Modeling Security Requirements Through Ownership, Permission and Delegation

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EMFASE

Vision Privacy Platform

FEDERATED SECURITY SHIELD

Motivation

- In 2005, mainstream approaches to security design focused on identifying security requirements after system design; and even today an overwhelming focus is still on system security.
- Security solutions have to fit a pre-existing design
  - may not be able to accommodate them;
  - security requirements may conflict with functional and quality requirements;
- Social concepts are fundamental to building secure systems
  - Security is often compromised by exploiting vulnerabilities in the social part of a socio-technical system.

Once upon a time

Università degli Studi di Trento

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www.troposproject.org

Some Ideas… we don't like

- **Idea 1**
  - Add primitives/constraints to Tropos/Kaos/name-your-pet-RE-formalism for the various security requirements
  - Confidentiality, authentication, access controls or so on are security services and mechanisms NOT security requirements!
  - ACID Transactions are a DB service not a IS requirement…
- **Idea 2**
  - Model security requirements separately from functional requirements
  - This is exactly the problem everybody is ranting about
- **Idea 3**
  - Model the goals of the attacker
  - They are not the goals of the security engineer!

Some ideas… we like

- **Hunch 1**
  - **Security Requirements are social requirements**
- **Hunch 2**
  - **We must model at the same time Functional Requirements and Security Requirements**
  - So we can see the interplay of both and check one does not get in the way of the other
- **Occam's Razor**
  - Add **few** primitive constructs
  - Other security requirements as patterns, services, mechs

We were not the first to address SRE

- Early RE models (SREs using “vanilla”RE)
  - [3] Anton, Privacy reqs with privacy goals. RE’02
  - [6] Crook+. SREs as anti-reqs. RE’02.
  - [19] Liu+. SREs with goal models. RE’03
  - [25] Toval+. Legal reqs. RE’02
- SRE specific graphical model but no logic
  - [9] Fredriksen+ CORAS for risk assessment. SAFE-COMP’02
  - [22] McDermott & Fox. Abuse Cases. ACSAC’99
  - [24] Sindre & Opdahl. Misuse Cases. TOOLS' 2000
- Logic and tool for security but no model
  - [11] Gans+. Trust and Distrust in Agents. AOIS’01
  - [15] Jones & Sergot Formal Institutionalised Power. JGPL 1996.
  - [18] Li+. Trust-management Framework. IEEE SSP'02
- Logic, graphical model and tool but focus on system
  - [16] Jurjens. UMLSec. 2004.
  - [20] Lodderstedt+ SecureUML. UML’02
  - [26] van Lamsweerde+ Anti-Goals. RHAS’03

