Multi-tier Architecture for Adaptive Systems

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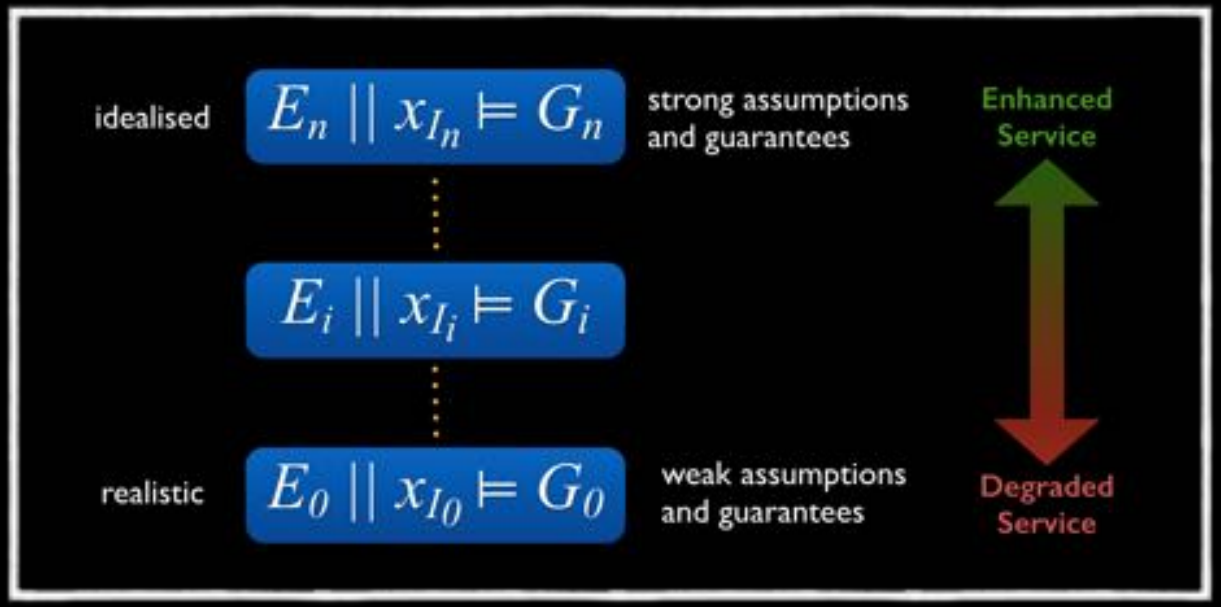
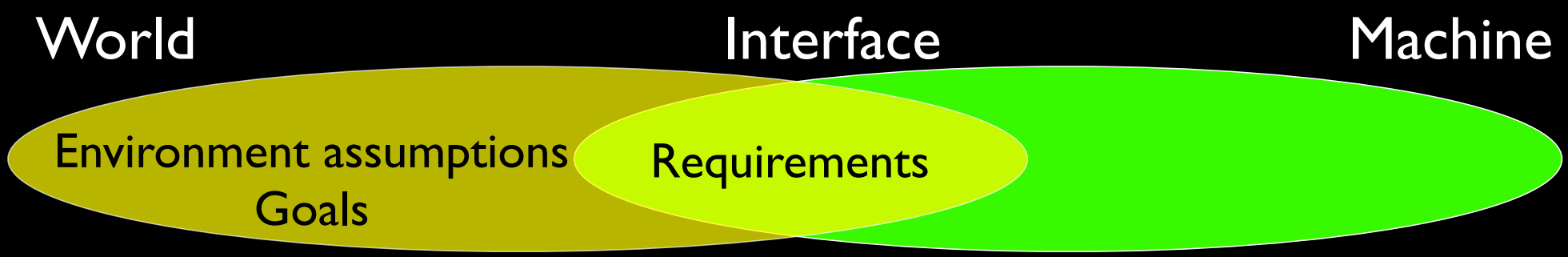
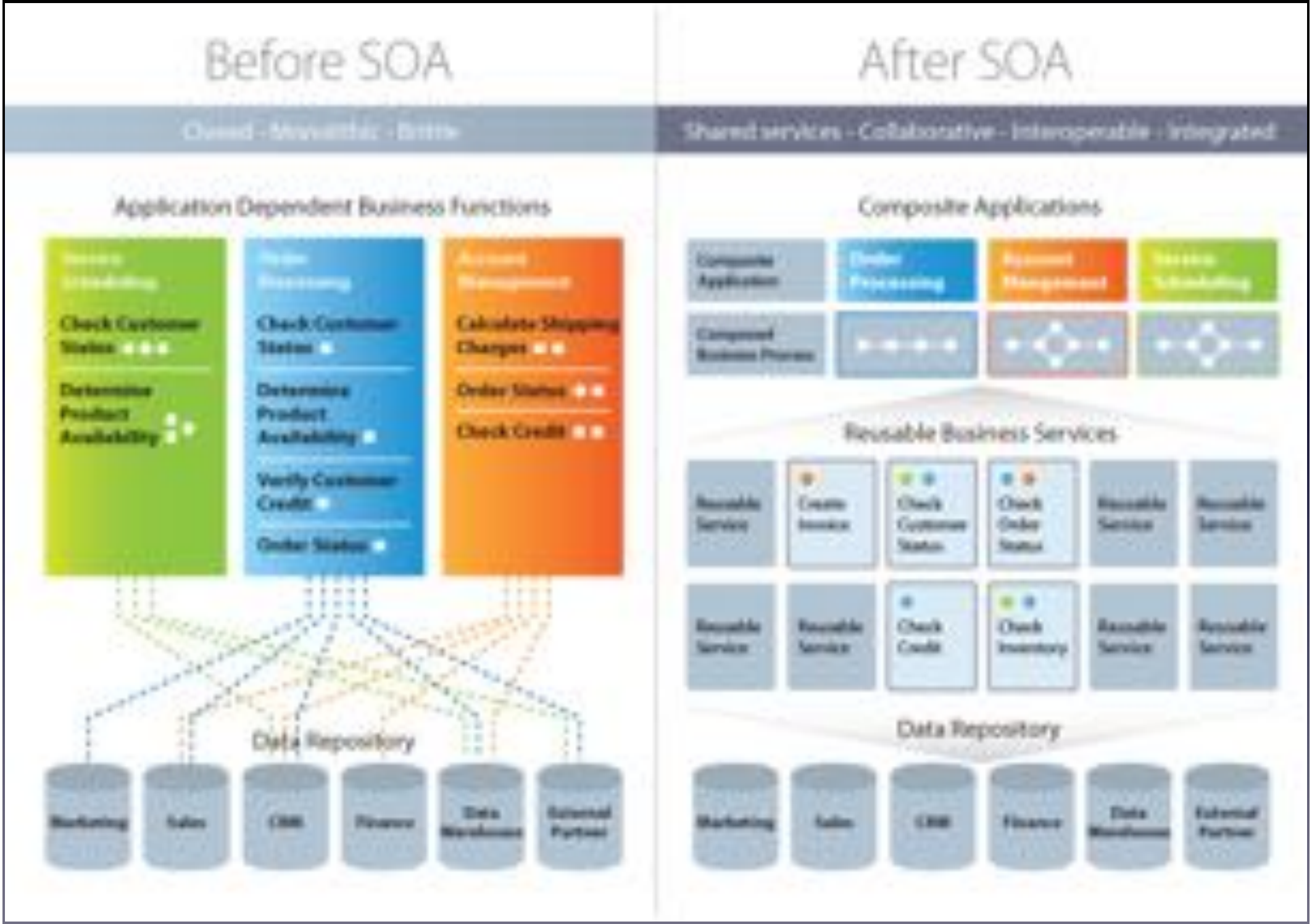
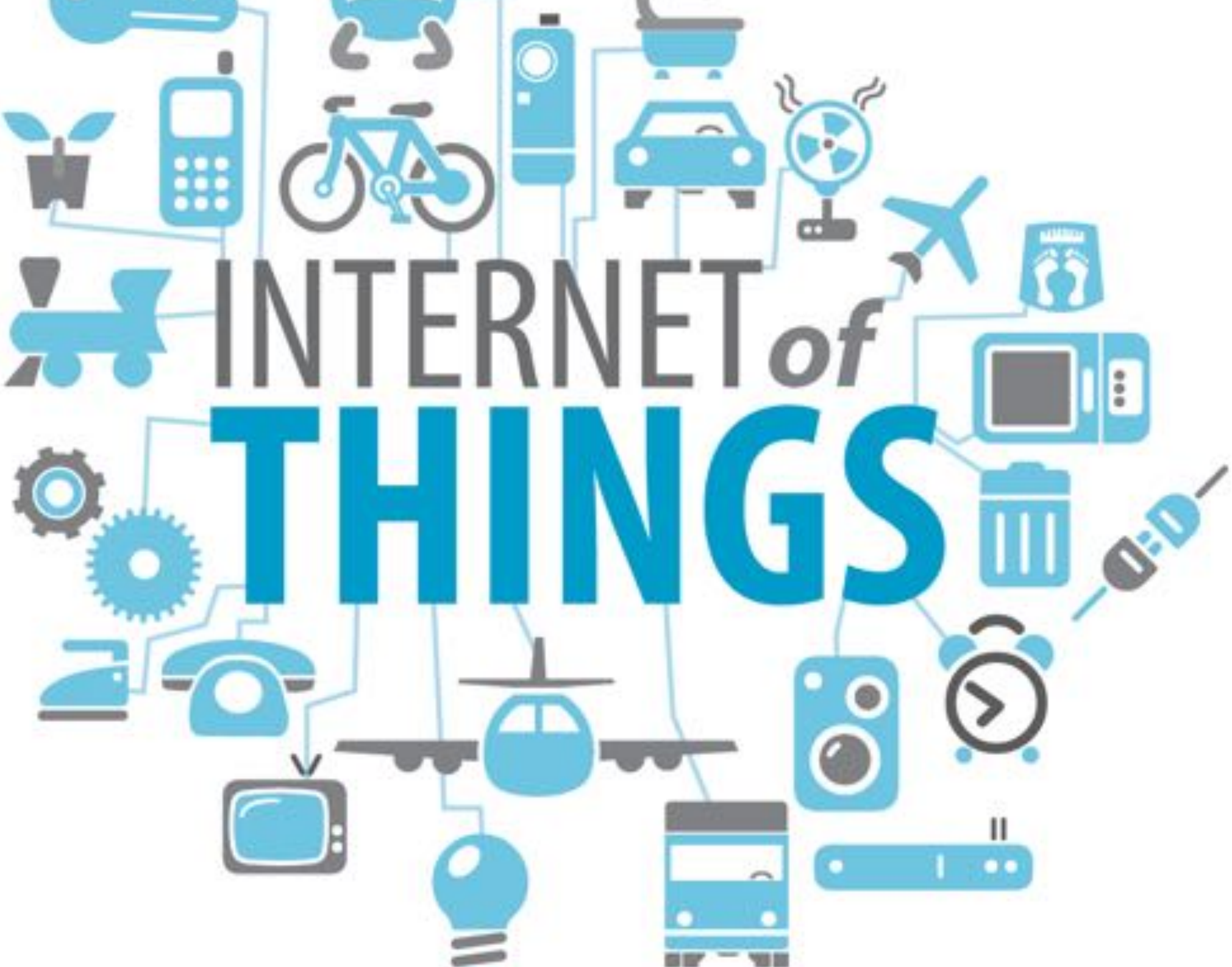


