Interactions between Automatic and Autonomous Systems

IF061

SEAS DTC Conference 2009

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Outline

What are automatic systems

Why are they required

Effects of an Automatic Protection System on an Autonomous System

Detecting Automatic Systems

How the Autonomous System reacts

Relationship between Automatic Systems and Autonomy

Future work

Questions at the end

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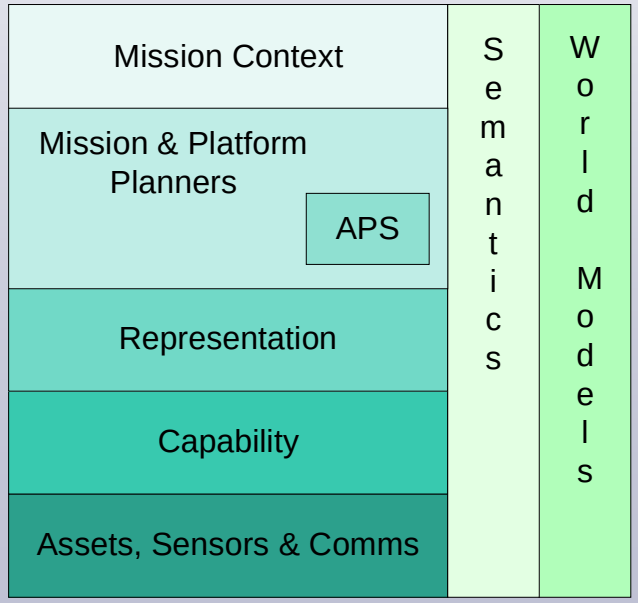
Purpose and Related Work

Purpose of the study

Investigate the interactions between reactive automatic systems and deliberative autonomous systems.

Related work



Examples:

PPEM015 IEPNEF

PPEM016 Intelligent Power Management

IF059 Multiplanner for Power Management

IF053 Hierarchical World Models

IF058 Semantics for Power Management

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Automatic and Autonomous systems

Automatic Systems

"Automation characterises a system that has fixed choice points, programmed with a number of fixed alternative actions which are selected by the system in response to inputs from particular sensors" PPEM008

[Reactive]

Autonomous Systems

"Autonomy is distinguished by the need for decisions to be made *at any time*, with some appreciation for the circumstance of the current situation (often referred to as *situation awareness*)." PPEM008

[Deliberative]

Automatic Protection Systems (APS)

Examples:

- **Traffic Collision Avoidance System (TCAS)**
- **Automatic Collision Avoidance Systems (ACAS)**
- **Full Authority Digital Engine Control (FADEC)**
  - **Flame-out recovery**
- **Power surge protection systems**
- **Automatic fire suppression systems**

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Why are they required?

Automatic System responses:

- **Predetermined**
- **Fast**
- **Predictable**
- **Actions easy to explain**

Characteristics preferred / required for:

- **Safety critical situations**
- **Situations where platform is at immediate risk**
- **Situations where the mission is at immediate risk**
- **To meet the criteria for certification**

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Effects of an APS on an Autonomous System