10 years later

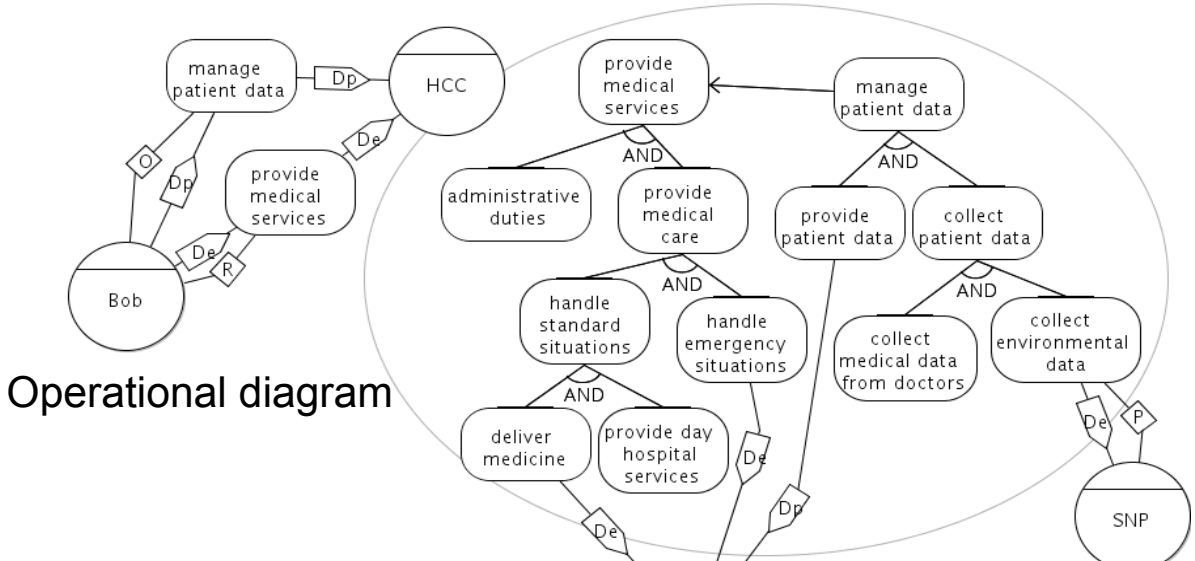
Contributions of our proposal

- The first work providing (at the same time):
  - a Security specific (and novel) ontology for talking about an important class of security requirements, namely ownership and permissions
  - a coherent graphical representation for both functional and security requirements
  - a reasoning technique for formal requirements analysis
- CASE tool support
- Cross communities
  - Requirements Engineering
  - Security

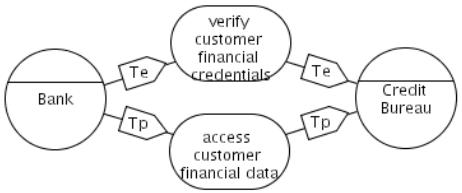
Security-specific Ontology

- Permission != Execution
  - Authority vs. Responsibility
- Ownership != Provisioning
  - Distinguishing who can fulfill a goal from who is entitled to decided who can fulfill a goal
- Trust relationship between actors
  - Distinguishing trusted actors from untrusted actors
