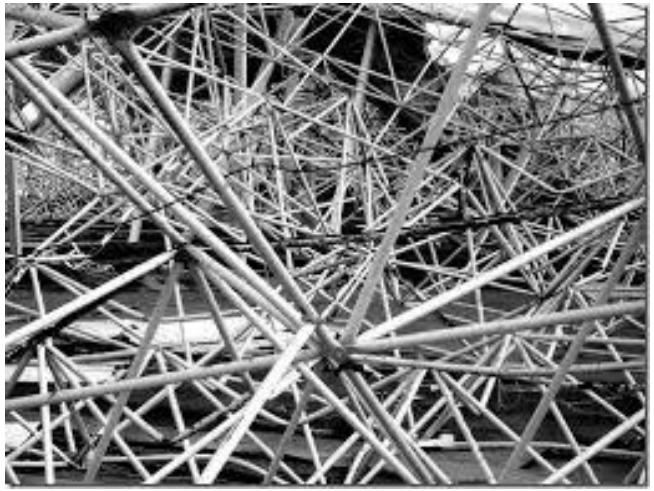
Self-adaptive Systems

Software Evolution Perspective of Autonomic Systems

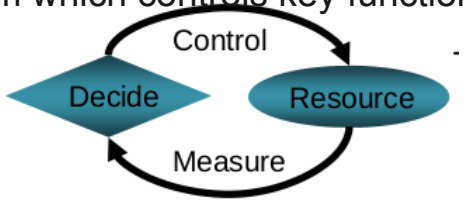
IBM’s Complexity Solution

Automation through self-adaptive, self-managing systems or autonomic computing

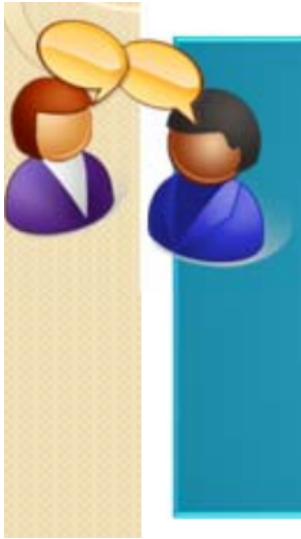


What is Autonomic Computing

- Webster’s defintion:
  - Acting or occurring involuntarily; automatic; an automatic reflex
  - Relating to, affecting, or controlled by the autonomic nervous system or its effects or activity
  - Autonomic nervous syst: that part of the nervous system that governs involuntary body functions like erspiration or heart rate
- IBM’s definition
  - An approach to self-managed computing systems with a minimum of human interference
  - The term derives from the body’s autonomic nervous system which controls key functions without conscious awarenesss or involvement



Autonomic Systems

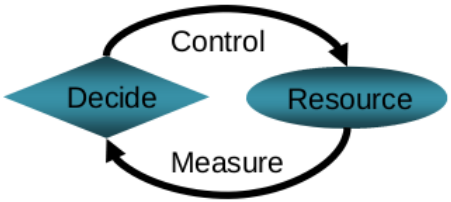


What is the most famous autonomic system?

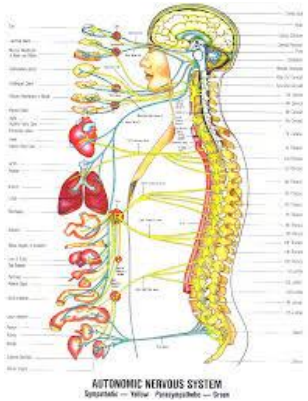
You all know it intimately ☺

Famous Autonomic System

- Autonomic nervous System
- Parasympathetic
  - Day-to-day internal processes
- Sympathetic
  - Stressful situation processes



Temperature, heartrate, breathing rate, bloodpressure, pupil dilation, tears, digestion, immune response



Monitor and Regulate!

Characteristics of autonomic or self-managing systems

- Self awareness, reflexivity, identy
  - Possesses a system identity
  - Must know itself
  - Needs detailed knowledge of its components, status, interconnections
- Able to configure and reconfigure itslef under varying conditions
  - adaptive algorithms, machine learning, optimizations, monitoring and execution

Characteristics of autonomic or self-managing systems

- Self-*
- Autonomic software system needs to be autonomic by suporting behaviour types
  - Self-configuring: means choosing a suitable behaviour based on user preferences, context
  - Self-tuning means choosing behaviours that optimize certain qualities (performance, profits…)

Characteristics of autonomic or self-managing systems

- Self-*
  - Self-configuring: means choosing a suitable behaviour based on user preferences, context
  - Self-tuning means choosing behaviours that optimize certain qualities (performance, profits…)
  - Self-repairing means shifting execution to another behaviour, given current one is failing
  - Self-protecting means choosing a behaviour that minimizes risk (attacks, virus)

