Requirements Engineering

(Summer 2019)
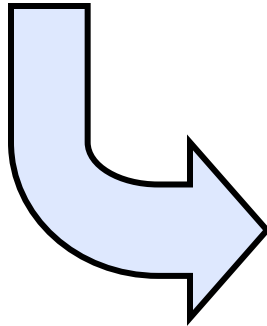
Prof. Nan Niu (nan.niu@uc.edu)

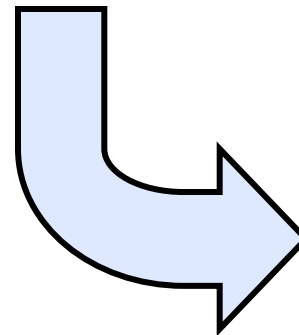## http://homepages.uc.edu/~niunn/courses

Today's Menu

Start Here

This Seminar:
Syllabus
"req.s", "why", & "RE"

Next Seminar:
Meaning of Requirements

About The Instructor

→ **Where's he coming from?**
- ✎ Hometown: Beijing, China
- ✎ B.Eng. (1995-1999), Beijing Institute of Technology, China
- ✎ Programmer (1999-2001), Lenovo, China
- ✎ M.Sc. (2001-2004), University of Alberta, Canada
- ✎ Ph.D. (2004-2009), University of Toronto, Canada
- ✎ Assistant Professor (2009-2014), Mississippi State Univ.
- ✎ Assistant Professor (2014-2018), Univ. of Cincinnati, USA
- ✎ Associate Professor (2018-Present), Univ. of Cincinnati

→ **What's his research area?**
- ✎ Software Engineering, RE, Information Seeking, Human-Centric Computing

→ **How to obtain course-related information?**
   http://homepages.uc.edu/~niunn/courses *(will be updated)*

→ **Anything else?**

What's His Teaching Style?

→**Interactive**

   ↷**Lecturing alone doesn't work well**

   ↷**Need feedback – both positive and negative**

   ↷**Need your participation, and YES, that counts in a BIG way!**

      40% **of your total grade, to be exact**

About This Course: Objectives

→ **Examine the state-of-the-art of research & current practice in RE**

  ↳ Role of RE in software and systems engineering
  ↳ Current techniques, notations, methods, processes, and tools used in RE

→ **Gain practical experience in selected RE techniques**

→ **Understand the essential nature of RE**

  ↳ Breadth of skills needed for RE, and the many disciplines on which it draws
  ↳ Contextual factors & practicalities

→ **Gain a basic grounding for research in RE**

  ↳ Methodological issues for RE research
  ↳ Current research issues & direction of the field
  ↳ Awareness of the literature

Class Participation #1

→Team yourselves up in size of 2-3

  ⇨Introduce each other

  ⇨Write every team member's name on a piece of paper (for <u>GRADING</u> purpose only & for the instructor to keep)

→Collectively define "requirements" in one sentence

  ⇨Work out your answer on the paper

What're "Requirements"?

→ **Requirements = stakeholders' needs and desires**

→ **Stakeholders = those who have a stake in the change being considered & who stand to gain or lose from the change**

    ↳ **The holders of the bets in a gambling game**

    ↳ **Exercise: Who're the <u>STAKEHOLDERS</u> of WeChat and what're their requirements (needs and desires)?**

Class Participation #2

→ **Stay with your current team**

→ **Collectively define "requirements engineering" and argue why "we should care about engineering requirements"**

⮫ **Work out your answer on the same or a different piece of paper**

Ana's Requirement

I want to have a program that
tells whether it terminates
on any given input.

Bob's Requirement

Make Eclipse work on tablet in 2 weeks.

Requirements Engineering (RE)

→is about:

↳ Discovering stakeholders' needs & desires

➢ Adjusting stakeholder expectations

↳ Communicating these to system implementers

➢ Adjusting implementer expectations

Why RE?

"The hardest single part of building a software system is deciding precisely what to build. No other part of the conceptual work is as difficult as establishing the detailed technical requirements, including the interfaces to people, to machines, and to other software systems. No other part of the work so cripples the resulting system if done wrong. No other part is as difficult to rectify later."

Frederick P. Brooks, Jr.

1999

"If you build software without [requirements and] specifications, it can never be incorrect -- it can only be surprising."

