

The Right Brain Architecture of a Holonic Manufacturing System

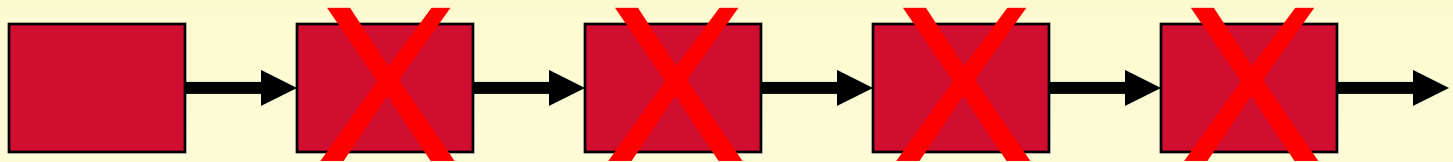
Application of KEEL[®] Technology
to Holonic Manufacturing Systems



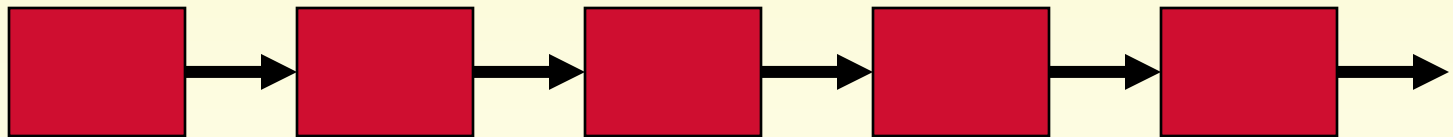
Industrial Automation Systems

- Discrete Manufacturing Systems

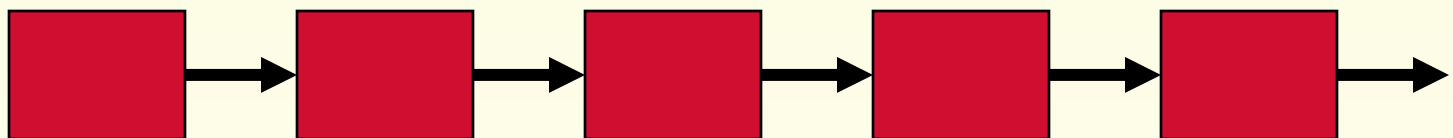
Line 1



Line 2

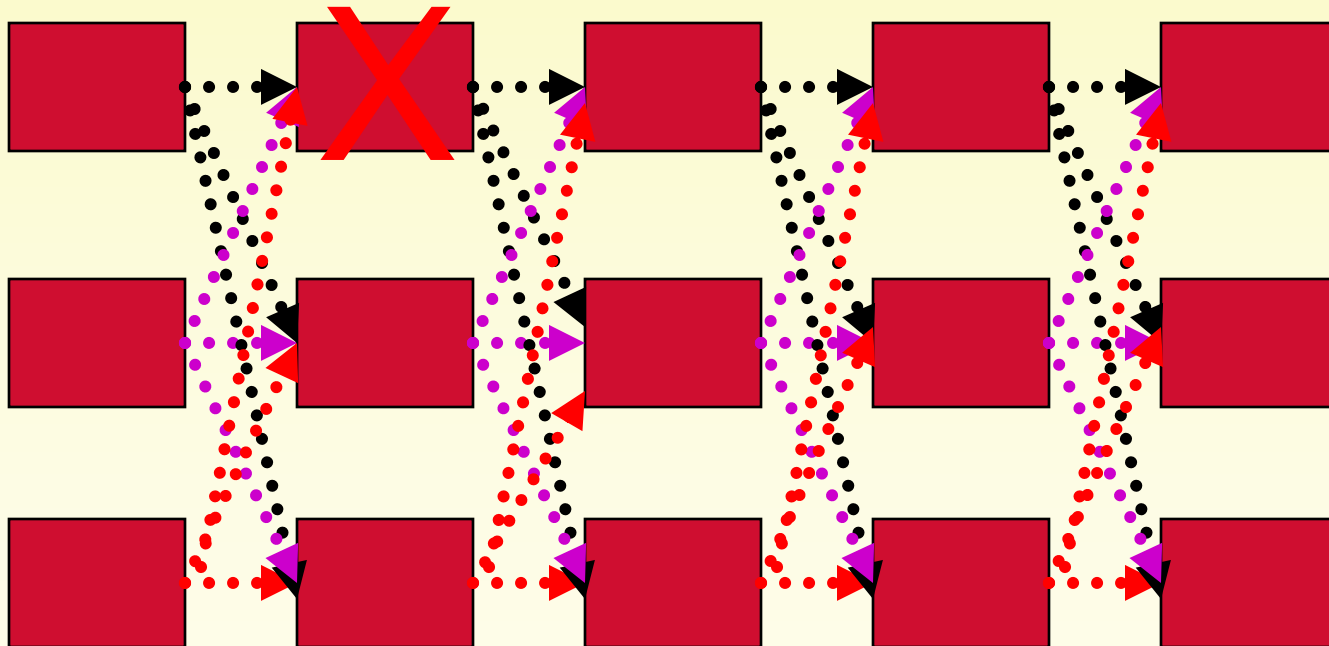


Line 3



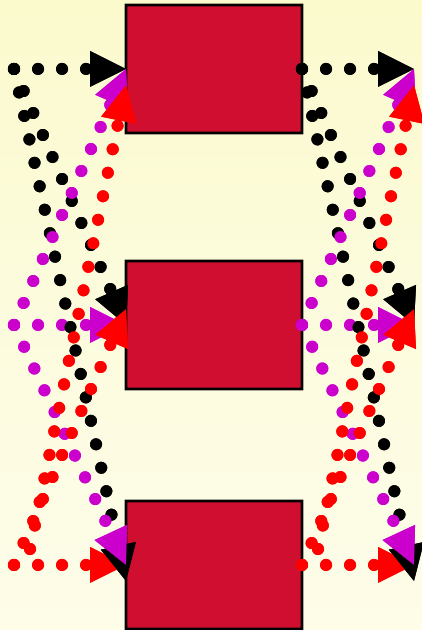
Holonic Manufacturing Systems

- Objective
 - Machines negotiate for work



Most Research on Infrastructure

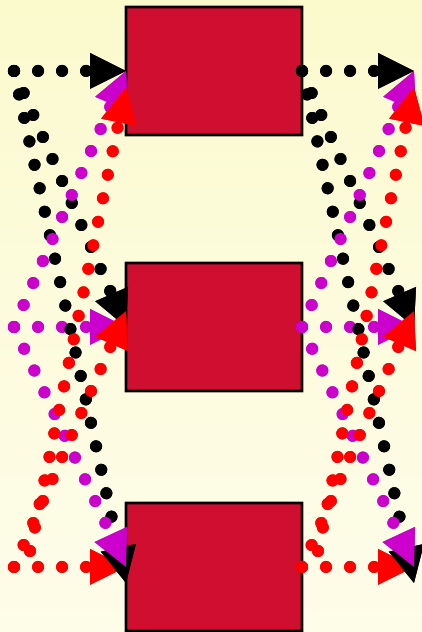
Left Brain Activity



- Architecture
- Protocol for Negotiation
- Symantics / Language
- Object Definition

Agent Reasoning

Right Brain Activity



- Why
- How Much
- When
- Who Should Know



Agent Model

- Normal Mode
 - Static Rules
 - Repetitive Operation
- Characterized By
 - Conventional Programming Languages
 - RLL Dominant
 - Structured Text
 - Sequential Function Charts
 - Function Block Programming
- Exception Mode
 - Multiple Courses of Action
 - Judgment
 - Balancing Options
 - Accept Human Advise
- Characterized TODAY by
 - Complex Code Segments

Reasoning for Agents

- Reasoning is more than just processing a linear set of rules.
- To fulfill their potential, Agents must incorporate reasoning to address subjective situations.
- At least today, there is an advantage to have that reasoning defined by humans.
 - Allowing auditing of the process
 - Allowing humans to correct / enhance the process



Problem with Conventional Logic

- Static rules will not solve many complex situations
- Defining solutions as a set of scenarios does not allow the agents to react to new situations
- Developing complex solutions with conventional programming practices creates solutions prone to logic errors.



