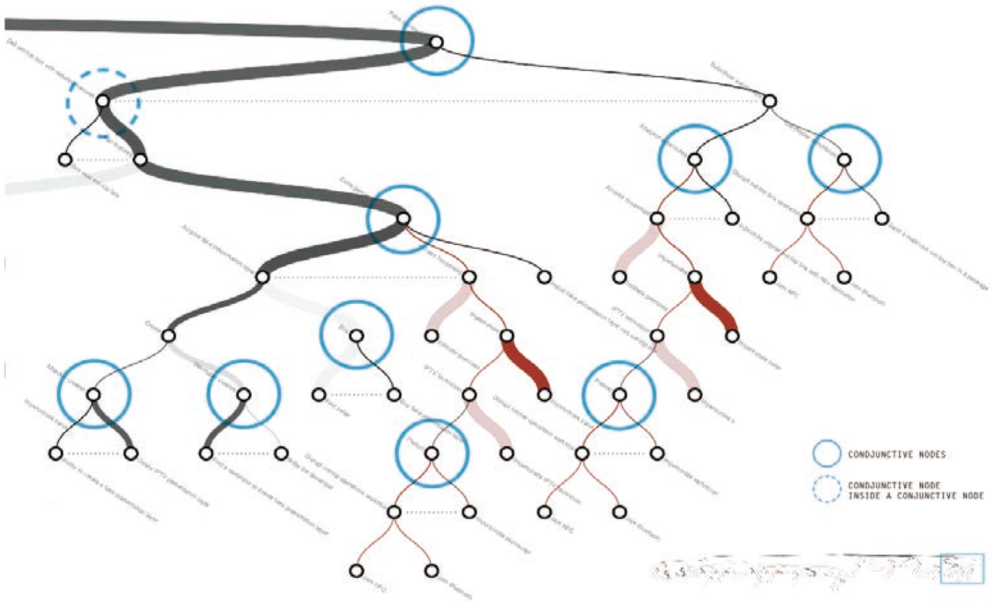
Model-based Risk Management for Socio-Technical Systems – Report on the TRE$_S$PASS Project

predict
prioritise
prevent

TRESPASS



SEVENTH FRAMEWORK PROGRAMME

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Hamburg University of Technology

European Commission

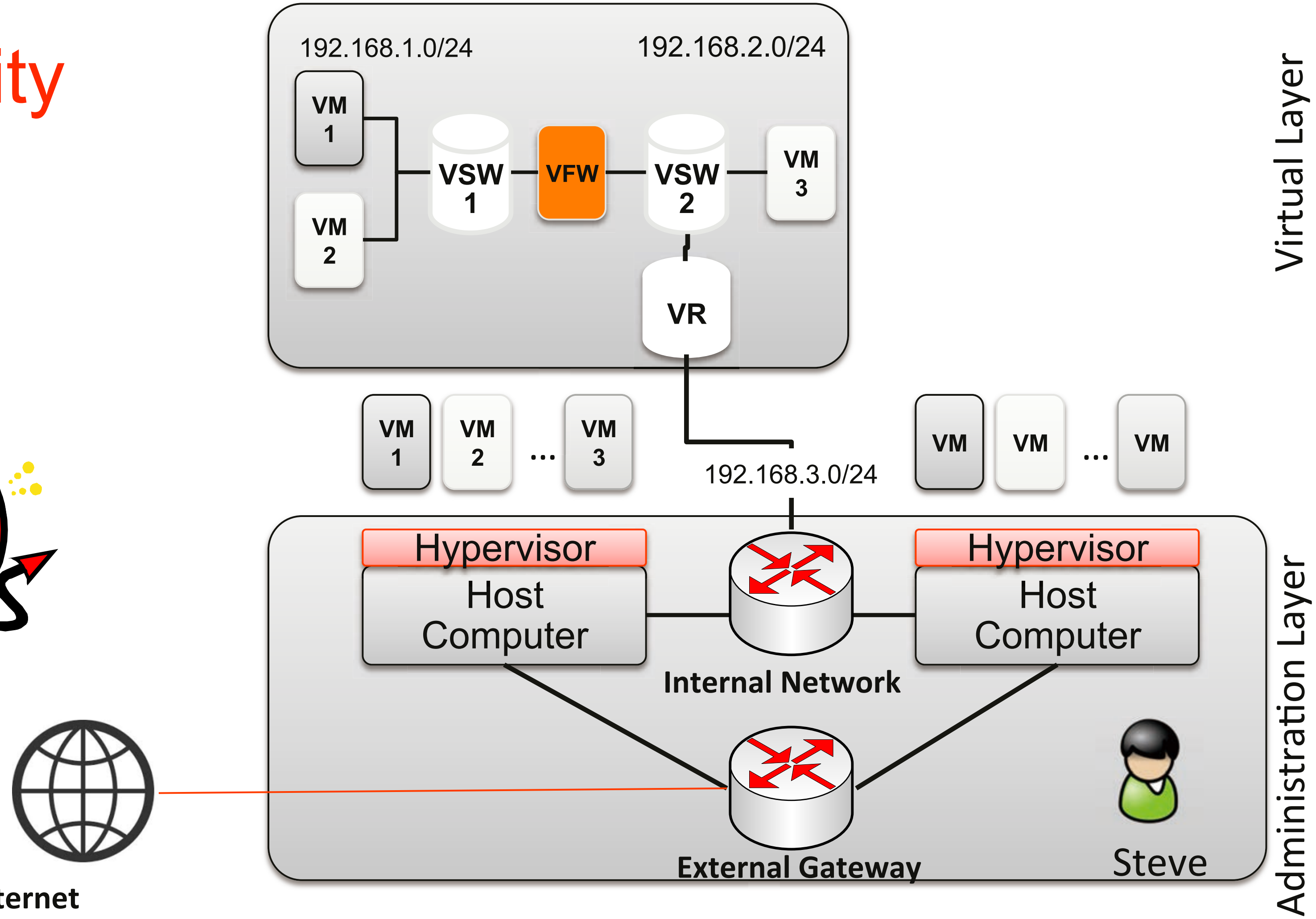
About the speaker

- PhD on a topic in cryptography, 1984
- Research on cryptographic algorithms & protocols, foundations of computer security, risk analysis
  - Container transport, German e-health card, now TRE$_S$PASS
- Course director, MSc in Information Security, Royal Holloway, University of London, 1992 – 1997
- Microsoft Research Cambridge, 1998 – 2003
- Chair for Security in Distributed Applications, Hamburg University of Technology, since 2003
- Now JSPS Invitational Fellowship at Kyushu University

Agenda

- My views on the intrinsic challenges in risk management
- Report on the way these challenges are addressed in the EU research project “Security is a people problem”
  - Be they part of the problem, be they part of the solution, people should be part of the model
- Acknowledgement: talk uses slides from project partners
- Talk gives my view, not necessarily the project’s view

From
IT security



Towards socio-technical systems

skills

goals

resources

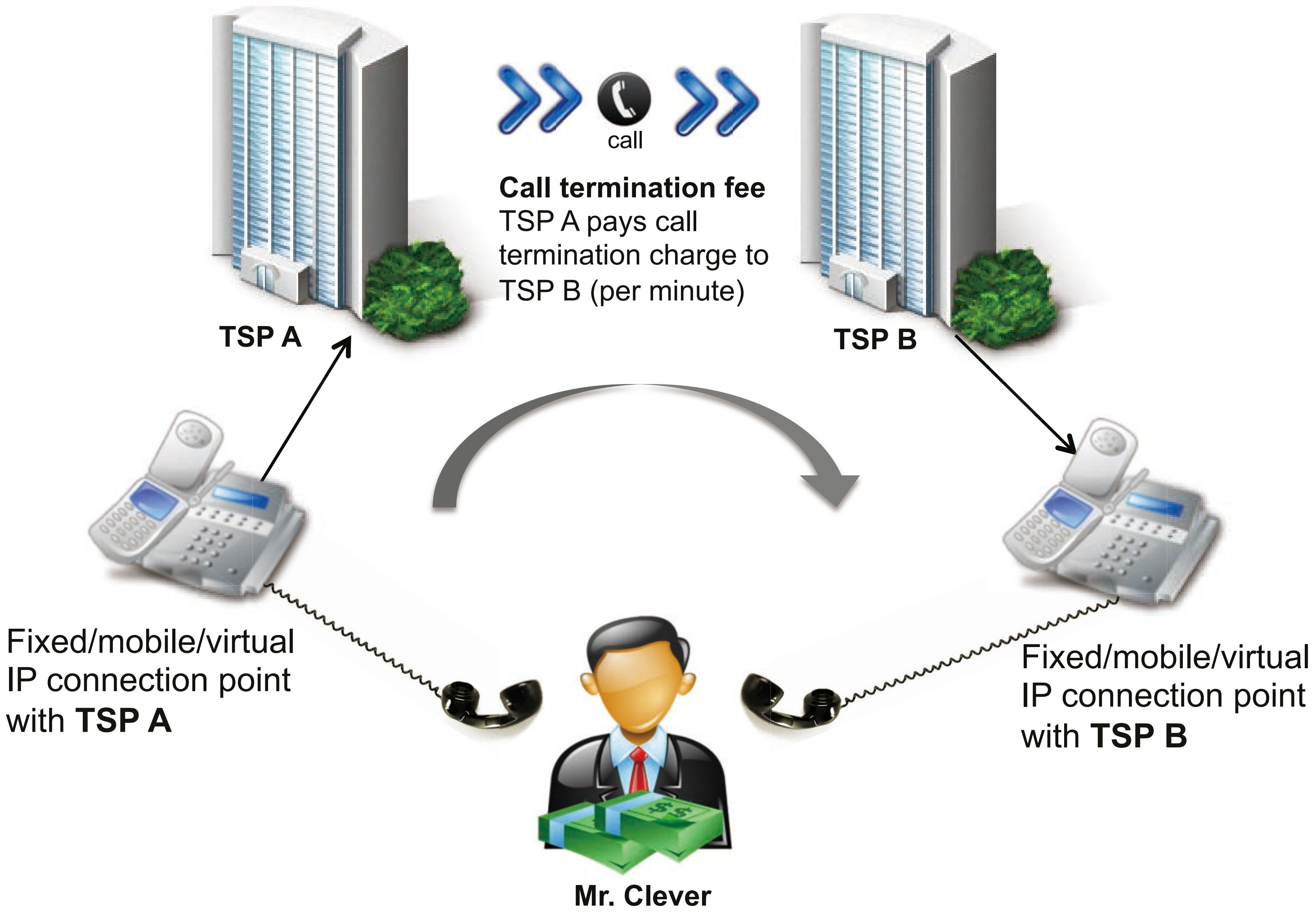
TRE$_S$PASS project 2012-2016

- EU FP 7 Integrated Project, funding ≈ € 10,000,000
- Seventeen partners, large companies, SMEs, academia
- Expertise ranges from visualization to model checking to criminology