What autonomic systems deliver

Increased Responsiveness

Adapt to dynamically changing environments

Business Resiliency

Discover, diagnose, and act to prevent disruptions

Operational Efficiency

Tune resources and balance workloads to maximize use of IT resources

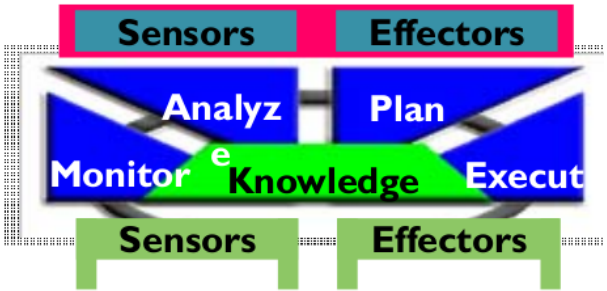
Secure Information and Resources

Anticipate, detect, identify, and protect against attacks

*Self – **

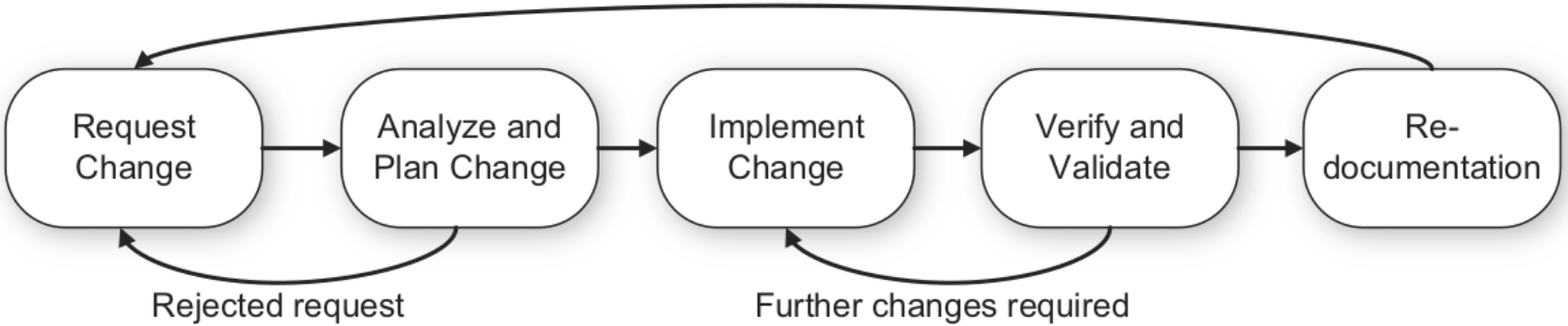
IBM's approach

- Create and deploy self-managing infrastructure technologies to
  - reduce complexity
  - lower cost of ownership
  - increase reliability
- Establish an architectural framework for autonomic computing
- Provide technologies to reduce the cost of managing systems
  - Automating automation