- Delegation relationship between actors
  - Formal transfer of authority/responsibility

Graphical Representation



Operational diagram



Trust diagram

O: owns
P: provide
R: request
Dp: permission delegation
De: execution dependency
Tp: trust of permission
Te: trust of execution

Formal Reasoning

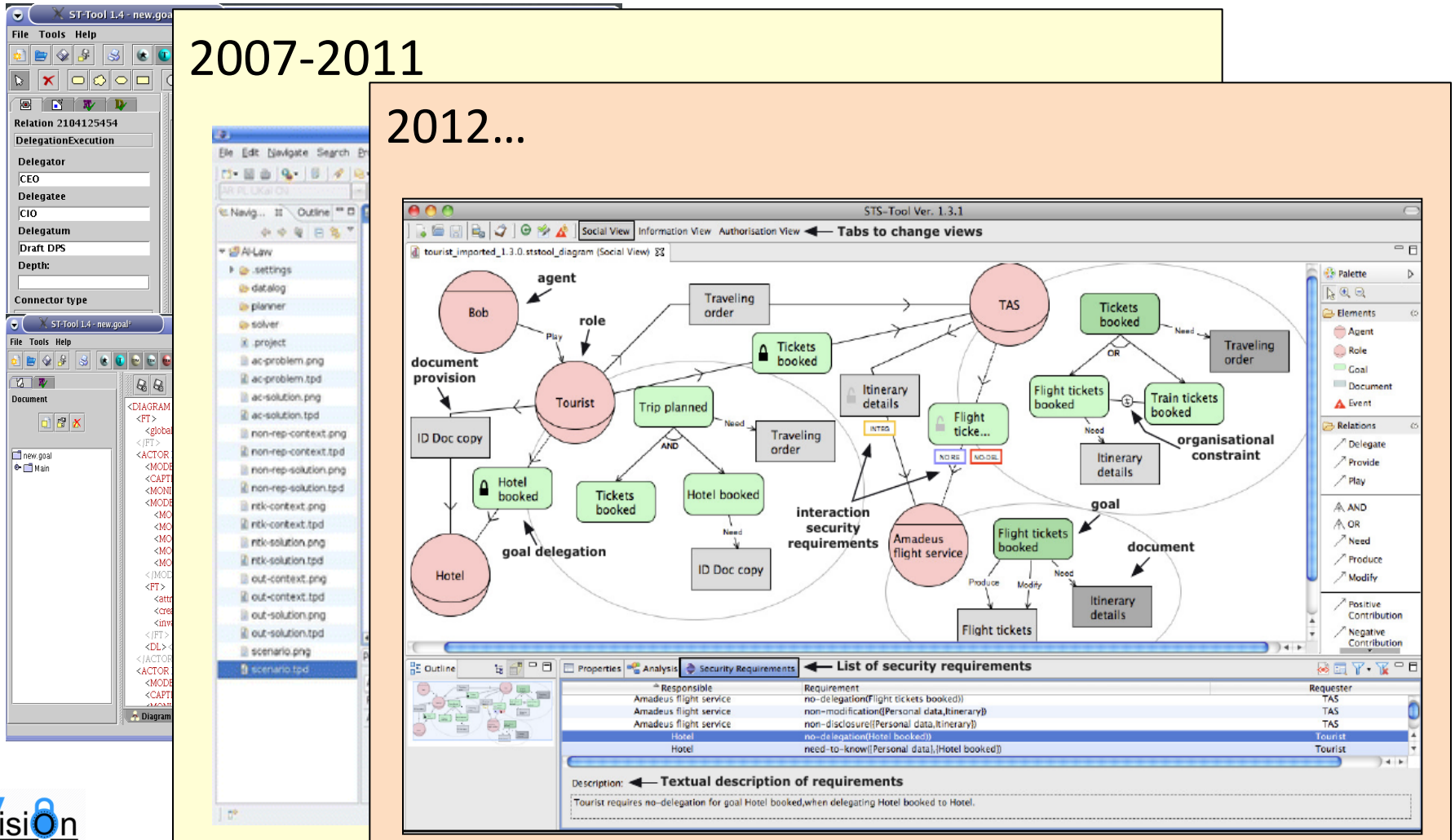
- Formal Model
  - Answer Set Programming (aka Datalog¬)
- Axioms
  - Intensional properties and rules
- Models (SI* diagrams)
  - Extensional properties of classes (and instances)
- Properties
  - Formulas that may be in true or may not be true
  - Availability (3), Confidentiality (1), Authorization (3), Avail+Auth (3), Privacy (1)
  - eg Need-to-know: all actors which have been delegated a permission to fulfill a goal has also been delegated the execution of the goal (directly or indirectly)

