Using evidence-based arguments to support dependability assurance – experience and challenges

(invited presentation)

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Workshop on Challenges and New Approaches for Dependable and Cyber-Physical Systems Engineering (DeCPS)
Warszawa, 14th June 2019, Poland

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- Leader of Information Assurance Group (IAG) – a research group at Department of Software Engineering, Faculty of Electronics, Telecommunications and Informatics, Gdansk University of Technology (http://iag.pg.gda.pl/)
  - Focusing on trust and risk management of computerized systems and services
    - Trust-IT methodology and the NOR-STA tool supporting application of evidence-based arguments to analyse and demonstrate asurance and compliance
- Proxy of ARGEVIDE sp. z o.o. – a spin-off of GUT
- Present involvement
  - EWICS Security (European Workshop on Industrial Computer Systems) MED&SEC
  - ISA99 Committee (International Society of Automation)
  - ICCS/ERNCIP (IACS components Cybersecurity Certification Schemes)
  - IoTSec (Internet of Things Security)

IAG R&D related to evidence-based arguments and their applications

- Research
  - 1993– 1995 Project SHIP (Safety of Hazardous Industrial Processess), European Program ENVIRONMENT
  - 2001 – 2003 Project DRIVE (Drugs in Virtual Enterprise), 5th EU FR
  - 2004 – 2007 Project PIPS (Personalised Information Platform for health and life Services), EU 6th FR
  - 2006 – 2008 Project ANGEL (Advanced Networked Gateway to Enhance quality of Life), EU 6th FR
  - 2009 Project ERM (Selected Problems in Environmental Risk Management and Emerging Threats), Polish-Norwegian Research Fund
- Industrial trials
  - 2010-2014 – Project NOR-STA, European Regional Development Fund
- Commercialization
  - 2014- now, ARGEVIDE sp. z o.o. – a spin-off of GUT (www.argevide.com)
    - Customers in Oil&Gas, Medical, Maritime, Railways, Automotive and Aviation sectors

Acknowledgement (significant contributors to this R&D)

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Dr Aleksander Jarzębowicz, Dr Jakub Miler,
Dr Andrzej Wardziński, Michał Witkowicz (programmer)

Contents

- What are the *evidence based arguments* and what are they for?
- Selected challenges
  - Argument representation
  - Support for communication and co-operation
  - Argument assessment
  - Scalability and change management
  - Integration
  - Argument structuring and reuse
  - Composability
  - ’Living’ arguments
- Experiences from develping and deploying a tool for supporting evidence based arguments

Evidence-based argument
What is it?

POLITECHNIKA GDAŃSKA

Evidence-based arguments

- **Argument** is *an attempt to persuade someone of **something**, by giving reasons and/or evidence for accepting a particular conclusion*

  - **This 'something'** can be:
    - assurance of some important property (safety, security, privacy, reliability, …)
    - conformance with a stated set of criteria (standard, norm, directive, recommendation and so on)
    - **…**

- **EXAMPLE ARGUMENT**

  Tests confirm that this software module satisfies its requirements because test results are positive and the test coverage is sufficient

Evidence-based arguments

- **Evidence** in its broadest sense *includes everything that is used to determine or demonstrate the truth of an assertion*.
  - Evidence can be used in arguments – to demonstrate the truth of the premises

EXAMPLE ASSERTION: It is raining outside

EVIDENCE:

Assumption:
Evidence is delivered in electronic documents of any form: text, graphics, image, video, audio etc.

*.txt, *.doc *.xls *.jpg *.mp3, *.pdf, *.mp4, …

A case study:
Evidence based argument about quality of a software module

Tests confirm that this software module satisfies its requirements because test results are positive and the test coverage is sufficient

Strategy of argumentation:

Argumentation by referring to test results and test coverage

Rationale:

Experience shows that positive results of tests of adequate coverage reliably demonstrate fulfillment of the requirements

Logic part

Claim:
Module meets requirements

Strategy of argumentation and its rationale

Fact:
adequate coverage and positive test results

Evidence:

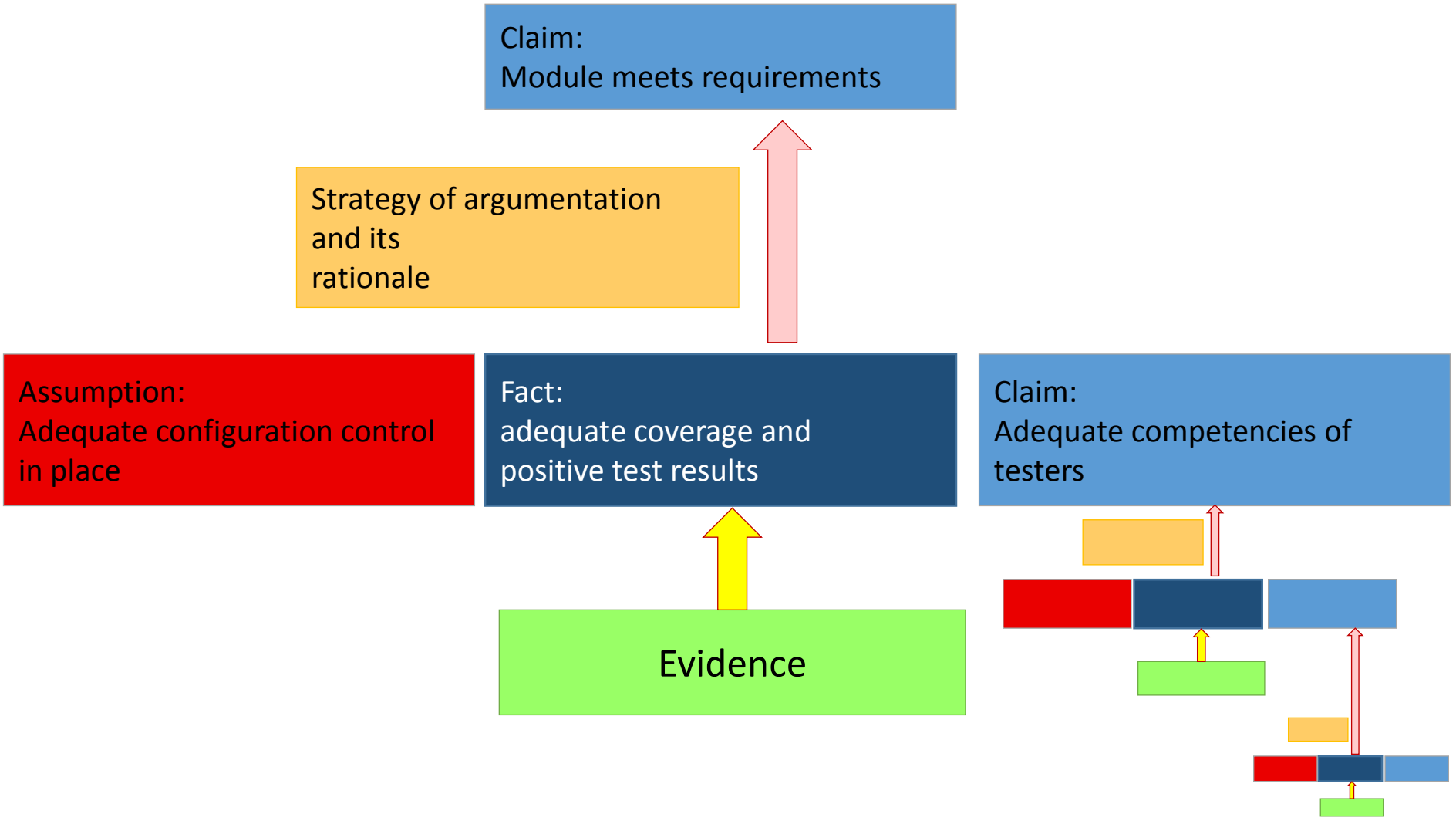
Demonstrates the fact about test results and test coverage

Epistemic part

Fact:
adequate coverage and positive test results

Evidence

A case study:
Evidence based argument about quality of a software module



Evidence-based arguments What are they for?

Argument and trust

Convincing arguments can be used to build trust

- ***because they demonstrate trustworthiness***

Such arguments we call *Trust Cases*

Example:

A convincing (supported by evidence) argument that a service is secure increases trust in the service

Evidence:

protective measures used,
certification procedures passed,
penetration tests results,
operating data,
development practices used …

Different types of trust cases

Assurance Cases

safety, security, privacy, dependability, reliability ...

Conformance Cases

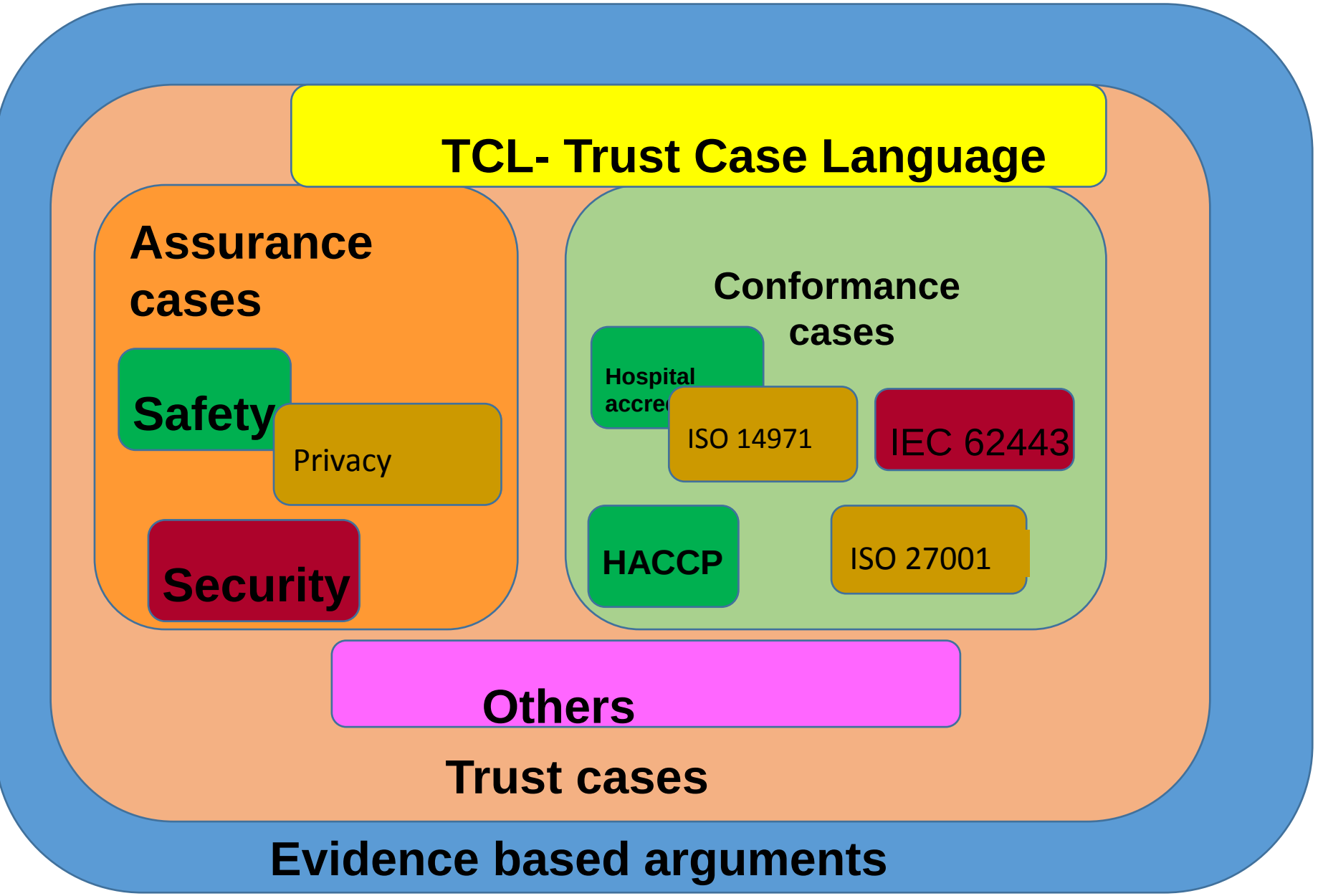
standards, norms, directives, regulations ...