Automation^2

Adaptation

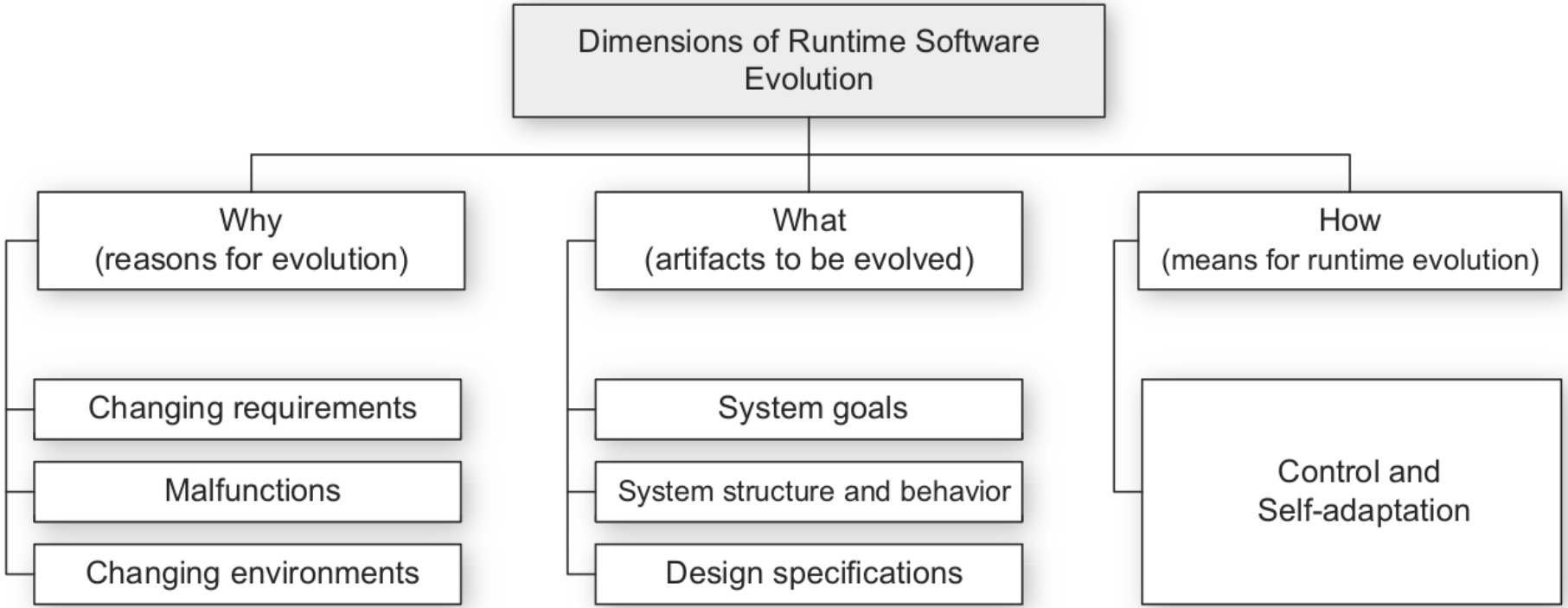


- Usually the model for offline adaptation

		Column 1	Column 2
	High off-line evolution cost	High uncertainty	Low uncertainty
Row 1	High frequency	**runE**	**runE**
Row 2	Low frequency	**runE** **offE**	**runE**

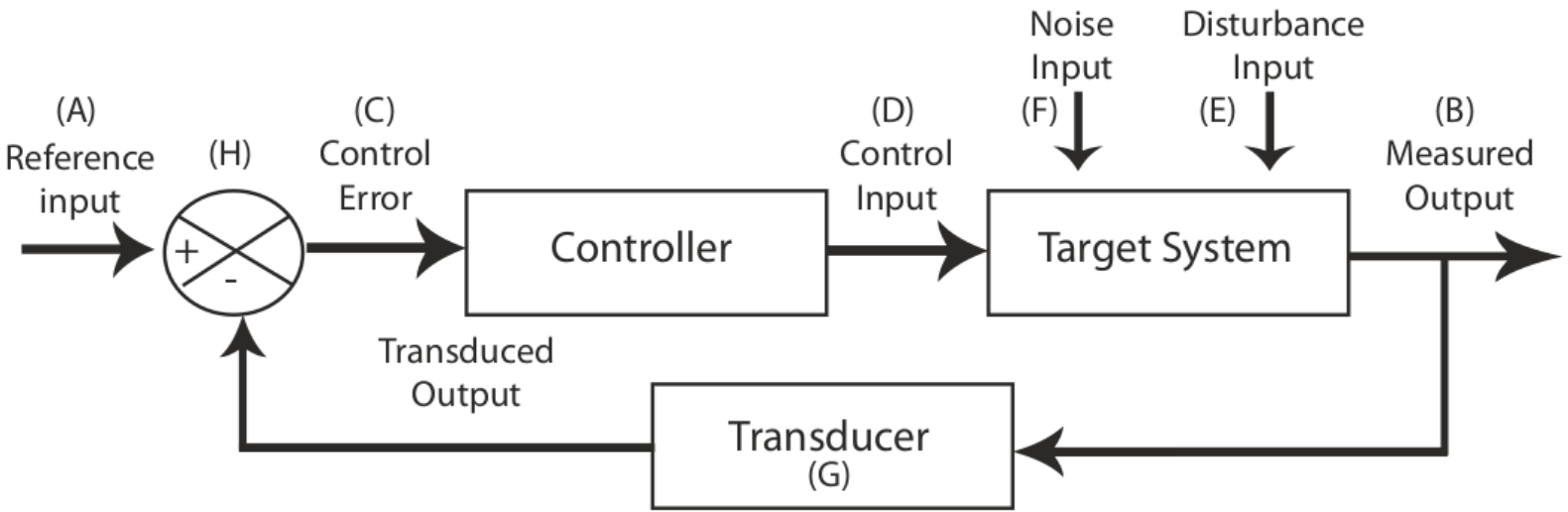
(a)

		Column 1	Column 2
	Low off-line evolution cost	High uncertainty	Low uncertainty
Row 1	High frequency	**offE** **runE**	**runE**
Row 2	Low frequency	**offE**	**offE**