Planners

- **Constraints - Broken**
- **Goals – Not achievable**

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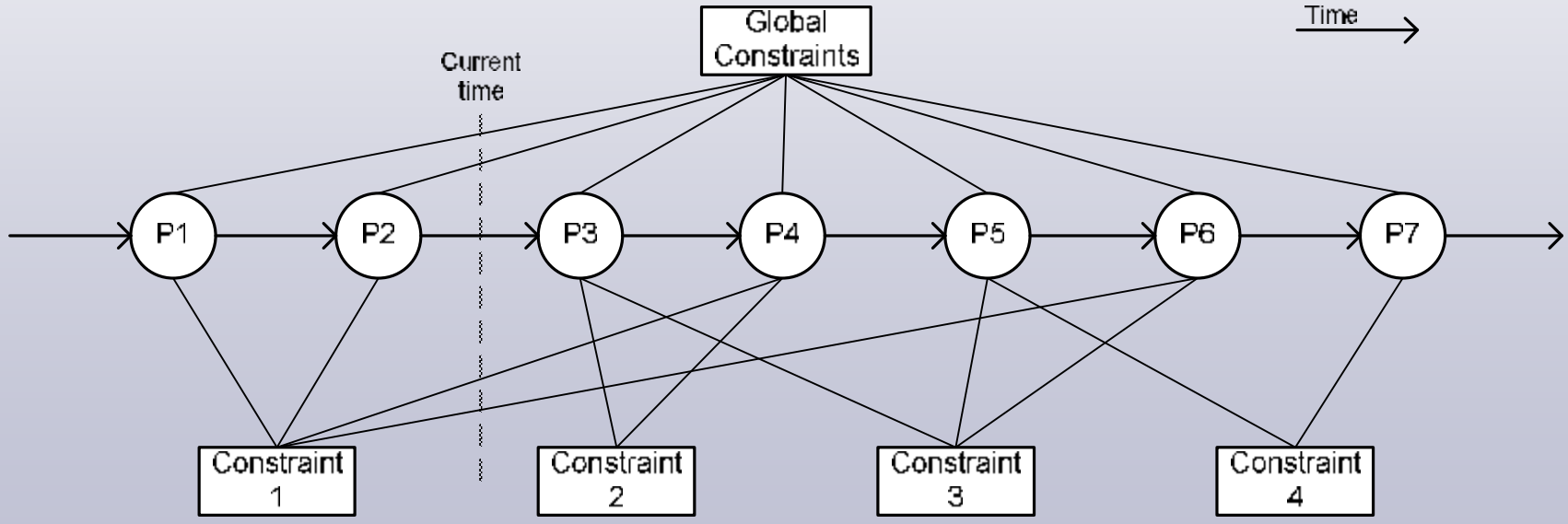

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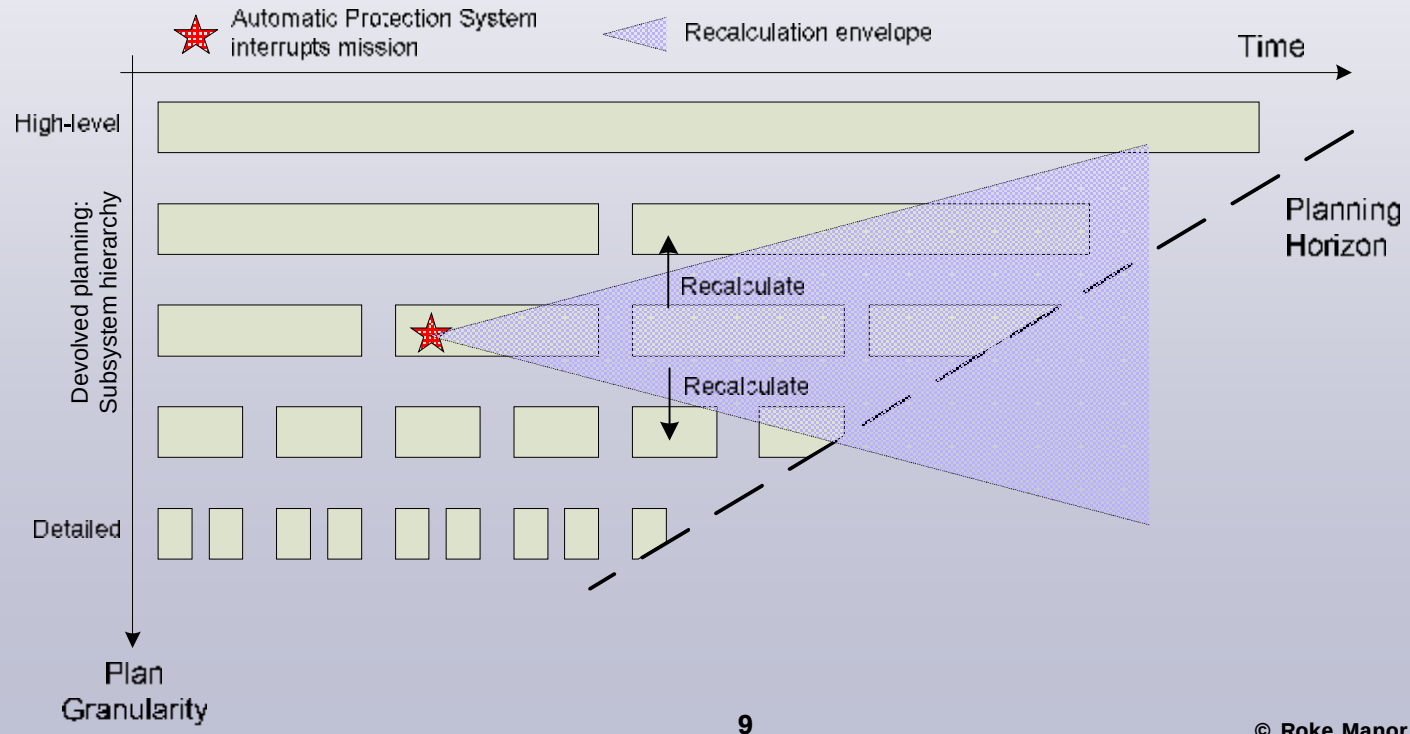