Metaphysical Cases

e.g arguing the existence of Santa Claus

and others…

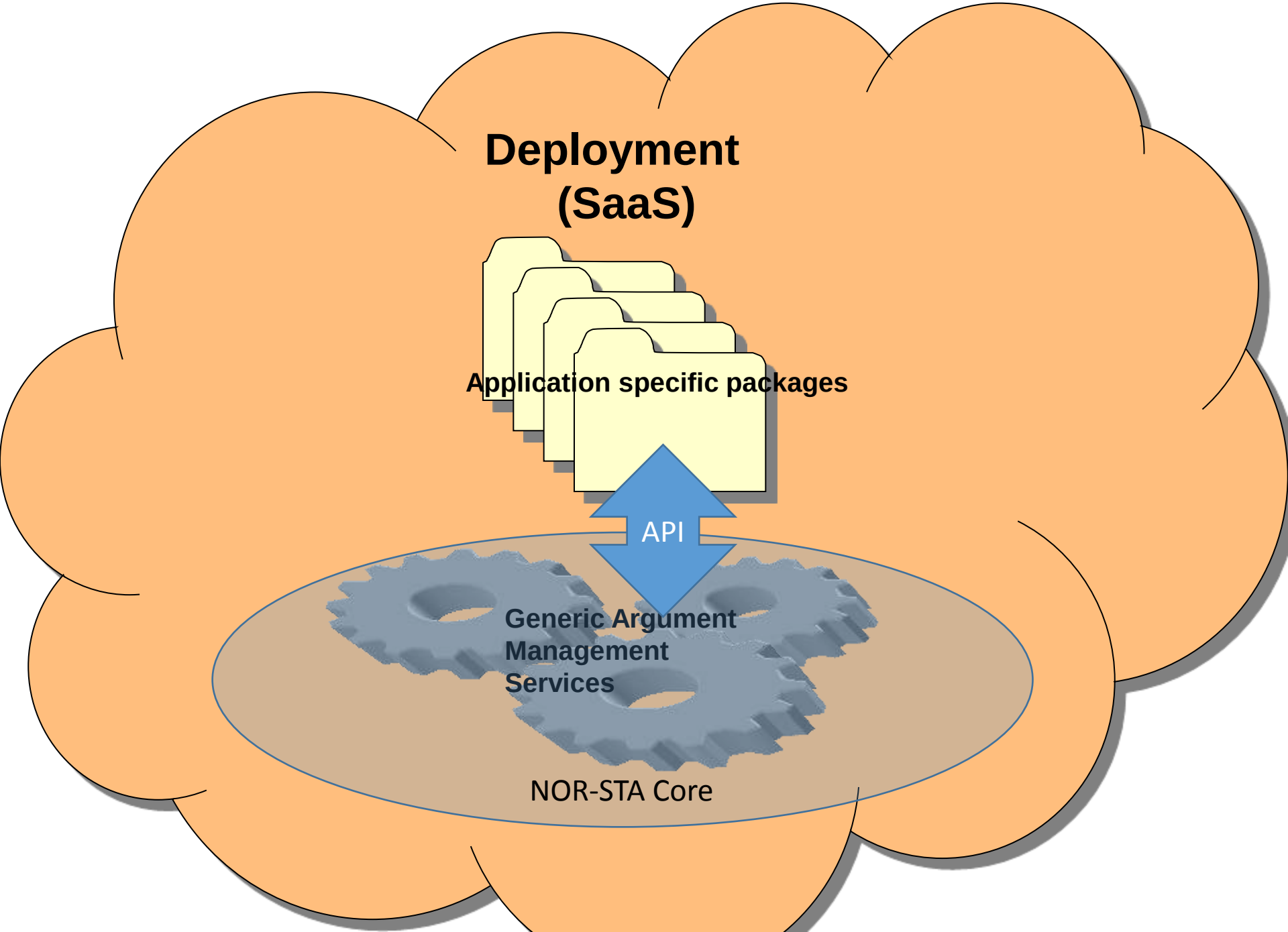
Trust-IT and NOR-STA


TCL- Trust Case Language
Assurance cases
Safety
Privacy
Security
Conformance cases
Hospital accre
ISO 14971
IEC 62443
HACCP
ISO 27001
Others
Trust cases
Evidence based arguments

trust-it

Trust cases

Evidence based arguments

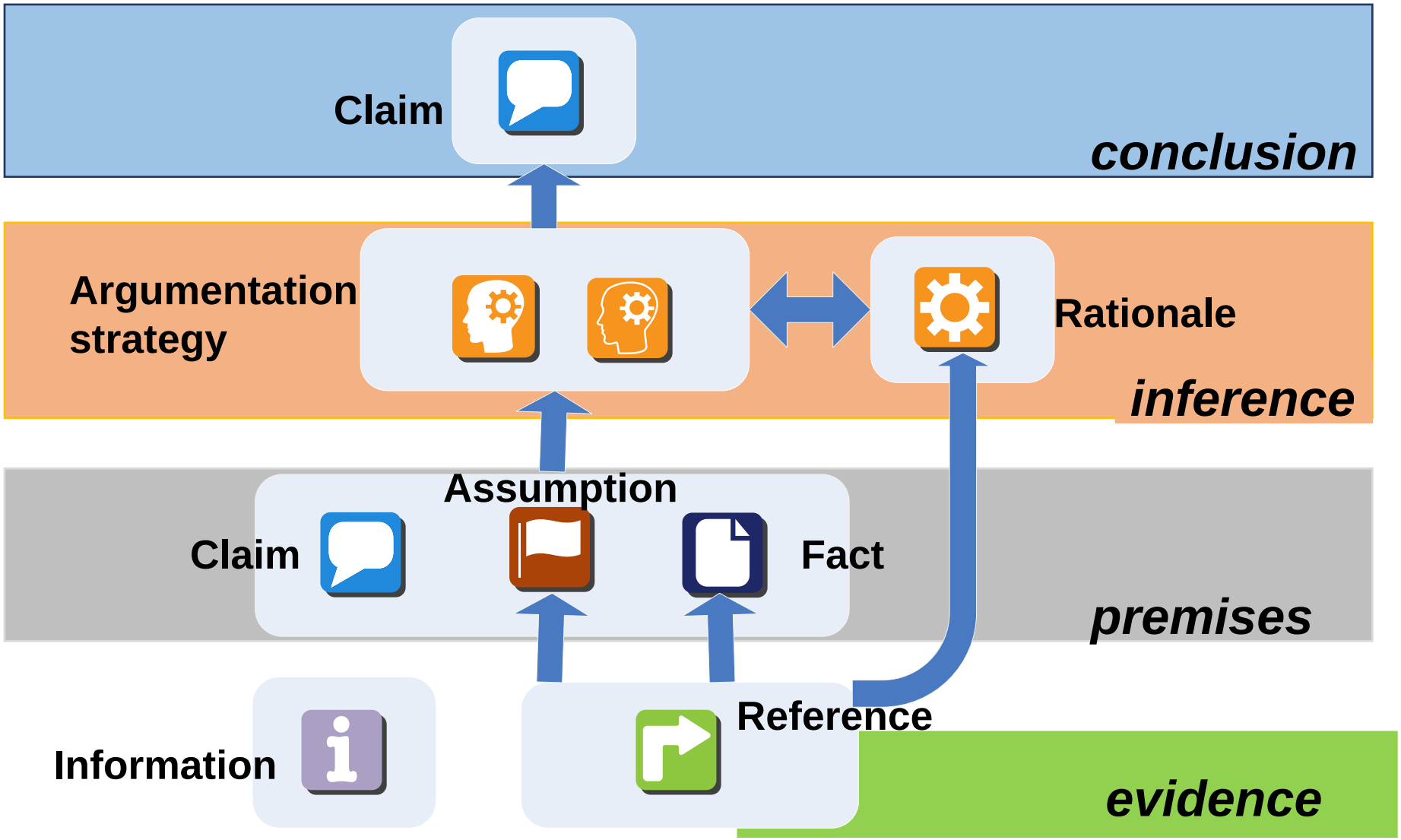

Deployment
(SaaS)
Application specific packages
API
Generic Argument
Management
Services
NOR-STA Core

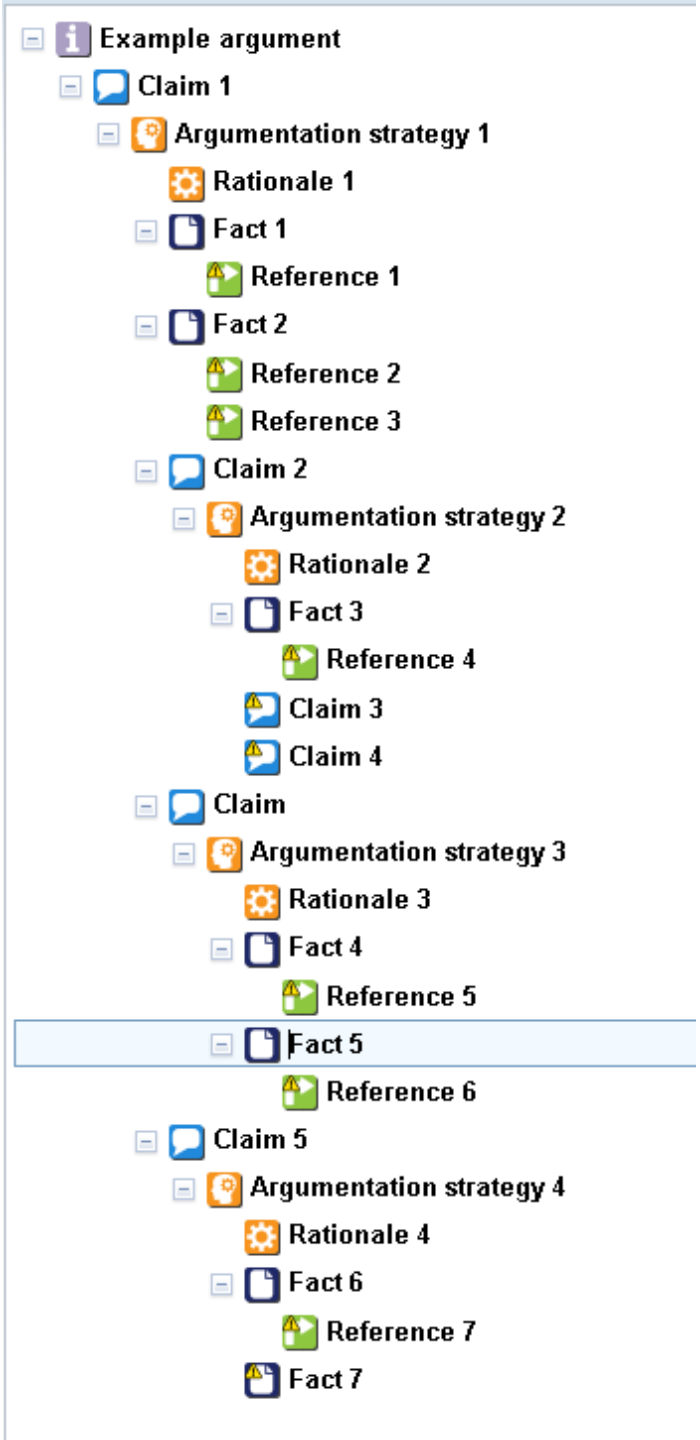
nor-sta

(Selected) challenges and experiences

Represenatation

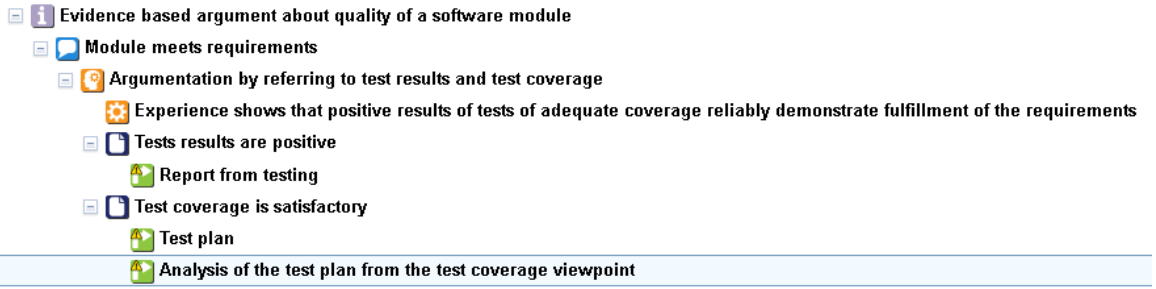
Trust Case Language (TCL)
and the underpinning argument model


Claim
conclusion
Argumentation strategy
Rationale
inference
Assumption
Claim
Fact
premises
Information
Reference
evidence

