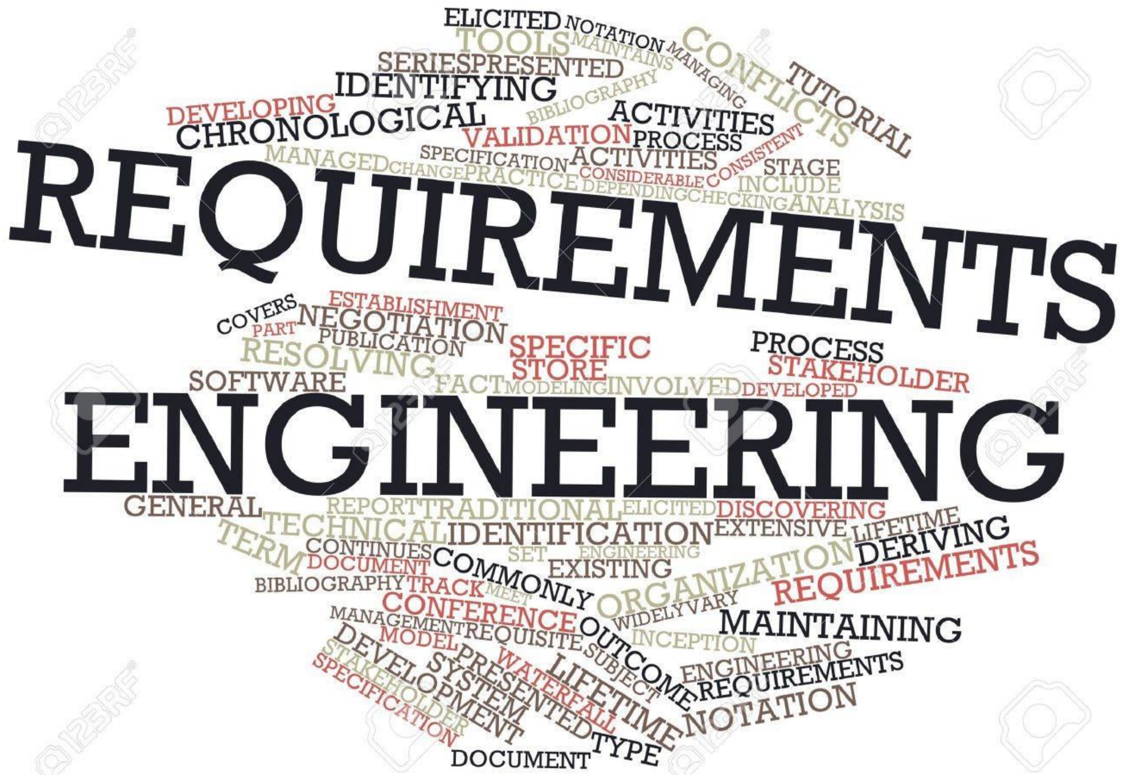


SWE 215: Software Requirements Engineering

Lecture 12

Fundamentals of Requirements Management

Course Topics

- ~~Why Requirements Engineering?~~
- ~~Introduction to Requirements~~
- ~~RE in Software Development Life Cycles~~
- ~~System Vision, Context, and RE Framework~~
- ~~Fundamentals of Goal Orientation~~
- ~~Fundamentals of Scenarios~~
- ~~Requirements Discovery~~
- ~~User Stories and Agile Estimation~~
- ~~Features Prioritization~~
- ~~Requirements Negotiation~~
- ~~Requirements Validation~~
- Fundamentals of Requirements Management

Lecture Objectives

- Learn how to manage requirements artifacts
- Learn the fundamentals of requirements traceability

Outline

- Why do requirements change?
- Problems caused by requirements changes
- Requirements management activities
- Requirements change factors
- Requirements change attributes and status
- Version Control
- Traceability
- Forwards and Backward Traceability
- Traceability Tools

Why do requirements change?

