IFIP WG10.4

Dependability Standards and our Challenge to Establish a New Standard for Open Systems

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- Dependability Standards Related Organizations
  - ISO/IEC JTC1/SC7/WG7, IEC TC56, TC65a, OMG,…
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- Our challenge and approach to new standards
  - Our concepts
  - Activity of ISO/IEC 15026
    (System and software assurance)
- Relationship among other talks in DEOS Project

Dependability Standards Related Organizations

IEC60300
Dependability management

IEC TC56/WG4

IEC61508
Functional safety of electrical/electronic/ programmable electronic safety-related systems

IEC TC65A

Notation of Assurance case

OMG

D-31
General requirements for software controlled measuring instruments

OIML TC5/SC2

ISO/IEC 15026
System and software assurance

ISO/IEC12207
Software life cycle processes

ISO/IEC15288
System life cycle processes

ISO/IEC JTC1/SC7/WG7

Dependability Standards and Organizations

- Dependability management (IEC TC56)
  - IEC 60300series
- System and Software assurance (JTC1/SC7/WG7)
  - ISO/IEC 15026
- System/SW lifecycle processes (JTC1/SC7/WG7)
  - ISO/IEC 15288, 12207
- Functional safety (IEC TC65a)
  - IEC 61508, (ISO26262)
    - Safety Integrity Level (SIL)
- Quality management (JTC1/SC7/WG6)
  - ISO/IEC 25000series
- Security (JTC1/SC27)
  - ISO/IEC 15408, 27001

Dependability Standards and Organizations

- IEC TC56: Dependability
  - Reliability and Maintainability (1965) ⇒Dependability (1990)～
  - Historically it started reliability of electric parts
    Hardware ⇒ + System and Software
  - FTA, FMEA, HAZOP
- JTC1/SC27 IT Security Techniques
  - ISO/IEC 15408 Common criteria , 27001 Security management
- JTC1/SC7 Software and Systems Engineering
  - WG6 Quality Management
    - Software quality requirement and evaluation (SQuaRE) 25000s
    - ISO/IEC 9126: product quality, 14598: product evaluation
  - WG7: Lifecycle Processes
    - ISO/IEC 15288, 12207
    - ISO/IEC 15026 system and software assurance

What is Dependability?

- RAS(1960s)
  - Reliability,
  - Availability,
  - Serviceability
- RASIS(1970s～)
  - RAS＋Integrity＋Security

- Dependability definition in IEC TC56
  - collective term used to describe the availability performance and its influencing factors reliability performance, maintainability performance and maintenance support performance

- In Avizienis et paper

Dependability
- Safety
- Maintainability
- Reliability
- Availability
- Integrity
- Confidentiality

Security
- Availability
- Integrity
- Confidentiality

  - Focus on Closed system
  - Fault-Error-Failure model
  - Means
    - Fault prevention
    - Fault tolerance
    - Fault remove
    - Fault forecasting
  - Adaptability, Usability, Manageability are mentioned that importance but not be considered enough

Definitions of Dependability

- Definition in Avizienis paper
  - *the ability to deliver service that can justifiable be trusted*
  - *the ability of a system to avoid service failure that are more frequent or more severe than is acceptable*
- Definition in IEC TC56
  - **Now** (IEC 60300-1)
    collective term used to describe the availability performance and its influencing factors reliability performance, maintainability performance and maintenance support performance
  - Software dependability
    ability of the software to perform as and when required when integrated in system operation
    (Guidance on software aspects of dependability 56/1349A/CD)
  - (Network) dependability
    ability to perform as and when required to meet specified communication and operational requirements
    (Methodology for communication network dependability assessment and assurance 56/1351/NP)

Current activities

- JTC1/SC7/WG7(System and Software lifecycle)
  - ISO/IEC 15026 are changing the subject, System integrity levels to System assurance
- IEC TC56(Dependability management)
  - Most generic standard IEC 60300-1,2 need to revise by considering to today's social needs.
    Definition of dependability will be reconsidered
  - Risk management are renewal the new standard ISO31000s. TC56 is working within the activity and revised IEC 60300-3-9 to ISO31010 (now final voting are done)
  - Lifecycle costing problem is still considered (IEC 60300-3-3) and further studies about software reusability issues for eco-friendly products (Dependability of Software products containing reused components NP/1332)
- These organizations need to adapt and revise the standards from stand-alone (Closed) system to complex, distributive and networked systems (we call these Open systems)

Our Definition of Open Systems Dependability

- We understand that complex, huge distributive and networked systems are Open systems
- Incompleteness and uncertainty could be factors that may result to failures in the future, and they are inherent to embedded systems (Factors of Open Systems Failure).
- Definition: Open Systems Dependability is to remove the said factors before they cause failure, to provide appropriate and quick action when they occur, to manage the failure in order to minimize the damage, and to safety and continuously provide the services expected by users as much as possible

Open Systems Dependability in practice

- Dependability is the degree of *Accountability*
- Accountability is secured by showing *evidences* of having done and doing *Risk Management in best effort*
  - to provide *expected services continuously*,
  - to manage quickly and properly *to minimize damages* when an incident occurs
  - to take countermeasures *never to let the same incidents occur again*
- Provide satisfactory service continuously as and when required, even if system failure happened, protect stakeholders (security, privacy, safety, … = 安心：Anshin)

Our Challenge to Open Systems Dependability

- *Dependability ≒ Accountability + Risk management*
- *Accountability*
  - Construct a System profiling methods
    - Scenario-based, Agent-based, Aspect-oriented analysis
  - Stakeholder analysis
    - Roles and Responsibility
      - sharing the responsibility,
        common-ownership of responsibility
      - Beyond Service level agreement (SLA),
        SLA is not enough
    - Define the Consensus building process among stakeholders (Assurance case)
    - Define the Decision-making process under uncertainty and incompleteness
- *Risk Management in best effort*
  - Risk communication (Assurance Case)
- Standardization for Accountability (risk management with evidence) with Dependability Level which is determined by system profiling

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  - Risk communication (Assurance Case)
  - unidentified risk
- Standardization for Accountability (risk management with evidence) with Dependability Level which is determined by system profiling

Standardizing Open Systems Dependability

- Construct Evidence based framework
  Define the framework to provide the evidence for Accountability
- Construct a System profiling method
  - Who are stakeholders in the system? ⇒ Stakeholder analysis
  - harmonize among dependability attribute
    (including trade-off analysis)
  - Aspects of assets
- Define the Consensus building process among stakeholders by Assurance Case
- Define the Decision-making process under uncertainty and incompleteness
- Define the improve process and these assessment
- Define the Business continuity plan
  - Contingency plan
- Roughly speaking, we will define the new specification language which is clear, no ambiguity, readable and compact not only for stakeholders but other persons who can verify the specification documents.

Stakeholders Analysis

- Identify the stakeholders
- Define stakeholders requirements
- Roles and responsibility,
  - sharing the responsibility,
    common ownership of responsibility
- Define the consensus-building process among stakeholders (Assurance case)
  - Risk communication
  - Beyond SLA
- Define the decision-making process

Summary

- Challenge to establish new standard for Open Systems
  - Define Stakeholder Analysis
  - Define Consensus-building process among stakeholders
    Assurance Case
  - Construct Evidence based framework
    Define the framework to provide the evidence for Accountability
  - Define the improve processes and these assessment
  - It is hard to understand entire behavior of an Open system. The structure, interactions, system boundary change dynamically. However, it is necessary to keep trying to understand the system through the lifecycle (System Profiling).
  - Define Risk management for Open systems
    Decision-making process under uncertainty and incompleteness

