

# CS 599

Software Engineering for Embedded Systems

Fall Semester, 2001

Location: [SCI 352 \(http://sunset.usc.edu/classes/cs599\\_2001/USC\\_Map.pdf\)](http://sunset.usc.edu/classes/cs599_2001/USC_Map.pdf)

Time: Tuesdays 2:00 – 4:50 pm

Class number: 048–33636D

Prerequisite: None (desired [CS 578 \(http://sunset.usc.edu/classes/cs578\\_2001/\)](http://sunset.usc.edu/classes/cs578_2001/) or [CS 612 \(http://sunset.usc.edu/classes/cs612\\_2000/\)](http://sunset.usc.edu/classes/cs612_2000/))

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[Instructor](#) | [Overview](#) | [Readings](#) | [Assignments](#) | [Schedule](#) | [PitM Tools](#) | [Final Grades \(http://sunset.usc.edu/classes/cs599\\_2001/GradeSheet.html\)](http://sunset.usc.edu/classes/cs599_2001/GradeSheet.html)

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## Instructor

- [Nenad Medvidovic \(http://sunset.usc.edu/~nen/\)](http://sunset.usc.edu/~nen/)
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- o Office: [SAL 338 \(http://sunset.usc.edu/classes/cs599\\_2001/USC\\_Map.pdf\)](http://sunset.usc.edu/classes/cs599_2001/USC_Map.pdf)
- o Office Phone: (213) 740–5579
- o Office Hours: Tuesdays 11:00 am – 12:00 pm

## Teaching Assistant

- [Marija Rakic \(http://sunset.usc.edu/~marija/\)](http://sunset.usc.edu/~marija/)
  - o Electronic Mail: [marija@usc.edu \(mailto:marija@usc.edu\)](mailto:marija@usc.edu)
  - o Office: [SAL 327 \(http://sunset.usc.edu/classes/cs599\\_2001/USC\\_Map.pdf\)](http://sunset.usc.edu/classes/cs599_2001/USC_Map.pdf)
  - o Office Phone: (213) 740–6504
  - o Office Hours: Thursdays 2:00 pm – 3:00 pm
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## Overview

Over the past decade, the world of computing has moved from large, static, desk-top machines to small, mobile, palm-top, and embedded devices. The methods, techniques, and tools for developing software systems that were successfully applied in the former scenario are not as readily applicable in the latter. Software systems running on networks of mobile, embedded devices

must necessarily exhibit properties that are not always required of more traditional systems: near-optimal performance, robustness, distribution, dynamism, mobility. This class will examine the key properties of software systems in the embedded, resource constrained, mobile, and highly distributed world. The class will assess the applicability of mainstream software engineering methods and techniques (e.g., object-orientation, component-based development, software architecture) to this domain. While not the primary focus of the class, enabling advances in other areas (e.g., embedded, real-time operating systems, wireless networking, the Internet) will be studied from a software application development perspective. A class project will give students hands-on experience with building software development infrastructure and/or applications in this important domain.

Course requirements are

- [1] reading and reviewing assigned papers,
- [2] a presentation of one of the papers,
- [3] participation in class discussions,
- [4] final exam, and
- [5] a semester project.

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## Readings

- There is no textbook for the course.
- Several papers (see the Schedule) will be used as the basis of the course. All papers are available on-line. Furthermore, students tasked with presenting a particular topic may need to locate additional relevant papers as needed.
- To aid your note taking, I will also make the lecture slides available on-line. Students in charge of a given presentation will be required to mail their slides to [me](mailto:nenom@usc.edu) (<mailto:nenom@usc.edu>) by 10 am of the day of the presentation. Students will be able to download the slides by going to the appropriate *Discussion Topic* in the Schedule.

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## Assignments

Name

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Description

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Weight

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## Paper reviews

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You will be required to write 1–page reviews of each paper assigned in class, starting with Week 4. You are not required to provide reviews of the papers marked as " *supplemental* " and highlighted in the Schedule. Additionally, these papers will not be presented in class. However, extra credit questions on the final exam may be based on these papers. Each paper review should

1. summarize the paper,
2. highlight its strengths,
3. highlight its weaknesses, and
4. point out its relevance to embedded software.