TRE$_S$PASS use cases

- Use cases to guide the project
- Obtained from industry partners and industry contacts
- For validating methods and tools developed
- To pose new research questions

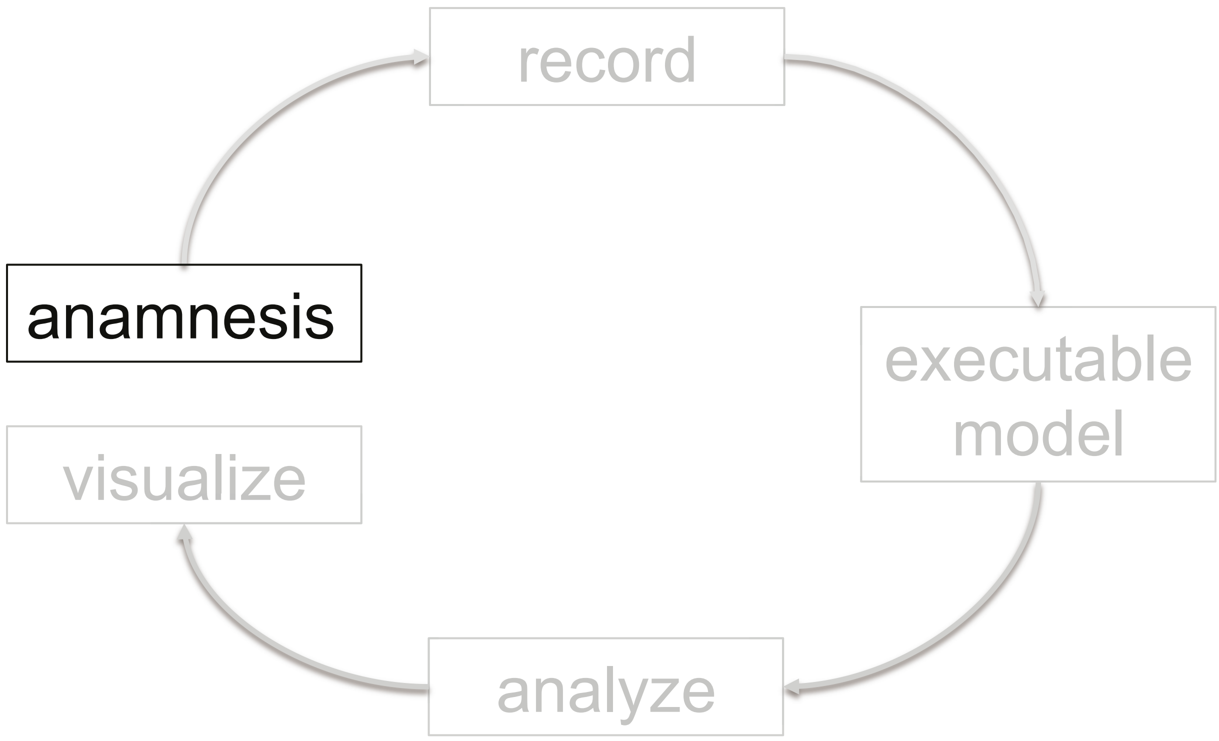
Parasitic business models
(tariff misuse of call termination)



Model-based risk management

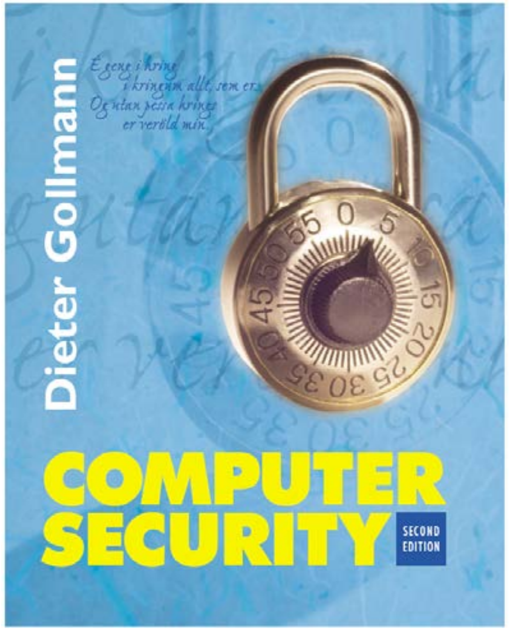
- Capture requirements – anamnesis
- Model system / organization, requirements, attacker
- Construct executable models
- Evaluate, analyze, communicate (visualize)
- Decide

Capture requirements



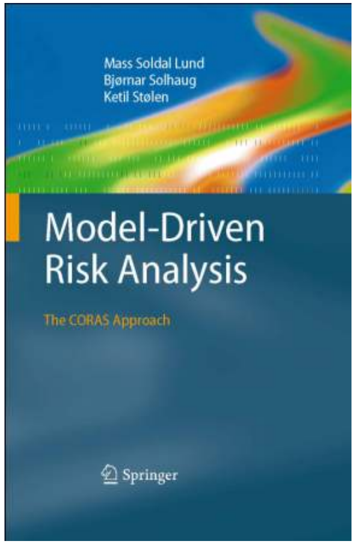
Fundamental dilemma of computer security

- **Security unaware** users have specific security requirements but usually no security expertise
- Risk management is communication
- How to get this communication started?



Facilitating communication

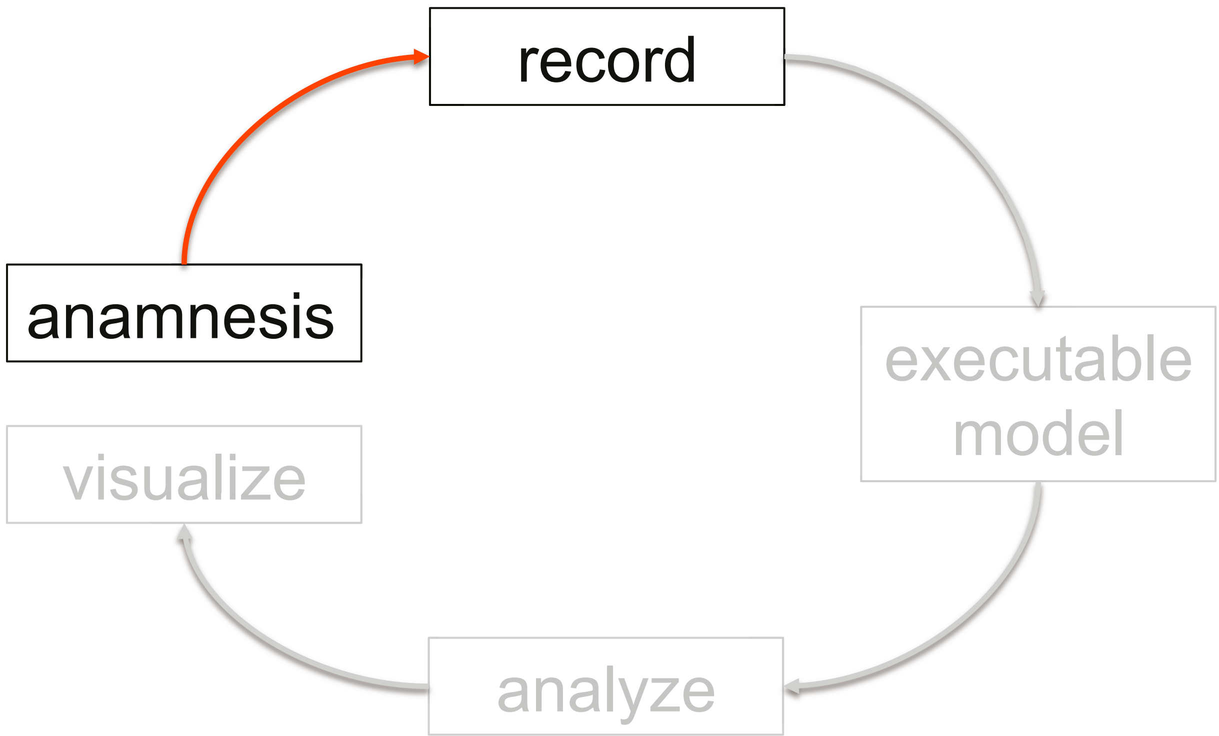
- CORAS: earlier EU project on model-based risk analysis
  - Stage 1: staff describes organization to security experts
  - Stage 2: security experts describe organization to its staff



- TRE$_S$PASS
  - Explores use of Lego building blocks in brainstorming sessions

http://heim.ifi.uio.no/~ketils/coras/index.htm

Model organization



Fundamental challenge in model-based risk analysis

- **Capturing and aligning two intrinsically different views of a system, the operator’s view and the attacker’s view**