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Effects of an APS on an Autonomous System

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- **Constraints - Broken**
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World Models

- **Self-model – Major changes required**
- **Truth Maintenance – Current beliefs no longer valid**

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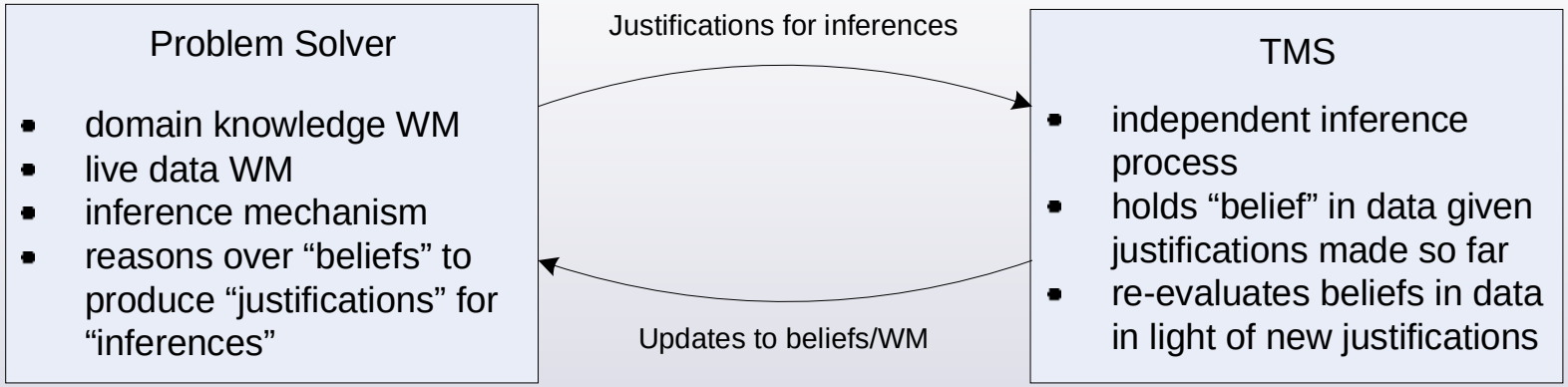
Detecting – using Truth Maintenance



- **Truth Maintenance Systems (TMS) converges current beliefs towards beliefs which satisfy goals**
- **If there is large divergence between these, significant unexpected changes are occurring in the world**
  - **May be the result of Automatic Systems' behaviour**

