

RESEARCH QUESTIONS 3

Aim – Evaluate how traceability research at the RE conference has contributed to the area

RQ1 - What topics within the traceability area have been studied?

RQ2 - What specific challenges have been addressed?

RQ3 - What contributions have been made to address the challenges?

RQ4 - What tool features have been developed to support traceability?

RQ5 - What types of systems have been considered?

RQ6 - What types of artifacts have been traced?

RQ7 - What empirical methods have been applied?

RQ8 – Which authors and institutions have conducted the research?

RESEARCH METHOD 4

A Literature Review @RE – Past 20 years proceedings

- Automatic search - “traceability” in the title, abstract, or keyword – 76 Papers
- Exclusion criteria – No answer for RQ3 (Contribution)
- 6 papers excluded – A final total of 70 papers
- Data extracted
 - Bibliographic information
 - Data related to the RQs
- Defined categories for RQ1-6 - Discussed & agreed by all authors

LIMITATIONS 5

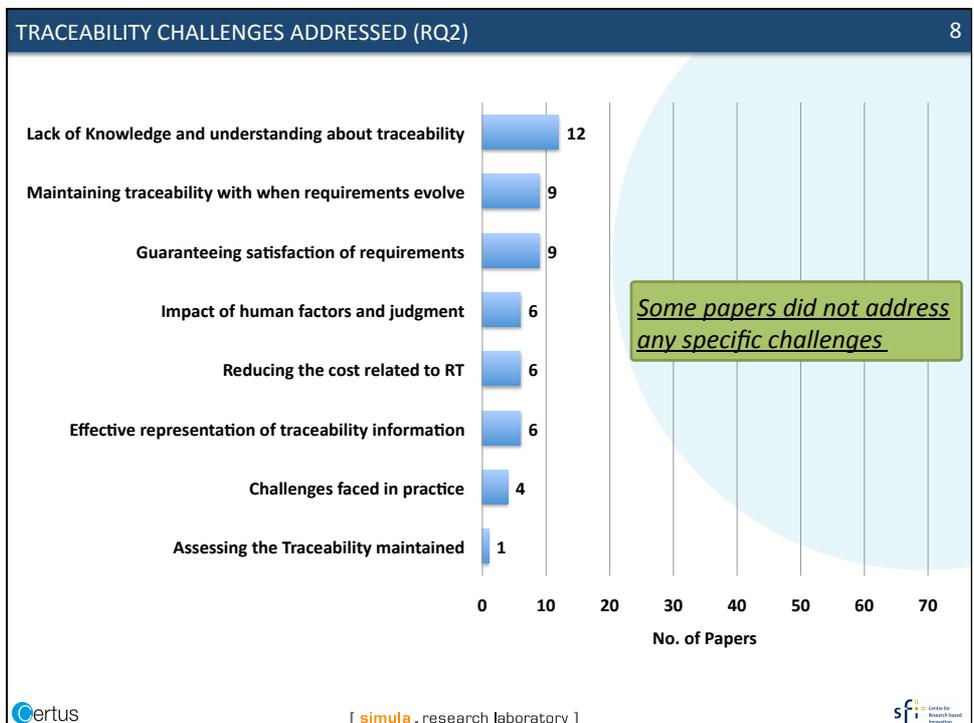
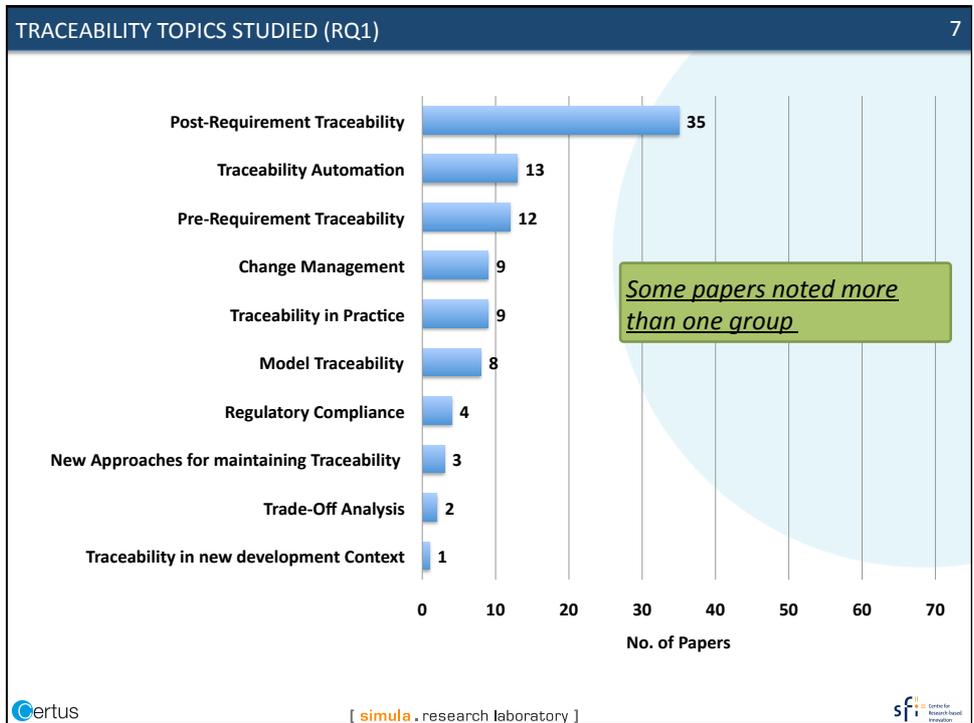
- Missing possible studies
 - Mitigation - A broad search term
- Empirical method – Lack of detail
 - Mitigation – Pre-agreed definitions
- Missing information
 - Mitigation – experience in SLR, RE & traceability

