Designing Security Requirements Through Planning

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Outline

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- Introduction
- Modeling with Secure Tropos
- Extending Secure Tropos Framework
  - Designing secure systems through planning
- Conclusions and Future Work

Introduction : What we are doing

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- **Problem**: design of secure and trusted systems.
- Existing solutions: refined SE methodologies, incl. tools for **automation** support.
- Which kind of automation the designer needs?
- *"Exploring **alternative** options is at the heart of the requirements and design processes"*
  - Letier and van Lamsweerde, 2004.
- **Objective** : provide support for exploring the space of design alternatives.

Introduction : Motivation

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- Design alternatives are ***potential choices*** designer may adopt.
- Current Software Engineering methodologies support reporting and verifying ***final choices***, but not exploring potential ones.

- Other proposals for automation
  - Deductive program synthesis
    - Theorem proving: a system goal from the axioms
  - Model-Driven Architecture
    - (Automatic) model transformation
  - Design patterns

Secure Tropos

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- Requirements Engineering methodology
  - which extends the Tropos methodology,
  - allows to model and analyze functional and security requirements.

- Secure Tropos concepts
  - Actor, Goal, Softgoal, Task, and Resource
  - Social relationships
    - Requesting, Ownership, Provisioning
    - Trust for Permission/Execution
    - Delegation of Permission/Execution

Example : Medical Care System

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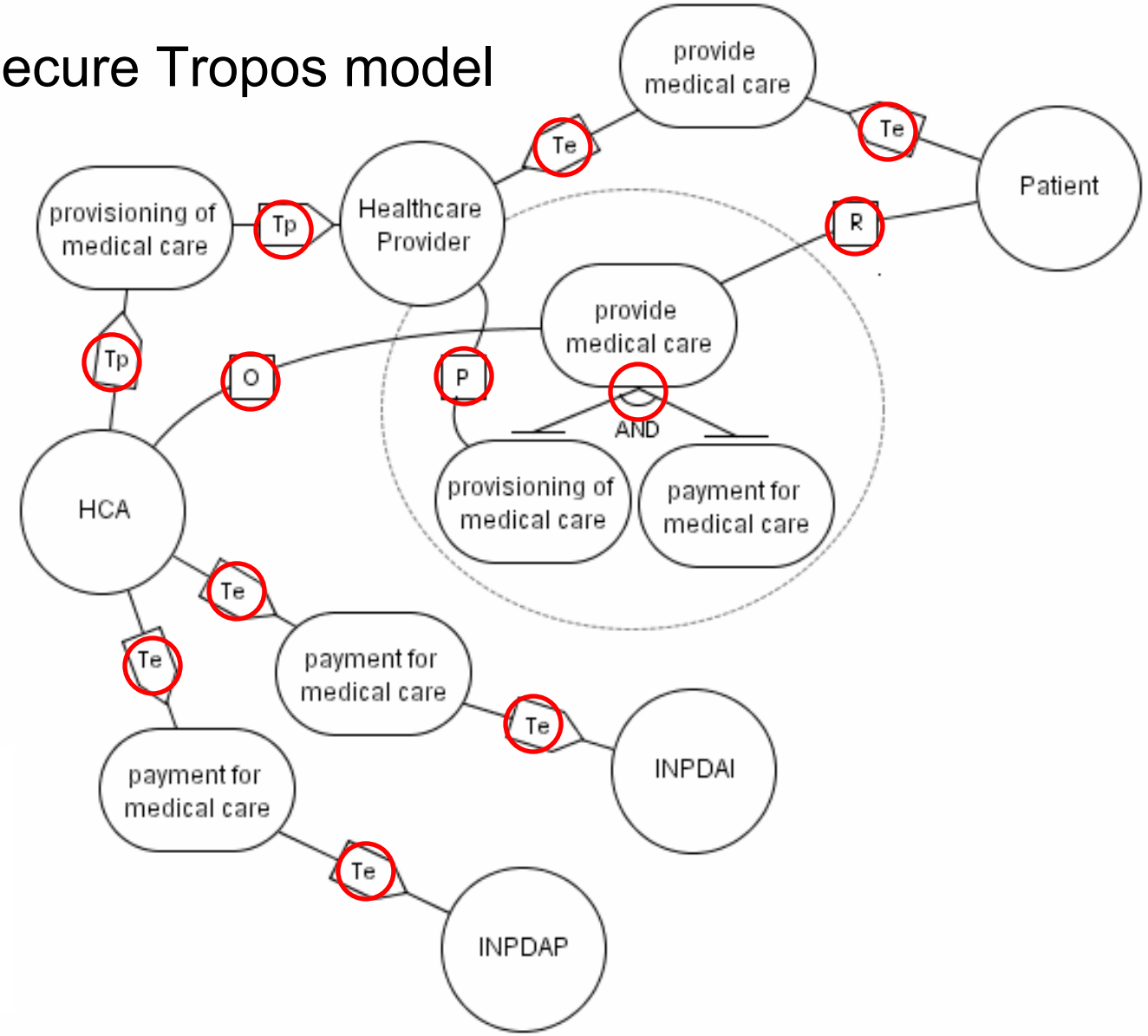
A fragment of Secure Tropos model