- **Change** in software development is **inevitable** and **difficult to control.**

- **Change may occur in:**
  - Business
  - Context
  - Technologies
  - Markets
  - …

- Possible responses to change:
  - Add new requirements,
  - modify existing requirements,
  - remove requirements

Some problems due to changing requirements

- Requirements changing **towards the end of development without any assessment of its impact**

- **Unmatched/outdated** requirements specifications causing **confusion** and **unnecessary rework**

- **Time** spent coding, writing test cases or documentation for **requirements that no longer exist**

Requirements Management

A **systematic approach** to **eliciting**, **organizing**, and **documenting the requirements** of the system, and **a process that establishes and maintains agreement between the customer and the project team on the changing requirements of the system.**

Requirements Management Activities

- Includes all activities intended to **maintain the integrity and accuracy of expected requirements**
- Manage changes to agreed requirements
- Keep project plans synchronized with requirements
- Control versions of individual requirements and versions of requirements documents
- Manage relationships between requirements
- Managing the dependencies between the requirements document and other documents produced in the systems engineering process
- Track requirements status

Requirements Change Factors

➢ Requirements errors, conflicts, and inconsistencies

- May be detected at any phase (when requirements are analyzed, specified, validated, or implemented)

➢ Evolving customer/user knowledge of the system

- When the requirements are developed, customers/users simultaneously develop a better understanding of what they really need

➢ Technical, schedule, or cost problems

- Difficult to plan and know everything in advance
- We may have to revisit the list of requirements and adapt it to the current situation

Requirements Change Factors (2)

Changing customer priorities, new needs:

- May be caused by a change in the system environment (technological, business, political...), i.e., the context
- Business and strategic goals may change
- May be caused by the arrival of a new competitor
- Laws and regulations may change
- Collaborating systems may change
- May also be caused by technology changes in the enterprise (migration to a new operating system, DBMS…)
- May be caused by organizational changes (organizational structure, business processes, employees…)

Requirements Volatility

Some requirements are usually more subject to change than others:

- **Stable requirements** are concerned with the essence of a system and its application domain
- Derived from the client's principal business activities or the domain model
- Example: **a hospital will always have doctors, nurses, patients…**

- **Volatile requirements** are specific to the instantiation of the system in a particular environment for a particular customer at a particular time
- Example: **in a hospital, we can think of requirements related to the policies of the government health system**

Expectations of Requirements Management

- ➢ Identification of individual requirements (**Unique Identification**)

- ➢ Traceability from highest level requirements to implementation
  - Established via **links** through a **requirements database**
  - **Links between requirements and design models, tests, code**…
  - Coverage and consistency analysis

- ➢ Impact assessments of proposed changes
  - Which other requirements (and other linked artifacts) will be affected by a change

Requirements Have Attributes

- ➢ Attributes establish **context** and **background**, and go beyond the requirement description

- ➢ For filtering, analysis, metrics…
- Creation date, Last update, Author, Stakeholders (Owners / Source)
- Version number
- Status, Priority, Importance, Stability
- Rationale, Comments
- Acceptance criteria
- Subsystem / Product release number

- ➢ The more complex the project, the richer the attributes…

Requirements Change Status

- Help manage the requirement lifecycle
  - Their number and nature depend on the process in place

- Examples of statuses:
  - Proposed: by some stakeholder
  - Approved: part of baseline, committed to implement
  - Rejected: after evaluation
  - Implemented: designed and implemented
  - Verified: Relevant tests have passed
  - Deleted: Removed from list

Version Control

- ➢ Every version of a requirement needs to be **uniquely** identified
  - Changes need to be **documented** and clearly **communicated**
  - A version identifier must be **updated** with **every change** to the requirement

- ➢ Requirements documents should include
  - **A revision history**: changes, dates, by whom, why...
  - Standard markers for revisions (e.g., strikethrough or underlined text, coloring, line markers…)