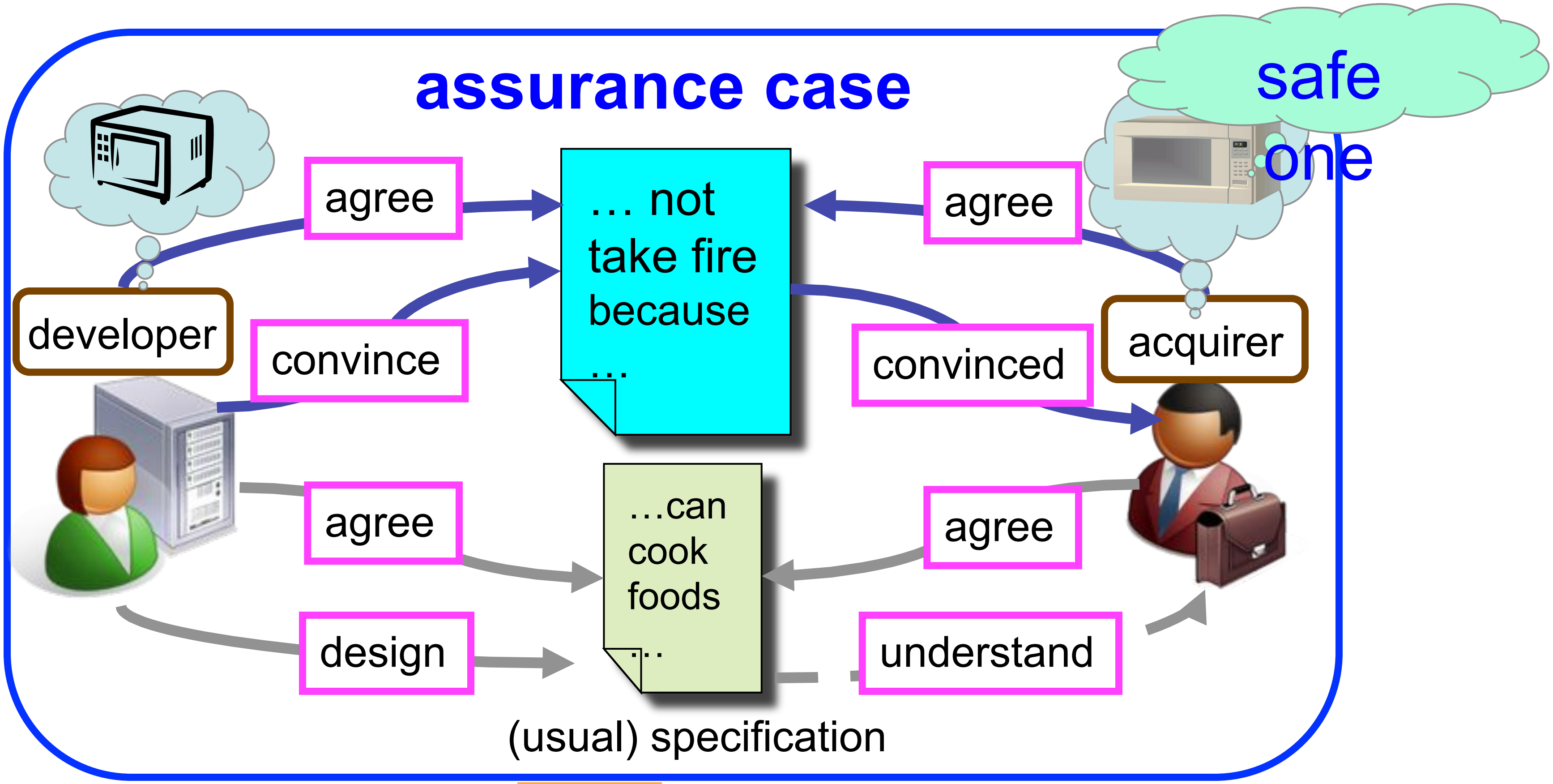
Assurance Case
ISO/IEC 15026

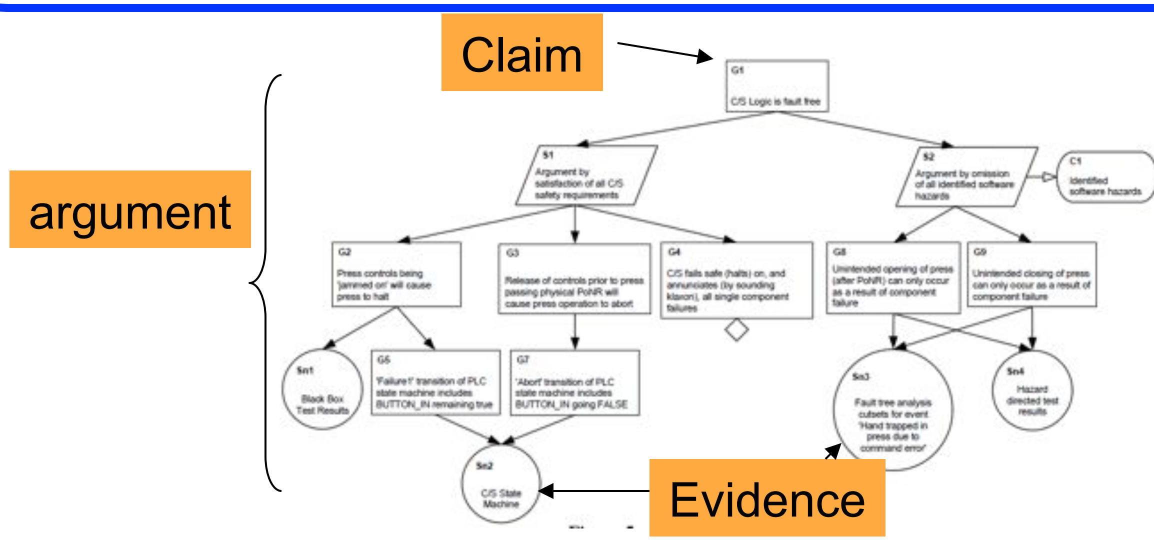
Toshinori Takai

(summary of the talk by Takamura-san)

Why we focus on assurance cases?

- For Open Systems, all risks cannot be known in advance
  - → we must treat unidentified risks
- One solution is agreement between stakeholders
  - ････→ assurance case

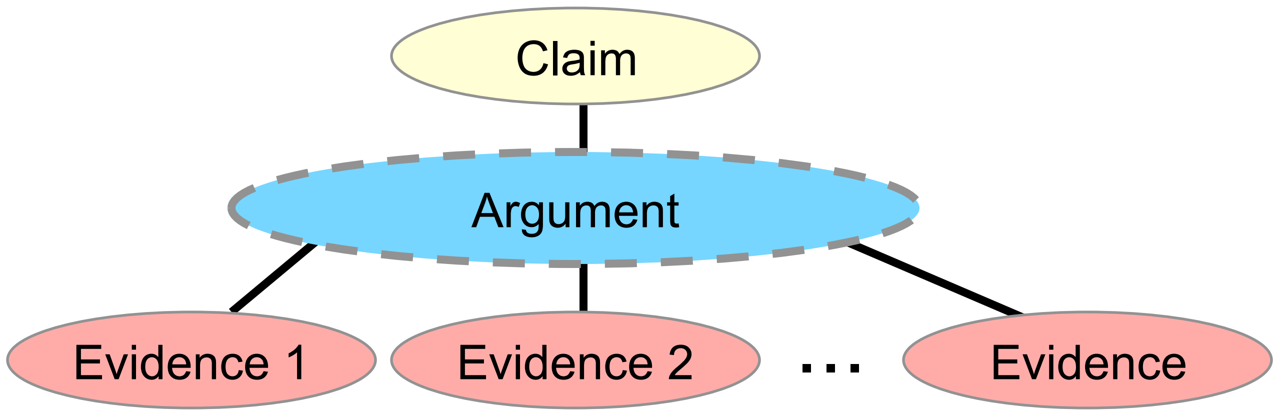

assurance case
safe one
agree
… not take fire because …
agree
developer
convince
convinced
acquirer
agree
…can cook foods …
agree
design
understand
(usual) specification


Claim
argument
Evidence

Definition and Role of Assurance Case (AC)

- Our definition:

  *A **documented body** of evidence which provides a convincing and correct argument that a system adequately satisfies the specified claim for a given application in a given environment*



- Role:
  - to give framework for reasoning and showing properties about systems
    - framework for evidences
    - information for decision making
  - risk communication tool
    - to convince the stakeholders of the claim which the AC argues for

Accountability

Management

An Example of Assurance Case

The microwave oven does not take fire under the condition that it is used only for foods

The hardware is the same one of the previous model of this product.
The software will almost be rewritten but the specification is well-written in formal way and it is developed using formal methods

Some reasoning may seem not reasonable but AC is for
- agreement or
- decision making

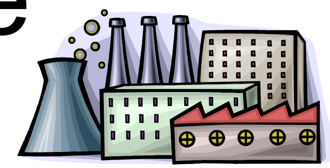
both may include subjectivity

Certification which states there have been no significant accident of the previous model for ten years

Formal software specification

Process model and plan for software development using formal methods

Background: Safety Case

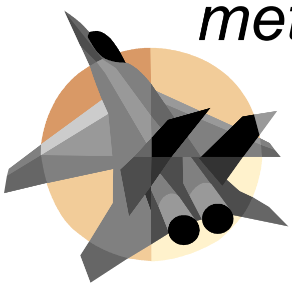


Most countries make efforts to continuously review and update the safety case (safety analysis report, procedures and other relevant technical documentation)

L. Högberg: *Convention on Nuclear Safety, First Review Meeting of Contracting Parties, Summary Report,* 1999

A software safety case, which justifies the suitability of the software development process, tools and methods, is required for software of all integrity levels

UK Defence Standard: *Requirements for safety related software in defence equipment*, 00-55(PART 1)/Issue 2, 1997



RVSM: THE EUR RVSM PRE-IMPLEMENTATION SAFETY CASE, EUROCONTROL, 2001.

Dependability Cases

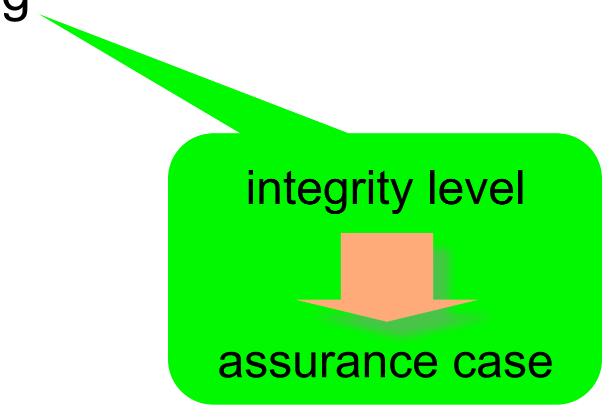
- Dep Case：G. Despotou, T. Kelly. Extending the Safety Case Concept to Address Dependability. ISSC 2004
- SEI: C.B.Winestock et.al. Dependability Cases, SEI techreport, 2004.