Requirements Engineering à la Michael Jackson



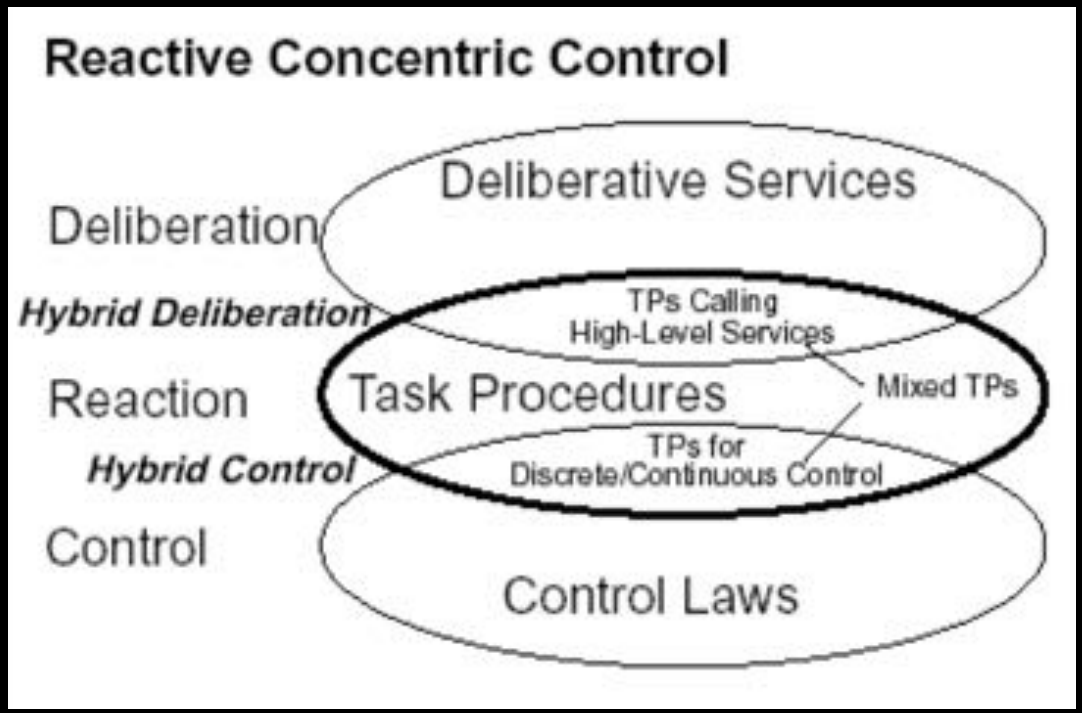
$$E, R_i \models G$$


Before SOA
After SOA
Application Dependent Business Functions
Check Customer Status
Determine Product Availability
Check Customer Status
Determine Product Availability
Verify Customer Credit
Order Status
Calculate Shipping Charges
Order Status
Check Credit
Data Repository
Marketing
Sales
CRM
Finance
Data Warehouse
External Partner
Composite Applications
Composite Application
Order Processing
Account Management
Service Scheduling
Composite Business Process
Reusable Business Services
Reusable Service
Create Invoice
Check Customer Status
Check Order Status
Reusable Service
Reusable Service
Reusable Service
Reusable Service
Check Credit
Check Inventory
Reusable Service
Reusable Service
Data Repository
Marketing
Sales
CRM
Finance
Data Warehouse
External Partner