- ➢ **Version control tool may be used**
  - To store and manage the revision history
  - To store justifications (to add, modify, delete, reject a requirement)

Traceability

Traceability Quotes (1)

- Requirements traceability refers to the ability to describe and follow the life of a requirement, in both **forwards** and **backwards** direction (i.e., from its origins, through its development and specification, to its subsequent deployment and use, and through all periods of ongoing refinement and iteration in any of these phases)”.[1]

- One cannot manage what cannot be traced.[2]

[1] Gotel & Finkelstein, 1994; [2] IEEE Standard 830-1998; [3] Palmer, 2000;

Traceability Quotes (2)

- Traceability gives essential assistance in understanding the relationships that exist within and across software requirements, design, and implementation.[3]
- Traceability information helps assess the impact of changes to requirements, connecting these requirements as well as requirements for other representations of the system.[3]
- Traceability is often mandated by contracts and standards, e.g., military and aerospace [1].

[1] Gotel & Finkelstein, 1994; [2] IEEE Standard 830-1998; [3] Palmer, 2000;

Benefits of Traceability

- Prevents losing knowledge
- Supports the verification process (certification, localization of defects)
- Impact analysis
- Change control
- Improved software quality (make changes correctly and completely)
- Reuse (by identifying what goes with a requirement: design, code…)
- Risk reduction (e.g., if a team member with key knowledge leaves)

Traceability Difficulties

- Various stakeholders require different information
- Huge amount of requirements traceability information must be tracked and maintained
- Manual creation of links is ***very*** demanding (**Likely the most annoying problem)**
- Specialized tools must be used
- Integrating heterogeneous models/information from/to different sources (requirements, design, tests, code, documentation, rationales…) **is not trivial**
- Requires organizational commitment (with an understanding of the potential benefits)