Brian Kernighan

Co-creator of UNIX
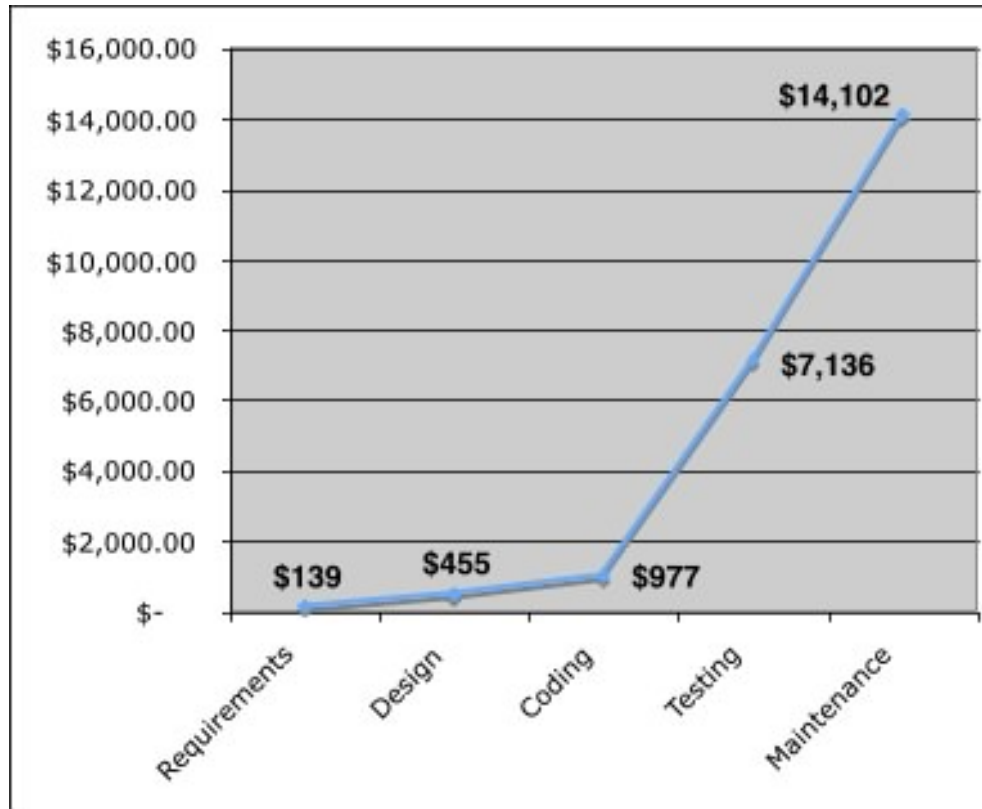
Answer: Because Doing RE Right Saves Money

Clearly, it pays off to invest effort in finding requirements errors early and correcting them in, say, 1 man-hour rather than waiting to find the error during operations and having to spend 100 man-hours correcting it.   *B. Boehm, Software Engineering Economics, 1981*

Importance of RE (some numbers)

→ Problems

- ↪ **Increased reliance on software**
  - ➢ E.g. cars, dishwashers, cell phones, web services, …
  - ➢ Philips estimates that the amount of software in consumer products is doubling every two years
- ↪ **Software now the biggest cost element for mission critical systems**
  - ➢ E.g. Boeing 777: approximately 50% of entire development cost for the plane was spent on the avionics software
- ↪ **Wastage on failed projects**
  - ➢ E.g. 1997 GAO (US Government Accountability Office) report: $145 billion over 6 years on software that was never delivered
- ↪ **High consequences of failure**
  - ➢ E.g. Ariane 5: $500 million payload
  - ➢ E.g. Intel Pentium bug: $475 million

→ Key factors:

- ↪ **Certification costs**
  - ➢ E.g. Boeing 777: >40% of software budget spent on testing to FAA standards compliance
- ↪ **Re-work from defect removal**
  - ➢ E.g. Motorola: 60-80% of software budget (was) spent on re-work
- ↪ **Changing Requirements**
  - ➢ E.g. California DMV (Dept of Motor Vehicles) system was cancelled after 6 years, after spending $44 million
  - ➢ E.g. London ambulance dispatch system; Denver airport luggage management system

Importance of RE (most memorable #)

RE defects cost 10-200 times more to correct once fielded than they would if they were detected during requirements development.

Source: S. McConnell, "*From the editor – an ounce of prevention*", IEEE SW., 18(3):5-7, 2001.   **15**

Recap So Far

→Requirements = stakeholders' needs & desires

⮩**Stakeholders = gamblers ➔ never neutral**

→RE = identifying, communicating, & adjusting requirements

→Why RE?

