DES203T:
Designing Intelligent Systems

Session 6

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY,
DESIGN AND MANUFACTURING,
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SESSION OUTLINE

- Architecture for Intelligent Behavior – Adaptive Models in Practice

- Architecture for Intelligent Behavior – Viable Systems Model (recursive)

What pattern of relations among P-F-S produces Intelligent Behavior w.r.t E?

A key Cybernetic Principle: Negative Feedback or Self-Regulation is critical for Goal Directed Behavior

LSM

3-D

(P)urpose

Goal (stability of key parameters?)

(F)unction

Process Information

(Abstraction/Modeling, Learn, Understand/Comprehend, Reason, Visualise, Interpret, Plan, Judge/Evaluate)

Physical Action (Matter-Energy Fns)

(S)tructure

Intelligence inside/outside product

Intelligence at part/system level

Degree of intelligent behavior

Reactive, Adaptive, Autonomous, Cooperative, Human Like, Personality

Chapter 18

(E)nvironment

Everyday, New, Hard, Uncertain, Variety

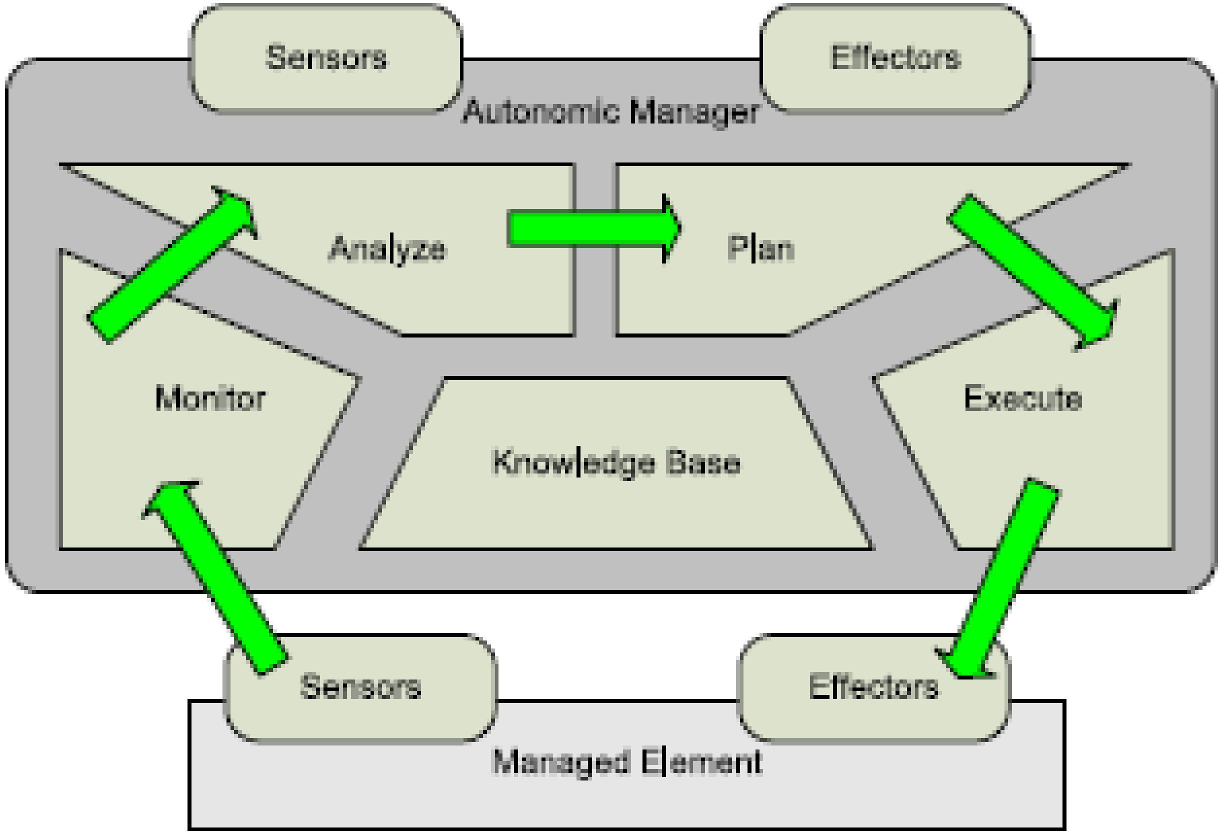
Design Direction:
Automation (Machine vs Human)
vs
Augmentation (Human and Machine)
Intelligence Amplifier