- Operator’s view framed by intended use of the system
  - Includes features relevant for describing operation of the system
  - May include defenses against anticipated types of attacks
- Attacker’s view
  - Can be approached in two ways

Attacker's view – 1

- Extend operator's view: attack points and attack patterns
  - Alignment of the two views is comparatively easy
  - View on attacks may be blinkered by too much familiarity with intended use of the system ("Betriebsblindheit")
  - May miss attacks exploiting features outside of the system model
- Artful attackers explore gaps between operator's model and actual system to find levers for an attack
  - If it is provably secure, it probably isn't [Lars R. Knudsen]
  - Models are abstractions; gaps MUST exist

Attacker’s view – 2

- Create attacker’s view independently of operator’s view
- Some information about the system must be available
- Attacks identified at this stage may turn out to be infeasible because of specific features of the system under analysis that had not been considered
  - “But this attack is not possible because …”
  - System model needs to be refined
- Aligning the two views tends to be more challenging

TRE$_S$PASS system model
(operator's view)

- Represented as a directed graph
- Nodes can be
  - Locations, in physical space (e.g. rooms) or in cyberspace (e.g. network nodes, virtual machines)
  - Actors, e.g. people and processes; these nodes can move
  - Assets, can be attached to locations or actors, can be annotated with metrics
- Edges define various physical and logical connections
- Description language with formal semantics

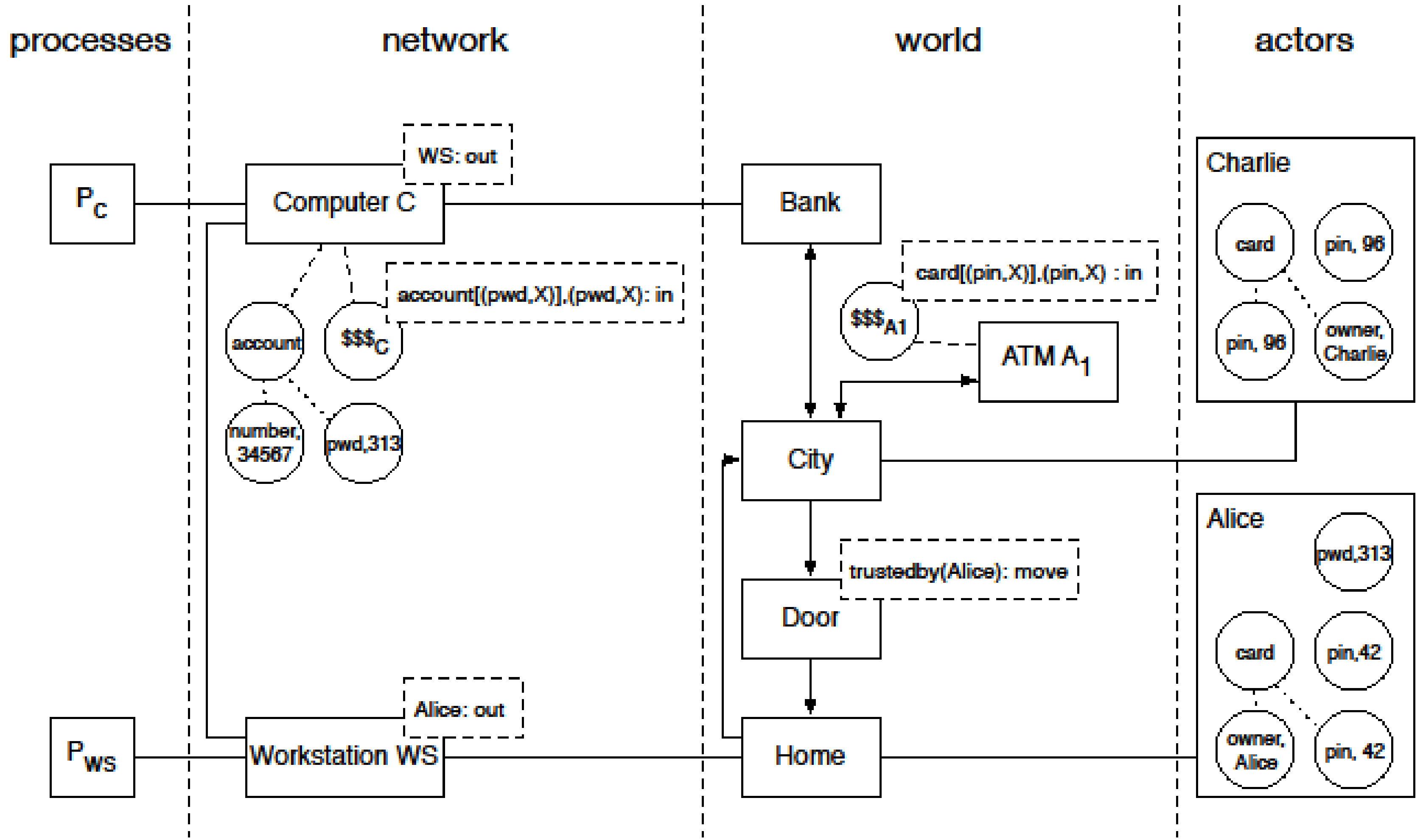
TRE$_S$PASS system model – quantities

- For actions, time to perform action, risk of detection when performing it, and cost of performing it
- For actors, likelihood of a social engineering attack to be successful and risk appetite of actor
- For locations, risk of detection at this location (for example due to surveillance cameras)

TRE$_S$PASS system model
– behavior and policies

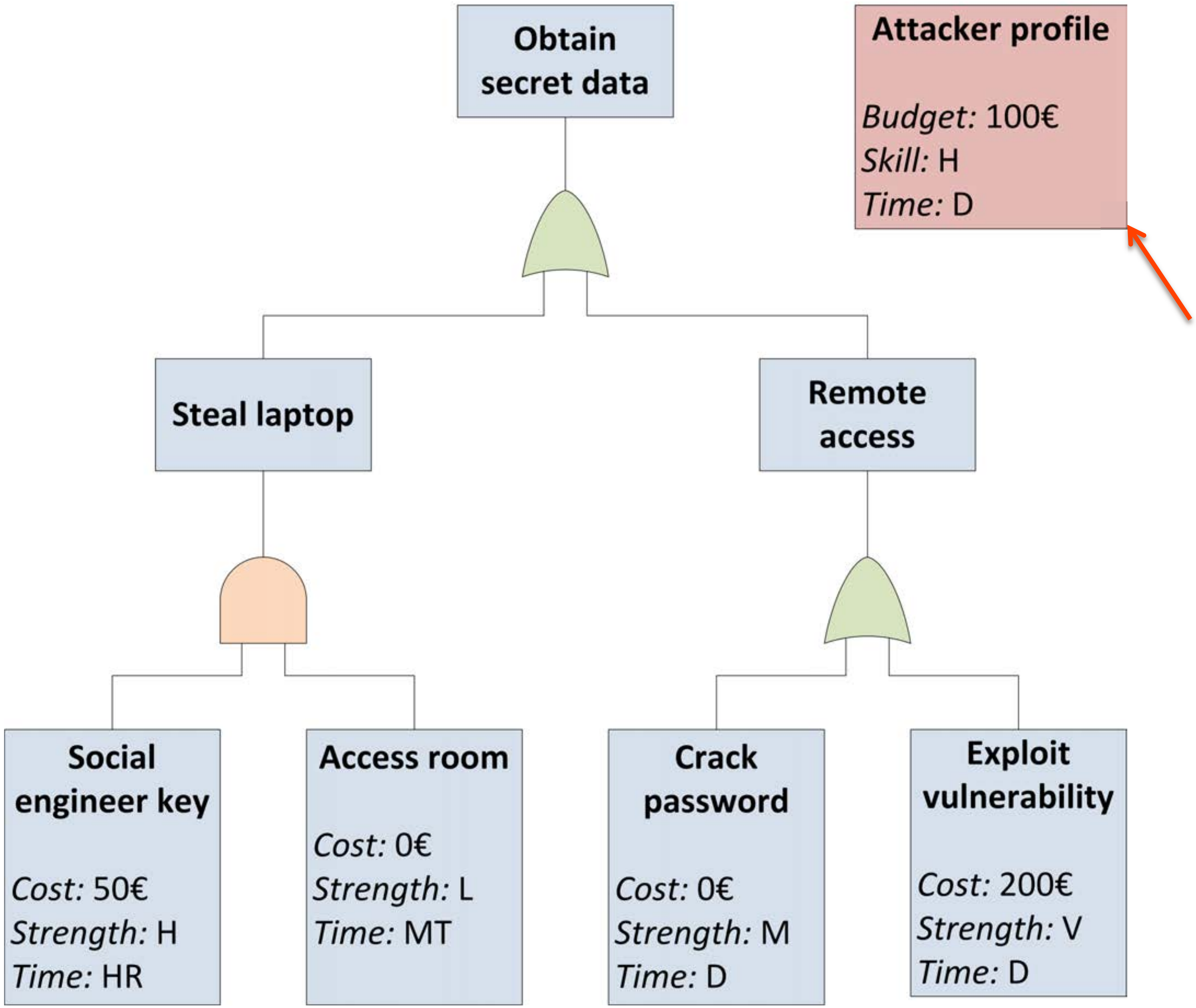
- Domains limit where processes can move
  - Human actors restricted to room nodes, computer processes restricted to network nodes
- Possible to define the behavior of actors
- Policies, both access control policies and security goals
  - “To access the account, a PIN is required”
  - “This data item must remain confidential”
- Attacks treated as policy violations