Dimensions of Runtime Software Evolution
Why (reasons for evolution)
What (artifacts to be evolved)
How (means for runtime evolution)
Changing requirements
Malfunctions
Changing environments
System goals
System structure and behavior
Design specifications
Control and Self-adaptation

Adaptation

- Feedback and Feedforward

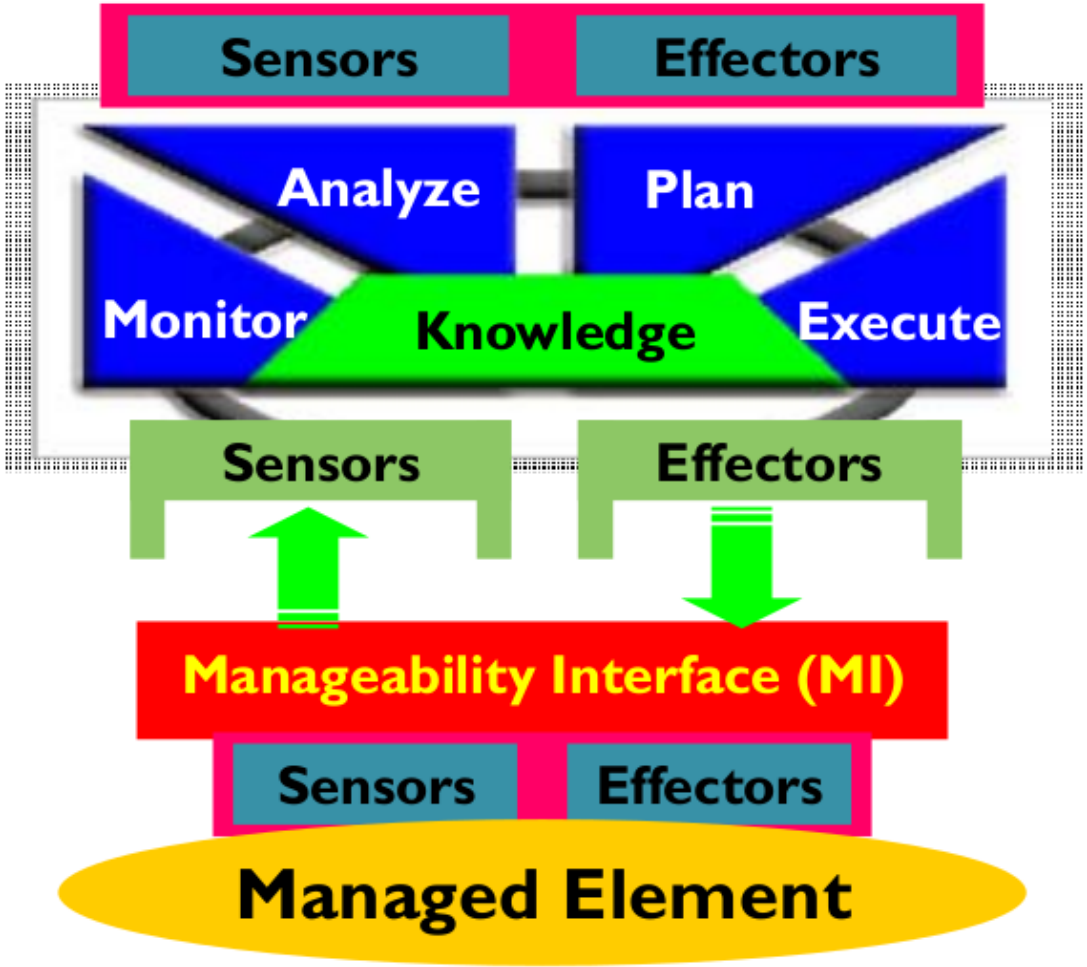


Autonomic System (AS)

Autonomic Element (AE)
Autonomic Manager (AM)
Managed Element (ME)

Manageability Endpoint (ME)
Manageability Interface (MI)