INTERNET of
THINGS

Adaptive System Architecture

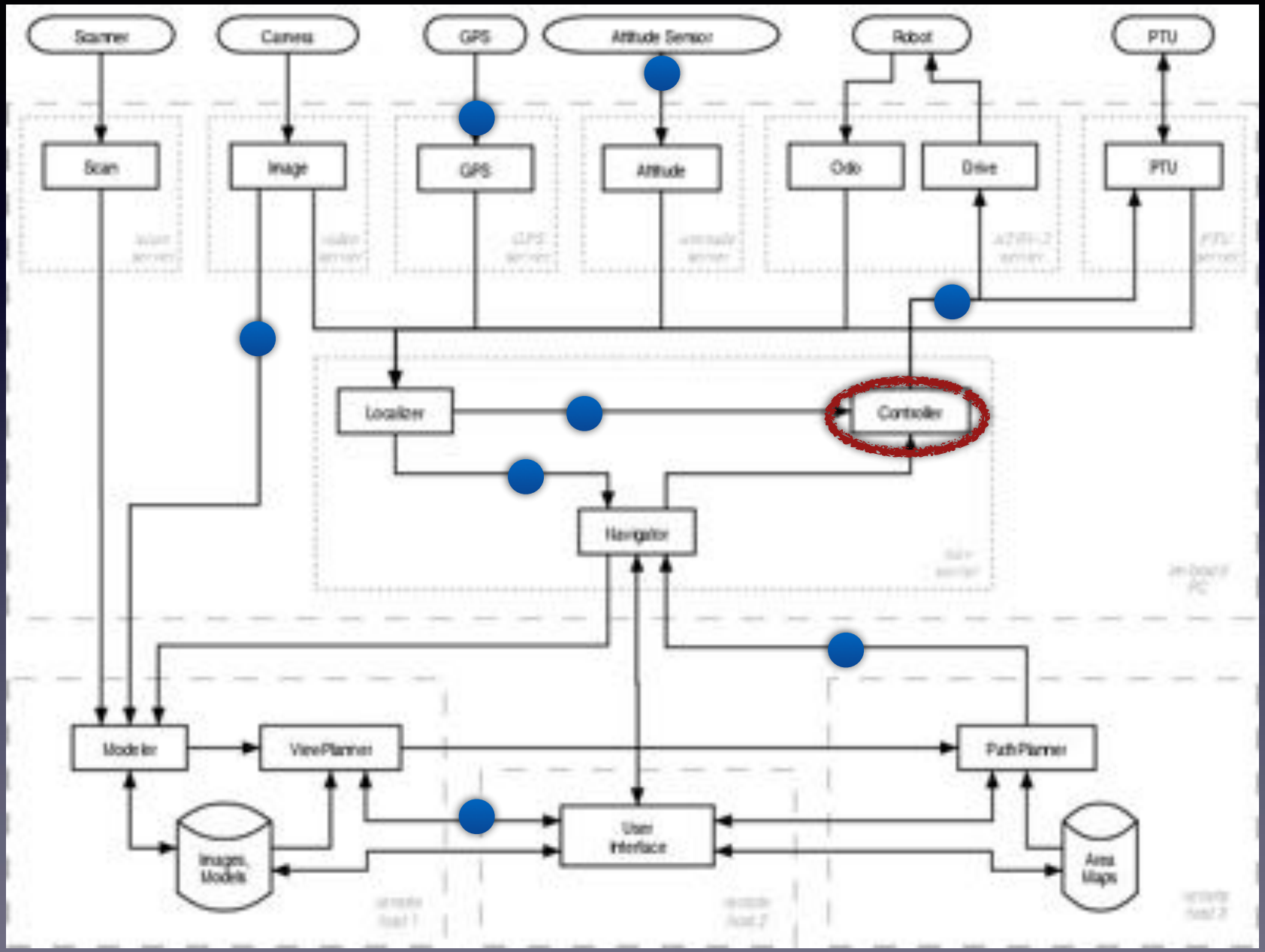
- Multi-layered
- Event-driven
- Top-down decreasing latency
- Bottom-up increasing statefullness and strategic planning



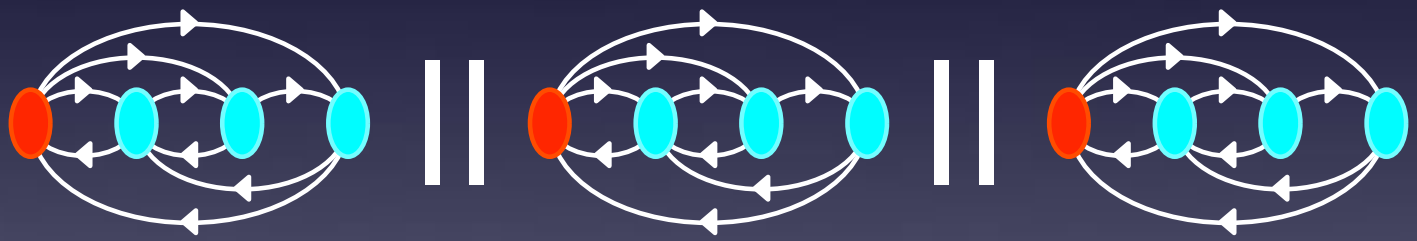
P. Doherty et al., 7th International Symposium on Distributed Robotic Autonomous Systems (DARS), 2004

Software Architecture for an Autonomous Vehicle

(AVENUE project - CMU)