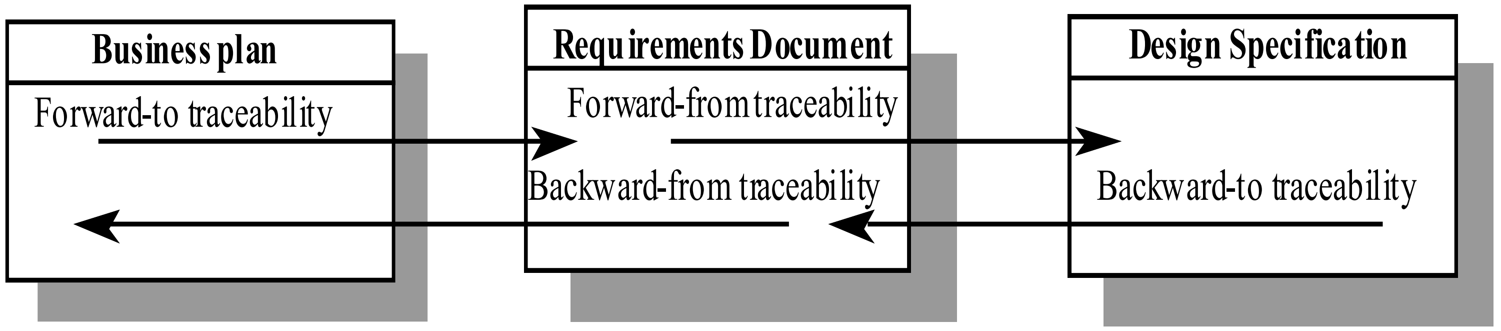
Backward and Forward Traceability

➢ Backward traceability

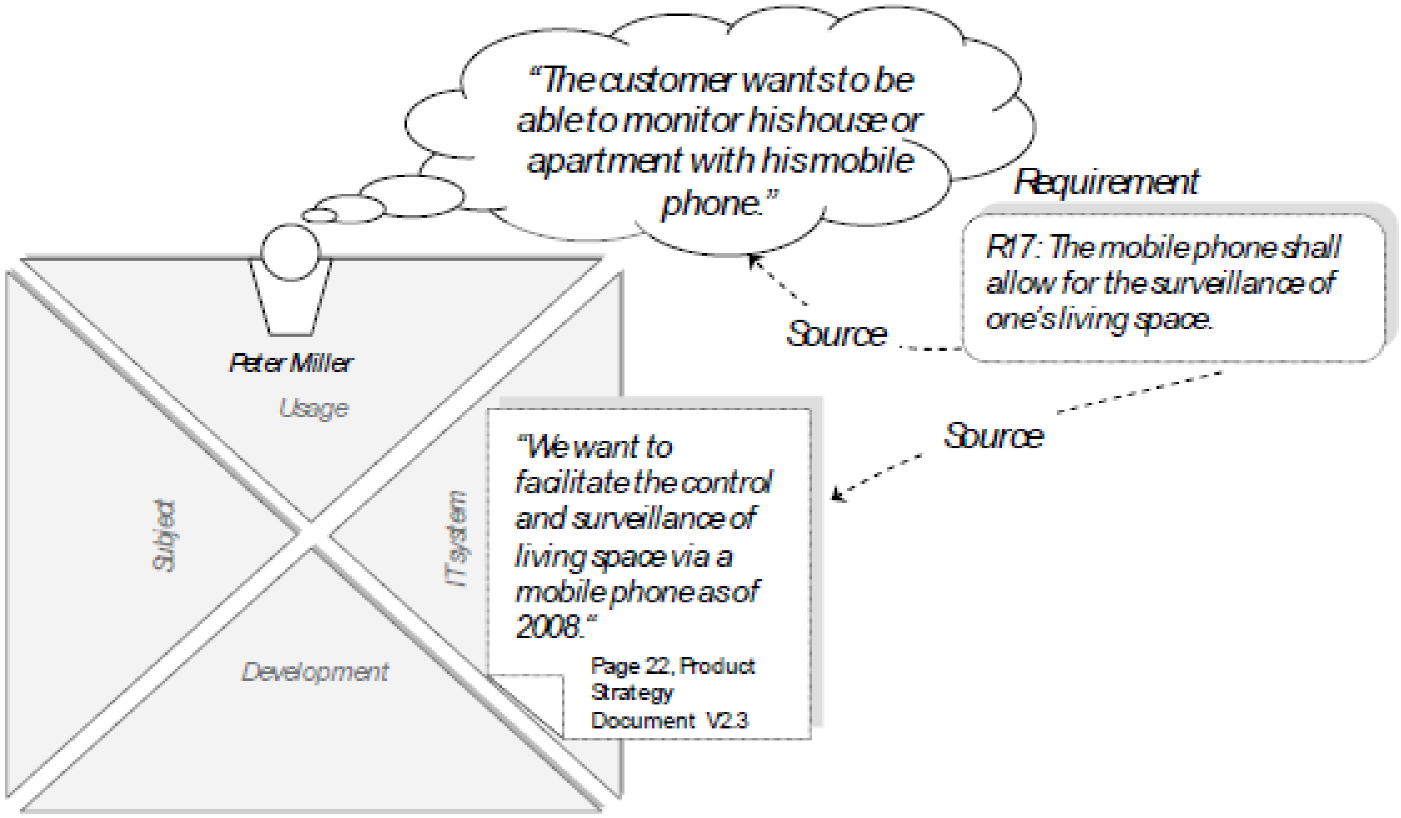
- To **previous** stages of development
- Links other documents (which may have preceded the requirements document) to relevant requirements
- **Help evaluate which requirements are affected by changes to users' needs**