Knowledge sources
Enterprise service bus

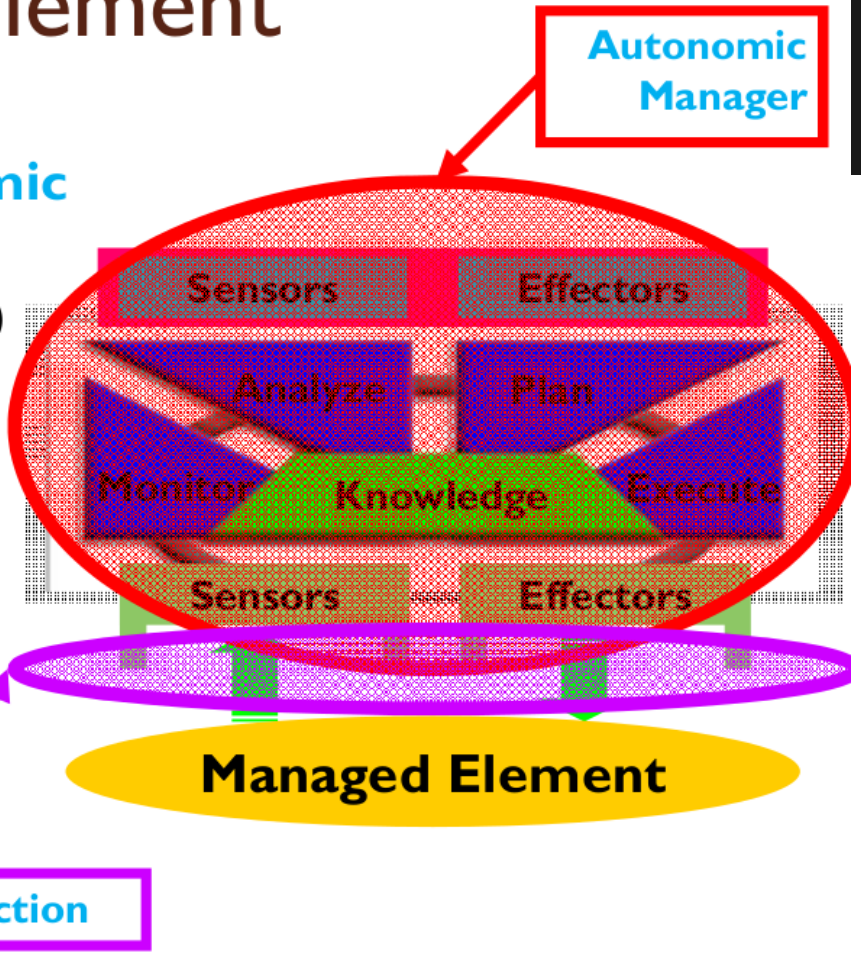


Autonomic Element

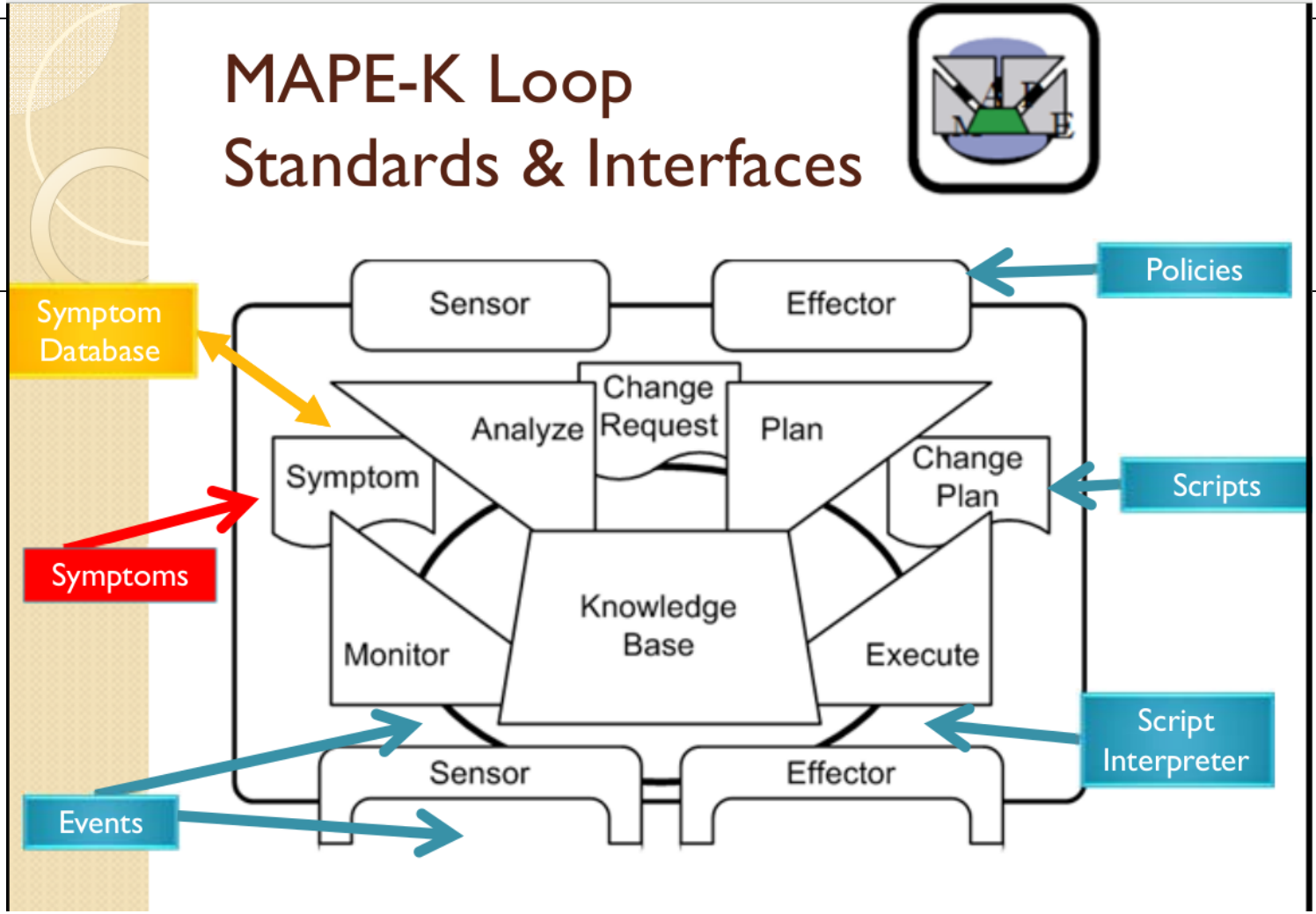
Consists of an **Autonomic Manager (AM)** and an Autonomic Element (AE)