Chapter 1

Architecture for Autonomic Computing (IBM)

Structure-Function

Environment



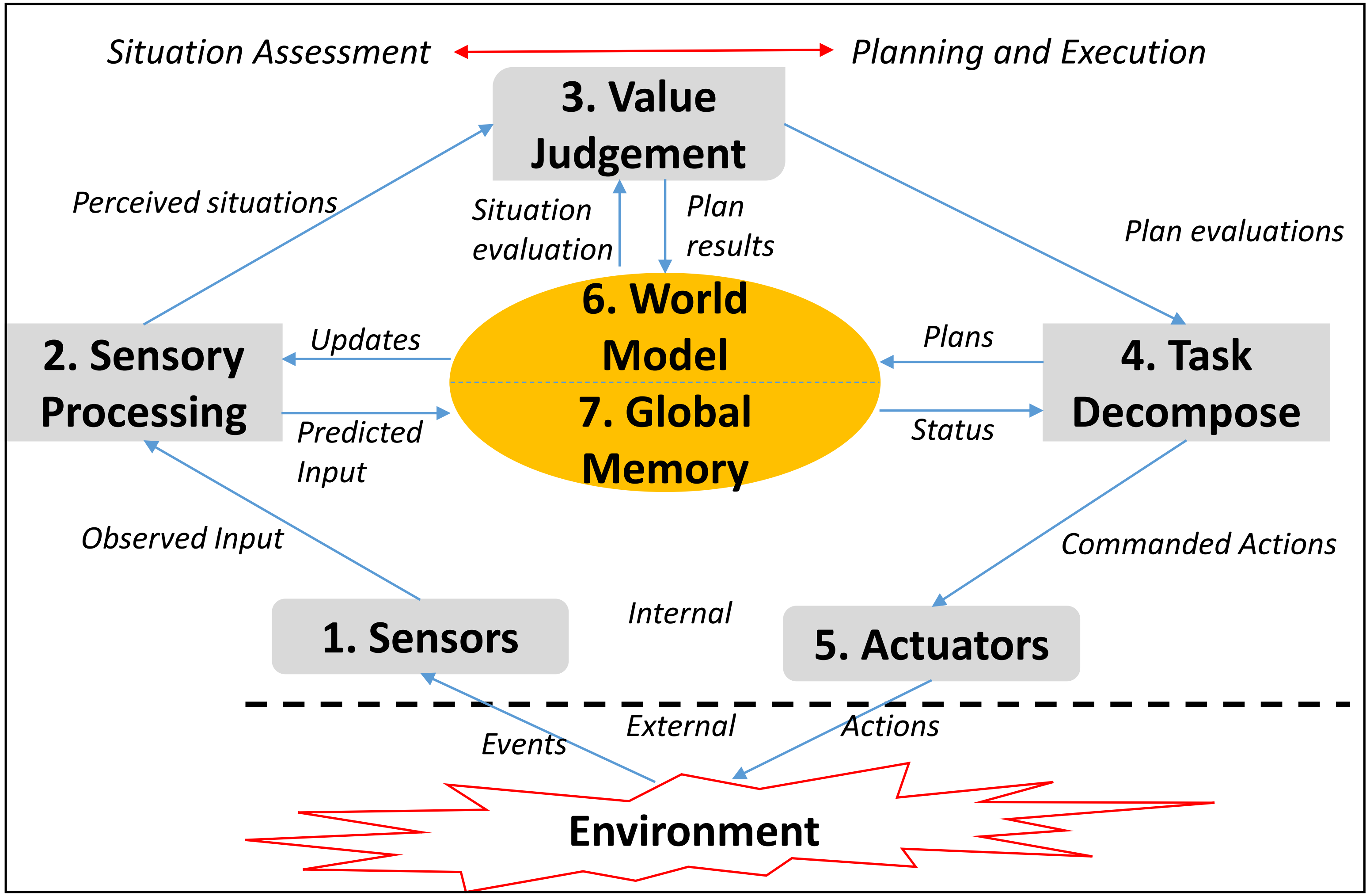
Claimed to be the first architecture for self-adaptive systems that explicitly exposes the feedback control loop