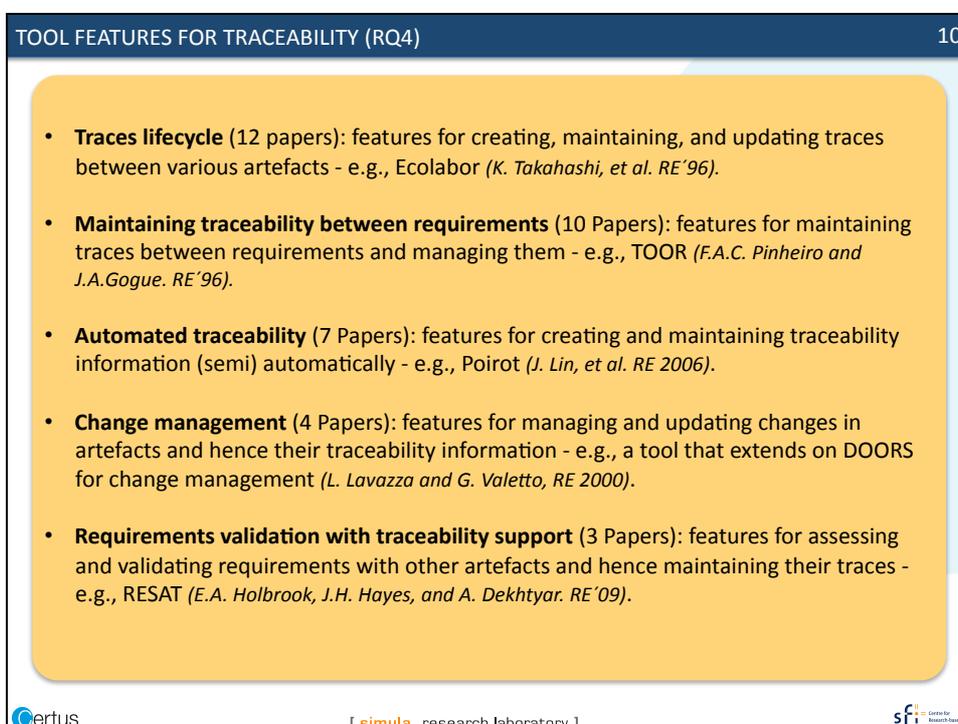
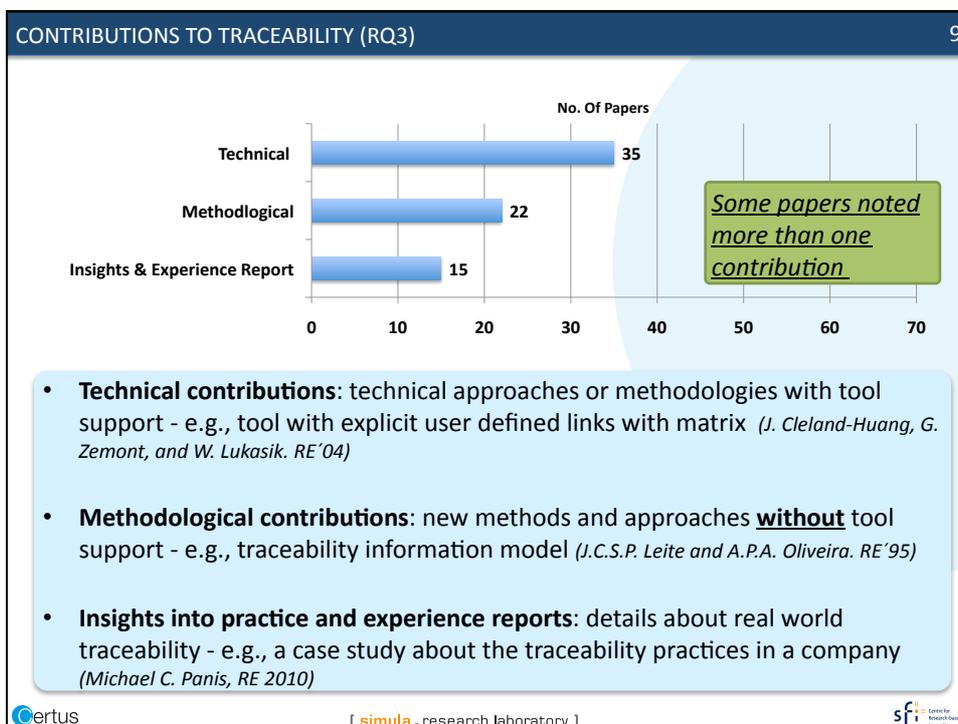
 [ research laboratory]  Centre for Research-based Innovation