CASE tool support

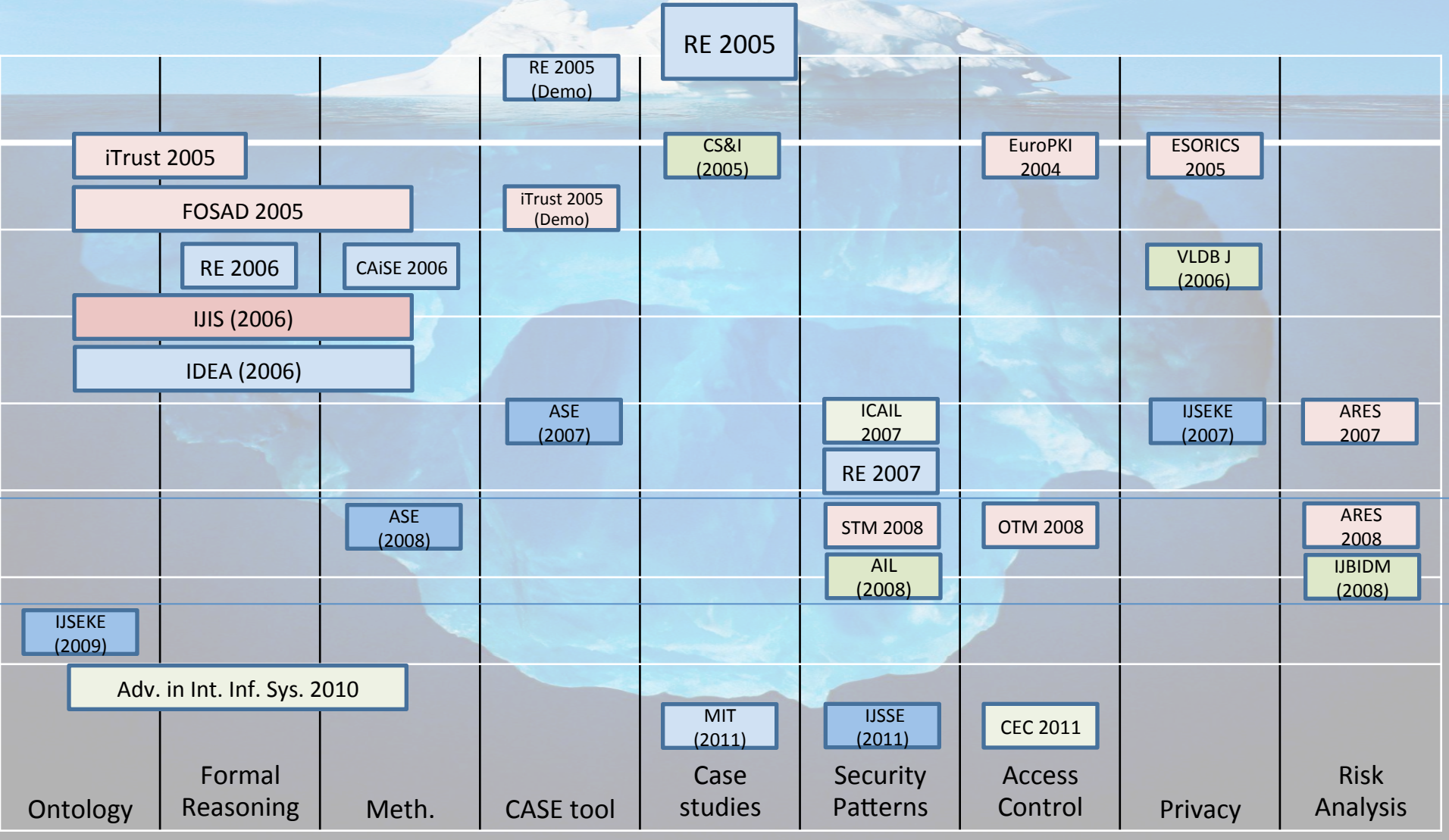
2005-2006 -→ RE'05 Tool Paper

2007-2011

2012…

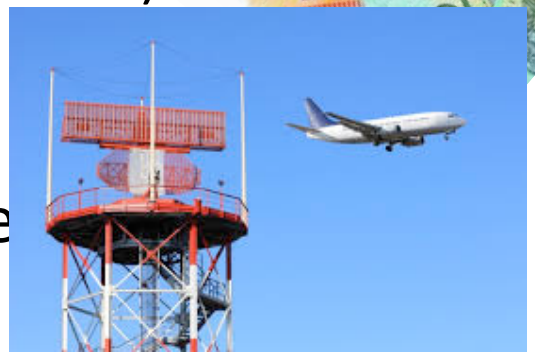


Beyond the tip of the iceberg



Involving Industry

- Several studies in joint research projects
  - SAP (SERENITY, MASTER, TAS3)
  - Thales (SECURECHANGE, ANIKETOS)
  - ATOS (MASTER,ANIKETOS)
  - Engineering SpA (SERENITY, MASTER)
  - British Telecom (MASTER)
  - DBlue (SERENITY, SECURECHANGE, ANIKETOS)
  - National GRID (SECONOMICS)
- A painful road to humility
- The realm of measurable value and the academically unexpected…



What is important in a tool for industry?

- Our Expectation [RE'05]
  - "In addition, the tool provides a user-friendly interface to the DLV system and permits a designer to select properties of each model and to specify additional security policies. The resulting Datalog specifications are automatically verified by the DLV system."
- VM, former Air Traffic Controller, Expert in Human Factors for Safety, 35+ years of experience, CTO of small company
  - "Your tool has a bug. We were verifying a safety pattern and a window popped up with… you know that Windows error… Ax07F12"
  - Well, it was not actually a bug, the window presented a datalog formula showing how trusted delegation would not hold
- Still "debugging it" after 10 years
  - E.g. Formal method is there but has to be "transparent"