Each student will be allowed to miss up to *three* reviews during the semester without penalty.

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15%

## Presentations

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Each student will be required to collaborate with one or two classmates and present the details of two papers and any accompanying information. The presentation should include at least, but need not be restricted to the material covered in the paper. The presentation should also address the same four categories as required for the paper reviews (summary, strengths, weaknesses, and relevance to embedded software). The presenters are responsible for familiarizing themselves with the necessary additional background information. They are also responsible for staying within the time allotted for the presentation.

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20%

## Class participation

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Students are expected to prepare for each class (by reading papers) and actively participate in the discussions of the topics for which they are not presenters.

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10%

## Class project

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Design and implementation of a novel application or development tool that exploits one or more existing approaches to software engineering in the context of embedded systems, demonstrates a novel idea in this domain, or overcomes a known significant challenge posed by embedded systems. The class project will be discussed in Week 4.

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35%

Examination

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The written exam will assess the students' understanding of the material covered in class.

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20%

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## Schedule (Subject to Change)

***Week***

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***Date***

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***Discussion Topic***

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**Readings**

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***Presenters***

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Aug 28

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- Course Introduction

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- Medvidovic (40 min.)
- Overview of Software Engineering Principles

- A. Finkelstein and J. Kramer. [Software Engineering: A Roadmap](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalfinkelstein.pdf) (<http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalfinkelstein.pdf>). In *The Future of Software Engineering*, Anthony Finkelstein (Ed.), pp. 5–22, ACM Press 2000.

- [Medvidovic](http://sunset.usc.edu/classes/cs599_2001/Week1.ppt) ([http://sunset.usc.edu/classes/cs599\\_2001/Week1.ppt](http://sunset.usc.edu/classes/cs599_2001/Week1.ppt)) (120 min.)

2

Sep 4

- Overview of Embedded Software Research at USC

- N. Medvidovic and M. Mikic–Rakic. [Architectural Support for Programming-in-the-Many](http://sunset.usc.edu/classes/cs599_2001/PitM.pdf) ([http://sunset.usc.edu/classes/cs599\\_2001/PitM.pdf](http://sunset.usc.edu/classes/cs599_2001/PitM.pdf)). Technical Report, USC–CSE–2001–506, University of Southern California, October 2001.

- [Mehta](http://sunset.usc.edu/classes/cs599_2001/Week2_Mehta.pdf) ([http://sunset.usc.edu/classes/cs599\\_2001/Week2\\_Mehta.pdf](http://sunset.usc.edu/classes/cs599_2001/Week2_Mehta.pdf)) (80 min.)

- Background and History of Embedded Systems

- V. Bush. [As We May Think](http://www.isg.sfu.ca/~duchier/misc/vbush/) (<http://www.isg.sfu.ca/~duchier/misc/vbush/>). *The Atlantic Monthly*, July 1945.
- M. Weiser. [The Computer for the Twenty-First Century](http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html) (<http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html>). *Scientific American*, \_\_ pp. 94–104, September 1991.
- M. Weiser. [Some Computer Science Issues in Ubiquitous Computing](http://www.acm.org/pubs/articles/journals/cacm/1993-36-7/p75-weiser/p75-weiser.pdf) (<http://www.acm.org/pubs/articles/journals/cacm/1993-36-7/p75-weiser/p75-weiser.pdf>). *Communications of ACM*, vol. 36, no. 7, pp. 75–84, July 1993.

- [Sukhatme](http://robotics.usc.edu/~gaurav/CS599-IES/CS599-IES-L1.ppt) (<http://robotics.usc.edu/~gaurav/CS599-IES/CS599-IES-L1.ppt>) (80 min.)

3

Sep 11

4

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Sep 18

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- The Problem Space

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- E. A. Lee. Embedded Software  
(<http://ptolemy.eecs.berkeley.edu/publications/papers/01/embsystems/embsystems.pdf>)  
Technical Memorandum UCB/ERL M001/26, University of California, Berkeley, CA, July 12, 2001.