➢ Forward traceability

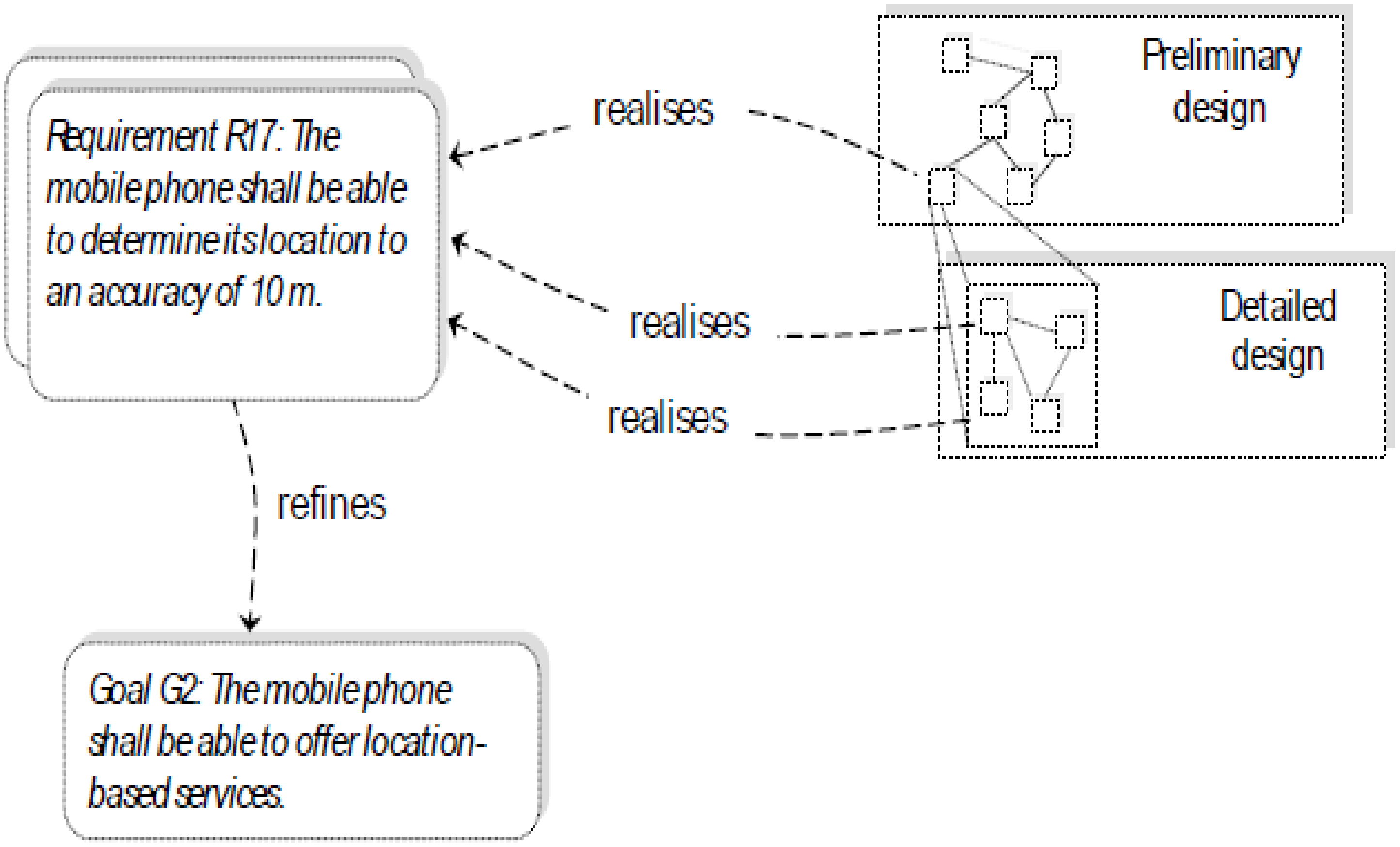
- Links requirements to the design and implementation components
- Help assure that all requirements have been satisfied