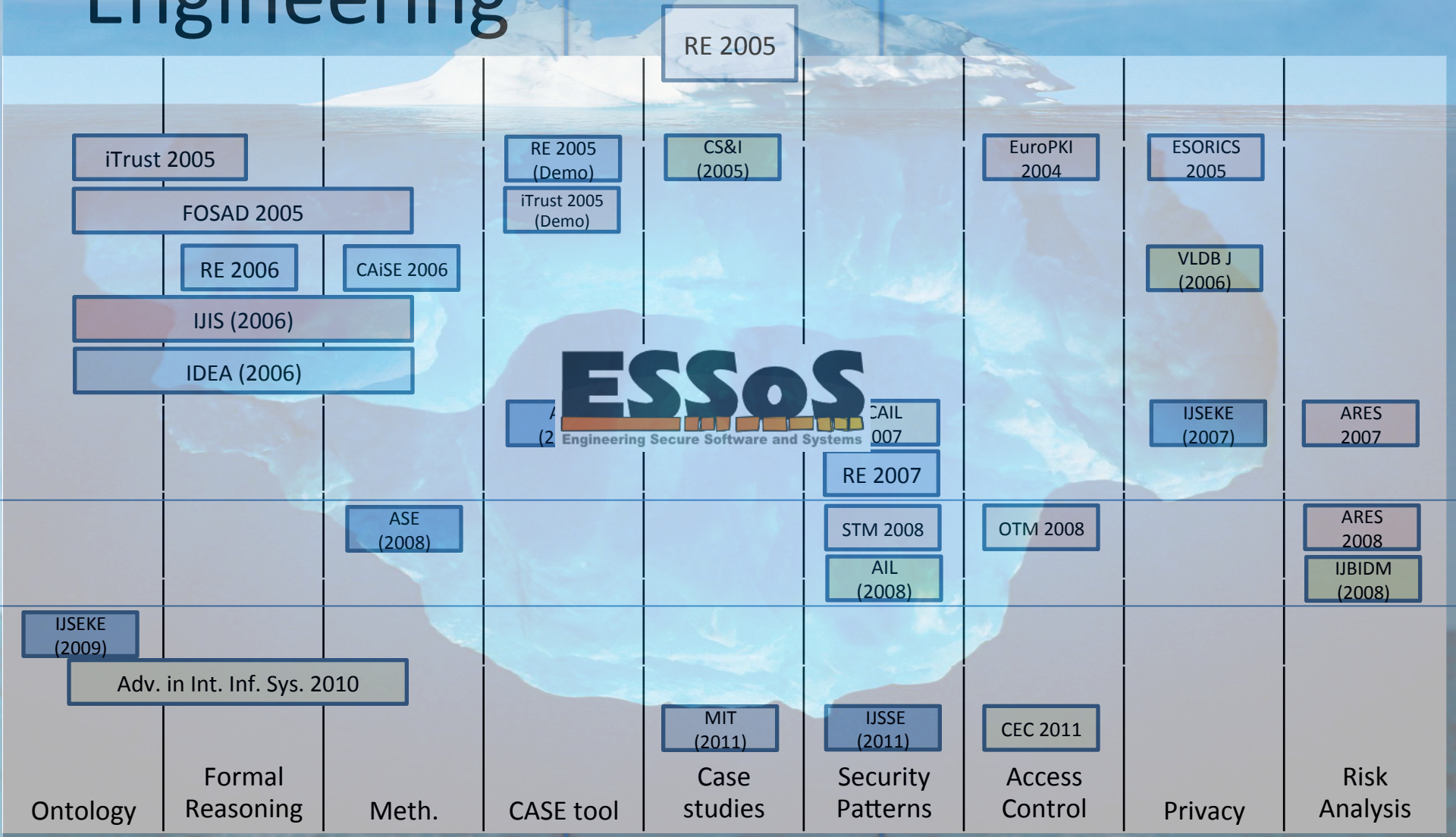
10 years later

tool != model stencil

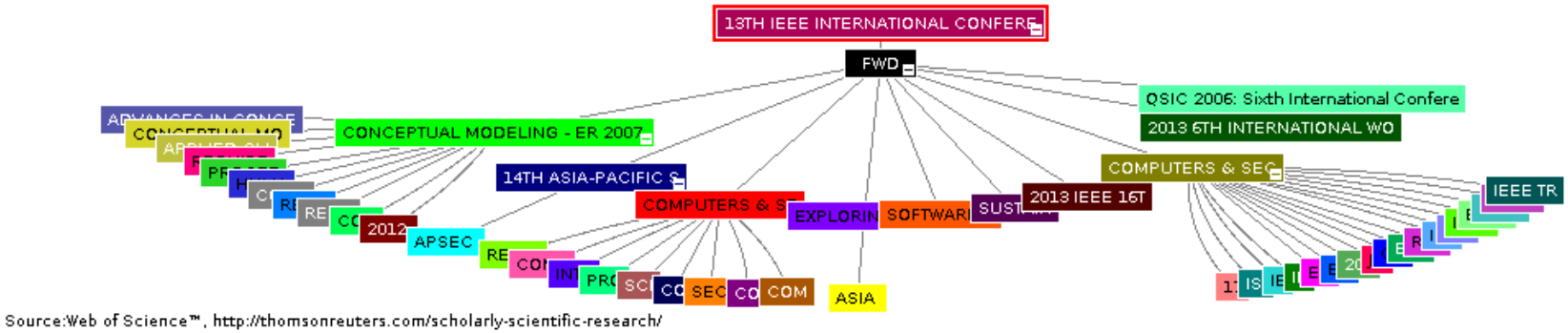
- Meta-Models not just Graphics
  - Different Industries → different graphics convention
    - Air Traffic Management vs Business Processes
  - Must have a flexible meta model for plugging different models
- Interface with Reasoning Capabilities
  - Different applications → different reasoning reqs
    - untangle trust relationships vs compute risk values
  - Interface with different reasoners might be needed
- Process Support
  - Main lesson from eRISE Challenge
    - evaluating SRE methods with professionals and students
  - You can't just leave dudes figuring out what to do next and whether they wrote is a 'model' or a 'pile of gibberish'
