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Architecture design in global and model-centric software development

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List of Illustrations

Figures

1.1 The 4 + 1-view model 5
1.2 Example of a UML class diagram 6
1.3 A recent version of the RUP "hump" diagram 9
1.4 The grounded theory data collection and analysis method – applied to a software project 14
1.5 Organization of the four chapters that address RQ1 17

2.1 BPMN diagram for GSD process description of case "XYZ" 26

3.1 Class diagram depicting the structure of the examined effort log files . 43
3.2 Effort distribution visualization for project A 45
3.3 Effort distribution visualization for project B 48
3.4 Effort distribution visualization for project C 49
3.5 Effort distribution visualization for project D 51

4.1 Theoretical framework of software architecture design dissemination . 61
4.2 Communication of the software architecture design from the onshore to the offshore location 68
4.3 Case 3 iteration strategy 86

5.1 Excerpt of (anonymized) chain-referral sampling graph of interview respondents 94
5.2 Concept relation graph (⟶ denotes cause and effect) 95
5.3 Contents of an SAD and associated stakeholder interest 99

6.1 Experiment environment 112

6.2 Example design 115
6.3 Histograms for the amount of correct answers per treatment 120
6.4 Density plot for amount of correct answers per treatment 121
6.5 Density plot for academic experience, industrial experience and Höst experience class of participants 128

7.1 Overview of case system components 140
7.2 Frequency of UML diagram type use 142
7.3 Model metrics and revision count over time 146
7.4 Project effort distribution on phase and model level 147
7.5 Effort and duration per phase (normalized at 100 percent). The black line represents the case. The dotted gray line in the background represents the average for a set of 17 projects similar in size and complexity 148
7.6 Software configuration and change management system usage 152
7.7 Cumulative defect discovery over time (case is labeled "Project Alpha") 154

8.1 Factor integration graph (⟶ denotes cause and effect) 163
8.2 MDD versus non-MDD maintenance (adapted from Van Vliet, 2008) . . 171

9.1 Cause-effect diagram integrating the main findings of the study 180

Tables

1.1 MDD provides a common language that augments the individual representations each software engineering stakeholder uses 10

2.1 Organizations Under Study 24
2.2 Comparison of GSD process descriptions 29
2.2 Comparison of GSD process descriptions (continued) 30
2.2 Comparison of GSD process descriptions (continued) 31
2.3 Approach to Process Description Use 33

3.1 Project Characteristics 44

4.1 Interview Questions as Derived from Theoretical Framework (Figure 4.1) 63
4.2 Case Characteristics 66

5.1 Overview of expert interview respondent characteristics 93

6.1 Experiment Variables 110
6.2 Media Dominance 116

6.3 Example of video coding log for a single question 117
6.4 Experiment Questions 119
6.5 Descriptive statistics for the amount of given answers that were correct for text-dominant versus diagram-dominant architecture descriptions . 120
6.6 Language Grouping & Distance 127
6.7 Multivariate regression for "Amount of Correct Answers" 129

7.1 Model Size Metrics 143
7.2 Model Complexity Metrics 144
7.3 Bi-Variate Correlation Matrix for Common Process Metrics in MDD Context 149
7.4 Bi-Variate Correlation Matrix for Defect Priority and Changes 151

8.1 Architectural Artifacts Available in the Case Project 168
8.2 Relating GSD best practices (Šmite et al., 2010) to MDD-related practices 176

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Bibliography

G. Abowd, R. Allen, and D. Garlan. Formalizing style to understand descriptions of software architecture. *ACM Transactions on Software Engineering and Methodology*, 4 (4):319–364, Oct. 1995. DOI 10.1145/226241.226244. (cited on page 105).

P. Abrahamsson, J. Warsta, M. T. Siponen, and J. Ronkainen. New directions on agile methods: a comparative analysis. In *Proceedings of the 25th International Conference on Software Engineering*, pages 244–254, Washington, DC, USA, 2003. IEEE Computer Society. ISBN 0-7695-1877-X. DOI 10.1109/ICSE.2003.1201204. (cited on page 58).

M. J. Albers. Signal to noise ratio of information in documentation. In *Proceedings of the 22nd annual International Conference on Design of Communication*, pages 41–44, New York, NY, USA, 2004. ACM. ISBN 1-58113-809-1. DOI 10.1145/1026533.1026546. (cited on page 109).

N. Ali, S. Beecham, and I. Mistrik. Architectural knowledge management in global software development: A review. In *Proceedings of the International Conference on Global Software Engineering*, pages 347–352, Los Alamitos, CA, USA, 2010. IEEE Computer Society. ISBN 978-0-7695-4122-8. DOI 10.1109/ICGSE.2010.48. (cited on page 104).

T. J. Allen. *Managing the Flow of Technology*. MIT Press, 1977. ISBN 978-0262510271. (cited on page 3).

B. Anda and K. Hansen. A case study on the application of UML in legacy development. In *Proceedings of the ACM/IEEE International Symposium on Empirical Software Engineering*, pages 124–133. ACM, 2006. ISBN 1-59593-218-6. DOI 10.1145/1159733.1159754. (cited on page 137).

B. S. Andaloussi and A. Braun. A test specification method for software interoperability tests in offshore scenarios: A case study. In *Proceedings of the International Conference on Global Software Engineering*, pages 169–178, Los Alamitos, CA, USA, 2006. IEEE Computer Society. DOI 10.1109/ICGSE.2006.261230. (cited on page 162).

E. Arisholm and D. I. K. Sjøberg. Evaluating the effect of a delegated versus centralized control style on the maintainability of object-oriented software. *IEEE Transactions on Software Engineering*, 30(8):521–534, 2004. DOI 10.1109/TSE.2004.43. (cited on page 131).

C. Atkinson and T. Kühne. Model-driven development: a metamodeling foundation. *IEEE Software*, 20(5):36–41, 2003. DOI 10.1109/MS.2003.1231149. (cited on page 10).

M. Babar, R. de Boer, T. Dingsøyr, and R. Farenhorst. Architectural knowledge management strategies: Approaches in research and industry. In *Proceedings of the 29th International Conference on Software Engineering Workshops*, page 2. IEEE Computer Society, 2007. DOI 10.1109/SHARK-ADI.2007.3. (cited on page 59).

F. Bachmann, L. Bass, J. Carriere, P. Clements, and D. Garlan. Software architecture documentation in practice: Documenting architectural layers. Technical Report CMU/SEI-2000-SR-004, Carnegie Mellon Software Engineering Institute, March 2000. (cited on page 105).

P. Baker, S. Loh, and F. Weil. Model-driven engineering in a large industrial context — Motorola case study. In L. C. Briand and C. Williams, editors, *Proceedings of the ACM/IEEE 8th International Conference on Model Driven Engineering Languages and Systems*, volume 3713 of *Lecture Notes in Computer Science*, pages 476–491. Springer, 2005. ISBN 3-540-29010-9. DOI 10.1007/11557432_36. (cited on pages 137 and 138).

K. Balasubramanian, A. Gokhale, G. Karsai, J. Sztipanovits, and S. Neema. Developing applications using model-driven design environments. *Computer*, 39(2):33–40, 2006. DOI 10.1109/MC.2006.54. (cited on page 155).

M. T. Baldassarre, N. Boffoli, D. Caivano, and G. Visaggio. Speed: Software project effort evaluator based on dynamic-calibration. In *Proceedings of the 22nd IEEE International Conference on Software Maintenance*, pages 272–273, Los Alamitos, CA, USA, 2006. IEEE Computer Society. DOI 10.1109/ICSM.2006.62. (cited on page 38).

R. Balzer. Tolerating inconsistency. In *Proceedings of the 13th International Conference on Software Engineering*, pages 158–165, 1991. DOI 10.1109/ICSE.1991.130638. (cited on page 125).

V. R. Basili and D. M. Weiss. A methodology for collecting valid software engineering data. *IEEE Transactions on Software Engineering*, 10(6):728–738, 1984. (cited on page 14).

V. R. Basili, G. Caldiera, and H. D. Rombach. The goal question metric approach. In *Encyclopedia of Software Engineering*, pages 528–532. Wiley, 1994. (cited on page 108).

R. D. Battin, R. Crocker, J. Kreidler, and K. Subramanian. Leveraging resources in global software development. *IEEE Software*, 18(2):70–77, 2001. DOI 10.1109/52.914750. (cited on page 23).

C. Bauer and G. King. *Hibernate in Action*. Manning Publications, 8 2004. ISBN 978-1932394153. (cited on page 140).

K. Beck. *Extreme Programming Explained: Embrace Change*. Addison-Wesley, 1999. ISBN 978-0201616415. (cited on page 165).

P. Bengtsson and J. Bosch. Haemo dialysis software architecture design experiences. In *Proceedings of the 21st International Conference on Software Engineering*, pages 516–525. IEEE Computer Society, 1999. DOI 10.1145/302405.302684. (cited on page 105).

B. Berenbach and M. Gall. Toward a unified model for requirements engineering. In *Proceedings of the International Conference on Global Software Engineering*, pages 237–238, Los Alamitos, CA, USA, 2006. IEEE Computer Society. ISBN 0-7695-2663-2. DOI 10.1109/ICGSE.2006.261238. (cited on page 161).

B. W. Boehm. A spiral model of software development and enhancement. *SIGSOFT Software Engineering Notes*, 11(4):14–24, 1986. DOI 10.1145/12944.12948. (cited on pages 8 and 40).