Example of backward-traceability of a requirement

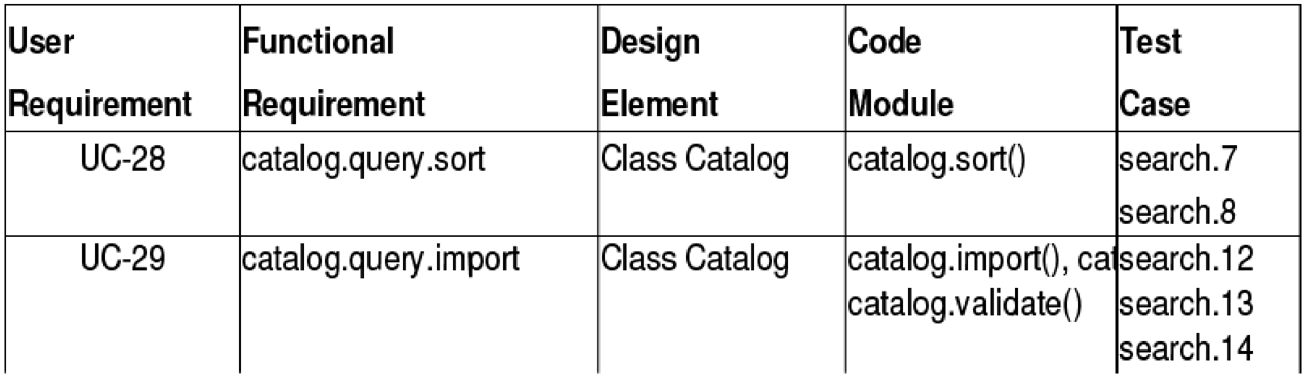

"The customer wants to be able to monitor his house or apartment with his mobile phone."
Requirement
R17: The mobile phone shall allow for the surveillance of one's living space.
Source
Source
Peter Miller
Usage
Subject
IT system
Development
"We want to facilitate the control and surveillance of living space via a mobile phone as of 2008."
Page 22, Product Strategy Document V2.3

Example of forward-traceability of requirements and traceability between requirements


Requirement R17: The mobile phone shall be able to determine its location to an accuracy of 10 m.
realises
Preliminary design
realises
Detailed design
realises
refines
Goal G2: The mobile phone shall be able to offer location-based services.

Representation – Traceability Table

- Show the relationships between requirements or between requirements and other artifacts
- Table can be set up to show links between several different elements
- Backward and forward traceability
- Difficult to capture different types of links



User Requirement	Functional Requirement	Design Element	Code Module	Test Case
UC-28	catalog.query.sort	Class Catalog	catalog.sort()	search.7 search.8
UC-29	catalog.query.import	Class Catalog	catalog.import(), cat catalog.validate()	search.12 search.13 search.14