- D-Case: developed in DEOS project
  - tomorrow talk
- “Assurance case” is a general word for *-lity cases
  - safety case
  - dependability case
  - security case

  …

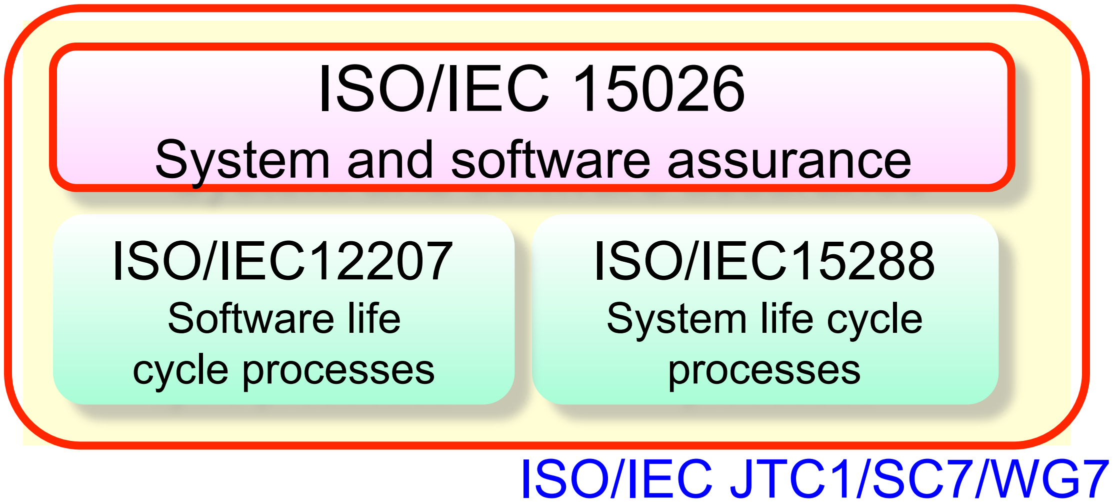
Communities for AC (Assurance Cases)

- International Working Group on Assurance Cases
  - Regular Members
    City University, London; UIUC; SEI; Adelard; University of York; CERT; Swedish Nuclear Power Inspectorate; CEC JRC, Ispra; CMU; DSTL (Defense Science and Technology Laboratory, UK); Mitre; NATO; CDA...
- ISO/IEC JTC1/SC7/WG7: ISO/IEC 15026
  - 1998 version is only for system integrity levels
    - integrity level of IEC61508 is an instance
  - currently, major revision process is running
    - 15026 Part1: Concepts and vocabulary
      - Technical Report (will be published soon)
    - 15026 Part2: Assurance case
      - Y. Kinoshita is a co-editor
    - 15026 Part3: System integrity level
      - T. Takai is a co-editor
    - 15026 Part4: Assurance in the life cycle
      - Y. Kinoshita is a co-editor



- OMG
  - notation

Characteristics of Standards proposed by JTC1/SC7/WG7



- Focus on sharing the concepts and providing the best practice
  - Unlike ISO9000、ISO14000、IEC61508
    (those are the standards for conformance assessment)
  - main aim is NOT the conformance assessment
- c.f. 12207and 15288 are the standard for sharing the concepts about each process in software/system lifecycle

Background: ISO/IEC 15026:1998
Integrity Level (IL)

- Def. (integrity level): A denotation of a range of values of a property of an item necessary to maintain system risks within tolerable limits

Table 2 - Example Risk Matrix

Frequency of Occurrence	Indicative Frequency (per year)	Severity of Consequence			
		Catastrophic	Major	Severe	Minor
Frequent	>1	High	High	High	Intermediate
Probable	$1 - 10^{-1}$	High	High	Intermediate	Low
Occasional	$10^{-1} - 10^{-2}$	High	High	Low	Low
Remote	$10^{-2} - 10^{-4}$	High	High	Low	Low
Improbable	$10^{-4} - 10^{-6}$	High	Intermediate	Low	Trivial
Incredible	$<10^{-6}$	Intermediate	Intermediate	Trivial	Trivial

Table 3 - Mapping Risk Class to System Integrity Level

Risk Class	System Integrity Level
High	A
Intermediate	B
Low	C
Trivial	D

Is Safety Integrity Level (SIL) Enough?

- Probabilistic characterization is not FIT for Software failure (including unidentified risk)
  - For instance, SIL 4 (the highest degree); Formal methods (FM) is Highly recommended in Software production
  - Define (Traceable) Evidence showing what and how to use FM in SW lifecycle
- Make Consensus-building based on the Evidence among Stakeholders

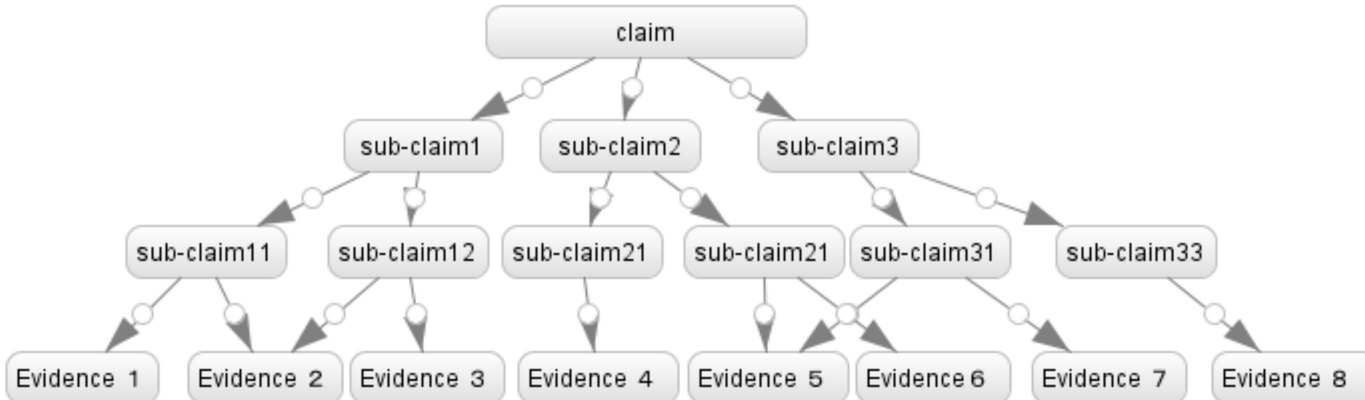
⇒Assurance Case

Observation: AC and Open system

1. For indentified risks, claims in AC are given in terms of IL
   - argument is important
   - the main role of AC is to show that a system has a certain IL
   - decision can be made automatically
2. For unidentified risks, claims in AC cannot be given in terms of IL
   - justification of the top level claim is important
   - the main role of AC is to make clear that what claim has to be considered
   - decision has to be made by human being

AC was introduced for open systems (?)
(maybe without intention)

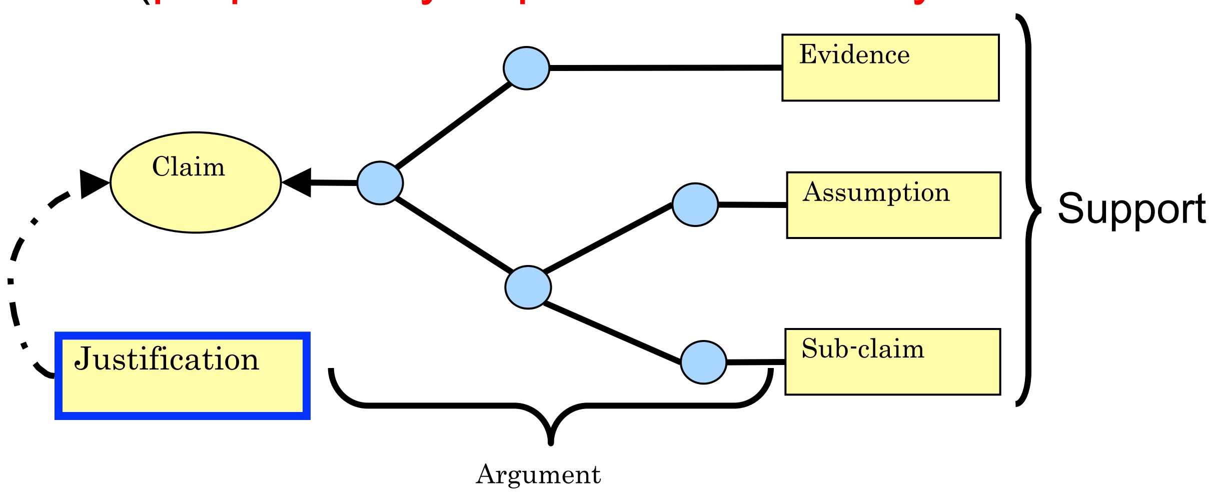
Problems on “Tree-Based” Assurance Case



- Problem1: “dividing” dependability is not obvious
  - reductionism does not work effectively
  - top-down analysis does not matched to dependability
- Problem 2: Each system has to have its own dependability attributes (availability, safety, etc)
  - Even if attributes are common, each system has its own dependence relation between those attributes
- Problem3: Need to provide a framework to modify the top level claim
  - when new threat is identified
  - the purpose of a system can also be changed