Tp – trust for permission
Te – trust for delegation
R – requesting
O – ownership
P – provisioning

Example : Design Alternatives

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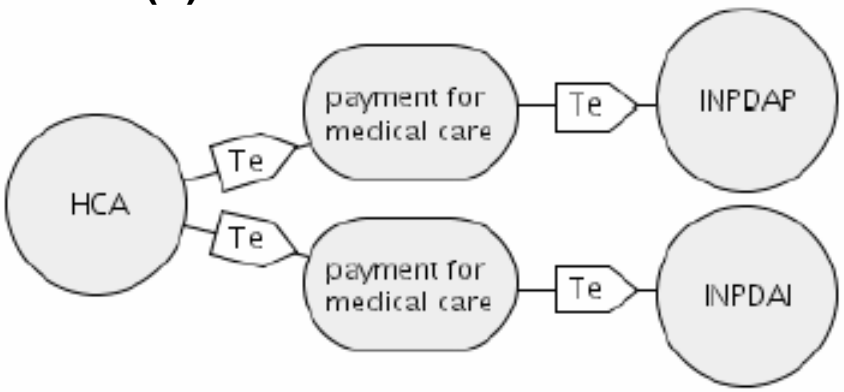
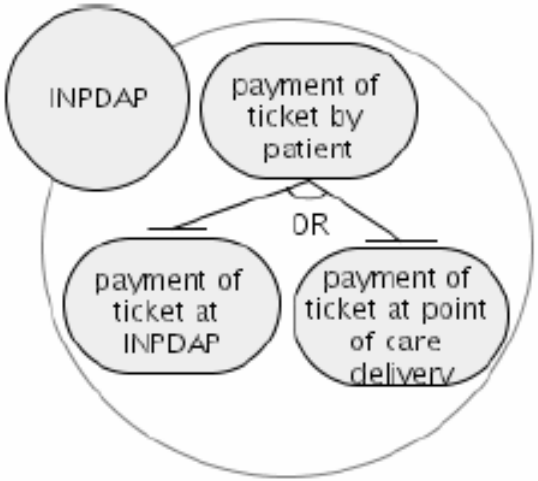
(a) Potential choice : trust

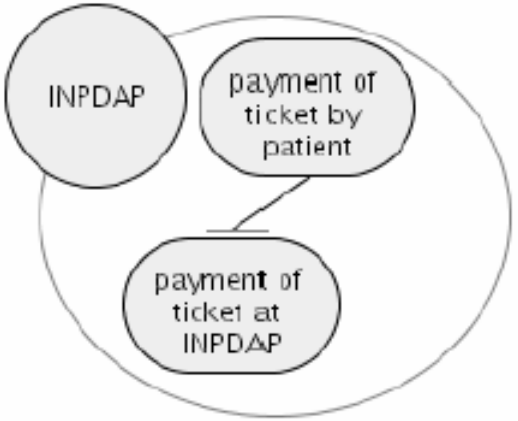


(a) Final choice : delegation

(b) Potential choice : or-decomposition



(b) Final choice : subgoal chosen



Design-As-Planning Problem

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- In Secure Tropos requirements are conceived as networks of delegations (of permission/execution) among actors for goals, tasks and resources.

- The task of designing such networks can be framed as a planning problem
  - selecting a suitable design corresponds to selecting a plan that satisfies the goals of human or system actors.

AI Planning

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- Planning approach
  - automatically determine the course of actions (a plan) to achieve a desired state (a goal), where an action is a transition rule from one system state to another.
- Planning problem is defined by
  - domain description: **predicates**, **actions**, axioms
  - problem description: initial and desired state

Predicates

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Goal Properties
and_decomposition_n(g : goal; g1 : goal, … , gn : goal) or_decomposition_n(g : goal; g1 : goal, … , gn : goal
Actor Properties
provides(a : actor, g : goal) requests(a : actor, g : goal) owns(a : actor, g : goal)
Actor Relations
trustexe(a : actor, b : actor, g : goal) trustper(a : actor, b : actor, g : goal)

Actions

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Defined in terms of **preconditions** and **effects** using above defined **predicates**