Figure modified from - J. de Kleer, "An Assumption-based TMS", Artificial Intelligence, Vol. 28, No. 2, March 1986

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Detecting – using rules

“Normal” behaviour constraints

- **New type of constraint**
- **Envelope of “normal” behaviour**
- **Soft constraint - don’t trigger replanning if broken in isolation**
- **Evaluate with rules encoded by Subject Matter Expert (SME)**
- **Efficient rule manipulation mechanisms exist**
  - **e.g. Rete algorithm**
- **Constraints and evaluation rules designed to detect and identify Automatic system behaviour**

“Plan vs. Reality” monitoring

- **Plan expectations compared with live monitoring data**

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How an autonomous system can react

Planners

- **Replanning / plan repair**
  - **Situated actions?**
- **Only repair those parts of the plan which are no longer valid**
  - **i.e. Constraints broken or goals no longer achievable**

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How an autonomous system can react

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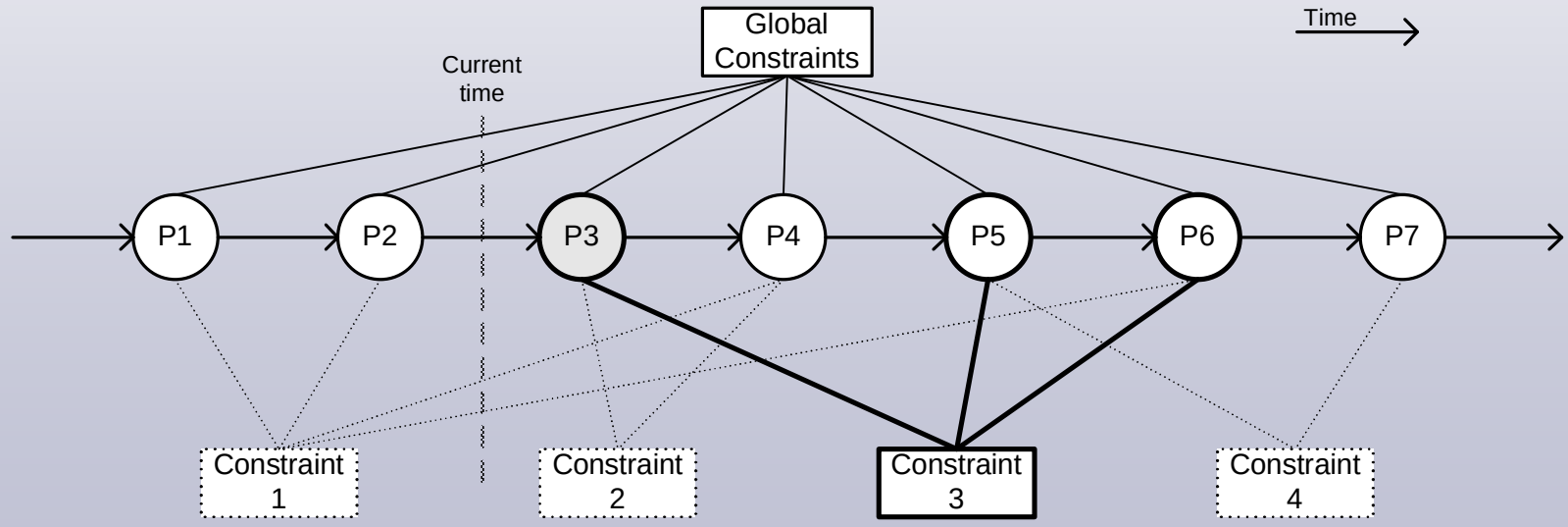