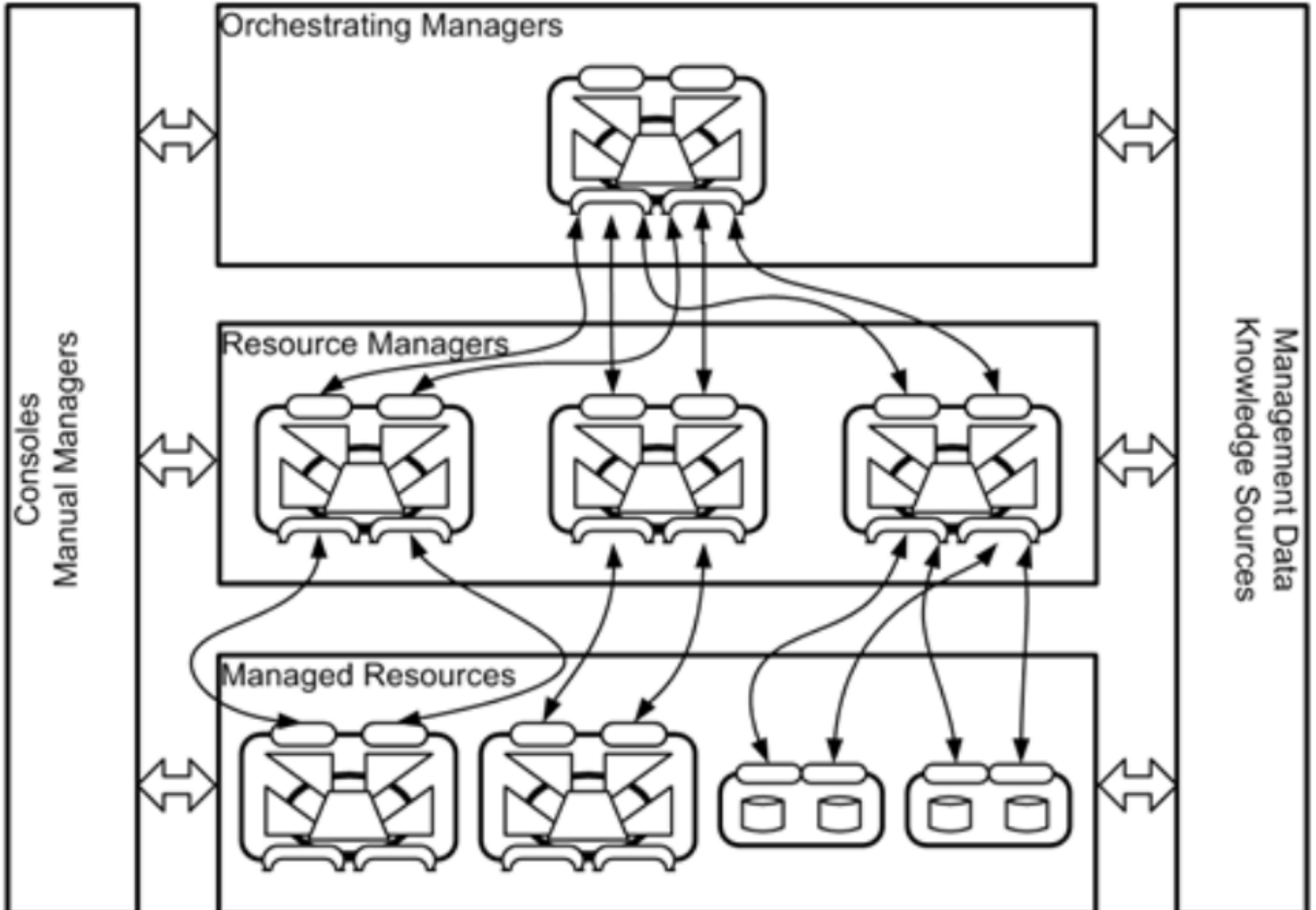
Manager and managed element form a **level of indirection**