B. W. Boehm. A spiral model of software development and enhancement. *Computer*, 21 (5):61–72, 1988. DOI 10.1109/2.59. (cited on pages 8 and 40).

B. W. Boehm, M. Abi-Antoun, A. Brown, N. Mehta, and D. Port. Guidelines for the life cycle objectives (LCO) and the life cycle architecture (LCA) deliverables for model-based architecting and software engineering (MBASE). Technical Report USC-CSE-98-519, University of Southern California, Los Angeles, CA, 90089, February 1999. URL http://sunset.usc.edu/publications/TECHRPTS/1998/usccse98-519/usccse98-519.pdf. (cited on page 40).

G. Booch. *Object solutions: managing the object-oriented project*. Addison Wesley Longman Publishing Co., Inc., 1995a. ISBN 978-0805305944. (cited on page 6).

G. Booch. *Object Solutions: Managing the Object-Oriented Project*. Addison Wesley Longman Publishing Co., Inc., Redwood City, CA, USA, 1995b. ISBN 0-8053-0594-7. (cited on page 40).

B. Bowerman and T. Richard. *Linear Statistical Models: An Applied Approach*. PWS-Kent Publishing Co., 1990. ISBN 978-0534380182. (cited on page 128).

L. Bratthall, E. Johansson, and B. Regnell. Is a design rationale vital when predicting change impact? — A controlled experiment on software architecture evolution. *Product Focused Software Process Improvement*, pages 77–100, 2000. DOI http://dx.doi.org/10.1007/978-3-540-45051-1_14. (cited on page 6).

M. R. Braz and S. R. Vergilio. Software effort estimation based on use cases. In *Proceedings of the 30th Annual International Computer Software and Applications Conference*, volume 1, pages 221–228, Los Alamitos, CA, USA, 2006. IEEE Computer Society. DOI 10.1109/COMPSAC.2006.77. (cited on page 38).

L. C. Briand, J. W. Daly, and J. K. Wüst. A unified framework for coupling measurement in object-oriented systems. *IEEE Transactions on Software Engineering*, 25(1):91–121, Jan. 1999. DOI 10.1109/32.748920. (cited on page 144).

L. C. Briand, Y. Labiche, M. D. Penta, and H. D. Yan-Bondoc. An experimental investigation of formality in UML-based development. *IEEE Transactions on Software Engineering*, 31(10):833–849, 2005. DOI 10.1109/TSE.2005.105. (cited on pages 108 and 131).

C. Brun and A. Pierantonio. Model differences in the eclipse modeling framework. *UPGRADE, The European Journal for the Informatics Professional*, IX(2):29–34, April 2008. URL http://www.cepis.org/upgrade/files/2008-II-pierantonio.pdf. (cited on page 166).

J. Cabot and E. Yu. Improving requirements specifications in model driven development processes. In M. R. Chaudron, editor, *Proceedings of the First International Workshop on Challenges in Model-Driven Software Engineering*, volume 5421 of *Lecture Notes in Computer Science*, pages 36–40. Springer, 2008. ISBN 978-3-642-01647-9. DOI 10.1007/978-3-642-01648-6_4. (cited on page 171).

J. Cannon-Bowers, E. Salas, and S. Converse. Shared mental models in expert team decision-making. *Environmental Effects of Cognitive Abilities*, pages 221–245, 2001. DOI 10.1016/S0898-1221(00)90067-1. (cited on pages 64, 65, 158 and 160).

E. Carmel. *Global Software Teams: Collaborating Across Borders and Time Zones*. Prentice Hall PTR, Upper Saddle River, NJ, USA, 1999. ISBN 0-13-924218-X. (cited on pages 24 and 174).

E. Carmel and R. Agarwal. Tactical approaches for alleviating distance in global software development. *IEEE Software*, 18(2):22–29, 2001. DOI 10.1109/52.914734. (cited on pages 2, 3, 4 and 94).

E. Carmel and P. Tjia. *Offshoring Information Technology: Sourcing and Outsourcing to a Global Workforce*. Cambridge University Press, 2005. ISBN 978-0-521-84355-3. (cited on page 3).

R. Carney and J. Levin. Pictorial illustrations still improve students' learning from text. *Educational Psychology Review*, 14(1):5–26, 2002. (cited on page 124).

P. Chen. The entity-relationship model—toward a unified view of data. *ACM Transactions on Database Systems*, 1(1):9–36, 1976. (cited on page 107).

M. Cherubini, G. Venolia, R. DeLine, and A. J. Ko. Let's go to the whiteboard: how and why software developers use drawings. In *Proceedings of the SIGCHI Conference on Human factors in Computing Systems*, pages 557–566, New York, NY, 2007. ACM. DOI 10.1145/1240624.1240714. (cited on pages 7 and 106).

B. R. Chiswick and P. W. Miller. Linguistic distance: A quantitative measure of the distance between English and other languages. Technical Report IZA DP No. 1246, Institute for the Study of Labor (IZA), August 2004. (cited on pages 126 and 127).

M. B. Chrissis, M. Konrad, and S. Shrum. *CMMI Guidelines for Process Integration and Product Improvement*. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA, 2003. ISBN 0321154967. (cited on page 24).

T. Clear. Documentation and agile methods: striking a balance. *ACM SIGCSE Bulletin*, 35(2):12–13, 2003. DOI 10.1145/782941.782949. (cited on page 58).

P. Clements, F. Bachmann, L. Bass, D. Garlan, J. Ivers, R. Little, R. Nord, and J. Stafford. *Documenting Software Architectures: Views and Beyond*. Addison-Wesley Professional, 2002. ISBN 0201703726. (cited on pages 59 and 105).

P. Clements, R. Kazman, M. Klein, D. Devesh, S. Reddy, and P. Verma. The duties, skills, and knowledge of software architects. In *Proceedings of the Working IEEE/IFIP Conference on Software Architecture*, pages 44–47, 2007. DOI 10.1109/WICSA.2007.41. (cited on page 158).

P. C. Clements and M. Shaw. "the golden age of software architecture" revisited. *IEEE Software*, 26(4):70–72, 2009. DOI 10.1109/MS.2009.83. (cited on page 104).

V. Clerc, P. Lago, and H. van Vliet. Global software development: Are architectural rules the answer? In *Proceedings of the IEEE International Conference on Global Software Engineering*, pages 225–234, 2007. DOI 10.1109/ICGSE.2007.21. (cited on page 161).

E. Ó. Conchúir, H. Holmström, P. J. Ågerfalk., and B. Fitzgerald. Exploring the assumed benefits of global software development. In *Proceedings of the International Conference on Global Software Engineering*, pages 159–168, 2006. DOI 10.1109/ICGSE.2006.261229. (cited on page 94).

E. O. Conchúir, P. J. Ågerfalk, H. H. Olsson, and B. Fitzgerald. Global software development: where are the benefits? *Communications of the ACM*, 52(8):127–131, Aug. 2009. DOI 10.1145/1536616.1536648. (cited on pages 2 and 3).

M. Conway. How do committees invent? *Datamation*, 14(4):28–31, 1968. (cited on page 161).

G. Costagliola, F. Ferrucci, G. Tortora, and G. Vitiello. Class point: An approach for the size estimation of object-oriented systems. *IEEE Transactions on Software Engineering*, 31(1):52–74, 2005. DOI 10.1109/TSE.2005.5. (cited on page 141).

B. Curtis, H. Krasner, and N. Iscoe. A field study of the software design process for large systems. *Communications of the ACM*, 31(11):1268–1287, Nov. 1988. DOI 10.1145/50087.50089. (cited on pages 59, 74, 104 and 106).

M. A. Cusumano. Managing software development in globally distributed teams. *Communications of the ACM*, 51(2):15–17, 2008. DOI 10.1145/1314215.1314218. (cited on page 23).

D. Damian, L. Izquierdo, J. Singer, and I. Kwan. Awareness in the wild: Why communication breakdowns occur. In *Proceedings of the Second IEEE International Conference on Global Software Engineering*, pages 81–90, 2007. DOI 10.1109/ICGSE.2007.13. (cited on page 59).

A. De Lucia, C. Gravino, R. Oliveto, and G. Tortora. An experimental comparison of ER and UML class diagrams for data modelling. *Empirical Software Engineering*, pages 1–38, 2010. DOI 10.1007/s10664-009-9127-7. (cited on page 107).

S. C. B. de Souza, N. Anquetil, and K. M. de Oliveira. A study of the documentation essential to software maintenance. In *Proceedings of the 23rd International Conference on Design of Communication*, pages 68–75, September 2005. DOI 10.1145/1085313.1085331. (cited on page 59).

U. Dekel and J. D. Herbsleb. Notation and representation in collaborative object-oriented design: an observational study. In *Proceedings of the 22nd annual ACM SIGPLAN conference on Object-oriented programming systems and applications*, volume 42, pages 261–280, New York, NY, USA, 2007. ACM. DOI 10.1145/1297105.1297047. (cited on page 106).

G. Deng, G. Lenz, and D. Schmidt. Addressing domain evolution challenges in software product lines. In J.-M. Bruel, editor, *Proceedings of the Satellite Events at the MoDELS 2005 Conference*, volume 3844 of *Lecture Notes in Computer Science*, pages 247–261, 2006. ISBN 978-3-540-31780-7. DOI 10.1007/11663430_26. (cited on page 173).

K. C. Desouza and J. R. Evaristo. Managing knowledge in distributed projects. *Communications of the ACM*, 47(4):87–91, 2004. DOI 10.1145/975817.975823. (cited on page 24).