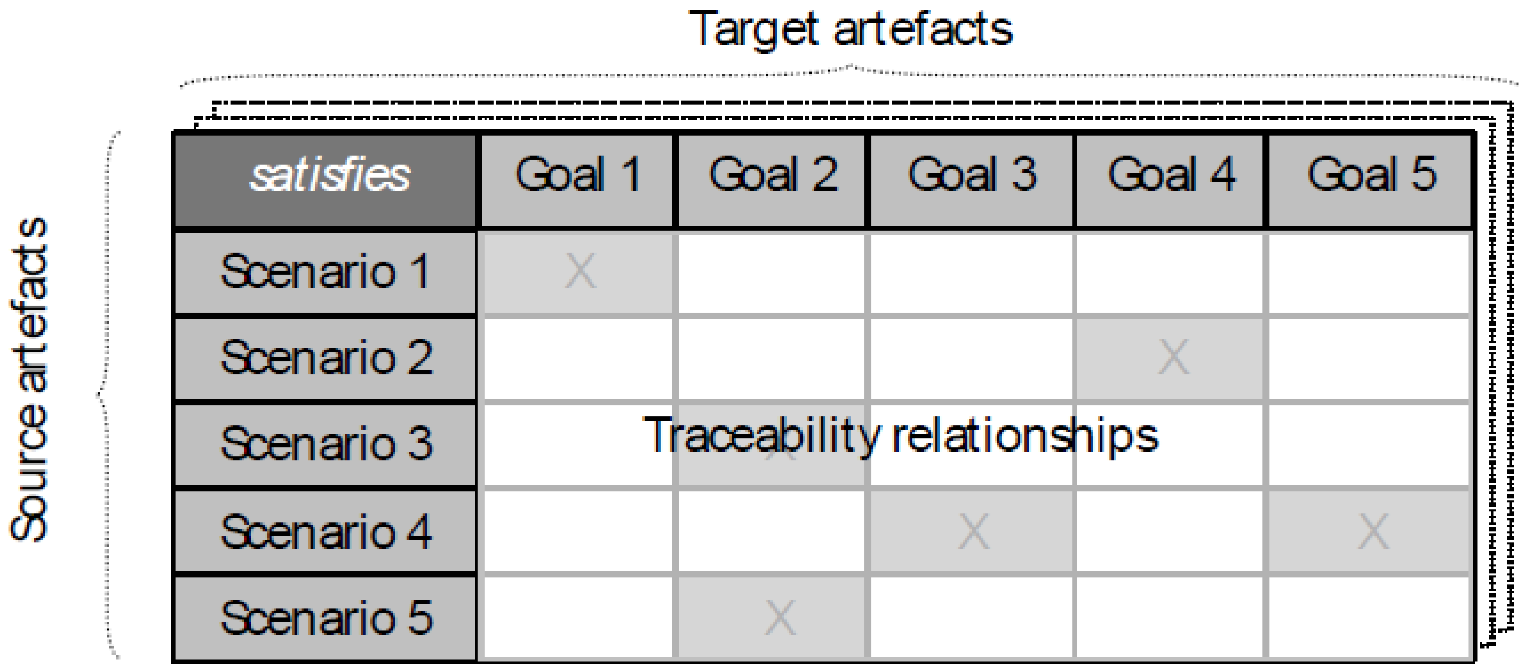
Representation – Traceability Matrix

- Define links between pairs of elements, e.g., requirements to requirement, use case to requirement, requirement to test case…
- Can be used to **defined relationships between pairs,** e.g., specifies/is specified by, depends on, is parent of, …
- More amenable to automation than traceability table