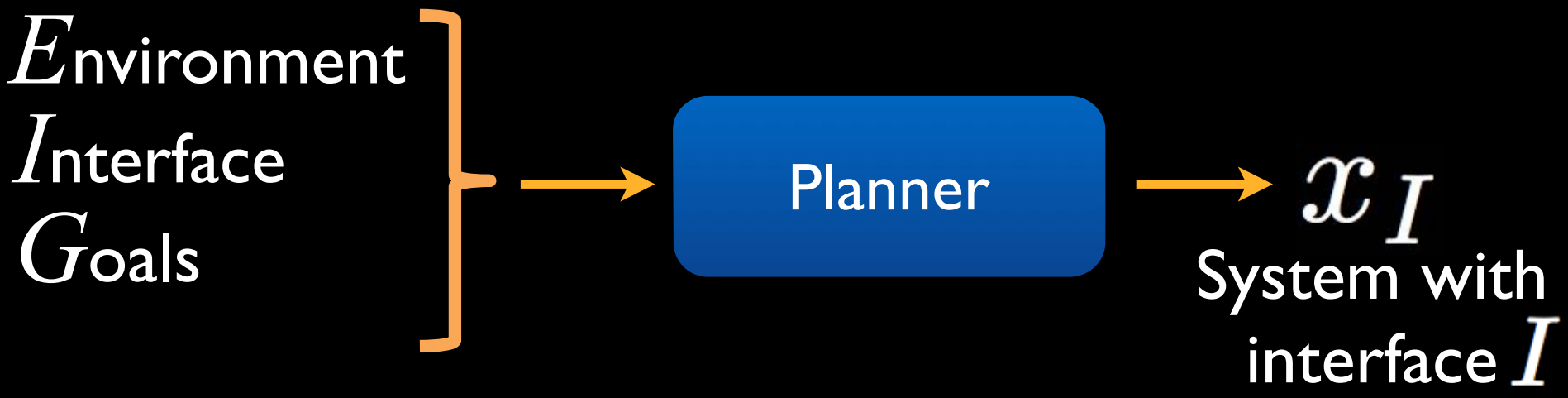
Architectural Behaviour Modelling



Controller Synthesis

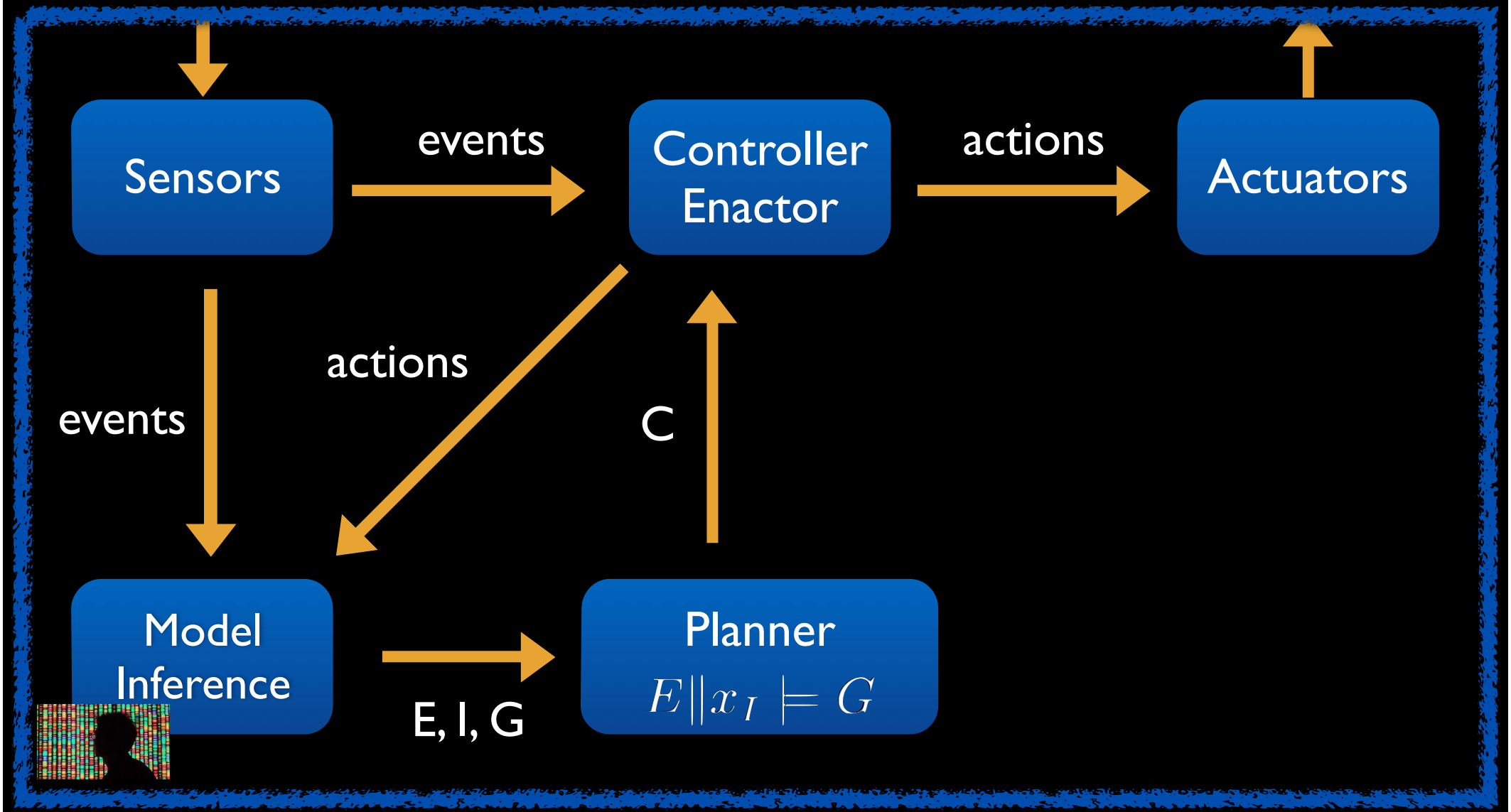
(~ Planning, Supervisory Control)