- ***Satisfy*** *(a : actor, g : goal)*
- ***DelegateExecution*** *(a : actor, b : actor, g : goal)*
- ***DelegatePermission*** *(a : actor, b : actor, g : goal)*
- ***AND_Refine_n*** *(a : actor, g : goal, g1 : goal, . . . , gn : goal)*
- ***OR_Refine_n*** *(a : actor, g : goal, g1 : goal, . . . , gn : goal)*

Example : Absence of Trust

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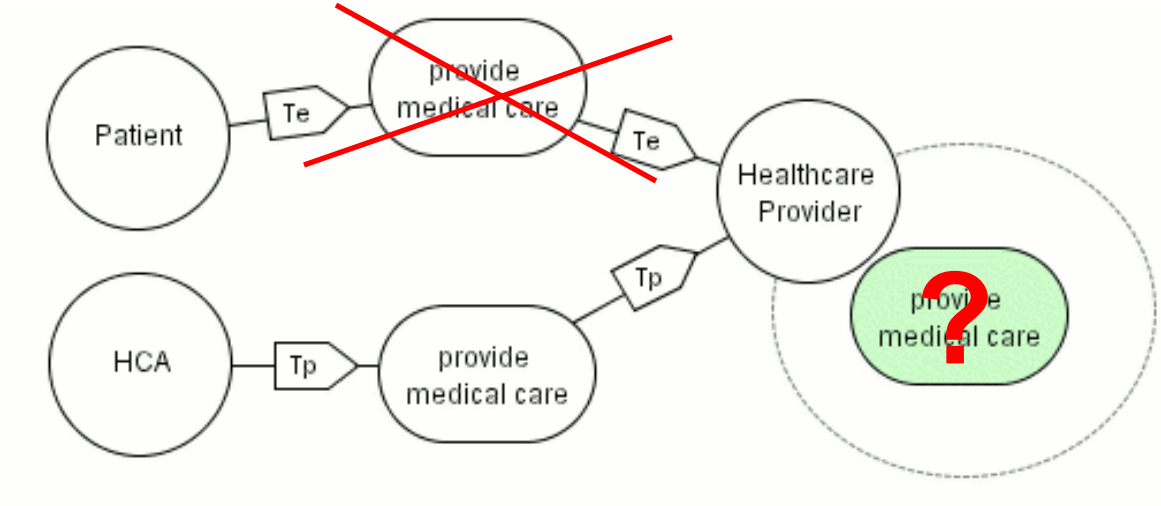
Fully trusted domains are unrealistic.



Absence of Trust

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- How to delegate execution with no trust?
  - Establish trust (create a contract) or
  - Control the execution.

- Our solution combines contract & control
  - Additional predicates and actions:

    DelegateExecution → Satisfy

    is replaced with

    Negotiate → Contract → DelegateExecution_under_suspicion → Fulfill → Evaluate

Implementation

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- Looking for off-the-shelf tool, requirements
  - should produce non-redundant plans
    - Need-to-Know property : no alternative delegation paths
  - should support PDDL 2.2
  - should be platform-independent
- Chosen planner: LPG-td
  - Does not produce optimal plans
- Experiments
  - Preliminary testing and the case study
  - Scalability tests