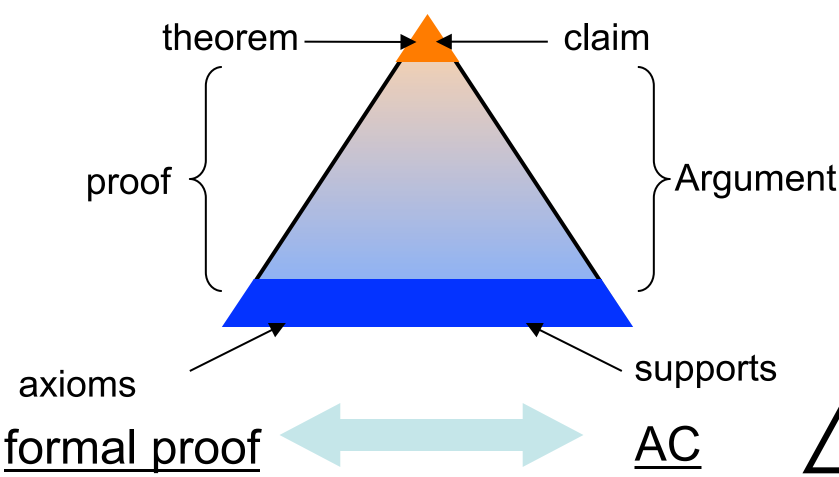
A new component of an AC (JTC1/SC7/WG7 version)

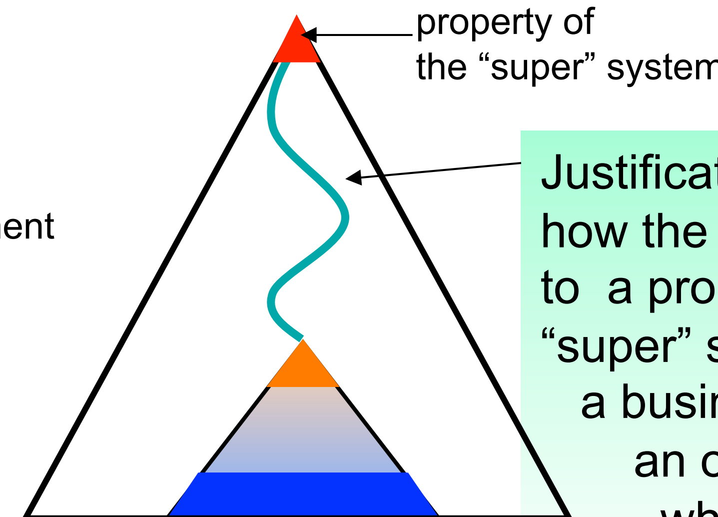
- *Claim*
  about an attribute or property of the system (usual)
- *Support*
  which can be either *Evidences*, (e.g., based on established scientific principles and prior research), *assumptions*, or *sub-claims*, derived from a lower-level sub-argument (usual)
- *Argument*
  showing how the evidence supports the claim, which can be deterministic, probabilistic or qualitative (usual)
- *Justification* which justifies the choice of claim
  (proposed by Japan national body of JTC1/SC7/WG7)



Definition of justification

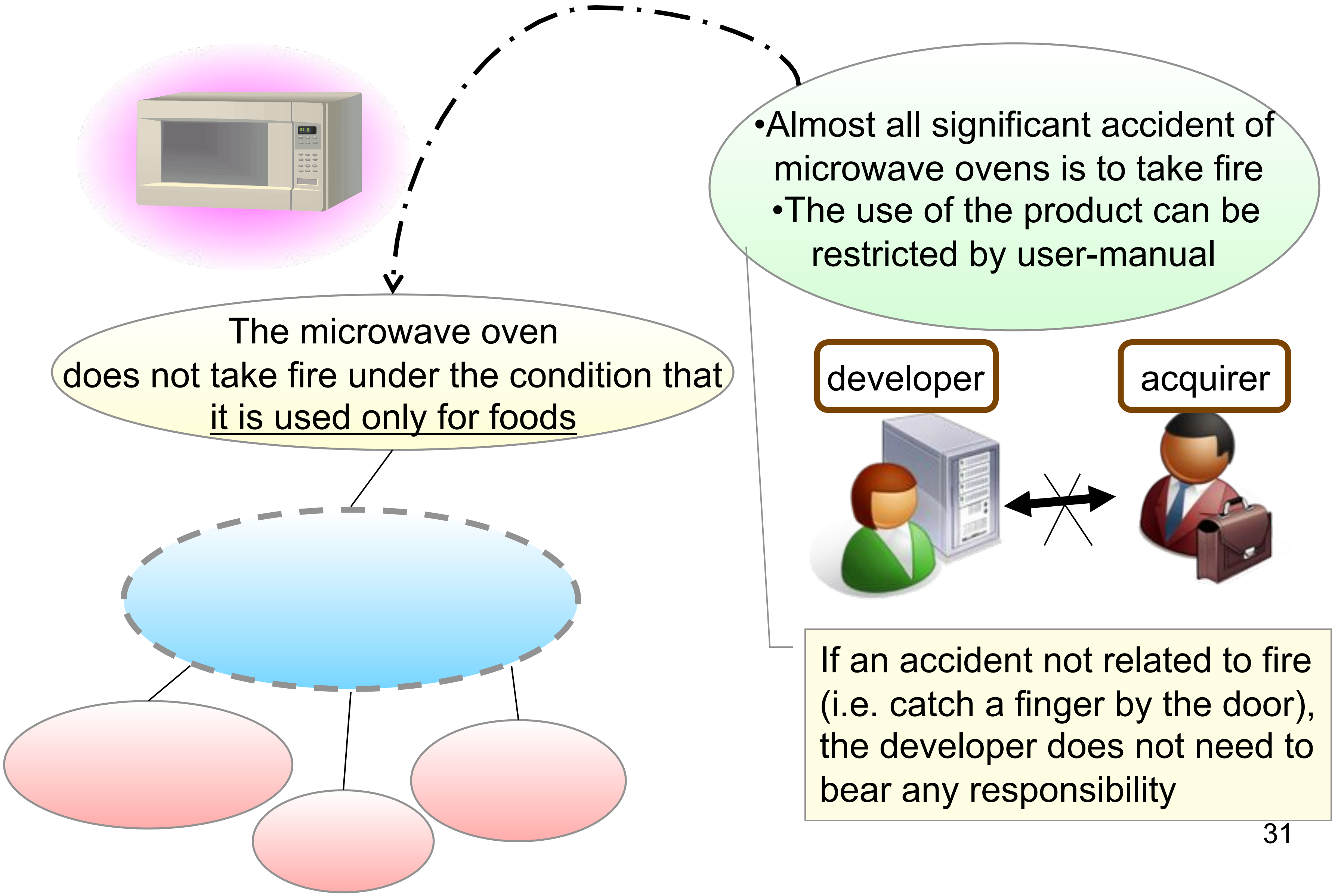
- A **justification** consists of data and explanation from which one can infer how the claims are chosen and why e.g.
  - results of risk assessments
  - results of requirement analysis and
  - explanation how these results lead to the choice of the top level claim
- proposed by Japan national body



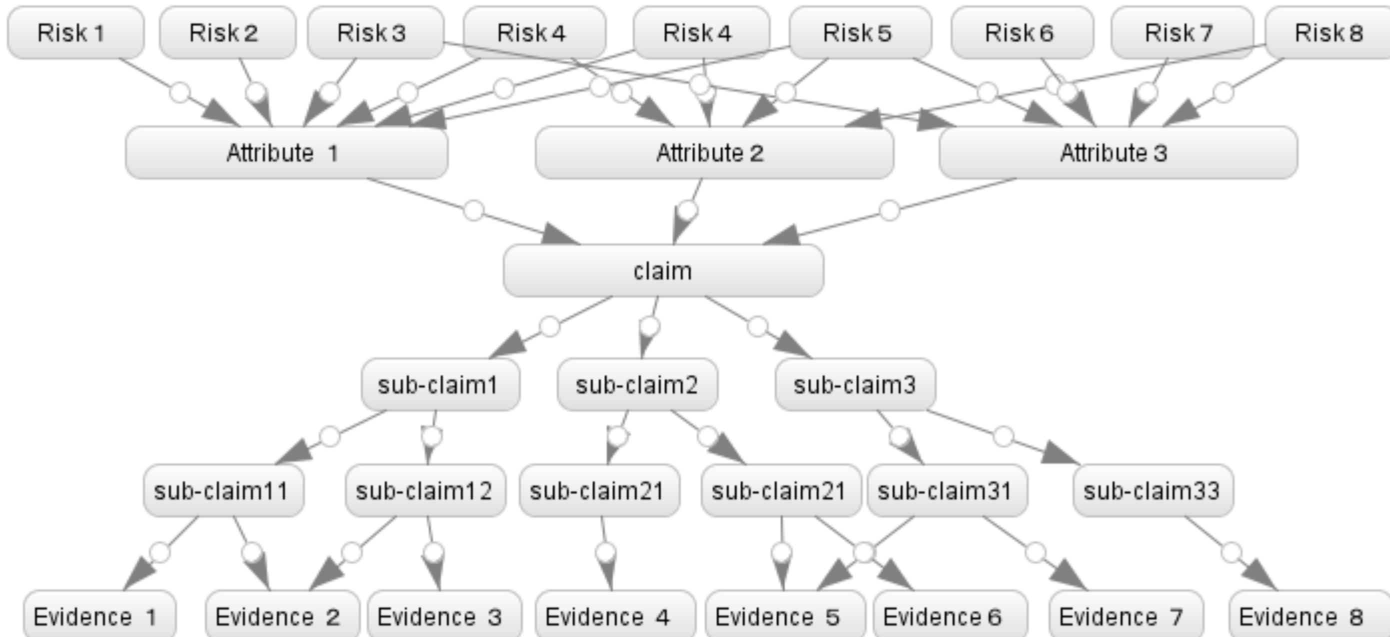


Justification explains how the claim contributes to a property of “super” system, e.g.
a business or
an organization
which uses
the system