IBM uses the autonomic element as a fundamental building block for realizing self-configuring, self-healing, self-protecting and self-optimizing systems

Source: Kephart, J.O. and Chess, D.M. (2003): The vision of autonomic computing. IEEE Computer 36(1), 41–50

Architecture from Real-time Control Systems

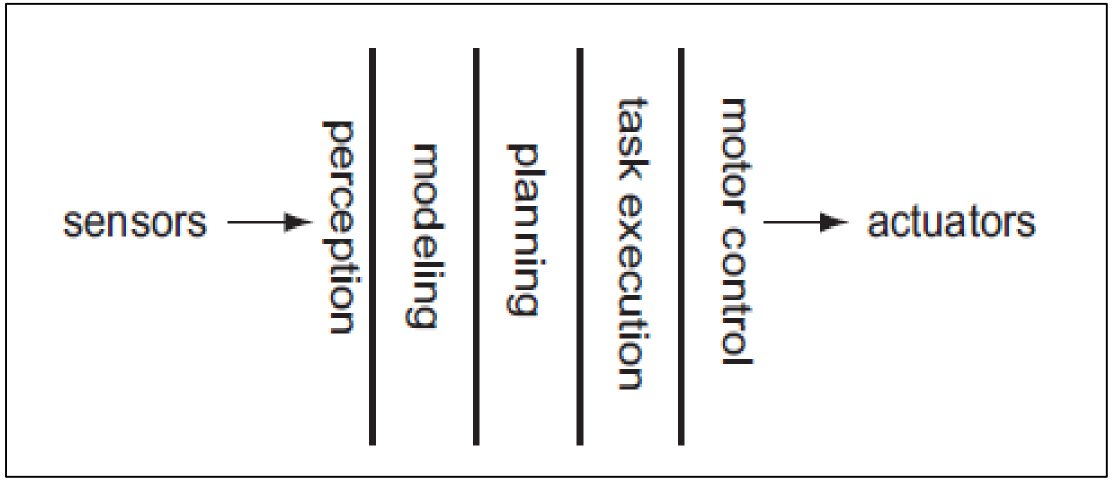
Albus, James.S. (1991), "Outline for a Theory of Intelligence". IEEE Transactions on Systems, Man and Cybernetics, 2 1(3): p. 473-509