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- Barrow  
Jakobac ([http://sunset.usc.edu/classes/cs599\\_2001/Week4\\_1.ppt](http://sunset.usc.edu/classes/cs599_2001/Week4_1.ppt))  
(40 min.)
- J. A. Stankovic et al. Strategic Directions in Real-Time and Embedded Systems  
(<http://www.acm.org/pubs/articles/journals/surveys/1996-28-4/p751-stankovic/p751-stankovic.pdf>). *ACM Computing Surveys*, vol. 28, no. 4, pp. 751–763, December 1996.

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- Patel ([http://sunset.usc.edu/classes/cs599\\_2001/Week4\\_2.ppt](http://sunset.usc.edu/classes/cs599_2001/Week4_2.ppt))  
\_ (30 min.)\_
- G. D. Abowd. Software Engineering Issues for Ubiquitous Computing  
(<http://www.acm.org/pubs/articles/proceedings/soft/302405/p75-abowd/p75-abowd.pdf>). In *Proceedings of the 21 st International Conference on Software Engineering (ICSE '99)*, pp. 75–84, Los Angeles, CA, May 1999.

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- Sonawane  
Su ([http://sunset.usc.edu/classes/cs599\\_2001/Week4\\_3.ppt](http://sunset.usc.edu/classes/cs599_2001/Week4_3.ppt))  
(30 min.)

- Project Discussion

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- Medvidovic ([http://sunset.usc.edu/classes/cs599\\_2001/ProjectDiscussion.ppt](http://sunset.usc.edu/classes/cs599_2001/ProjectDiscussion.ppt)) (60 min.)

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Sep 25

- Project Discussion (cont.)

- [Medvidovic \(http://sunset.usc.edu/classes/cs599\\_2001/ProjectDiscussion.ppt\)](http://sunset.usc.edu/classes/cs599_2001/ProjectDiscussion.ppt) (80 min.)
- Requirements Engineering

- B. Nuseibeh and S. Easterbrook. [Requirements Engineering: A Roadmap \(http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalnuseibeh.pdf\)](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalnuseibeh.pdf). In *The Future of Software Engineering*, Anthony Finkelstein (Ed.), pp. 37–46, ACM Press 2000.

- [Chen R. Gupta \(http://sunset.usc.edu/classes/cs599\\_2001/Week5\\_1.ppt\)](http://sunset.usc.edu/classes/cs599_2001/Week5_1.ppt) (40 min.)
- R. R. Lutz. [Analyzing Software Requirements Errors in Safety-Critical, Embedded Systems \(http://sunset.usc.edu/classes/cs599\\_2001/isre93.pdf\)](http://sunset.usc.edu/classes/cs599_2001/isre93.pdf). In *Proceedings of the IEEE International Symposium on Requirements Engineering*, 1993.

- [Powell Shah \(http://sunset.usc.edu/classes/cs599\\_2001/Week5\\_2.ppt\)](http://sunset.usc.edu/classes/cs599_2001/Week5_2.ppt) (40 min.)
- N. G. Leveson, M. P. E. Heimdahl, H. Hildreth, and J.D. Reese. [Requirements Specification for Process-Control Systems \(http://www.cs.umn.edu/crisys/publications/leveson-tse94-tcas.pdf\)](http://www.cs.umn.edu/crisys/publications/leveson-tse94-tcas.pdf). *IEEE Transactions on Software Engineering*, pp. 684–707, vol. 20, no. 9, September 1994.

- *supplemental*

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Oct 2

- Software Modeling

- D. Garlan. [Software Architecture: A Roadmap \(http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalgarlan.pdf\)](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalgarlan.pdf). In *The Future of Software Engineering*, Anthony Finkelstein (Ed.), pp. 93–101, ACM Press 2000.

- [Liu](#)  
[Roshandel \(http://sunset.usc.edu/classes/cs599\\_2001/Week6\\_1.ppt\)](http://sunset.usc.edu/classes/cs599_2001/Week6_1.ppt)  
(45 min.)
- D. C. Luckham, J. J. Kenney, L. M. Augustin, J. Vera, D. Bryan, and W. Mann \_ [Specification and Analysis of System Architecture Using Rapide](#)  
(<http://citeseer.nj.nec.com/cache/papers2/cs/1435/http:zSzzSzenya.ms.mff.cuni.czzSzt>)  
*IEEE Transactions on Software Engineering* , vol. 21 no. 4, pp. 336–355, April 1995.