- Automatic report generation in a pdf
  - Yes, that's measurable value (writing reports is expensive!)

Software Engineering

Behind the tip of the Security



Impact of this work on others



Source:Web of Science™, http://thomsonreuters.com/scholarly-scientific-research/

- **Legal requirements**: our ontology provided a baseline for the definition of ontologies for modeling legal requirements
- **Trust management**: inspired methods for elicitation, specification and analysis of trust requirements
- **Security patterns**: inspired the definition of security patterns at organizational level

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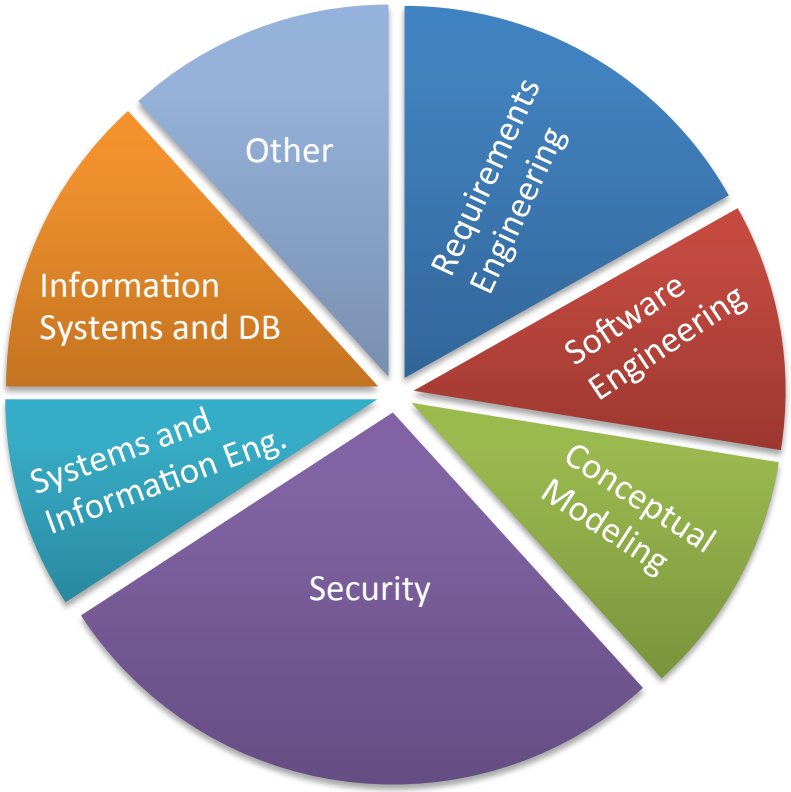
Google Scholar (200 cit.)