K. C. Desouza, Y. Awazu, and P. Baloh. Managing knowledge in global software development efforts: Issues and practices. *IEEE Software*, 23:30–37, 2006. DOI 10.1109/MS.2006.135. (cited on page 56).

B. Dobing and J. Parsons. How UML is used. *Communications of the ACM*, 49(5):109–113, 2006. (cited on page 7).

T. Dybå and T. Dingsøyr. Empirical studies of agile software development: A systematic review. *Information and Software Technology*, 50(9-10):833–859, August 2008. DOI 10.1016/j.infsof.2008.01.006. (cited on page 58).

C. Ebert and P. De Neve. Surviving global software development. *IEEE Software*, 18(2): 62–69, 2001. DOI 10.1109/52.914748. (cited on pages 2 and 94).

C. Ebert, C. H. Parro, R. Suttels, and H. Kolarczyk. Improving validation activities in a global software development. In *Proceedings of the 23rd international Conference on Software Engineering*, pages 545–554, 2001. DOI 10.1109/ICSE.2001.919129. (cited on page 94).

A. H. Eden and R. Kazman. Architecture, design, implementation. In *Proceedings of the 25th International Conference on Software Engineering*, pages 149–159, Piscataway, NJ, USA, 2003. IEEE CS. DOI 10.1109/ICSE.2003.1201196. (cited on page 105).

J. Eder, G. Kappel, and M. Schrefl. Coupling and cohesion in object-oriented systems. *Technical Report, University of Klagenfurt, Austria*, pages 1–34, 1994. (cited on page 2).

A. Egyed. Fixing inconsistencies in UML design models. In *Proceedings of the 29th International Conference on Software Engineering*, pages 292–301. IEEE Computer Society, 2007. DOI 10.1109/ICSE.2007.38. (cited on page 141).

A. J. Espinosa, R. E. Kraut, J. F. Lerch, S. A. Slaughter, J. D. Herbsleb, and A. Mockus. Shared mental models and coordination in large-scale, distributed software development. In *Proceedings of the Twenty-Second International Conference on Information Systems*, pages 513–518, New Orleans, LA, 2001. URL http://www.cs.cmu.edu/afs/cs/Web/People/jdh/collaboratory/research_papers/ICIS_2001.pdf. (cited on pages 65, 158, 160 and 174).

J. A. Espinosa and E. Carmel. Modeling coordination costs due to time separation in global software teams. In *Proceedings of the International Workshop on Global Software Development*, pages 64–68, 2003. URL http://gsd2003.cs.uvic.ca/upload/Espinosa.pdf. (cited on page 94).

R. Farenhorst, J. F. Hoorn, P. Lago, and H. van Vliet. What architects do and what they need to share knowledge. Technical Report Technical Report IR-IMSE-003, VU University Amsterdam, April 2009. (cited on pages 158 and 160).

R. Fish, R. Kraut, R. Root, and R. Rice. Video as a technology for informal communication. *Communications of the ACM*, 36(1):48–61, 1993. DOI 10.1145/142750.142755. (cited on page 59).

E. Flaherty. The thinking aloud technique and problem solving ability. *The Journal of Educational Research*, pages 223–225, 1975. (cited on page 131).

F. Fleurey, E. Breton, B. Baudry, A. Nicolas, and J.-M. Jézéquel. Model-driven engineering for software migration in a large industrial context. In G. Engels, B. Opdyke, D. C. Schmidt, and F. Weil, editors, *Proceedings of the ACM/IEEE 10th International Conference on Model Driven Engineering Languages and Systems*, volume 4735 of *Lecture Notes in Computer Science*, pages 482–497. Springer, 2007. ISBN 978-3-540-75208-0. DOI 10.1007/978-3-540-75209-7_33. (cited on page 137).

A. Forward and T. Lethbridge. The relevance of software documentation, tools and technologies: a survey. In *Proceedings of the ACM Symposium on Document Engineering*, pages 26–33, 2002. DOI 10.1145/585058.585065. (cited on pages 58 and 105).

R. France and B. Rumpe. Model-driven development of complex software: A research roadmap. In *Proceedings of the Future of Software Engineering*, pages 37–54, Washington, DC, USA, 2007. IEEE Computer Society. ISBN 0-7695-2829-5. DOI 10.1109/FOSE.2007.14. (cited on page 155).

J. Galbraith. *Organization design*. Addison-Wesley Pub. Co., Reading, Mass, 1977. ISBN 0201025582. (cited on page 59).

A. Gemino and Y. Wand. Evaluating modeling techniques based on models of learning. *Communications of the ACM*, 46:79–84, October 2003. DOI 10.1145/944217.944243. (cited on pages 107 and 125).

A. Gemino and Y. Wand. Complexity and clarity in conceptual modeling: Comparison of mandatory and optional properties. *Data & Knowledge Engineering*, 55(3):301–326, 2005. DOI 10.1016/j.datak.2004.12.009. (cited on page 107).

M. Genero, L. Jiménez, and M. Piattini. A controlled experiment for validating class diagram structural complexity metrics. In Z. Bellahsène, D. Patel, and C. Rolland, editors, *Proceedings of the 8th International Conference on Object-Oriented Information Systems*, volume 2425 of *Lecture Notes in Computer Science*, pages 483–487, 2002. ISBN 978-3-540-44087-1. DOI 10.1007/3-540-46102-7_40. (cited on page 141).

C. Ghezzi, M. Jazayeri, and D. Mandrioli. *Fundamentals of Software Engineering*. Prentice Hall PTR, Upper Saddle River, NJ, USA, 2002. ISBN 0133056996. (cited on page 8).

R. Grinter, J. Herbsleb, and D. Perry. The geography of coordination: dealing with distance in r&d work. In *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work*, pages 306–315, 1999. DOI 10.1145/320297.320333. (cited on pages 2 and 3).

R. E. Grinter. Doing software development: occasions for automation and formalisation. In *Proceedings of the fifth conference on European Conference on Computer-Supported Cooperative Work*, pages 173–188, Norwell, MA, USA, 1997. Kluwer Academic Publishers. ISBN 0-7923-4638-6. URL http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.106.3437&rep=rep1&type=pdf. (cited on page 24).

M. Hansen, N. Nohria, and T. Tierney. What's your strategy for managing knowledge? *Harvard Business Review*, 77(2):106–116, 1999. (cited on pages 55, 56 and 59).

L. Hart-Gonzalez and S. Lindemann. Expected achievement in speaking proficiency. Technical report, School of Language Studies, Foreign Services Institute, United States Department of State, 1993. (cited on pages 126 and 127).

J. H. Hayes. Do you like Piña Coladas? How improved communication can improve software quality. *IEEE Software*, 20(1):90–92, 2003. DOI 10.1109/MS.2003.1159036. (cited on page 11).

D. Heckathorn. Respondent-driven sampling: a new approach to the study of hidden populations. *Social Problems*, 44(2):174–199, 1997. (cited on page 92).

D. Heckathorn. Respondent-driven sampling II: deriving valid population estimates from chain-referral samples of hidden populations. *Social Problems*, pages 11–34, 2002. (cited on page 92).

M. Hegarty and M. A. Just. Constructing mental models of machines from text and diagrams. *Journal of Memory and Language*, 32(6):717–742, December 1993. (cited on page 130).

W. Heijstek and M. R. V. Chaudron. Effort distribution in model-based development. In *Proceedings of the 2nd workshop on Model Size Metrics*, pages 26–38, October 2007. URL http://www.win.tue.nl/~clange/MSM2007/MSM2007.pdf. (cited on pages 16, 39 and 96).

W. Heijstek and M. R. V. Chaudron. Exploring effort distribution in RUP projects. In *Proceedings of the 2nd International Symposium on Empirical Software Engineering and Measurement*, page 359, 2008a. DOI 10.1145/1414004.1414083. (cited on page 16).

W. Heijstek and M. R. V. Chaudron. Evaluating RUP software development processes through visualization of effort distribution. In *Proceedings of the 34th Euromicro Conference on Software Engineering and Advanced Applications*, pages 266–273, 2008b. DOI 10.1109/SEAA.2008.43. (cited on page 16).

W. Heijstek and M. R. V. Chaudron. Empirical investigations of model size, complexity and effort in large scale, distributed model driven development processes — a case study. In *Proceedings of the 35th Euromicro Conference on Software Engineering and Advanced Applications*, pages 113–120, 2009. DOI 10.1109/SEAA.2009.70. (cited on pages 17 and 84).

W. Heijstek and M. R. V. Chaudron. The impact of model driven development on the software architecture process. In *Proceedings of the 36th Euromicro Conference on Software Engineering and Advanced Applications*, pages 333–341, 2010. DOI 10.1109/SEAA.2010.63. (cited on pages 17, 84 and 87).

W. Heijstek and M. R. V. Chaudron. On the use of UML diagrams in industrial software architecture documents. Technical Report TR2011-02, Leiden Institute of Advanced Computer Science (LIACS) / Faculty of Science, Leiden University, 2011. (cited on pages 105 and 124).

W. Heijstek, M. R. Chaudron, L. Qiu, and C. C. Schouten. A comparison of industrial process descriptions for global custom software development. In *Proceedings of the International Conference on Global Software Engineering*, pages 277–284, Los Alamitos, CA, USA, 2010. IEEE Computer Society. ISBN 978-0-7695-4122-8. DOI 10.1109/ICGSE.2010.39. (cited on pages 16 and 174).