An Example of Justification



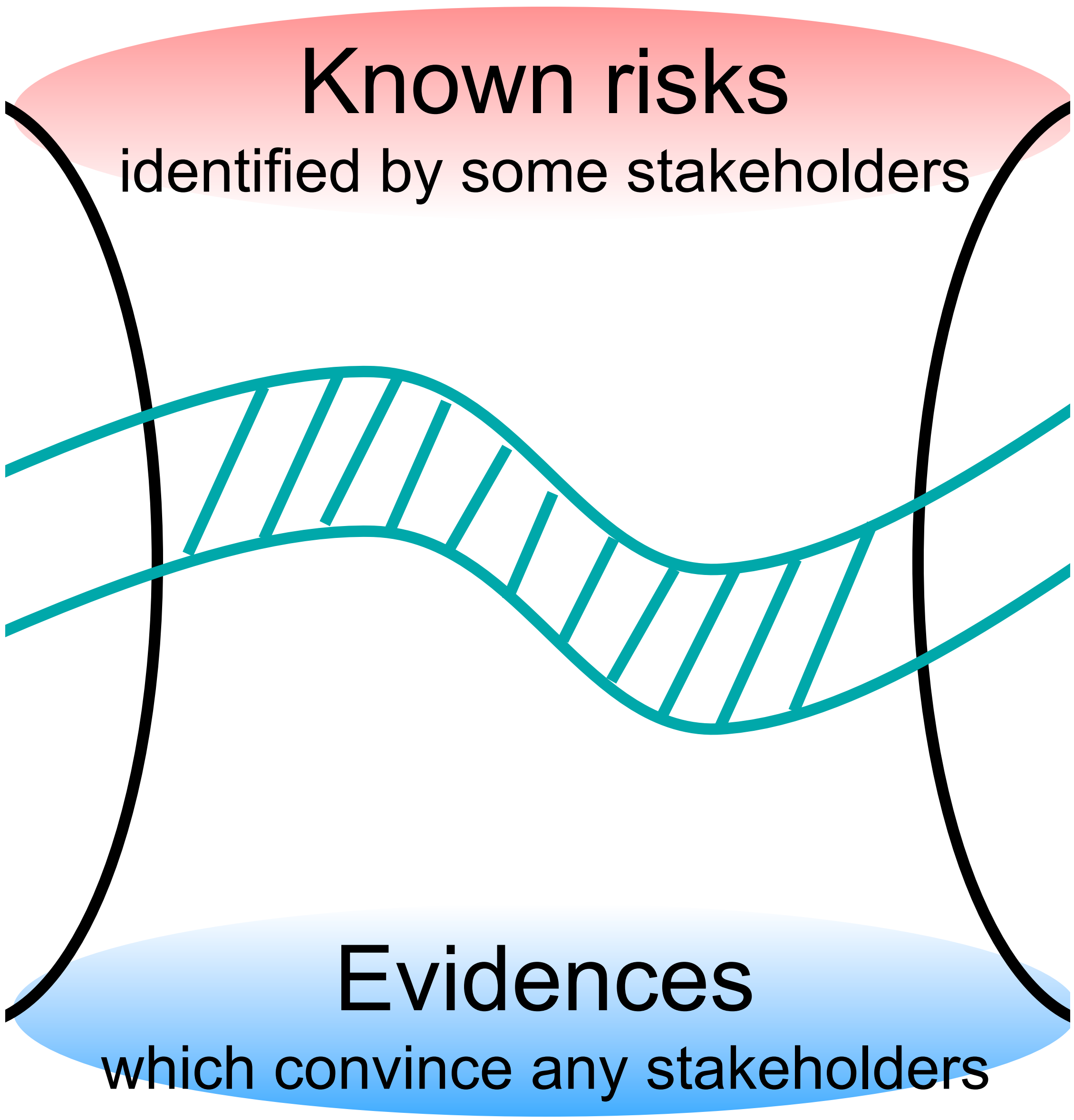
Possible structure of Justification



To record the reason of the choice of the top level claim in AC

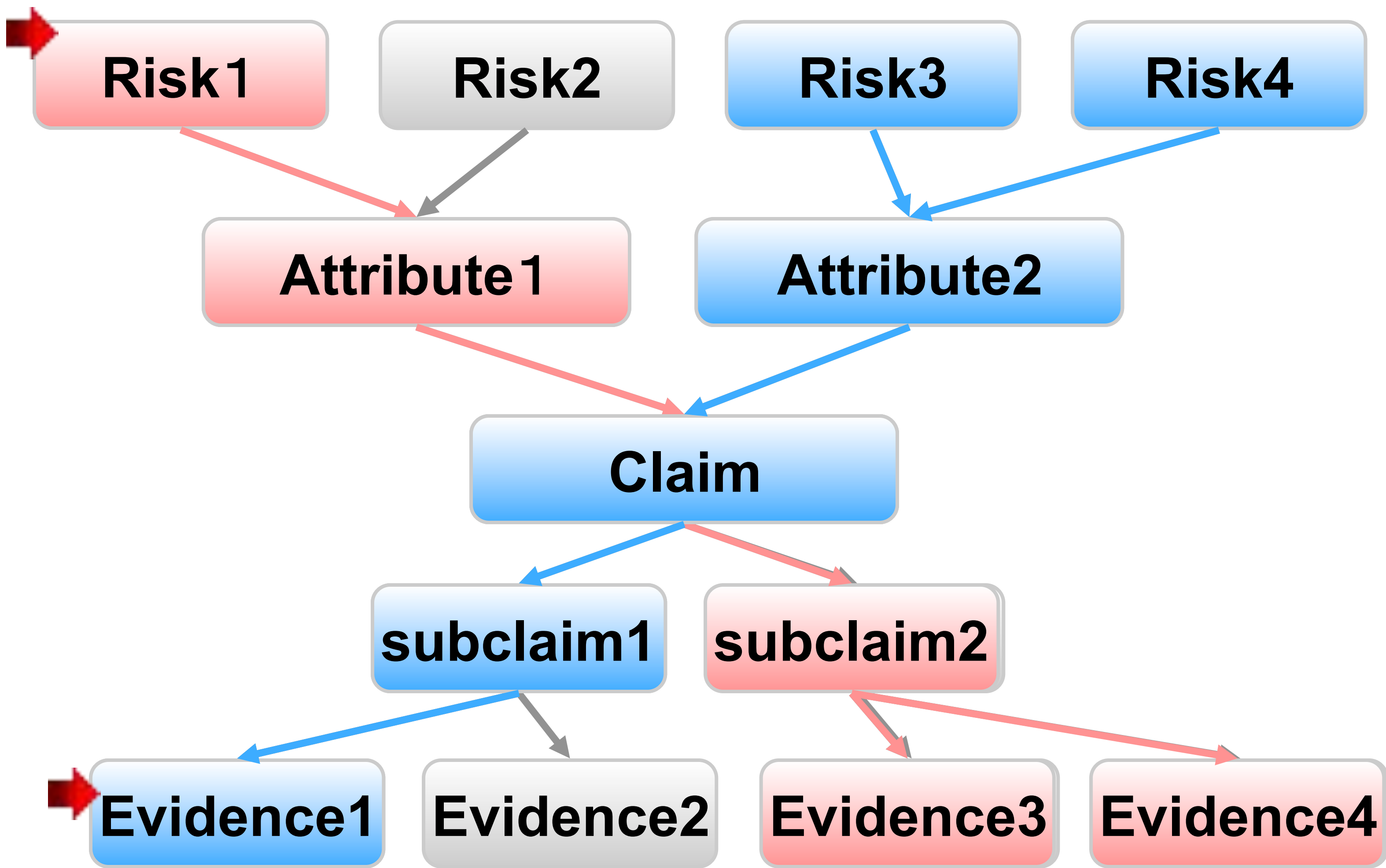
→ When a new threat is identified
the top level claim can be changed