6

Results

 [ research laboratory]  Centre for Research-based Innovation





TOOL FEATURES FOR TRACEABILITY (RQ4) 11

- **Model management with traceability support** (3 Papers): features for creating and maintaining traces between and in models used in the development process - e.g., a tool for model merging and verification (*E.A. Holbrook, J.H. Hayes, and A. Dekhtyar. RE'09*).
- **Support for regulatory compliance** (1 Paper): features for maintaining traceability towards compliance purposes - e.g., for compliance with DOD-STD-2176A (*M. Sabetzadeh, et al. RE'07*).
- **Project management** (1 Paper): features for controlling and monitoring a project - e.g., charts generation (*T.J. Smith. RE'93*).
- **Traceability visualization** (1 Paper): features for visualizing the traces maintained between artefacts - e.g., CREWS-EVE (*P. Haumer, et al. RE'99*).

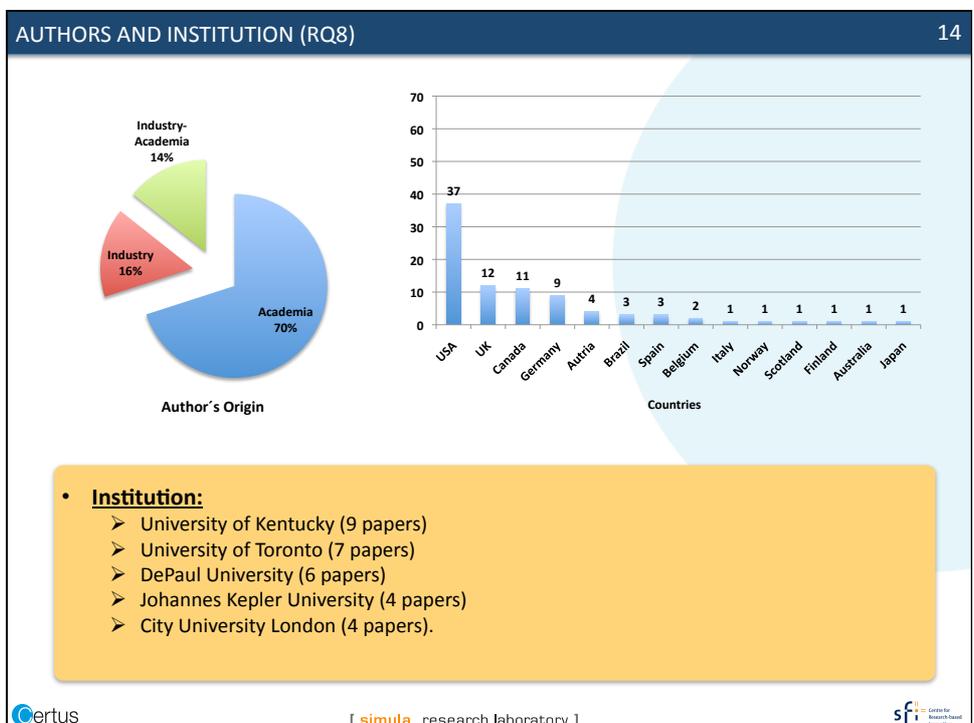
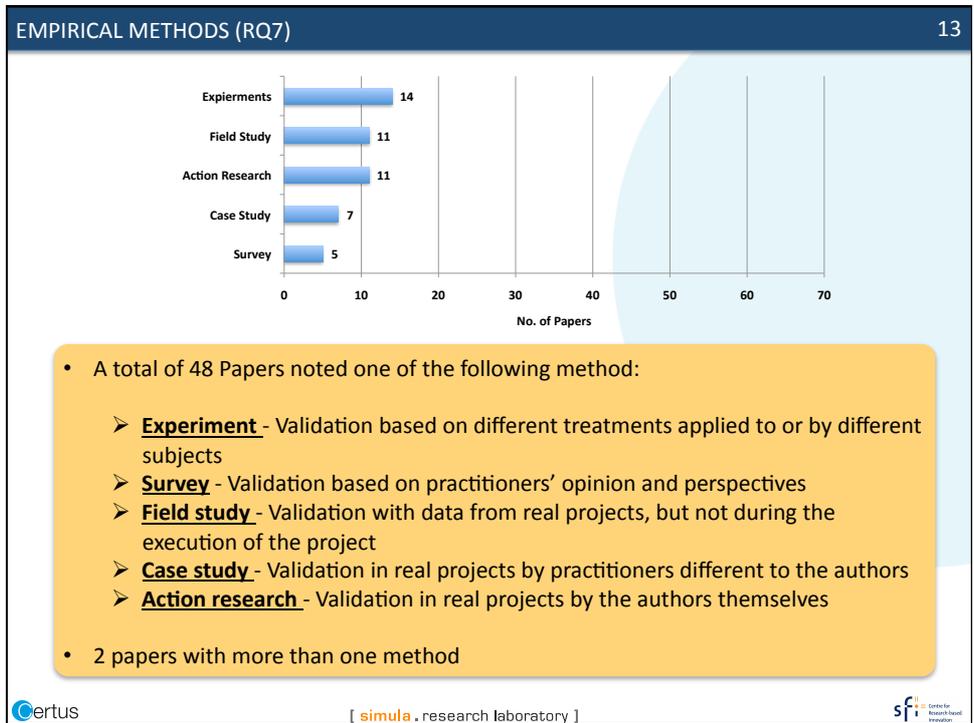
 [[simula](#) research laboratory]  Centre for
Research-based
Innovation

TYPES OF ARTEFACT TRACED (RQ6) 12

- **Traces between requirements specification artefacts** (42 papers):
 - high-level and low-level requirements
 - requirements and source
 - requirements and rationale
 - Etc... *
- **Traces between requirements specification artefacts and other types of artefacts** (41 Papers):
 - Design
 - Testing artefacts
 - Code
 - Etc... *
- **Traces between other types of artefacts** (10 Papers):
 - design and code
 - design and testing
 - design components
 - Etc... *

*Please refer to the paper for more details

 [[simula](#) research laboratory]  Centre for
Research-based
Innovation



15

Discussion

TRACEABILITY RESEARCH EVOLUTION @ RE 16

All editions Vs last 6 editions (2007 onwards)

- Since 2007
 - 32 papers published (46% of all the papers published)
 - No paper in the context of new approaches for maintaining traceability
 - 10 out of the 13 papers on traceability automation
 - Challenge related to assessing the traceability maintained
 - Tool features specifically targeted at model management
 - 72% of the experiments identified were conducted in the last six years
 - Industry-academia collaboration – 7 papers