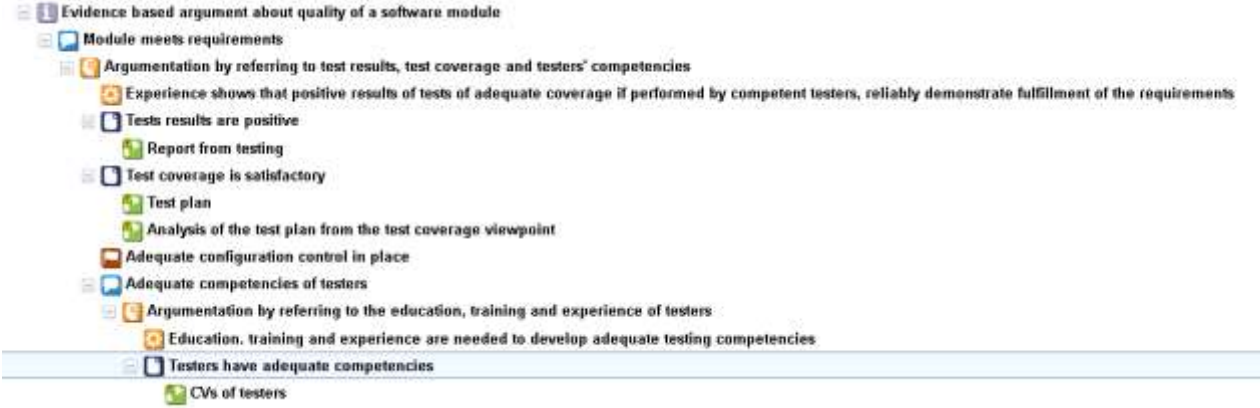

Example argument
Claim 1
Argumentation strategy 1
Rationale 1
Fact 1
Reference 1
Fact 2
Reference 2
Reference 3
Claim 2
Argumentation strategy 2
Rationale 2
Fact 3
Reference 4
Claim 3
Claim 4
Claim
Argumentation strategy 3
Rationale 3
Fact 4
Reference 5
Fact 5
Reference 6
Claim 5
Argumentation strategy 4
Rationale 4
Fact 6
Reference 7
Fact 7

A case study:
Evidence based argument about quality of a software module

Tests confirm that this software module satisfies its requirements because test results are positive and the test coverage is sufficient

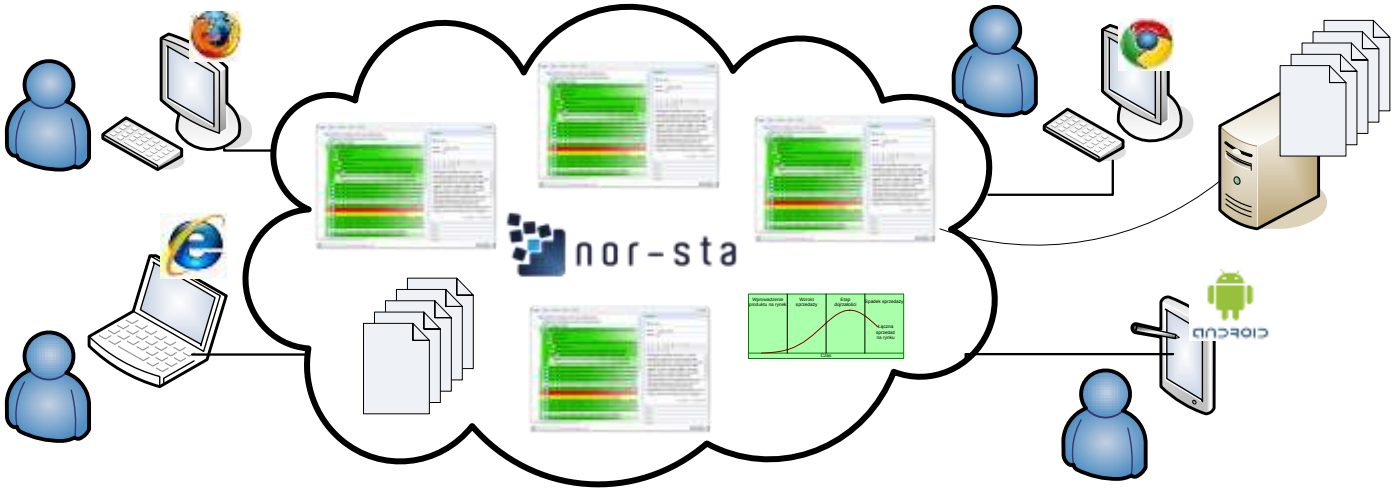


With the assumption that this module was not changed during testing, the tests performed by competent testers confirm that the module satisfies its requirements because test results are positive and the test coverage is sufficient



Communication and co-operation

Communication and co-operation



- Argument sharing
- Multiple viewpoints (managers, suppliers, certifying/qualifying institutions, argumentation developers, evidence suppliers, external world,..)
  - Different roles (developer, assessor, viewer, administrator…)
  - Access control
  - Different views at the argument
- Support for decision making
  - Argument assessment
- Support for consensus building
- Support for diputes

Argument assessment

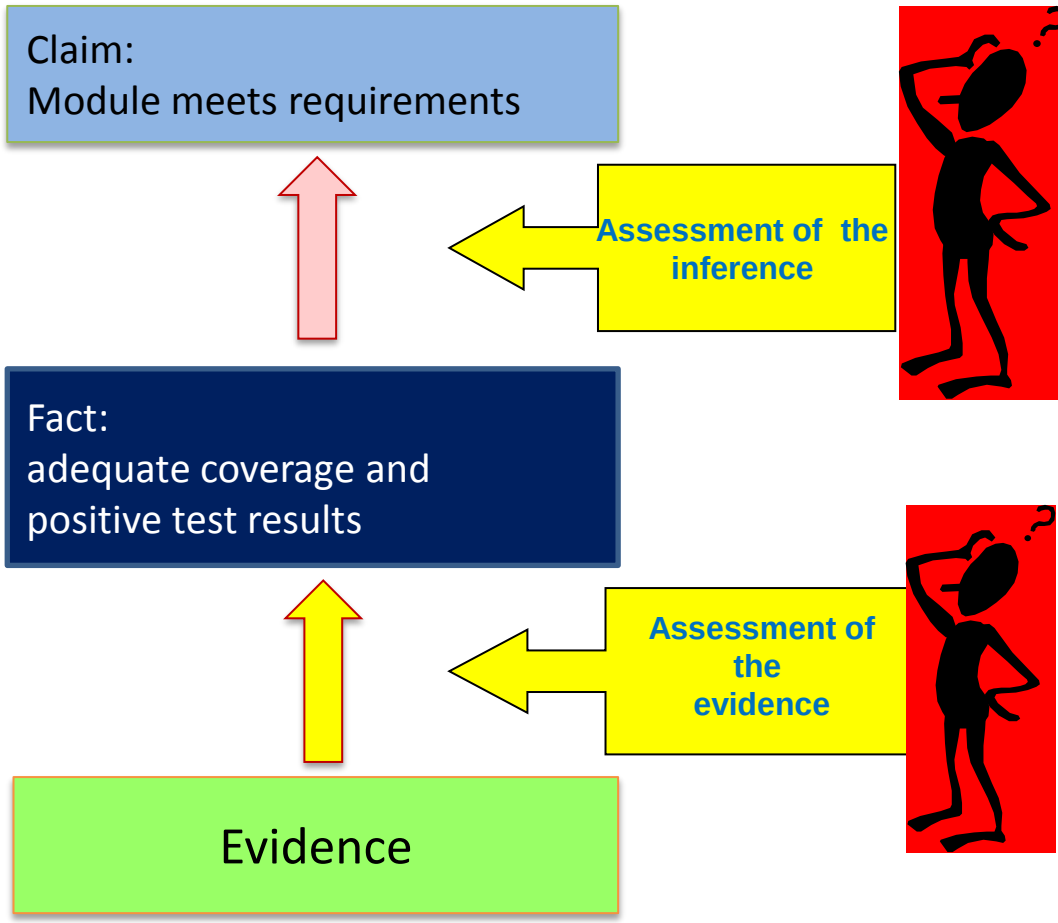
Assessing the the 'compelling power' of argument

Argument assessment

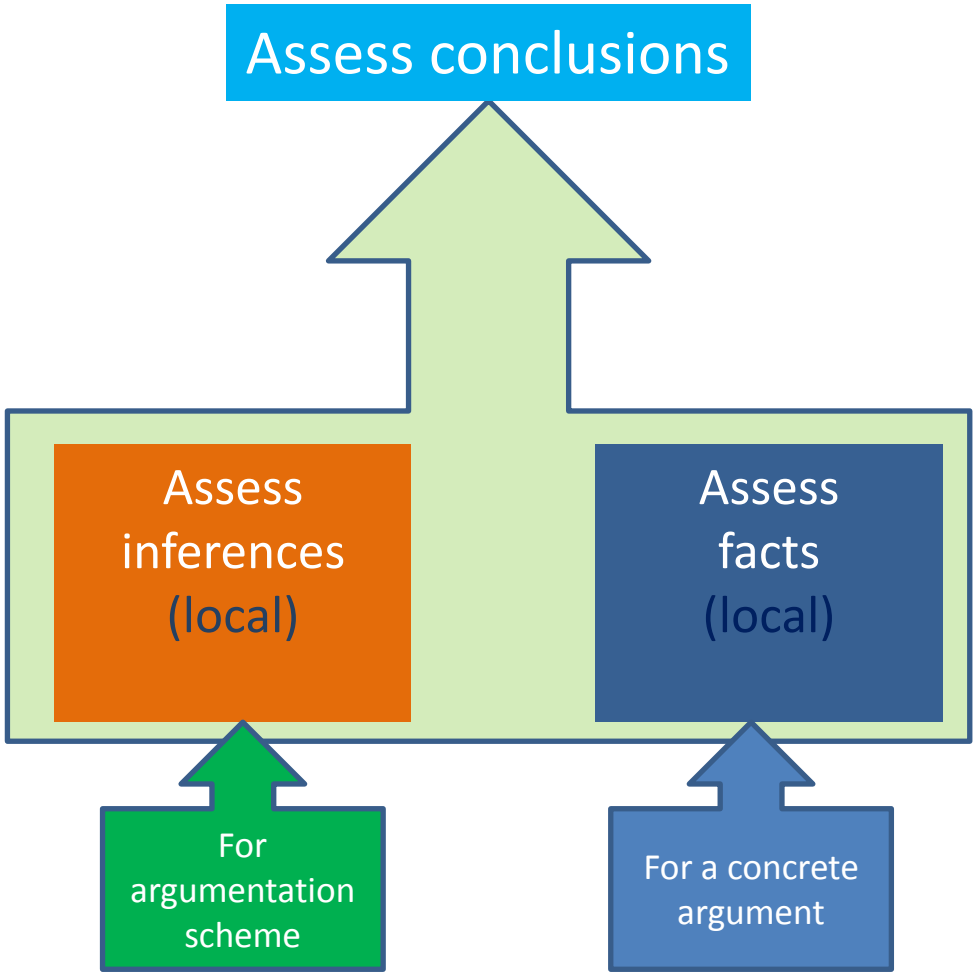
Tests confirm that this software module satisfies its requirements because tests results are positive and test coverage is sufficient

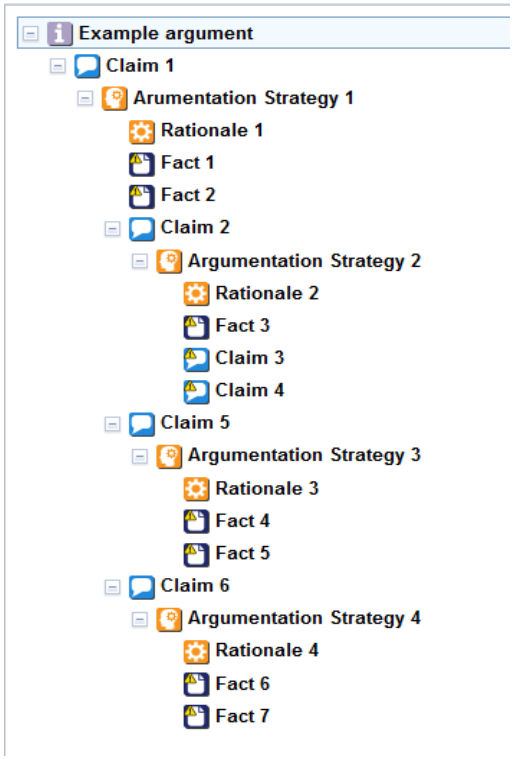
Logic doubt:
Do successful tests of right coverage really determine the success of testing?

