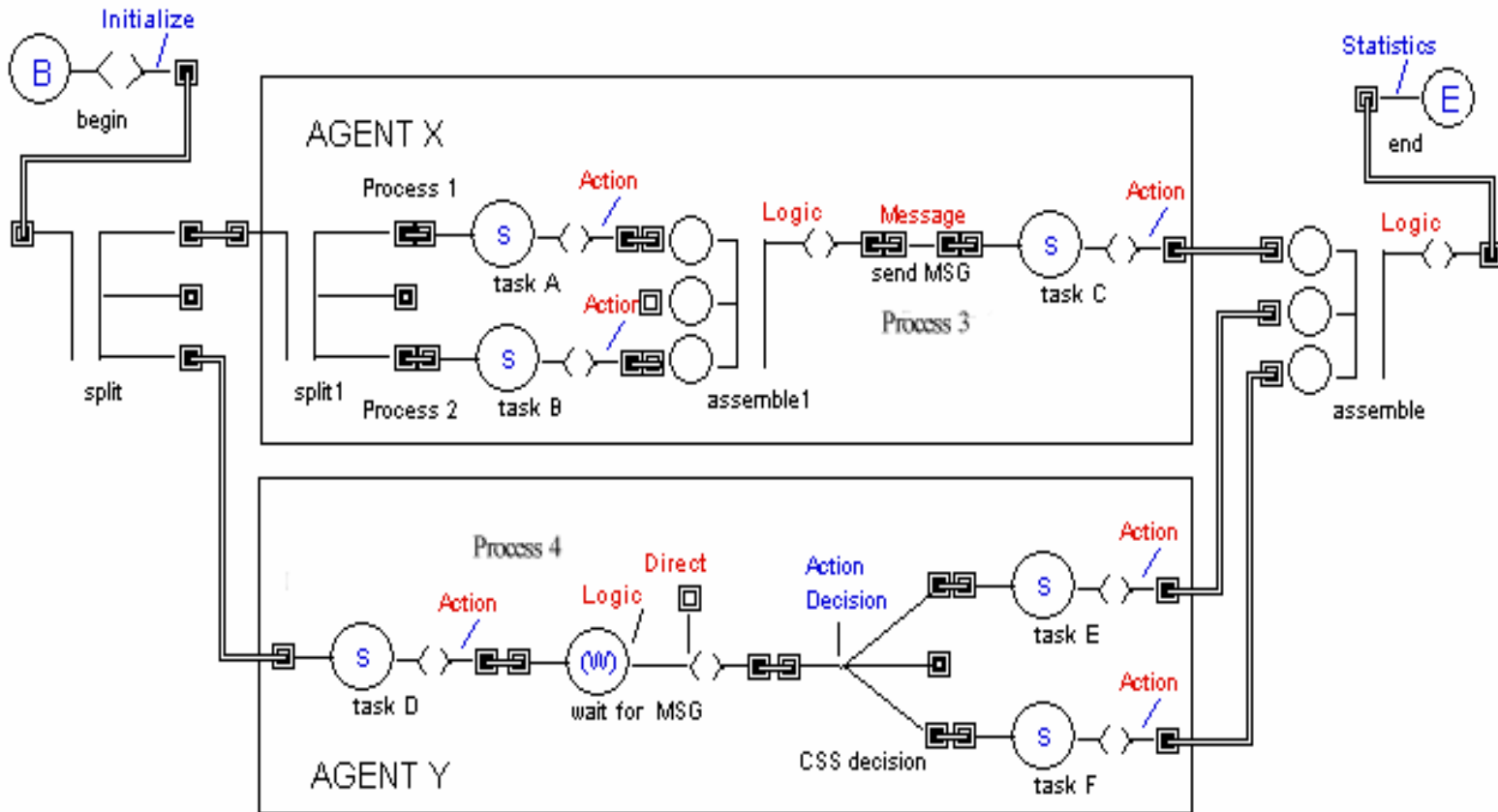
Types of Complex System Interactions





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Context-Sensitive System Interaction