Duality between risks and evidences



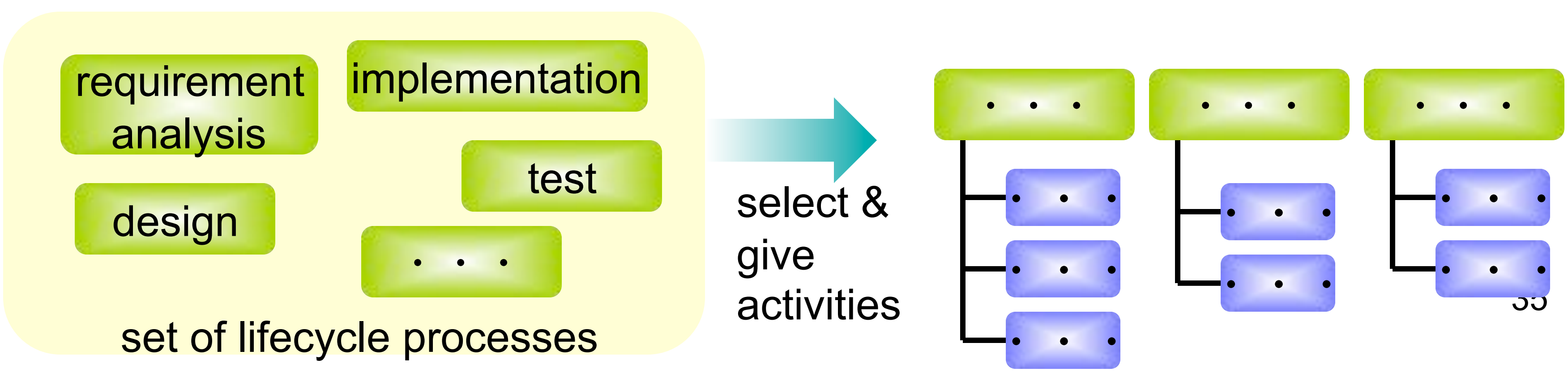
Claim =
a representation of
dependability which
can be understood
and convinced by
related stakeholders

Tool?


Risk1
Risk2
Risk3
Risk4
Attribute1
Attribute2
Claim
subclaim1
subclaim2
Evidence1
Evidence2
Evidence3
Evidence4

Future Plan：to propose Dependability Process View

- ISO/IEC12207/15288 do not define “right” or “wrong” lifecycle process, but define concepts and vocabulary
  - to define criteria for evaluating lifecycles, deciding a point of view is necessary
- Process View：in an system/software lifecycle, in order to achieve some specific goal, to select relating processes from 12207 or 15288 and to give necessary activities for their processes, e.g. usability process view



Observation: What's new on AC?

Usual specification can be seen as a document produced by agreement between acquirer and developer

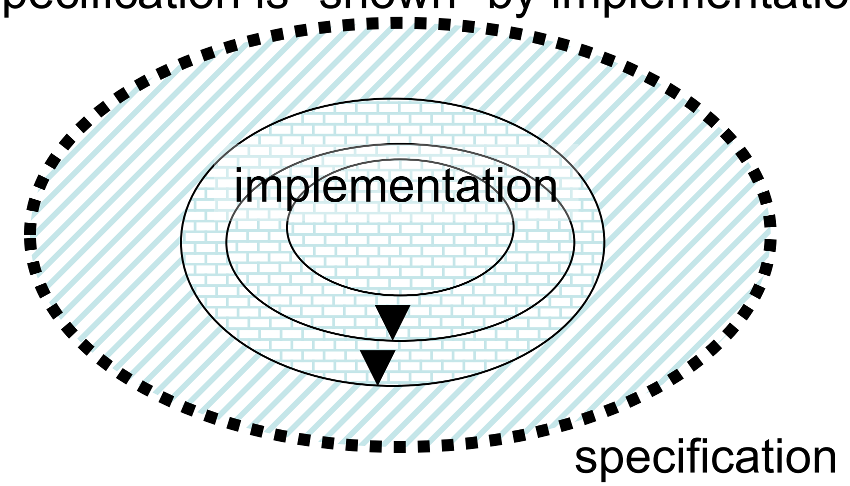
AC is a special case of usual specification ?

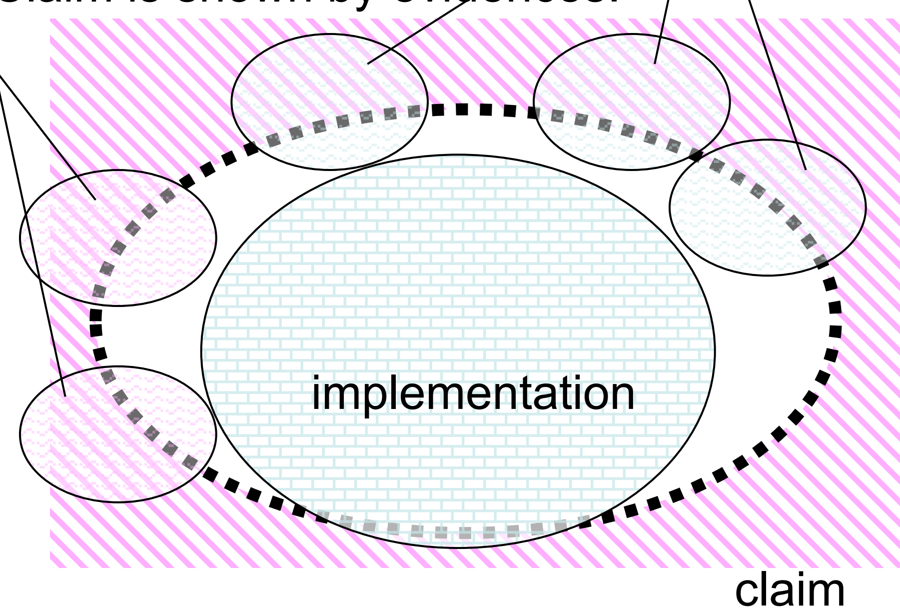
implementation of constraint (e.g. assertion or implementation of "functional safety")

assumption or evidence of environment

Claim is shown by evidences.

Specification is "shown" by implementation.





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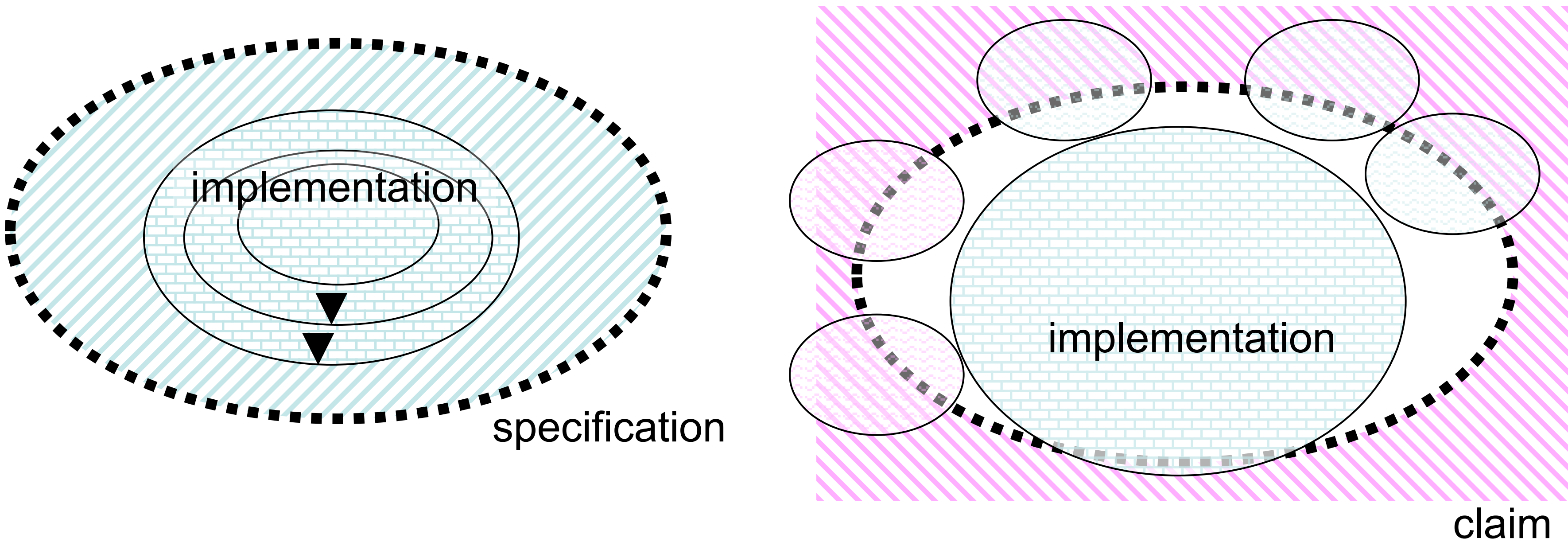