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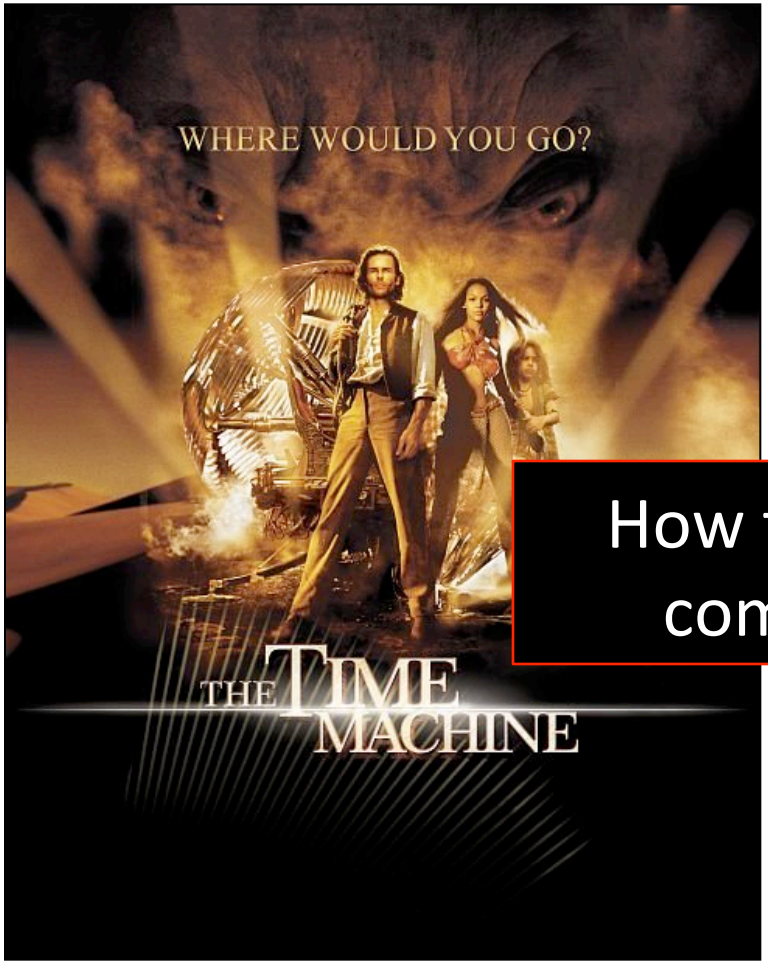
Sample Citation Venues (>2cit)

What happened next?