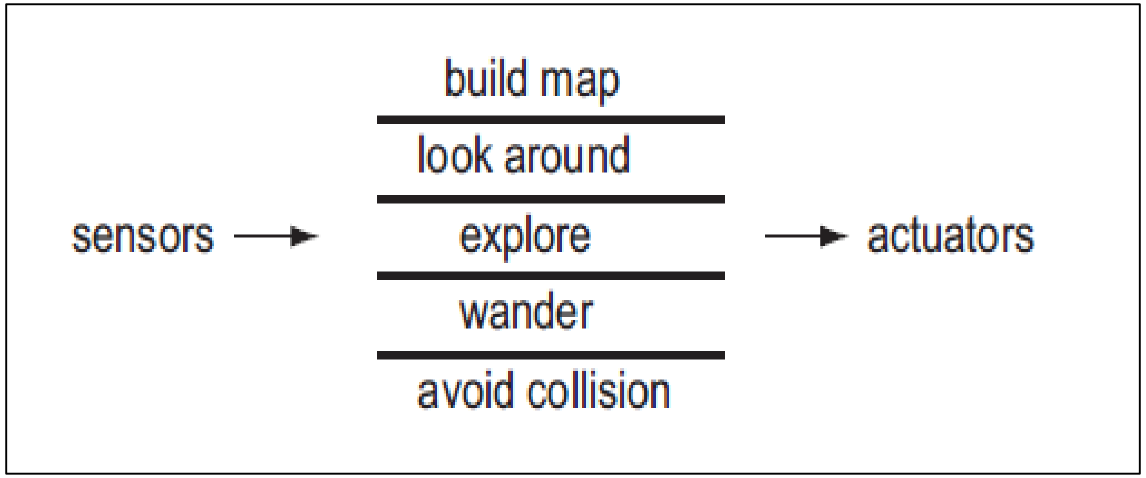
An intelligent system comprises 7 elements in a **hierarchical** architecture wherein: a) control bandwidth decreases about an order of magnitude at each higher level, b) perceptual resolution of spatial and temporal patterns contracts about an order-of magnitude at each higher level, c) goals expand in scope and planning horizons expand in space and time about an order-of magnitude at each higher level, and d) models of the world and memories of events expand in space and time by an order-of magnitude at each higher level.

At each level, tightly coupled functional modules perform task decomposition, world modeling, sensory processing, and value judgment. Feedback control loops are closed at every level

Behavior based Robots (Reactive components that produce emergent behavior)



Functional Decomposition of Robot Control (Sequence of information processing functions … focus on <u>model</u>)