Example : Problem Definition

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```
: objects
        Pat HCA HP INPDAP INPDAI - actor
        ProvideMC ProvisioningMC PaymentMC - goal
        PaymentTicket PaymentHCA - goal
        PaymentTicketHP PaymentTicketINPDAP - goal
        PaymentFullCost Reimbursement - goal
        CollectionINPDAI CollectionHP - goal
        ReimbursementINPDAI ReimbursementHP - goal
: goal
        (done ProvideMC)
: init
        (owns HCA ProvideMC)
        (requests Pat ProvideMC)
        (provides HP ProvisioningMC)
        (provides HCA PaymentHCA)
        (provides INPDAP PaymentTicketINPDAP)
        …
        (trustexe Pat HP ProvideMC)
        (trustper HCA HP ProvisioningMC)
        (trustexe HP HCA PaymentMC)
        (trustexe HCA INPDAP PaymentMC)
        (trustper HCA INPDAI ReimbursementINPDAI)
        (trustexe INPDAI HP ReimbursementHP)
        …
        (AND decomposition2 ProvideMC ProvisioningMC PaymentMC)
        (AND decomposition2 PaymentMC PaymentTicket PaymentHCA)
        (OR decomposition2 PaymentFullCost CollectionINPDAI CollectionHP)
        (OR decomposition2 Reimbursement ReimbursementINPDAI ReimbursementHP)
        …
```

Example : Solution

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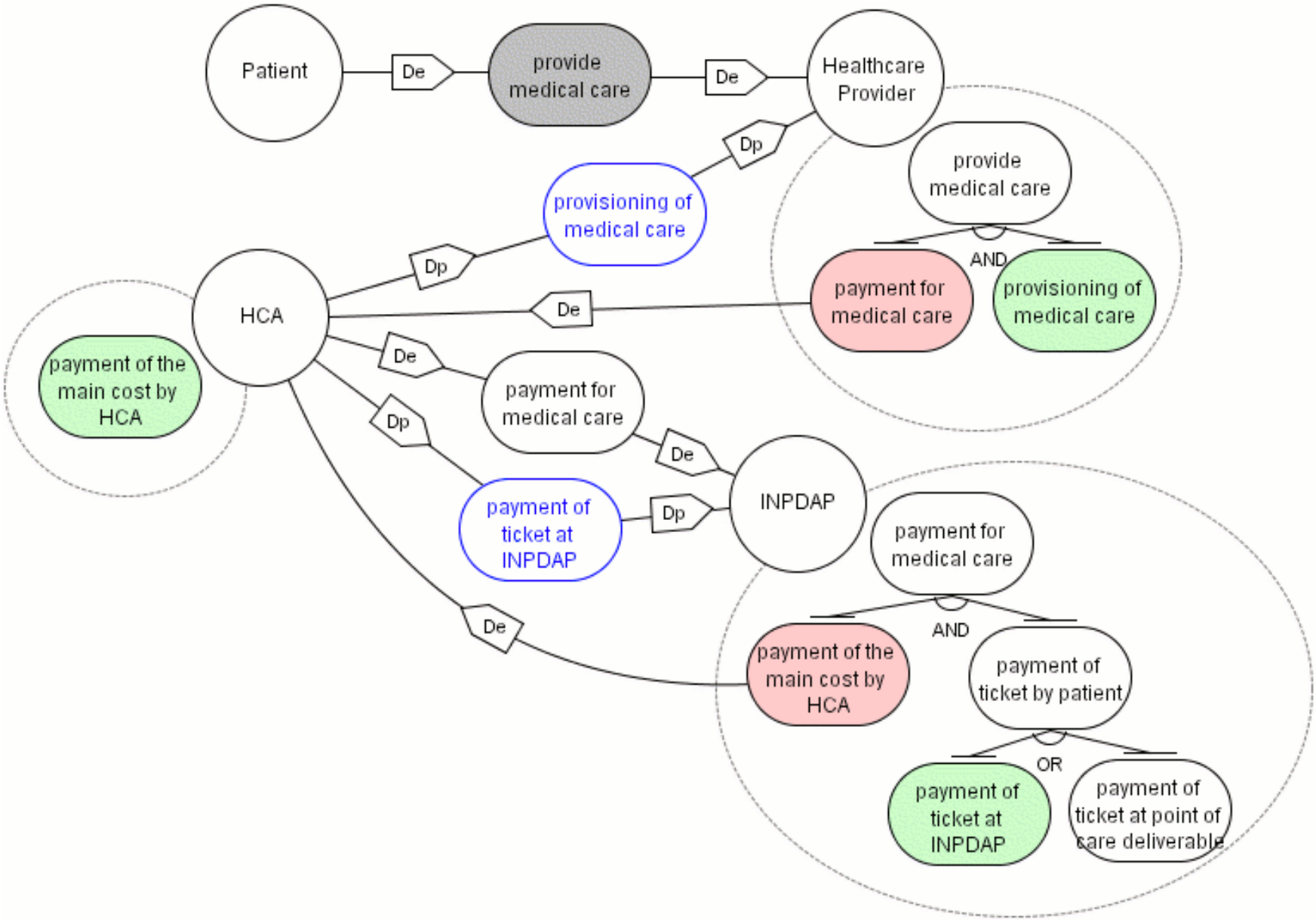
DelegateExecution Pat HP ProvideMC
AND_Refine HP ProvideMC ProvisioningMC PaymentMC
DelegatePermission HCA HP ProvisioningMC
Satisfy HP ProvisioningMC
DelegateExecution HP HCA PaymentMC
DelegateExecution HCA INPDAP PaymentMC
AND_Refine INPDAP PaymentMC PaymentTicket PaymentHCA
DelegateExecution HCA INPDAP PaymentHCA
Satisfy HCA PaymentHCA
OR_Refine INPDAP PaymentTicket PaymentTicketINPDAP
PaymentTicketHP
DelegatePermission HCA INPDAP PaymentTicketINPDAP
Satisfy INPDAP PaymentTicketINPDAP

Example : Solution



Conclusions

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- **Objective** : provide support for exploring the space of design alternatives
  - Important design activity
  - Not addressed in current SE methodologies
- **Result** : we have proposed the way to automate the selection of design alternatives
  - In context of Secure Tropos
  - Through viewing the design problem as a planning one
- Future work
  - Elaborate on the planning part (e.g. consider costs of actions)
  - Try larger industrial case studies
  - Perform thorough scalability testing

Acknowledgements

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Thank you. Questions?