Some Cognitive Solutions

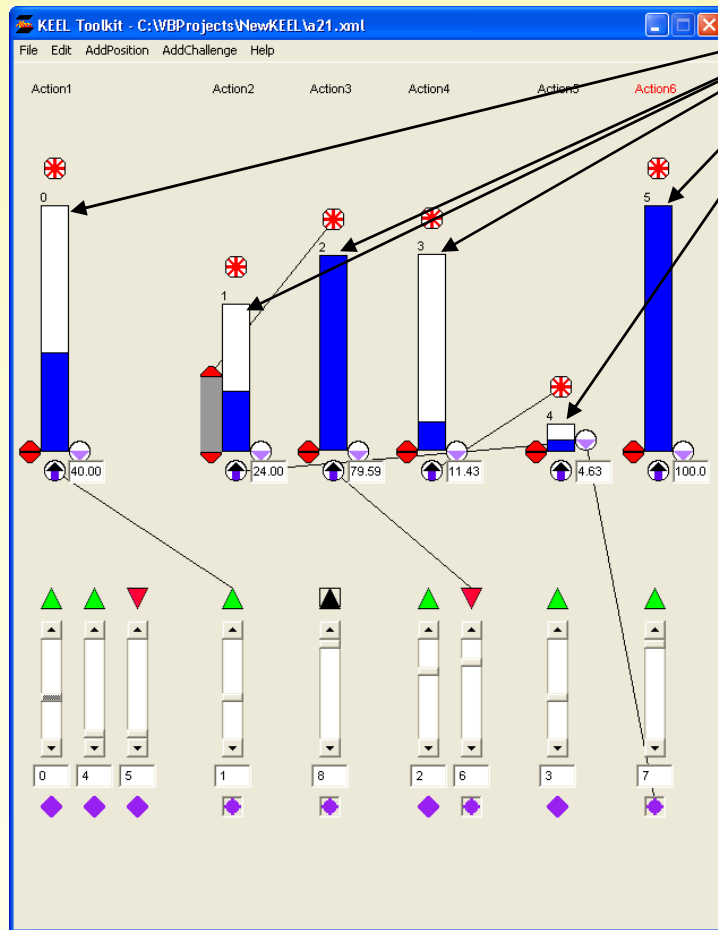
- Artificial Neural Nets (ANN)
 - Pattern Matching Solution – not reasoning
 - Mechanism Model (models the human brain)
 - Training is an issue
 - Results / Actions are not “explainable”
- Fuzzy Logic
 - Fuzzy Rules (“Expert System”)
 - Process Model (based on linguistic uncertainty)
 - Design is an art - inexplicit
 - Results / Actions are “mathematically explainable”



KEEL[®]

- Knowledge Enhanced Electronic Logic (KEEL[®])
 - Graphical Rules Based ("Expert System")
 - Process Model (Graphical Rules)
 - Models Reasoning of Human Expert
 - Dynamic Rules
 - Results / Actions are Visually Explainable