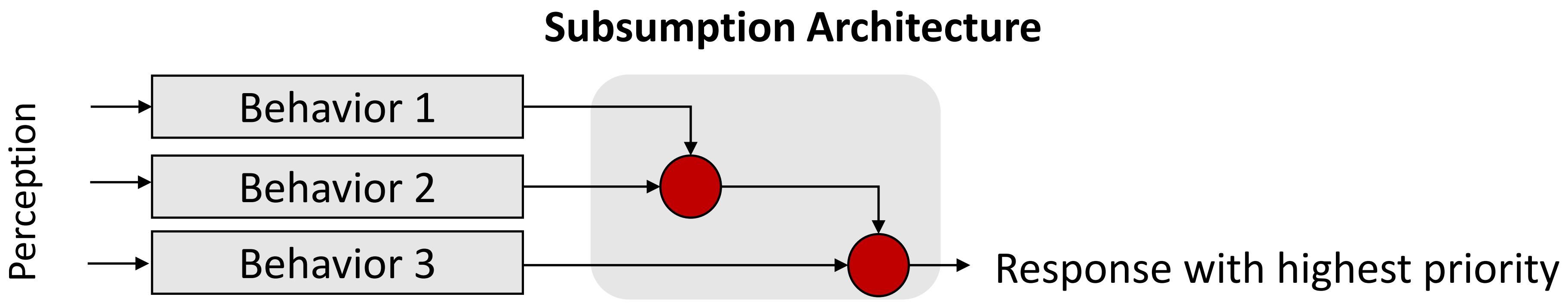


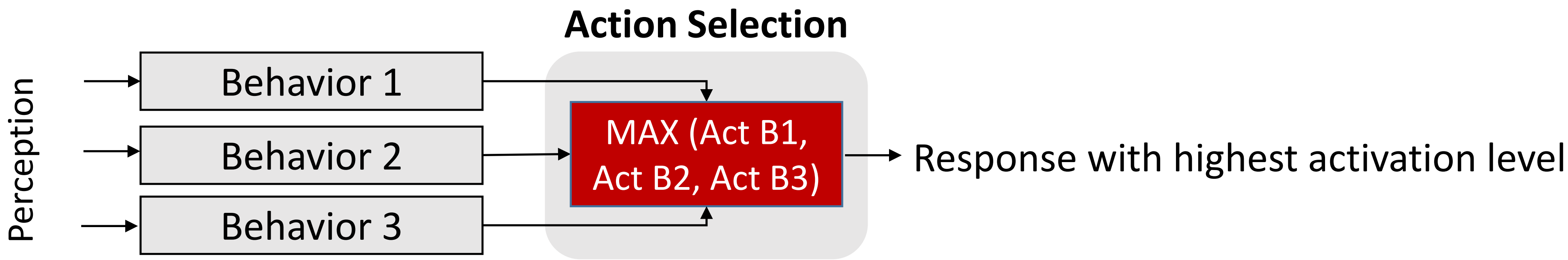
Behavioral Decomposition of Robot Control (Hierarchy of behaviors ... Response to env)

Source: Brooks (1986)

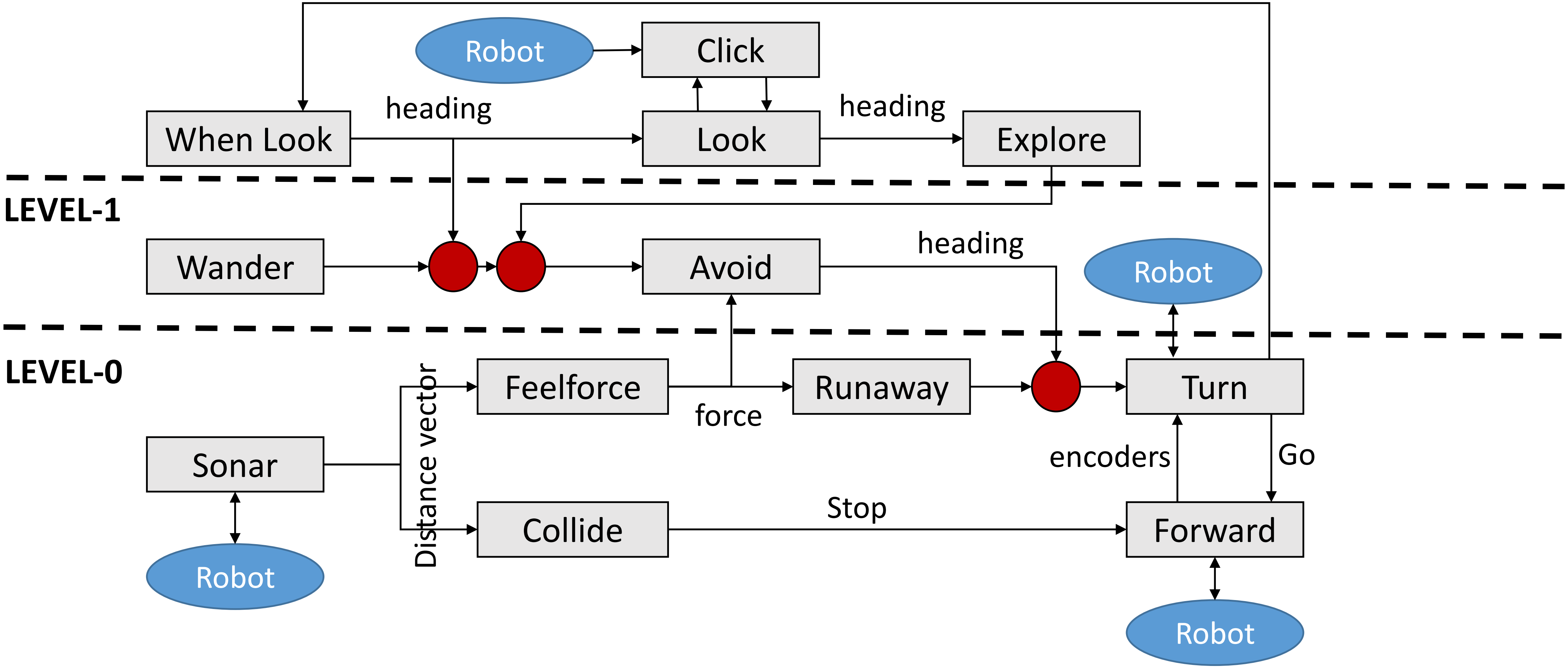
Also, Read Chapter 6 in Bio-Inspired Artificial Intelligence by Dario Floreano and Claudio Mattiussi