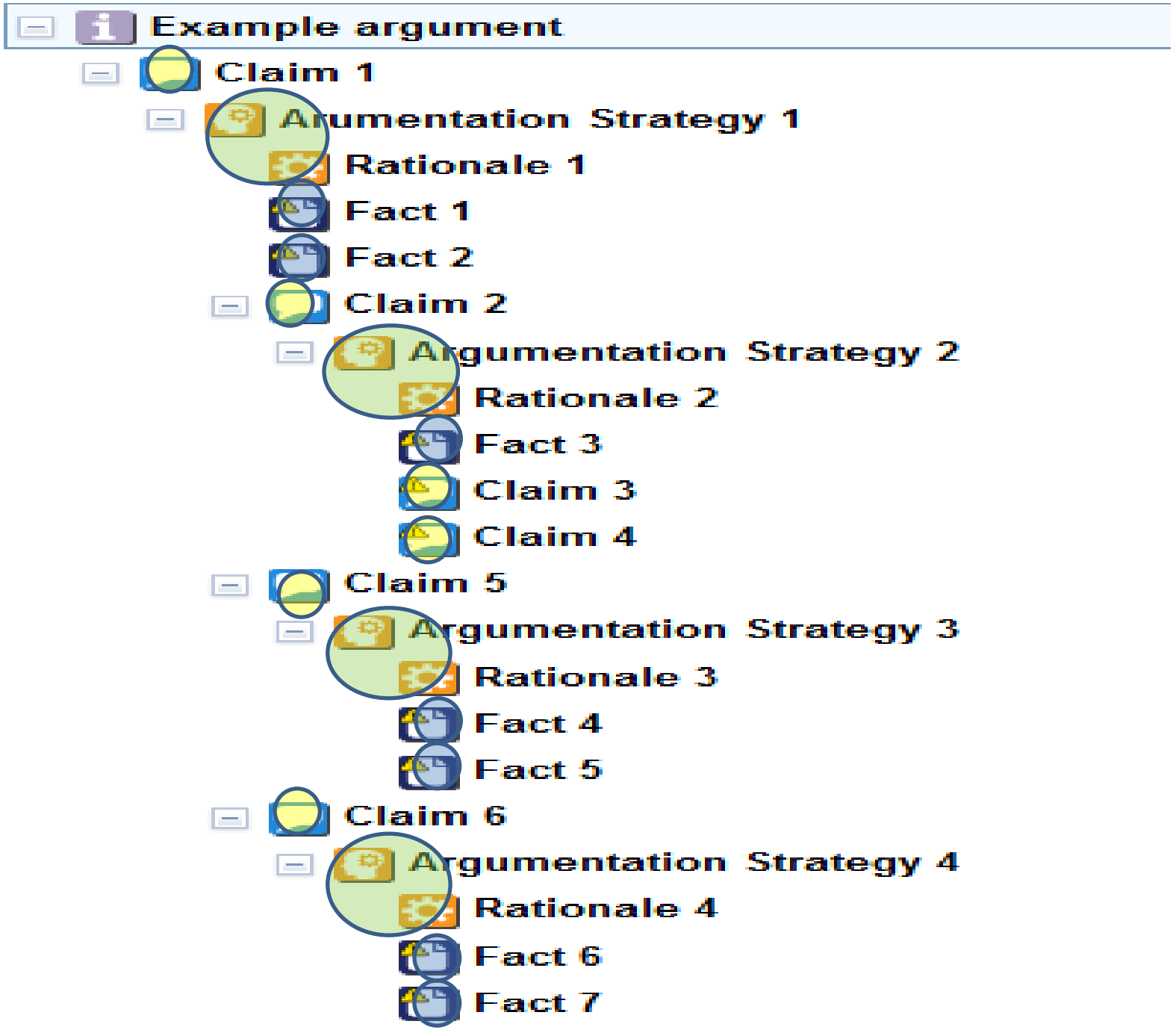
Epistemic doubt:
Do we really have positive test results and the right coverage?



The assessment process






Example argument
Claim 1
Argumentation Strategy 1
Rationale 1
Fact 1
Fact 2
Claim 2
Argumentation Strategy 2
Rationale 2
Fact 3
Claim 3
Claim 4
Claim 5
Argumentation Strategy 3
Rationale 3
Fact 4
Fact 5
Claim 6
Argumentation Strategy 4
Rationale 4
Fact 6
Fact 7

Assessment of an argument (based on Dempster-Shafer believe functions)

Assessment of evidence

- **Fact: ‘test results are positive’**

  Test report for this module demonstrating that the test results are positive

  Test report for different module

  Test report for this module demonstrating that the tests failed

- **Assessment**

Acceptance	Uncertainty	Rejection

Assessment of an argument (based on Dempster-Shafer believe functions)

Assessment of evidence

- Fact: ‘test results are positive’

  Test report for this module demonstrating that the test results are positive

  Test report for different module

  Test report for this module demonstrating that the tests failed

- Assessment

Acceptance	Uncertainty	Rejection

Assessment of inference

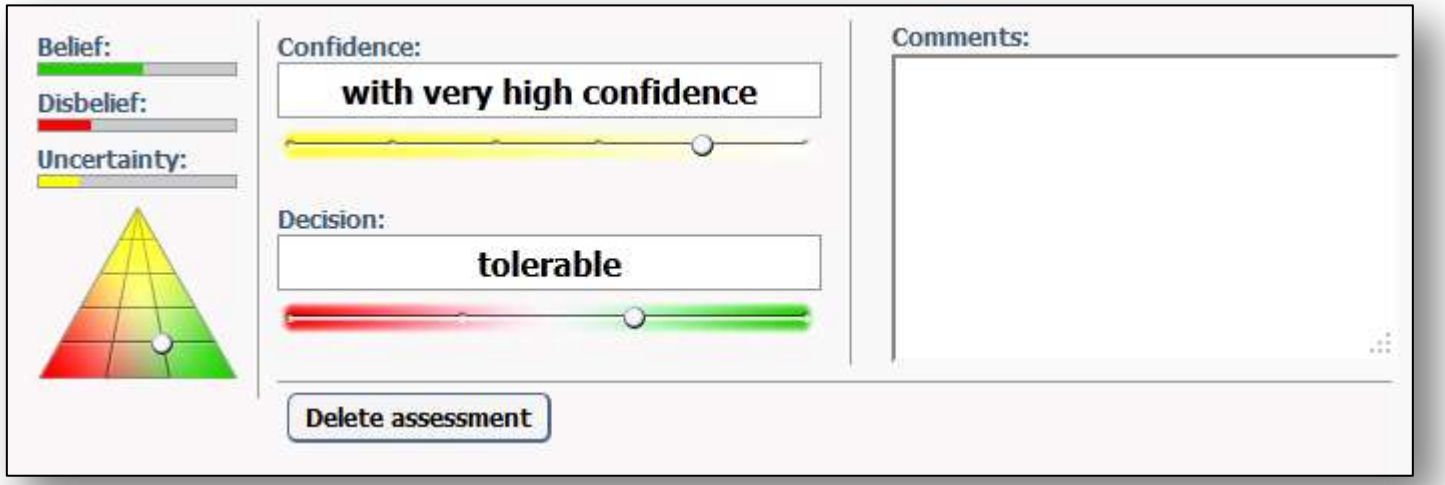
- ‘if we have positive test results and adequate tests coverage, then the module meets its requirements’

  How reliable is such reasoning?

- Assessment

Acceptance	Uncertainty	Rejection

User interface

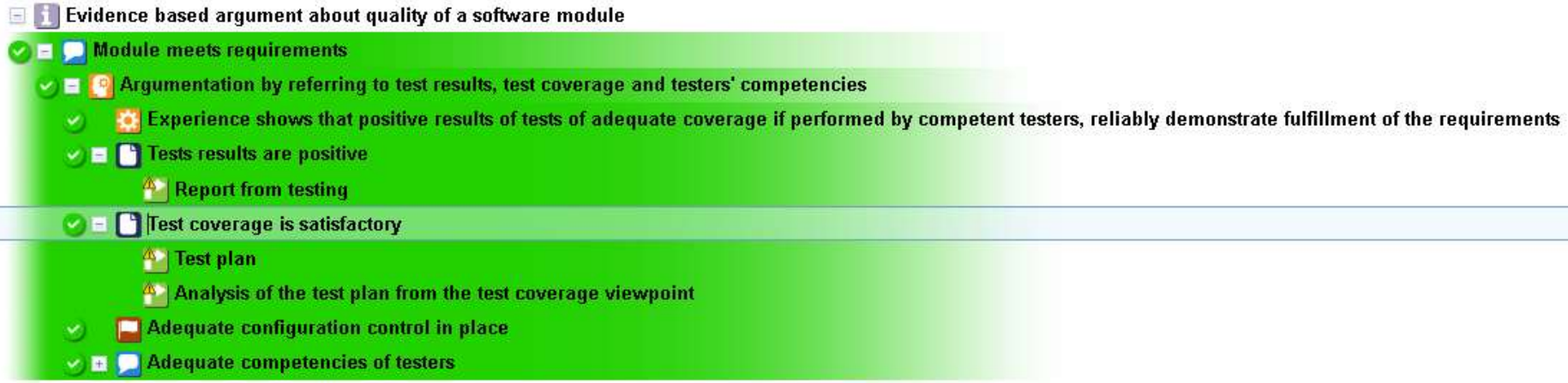


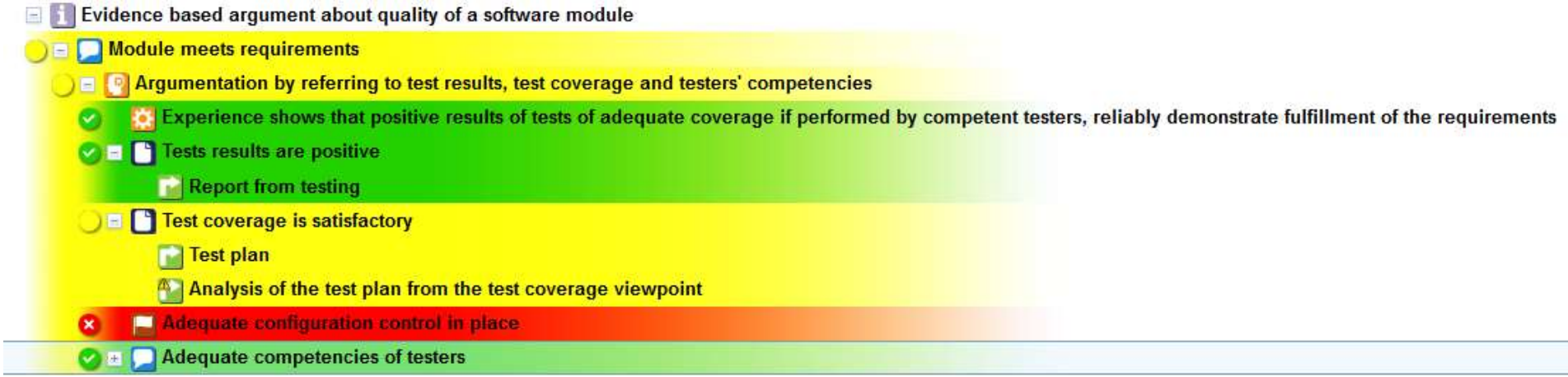
Linguistic values make the scale more human friendly:

Decision: *rejectable, opposable, tolerable, acceptable*

Confidence: *sure, very high, high, low, very low, uncertain*

Communicating the assessment results

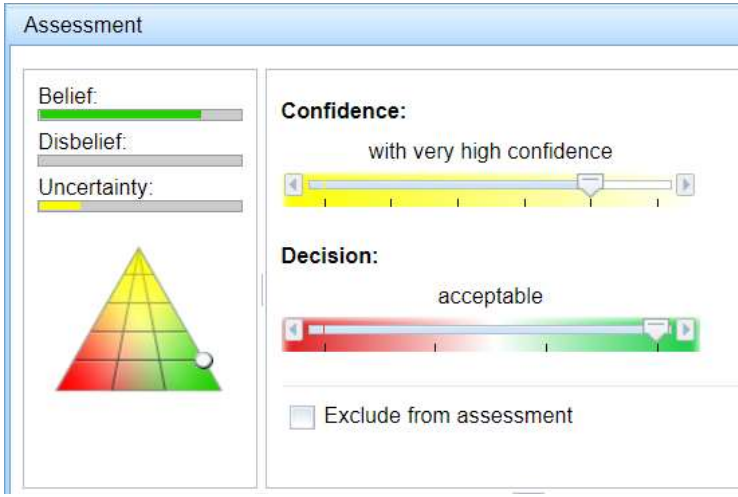


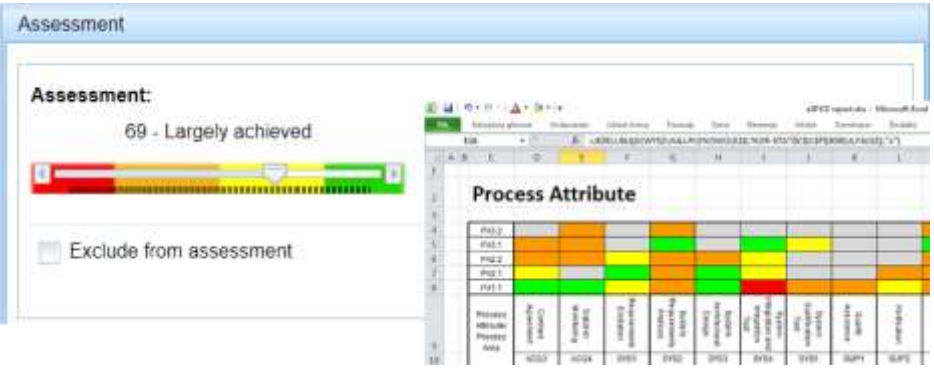


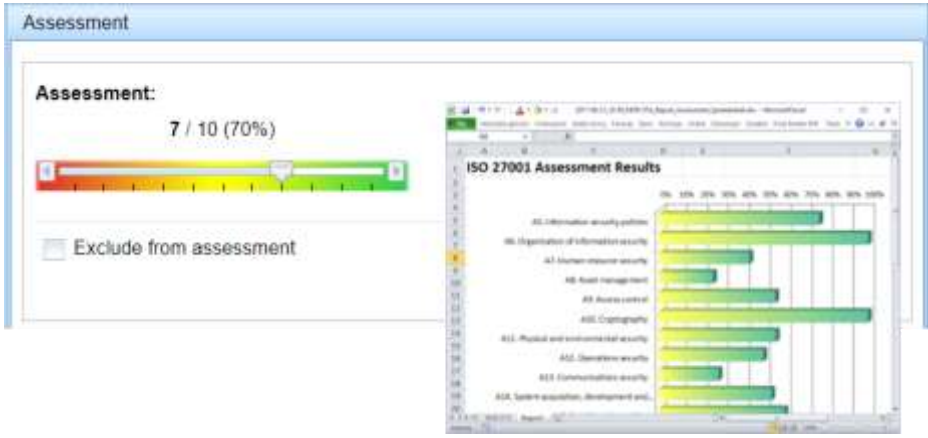
Argument assessment in NOR-STA

Presently 9 different methods of argument assessment are implemented:

- Dempster-Shafer
- ISO 33000 (SPICE, Automotive SPICE, …)
- Rating scale (numerical)
- Three-level assessment
- and others…



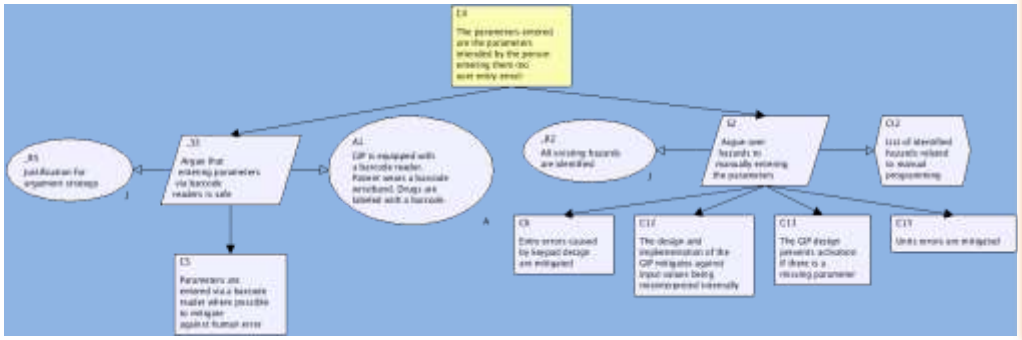


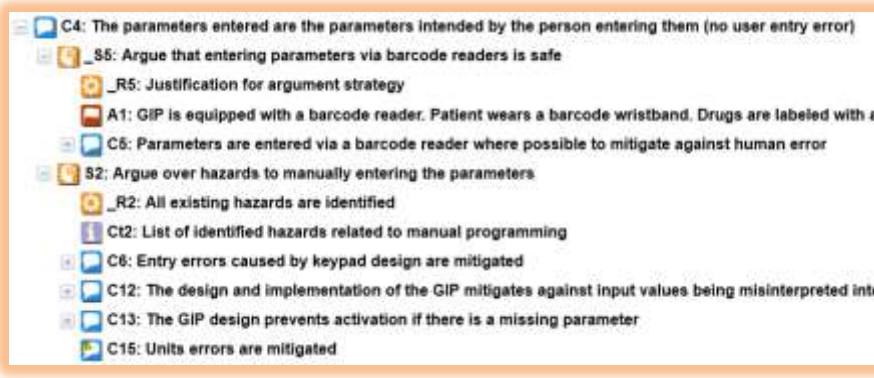


Scalability and change management

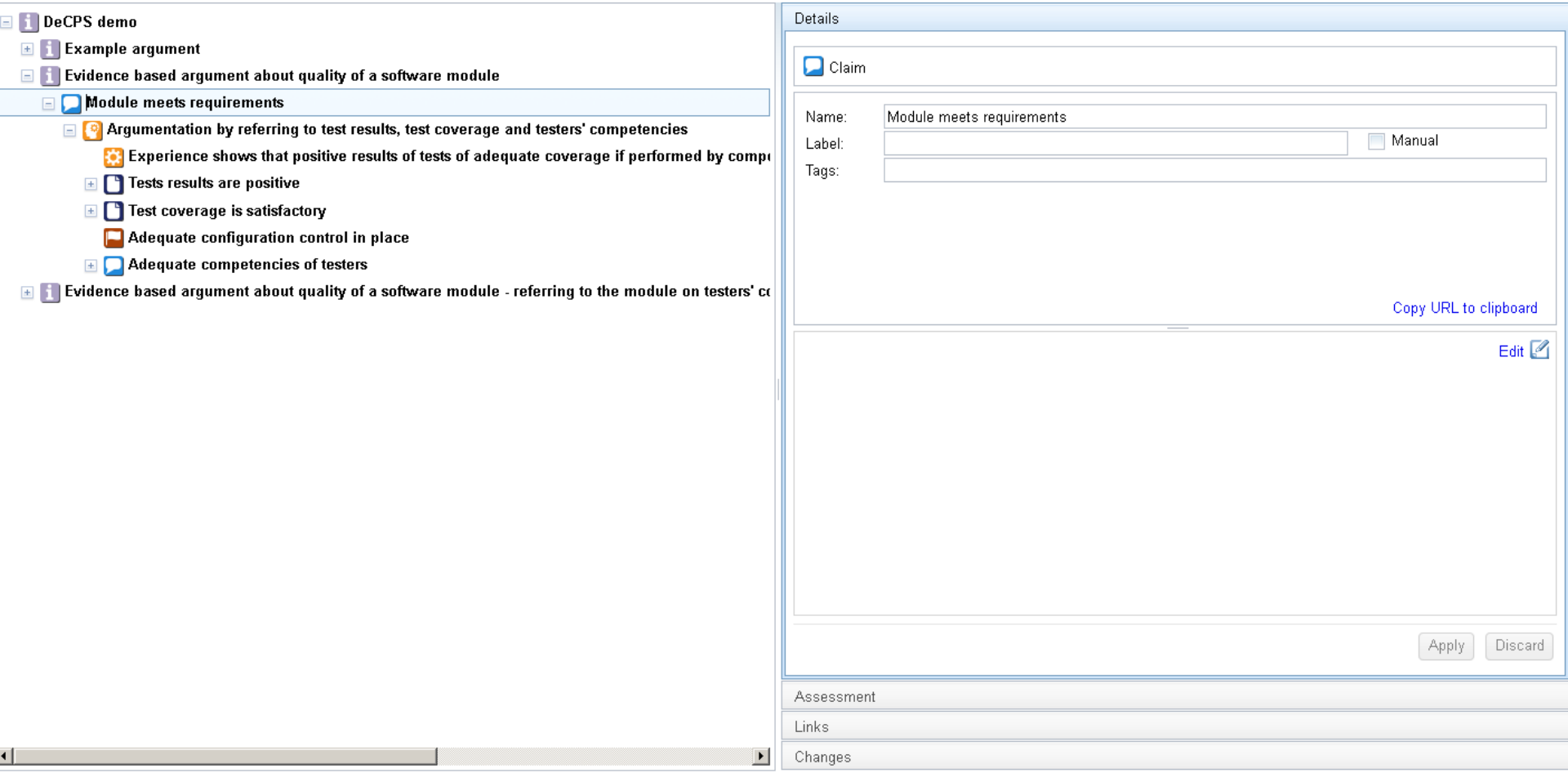
Operating large arguments

- Large arguments are difficult to handle and to understand
  - What does it maen ’large’?
    - Experience with arguments up to 8000 nodes
- Graphical representation inadequate
  - Adding/modifying a node can change the graph in two dimentions
  - Adding more explanatory text expands a node and gives a false feeling of growing importance of the node



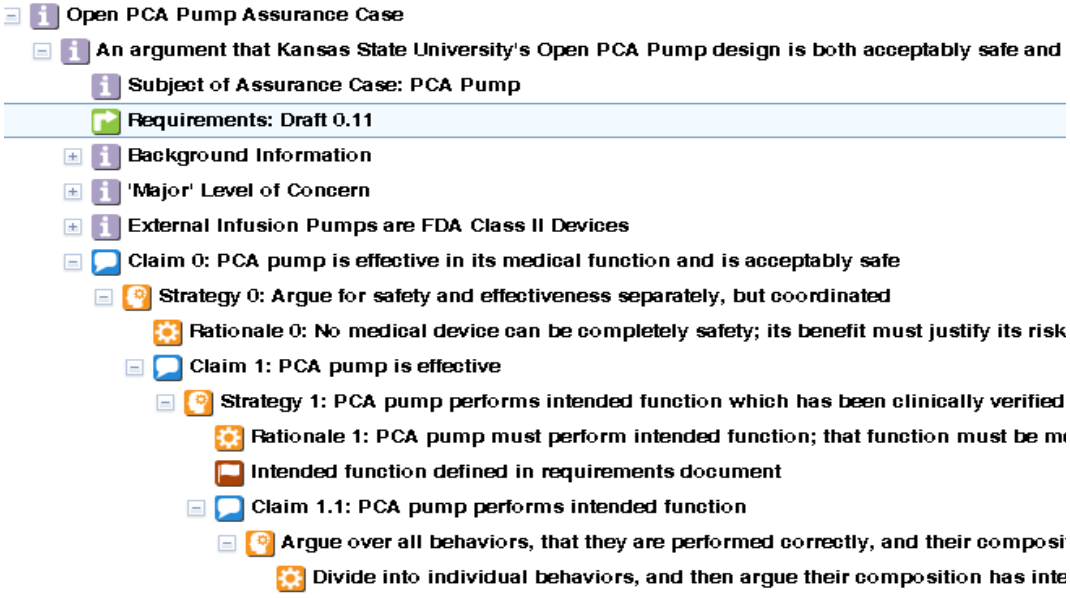


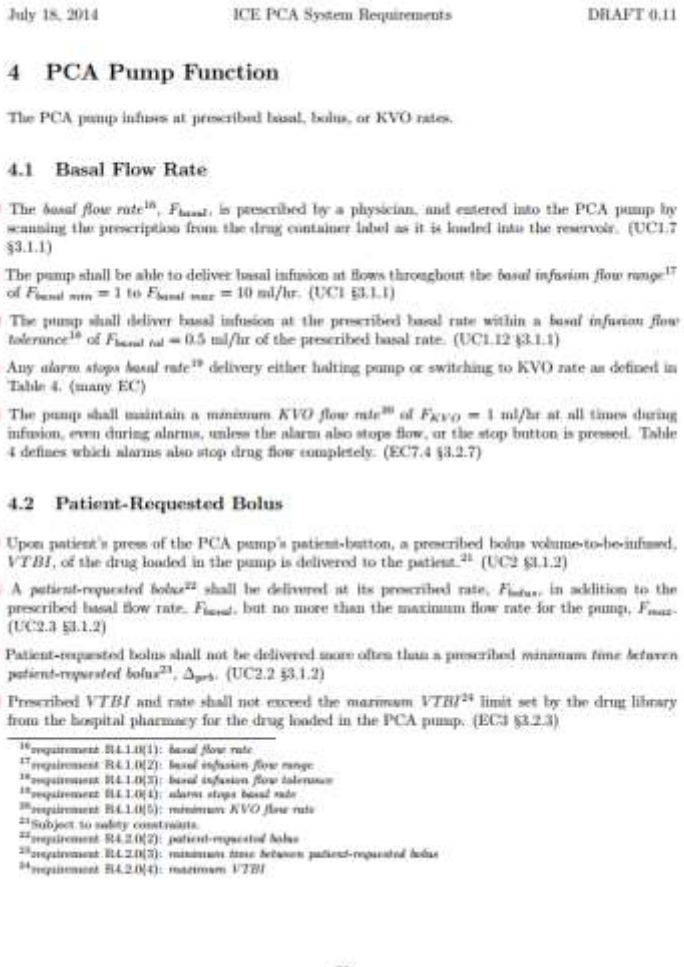
Operating large arguments



Managing massive evidence

- Integrating any electronic document as an e
  video stream,audio,…
- Providing for referencing any place the docu
  svn, …)
- Referencing selected fragments of bigger d
  sections, …)
- Providing for user selected repositories




July 18, 2014 ICE PCA System Requirements DRAFT 0.11

4 PCA Pump Function

The PCA pump infuses at prescribed basal, bolus, or KVO rates.