W. Heijstek, T. Kühne, and M. R. V. Chaudron. Experimental analysis of textual and graphical representations for software architecture design. In *Proceedings of the 5th ACM/IEEE International Symposium on Empirical Software Engineering and Measurement*, pages 167–176, September 2011. DOI 10.1109/ESEM.2011.25. (cited on page 17).

T. Heistracher, T. Kurz, G. Marcon, and C. Masuch. Collaborative software engineering with a digital ecosystem. In *Proceedings of the International Conference on Global Software Engineering*, pages 119–126, 2006. ISBN 0-7695-2663-2. (cited on page 161).

J. D. Herbsleb and R. E. Grinter. Architectures, coordination, and distance: Conway's law and beyond. *IEEE Software*, 16(5):63–70, 1999a. DOI 10.1109/52.795103. (cited on pages 4 and 59).

J. D. Herbsleb and R. E. Grinter. Splitting the organization and integrating the code: Conway's law revisited. In *Proceedings of the 21st International Conference on Software Engineering*, pages 85–95, Los Angeles, CA, USA, 1999b. URL http://portal.acm.org/citation.cfm?id=302405.302455. (cited on page 2).

J. D. Herbsleb and D. Moitra. Global software development. *IEEE Software*, 18(2):16–20, March/April 2001. DOI 10.1109/52.914732. (cited on page 106).

J. D. Herbsleb, A. Mockus, T. A. Finholt., and R. E. Grinter. Distance, dependencies, and delay in a global collaboration. In *Proceedings of the 2000 ACM conference on Computer supported cooperative work*, pages 319–328, New York, NY, USA, 2000. ACM. ISBN 1-58113-222-0. DOI 10.1145/358916.359003. (cited on pages 2, 3, 23, 173 and 174).

J. D. Herbsleb, A. Mockus, T. A. Finholt, and R. E. Grinter. An empirical study of global software development: distance and speed. In *Proceedings of the 23rd International Conference on Software Engineering*, pages 81–90, 2001. URL http://mockus.org/papers/speed.pdf. (cited on pages 59 and 94).

J. D. Herbsleb, D. J. Paulish, and M. Bass. Global software development at siemens: experience from nine projects. In *Proceedings of the International Conference on Software Engineering*, pages 524–533. ACM, 2005. DOI 10.1109/ICSE.2005.1553598. (cited on page 4).

J. Highsmith and M. Fowler. The agile manifesto. *Software Development Magazine*, 9(8): 29–30, 2001. (cited on pages 56, 58 and 105).

A. Hindle, M. Godfrey, and R. Holt. Software process recovery using recovered unified process views. In *Proceedings of the IEEE International Conference on Software Maintenance*, pages 1–10, 2010. DOI 10.1109/ICSM.2010.5609670. (cited on pages 39, 40 and 41).

M. Hirsch. Making RUP agile. In *Proceedings of the OOPSLA 2002 Practitioners Reports*, pages 1–8, New York, NY, USA, 2002. ACM. ISBN 1-58113-471-1. DOI 10.1145/604251.604254. (cited on page 105).

R. R. Hocking. The analysis and selection of variables in linear regression. *Biometrics*, 32(1):1–49, March 1976. (cited on page 126).

C. Hofmeister. Technical Committee (TC) 2 — SOFTWARE: Theory and Practice — Aims and Scopes of Workgroup (WG) 2.10 — Software Architecture. Technical Report WG210, International Federation for Information Processing (IFIP), 2000. URL http://www.ifip.org/bulletin/bulltcs/tc2_aim.htm#wg210. (cited on pages 59 and 104).

C. Hofmeister, R. L. Nord, and D. Soni. Describing software architecture with UML. In *Proceedings of the TC2 First Working IFIP Conference on Software Architecture*, volume 140, pages 145–160. Kluwer, 1999. ISBN 0-7923-8453-9. URL www.users.abo.fi/lpetre/SA10/paper99.pdf. (cited on page 105).

G. Hofstede. *Culture's Consequences: International Differences in Work-related Values*. Sage Publications, Inc, 1984. ISBN 0-8039-1306-0. (cited on page 4).

H. Holmström, E. Ó. Conchúir, P. J. Ågerfalk, and B. Fitzgerald. Global software development challenges: A case study on temporal, geographical and socio-cultural distance. In *Proceedings of the First IEEE International Conference on Global Software Engineering*, pages 3–11. IEEE, October 2006. DOI 10.1109/ICGSE.2006.261210. (cited on page 3).

J. Holsanova, N. Holmberg, and K. Holmqvist. Reading information graphics: The role of spatial contiguity and dual attentional guidance. *Applied Cognitive Psychology*, 23 (9):1215–1226, 2009. (cited on page 132).

R. Holt. Software architecture as a shared mental model. In *Proceedings of the ASERC Workhop on Software Architecture, University of Alberta*, 2002. URL http://plg.uwaterloo.ca/~holt/papers/sw-arch-mental-model-020314c-1.pdf. (cited on pages 64 and 106).

M. Höst, B. Regnell, and C. Wohlin. Using students as subjects—a comparative study of students and professionals in lead-time impact assessment. *Empirical Software Engineering*, 5(3):201–214, 2000. DOI 10.1023/A:1026586415054. (cited on page 131).

M. Höst, C. Wohlin, and T. Thelin. Experimental context classification: incentives and experience of subjects. In *Proceedings of the 27th international conference on Software engineering*, pages 470–478, New York, NY, USA, 2005. ACM. ISBN 1-59593-963-2. DOI 10.1145/1062455.1062539. (cited on page 127).

B. C. Hungerford, A. R. Hevner, and R. W. Collins. Reviewing software diagrams: A cognitive study. *IEEE Transactions on Software Engineering*, 30(2):82–96, 2004. URL http://csdl.computer.org/comp/trans/ts/2004/02/e0082abs.htm. (cited on page 106).

J. M. Hussey and S. E. Hall. *Managing Global Development Risk*. Auerbach Publications, 1st edition, November 2007. ISBN 978-1420055207. (cited on page 23).

J. Hutchinson, J. Whittle, M. Rouncefield, and S. Kristoffersen. Empirical assessment of MDE in industry. In *Proceedings of the 33rd International Conference on Software Engineering*, pages 471–480, 2011. DOI 10.1145/1985793.1985858. (cited on pages 137 and 138).

M. Huysman and V. Wulf. IT to support knowledge sharing in communities, towards a social capital analysis. *Journal of Information Technology*, 21(1):40–51, 2005. DOI 10.1057/palgrave.jit.2000053. (cited on page 57).

IEEE. 1471-2000: Recommended practice for architectural description of software-intensive systems. Technical report, IEEE, 2000. (cited on pages 5 and 105).

International Software Benchmarking Standards Group. The benchmark-release 9. Technical report, ISBSG, Warrandyte, Australia, 2006. URL http://www.isbsg.org/. (cited on page 85).

E. Isaacs and J. Tang. What video can and cannot do for collaboration: a case study. In *Proceedings of the First ACM International Conference on Multimedia*, volume 2, pages 63–73. ACM Press, 1994. DOI 10.1145/166266.166289. (cited on page 4).

ISO/IEC. 19501:2005 Information technology — Open Distributed Processing — Unified Modeling Language (UML) Version 1.4.2. Technical report, ISO/IEC, 2005. (cited on page 6).

ISO/IEC. 12007:2008 Systems and software engineering — Software Life Cycle Processes. Technical report, ISO/IEC, 2008. (cited on page 22).

ISO/IEC/IEEE. 42010:2011 Systems and software engineering — Architecture description. Technical report, ISO/IEC/IEEE, Oct. 2011. (cited on page 5).

K. Iwata, T. Nakashima, Y. Anan, and N. Ishii. Improving accuracy of multiple regression analysis for effort prediction model. In *Proceedings of the first IEEE/ACIS International Workshop on Component-Based Software Engineering, Software Architecture and Reuse (COMSAR 2006)*, volume 1, pages 48–55, Los Alamitos, CA, USA, 2006. IEEE Computer Society. ISBN 0-7695-2613-6. DOI 10.1109/ICIS-COMSAR.2006.46. (cited on page 38).

I. Jacobson. Object-oriented development in an industrial environment. In *Proceedings of the Conference on Object-oriented programming systems, languages and applications*, pages 183–191, New York, NY, USA, 1987. ACM Press. ISBN 0-89791-247-0. DOI 10.1145/38765.38824. (cited on page 8).

I. Jacobson, M. Christenson, P. Jonsson, and G. Overgaard. *Object-Oriented Software Engineering, A Use Case Driven Approach*. Addison-Wesley, Reading, Massachusetts, USA, July 1992. ISBN 978-0201544350. (cited on pages 6 and 8).

I. Jacobson, G. Booch, and J. Rumbaugh. *The Unified Software Development Process*. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA, 1999. ISBN 0-201-57169-2. (cited on page 40).

A. Jansen and J. Bosch. Software architecture as a set of architectural design decisions. In *Proceedings of the 5th Working IEEE/IFIP Conference on Software Architecture*, pages 109–120. IEEE Computer Society, 2005. ISBN 0-7695-2548-2. DOI 10.1109/WICSA.2005.61. (cited on page 105).

M. Jiménez, M. Piattini, and A. Vizcaíno. Challenges and improvements in distributed software development: A systematic review. *Advances in Software Engineering*, pages 1–15, 2009. DOI 10.1155/2009/710971. (cited on pages 23, 136 and 158).