Behavior Based Architectures





Subsumption Architecture: Levels of Competence



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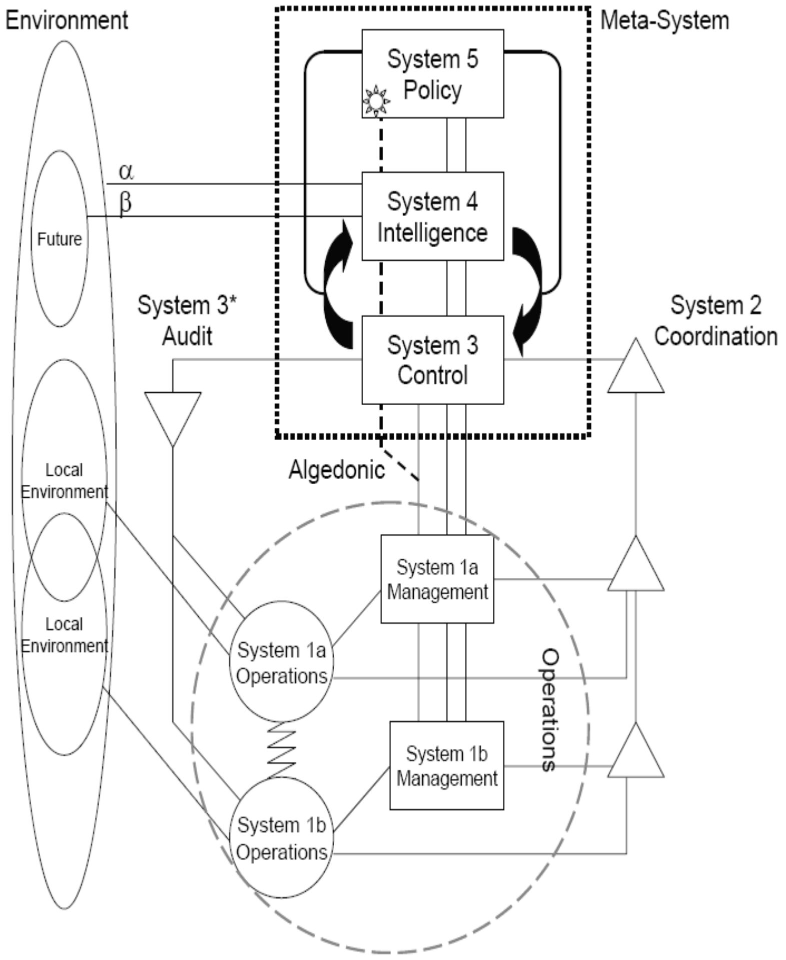
- Architecture for Intelligent Behavior – Viable Systems Model (recursive)

Architecture for Intelligent Behavior based on principles of viabilitv

- Developed by Stafford Beer (1979) – based on Ashby's Design for Brain
- Viability is the ability to maintain an independent existence
- Based on principles of requisite variety, self-regulation and recursion