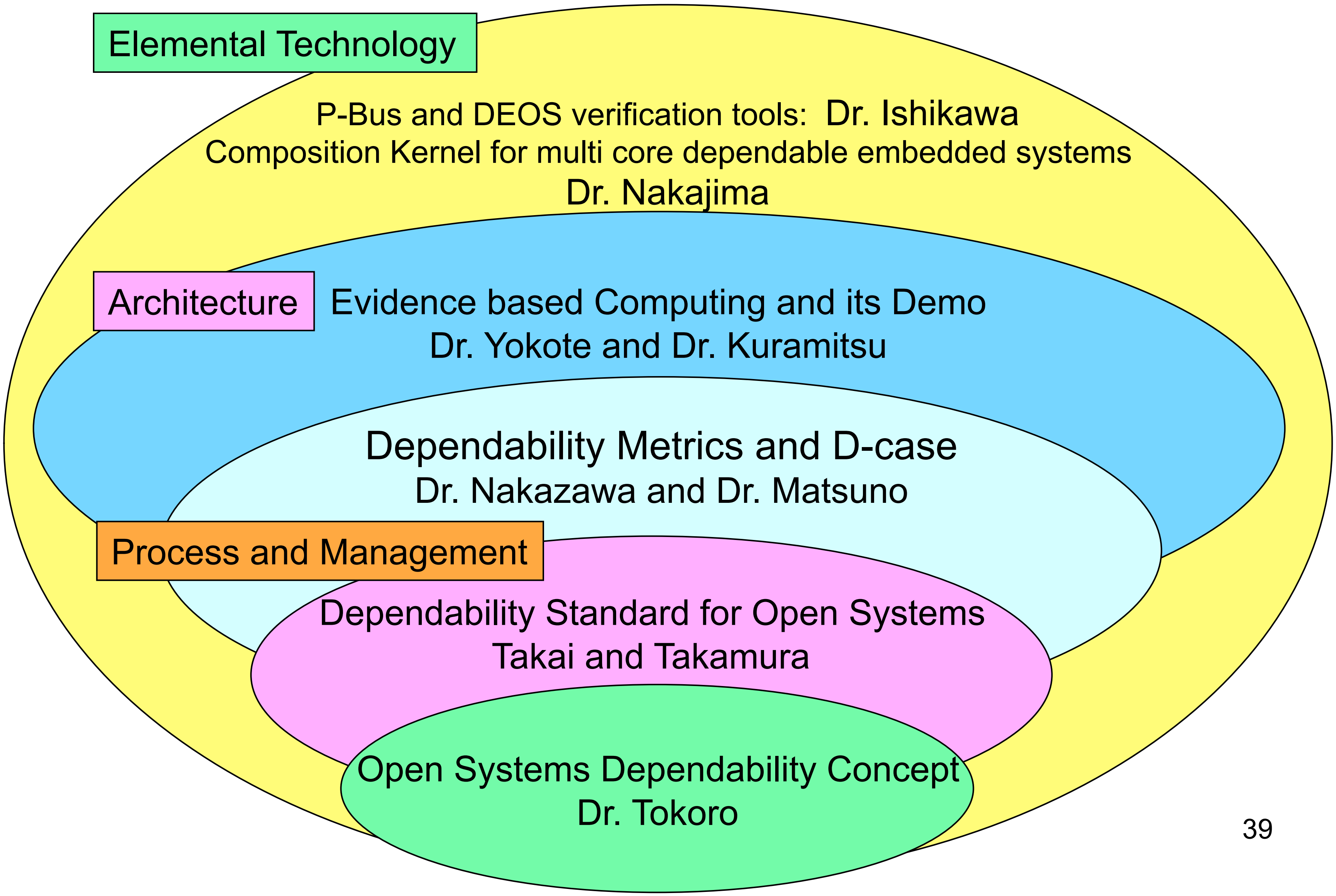
It is hard to show that some program code has some property relating to dependability

- formal specification languages will play an important role for traceability of dependability

Summary

- Our observation: for open systems, unidentified risks have to be considered
- Our focus: one solution is agreement between stakeholders
  - assurance case (AC) can be a tool for those agreements
- Activities for AC:
  - ISO/IEC JTC1/SC7/WG7 is working for standardizing AC and
  - DEOS project is now developing an implementation of AC, called D-Case (appeared in the following talks)
- Our proposal:
  - Unlike cases for specific attribute, (e.g. safety case, security case) justification plays an important role
  - Formal specification languages for dependability is important for traceability of dependability

Relationship among other talks in DEOS Project



資料など

課題

- システムのステークホルダーは誰か明示し、規格化
  - 誰が何をするのか（役割）
  - 責任はどこにあるのか（責任分担・責任共有）
  - 利害関係者間の合意形成
  - 情報の共有と情報の流れ
  - リスクコミュニケーション
- どのフェーズでもエビデンスを提示する機構の実現
  - D-fopsでの実装
- オープンシステムには、システム境界を変化による影響分析を実施
- リスク分析の徹底（回避・転嫁・軽減・受容）
- 緊急時（不確定要因）への対応：コンテンジェンシープラン

課題

- 生物としてシステムをとらえる方法論の確立
  - 創発し階層を超える活性をどう記述するのか？
  - 部分の総和≠全体
  - 自己治癒・内科的処置・外科的処置に対応する技術
    - Self-adaptability, Self-monitoring
    - Policy based reconfiguration
    - Property based isolation
- システム評価は稼動中と廃棄後の両面で
  - 資産の観点の導入
    - 後継システムに何を残したのか？
    - 資産には再利用可能なコードのみならずプロジェクト管理法など

オープンシステムに対して
-不完全・不確定には-

- 発展・改善プロセスをどうするのか？
  - 誰がどこで実施するのか？PDCAサイクルで対応するのか？
  - 運用・保守フェーズが重要か？
  - 発展の方法論をどのように定義するのか？
  - 改善されているとは？
- 柔軟に対応できるようにシステムを設計する
  - 汎用的な設計
  - ポリシーによる再構成
- Evidenceを残す仕組みを用意
  - 何かあったときに説明するため

    ⇒　説明責任
- 対策に解はないかもしれないし、あっても唯一ではない可能性も考慮

  ⇒　**マネージメントで対応**する

Our challenge to Open Systems Dependability

- オープンシステムへの対応
  - 不確定・不完全への対応
  - 説明責任の徹底
  - リスクマネージメント・リスクコミュニケーション
    - リスクの裏返し⊆不確定・不完全への対応
    - unidentified riskへの対応
  - 生物としてのシステム：恒常性の維持
    - 全体≠部分の総和　創発への対応
  - 緊急時対応は行動で
    - コンティジェンシー計画
  - システム評価：運用中、廃棄後、資産の観点、再利用、LCC
  - システムプロファイリング
  - 安全文化、改善：PDCAなど醸成するもの
  - ディペンダビリティ属性間の調和の決定法
  - manageability, adaptability, usability への対応
  - stakeholder間の合意形成 assurance case

Our challenge to Open Systems Dependability

- Dependability ≒ Accountability + Risk management
- How to deal with uncertainty and incompleteness
- Risk management and Risk communication
  - How to treat unidentified risk
- System as a Life (Human)
  - Keep a service continuously ≒ maintain homeostasis
  - Sum of parts in system ≠ Whole system
  - Emergence
- Business continuity plan
  - Contingency plan
  - manageability, adaptability, usability
- System profiling
- Improvement processes
  - PDCA cycle
  - harmonize among dependability attribute (including trade-off analysis)
- Define the Consensus building process among stakeholders (Assurance case)

安全と安心

- 危険を排除
  - 安全性を高めた
- 不安を軽減
  - 安心を提供した
- 不満に対応
  - 満足を提供した

- 安全とは、
  - 危険がないこと（絶対安全）から、許容できないリスクながいこと（機能安全）へ
  - リスク= ハザード×遭遇確率
  - 安全文化の醸成
    - **マネージメント**でも安全を保障する仕組み