$$E \,||\, x_i \models G$$

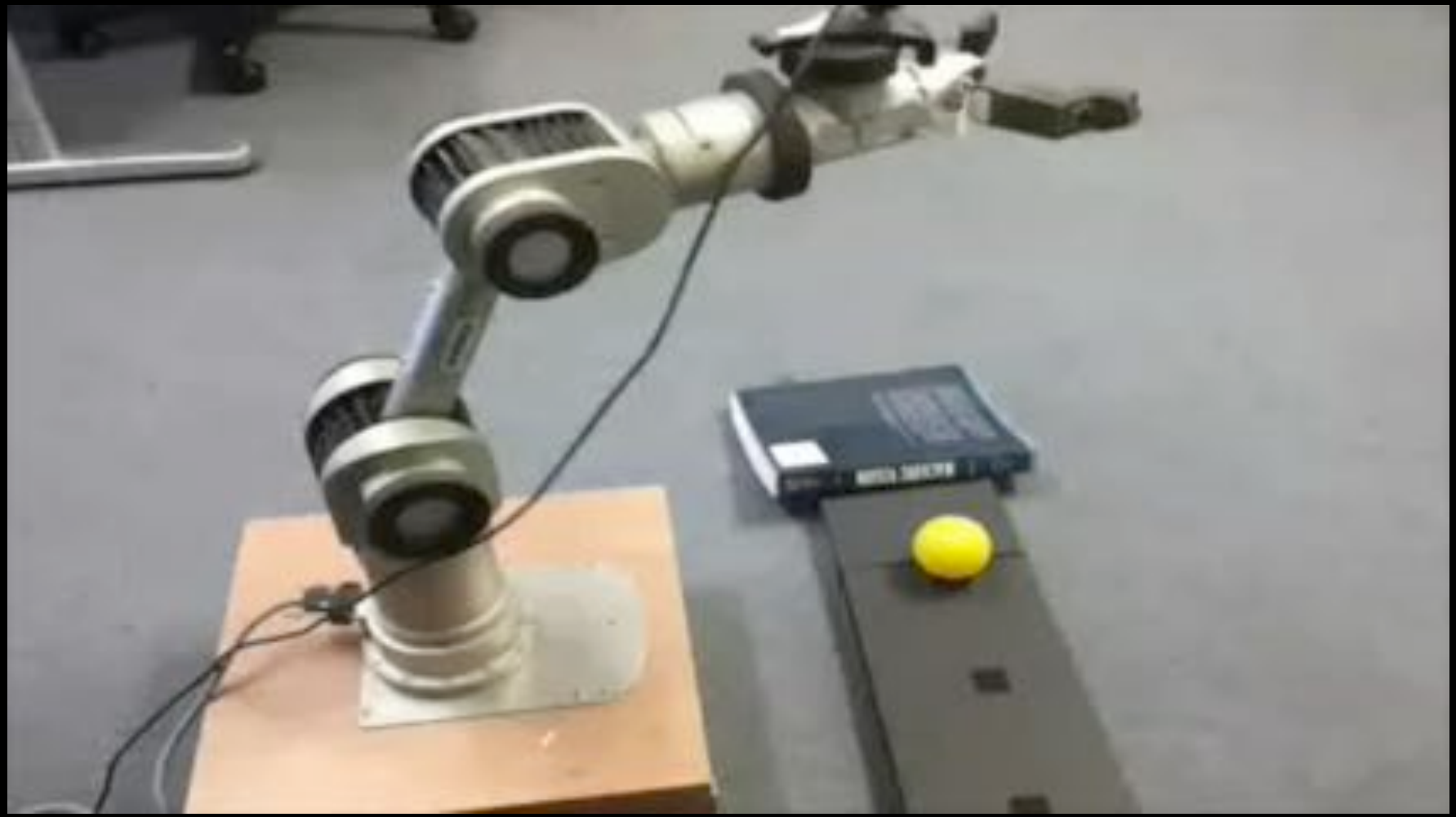


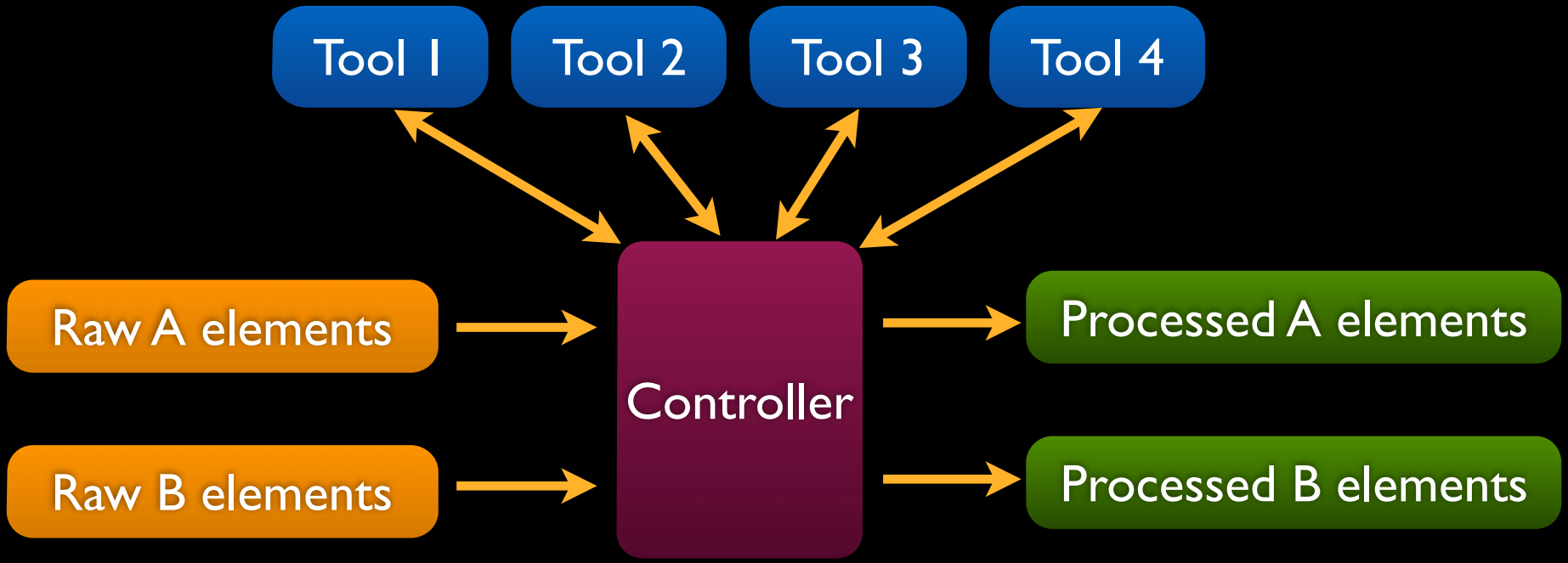
Build a strategy for the controller that always beats its adversary

Synthesis at Runtime




ATOP



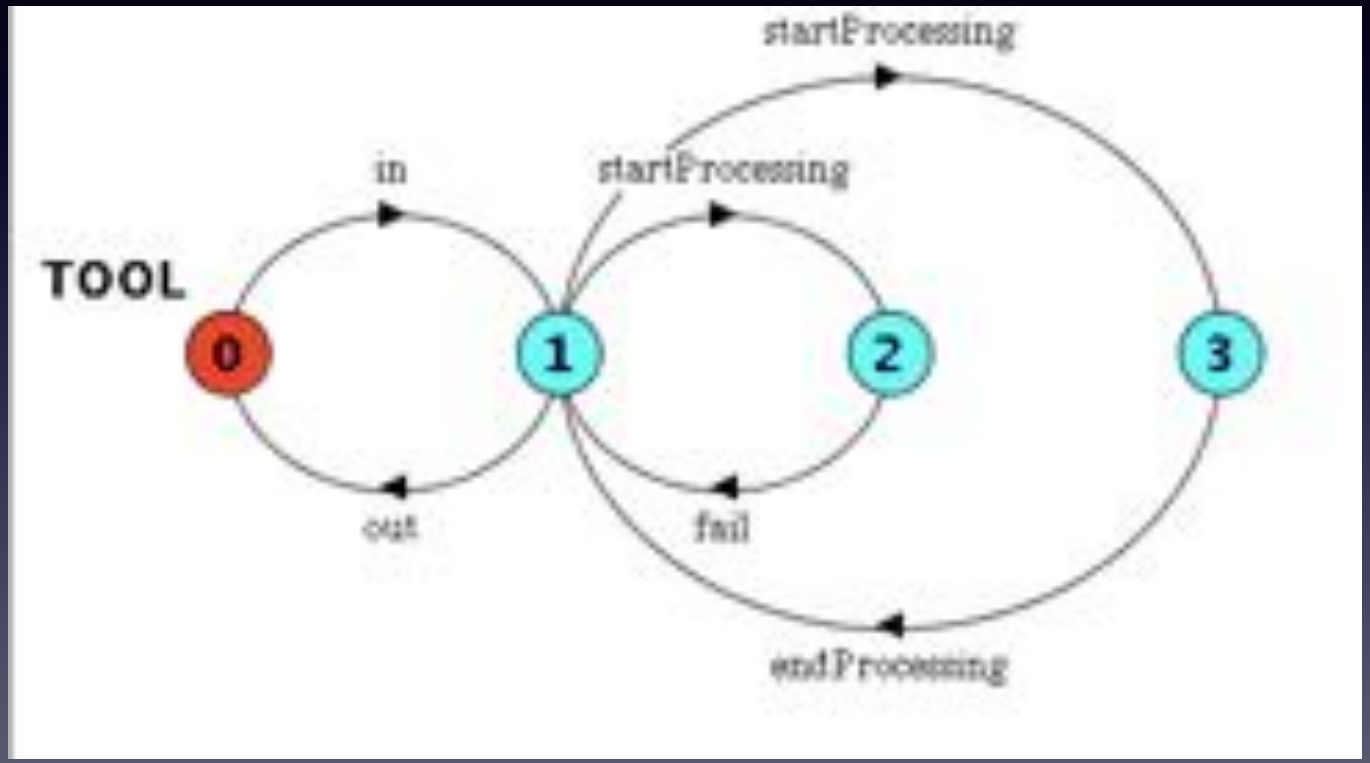


$$\Box\Diamond InRawA \wedge \Box\Diamond InRawB$$

$$\Rightarrow$$

$$\Box\Diamond OutProcessedA \wedge \Box\Diamond OutProcessedB$$

Environment



Risk Management

$$E \,||\, x_i \models G$$

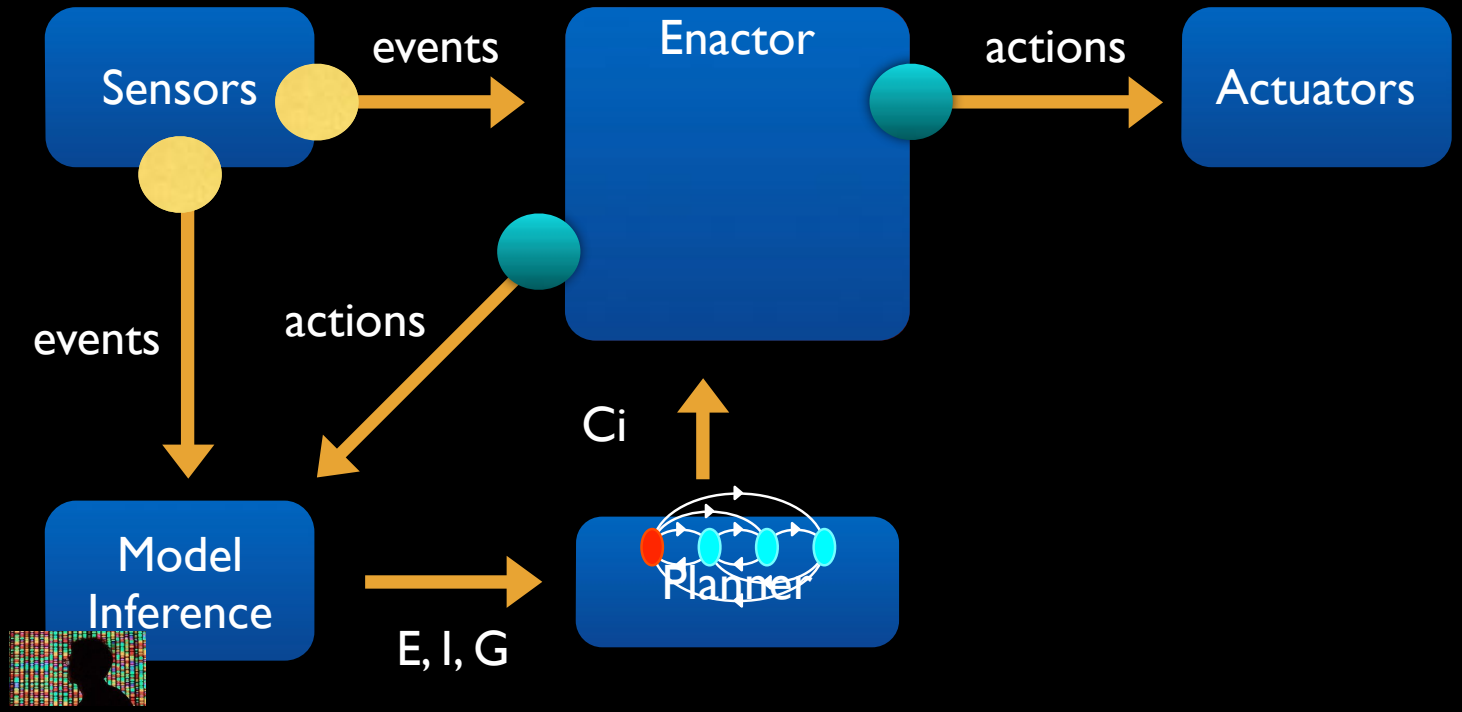
What if our environment model is wrong?