TRE$_S$PASS system model – example

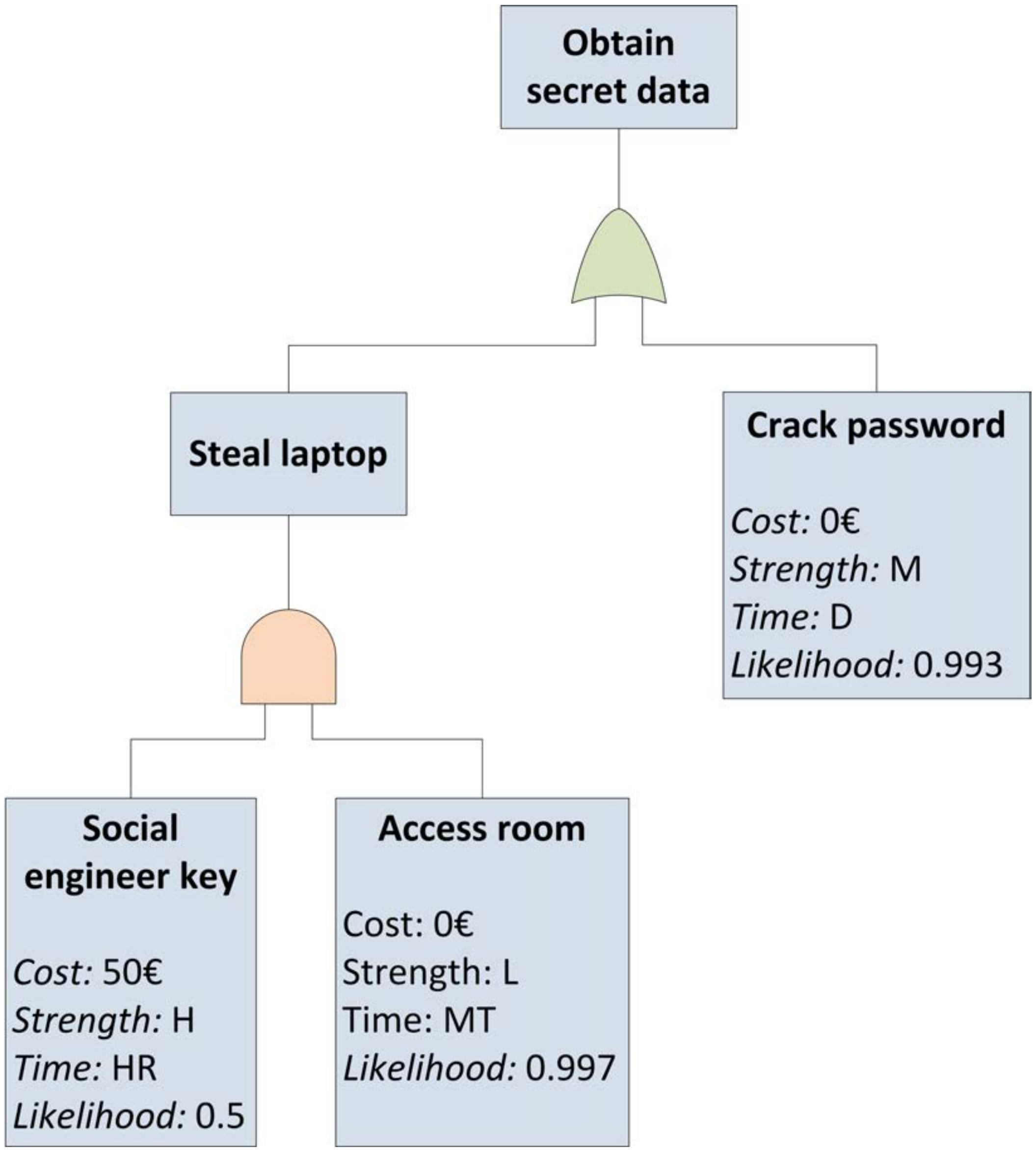


Attacker's view

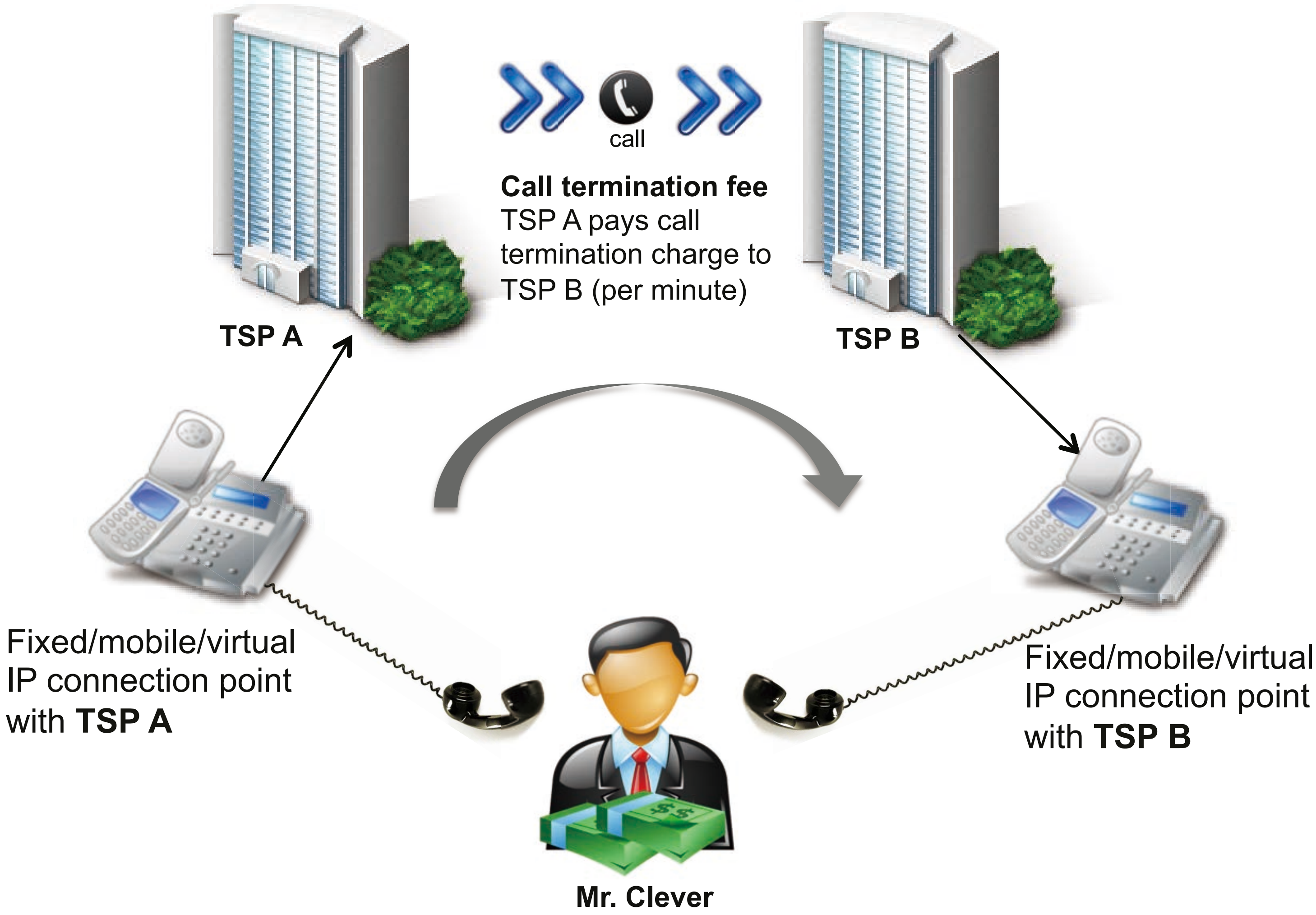
- Attack trees for structuring brainstorming about attacks
- Attack tress augmented with
  - Attributes: likelihood, cost, time, skill level, …
  - Defense nodes (attack-defense trees, also work in TRE$_S$PASS)
- Tool support (also work in TRE$_S$PASS, ADTree tool)
- E.g. pruning of trees with respect to attacker profiles