4.1 Basal Flow Rate

(1) The *basal flow rate*[16], F_{basal}, is prescribed by a physician, and entered into the PCA pump by scanning the prescription from the drug container label as it is loaded into the reservoir. (UC1.7 §3.1.1)

(2) The pump shall be able to deliver basal infusion at flows throughout the *basal infusion flow range*[17] of $F_{basal\ min} = 1$ to $F_{basal\ max} = 10$ ml/hr. (UC1 §3.1.1)

(3) The pump shall deliver basal infusion at the prescribed basal rate within a *basal infusion flow tolerance*[18] of $F_{basal\ tol} = 0.5$ ml/hr of the prescribed basal rate. (UC1.12 §3.1.1)

(4) Any *alarm stops basal rate*[19] delivery either halting pump or switching to KVO rate as defined in Table 4. (many EC)

(5) The pump shall maintain a *minimum KVO flow rate*[20] of $F_{KVO} = 1$ ml/hr at all times during infusion, even during alarms, unless the alarm also stops flow, or the stop button is pressed. Table 4 defines which alarms also stop drug flow completely. (EC7.4 §3.2.7)

4.2 Patient-Requested Bolus

(1) Upon patient's press of the PCA pump's patient-button, a prescribed bolus volume-to-be-infused, $VTBI$, of the drug loaded in the pump is delivered to the patient.[21] (UC2 §3.1.2)

(2) A *patient-requested bolus*[22] shall be delivered at its prescribed rate, F_{bolus}, in addition to the prescribed basal flow rate, F_{basal}, but no more than the maximum flow rate for the pump, F_{max}. (UC2.3 §3.1.2)

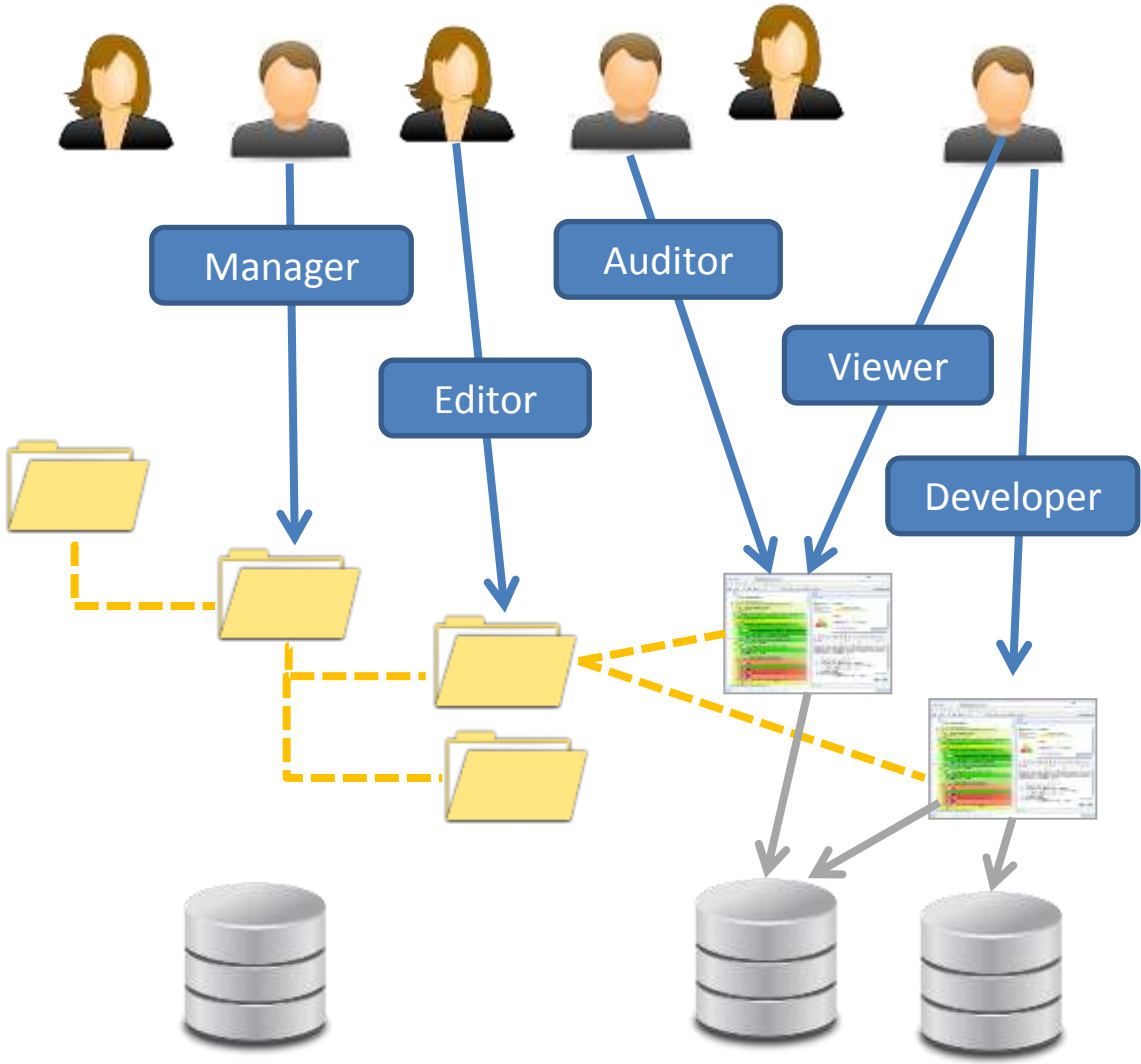
(3) Patient-requested bolus shall not be delivered more often than a prescribed *minimum time between patient-requested bolus*[23], Δ_{prh}. (UC2.2 §3.1.2)

(4) Prescribed $VTBI$ and rate shall not exceed the *maximum* $VTBI$[24] limit set by the drug library from the hospital pharmacy for the drug loaded in the PCA pump. (EC3 §3.2.3)

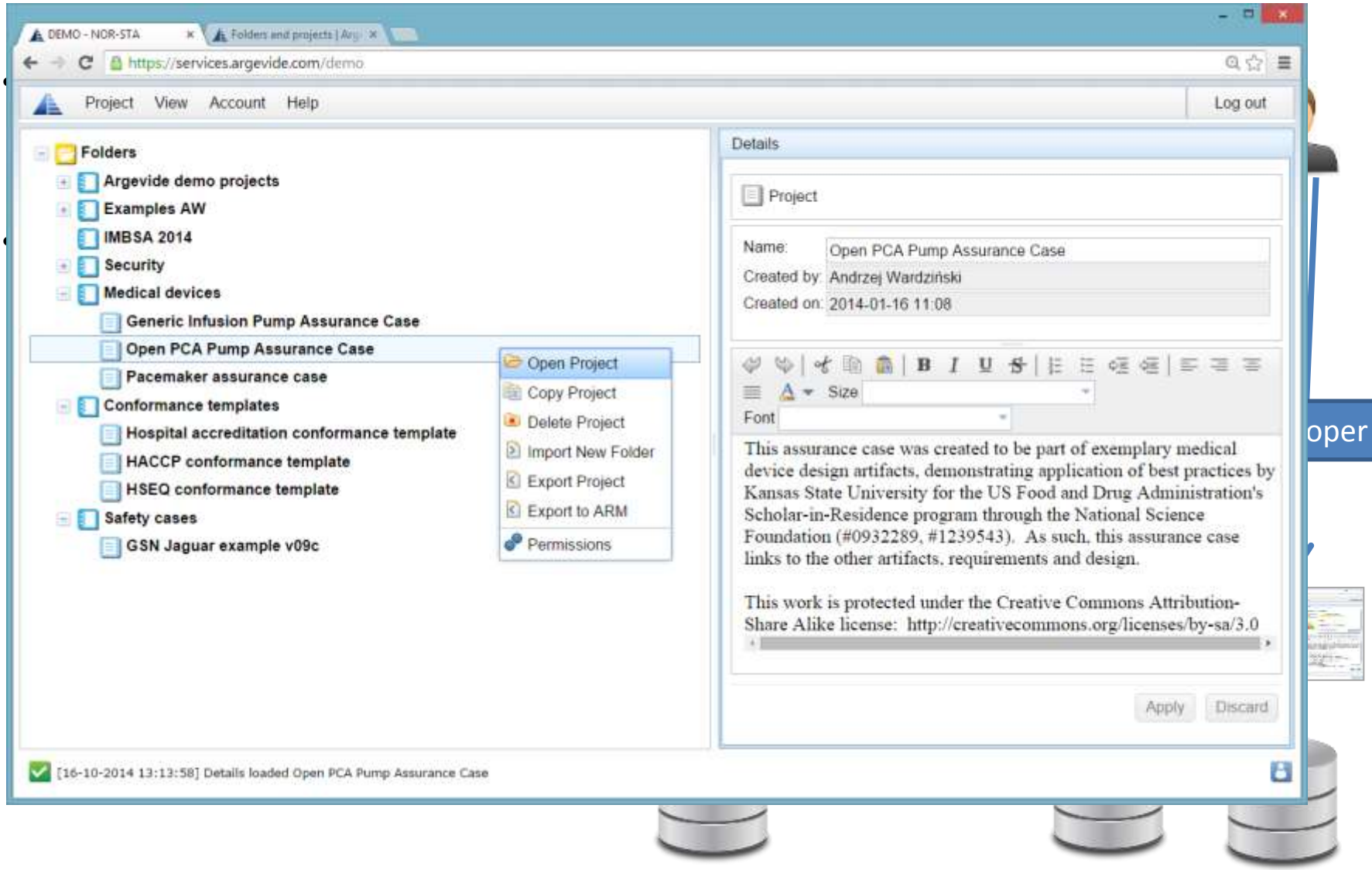
[16] requirement R4.1.0(1): *basal flow rate*
[17] requirement R4.1.0(2): *basal infusion flow range*
[18] requirement R4.1.0(3): *basal infusion flow tolerance*
[19] requirement R4.1.0(4): *alarm stops basal rate*
[20] requirement R4.1.0(5): *minimum KVO flow rate*
[21] Subject to safety constraints.
[22] requirement R4.2.0(2): *patient-requested bolus*
[23] requirement R4.2.0(3): *minimum time between patient-requested bolus*
[24] requirement R4.2.0(4): *maximum VTBI*

Managing multiple arguments and multiple users

- User accounts: roles and permissions
- Containers for arguments: folders and projects
  - Project contains a single argument
  - It is useful to group them together in folders to facilitate access and to enforce common policies
    - Patterns libraries
    - Assurance cases of subsystems
    - Arguments dedicated to a specific user
    - …

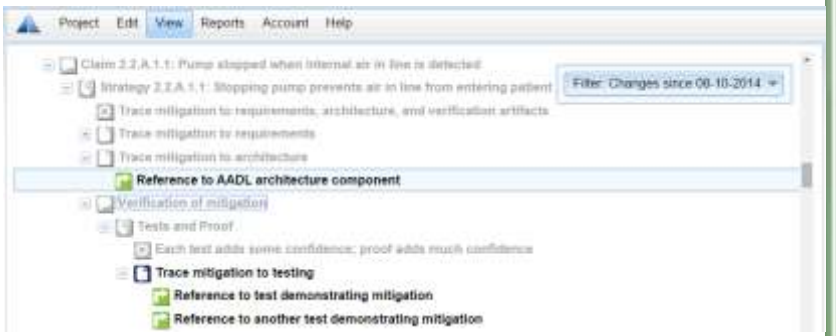


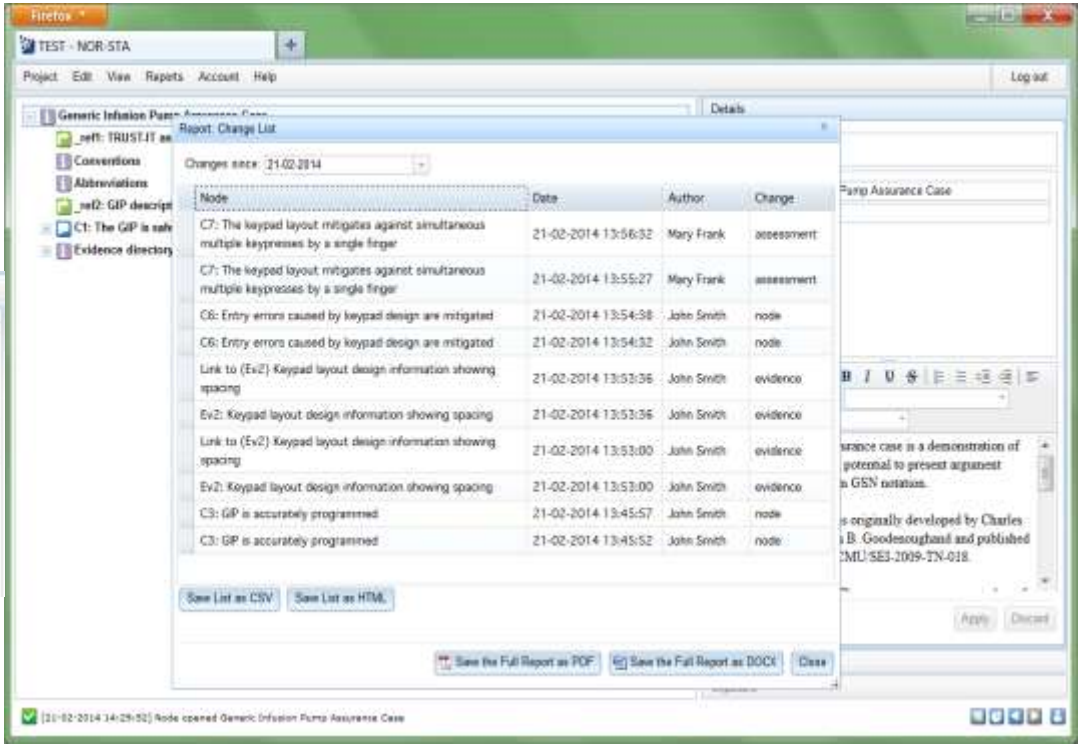
Managing multiple arguments and multiple users