S. Johnson and C. Shih-Ping. The effect of thinking aloud pair problem solving (TAPPS) on the troubleshooting ability of aviation technician students. *Journal of Industrial Teacher Education*, 37(1):7–25, 1999. URL http://scholar.lib.vt.edu/ejournals/JITE/v37n1/john.html. (cited on page 131).

C. Jones. *Software Assessments, Benchmarks, and Best Practices*. Addison-Wesley Longman Publishing Co., Inc., 2000. ISBN 978-0201485424. (cited on page 85).

M. I. Kellner, R. J. Madachy, and D. M. Raffo. Software process simulation modeling: why? what? how? *Journal of Systems and Software*, 46(2):91–105, 1999. DOI 10.1016/S0164-1212(99)00003-5. (cited on page 96).

H. Kim and C. Boldyreff. Developing software metrics applicable to UML models. In *Proceedings of the 6th ECOOP Workshop on Quantitative Approaches in Object-Oriented Software Engineering*, 2002. URL http://alarcos.inf-cr.uclm.es/qaoose2002/docs/QAOOSE-Kim-Bol.pdf. (cited on page 141).

A. G. Kleppe, J. Warmer, and W. Bast. *MDA Explained: The Model Driven Architecture: Practice and Promise*. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA, 2003. ISBN 032119442X. (cited on pages 137 and 160).

J. Knodel, D. Muthig, and M. Naab. An experiment on the role of graphical elements in architecture visualization. *Empirical Software Engineering*, 13(6):693–726, 2008. DOI 10.1007/s10664-008-9069-5. (cited on page 108).

P. Kogut and P. Clements. The software architecture renaissance. *Crosstalk-The Journal of Defense Software Engineering*, 7(11):1–5, 1994. URL http://www.sei.cmu.edu/library/assets/sw_arch_renaissance.pdf. (cited on page 5).

A. G. Koru, D. Zhang, K. El Emam, and H. Liu. An investigation into the functional form of the size-defect relationship for software modules. *IEEE Transactions on Software Engineering*, 35(2):293–304, March-April 2009. DOI 10.1109/TSE.2008.90. (cited on page 153).

G. Koru, H. Liu, D. Zhang, and K. Emam. Testing the theory of relative defect proneness for closed-source software. *Empirical Software Engineering*, 15(6):577–598, Dec. 2010. DOI 10.1007/s10664-010-9132-x. (cited on page 153).

J. Kotlarsky, P. C. van Fenema, and l. P. Willcocks. Developing a knowledge-based perspective on coordination: the case of global software projects. *Information and Management*, 45:96–108, 2008. DOI 10.1016/j.im.2008.01.001. (cited on page 11).

R. E. Kraut and L. A. Streeter. Coordination in software development. *Communications of the ACM*, 38(3):69–81, March 1995. DOI 10.1145/203330.203345. (cited on pages 59 and 106).

P. Kruchten. The 4 + 1 view model of architecture. *IEEE Software*, 12(6):42–50, Nov. 1995. DOI 10.1109/52.469759. (cited on pages 5, 56 and 75).

P. Kruchten. A brief history of the RUP "hump chart". Technical report, University of British Columbia, 2003a. (cited on page 40).

P. Kruchten. *The Rational Unified Process: An Introduction*. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA, 2003b. ISBN 0321197704. (cited on pages 8, 38, 40, 73 and 139).

P. Kruchten, P. Lago, H. van Vliet, and T. Wolf. Building up and exploiting architectural knowledge. In *Proceedings of the Working IEEE/IFIP Conference on Software Architecture*, pages 291–292. IEEE Computer Society, 2005. ISBN 0-7695-2548-2. DOI 10.1109/WICSA.2005.19. (cited on page 158).

S. Kvale. *InterViews: An Introduction to Qualitative Research Interviewing*. Sage Publications, 1996. ISBN 978-0803958203. (cited on page 15).

C. F. J. Lange. Model size matters. In T. Kühne, editor, *Proceedings of the MoDELS 2006 Workshops*, volume 4364 of *Lecture Notes in Computer Science*, pages 211–216. Springer, 2006. ISBN 978-3-540-69488-5. DOI 10.1007/978-3-540-69489-2_26. (cited on pages 106 and 141).

C. F. J. Lange and M. R. V. Chaudron. Managing model quality in UML-based software development. In *Proceedings of the 13th IEEE International Workshop on Software Technology and Engineering Practice*, pages 7–16. IEEE Computer Society, 2005. ISBN 0-7695-2639-X. DOI 10.1109/STEP.2005.16. (cited on page 141).

C. F. J. Lange and M. R. V. Chaudron. Effects of defects in UML models: an experimental investigation. In *Proceedings of the 22nd IEEE International Conference on Software Maintenance*, pages 401–411. ACM, 2006. ISBN 1-59593-375-1. DOI 10.1145/1134285.1134341. (cited on pages 107 and 125).

C. F. J. Lange, M. R. V. Chaudron, J. Muskens, L. J. Somers, and H. M. Dortmans. An empirical investigation in quantifying inconsistency and incompleteness of UML designs. In *Proceedings of the Workshop on Consistency Problems in UML-based Software Development*, pages 26–34, 2003. (cited on pages 106 and 169).

C. F. J. Lange, M. R. V. Chaudron, and J. Muskens. In practice: UML software architecture and design description. *IEEE Software*, 23(2):40–46, 2006. DOI 10.1109/MS.2006.50. (cited on page 166).

T. D. LaToza, G. Venolia, and R. DeLine. Maintaining mental models: a study of developer work habits. In *Proceedings of the 28th International Conference on Software Engineering*, pages 492–501, Shanghai, China, 2006. ACM. ISBN 1-59593-375-1. DOI 10.1145/1134355. (cited on page 106).

G. Lee, W. DeLone, and J. Espinosa. Ambidextrous coping strategies in globally distributed software development projects. *Communications of the ACM*, 49(10):35–40, 2006. (cited on pages 80 and 104).

N. Lester and F. Wilkie. Evaluating UML tool support for effective coordination and communication across geographically disparate sites. In *Proceedings of the International Workshop on Software Technology and Engineering Practice*, pages 57–64, Los Alamitos, CA, USA, 2004. IEEE Computer Society. ISBN 0-7695-2293-9. DOI 10.1109/STEP.2004.10. (cited on page 161).

T. Lethbridge, J. Singer, and A. Forward. How software engineers use documentation: The state of the practice. *IEEE Software*, 20(6):35–39, 2003. DOI 10.1109/MS.2003.1241364. (cited on pages 58, 105 and 107).

L. L. Levesque, J. M. Wilson, and D. R. Wholey. Cognitive divergence and shared mental models in software development project teams. *Journal of Organizational Behavior*, 22:135–144, 2001. (cited on page 174).

J. R. Levin, G. J. Anglin, and R. N. Carney. *The Psychology of Illustration: I. Basic Research*, chapter On empirically validating functions of pictures in prose, pages 51—85. Springer, New York, 1987. (cited on page 124).

W. Li and S. Henry. Object-oriented metrics that predict maintainability. *The Journal of Systems and Software*, 23(2):111–122, Nov. 1993. (cited on page 144).

Y. Lin, J. Gray, and F. Jouault. DSMDiff: a differentiation tool for domain-specific models. *European Journal of Information Systems*, 16(4):349–361, 2007. DOI doi:10.1057/palgrave.ejis.3000685. (cited on page 166).

B. Lings, B. Lundell, P. J. Ågerfalk, and B. Fitzgerald. A reference model for successful distributed development of software systems. In *Proceedings of the Second IEEE International Conference on Global Software Engineering*, pages 130–139, 2007. DOI 10.1109/ICGSE.2007.6. (cited on page 161).

C. Lopez-Martin, C. Yanez-Marquez, and A. Gutierrez-Tornes. A fuzzy logic model based upon reused and new & changed code for software development effort estimation at personal level. In *Proceedings of the 15th International Conference on Computing*, pages 298–303, Los Alamitos, CA, USA, 2006. IEEE Computer Society. ISBN 0-7695-2708-6. DOI 10.1109/CIC.2006.5. (cited on page 38).

M. Lorenz and J. Kidd. *Object-Oriented Software Metrics*. Prentice Hall, Englewood Cliffs, 1994. ISBN 0-13-179292-X. (cited on page 143).

A. MacDonald, D. M. Russell, and B. Atchison. Model-driven development within a legacy system: An industry experience report. In *Proceedings of the Australian Software Engineering Conference*, pages 14–22, Los Alamitos, CA, USA, 2005. IEEE Computer Society. ISBN 0-7695-2257-2. DOI 10.1109/ASWEC.2005.32. (cited on page 138).

M. Marchesi. OOA metrics for the unified modeling language. In *Proceedings of the 2nd Euromicro Conference on Software Maintenance and Reengineering*, pages 67–73. IEEE Computer Society, 1998. ISBN 0-8186-8421-6. URL http://csdl.computer.org/comp/proceedings/csmr/1998/8421/00/84210067abs.htm. (cited on page 141).

J. Marciniak, editor. *Encyclopedia of software engineering*. John Wiley & Sons, Inc., 2002. ISBN 978-0471028956. DOI 10.1002/0471028959. (cited on page 22).

J. Mathieu, T. Heffner, G. Goodwin, E. Salas, and J. Cannon-Bowers. The influence of shared mental models on team process and performance. *Journal of Applied Psychology*, 85(2):273, 2000. DOI 10.1037/0021-9010.85.2.273. (cited on page 65).

R. E. Mayer. *Multimedia Learning*. Cambridge University Press, second edition, 2009. ISBN 978-0521735353. (cited on page 107).

