Modeling Security Requirements Through Ownership, Permission and Delegation

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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
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

- Logic and tool for security but no model
  - [18] Li+. Trust-management Framework. IEEE SSP'02

- Logic, graphical model and tool but focus on system
  - [20] Lodderstedt+ SecureUML. UML’02
  - [26] van Lamsweerde+ Anti-Goals. RHAS’03
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

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

#### Ontology
- iTrust 2005
- FOSAD 2005
- RE 2006
- IJIS (2006)
- IDEA (2006)

#### Formal Reasoning
- RE 2005 (Demo)
- iTrust 2005 (Demo)
- CAiSE 2006

#### Methodology
- ASE (2007)
- RE 2007
- ASE (2008)

#### CASE tool
- CS&I (2005)
- ICAIL 2007
- STM 2008
- AIL (2008)

#### Case studies
- RE 2005
- IJSEKE (2007)
- OTM 2008

#### Security Patterns
- EuroPKI 2004
- VLDB J (2006)
- ARES 2008

#### Access Control
- ESORICS 2005

#### Privacy
- IJSEKE (2009)
- ARES 2007
- IJIBIDM (2008)

#### Risk Analysis
- Adv. in Int. Inf. Sys. 2010
- MIT (2011)
- USSE (2011)
- CEC 2011

#### Events
- CAiSE 2006
- IJIS (2006)
- iTrust 2005
- RE 2005
- STM 2008
- ARES (2008)
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”
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 Iceberg

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**Software Engineering**

- **ASE (2007)**
- **IJSSE (2011)**
- **MIT (2011)**
- **CEC 2011**
Impact of this work on others

- **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
Google Scholar (200 cit.)

10 years later

- Security
- Requirements Engineering
- Software Engineering
- Conceptual Modeling
- Systems and Information Eng.
- Information Systems and DB
- Other
Sample Citation Venues (>2cit)

10 years later
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?
Security Requirements Engineering

Designing Secure Socio-Technical Systems

Fabiano Dalpiaz,
Elda Paja,
and Paolo Giorgini
You elicited, so what?

- Realization of security and trust requirements
- Two inspiring follow-ups:
  - (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
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
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.
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 requirements analysis.
- Representation, Reasoning, Running Code.
  - You need all three to make an impact.
  - Just adding the label “S” for “Security” doesn’t make it a SRE.
- Industrial evaluation is not the ‘last mile’; it’s the ‘last light year’.

- 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’; it’s the ‘last light year’.