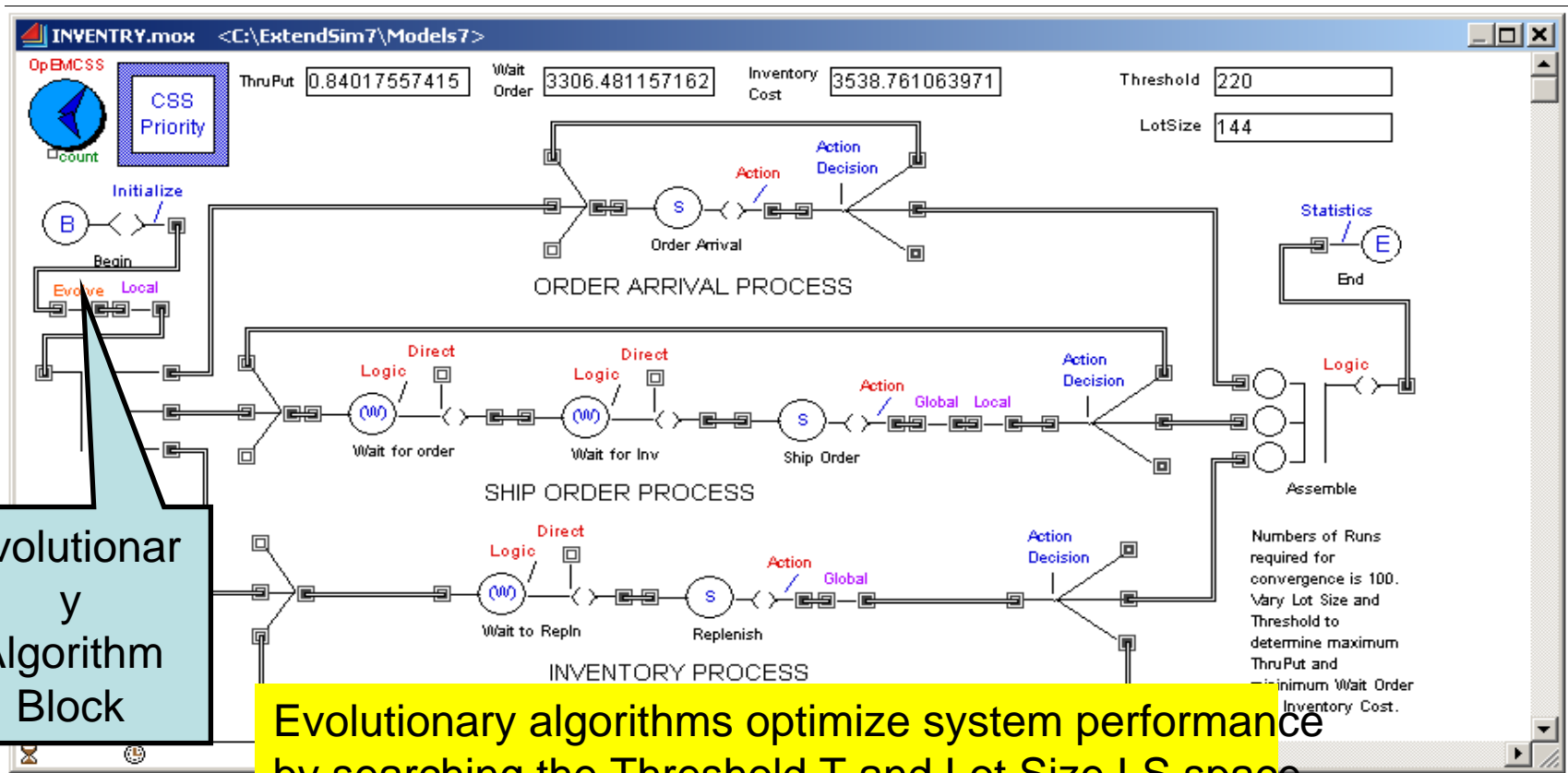


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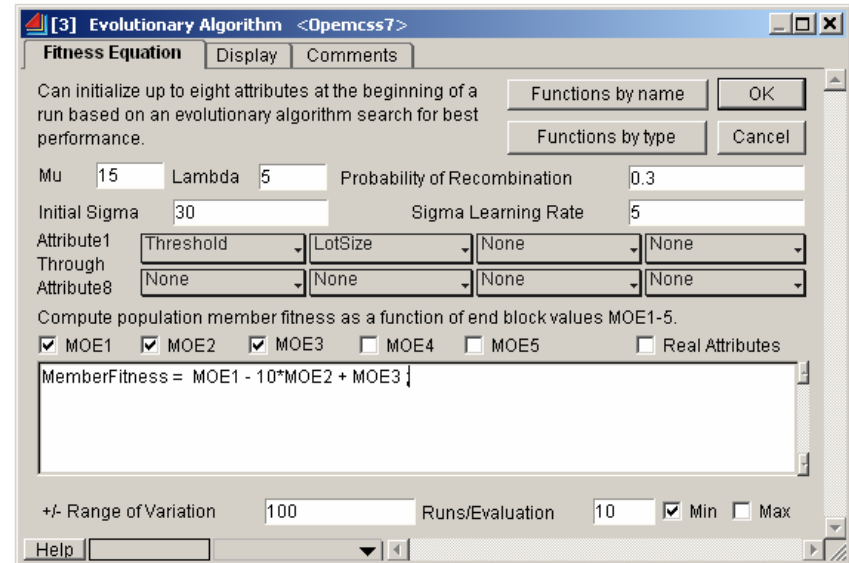
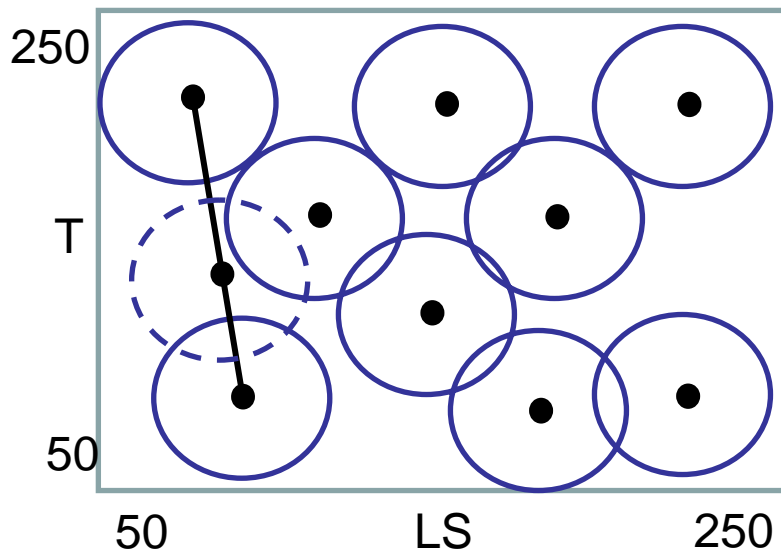
Inventory Model



Evolutionary Algorithm Block

Evolutionary algorithms optimize system performance by searching the Threshold T and Lot Size LS space