COMPARISON WITH OTHER SECONDARY STUDIES 17

- To evaluate RE's contribution
- To compare the maturity of traceability research @ RE with other RE areas

- Results from the review coincide with results reported in other studies
 - Similar challenges reported in other studies
 - Similar ranking of institutions and countries reported in other studies (*A. Davis and A. Hickney, REFSQ 2009*)
- Results suggest:
 - RE conference provides excellent overview of the area
 - Has significantly contributed to its progress
 - Has been the source of input for other studies
- Not much focus on Model-driven Traceability
- Higher frequency of the use of empirical methods @ RE

Certus [simula , research laboratory] sfi Centre for Research-based Innovation

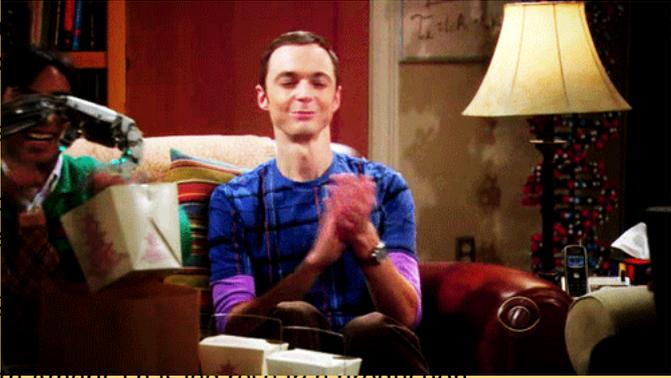
ASPECTS FOR FURTHER RESEARCH 18

- **Traceability Visualization**
- **Consideration of more artefacts**
- **Traces semantics for impact analysis**
- **Advanced empirical evaluation**
- **Advanced tool support**

Certus [simula , research laboratory] sfi Centre for Research-based Innovation

CONCLUSION 19

- Greatly focused on post-requirement traceability
- Challenging about understanding
- Most research support
- Traceability research
- 69%
- North America has led research production
- Increasing interest in automated traceability & industry-academia collaboration



Certus [simula , research laboratory] sf Center for Research-based Innovation

REFERENCES

1. N. Aizenbud-Reshef, et al., "Model traceability", IBM Systems Journal, vol. 45, no. 3, pp. 515-526, 2006.
2. M. Borg, P. Runeson, and A. Ardö, "Recovering from a Decade: A Systematic Mapping of Information Retrieval Approaches to Software Traceability", Empirical Softw. Eng. (to appear), 2013.
3. B.H.C. Cheng and J.M. Atlee, "Research Directions in Requirements Engineering", FOSE 2007, pp. 285-303.
4. J. Cleland-Huang, O. Gotel, and A. Zisman (eds.), Software and Systems Traceability. Springer, 2012.
5. N. Condori-Fernández, et al. "A Systematic Mapping Study on Empirical Evaluation of Software Requirements Specifications Techniques", ESEM 2009, pp. 502-505.
6. Å.G. Dahlstedt and A. Persson, "Requirements Interdependencies – Moulding the State of Research into a Research Agenda", REFSQ 2003, pp. 55-64.
7. A. Davis and A. Hickney, "A Quantitative Assessment of Requirements Engineering Publications – 1963-2008", REFSQ 2009, pp. 129-143.
8. A. Espinoza, P.P. Alarcón, and J. Garbajosa, "Analyzing and Systematizing Current Traceability Schemas", SEW 2006, pp. 21-32.
9. I. Galvão and A. Goknil, "Survey of Traceability Approaches in Model-Driven Engineering", EDOC 2207, pp. 313-313.
10. T. Gorschek, et al., "A Model for Technology Transfer in Practice", IEEE Software, vol. 23, no. 6, pp. 88-95, 2006.
11. IEEE, IEEE Standard Glossary of Software Engineering Terminology, Std. 610.12-1990.
12. M. Ivarsson and T. Gorschek, "A method for evaluating rigor and industrial relevance of technology evaluations", Empirical Software Engineering, vol. 16, no. 3, pp. 365-395, 2011.
13. Kannenberg and H. Saiedian, "Why Software Requirements Traceability Remains a Challenge", Cross Talk, vol. 22, no. 5, pp.14-17, 2009.
14. B.A. Kitchenham and S. Charters, "Guidelines for performing systematic literature reviews in software engineering", Version 2.3, EBSE Technical Report, 2007.
15. S.F. Königs, et al., "Traceability in Systems Engineering – Review of industrial practices, state-of-the-art technologies and new research solutions", Advanced Engineering Informatics, vol. 26, no. 4, pp. 924-940, 2012.
16. Y. Li and W. Maalej, "Which Traceability Visualization Is Suitable in This Context? A Comparative Study", REFSQ 2012, pp. 194-210.
17. F. McCaffery, et al., "Medical Device Software Traceability", in [3], pp. 321-339, 2012.
18. S. Nair, J.L. de la Vara, and S. Sen, "Traceability Research at the Requirements Engineering Conference: Results and Data Extracted", Simula Research Laboratory, Technical Report, 2013 <http://simula.no/publications/Simula.simula.1876>
19. S. Nair, et al., "Classification, Structuring, and Assessment of Evidence For Safety: A Systematic Literature Review", ICST 2013.
20. B. Nuseibeh and S. Easterbrook, "Requirements engineering: a roadmap", FOSE 2000, pp. 35-46.