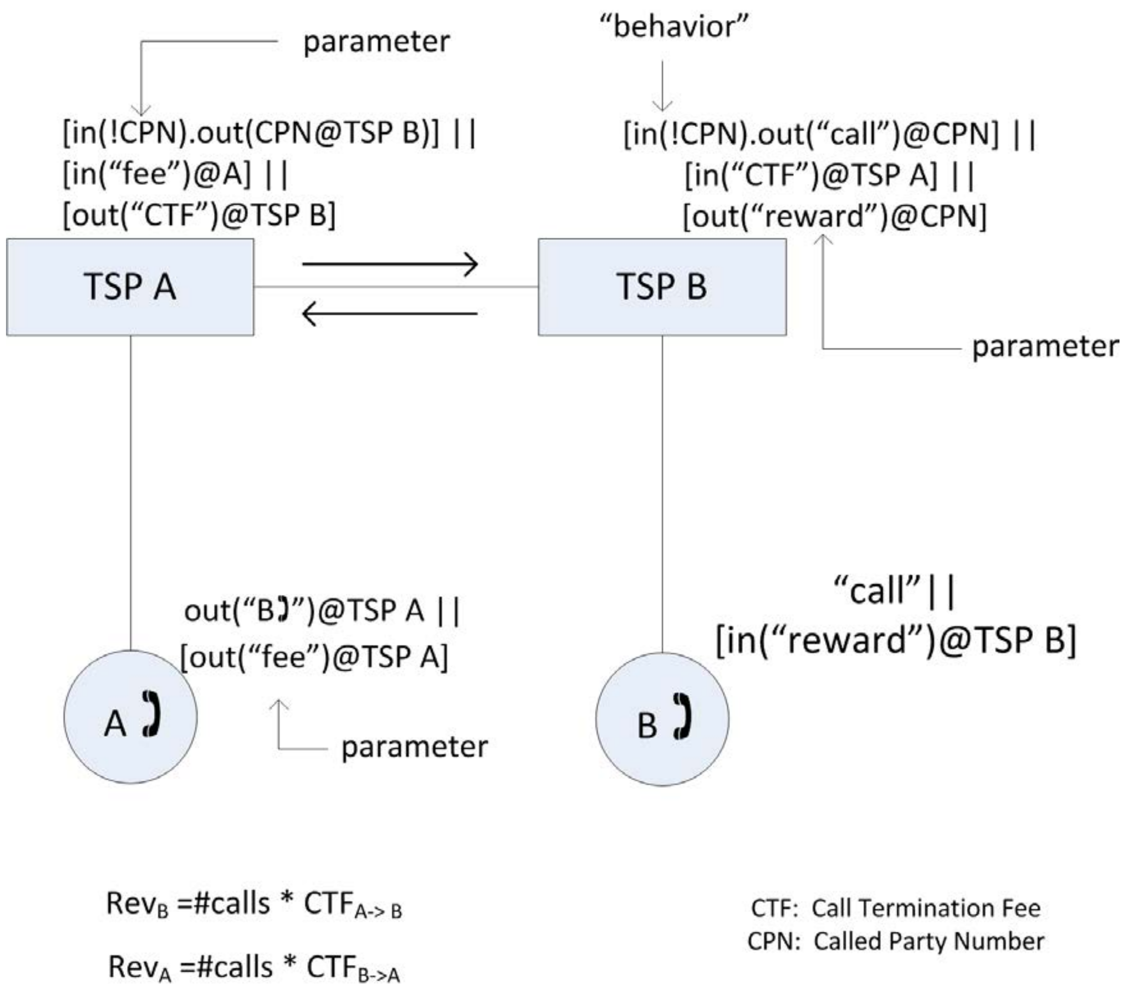
Obtain secret data
Attacker profile
Budget: 100€
Skill: H
Time: D
Steal laptop
Remote access
Social engineer key
Cost: 50€
Strength: H
Time: HR
Access room
Cost: 0€
Strength: L
Time: MT
Crack password
Cost: 0€
Strength: M
Time: D
Exploit vulnerability
Cost: 200€
Strength: V
Time: D


Obtain secret data
Steal laptop
Crack password
Cost: 0€
Strength: M
Time: D
Likelihood: 0.993
Social engineer key
Cost: 50€
Strength: H
Time: HR
Likelihood: 0.5
Access room
Cost: 0€
Strength: L
Time: MT
Likelihood: 0.997

Parasitic business models
(tariff misuse of call termination)



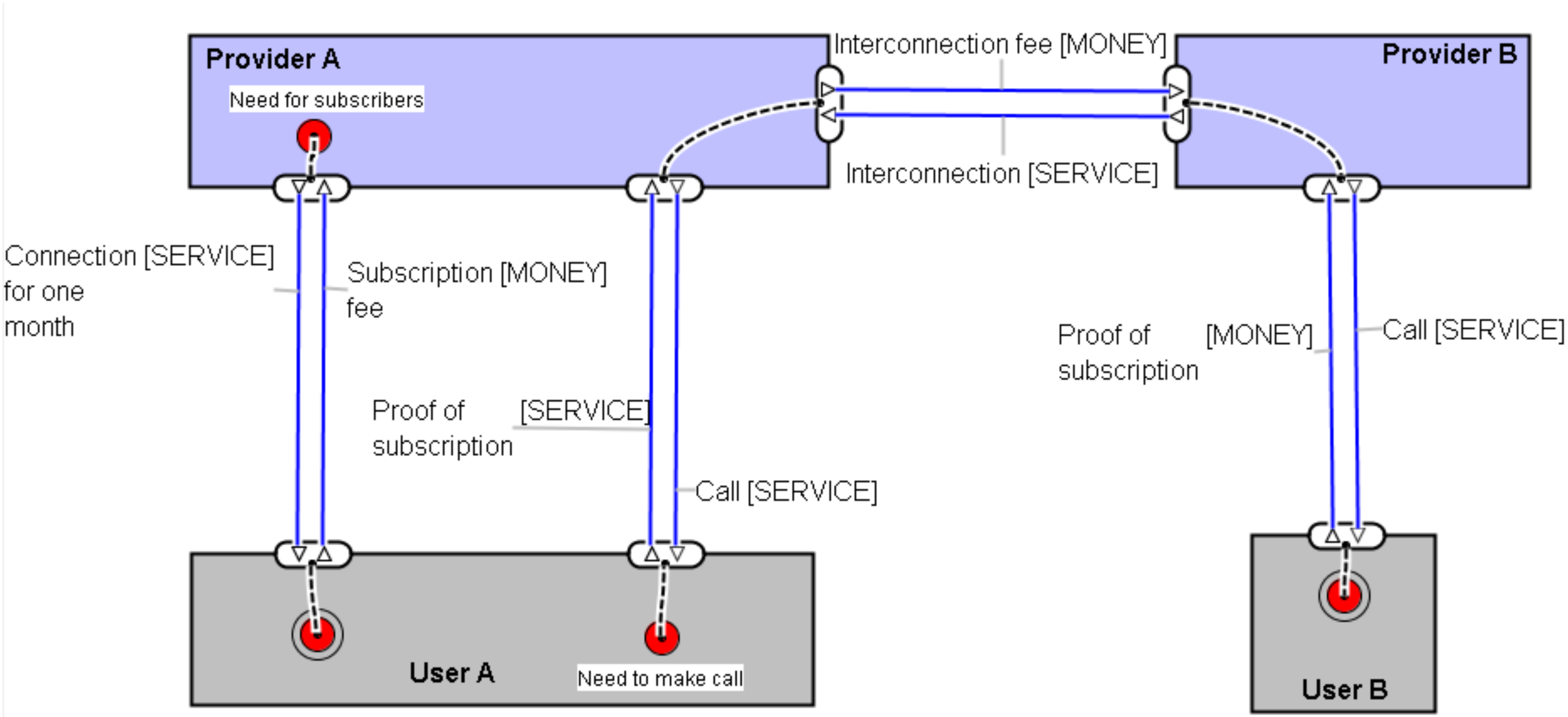
TRE$_s$PASS model



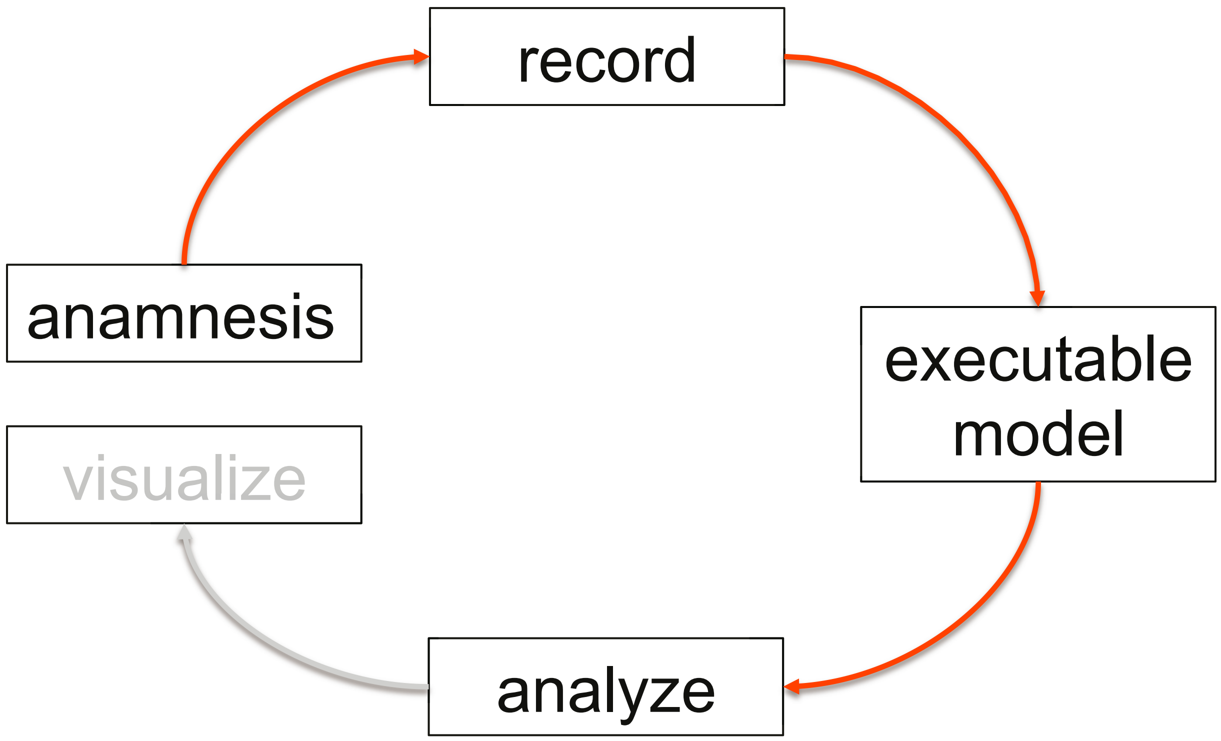
Actions	Description
in	Waiting for incoming action
out	Outgoing action to other actors

Operators	Description
!	Waiting for an input
dot(.)	Sequential actions
||	Executing actions in parallel
@	"from" where the action is performed

Value modelling using e3fraud



Analysis



Fundamental challenges in analysis and evaluation

- How to deal with uncertainty?
- How to deal with complexity?
- How to deal with dependencies?
- How to achieve completeness?