Evolutionary Algorithm Searches Threshold(T)-LotSize(LS) Space

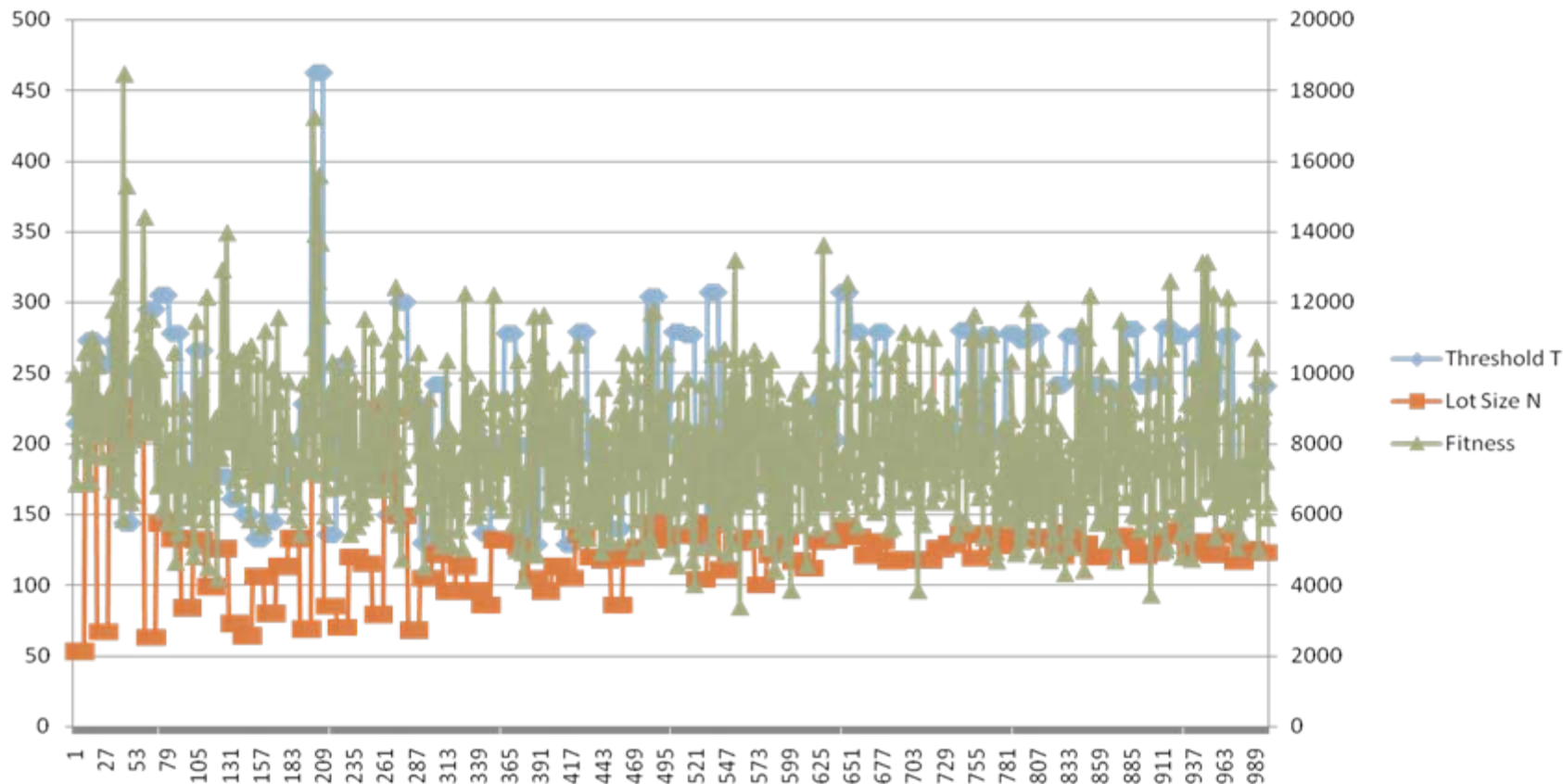


- Black dots are population members
 - Initial Sigma defines radius of search around each member
 - Recombination of two population members can fill in search space