RE'05 - Modeling Security Requirements

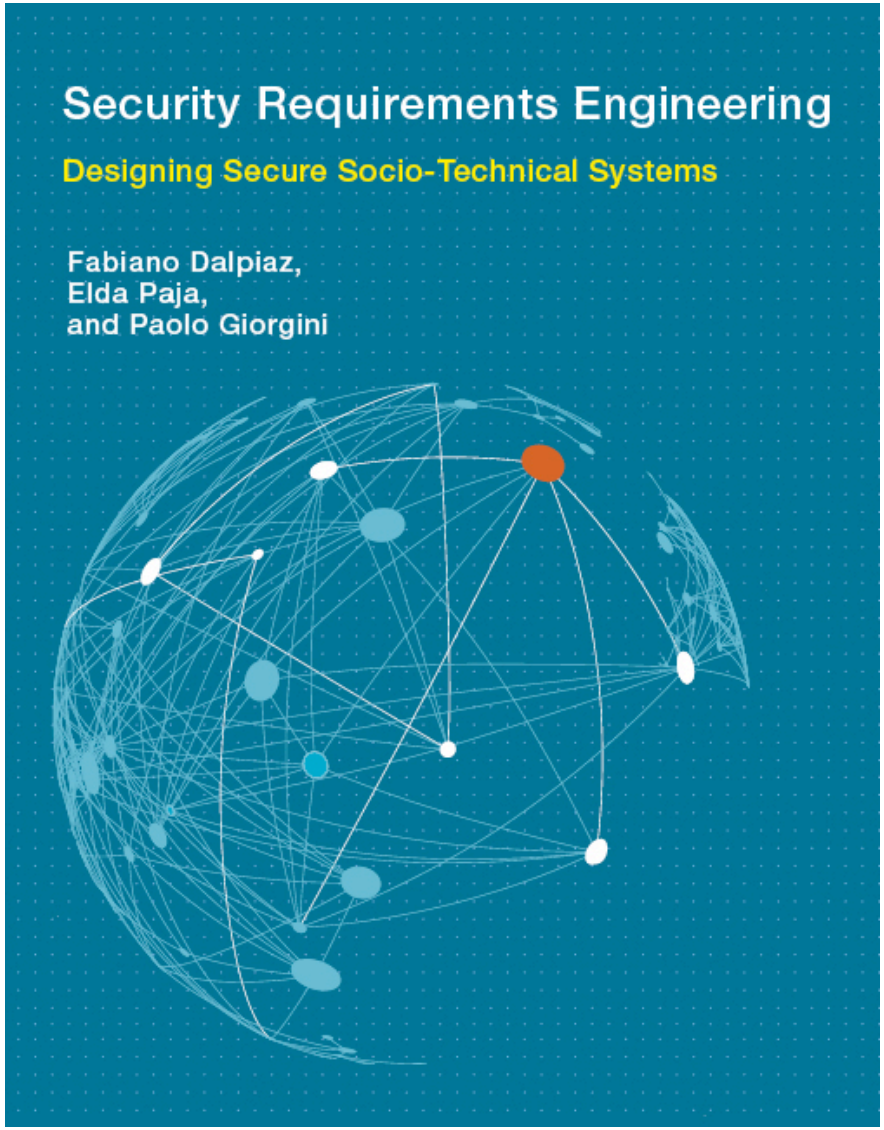
What to do with elicited SRs?

How to manage complexity?

How to close the gap to design?

Does it really work in practice?

A MIT Press Book



10 years later

You elicited, so what?

- Realization of security and trust requirements
- Two inspiring follow-ups:
  - (2008) A Model-Driven Approach for the Specification and Analysis of Access Control Policies
  - (2006) Hierarchical Hippocratic databases with minimal disclosure for virtual organizations
- Ongoing research directions
  - Access control for distributed and collaborative systems
    - automotive, cloud, smart grid, social networks, systems of systems
  - Privacy compliance
  - Anomaly detection and analysis
  - Trust management
    - Credential-based, reputation-based

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How to manage complexity?

- You can't just plug everything into a model
- Multi-view Socio-Technical Security (STS)
  - Social, Information and Authorization views
- From STS specification down to BP design and security enforcement
  - Security requirements refinement
- Visual Privacy (EU H2020 Project)
  - Visual models for information owners

SecBPMN

VisiOn
Privacy Platform

10 years later

And the gap towards architecture?

- Vanilla security analysis focuses on the system level; in our RE'05 paper we focused on the social level.
- But attacks often strike at the weakest link of a socio-technical system, social, system or infrastructure, and nowadays are often composite.
- Tong Li (PhD student, UniTN) is developing a holistic security analysis framework that supports analysis across all three levels.
- His analysis uses anti-goals and attack patterns from public domain repositories.

10 years later

Does it really work?

- Full fledge security requirements engineering is often too costly (Industry paper at ESEM'14)
  - We need empirical protocols to evaluate RE models & methods, and understand what works, what doesn't work and why → K. Labunets (PhD @ UNITN)
- Is Process is more important than graphics? (NordSec'12)
- Is Perception everything?
  - Graphical SRE method are systematically ***perceived*** as superior to tabular SRE methods (ESEM'13,EMPIRE'14)
  - But there is ***no diff in actual result*** when industry people evaluate the final outcome (EMPIRE'14)
  - What about comprehension? (Watch this space)
- Do catalogues make a difference? (REFSQ'15)

Take Away Messages

- Security & functional reqs can be elicited together
- Social models have a place in Security RE
- Representation, Reasoning, Running Code
  - You need all three to make an impact
  - Just adding the label “S” for “Security” to your pet RE method doesn’t make it a SRE
- Industrial evaluation is not the ‘last mile’ is the ‘last light year’