Viable systems comprise five key functions at every level of recursion



Policy (System 5)
Provides closure

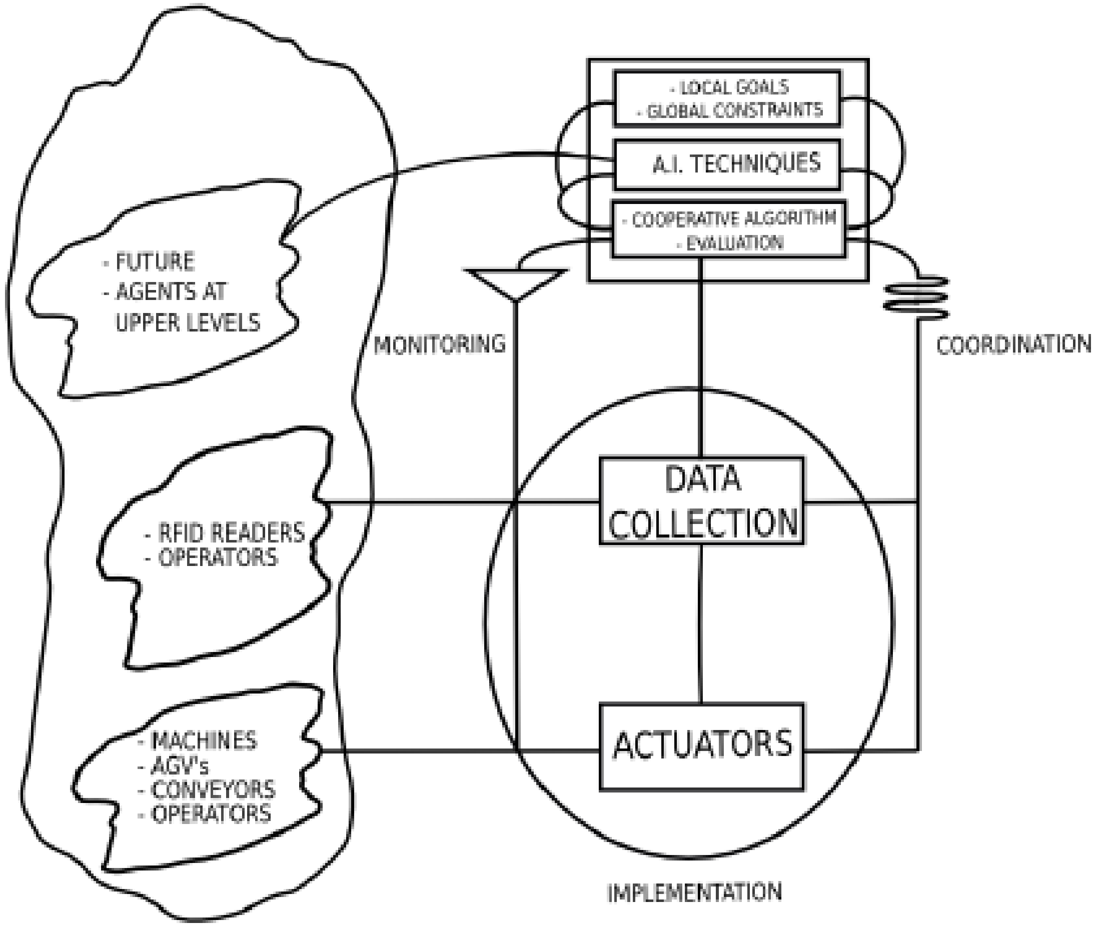
Intelligence (System 4)
Identifies external opportunities and threats