Change control

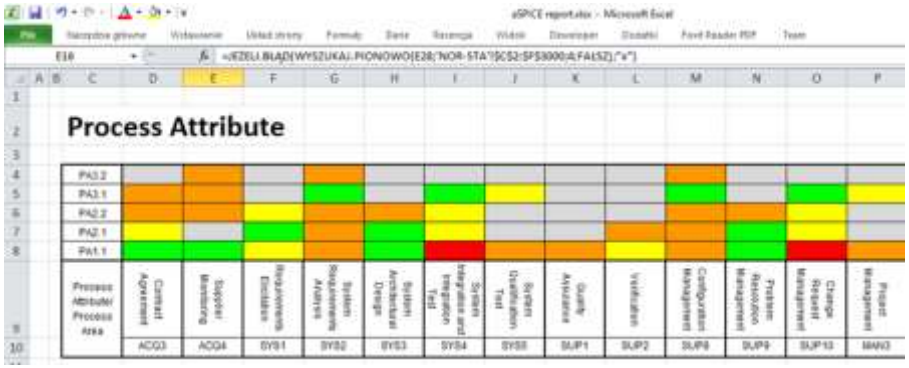
- Evolution of argument, assessments and evidence
- Baselines
- Rollback
- Accountability of changes

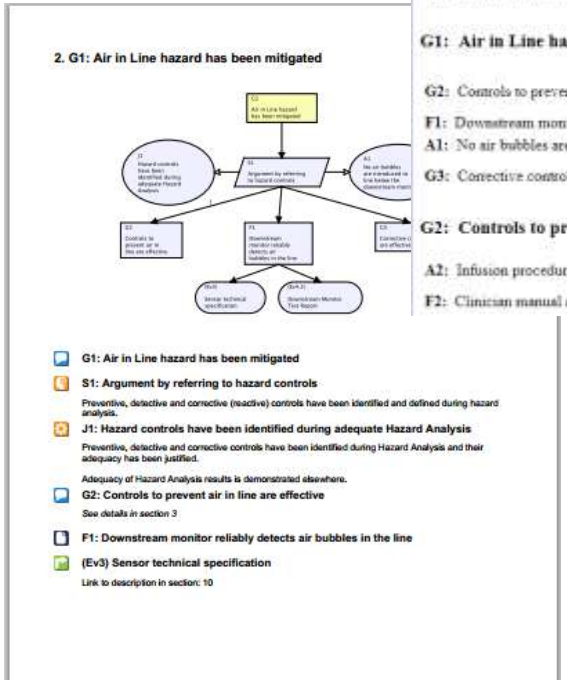




Reporting

- Customizable **Excel** reports
  - assessment history
- Customizable **XML/HTML** reports
  - XLS scripts to process XML data
  - assessment history
- Dedicated reports
  - Project metrics
  - Project change list
  - NOR-STA users' activities (for administrators)
- **GSN** diagrams generated for argument sections





Integration

Integration

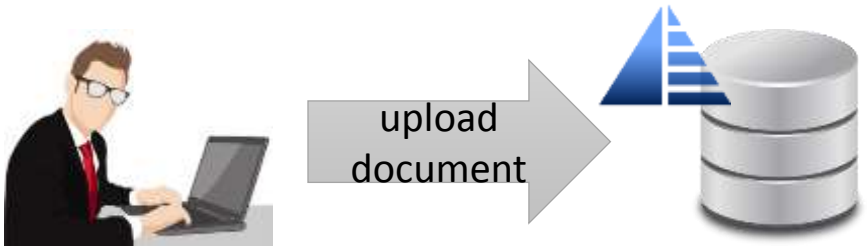
- Evidence
- External systems
- SACM (Structured Assurance Case Matamodel)

Integrating arguments with evidence

- **Direct links** to evidence (resources on the internet)

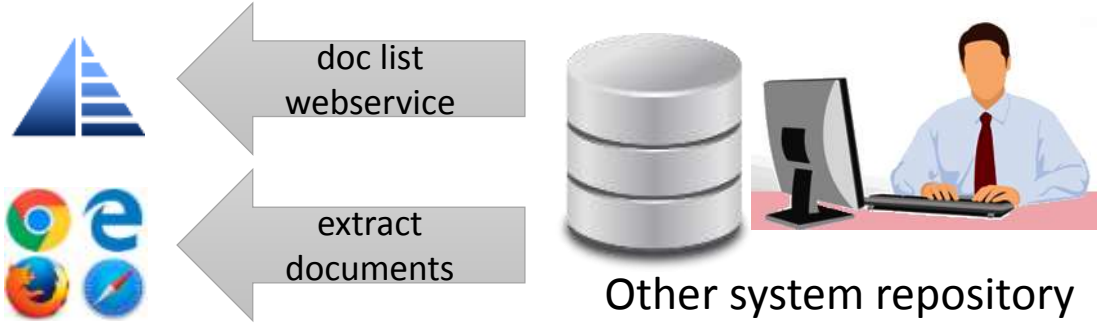
http://www.omg.org/spec/SACM/

- **Internal** NOR-STA repository



- **External repositories** (HTTP Basic Authentication, for example SVN, GIT)

- External repository with **webservice** interface for listing documents (used for integration with Siemens Teamcenter)



Integration with other systems

NOR-STA API (webservices)

- JSON REST webservices cover full NOR-STA functionality

Single Sign On (SSO)

- Active Directory Federation Services ADFS (Oauth 2.0)
- Azure B2C

XML export/import

- TCL format

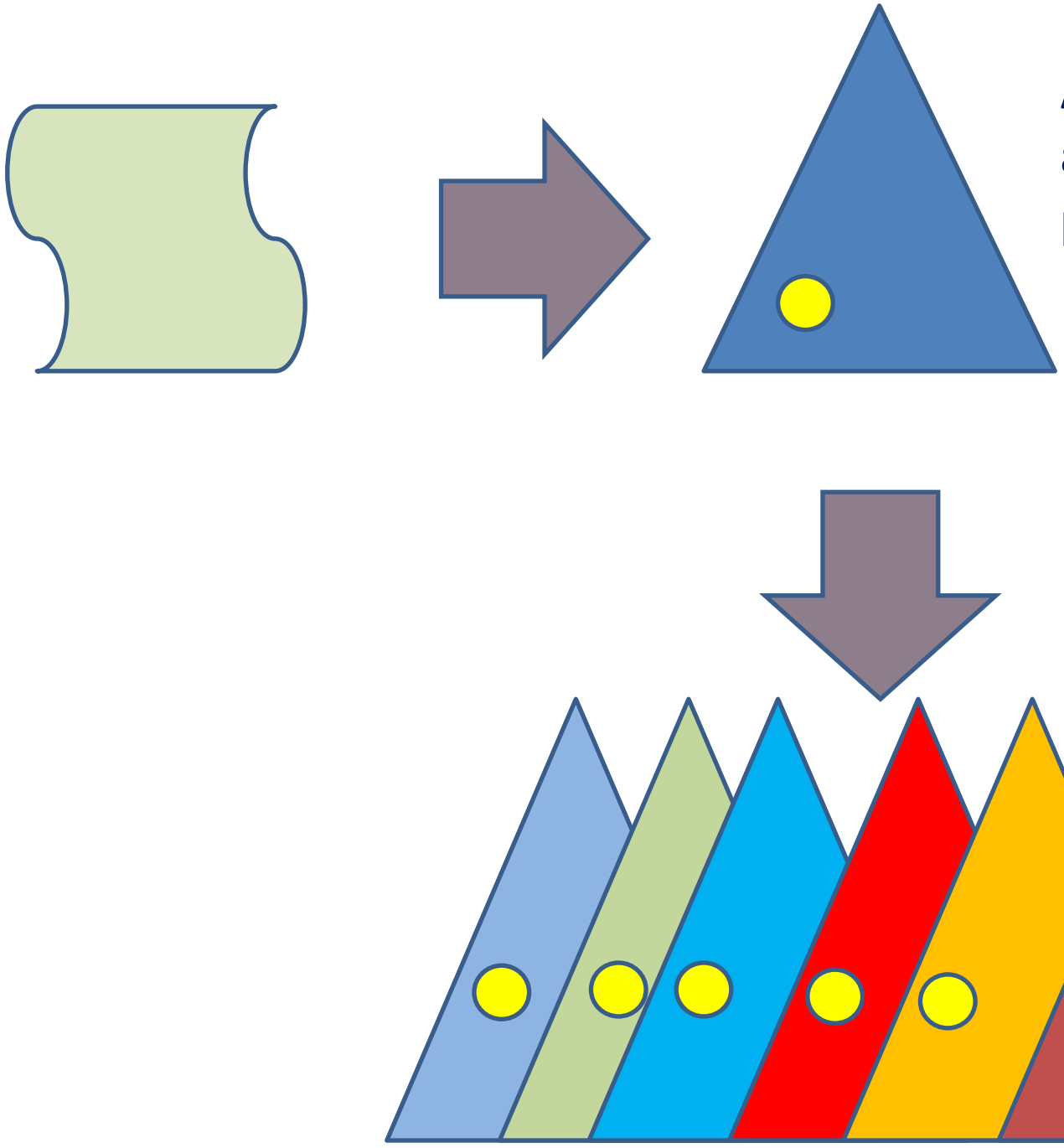
SACM 2.0 compliance

- NOR-STA use TCL (Trust Case Language) notation which complies to SACM 2.0 (published March 2018)

Argument structuring and reuse

Argument structuring and reuse

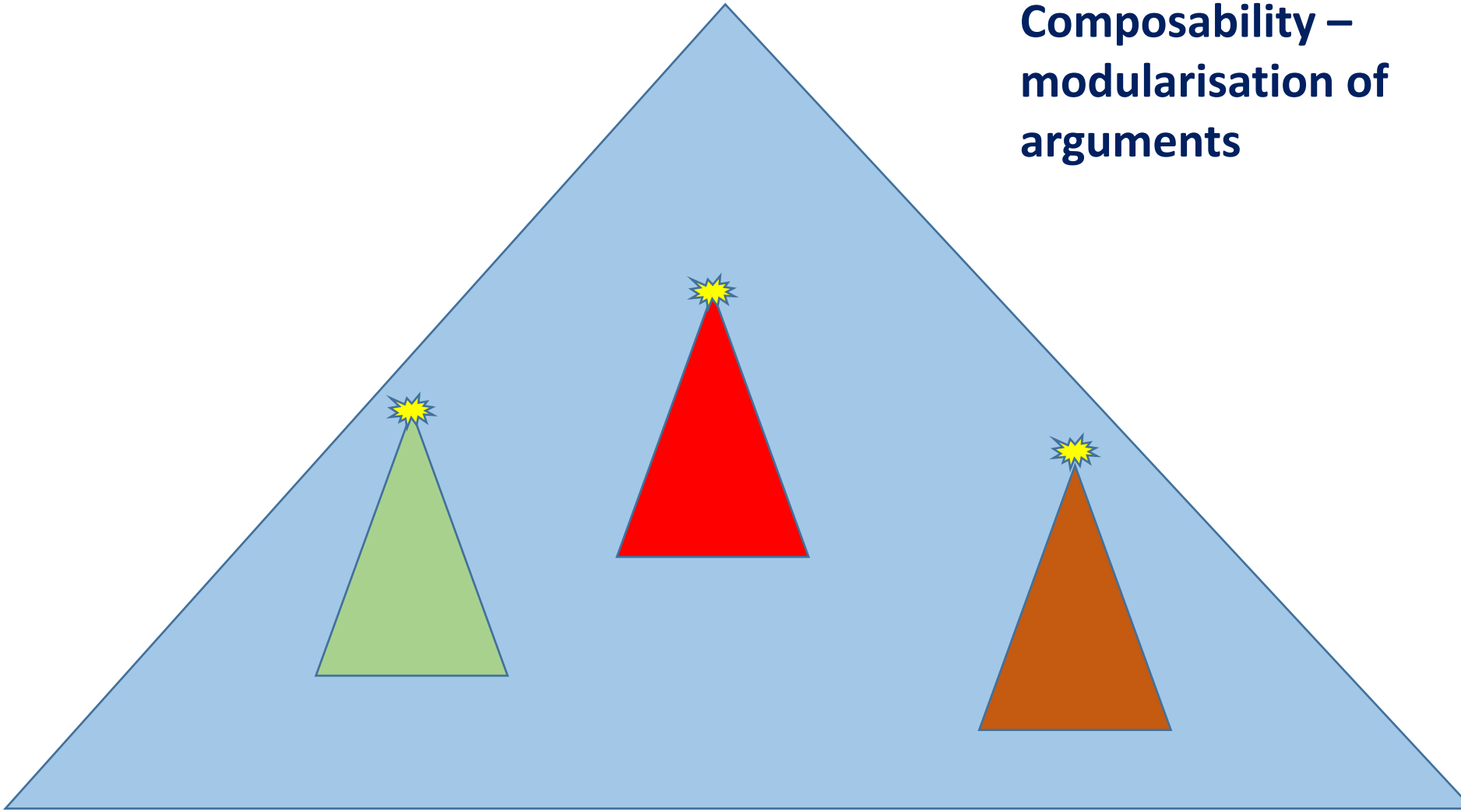
- Links in the argument structure
  - DAG instead of tree
- Patterns and pattern libraries
- Templates
  - Deriving structure from standards
  - Following changes in standards
- Deriving argumentation structure from models
  - Architectural models
  - Risk analysis reports