Uncertainty

- How to model uncertainty?
  - Subjective probabilities (Bayesian approach)?
  - Frequencies (frequentist approach)?
  - Other mathematical frameworks, fuzzy theory, etc.?
- Do we have the data and do probabilities work at all?
  - Expectations that mandatory reporting will improve the situation
  - Current disillusion in the UK about data-driven approach
  - "We had lots of data on the financial markets but did not foresee the crisis of 2008 …"
  - "In security the past is a poor indicator of the future!"

Complexity

- Divide-and-conquer is a powerful strategy
  - E.g., attack trees break down a high-level goal into basic actions
  - Easier to assign metrics to basic actions than to high level goals
- How to return from divide-and-conquer?
  - Methods for combining metrics for subsystems to achieve compositionality
- How to deal with dependencies?

Completeness

- How to avoid missing out on attacks?
- Brainstorming is a creative but informal process, may miss attacks that are obvious in hindsight
- TRE$_S$PASS explores the use of model checking for systematic attack discovery

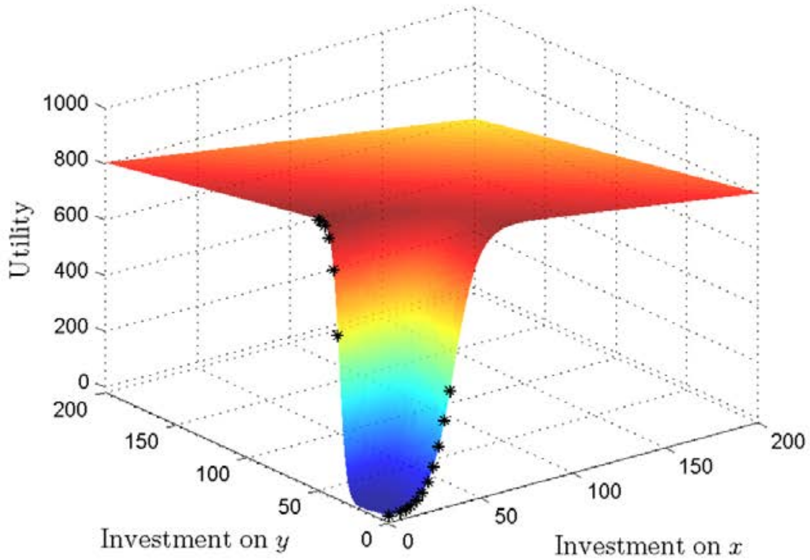
TRE$_S$PASS analysis methodology

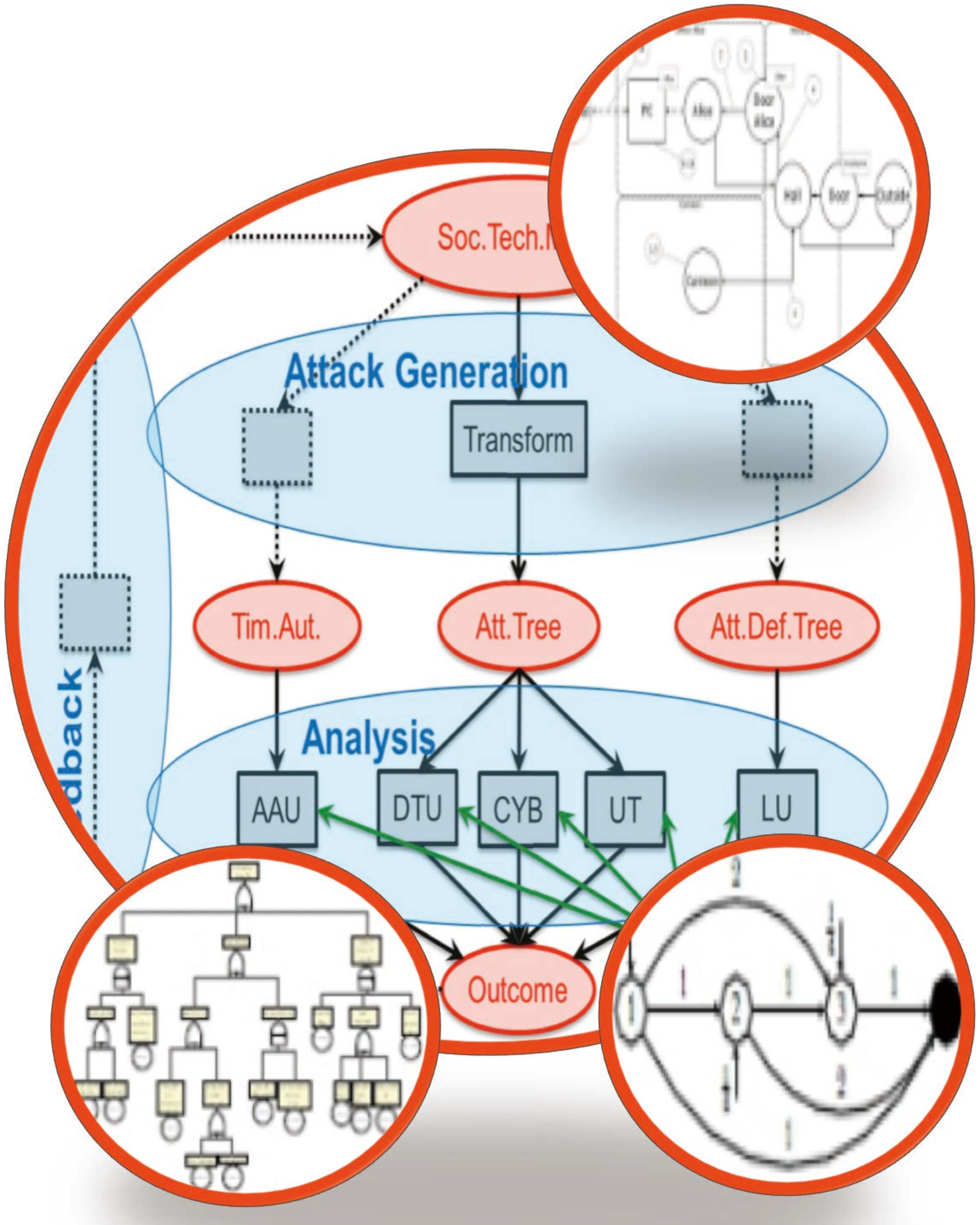
- Start from an attack tree
- Convert attack tree into an executable stochastic model
  - Interactive Markov chains
  - Markov automata (choice + time-dependent success probability)
  - Priced (weighted) timed automata (basis for model checking)
- Check for security properties in the executable model
  - Ideally, cover all possible executions of the system

TRE$_S$PASS analysis methods (sample)

- Computational analysis methods for attack trees
  - Extended to attack-defence trees
  - Pareto-optimal solutions considering multiple attributes
- Statistical model checking of timed automata
  - Derive results from several simulations of the system
  - Scales better than normal model checking
  - Deals with uncertainties in input values
- Model checking for policy violations
  - Delivers attack traces if a violation is found
  - Deals with completeness

Analyse


1000
800
600
400
200
0
Utility
200
150
100
50
0
Investment on y
0
50
100
150
200
Investment on x


Soc.Tech.
Attack Generation
Transform
Tim.Aut.
Att.Tree
Att.Def.Tree
Analysis
AAU
DTU
CYB
UT
LU
Outcome
dback

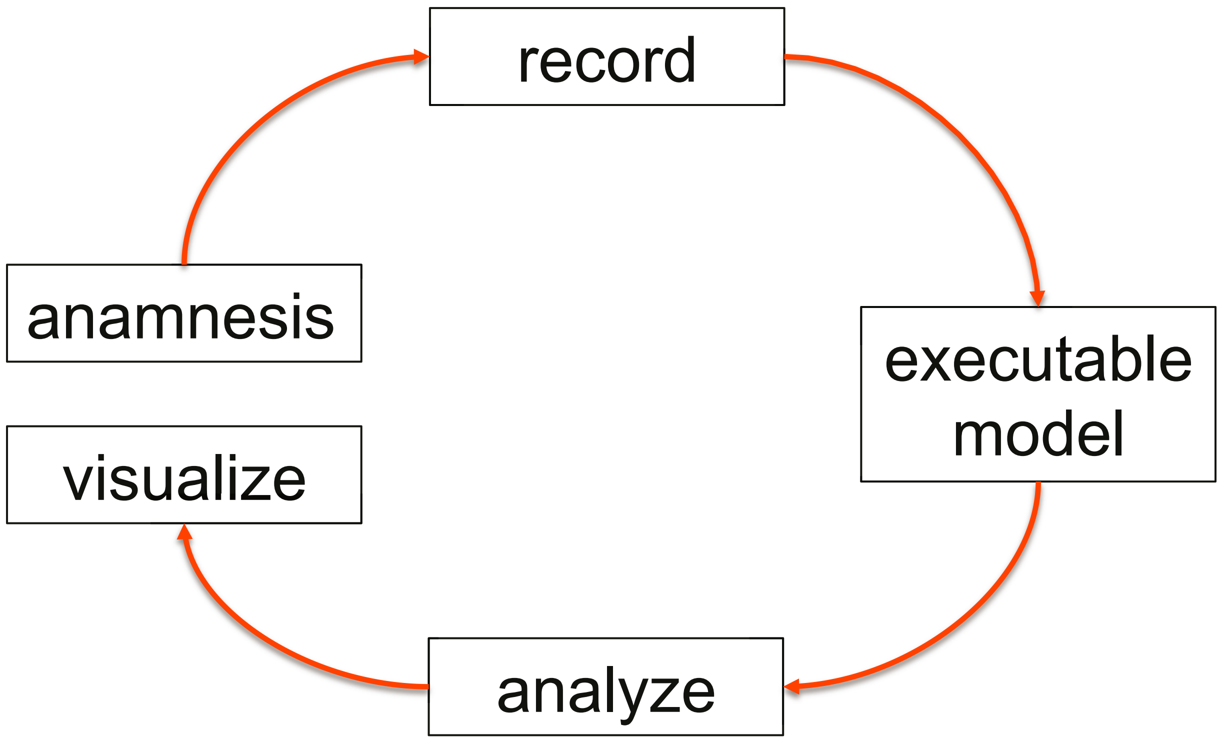
Understanding human actors

- Experiments on stealing laptops (in the past) and door keys (within TRE$_S$PASS) at Twente University
- Prevention campaign in key experiment significantly reduced vulnerability of people in an office environment
- Key-fob reduced cases of handing over a key to an attacker from 62.5% to 37%