Certus [simula , research laboratory] sf Center for Research-based Innovation

REFERENCES

21. B. Nuseibeh and S. Easterbrook, "Requirements engineering: a roadmap", FOSE 2000, pp. 35-46.
22. R. Oliveto, et al., "Software Artefact Traceability: the Never-Ending Challenge", ICSM 2007, pp. 485-488.
23. K. Pohl, Requirements Engineering. Springer, 2010.
24. G. Regan, et al., "The Barriers to Traceability and their Potential Solutions: Towards a Reference Framework", SEAA 2012, pp. 319-322.
25. G. Regan, et al., "Traceability – Why Do It?", SPICE 2012, pp. 161-172.
26. I. Santiago, et al., "Model-Driven Engineering as a new landscape for traceability management: A systematic literature review", Information and Software Technology, vol. 54, no. 12, pp. 1340-1356, 2012.
27. G. Spanoudakis and A. Zisman, "Software traceability: a roadmap", in Handbook of Software Eng. and Knowledge Engineering, 2005.
28. R. Torkar, et al., "Requirements traceability: a systematic literature review and industry case study", International Journal of Software Engineering and Knowledge Engineering, vol. 22, no. 3, pp. 1-49, 2012.
29. A. von Knechten and B. Paech, "A Survey on Tracing Approaches in Practice and Research", IESE-Report No. 095.01/E, 2002.
30. S. Winkler and J. von Pilgrim, "A survey of traceability in requirements engineering and model-driven development", Softw. and Systems Modeling, vol. 9, no. 4, pp. 529-565, 2010.

Primary Studies:

1. J.E. Archer, "Requirement Tracking: A Streamlined Approach", RE 2003, pp. 305.
2. P. Arkley and S. Riddle, "Overcoming the Traceability Benefit Problem", RE 2005, pp. 385-389.
3. P. Arkley, S. Riddle, and T. Brookes, "Tailoring Traceability Information to Business Needs", RE 2006, pp. 239-244.
4. D. Becker, "Measuring Requirements Traceability from Multiple Angels at Multiple Lifecycle Entry Points", RE 2003, pp. 291.
5. S. Catrava, "Testing with Partial Traced Requirements: A Necessary Step Towards Higher Quality System Level Verification", RE 2003, pp. 303.
6. E. B., Charrada, et al., "Identifying Outdated Requirements Based on Source Code Changes", RE 2012, pp. 61-70.
7. J. Chisan and D. Damian, "Exploring the role of requirements engineering in improving risk management", RE 2005, pp. 481-482.
8. J. Cleland-Huang, et al., "Automating Speculative Queries through Event-Based Requirements Traceability", RE 2002, pp. 289-296.
9. J. Cleland-Huang, G. Zemont, and W. Lukasik, "A Heterogeneous Solution for Improving the Return on Investment of Requirements Traceability", RE 2004, pp. 230-239.
10. J. Cleland-Huang, et al., "Utilizing Supporting Evidence to Improve Dynamic Requirements Traceability", RE 2005, pp. 135-144.
11. J. Cleland-Huang, "Requirements Traceability - When and How does it Deliver more than it Costs?", RE 2006, pp. 323.
12. J. Cleland-Huang, et al., "Breaking the big-bang practice of traceability: Pushing timely trace recommendations to project stakeholders", RE 2012, pp. 231-240.
13. D. Cuddeback, A. Dekhtyar, and J.H. Hayes, "Automated Requirements Traceability: The Study of Human Analysts", RE 2010, pp. 231-240.