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Evolutionary Search Discovers the Best Combinations of Control Parameters





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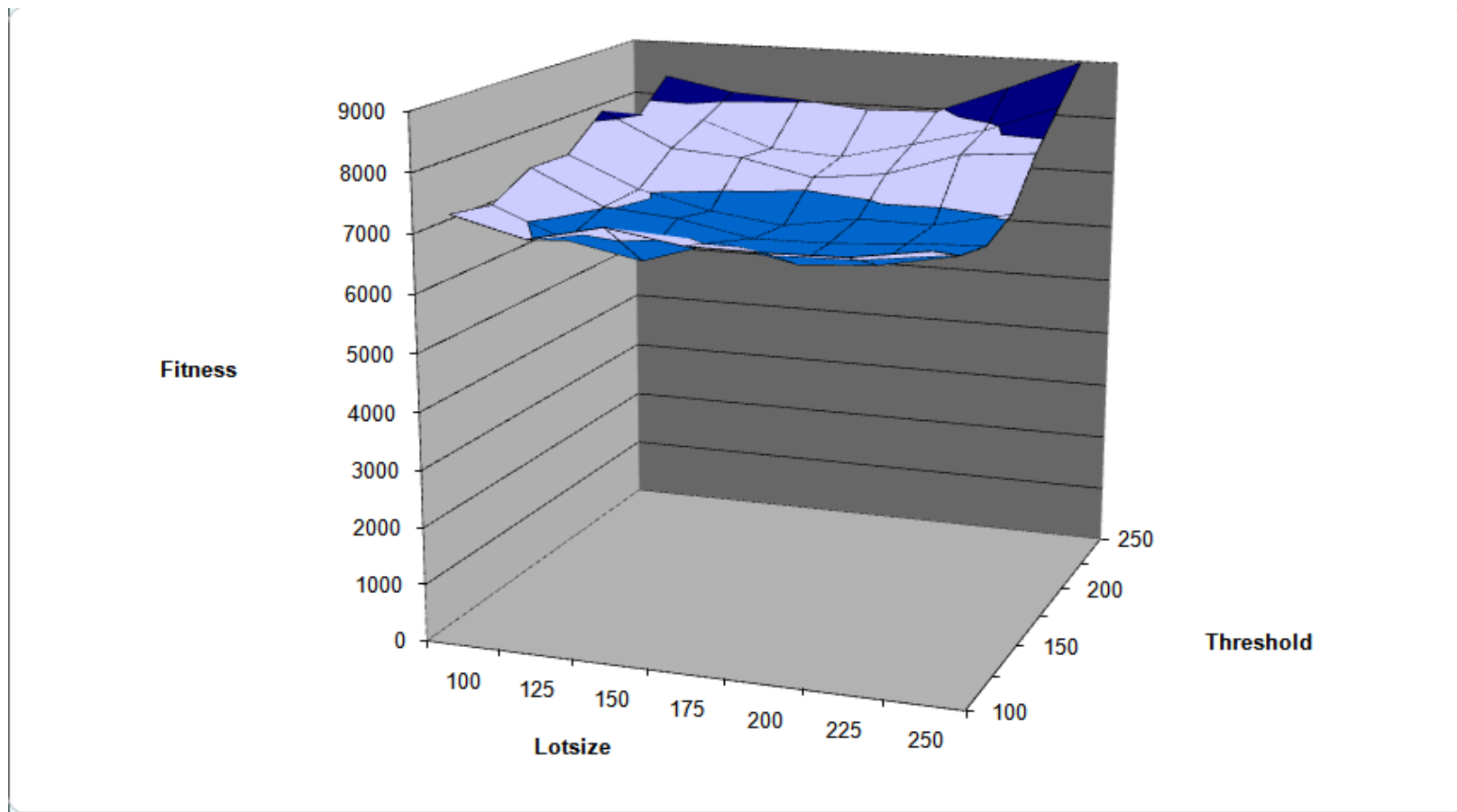
Sample of the Best Solutions