M. McDaniel and M. Pressley. *Imagery and Related Mnemonic Processes: Theories, Individual Differences, and Applications*. Springer-Verlag Publishing, 1987. ISBN 978-1461291114. (cited on page 124).

C. McNamara. General guidelines for conducting interviews. Technical report, Authenticity Consulting, LLC, Minneapolis, MN, 1999. URL http://managementhelp.org/businessresearch/interviews.htm. (cited on page 15).

N. Medvidovic, D. S. Rosenblum, D. F. Redmiles, and J. E. Robbins. Modeling software architectures in the Unified Modeling Language. *ACM Transaction on Software Engineering and Methodology*, 11(1):2–57, Jan. 2002. DOI 10.1145/504087.504088. (cited on page 106).

T. Menzies, Z. Chen, J. Hihn, and K. Lum. Selecting best practices for effort estimation. *IEEE Transactions on Software Engineering*, 32(11):883–895, 2006. DOI 10.1109/TSE.2006.114. (cited on page 38).

D. Milicic and C. Wohlin. Distribution patterns of effort estimations. In *Proceedings of the 30th Euromicro Conference on Software Engineering and Advanced Applications*, pages 422–429, Los Alamitos, CA, USA, 2004. IEEE Computer Society. DOI 10.1109/EURMIC.2004.1333398. (cited on page 38).

A. Mockus and J. D. Herbsleb. Challenges of global software development. In *Proceedings of the IEEE International Symposium on Software Metrics*, page 182, Los Alamitos, CA, USA, 2001. IEEE Computer Society. DOI 10.1109/METRIC.2001.915526. (cited on pages 23 and 174).

A. Mockus and D. M. Weiss. Globalization by chunking: A quantitative approach. *IEEE Software*, 18(2):30–37, 2001. DOI 10.1109/52.914737. (cited on pages 11, 23, 50 and 56).

MODELWARE D5.3-1. Industrial ROI, Assessment, and Feedback — Master Document. Technical Report Revision 2.2, Master Document, 2006. URL http://www.modelware-ist.org. (cited on page 138).

P. Mohagheghi and V. Dehlen. Where is the proof? — A review of experiences from applying MDE in industry. In I. Schieferdecker and A. Hartman, editors, *Proceedings of the Fourth European Conference on Model Driven Architecture: Foundations and Applications*, volume 5095 of *Lecture Notes in Computer Science*, pages 432–443. Springer, 2008. ISBN 978-3-540-69095-5. DOI 10.1007/978-3-540-69100-6_31. (cited on pages 137, 138 and 168).

M. Müller and W. Tichy. Case study: extreme programming in a university environment. In *Proceedings of the 23rd international Conference on Software Engineering*, pages 537–544, 2001. DOI 10.1109/ICSE.2001.919128. (cited on page 106).

N. Mullick, M. Bass, Z. Houda, P. Paulish, and M. Cataldo. Siemens global studio project: Experiences adopting an integrated GSD infrastructure. In *Proceedings of the IEEE international conference on Global Software Engineering*, pages 203–212, 2006. URL www.casos.cs.cmu.edu/publications/papers/cataldo_p4.pdf. (cited on page 161).

P. Naur and B. Randell, editors. *Software Engineering: Report of a conference sponsored by the NATO Science Committee, Garmisch, Germany*, October 1968. Brussels, Scientific Affairs Division, NATO. URL http://homepages.cs.ncl.ac.uk/brian.randell/NATO/nato1968.PDF. (cited on page 1).

T. Nguyen, T. Wolf, and D. Damian. Global software development and delay: Does distance still matter? In *Proceedings of the IEEE International Conference on Global Software Engineering*, pages 45–54, 2008. DOI 10.1109/ICGSE.2008.39. (cited on page 59).

C. Nielson. An empirical examination of the role of "closeness" in industrial buyer-seller relationships. *European Journal of Marketing*, 32(5/6):441–463, 1998. DOI 10.1108/03090569810215812. (cited on page 59).

G. E. Noether. Why Kendall tau? *Teaching Statistics*, 3(2):41–43, 1981. DOI 10.1111/j.1467-9639.1981.tb00422.x. (cited on page 127).

M. E. Nordberg III. Managing code ownership. *IEEE Software*, 20:26–33, 2003. DOI 10.1109/MS.2003.1184163. (cited on page 59).

A. Nugroho. Level of detail in UML models and its impact on model comprehension: A controlled experiment. *Information & Software Technology*, 51(12):1670–1685, 2009. DOI 10.1016/j.infsof.2009.04.007. (cited on page 125).

A. Nugroho and M. R. V. Chaudron. A survey into the rigor of UML use and its perceived impact on quality and productivity. In *Proceedings of the Second ACM-IEEE international symposium on Empirical software engineering and measurement*, pages 90–99, New York, NY, USA, 2008. ACM. ISBN 978-1-59593-971-5. DOI 10.1145/1414004.1414020. (cited on page 106).

A. Nugroho and M. R. V. Chaudron. Evaluating the impact of UML modeling on software quality: An industrial case study. In *Proceedings of the 12th International Conference on Model Driven Engineering Languages and Systems*, pages 181–195, Denver, CO, USA, 2009. Springer. ISBN 978-3-642-04424-3. DOI 10.1007/978-3-642-04425-0. (cited on page 106).

A. Nugroho and C. F. J. Lange. On the relation between class-count and modeling effort. In *Proceedings of the ACM/IEEE 10th International Conference on Model Driven Engineering Languages and Systems*, volume 5002, pages 93–104. Springer, 2007. ISBN 978-3-540-69069-6. DOI 10.1007/978-3-540-69073-3_11. (cited on page 141).

Object Management Group. Technical Guide to Model Driven Architecture: The MDA Guide v1.0.1. Technical report, Object Management Group, June 2003a. URL http://www.omg.org/cgi-bin/apps/doc?omg/03-06-01.pdf. (cited on page 160).

Object Management Group. *MDA Guide Version 1.0.1*. Object Management Group, Framingham, Massachusetts, June 2003b. (cited on page 160).

Object Management Group. Meta Object Facility (MOF) Core Specification Version 2.0. Technical report, Object Management Group, 2006. URL http://www.omg.org/spec/MOF/. (cited on page 160).

Object Management Group. *XML Metadata Interchange (XMI)*. Object Management Group, 2007. URL http://www.omg.org/spec/XMI/. (cited on pages 85 and 160).

Object Management Group. Business Process Model and Notation (BPMN) Version 1.2. Technical Report formal/2009-01-03, Object Management Group, 140 Kendrick Street, Building A, Suite 300, Needham, MA 02494 USA, January 2009. URL http://www.omg.org/spec/BPMN/1.2. (cited on page 25).

Object Management Group. Unified modeling language superstructure. Technical Report formal/2011-08-05, Object Management Group, August 2011. URL http://www.omg.org/spec/UML/2.4.1/Superstructure/PDF. (cited on page 6).

J. Oei, L. Van Hemmen, E. Falkenberg, and S. Brinkkemper. The meta model hierarchy: a framework for information systems concepts and techniques. Technical Report No. 92-17, Department of Informatics, Faculty of Mathematics and Informatics, Katholieke Universiteit, Nijmegen, the Netherlands, July 1992. (cited on page 125).

T. Ohno. *Toyota Production System: Beyond Large-Scale Production*. Productivity Press, March 1988. ISBN 978-0915299140. (cited on page 49).

A. N. Oppenheim. *Questionnaire Design, Interviewing and Attitude Measurement*. Heinemann Educational Books, 1966. ISBN 0-8264-5176-4. (cited on page 112).

C. O'Neill. Delivering systems faster with less risk: The macro-iterative dimension of RUP. *The Rational Edge*, September 2007. URL https://www.ibm.com/developerworks/rational/library/sep07/oneill/?ca=drs. (cited on page 40).

C. Pahl. Layered ontological modelling for web service-oriented model-driven architecture. In A. Hartman and D. Kreische, editors, *Model Driven Architecture — Foundations and Applications*, volume 3748 of *Lecture Notes in Computer Science*, pages 88–102. Springer, 2005. ISBN 978-3-540-30026-7. DOI 10.1007/11581741_8. (cited on page 161).

M. Papazoglou and D. Georgakopoulos. Introduction: Service-oriented computing. *Communications of the ACM*, 46(10):25–28, 2003. DOI 10.1145/944217.944233. (cited on page 65).

D. Parnas and P. Clements. A rational design process: How and why to fake it. In H. Ehrig, C. Floyd, M. Nivat, and J. Thatcher, editors, *Formal Methods and Software Development*, volume 186 of *Lecture Notes in Computer Science*, pages 80–100. Springer, 1985. ISBN 978-3-540-15199-9. DOI 10.1007/3-540-15199-0_6. (cited on page 22).

D. Perry and A. Wolf. Foundations for the study of software architecture. *ACM SIGSOFT Software Engineering Notes*, 17(4):40–52, 1992. DOI 10.1145/141874.141884. (cited on page 5).

G. Pollice. Using the RUP for small projects: Expanding upon eXtreme Programming. Technical report, Rational Software, 2001. (cited on page 105).

M. Poppendieck and T. Poppendieck. *Lean software development: An agile toolkit*. Addison-Wesley Professional, 2003. ISBN 978-0321150783. (cited on page 49).

D. Port, Z. Chen, and P. Kruchten. An empirical validation of the RUP "hump" diagram. In *Proceedings of the 4th International Symposium on Empirical Software Engineering*, 2005. (cited on pages 39 and 40).