Depends-on

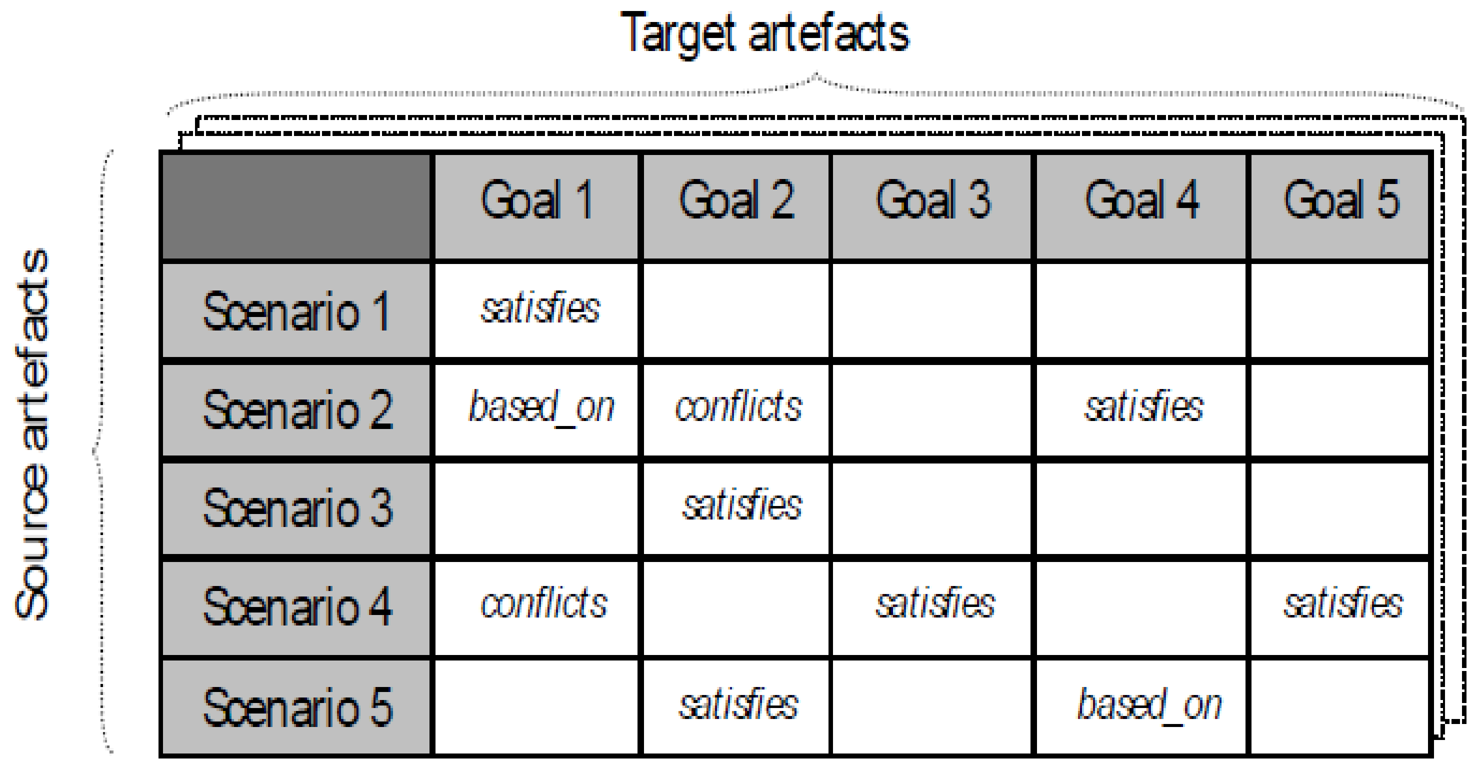
	R1	R2	R3	R4	R5	R6
R1			*	*		
R2					*	*
R3				*	*	
R4		*				
R5						*
R6						

Traceability matrix for a single relationship type (ex. satisfies relationship)


Target artefacts
Source artefacts
Traceability relationships

satisfies	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5
Scenario 1	X				
Scenario 2				X	
Scenario 3		X			
Scenario 4			X		X
Scenario 5		X			

Traceability matrix for several relationship types


Target artefacts
Source artefacts

	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5
Scenario 1	*satisfies*				
Scenario 2	*based_on*	*conflicts*		*satisfies*	
Scenario 3		*satisfies*			
Scenario 4	*conflicts*		*satisfies*		*satisfies*
Scenario 5		*satisfies*		*based_on*	

Representation – Traceability List

- **Traceability matrices** become more of a problem when there are hundreds or thousands of requirements as the matrices become large and are sparsely populated
- **A simplified form** of a traceability matrix may be used where, along with each requirement description, one or more lists of the identifiers of related requirements are maintained

Requirement	Depends-on
R1	R3, R4
R2	R5, R6
R3	R4, R5
R4	R2
R5	R6

Tools to document traceability Information

- General purpose tools (e.g., **spreadsheet programs, word processors, hypertext editors**)
- Suitable for small and short term projects
- Not sufficient for extensive requirements tracing purposes

Requirements management tools

- Suitable for projects producing large and complex systems
- Require investments (e.g., licenses, training end-users, system maintenance, consultation)

- Examples: **Rational RequisitePro, DOORS**