1. Member Weights: 201 128	Fitness: 6472.5112242583
3. Member Weights: 242 122	Fitness: 6520.1786541715
2. Member Weights: 180 118	Fitness: 6652.7096144387
2. Member Weights: 183 117	Fitness: 6657.0777128067
3. Member Weights: 276 137	Fitness: 6666.3588833294
1. Member Weights: 201 133	Fitness: 6669.0098671138
3. Member Weights: 276 138	Fitness: 6695.1668568422
1. Member Weights: 199 127	Fitness: 6840.8103452362
1. Member Weights: 200 134	Fitness: 6886.4674095958
3. Member Weights: 279 136	Fitness: 6972.072228327



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Fitness Surface: Inventory System





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Intelligent Enterprises

- Collection of projects where each project takes requests and returns artifacts (value carriers)
 - Co-Align projects: Rewards received are allocated using an enterprise model to maximize ROI
 - Hire / train workers
 - Purchase equipment
 - Build new facilities
 - IR&D

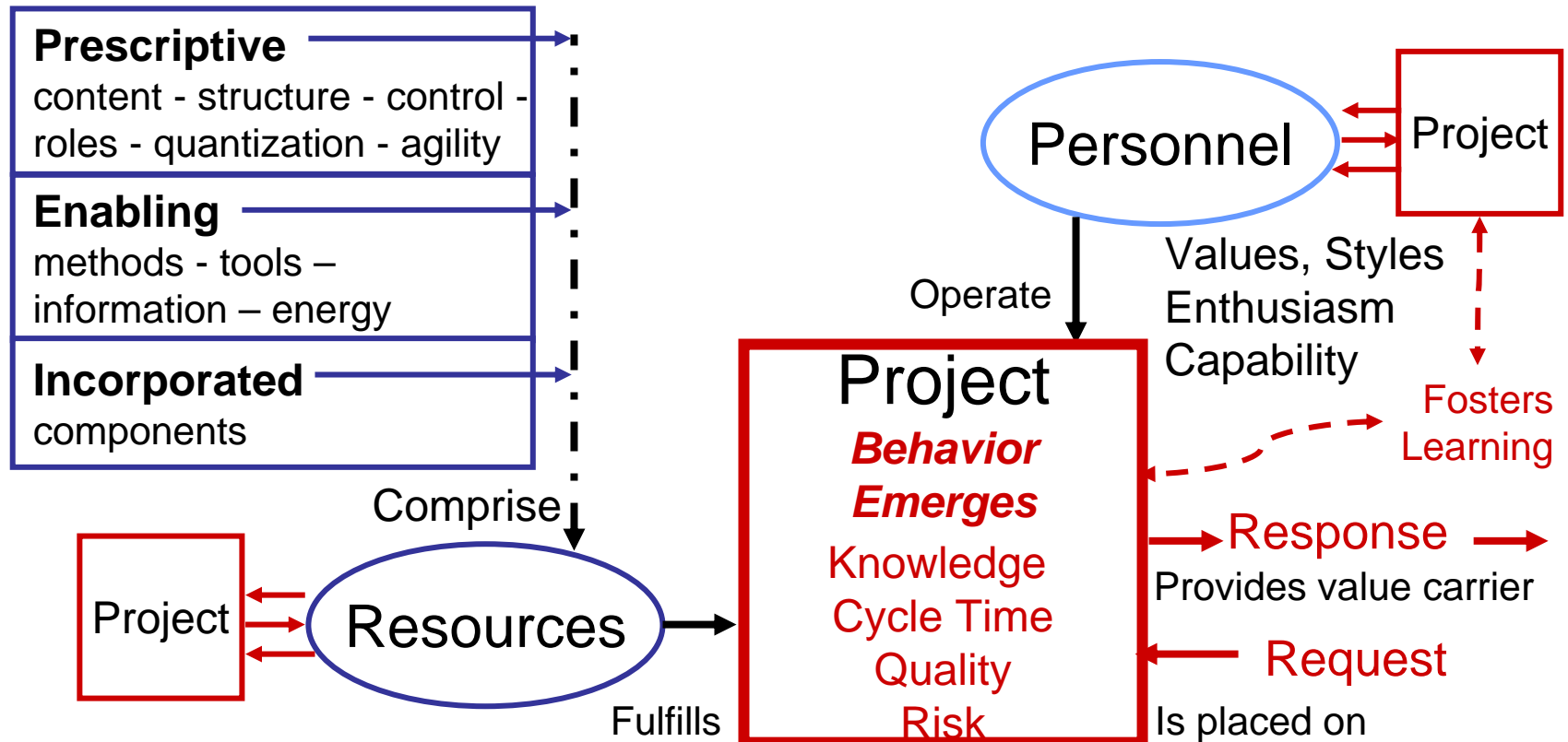


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Jack Ring's Seed Holon



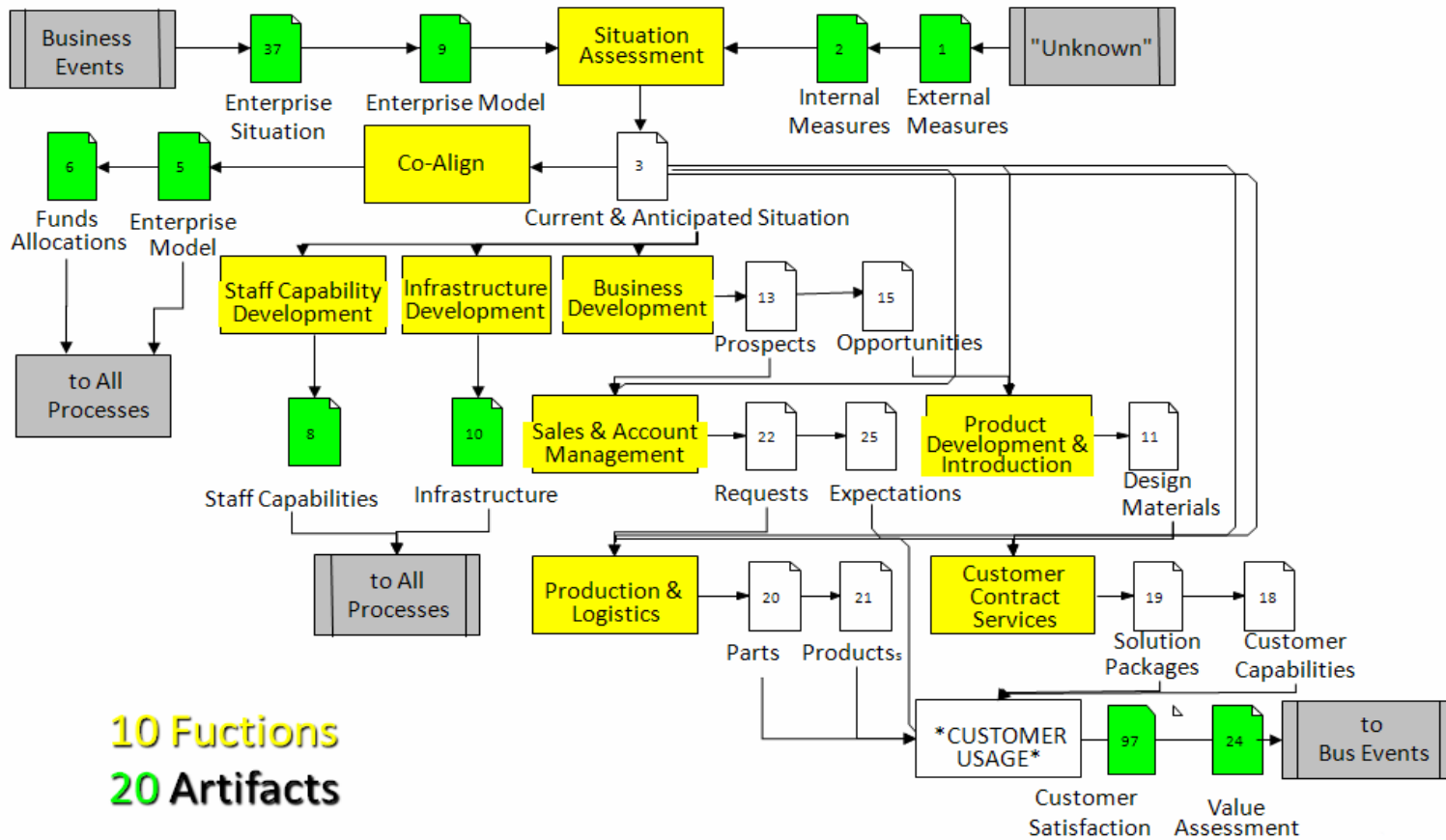


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Jack Ring's Intelligent Enterprise