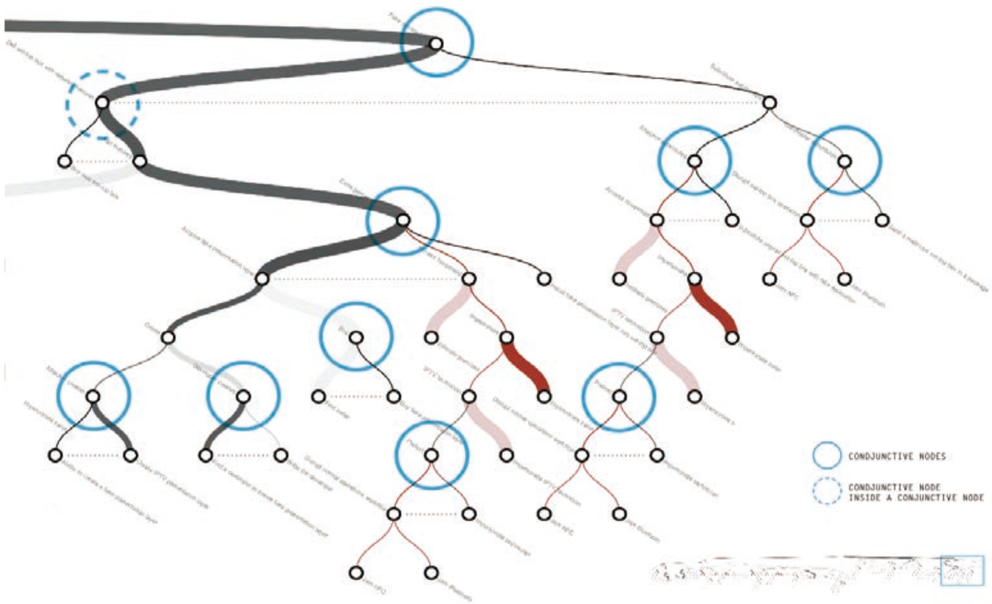
Cues and warnings experiment

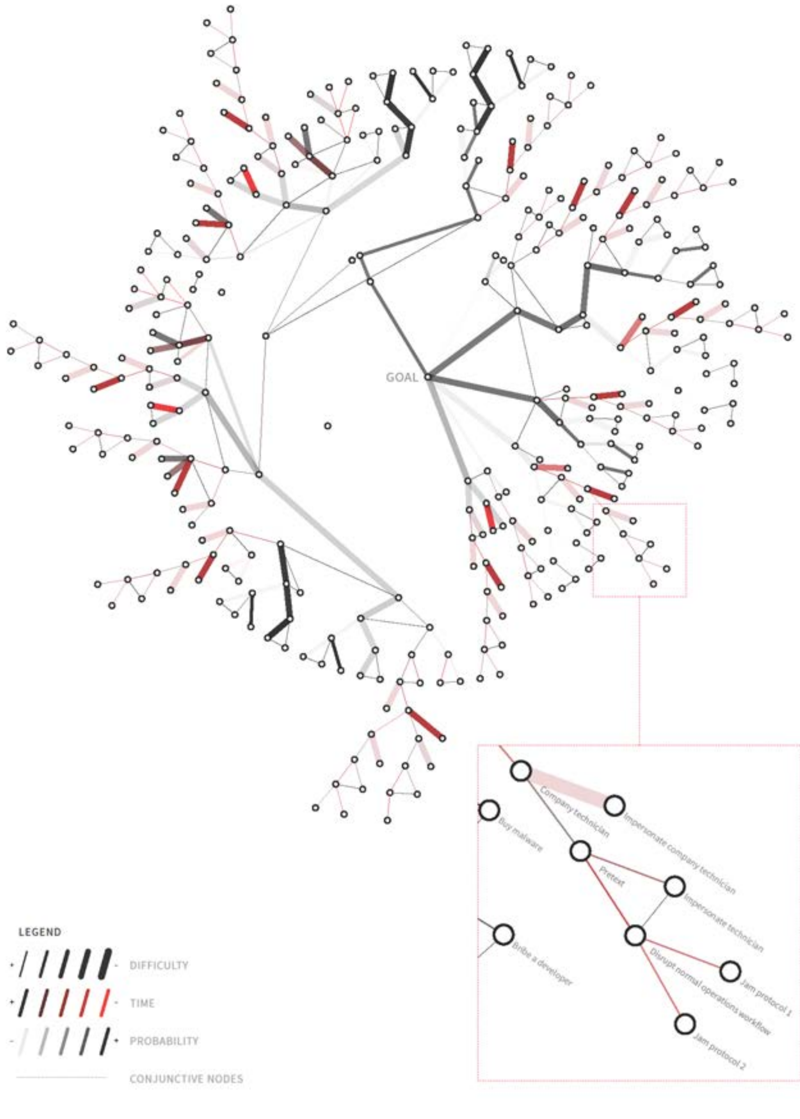
- Asked people in a shopping mall for email address, half of bank account number, data on online shopping
- Cues to cybercrime didn't reduce cases of revealing data
- Warning leaflet decreased revealing of emails addresses but not of bank account information or online shopping
- Differences due to changes in context, from a quiet office environment to a square in a shopping mall?
  - J-W. Bullée et al.: The persuasion and security awareness experiment: reducing the success of social engineering attacks

Visualize



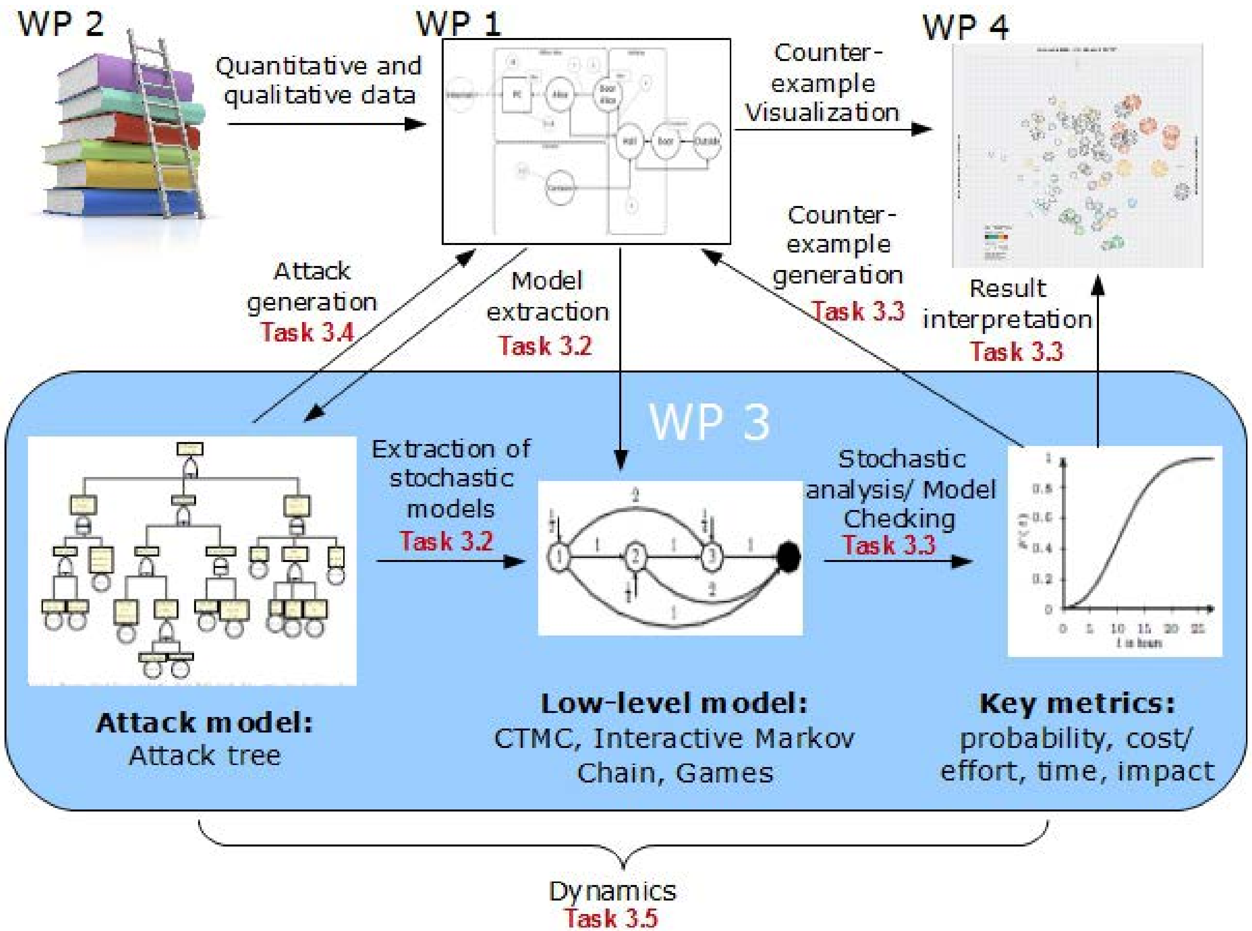
Visualise


CONJUNCTIVE NODES
CONJUNCTIVE NODE INSIDE A CONJUNCTIVE NODE


GOAL
LEGEND
DIFFICULTY
TIME
PROBABILITY
CONJUNCTIVE NODES
Company technician
Impersonate company technician
Buy malware
Pretext
Impersonate technician
Bribe a developer
Disrupt normal operations workflow
Jam protocol 1
Jam protocol 2