- *supplemental*
- B. Selic. [Turning Clockwise: Using UML in the Real-Time Domain](#)  
(<http://www.acm.org/pubs/articles/journals/cacm/1999-42-10/p46-selic/p46-selic.pdf>). *Communications of the ACM* , vol. 42, no. 10, pp. 46–54, October 1999.

- [S. Gupta](#)  
[Xiong \(http://sunset.usc.edu/classes/cs599\\_2001/Week6\\_2.ppt\)](http://sunset.usc.edu/classes/cs599_2001/Week6_2.ppt) \_  
(45 min.)\_
- D. Harel and A. Naamad. [The STATEMATE Semantics of Statecharts](#)  
(<http://www.acm.org/pubs/articles/journals/tosem/1996-5-4/p293-harel/p293-harel.pdf>). *ACM Transactions on Software Engineering and Methodology* , vol. 5, no. 4, pp. 293–333, October 1996.

- [Alsawi](#)  
[Chen](#)  
[Xie \(http://sunset.usc.edu/classes/cs599\\_2001/Week6\\_3.ppt\)](http://sunset.usc.edu/classes/cs599_2001/Week6_3.ppt) \_  
(70 min.)\_

7

Oct 9

- Implementation Issues
- D. M. Ritchie. [The Development of the C Language \(http://www.cs.bell-labs.com/who/dmr/chist.pdf\)](#). In *History of Programming Languages II* , Cambridge, MA, April 1993.
- *supplemental*



- M. Hicks, J. T. Moore, and S. Nettles. [Dynamic Software Updating](http://citeseer.nj.nec.com/cache/papers2/cs/21250/http:zSzzSzwww.cis.upenn.eduSz~jsoftware-updating.pdf) (<http://citeseer.nj.nec.com/cache/papers2/cs/21250/http:zSzzSzwww.cis.upenn.eduSz~jsoftware-updating.pdf>). In *Proceedings of the ACM SIGPLAN 2001 Conference on Programming Language Design and Implementation (PLDI '01)*, Snowbird, UT, June 2001.

- [R. Gupta](#)  
[Varma](#)  
[Puri](#) ([http://sunset.usc.edu/classes/cs599\\_2001/Week7\\_1.ppt](http://sunset.usc.edu/classes/cs599_2001/Week7_1.ppt))  
(45 min.)

- W. Emmerich. [Software Engineering and Middleware: A Roadmap](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalemmerich.pdf) (<http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalemmerich.pdf>). In *The Future of Software Engineering*, Anthony Finkelstein (Ed.), pp. 119–129, ACM Press 2000.

- [Dincel](#)  
[S. Gupta](#) ([http://sunset.usc.edu/classes/cs599\\_2001/Week7\\_2.ppt](http://sunset.usc.edu/classes/cs599_2001/Week7_2.ppt))  
(45 min.)

- A. Carzaniga, D. S. Rosenblum, and A. L. Wolf. [Design and Evaluation of a Wide-Area Event Notification Service](ftp://ftp.cs.colorado.edu/users/alw/doc/papers/tocs0801.pdf) (<ftp://ftp.cs.colorado.edu/users/alw/doc/papers/tocs0801.pdf>). *ACM Transactions on Computer Systems*, vol. 19 no. 3, pp. 332–383, August 2001.

- [Balasubramanian](#)  
[Lin](#)  
[Prasanna](#) ([http://sunset.usc.edu/classes/cs599\\_2001/Week7\\_3.ppt](http://sunset.usc.edu/classes/cs599_2001/Week7_3.ppt))  
(70 min.)

8

Oct 16

- Analysis, Testing, and Simulation

- M. J. Harrold. [Testing: A Roadmap](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalharrold.pdf) (<http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalharrold.pdf>). In *The Future of Software Engineering*, Anthony Finkelstein (Ed.), pp. 63–71, ACM Press 2000.

- [Matada](#)  
[Prashanth](#) ([http://sunset.usc.edu/classes/cs599\\_2001/Week8\\_1.ppt](http://sunset.usc.edu/classes/cs599_2001/Week8_1.ppt))  
(45 min.)