KEEL[®] Source Code



6 Decisions / Actions

Potential Outputs

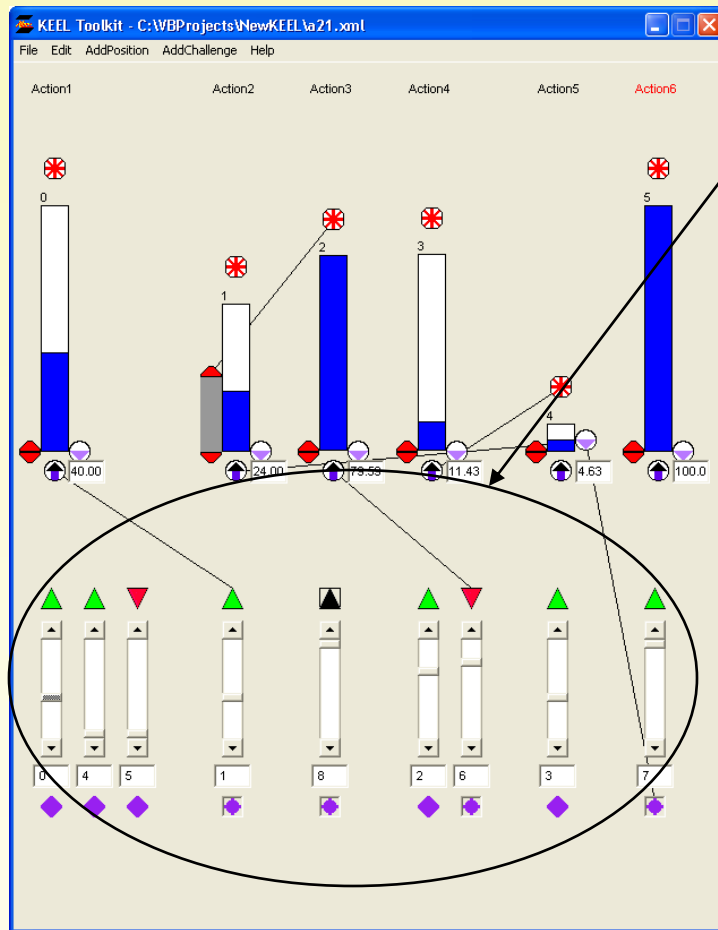
Yes / No (On/Off)

Or Analog

Height of bars

indicates importance

KEEL[®] Source Code



Inputs

Supporting /
Driving Inputs
(Green)

Blocking /
Objecting Inputs
(Red)

Adaptive Behavior

➤ Humans

- Adapt to a changing environment by allocating resources
- Importance of information changes as their environment changes
- Balance a number of problems / possible actions at any time determine value of information and how resources should be applied
- Rules by which humans operate change based on the resources available and by their perception of their environment