Conclusions

TRE$_S$PASS work flow

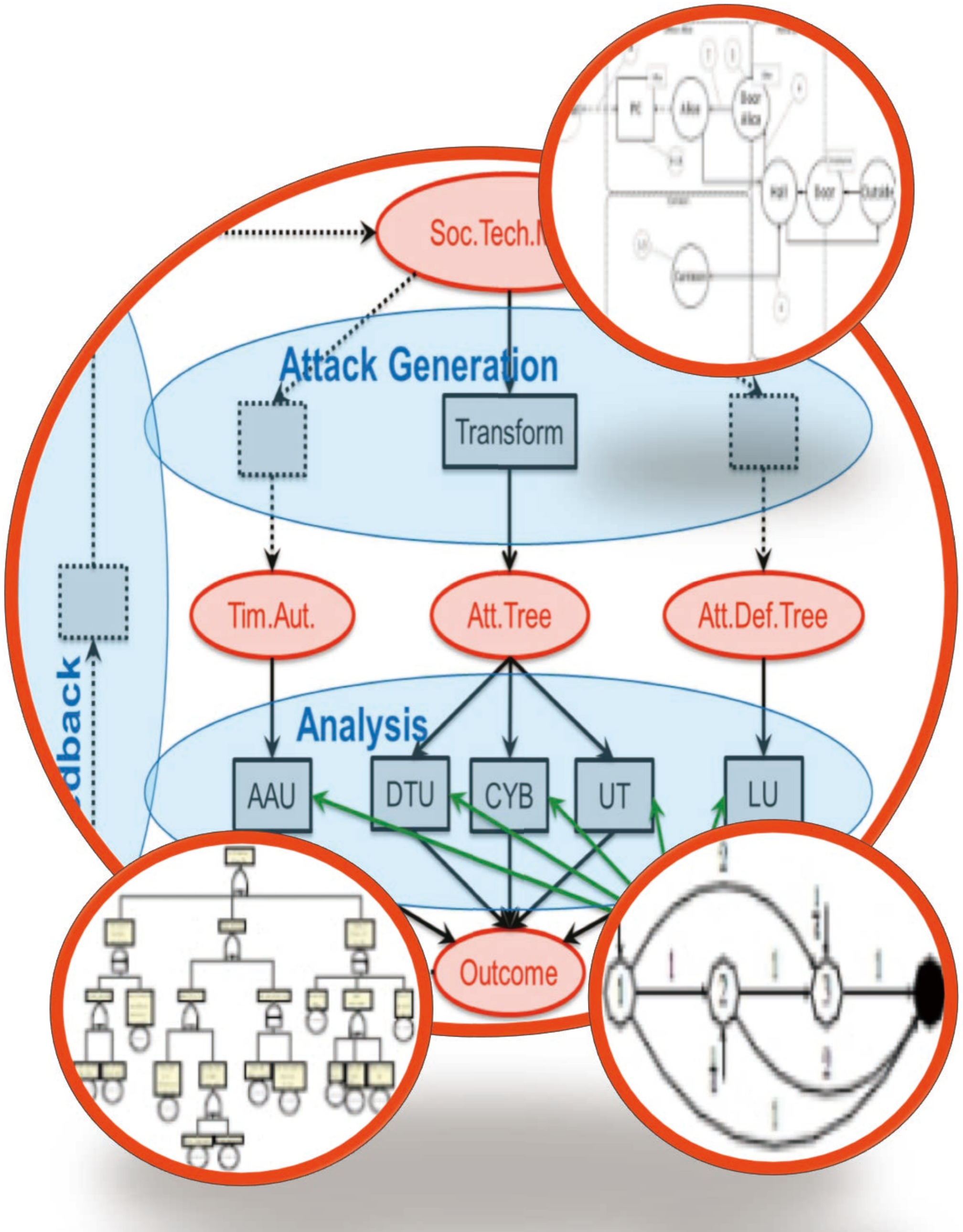


Innovation 1

- A **process methodology** to support risk analysis in socio-technical environments

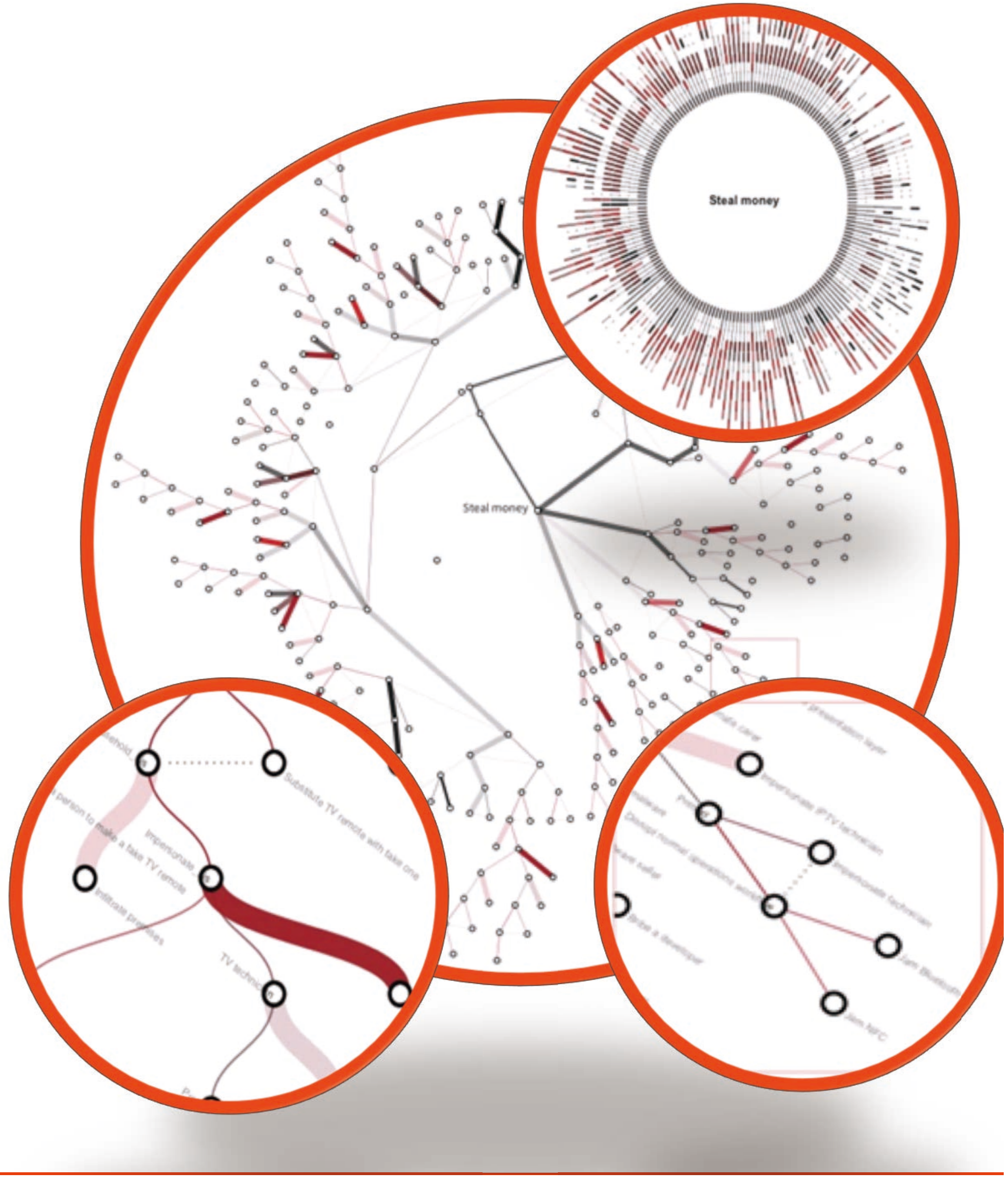
Innovation 2

- New and improved attack navigation **tools** to support these risk analyses of socio-technical attacks
- A portfolio of tools – not a single tool chain
- Many extensions of open source tooling



Innovation 3

- New **visualisation techniques** to enhance the presentation of complex socio-technical attacks
- Designed to :
  - Highlight important information
  - Better scalability



Summary

- TRE$_S$PASS includes human actors in its models
- Attack tress currently constructed manually, automatic generation under consideration
  - But would this be sufficient for capturing attacker's view?
- TRE$_S$PASS moves risk management from descriptive models to executable models
- Validation of methods in various case studies with industrial partners, more in the final project year

Next dissemination event

January 13-15, 2016	TREsPASS winter school on Security in Socio-Technical Systems

- Organizers: Christian W Probst, Rene Rydhof Hansen
- Technical University of Denmark, Campus Lyngby
- http://winterschool2015.trespass-project.eu/

Security by design is an oxymoron

- Core question: is data driven analysis right way forward?
  - TRE$_S$PASS started from this assumption but where can it get us?
- Is risk management about avoiding unforgivable vulnerabilities?
  - Automated tools are the way forward towards complete coverage of known attacks
- Is risk management about avoiding awkward surprises?
  - If you can predict something, it is no longer a surprise

Contact

predict
prioritise
prevent
TREsPASS

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Contact us to join our public mailing list!

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 318003 (TREsPASS). This publication reflects only the author's views and the Union is not liable for any use that may be made of the information contained herein.

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