⮩**Because doing RE right saves money**

About This Course

→Class

⇨July 8-17, work days, starting at 8:30am, Grad Building 206

⇨Mix of: lecturing, class participation, assignment Q&A, assignment checks & assessments

→No one textbook covers the field well ➔ No required textbook for this course

⇨Background readings will be made available on the course website
http://homepages.uc.edu/~niunn/courses/

Just because we don't use a textbook…

Research Literature

Conferences

- IEEE International Symposium on Requirements Engineering
  - RE'93 - Jan 1993, San Diego, USA
  - RE'95 - Mar 1995, York, UK.
  - …
  - RE'01 - Aug 2001, Toronto, Canada
- IEEE International Conference on Requirements Engineering
  - ICRE'94 - Apr 1994. Colorado Springs, USA.
  - ICRE'96 - Apr 1996. Colorado Springs, USA.
  - …
  - ICRE'00 - Jun 2000, Schaumburg, USA
- In 2002, ICRE and RE merged...
- IEEE International Requirements Engineering Conferences
  - RE'02 - Sept 2002, Essen, Germany
  - RE'03 - Sept 2003, Monterey Bay, USA
  - RE'04 - Sept 2004, Kyoto, Japan
  - RE'05 - Sept 2005, Paris, France
  - …
  - RE'16 – Sept 2016, Beijing, China
  - RE'17 – Sept 2017, Lisbon, Portugal
  - RE'18 – Aug 2018, Banff, Canada
  - RE'19 – Sept 2019, Jeju Island, Korea

Journals

- Requirements Engineering Journal
  - published quarterly by Springer
- IEEE Transactions on Software Engineering
  - (published bi-monthly)
- ACM Transactions on Software Engineering and Methodology
  - (published quarterly)
- Various other SE journals:
  - IEEE Software
  - Automated Software Engineering
  - Journal of Systems and Software
  - Information and Software Technology

Workshops

- REFSQ - Int. Working Conference on Requirements Engineering: Foundations of Software Quality
- RE Tracks @ ACMSAC (ACM Symposium on Applied Computing), QUATIC (Int'l Conf. on the Quality of Info. and Comm.s Tech), …

Research Literature

Conferences

↳ **IEEE International Symposium on Requirements Engineering**
  - ➤ RE'93 - Jan 1993, San Diego, USA
  - ➤ RE'95 - Mar 1995, York, UK.
  - ➤ …
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↳ **IEEE International Conference on Requirements Engineering**
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  - ➤ …
  - ➤ ICRE...

  - ➤ ..., USA
  - ➤ ..., Japan
  - ➤ ..., Paris, France
  - ➤ ... - Sept 2016, Beijing, China
  - ➤ RE'17 - Sept 2017, Lisbon, Portugal
  - ➤ RE'18 - Aug 2018, Banff, Canada
  - ➤ RE'19 - Sept 2019, Jeju Island, Korea

Journals

↳ **Requirements Engineering J...al**
  - ➤ published quarterly...

↳ **IEEE Transac... Engine...**

  - ... Software Engineering
  - ...nal of Systems and Software
  - ➤ Information and Software Technology

Workshops

↳ **REFSQ - Int. Working Conference on Requirements Engineering: Foundations of Software Quality**

↳ **RE Tracks @ ACMSAC (ACM Symposium on Applied Computing), QUATIC (Int'l Conf. on the Quality of Info. and Comm.s Tech), …**

RE portal link http://requirements-engineering.org on course website

Assessments

↳**60% Assignments**

➢**A mixed individual and group assignments**

➢**Will allocate certain class time to work on assignments**

➢**Students may need additional after-class time to complete the assignments**

↳**40% Class Participation**

➢**Will be carried out in class time**

I've got some:

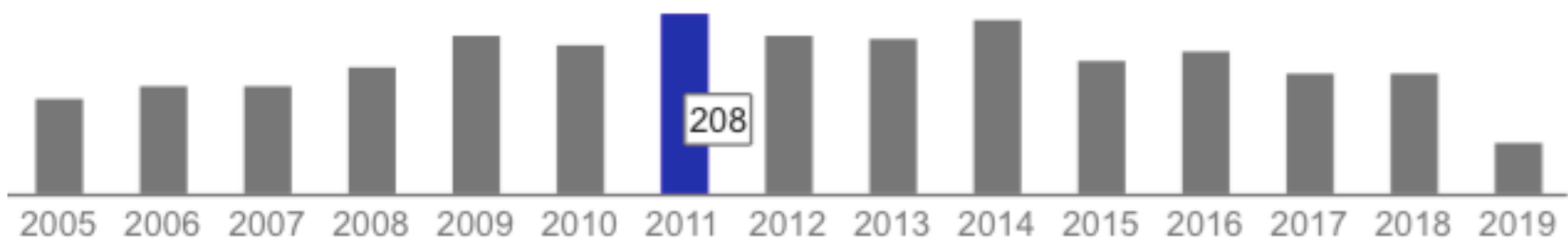What're requirements?