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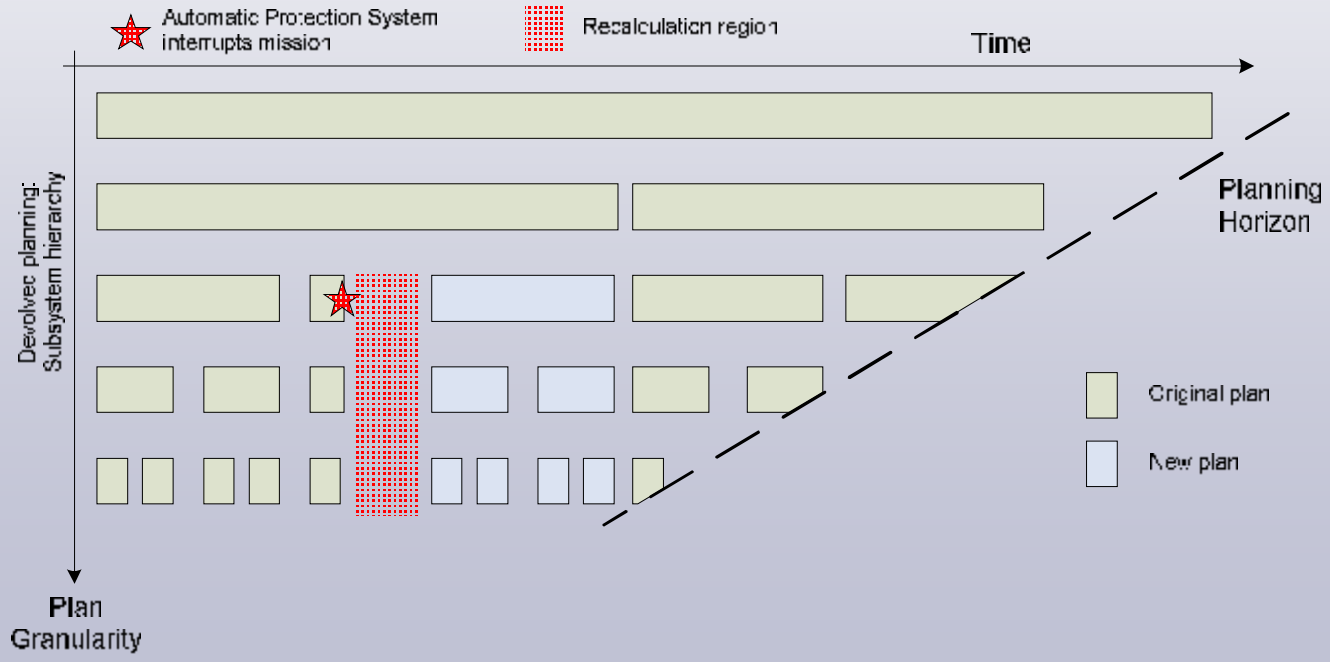

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World Models

- Model updating
- Hierarchical WMs
  - Only update part(s) of model directly or indirectly affected
    - ie. beliefs no longer justified and those inferred from them

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Relationship between APS and autonomy

Automatic systems can take control away from an autonomous entity

Automatic systems:

- **Have very limited situational awareness**
- **Act independently from other systems**
- **Will be present in most/all deployed systems**

Autonomous systems:

- **Have far richer situational awareness**
- **Have an overview of the whole system, e.g. own-vehicle autonomy**

Situation where automatic can cause problems:

- **Two automatic systems perform conflicting actions**
- **Take action after misunderstanding the situation**

Solutions?

- **Employ canned responses to get back on track after APS events**
- **Mechanism whereby autonomy suppresses APS when appropriate**
- **Problems for certification**

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Future work

“Normal” behaviour constraints

- **What is “normal” behaviour for autonomous systems?**
- **System analysis needed for platform behaviour**

Empirical investigation by simulation

- **Evaluate strategies discussed in this study**
- **Rapid software prototypes**

PPEM016 IPM (proposed project)

- **Strategies could be applied to this project**

PPEM015 IEPNEF (ongoing project)

- **Could provide insight into “normal” behaviour**

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Discussion

Any questions?

Thank you

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