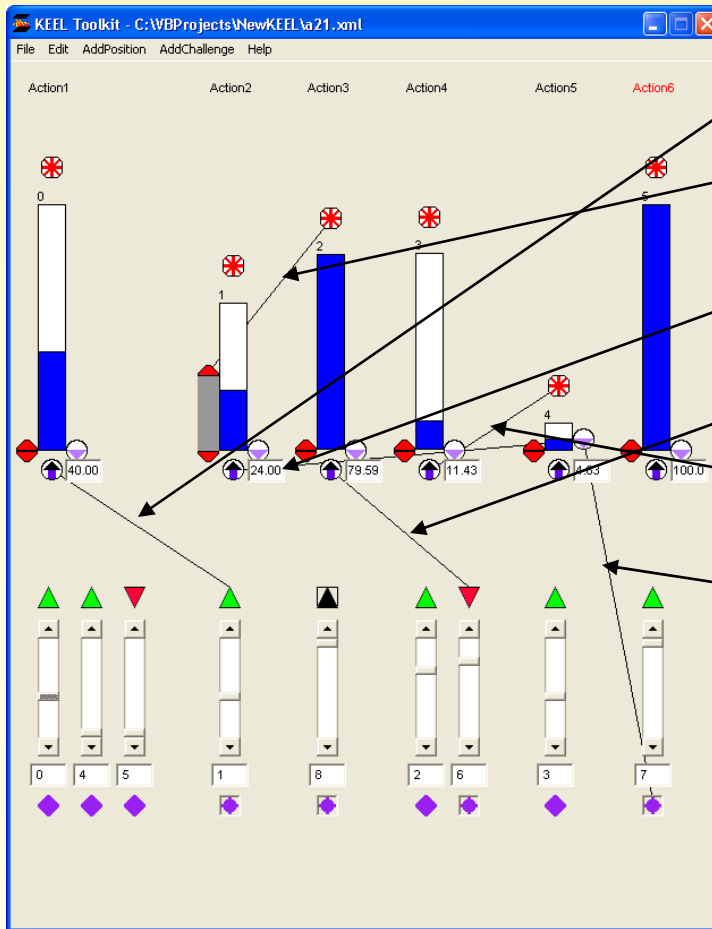
➤ Holons

- Need to do the same things

➤ KEEL Engines

- Iteratively process information (inputs)
- Adjust the importance of information
- In order to balance all of the options / actions
- Until a stable set of outputs is achieved

Explainable



- Drives
- Sets the importance of
- Determines the threshold of
- Inhibits (objects too)
- Sets the importance of
- Turns On/Off

Trace the lines to see exactly why any decision or action is taken

Learning versus Adapting

➤ Learning

- Psychologists consider learning as the ability to acquire new information (automatically) and generate all necessary linkages and values (automatically).
- We suggest that this is not what we want with a holonic manufacturing system.

➤ Adapting

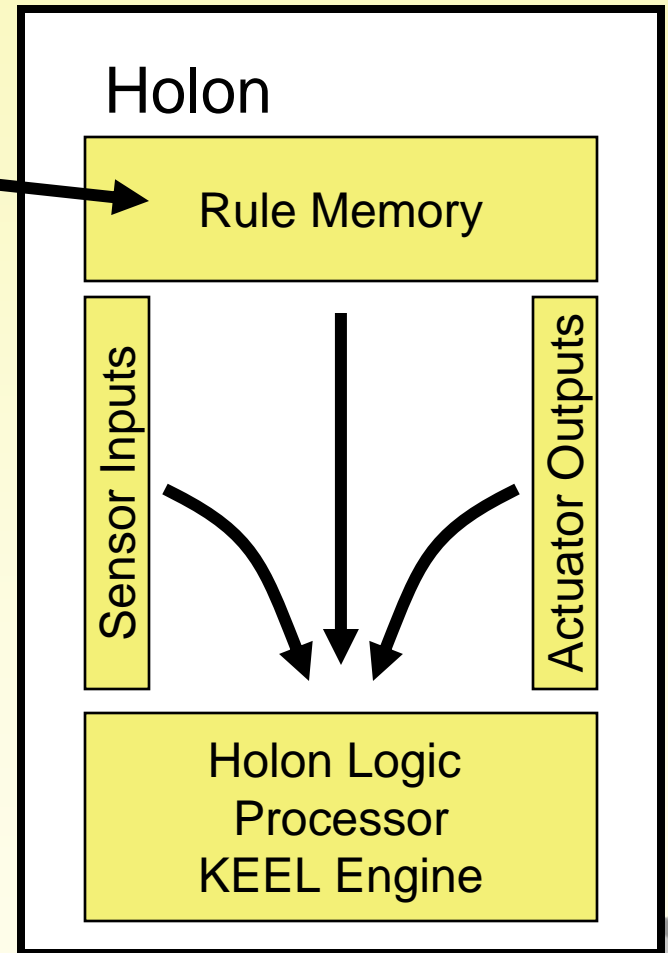
- Holonic Agents need more control
- They need to be accountable to their human supervisors
- In our view Adapting is more appropriate than Learning
 - Holons “adapt to changing values” described by human experts
 - Holons “react according to” planned relationships defined by human experts

Extending a Holon

Judgmental Rule
Construction
Environment

Reload

Rules are data
structures, not
formulas or
sequential
instructions



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