- Spatially and temporally separate entities
- Enterprise Service Bus



MAPE-K Loop
Standards & Interfaces




Orchestrating Managers
Resource Managers
Managed Resources
Consoles
Manual Managers
Management Data
Knowledge Sources

Models

- Perspective of control theory, adaptive control concerns the automatic adjustment of control mechanisms.
- Adaptive control researchers investigate parameter adjustment algorithms that allow the adaptation of the control mechanisms while guaranteeing global stability and convergence
- Control theory offers several reference models for realizing adaptive control.
- Model Reference Adaptive Control (MRAC)
- Model Identification Adaptive Control (MIAC)

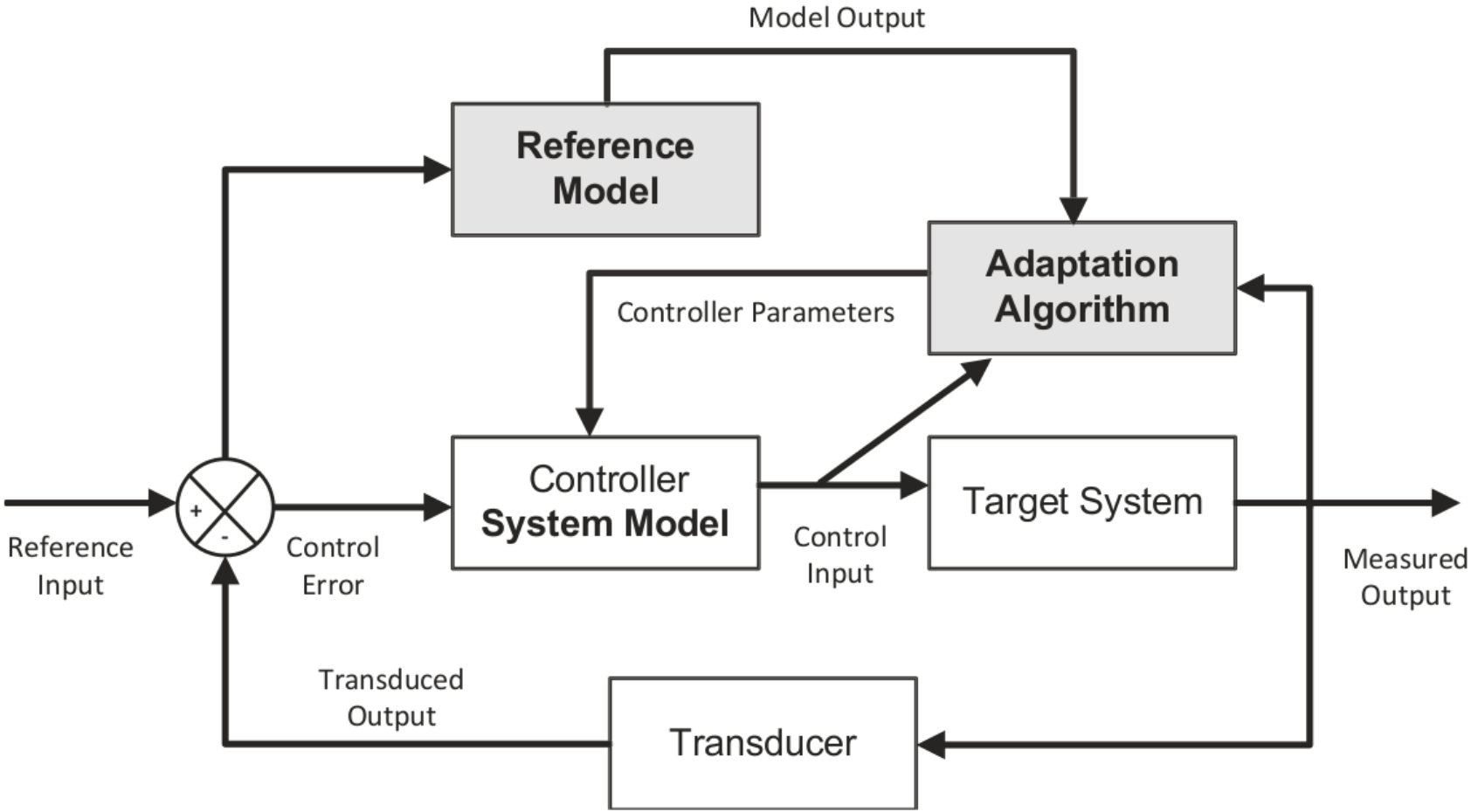


Fig. 8.5: Model Reference Adaptive Control (MRAC)