10 Functions
20 Artifacts

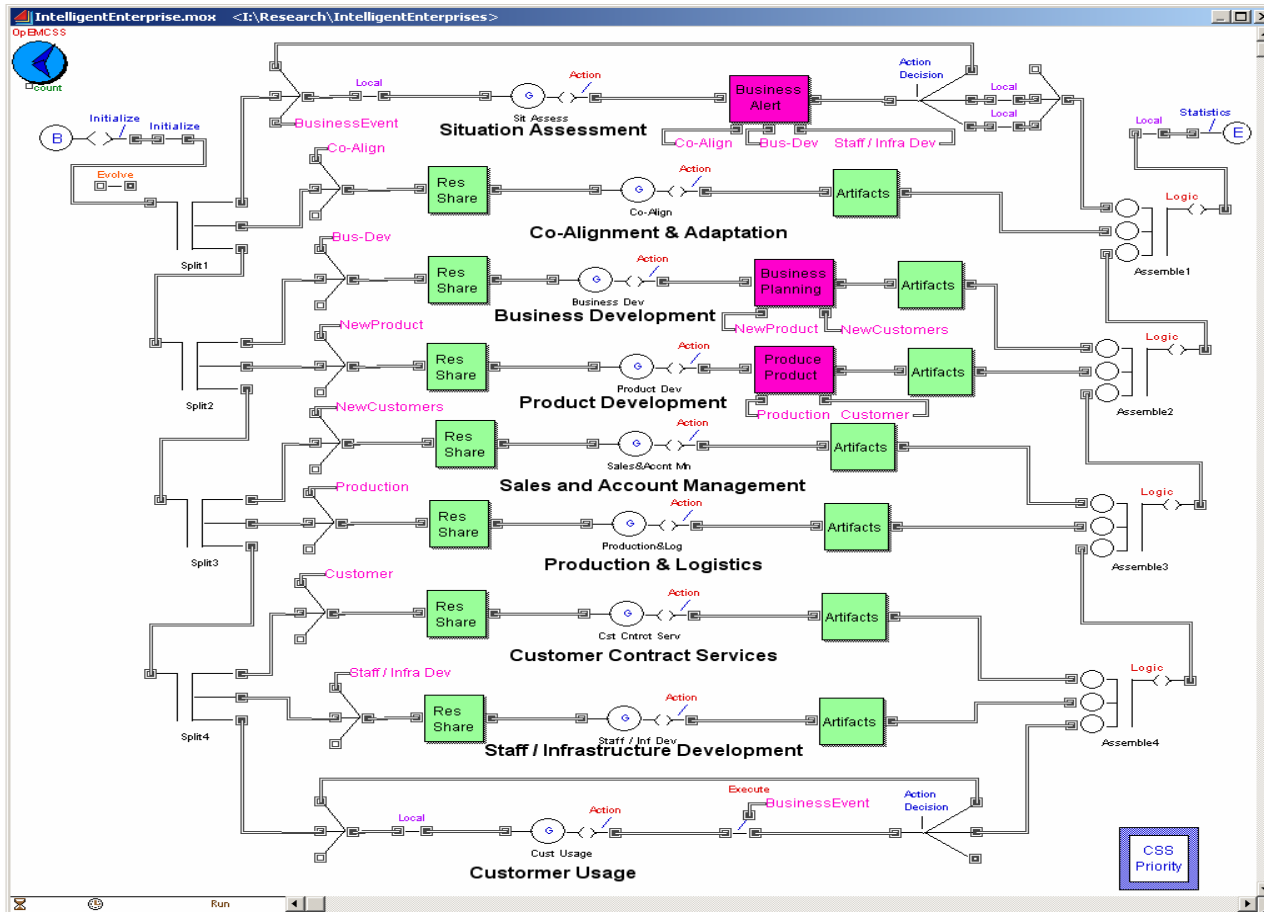


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OpEMCSS Model of Intelligent Enterprise





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Features of IE Model

- IE operates in a dynamic external environment
 - Changing business situations
 - Competition with existing products / customer services
 - Opportunity for new products / customer services
 - Changing customer preferences
 - Product value to customer
 - Customer satisfaction
 - Intelligent agent will learn to recognize situations that require co-alignment



Features of IE Model (Continued)

- IE operates in a dynamic internal environment
 - Deciding when to train workers
 - Allocating shared workers and resources among projects
 - Intelligent agent will learn to recognize internal situations that require co-alignment