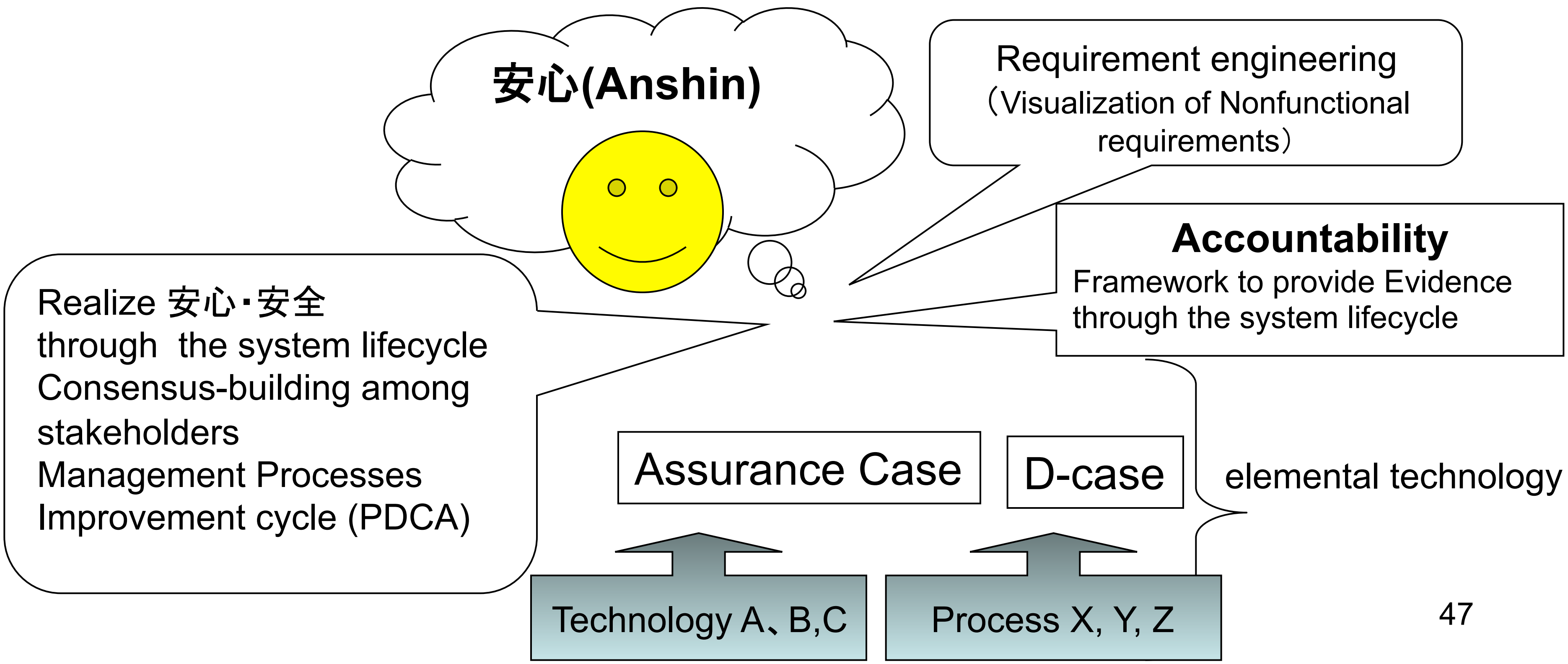
- 開発者は安全性を高めることで信頼性やらを技術・プロセスにより保証する

- 利用者には技術の中身よりも、漠然とした「不安」が軽減されている方が重要かも知れない
  - 安心を得るためには、不安(anxiety)を軽減する仕組み

- 安全文化では、被害を受ける可能性がある立場について充分には考慮されていない
  - 利便性などとの相反は？

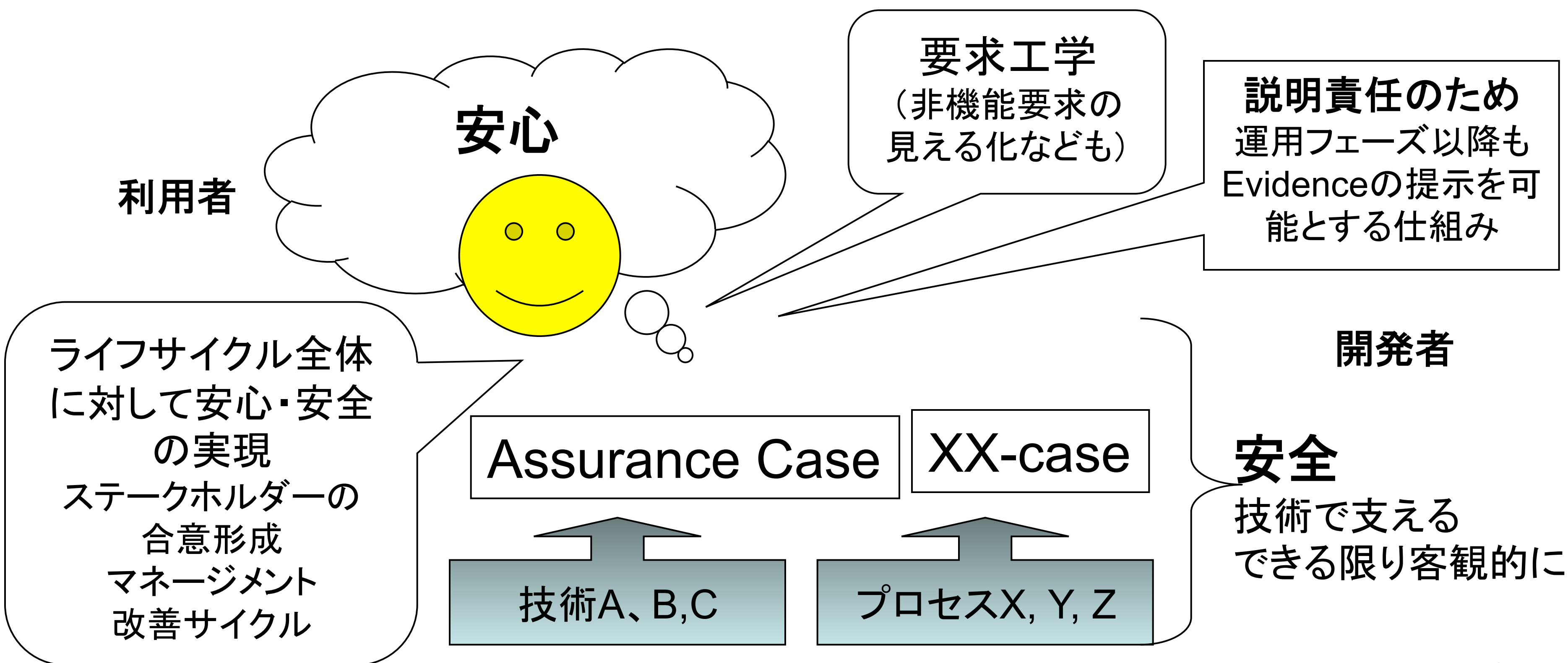
Realize 安心(Anshin)･安全(Anzen)
-connecting requirement and technology-

- Realize Dependability (安心･安全) by connecting elemental technology and management processes.
- It is necessary to provide the consensus-building process among the stakeholders ⇒ Assurance Case



安全・安心を繋ぐ-要求と技術を結ぶ-

- 安心・安全を実現するために、さらに技術でそれらを担保するために、ステークホルダー間に何らかの形での合意形成を、そのための一手段としてAssurance Caseなどによるものが最低限用意されている必要がある。



規格について

- オープンシステムを対象に全ライフサイクルでディペンダビリティを担保するための規格
  - システムプロファイリングによるシステムディペンダビリティレベルの設定
- 継続的に満足いくサービスを、使いたいときに提供し、それが出来ない状態になったときにでも、保護してくれる安心な仕組みの提供
  - リスクマネージメントも含めて、各種（運用・保守等）マネージメントを
  - PDCAにかわる改善サイクルの提案
- Evidenceを基礎に設計から運用フェーズ以降も論拠が提出できる仕組みを規定
  - 全容把握は困難なので、どこかで切り分け；システム境界などカバーする範囲を設定しながら
- ステークホルダ間の合意形成（Assurance Caseの導入）
  - 契約を超えた納得（SLAで充分ではない）
  - 責任の明確化は分担だけではなく、共有と被覆・融合（和解のプロセス？）も含めて検討

System Profiling

- システム境界を変化させる、ステークホルダーの役割と情報の流れ（シナリオベース）、アスペクト指向ベース等、さまざまな視点・観点から、システムの挙動・障害発生時の影響等を解析して対応を考える
- ステークホルダーそれぞれの立場に応じてどのようなサービスを提供し（され）、責任として何をすべきなのかを明確にする
- 役割・責任共有など合意形成をスムーズに行うためのシステムの分析と運用方法など総合的にとらえるためのプロファイリング
- システムが故障したときの影響についても評価、その評価に応じた対策をシステム構築時に課すことも
- 全容把握は困難（不可能？）でも、つねに全体像の把握を試みること

System as a Life (Human)

- システムを生物（人間）と見る観点から、システムへの対応を探る
- 生命を維持するための仕組み：
  - 恒常性の維持のために必要な事柄: 自己回復力（免疫力）
  - 内科的処置（medical therapy）： Policy based reconfiguration
  - 外科的処置（surgical manipulation）: Property based isolation
- 環境変化へのシステムの対応：adaptanility
  - システム発展（進化）・超回復（overcompensation ）の観点から
- 「部分の総和≠全体」への対応：
  - 自己組織化（self-organization）、創発（emergence）をどう表現し、どう対応するか
  - autonomic computing の考え方 MAPE ループ
  - 階層を超えた挙動などの取り扱い

- What can be said at all can be said clearly; and whereof one cannot speak thereof one must be silent. (Ludwing Wittgenstein, Tractatus Logico-Philosophicus)
- Management Processes
  - what we need to manage?
    - resource, process (development, operation and maintenance,…), information, knowledge, assurance, asset, configuration, performance, project, …
  - Processes for PDCA (using available software processes, etc)
  - Processes for Risk Management
  - Standardization for Accountability (risk management with evidence) with Dependability Level
- 合意せざるを得ないもの
  - 合意形成プロセスは明示的に、第三者が見てもわかるようにする。
- SW工学、要求工学でなされてはいるが、不十分な点を浮き彫りにしてよりよい解法を提案する。ラフにいえば新しい仕様記述言語の設計
  - より可読性が高く、コンパクトにステークホルダーの全てが納得のいく形で記述、意思決定し、合意形成をするための方法としてassurance case
- In general, we can view a specification as the statement of an agreement between a producer of a service and a consumer of the service or between an implementer and a user