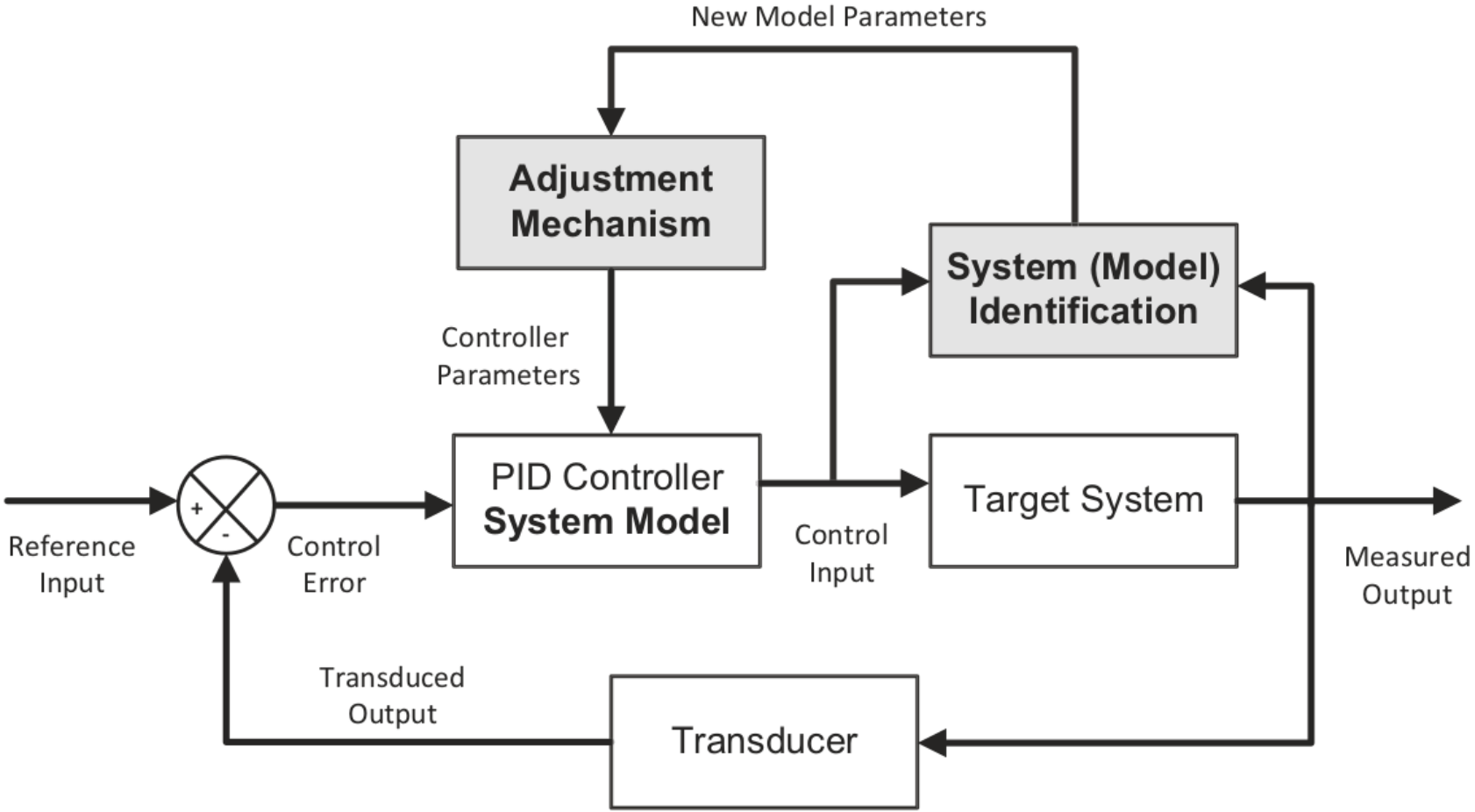


Fig. 8.6: Model Identification Adaptive Control (MIAC)

Conclusions

- Models (control theory lends a helping hand)
- Self-* properties
- Offline vs. Runtime evolution