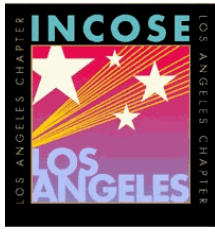
Features of IE Model (Continued)

- Projects in model
 - Staff / capability development – Hire and train workers
 - Infrastructure development – Acquire resources / facilities
 - Business development – New and modified products and services
 - Sales & account management – Budgeting and production quotas
 - Product development and introduction
 - Production and logistics – Manufacture products and maintain products at customer locations
 - Customer & contract services – Evaluate customer satisfaction with products and services



Project Plan for IE Modeling and Analysis

- Complete model:
 - Model all project thread types that accept requests and produce artifacts
 - Model shared resources and workers
 - Within same project
 - Among different projects
 - Model each situation event and proper project threads



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Project Plan for IE Modeling and Analysis (Continued)

- Verify model is correct
- Determine optimal number of each worker type and resource type for initial operation
- Demonstrate that situation events cause proper worker or resource changes
- Demonstrate that situation events cause proper addition of new products and other product changes.



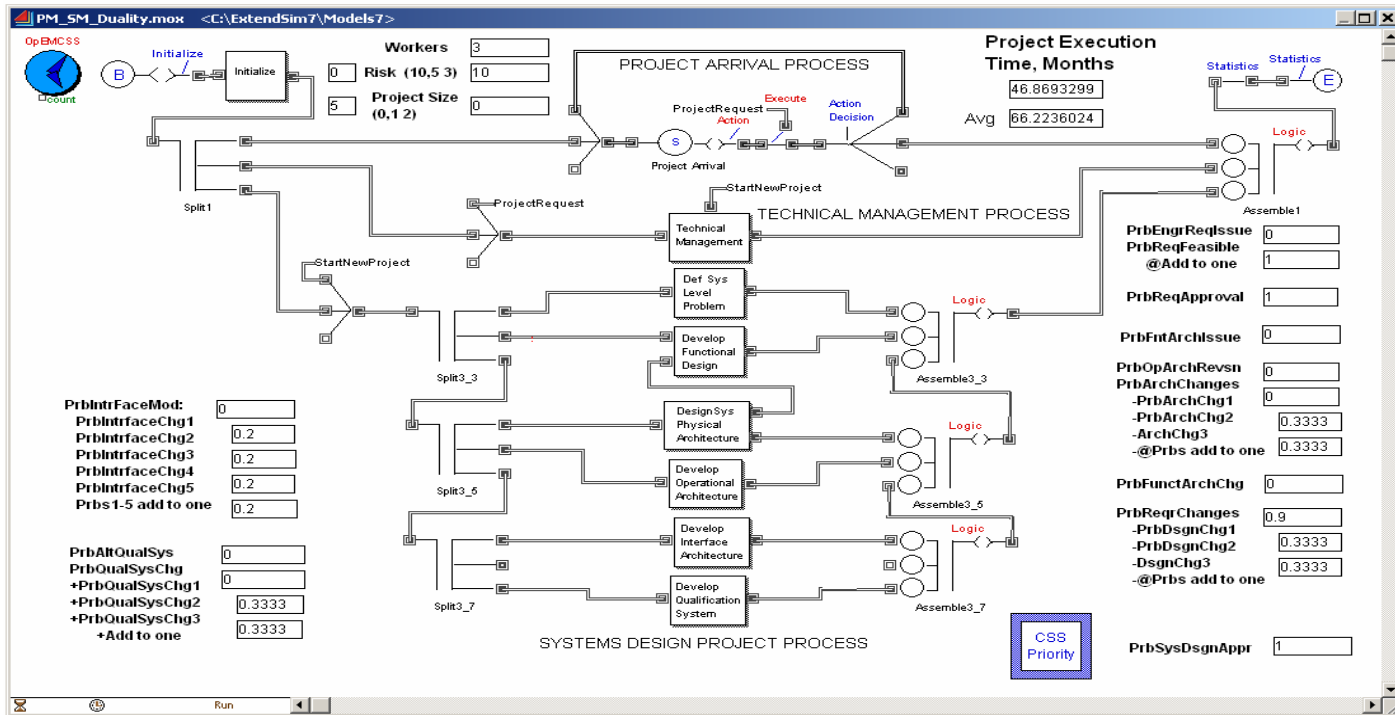
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Other Continued IE Research

- Will also continue to explore behavior of an IE that performs SE





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Summary

- OpEMCSS is a simulation tool that can meet all IE modeling requirements
 - Complex system interactions
 - System design optimization
- Described a generic organization as an IE
 - Environmental situations drive IE behavior and adaptation
- Have begun model development of the generic IE