Monitoring and Control (System 3)
Monitors internal strengths and weaknesses

Co-ordination (System 2)
Reduces instability across system 1s

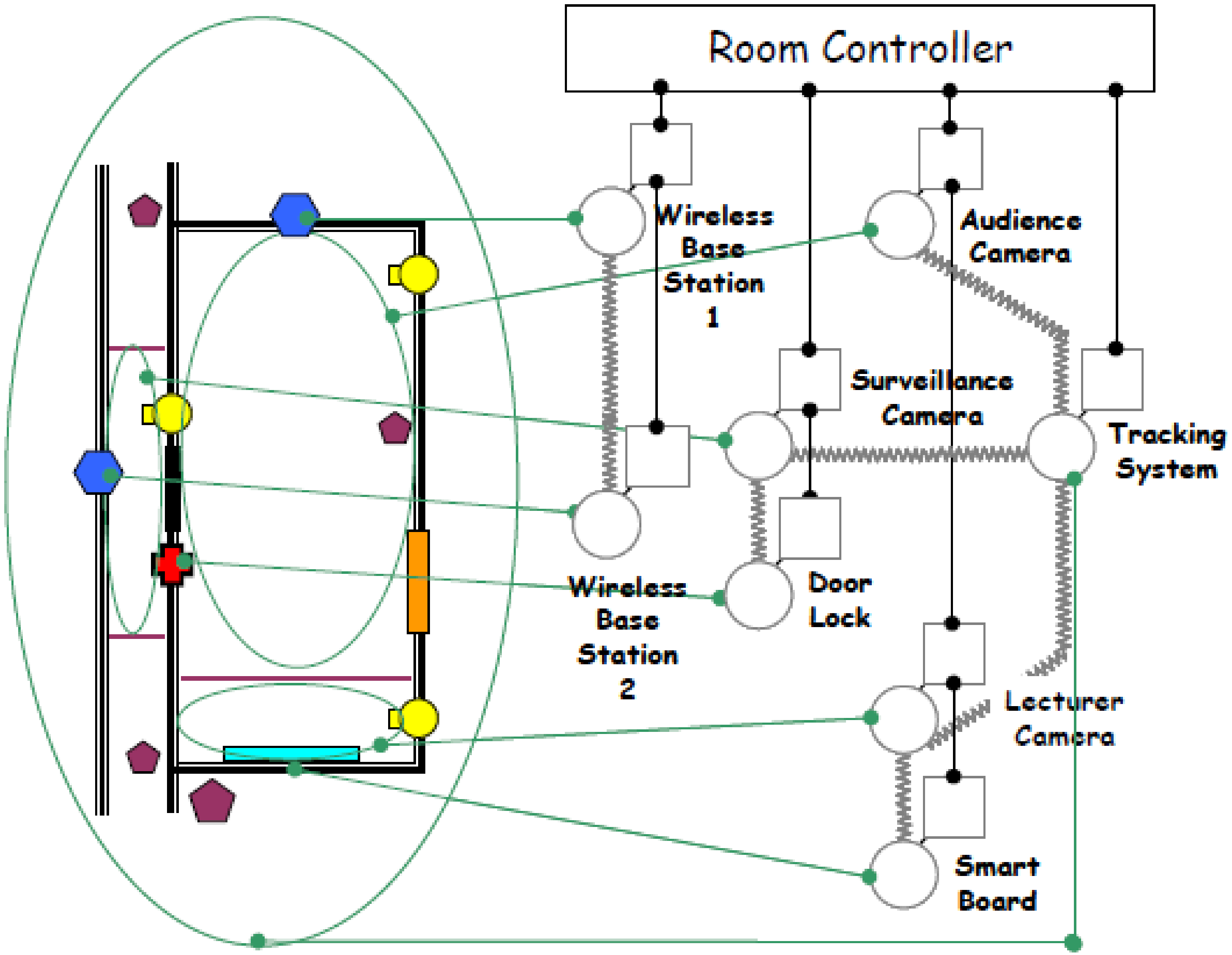
Operations (System 1)
Directly interacts with the environment
Equivalent to the core functions of the product. But, may also include those processes that have extensive interaction with the environment Indicates the actual purpose of the system

Intelligent Product as a Viable System



Function	Description
Primary Activities	Input / Output data (data collection) Environment interaction activities (actuators)
Coordination	Communication between data collection and interaction activities
Control	Internal activity regulation by coordinating and monitoring Auto-organization and evaluation Cooperative algorithm (interaction with other products)
Monitoring	Sporadic audit of the primary activities
Intelligence	External knowledge, future anticipation, response actions
Policy	Local goals and global constraints

VSM of a Smart Room



Exercise 6

- Analyze the functional model of your product concept using VSM and identify potential gaps w.r.t intelligent behavior

- Enrich the functional model of your product concept using VSM. How can you use the concept of recursion?

Next session we will look at the principles of self-organization

Collective Systems Metaphors