[simula . research laboratory]



REFERENCES

14. A. Dekhtyar, et al., "Technique Integration for Requirements Assessment", RE 2007, pp. 141-150.
15. A. Dekhtya, et al. "On human analyst performance in assisted requirements tracing: Statistical analysis", RE 2011, pp. 111-120.
16. S. Easterbrook, et al., "Do viewpoints lead to better conceptual models? An exploratory case study", RE 2005, pp. 199-208.
17. A. Egyed, et al., "Value-based requirements traceability: Lessons Learned." RE 2007, pp. 115-118.
18. A. Egyed, F. Graf, and P. Grünbacher, "Effort and Quality of Recovering Requirements-to-Code Traces: Two Exploratory Experiments", RE 2010, pp. 221-230.
19. N.A. Ernst, et al., "Supporting Requirements Model Evolution throughout the System Life-Cycle", RE 2008, pp. 321-322.
20. O. Glorio, et al., "DaWaRA: An Eclipse Plugin for Using i* on Data Warehouse Requirement Analysis", RE 2008, pp. 317-318.
21. O. Gotel and A. Finkelstein, "An analysis of the requirements traceability problem", RE 1994, pp. 94-101.
22. O. Gotel and A. Finkelstein, "Contribution Structures", RE 1995, pp. 100-107.
23. O. Gotel and A. Finkelstein, "Extended Requirements Traceability: Results of an Industrial Case Study", RE 1997, pp. 169-178.
24. O. Gotel and S.J. Morris, "Out of the labyrinth: Leveraging other disciplines for requirements traceability", RE 2011, pp. 121-130.
25. O. Gotel, et al., "The Quest for Ubiquity: A Roadmap for Software and Systems Traceability Research", RE 2012, pp.71-80.
26. P. Haumer, et al., "Bridging the gap between past and future in RE: a scenario-based approach", RE 1999, pp. 66-73.
27. J.H. Hayes, A. Dekhtyar, and J. Osborne, "Improving Requirements Tracing via Information Retrieval", RE 2003, pp. 138-147.
28. J.H. Hayes, et al., "Helping Analysts Trace Requirements: An Objective Look", RE 2005, pp. 249-259.
29. J. Hill and S. Tilley, "Creating Safety Requirements Traceability for Assuring and Recertifying Legacy Safety-Critical Systems", RE 2010, pp. 297-302.
30. E.A. Holbrook, J.H. Hayes, and A. Dekhtyar, "Toward Automating Requirements Satisfaction Assessment", RE 2009, pp. 149-158.
31. O. Inah, et al., "Use case to source code traceability: The developer navigation view point." RE 2009, pp. 237-242.
32. M. Jarke, et al., "Media-Assisted Product and Process Requirements Traceability in Supply Chains", RE 2003, pp. 375-376.
33. S. Katz and A. Rashid, "From aspectual requirements to proof obligations for aspect-oriented systems", RE 2004, pp. 48-57.
34. W.K. Kong, et al., "Process improvement for traceability: A study of human fallibility", RE 2012, p. 31-40.
35. P. Laurent, J. Cleland-Huang, and C. Duan, "Towards Automated Requirements Triage", RE 2007, pp. 131-140.
36. L. Lavazza and G. Valetto, "Enhancing requirements and change management through process modelling and measurement", RE 2000, pp. 106-115.
37. J.C.S.P. Leite and A.P.A. Oliveira, "A client oriented requirements baseline", RE 1995, pp. 108-115.
38. J. Lin, et al. "Poivot: A Distributed Tool Supporting Enterprise-Wide Automated Traceability", RE 2006, pp. 363-364.
39. I.A. Macfarlane and I. Reilly, "Requirements traceability in an integrated development environment", RE 1995, pp. 116-123.
40. A. Mahmoud and N. Niu, "TraCter: A tool for candidate traceability link clustering", RE 2011, pp. 335-336.
41. J. Muñoz, et al., "Requirements Engineering for Pervasive Systems", RE 2006, pp. 351-352.
42. P. Mäder, et al. "traceMaintainer - Automated Traceability Maintenance", RE 2008, pp. 329-330.
43. P. Mäder, O. Gotel, and I. Philippow, "Motivation Matters in the Traceability Trenches", RE 2008, pp. 143-148.