Risk Management

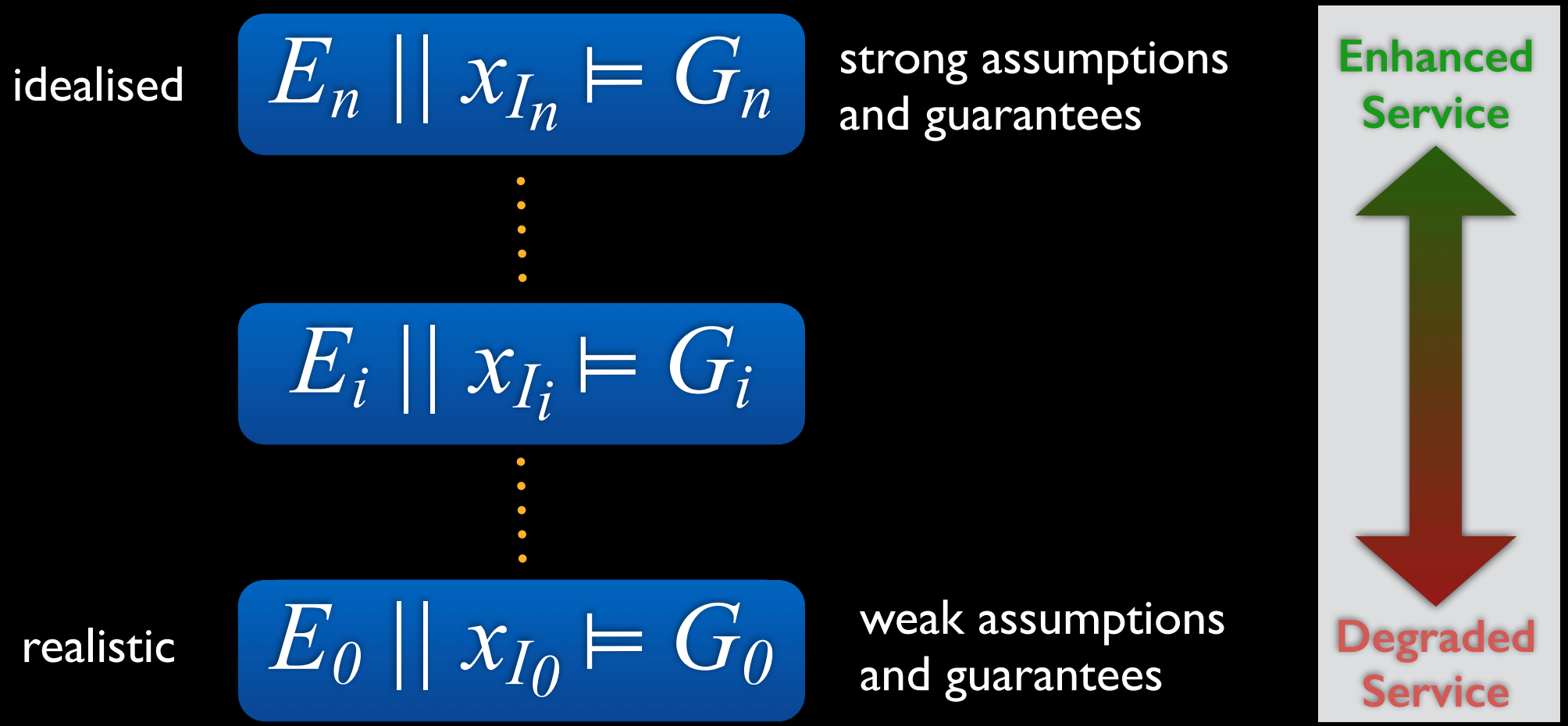
$$E \,||\, x_i \models G$$

Risk	(Idealised) Models
Achievable Goals	Robustness

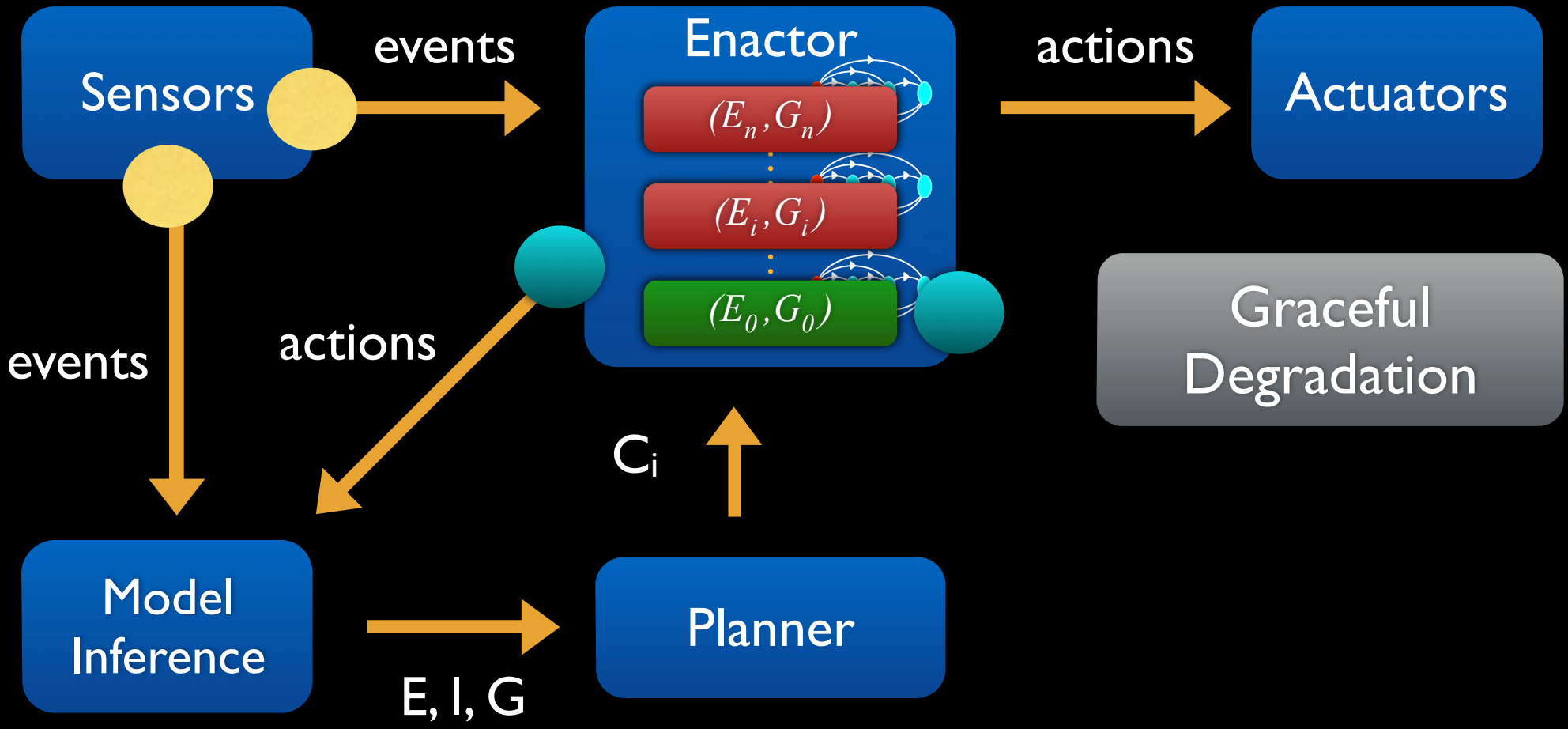
How should this tradeoff be resolved?