M. E. Porter. *Competitive Advantage: Creating and Sustaining Superior Performance*. Free Press, New York, 1985. ISBN 0029250900. (cited on page 3).

R. Premraj, M. Shepperd, B. Kitchenham, and P. Forselius. An empirical analysis of software productivity over time. In *Proceedings of the 11th IEEE International Symposium on Software Metrics*, pages 10–37, 2005. DOI 10.1109/METRICS.2005.8. (cited on page 85).

K. H. Pries and J. M. Quigley. *Scrum project management*. CRC Press, 2010. ISBN 978-1439825150. URL http://www.crcpress.com/product/isbn/9781439825150. (cited on page 58).

R. Prikladnicki, J. L. N. Audy, and R. Evaristo. A reference model for global software development: Findings from a case study. *International Conference on Global Software Engineering*, pages 18–28, 2006. DOI 10.1109/ICGSE.2006.261212. (cited on page 21).

L. Qiu. A comparison of process descriptions and specifications in the offshored software development industry. Master's thesis, M.Sc. ICT in Business, Leiden University, August 2009. (cited on page 27).

R Development Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2011. URL http://www.R-project.org/. ISBN 3-900051-07-0. (cited on page 43).

P. J. Ågerfalk and B. Fitzgerald. Introduction: Special issue: Flexible and distributed software processes: old petunias in new bowls? *Communications of the ACM*, 49(10): 26–34, Oct. 2006. DOI 10.1145/1164394.1164416. (cited on page 58).

P. J. Ågerfalk, B. Fitzgerald, H. Holmström, B. Lings, B. Lundell, and E. Ó. Conchúir. A framework for considering opportunities and threats in distributed software development. In *Proceedings of the International Workshop on Distributed Software Development*, pages 47–61, 2005. URL http://www.idi.ntnu.no/grupper/su/bibliography/pdf/OpenSource/print_DiSD05-Agerfalk-etal_CamReady.pdf. (cited on page 3).

C. Raistrick. Applying MDA and UML in the development of a healthcare system. In N. J. Nunes, B. Selic, A. R. da Silva, and J. A. T. Álvarez, editors, *Proceedings of the UML 2004 Satellite Activities*, volume 3297 of *Lecture Notes in Computer Science*, pages 203–218. Springer, 2004. ISBN 3-540-25081-6. DOI 10.1007/978-3-540-31797-5_21. (cited on page 137).

T. Reus, H. Geers, and A. van Deursen. Harvesting software systems for MDA-based reengineering. In A. Rensink and J. Warmer, editors, *Proceedings of the Second European Conference on Model Driven Architecture - Foundations and Applications*, volume 4066 of *Lecture Notes in Computer Science*, pages 213–225. Springer, 2006. ISBN 3-540-35909-5. DOI 10.1007/11787044_17. (cited on page 137).

J. Rosik, A. L. Gear, J. Buckley, M. A. Babar, and D. Connolly. Assessing architectural drift in commercial software development: a case study. *Software — Practice and Experience*, 12:63–86, November 2010. DOI 10.1002/spe.999. (cited on pages 81 and 100).

W. Royce. Managing the development of large software systems. In *Proceedings of IEEE WESCON*, volume 26, pages 1–9, 1970. URL www.cs.huji.ac.il/~feit/sem/se09/Waterfall.pdf. (cited on page 22).

W. Royce. *Software Project Management: A Unified Framework*. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA, 1998. ISBN 0-201-30958-0. (cited on page 40).

E. Rubin and H. Rubin. Supporting agile software development through active documentation. *Requirements Engineering*, 16:117–132, 2011. DOI 10.1007/s00766-010-0113-9. (cited on page 58).

J. Rumbaugh, M. Blaha, W. Premerlani, F. Eddy, and W. Lorensen. *Object-oriented modeling and design*, volume 38. Prentice hall, 1990. ISBN 978-0136298410. (cited on page 6).

P. Runeson and M. Höst. Guidelines for conducting and reporting case study research in software engineering. *Empirical Software Engineering*, 14(2):131–161, April 2009. DOI 10.1007/s10664-008-9102-8. (cited on page 13).

P. Runeson, M. Höst, A. Rainer, and B. Regnell. *Case Study Research in Software Engineering — Guidelines and Examples*. John Wiley & Sons, 1 edition, April 2012. ISBN 978-1-118-10435-4. (cited on page 13).

B. Russell. *A History of Western Philosophy*. Simon & Schuster/Touchstone, 1945. ISBN 978-0671201586. (cited on page 12).

S. Sahay, B. Nicholson, and K. S. *Global IT Outsourcing: Software Development Across Borders*. Cambridge University Press, 2003. ISBN 978-0521039482. (cited on pages 2 and 3).

F. Salger. On the use of handover checkpoints to manage the global software development process. In R. Meersman, P. Herrero, and T. S. Dillon, editors, *Proceedings of the OTM Workshops*, volume 5872 of *Lecture Notes in Computer Science*, pages 267–276. Springer, 2009. ISBN 978-3-642-05289-7. DOI 10.1007/978-3-642-05290-3. (cited on pages 2 and 23).

G. Scanniello, C. Gravino, M. Risi, and G. Tortora. A controlled experiment for assessing the contribution of design pattern documentation on software maintenance. In *Proceedings of the ACM-IEEE International Symposium on Empirical Software Engineering and Measurement*, pages 1–4, New York, NY, USA, 2010. ACM. ISBN 978-1-4503-0039-1. DOI 10.1145/1852786.1852853. (cited on page 106).

I. Schieferdecker, Z. R. Dai, J. Grabowski, and A. Rennoch. The UML 2.0 testing profile and its relation to TTCN-3. In D. Hogrefe and A. Wiles, editors, *Proceedings of the 15th IFIP international conference on Testing of communicating systems*, volume 2644 of *Lecture Notes in Computer Science*, pages 79–94. Springer, 2003. ISBN 978-3-540-40123-0. DOI 10.1007/3-540-44830-6_7. (cited on page 162).

K. Schneider, K. Stapel, and E. Knauss. Beyond documents: visualizing informal communication. In *Proceedings of Requirements Engineering Visualization*, pages 31–40, 2008. DOI 10.1109/REV.2008.1. (cited on page 59).

K. Schwaber and M. Beedle. *Agile Software Development with Scrum*. Prentice Hall PTR, Upper Saddle River, NJ, USA, 1st edition, 2001. ISBN 0130676349. (cited on page 58).

B. Selic. The pragmatics of model-driven development. *IEEE Software*, 20(5):19–25, 2003. DOI 10.1109/MS.2003.1231146. (cited on pages 10 and 136).

C. Shannon and W. Weaver. A mathematical theory of communication. *University of Illinois Press, Urbana, Ill*, pages 3–55, 1949. DOI 10.1145/584091.584093. (cited on page 60).

S. Sharma and G. Seshagiri. Point/counterpoint: Making global software development work – GSD: Not a business necessity, but a march of folly. *IEEE Software*, 23(5): 62–65, 2006. DOI 10.1109/MS.2006.138. (cited on page 11).

M. Shaw and P. C. Clements. The golden age of software architecture. *IEEE Software*, 23(2):31–39, 2006. DOI 10.1109/MS.2006.58. (cited on page 104).

D. Shirtz, M. Kazakov, and Y. Shaham-Gafni. Adopting model driven development in a large financial organization. In D. H. Akehurst, R. Vogel, and R. F. Paige, editors, *Proceedings of the Third European Conference on Model Driven Architecture: Foundations and Applications*, volume 4530 of *Lecture Notes in Computer Science*, pages 172–183. Springer, 2007. ISBN 978-3-540-72900-6. DOI 10.1007/978-3-540-72901-3_13. (cited on page 138).

B. Shneiderman. The eyes have it: A task by data type taxonomy for information visualizations. In *Proceedings of the 1996 IEEE Symposium on Visual Languages*, pages 336–343, 1996. DOI 10.1109/VL.1996.545307. (cited on page 122).

A. Sillitti, M. Ceschi, B. Russo, and G. Succi. Managing uncertainty in requirements: A survey in documentation-driven and agile companies. In *Proceedings of the 11th IEEE International Symposium on Software Metrics*, pages 10–17, Washington, DC, USA, 2005. IEEE Computer Society. ISBN 0-7695-2371-4. DOI 10.1109/METRICS.2005.29. (cited on page 58).

J. Smith. A comparison of RUP and XP. Technical Report TP167, Rational Software, May 2001. (cited on pages 58 and 105).

E. Soloway, R. Lampert, S. Letovsky, D. Littman, and J. Pinto. Designing documentation to compensate for delocalized plans. *Communications of the ACM*, 31(11):1259–1267, 1988. DOI 10.1145/50087.50088. (cited on page 11).

D. Soni, R. L. Nord, and C. Hofmeister. Software architecture in industrial applications. In *Proceedings of the 17th International Conference on Software Engineering*, pages 196–206. ACM Press, 1995. DOI 10.1145/225014.225033. (cited on pages 104 and 105).

H. Spanjers, M. ter Huurne, B. Graaf, M. Lormans, D. Bendas, and R. van Solingen. Tool support for distributed software engineering. In *Proceedings of the International Conference on Global Software Engineering*, pages 187–198, 2006. DOI 10.1109/ICGSE.2006.261232. (cited on page 161).

J. Sprinkle and G. Karsai. A domain-specific visual language for domain model evolution. *Journal of Visual Languages & Computing*, 15(3-4):291–307, 2004. DOI 10.1016/j.jvlc.2004.01.006. (cited on page 173).