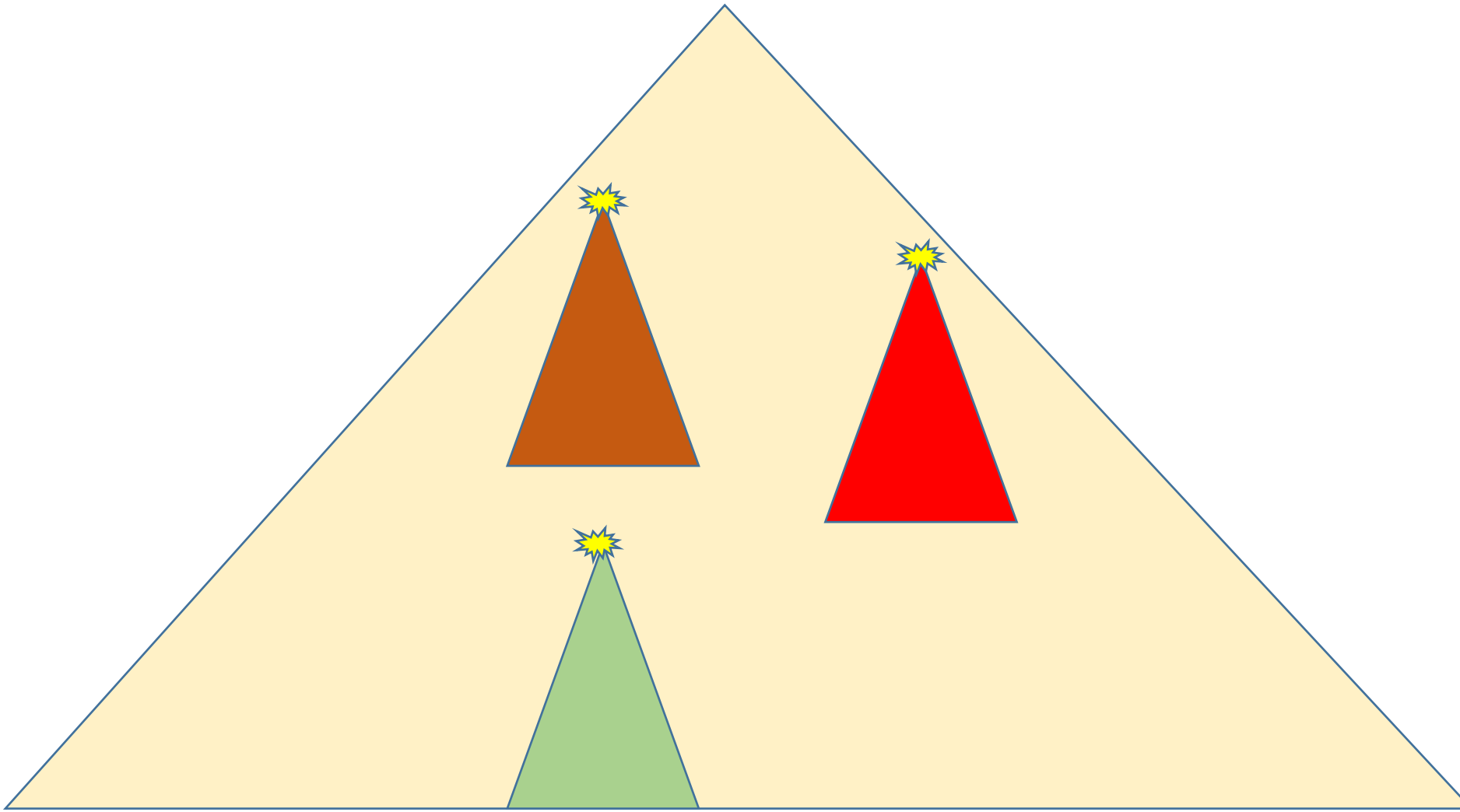


Argument templates and changes propagation

Composability

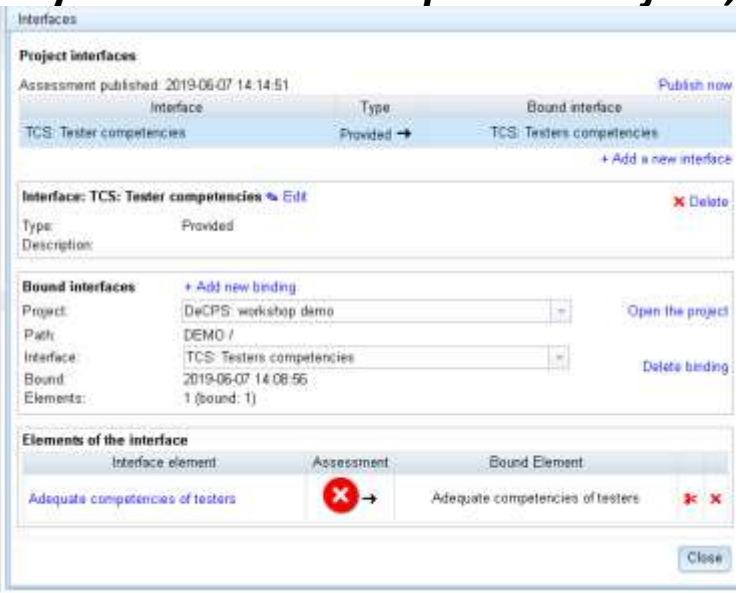
Composability – modularisation of arguments

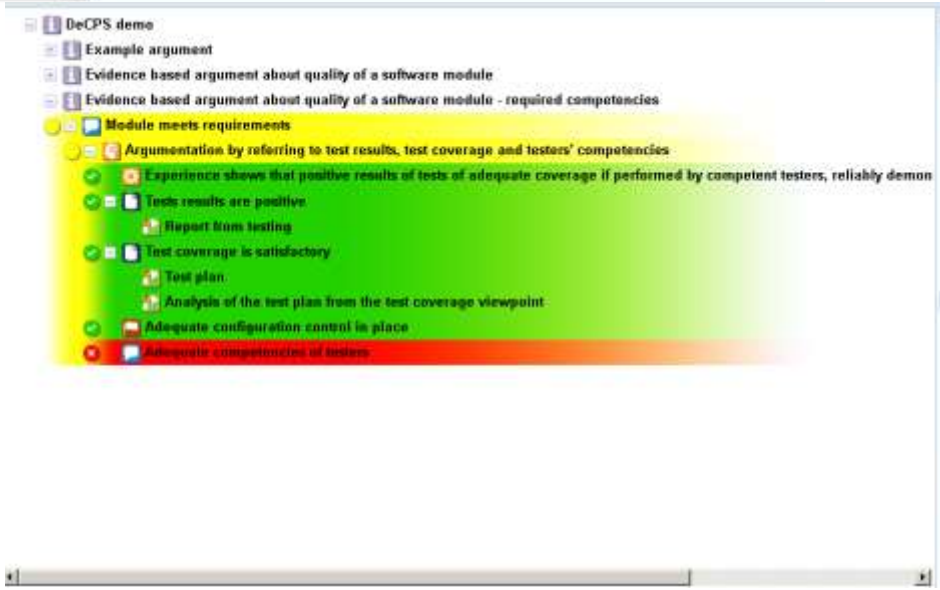


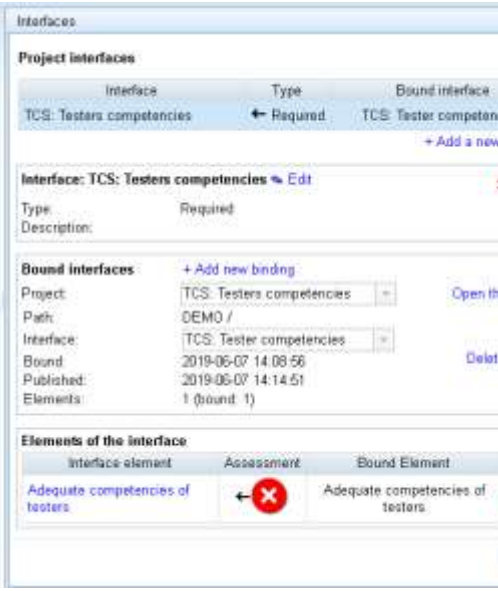


- Interfaces between the components and the embedding argument
- Changing context can invalidate evidence and argumentation strategies

Simple solution: syntactic match *Required interface, Provided interface*







Difficult problem: semantic contracts with change control

’Living’ arguments

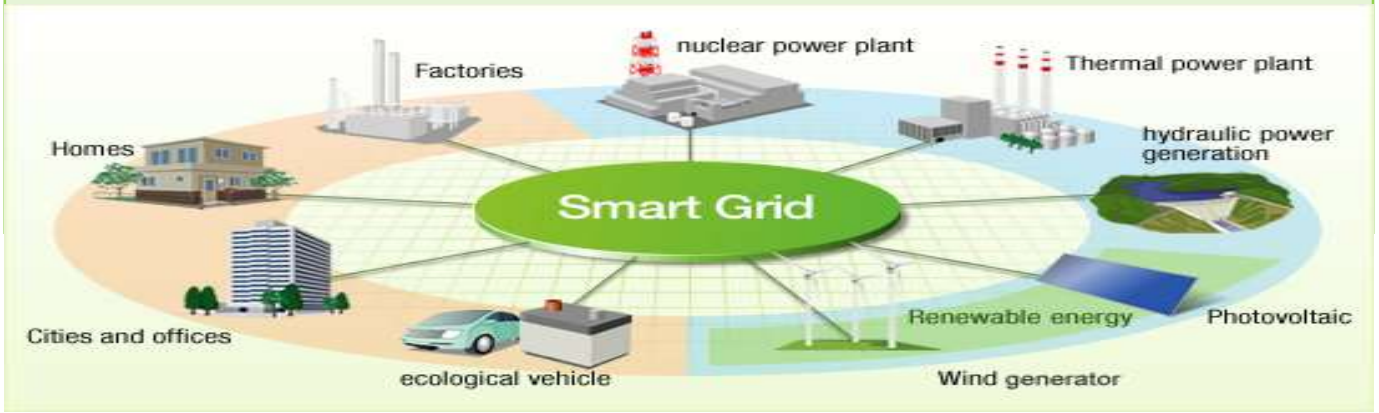
Living argument

S&P&D

Objectives

Logic decomposition into more specific objectives

Analytical and measurement leyer – collecting evidence that demonstrates objectives



Smart grid

Living argument

Logic decomposition into more specific objectives

Analytical and measurement leyer – collecting evidence that demonstrates objectives

Smart grid

Conclusion

- Argument is a focal point situated between different stakeholders and addressing their important concerns
  - Argument model and its representation – a crucial decision
  - SaaS model of deployment
- Argument is un ’umbrella’ under which we can integrate the results of a wide range of more focused analytical methods and techniques
- Conformance arguments have a potential to support emerging certification frameworks
  - Cybersecurity of components (and systems)
  - Qualification of medical devices
- Discovering new application domains
  - ’Customer driven’ development
- For materialisation of the vision of ’living’ arguments more automation is needed
  - automatic determination of an argumenttation structure
  - automatic evidence collection and assessment
  - strong context awareness
- SLA, Data Security and Privacy Protection – of high and growing relevance

Thank you for your attention