Sensors
events
Enactor
actions
Actuators
events
actions
Ci
Model
Inference
E, I, G
Planner

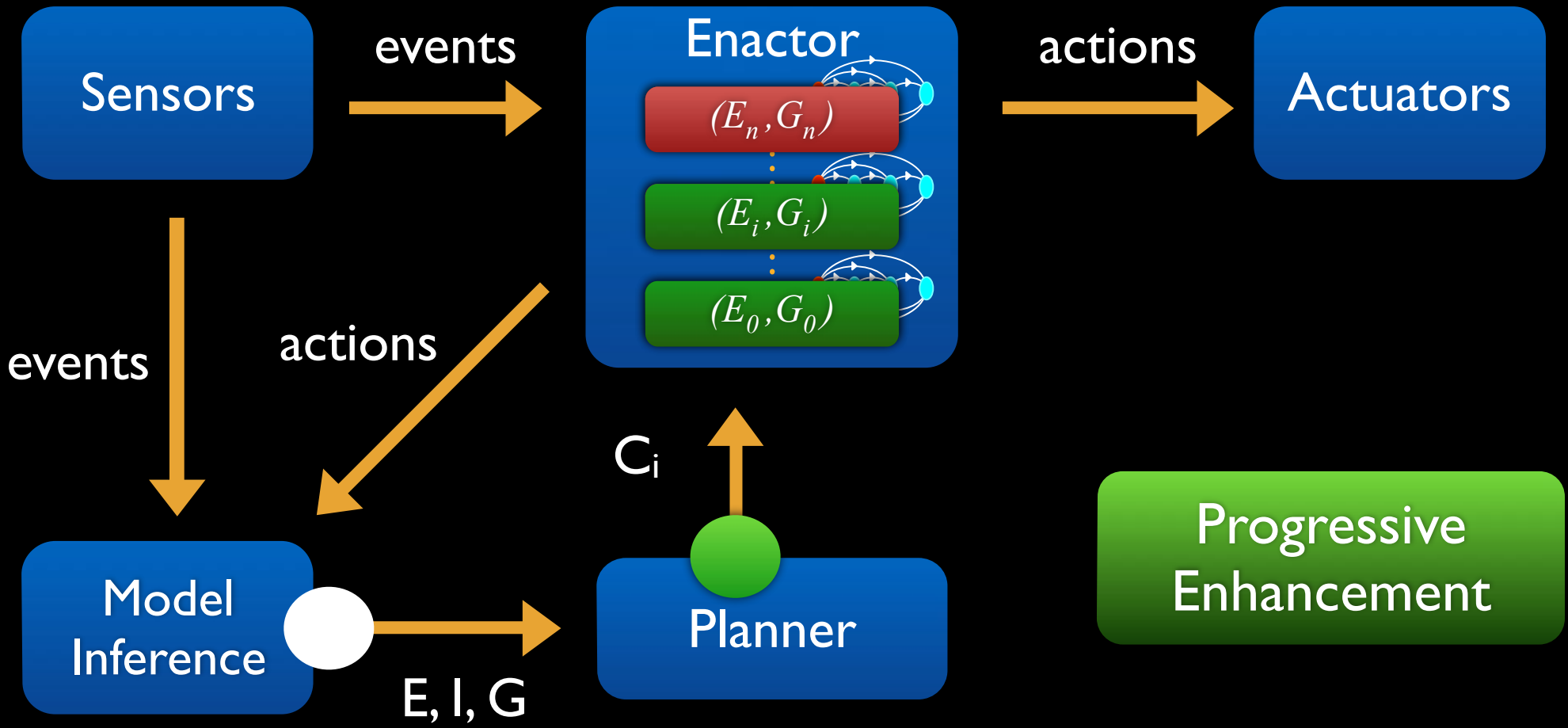
Multi-tier Architecture



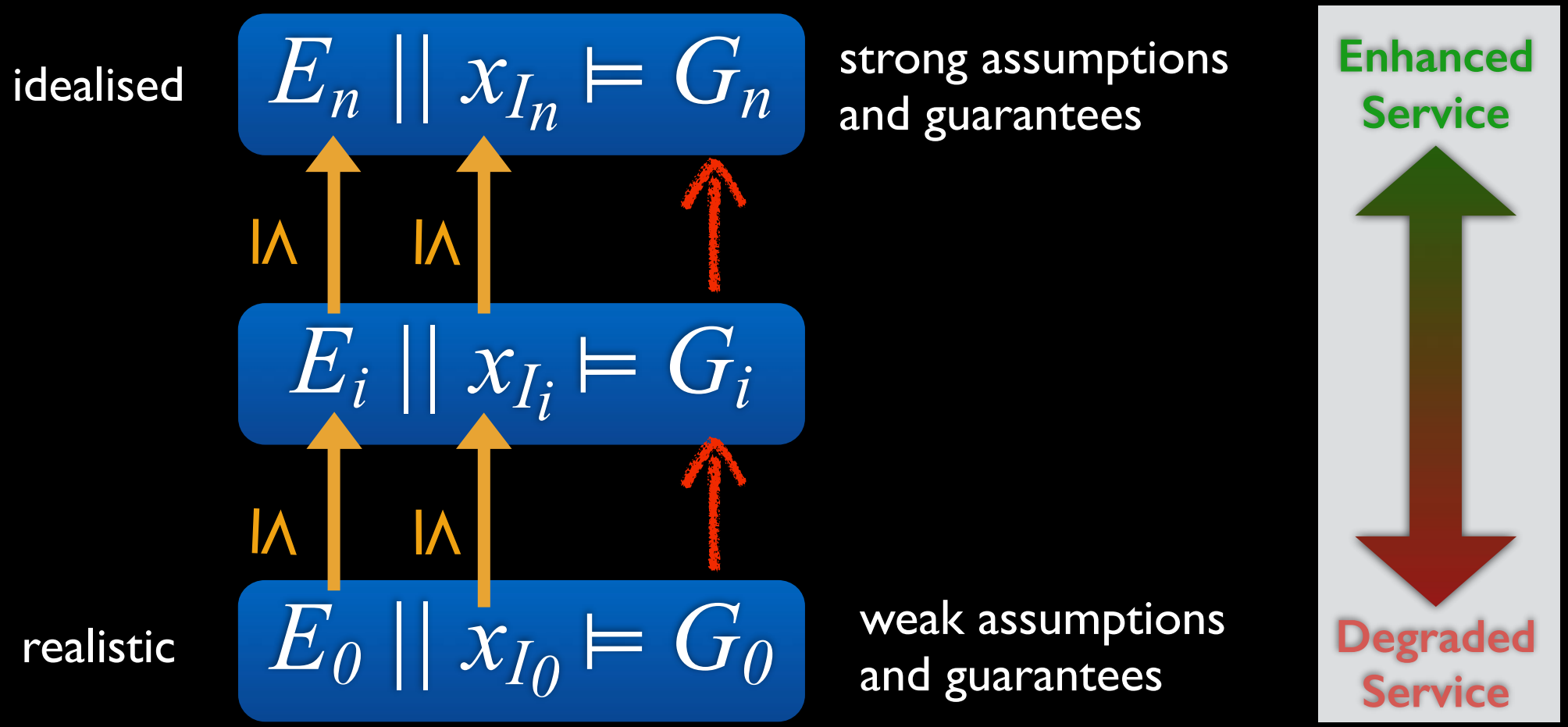
Multi-tier Controller at Runtime



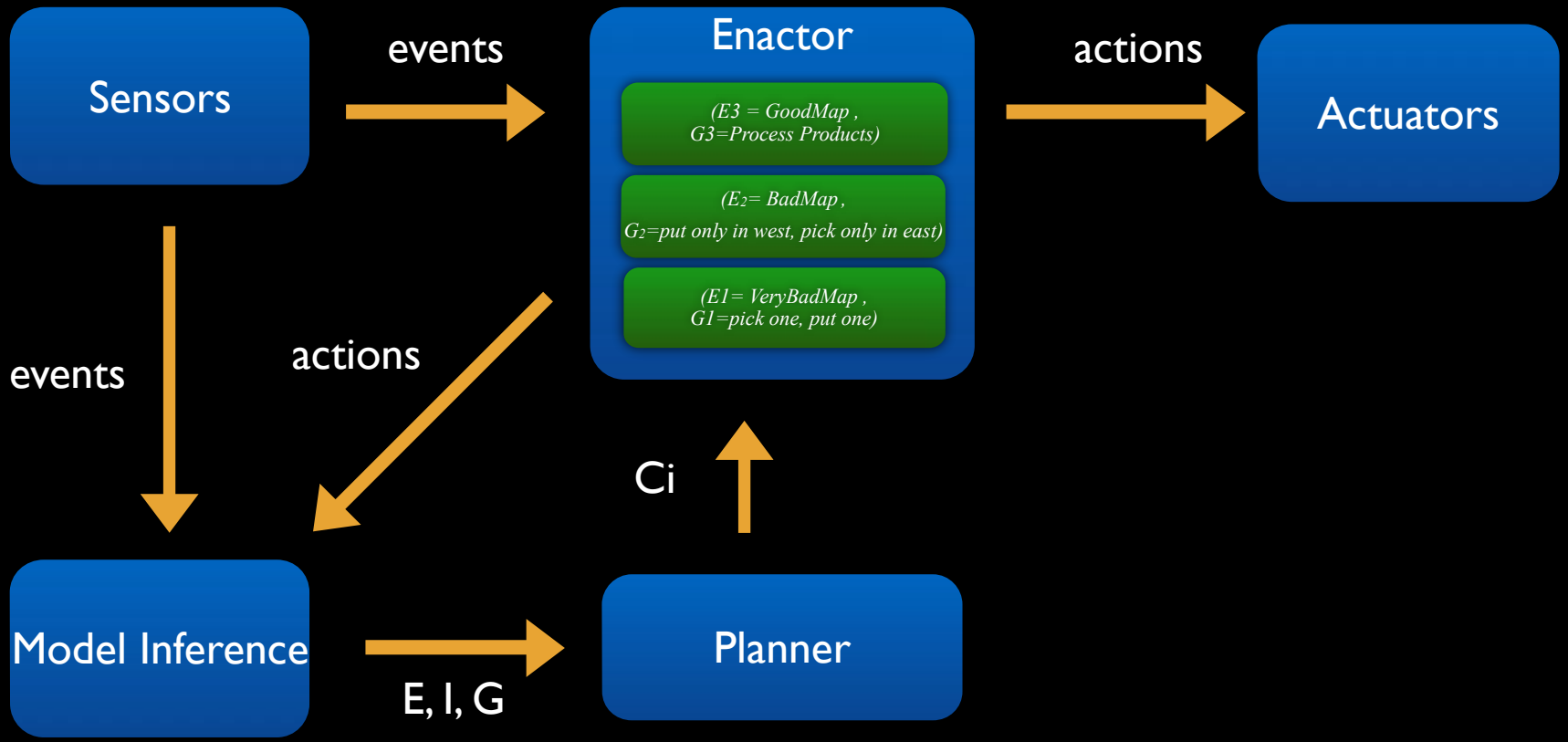
Multi-tier Controller at Runtime



Inter-Tier Relations



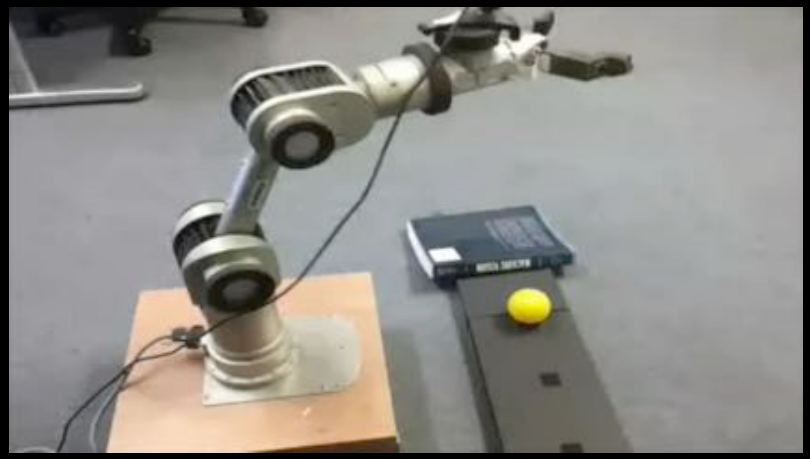
Experimental Platform



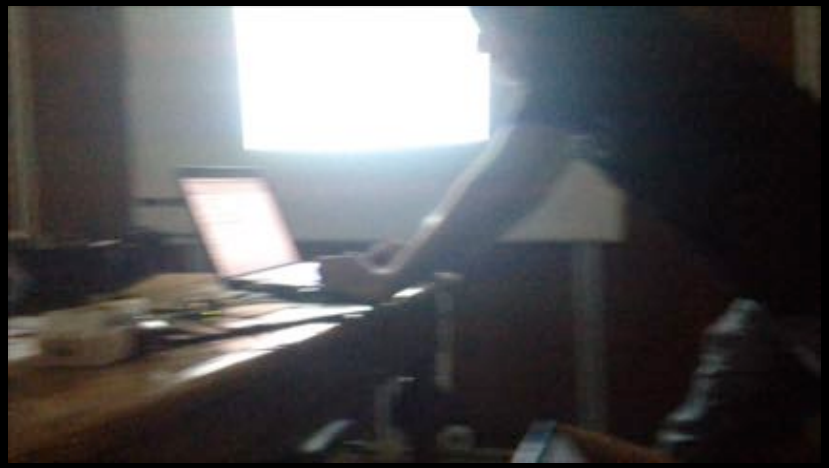
Case Studies

Quadrotor@NII

Nao@Imperial College



Robot Arm@Imperial College



Arduino@Buenos Aires

Lessons Learned

- Liveness
- Bounded Liveness
- Safety
- Physical Safety

Conclusions

Architecture for High Level System Adaption

- Automated strategic planning through synthesis
- Supports multiple levels of robustness and risk
- Supports graceful degradation and progressive enhancement

Available at: sourceforge.net/projects/mtsa/

Hope for the Best, Prepare for the Worst: Multi-tier Control for Adaptive Systems

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