R. Stake. *The Art of Case Study Research*. Sage Publications, Inc, 1995. ISBN 978-0803957671. (cited on pages 13 and 60).

M. Staron. Adopting model driven software development in industry — A case study at two companies. In O. Nierstrasz, J. Whittle, D. Harel, and G. Reggio, editors, *Proceedings of the 9th International Conference on Model Driven Engineering Languages and Systems*, volume 4199 of *Lecture Notes in Computer Science*, pages 57–72. Springer, 2006. ISBN 3-540-45772-0. DOI 10.1007/11880240_5. (cited on pages 137 and 160).

C. J. Stettina and W. Heijstek. Five agile factors: Helping self-management to self-reflect. In R. O'Connor, J. Pries-Heje, and R. Messnarz, editors, *Proceedings of the 18th European Conference on Systems, Software and Service Process Improvement*, pages 84–96, Roskilde, Denmark, June 2011a. DOI 10.1007/978-3-642-22206-1_8. (cited on page 58).

C. J. Stettina and W. Heijstek. Necessary and neglected? an empirical study of internal documentation in agile software development teams. In *Proceedings of the 29th ACM International Conference on Design of Communication (SIGDOC 2011)*, pages 159–166, October 2011b. DOI 10.1145/2038476.2038509. (cited on pages 58, 105 and 107).

A. C. Strauss and J. Corbin. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Sage Publications, Inc, 2nd edition, September 1990. ISBN 978-0803932500. (cited on pages 13 and 62).

P. Taylor, D. Greer, P. Sage, G. Coleman, K. McDaid, and F. Keenan. Do agile GSD experience reports help the practitioner? In *Proceedings of the 2006 international workshop on Global software development for the practitioner*, pages 87–93, 2006. DOI 10.1145/1138506.1138526. (cited on page 84).

R. N. Taylor, N. Medvidovic, and E. M. Dashofy. *Software Architecture: Foundations, Theory, and Practice*. Wiley, January 2009. ISBN 978-0470167748. (cited on page 105).

The Middleware Company. Model driven development for J2EE utilizing a model driven architecture (MDA) approach: Productivity analysis. Technical report, The Middleware Company, June 2003. URL http://www.omg.org/mda/mda_files/MDA_Comparison-TMC_final.pdf. (cited on page 160).

S. Tilley. Documenting software systems with views VI: lessons learned from 15 years of research & practice. In *Proceedings of the 27th ACM international Conference on Design of Communication*, pages 239–244, 2009. DOI 10.1145/1621995.1622043. (cited on page 108).

S. Tilley and S. Huang. A qualitative assessment of the efficacy of UML diagrams as a form of graphical documentation in aiding program understanding. In *Proceedings of the 21st annual international conference on Documentation*, pages 184–191, October 2003. ISBN 1-58113-696-X. DOI 10.1145/944868.944908. (cited on pages 11 and 106).

F. Trompenaars and P. Prud'homme van Reine. *Managing Change Across Corporate Cultures*. Capstone Publishing Ltd., 2004. ISBN 978-1841125787. (cited on page 4).

M. Tsunoda, A. Monden, H. Yadohisa, N. Kikuchi, and K. Matsumoto. Software development productivity of Japanese enterprise applications. *Information Technology and Management*, 10(4):193–205, Dec. 2009. DOI 10.1007/s10799-009-0050-9. (cited on page 85).

A. Van Deursen, P. Klint, and J. Visser. Domain-specific languages: An annotated bibliography. *ACM Sigplan Notices*, 35(6):26–36, June 2000. DOI 10.1145/352029.352035. (cited on pages 11 and 137).

H. van Vliet. *Software Engineering: Principles and Practice*. Wiley, 3rd edition, June 2008. ISBN 978-0470031469. (cited on pages 171 and 194).

D. Šmite, C. Wohlin, T. Gorschek, and R. Feldt. Empirical evidence in global software engineering: a systematic review. *Empirical Software Engineering*, 15(1):91–118, 2010. DOI 10.1007/s10664-009-9123-y. (cited on pages 2, 24, 94, 158, 173, 174, 176 and 195).

D. B. Walz, J. J. Elam, and B. Curtis. Inside a software design team: knowledge acquisition, sharing, and integration. *Communications of the ACM*, 36:63–77, October 1993. DOI 10.1145/163430.163447. (cited on page 58).

J. Wang, R. G. Carlson, R. S. Falck, H. A. Siegal, A. Rahman, and L. Li. Respondent-driven sampling to recruit MDMA users: a methodological assessment. *Drug and Alcohol Dependence*, 78(2):147–157, May 2005. DOI 10.1016/j.drugalcdep.2004.10.011. (cited on page 92).

J. Warmer and A. Kleppe. *The Object Constraint Language: Precise Modeling With UML (Addison-Wesley Object Technology Series)*. Addison-Wesley Professional, 1998. ISBN 978-0201379402. (cited on page 108).

T. Weigert, F. Weil, K. Marth, P. Baker, C. Jervis, P. Dietz, Y. Gui, A. van den Berg, K. Fleer, D. Nelson, M. Wells, and B. E. Mastenbrook. Experiences in deploying model-driven engineering. In E. Gaudin, E. Najm, and R. Reed, editors, *Proceedings of the 13th International SDL Forum on Design for Dependable Systems*, volume 4745 of *Lecture Notes in Computer Science*, pages 35–53. Springer, 2007. ISBN 978-3-540-74983-7. DOI 10.1007/978-3-540-74984-4_3. (cited on page 138).

J. White, D. C. Schmidt, and A. S. Gokhale. Simplifying autonomic enterprise java bean applications via model-driven development: A case study. In L. C. Briand and C. Williams, editors, *Proceedings of the ACM/IEEE 8th International Conference on Model Driven Engineering Languages and Systems*, volume 3713 of *Lecture Notes in Computer Science*, pages 601–615. Springer, 2005. ISBN 3-540-29010-9. DOI 10.1007/11557432_45. (cited on page 138).

H. Wickham. *ggplot2: elegant graphics for data analysis*. Springer, 2009. ISBN 978-0-387-98140-6. URL http://had.co.nz/ggplot2/book. (cited on page 43).

C. Wohlin, P. Runeson, M. Höst, M. C. Ohlsson, B. Regnell, and A. Wesslén. *Experimentation in Software Engineering: An Introduction*. Kluwer Academic Publishers, Norwell, MA, USA, 2000. ISBN 0-7923-8682-5. (cited on pages 13, 111 and 130).

J. Wüst. The software design metrics tool for the UML 2.11, 2009. URL http://www.sdmetrics.com/. (cited on page 141).

J. Wüst. *SDMetrics User Manual V2.2*. In der Lache 17, Zellertal, Germany, February 2011. URL www.sdmetrics.com/down/SDMetricsManual.pdf. (cited on pages 143 and 144).

Y. Yang, M. He, M. Li, Q. Wang, and B. W. Boehm. Phase distribution of software development effort. In *Proceedings of the Second ACM-IEEE international symposium on Empirical software engineering and measurement*, pages 61–69, New York, NY, USA, 2008. ACM. ISBN 978-1-59593-971-5. DOI 10.1145/1414004.1414016. (cited on page 96).

P. Yiftachel, I. Hadar, D. Peled, E. Farchi, and D. Goldwasser. The study of resource allocation among software development phases: An economics-based approach. *Advances in Software Engineering*, art. 579292, 2011. DOI 10.1155/2011/579292. (cited on page 96).

R. K. Yin. *Case Study Research: Design and Methods, Third Edition, Applied Social Research Methods Series, Vol 5*. Sage Publications, Inc, 3rd edition, December 2002. ISBN 0-761925538. (cited on page 13).

S. Yusuf, H. Kagdi, and J. Maletic. Assessing the comprehension of UML class diagrams via eye tracking. In *Proceedings of the 15th IEEE International Conference on Program Comprehension*, pages 113–122, 2007. DOI 10.1109/ICPC.2007.10. (cited on page 123).

Y. Zhang and S. Patel. Agile model-driven development in practice. *IEEE Software*, 28 (2):84–91, March 2011. DOI 10.1109/MS.2010.85. (cited on page 84).

S. Zopf. Success factors for globally distributed projects. *Software Process: Improvement and Practice*, 14(6):355–359, 2009. DOI 10.1002/spip.v14:6. (cited on page 28).

Glossary

ADL Architecture Description Language

BOA Back Office Architect
BPMN Business Process Model and Notation

CASE Computer-Aided Software Engineering
CM Change Management
CMMI Capability Maturity Model Integration
CRS Chain Referral Sampling

DSL Domain-Specific Language

ERD Entity-Relation Diagram
ERP Enterprise Resource Planning

FOA Front Office Architect
FTE Full-Time Equivalent

GNU GNU's not Unix!
GQM Goal-Question-Metric
GSD Global Software Development

HR Human Resources

IT Information Technology

MDA Model-Driven Architecture
MDD Model-Driven Development
MDE Model-Driven Engineering
MOF Meta Object Framework

OCL Object Constraint Language

POC Proof Of Concept

RFC Request For Change
RUP Rational Unified Process

SAD Software Architecture Document
SCCMS Software Configuration and Change Management System
SLA Service-Level Agreement
SLOC Source Lines of Code
SQL Structured Query Language
SS Supplementary Specification
SVN Subversion

UML Unified Modeling Language

XMI XML Metadata Interchange
XML Extensible Markup Language