[simula . research laboratory]



REFERENCES

44. P. Mäder, O. Gotel, and I. Philippow, "Rule-Based Maintenance of Post-Requirements Traceability Relations", RE 2009, p. 23-32.
45. N. Niu and A. Mahmoud, "Enhancing candidate link generation for requirements tracing: The cluster hypothesis revisited", RE 2012, pp. 81-90.
46. K. Ohashi, et al., "A means of establishing traceability based on a UML model in business application development", RE 2011, pp. 279-284.
47. M.C. Panis, "Successful Deployment of Requirements Traceability in a Commercial Engineering Organization...Really", RE 2010, pp. 303-307.
48. F.A.C. Pinheiro and J.A.Gogue, "An Object-Oriented Tool for Tracing Requirements", RE 1996, pp. 52-64.
49. K. Pohl, "PRO-ART: Enabling Requirements Pre-Traceability", RE 1996, pp. 76-84.
50. H. Post, et al., "Linking Functional Requirements and Software Verification", RE 2009, pp. 295-302.
51. B. Ramesh and M. Edwards, "Issues in the development of a requirements traceability model", RE 1993, pp. 256-259.
52. B. Ramesh, et al., "Implementing requirements traceability: a case study", RE 1995, pp. 89-95.
53. G. Romanski, "Requirements, Configuration Management and Traceability for Safety Critical Software", RE 2003, pp. 304.
54. M. Sabetzadeh and S. Easterbrook, "An algebraic framework for merging incomplete and inconsistent views", RE 2005, pp. 306-315.
55. M. Sabetzadeh, et al., "Consistency Checking of Conceptual Models via Model Merging", RE 2007, pp. 221-230.
56. R. Salay, M., et al., "Managing Requirements Uncertainty with Partial Models." RE 2012, pp. 1-10.
57. S. Siegl, K.S. Hielscher, and R. German, "Model Based Requirements Analysis and Testing of Automotive Systems with Timed Usage Models", RE 2010, pp. 345-350.
58. T.J. Smith, "READS: a requirements engineering tool", RE 1993, pp. 94-97.
59. X. Song, et al., "Lessons Learned from Building a Web-Based Requirements Tracing System", RE 1998, pp. 41-50.
60. C. Stanbridge, "Retrospective Requirement Analysis Using Code Coverage of GUI Driven System Tests", RE 2010, pp. 411-412.
61. A. Stone and P. Sawyer, "Exposing Tacit Knowledge via Pre-Requirements Tracing", RE 2006, pp. 353-354.
62. H. Sultanov and J.H. Hayes, "Application of Swarm Techniques to Requirements Engineering: Requirements Tracing", RE 2010, pp. 211-220.
63. K. Takahashi, et al., "Hypermedia support for collaboration in requirements analysis", RE 1996, pp. 31-40.
64. E.J. Uusitalo, et al., "Linking Requirements and Testing in Practice", RE 2008, pp. 265-270.
65. A. van Lamswerde, et al., "Goal-directed elaboration of requirements for a meeting scheduler" RE 1995, pp. 194-203.
66. A. von Knethen, et al., "Systematic Requirements Recycling through Abstraction and Traceability", RE 2002, pp. 273-281.
67. J.H. Weber-Jahnke and A. Onabajo, "Finding Defects in Natural Language Confidentiality Requirements", RE 2009, pp. 213-222.
68. D.P. Wood, M.G. Christel, and S.M. Stevens, "A multimedia approach to requirements capture and modeling", RE 1994, pp. 53-56.
69. Y. Yu, et al., "Reverse engineering goal models from legacy code", RE 2005, pp. 363-372.
70. Y. Yu, et al., "Tracing and Validating Goal Aspects", RE 2007, pp. 53-56.

ACKNOWLEDGMENT

20

We acknowledge funding from

- FP7 programme under grant agreement n° 289011 (OPENCROSS) 
- The Research Council of Norway under Project No. 203461/030

Many thanks to RE'13 reviewers and Program Board

Thank you !!



Comments and Questions ?