- D. Jackson and M. Rinard. [Software Analysis: A Roadmap](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finaljackson.pdf) (<http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finaljackson.pdf>). In *The Future of*

*Software Engineering* , Anthony Finkelstein (Ed.), pp. 135–146, ACM Press 2000.

- *supplemental*
- H. Koehnemann and T. Lindquist. [Towards Target-Level Testing and Debugging Tools for Embedded Software](http://sunset.usc.edu/classes/cs599_2001/Koehnemann.pdf) ([http://sunset.usc.edu/classes/cs599\\_2001/Koehnemann.pdf](http://sunset.usc.edu/classes/cs599_2001/Koehnemann.pdf)). In *Proceedings of TRI-Ada '93*, pp. 288–298, September 18 – 23, 1993, Seattle, WA USA

- [Prasanna Roshandel Varma](#) ([http://sunset.usc.edu/classes/cs599\\_2001/Week8\\_2.ppt](http://sunset.usc.edu/classes/cs599_2001/Week8_2.ppt)) (45 min.)
- J. T. Buck, S. Ha, E. A. Lee, and D. G. Messerschmitt. [Ptolemy: A Framework for Simulating and Prototyping Heterogeneous Systems](http://ptolemy.eecs.berkeley.edu/publications/papers/94/JEurSim/JEurSim.pdf) (<http://ptolemy.eecs.berkeley.edu/publications/papers/94/JEurSim/JEurSim.pdf>). *International Journal of Computer Simulation* , vol. 4, pp. 155–182, April, 1994.

- [Barrow Powell P. Qui](#) ([http://sunset.usc.edu/classes/cs599\\_2001/Week8\\_3.ppt](http://sunset.usc.edu/classes/cs599_2001/Week8_3.ppt)) (70 min.)

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Oct 23

- Cross-Cutting Issues
- H. Kopetz. [Software Engineering for Real-Time: A Roadmap](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalkopetz.pdf) (<http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalkopetz.pdf>). In *The Future of Software Engineering* , Anthony Finkelstein (Ed.), pp. 203–211, ACM Press 2000.
- [Banwait Samant](#) ([http://sunset.usc.edu/classes/cs599\\_2001/Week9\\_1.ppt](http://sunset.usc.edu/classes/cs599_2001/Week9_1.ppt)) (50 min.)
- B. Littlewood and L. Strigini. [Software Reliability and Dependability: A Roadmap](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finallittlewood.pdf) (<http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finallittlewood.pdf>). In *The Future of Software Engineering* , Anthony Finkelstein (Ed.), pp. 177–188, ACM Press 2000.

- \_ supplemental\_
- R. R. Lutz. [Software Engineering for Safety: A Roadmap](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finallutzt.pdf) (<http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finallutzt.pdf>). In *The Future of Software Engineering*, Anthony Finkelstein (Ed.), pp. 215–224, ACM Press 2000.

- [Alsawi](#)  
[Jakobac](#)  
[Xie \(http://sunset.usc.edu/classes/cs599\\_2001/Week9\\_2.ppt\)](http://sunset.usc.edu/classes/cs599_2001/Week9_2.ppt) \_  
(50 min.)\_
- P. Devanbu and S. Stubblebine. [Software Engineering for Security: A Roadmap](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finaldevanbu.pdf) (<http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finaldevanbu.pdf>). In *The Future of Software Engineering*, Anthony Finkelstein (Ed.), pp. 227–239, ACM Press 2000.

- [H. Qiu](#)  
[P. Qiu](#)  
[Patel \(http://sunset.usc.edu/classes/cs599\\_2001/Week9\\_3.ppt\)](http://sunset.usc.edu/classes/cs599_2001/Week9_3.ppt) \_  
(60 min.)\_

10

Oct 30

- Runtime Support:  
Deployment, (re)Configuration
- J. Estublier. [Software Configuration Management: A Roadmap](http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalestublier.pdf) (<http://www.cs.ucl.ac.uk/staff/A.Finkelstein/fose/finalestublier.pdf>). In *The Future of Software Engineering*, Anthony Finkelstein (Ed.), pp. 281–290, ACM Press 2000.