What's requirements engineering?

Why bother?

Requirements engineering: a roadmap

Authors	Bashar Nuseibeh, Steve Easterbrook
Publication date	2000/5/1
Conference	Proceedings of the Conference on the Future of Software Engineering
Pages	35-46
Publisher	ACM

Total citations   Cited by 2545

| 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |

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"Requirements engineering is the branch of software engineering concerned with the real-world goals for, functions of, and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behavior, and to their evolution over time and across software families."

- *eliciting* requirements,
- *modelling* and *analysing* requirements,
- *communicating* requirements,
- *agreeing* requirements, and
- *evolving* requirements.

Basics of RE

→ **Although the focus of Zave's definition shown in the previous slide is on _software_ engineering, in reality, software _cannot_ function in isolation from the system in which it is embedded. Thus, RE has to encompass a _systems_ level view**

  ↳ software systems requirements engineering

→ **RE is a multi-disciplinary, human-centered process**

  ↳ Computer science, e.g., feasibility of req.s

  ↳ Logic, e.g., temporal logic for describing timing info.

  ↳ Cognitive psychology, e.g., domain experts' tacit knowledge

  ↳ Anthropology, e.g., observing collaborative work

  ↳ Sociology, e.g., cultural changes caused by computerization

  ↳ Linguistics, e.g., ambiguity

  ↳ ...

The following natural-language requirement is incomplete, but is also _ambiguous_. Can you see how?

REQ: "The smart phone shall display the weather data for 24 hours."

"The smart phone shall display the 24-hour weather data."

"24 hours" modifies "weather data"

"The smart phone shall display for (only) 24 hours the weather data."

"24 hours" modifies "display"

Domain Expertise

→ Natural Language

⇨ **"The system shall report to the operator all faults that originate in critical functions or that occur during execution of a critical sequence and for which there is no fault recovery response."**

(adapted from the spec.s for the international space station)

→ A decision table

Originate in critical functions	F	T	F	T	F	T	F	T
Occur during critical seqeunce	F	F	T	T	F	F	T	T
No fault recovery response	F	F	F	F	T	T	T	T
Report to operator?								

Source: Adapted from Easterbrook & Callahan, 1997.

Yet Another Definition of RE

Not a phase
or stage!

Communication
is as important
as the analysis

Quality means
fitness-for-purpose.
Cannot say anything
about quality unless
you understand the
purpose

Requirements Engineering (RE) is a set of activities concerned with identifying and communicating the purpose of a software-intensive system, and the contexts in which it will be used. Hence, RE acts as the bridge between the real world needs of users, customers, and other constituencies affected by a software system, and the capabilities and opportunities afforded by software-intensive technologies

Designers need to
know how and where
the system will be
used

Requirements are
partly about what
is needed…

…and partly about
what is possible

Need to identify all the stakeholders -
not just the customer and user

Defining "requirement"

→ **IEEE standard glossary of SW Eng terminology:**

1. a condition or capability needed by a user to solve a problem or achieve an objective

2. a condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed document

Here   There

A problem is a *difference*

between things as desired
and things as perceived

Summary

→ **RE**

↳ **A set of activities (plan & elicit, model & analyze, communicate & agree, realize & evolve)**

↳ **Concerned with the real-world goals for, functions of, and constraints on software systems**

↳ **Multi-disciplinary & human-centered**

→ **Requirements**

↳ **Stakeholders' needs and desires**

↳ **Differences between things as desired and things as perceived**

→ **Next**

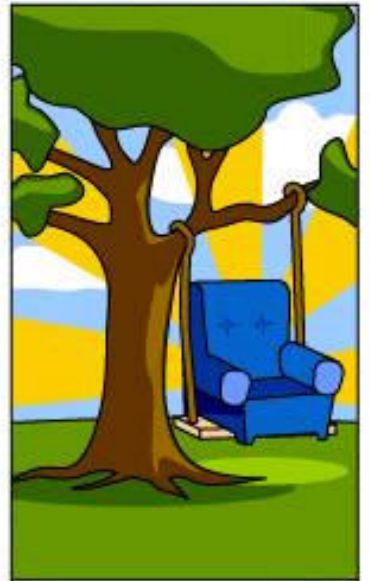↳ **"Meaning of Req.s" by M. Jackson**
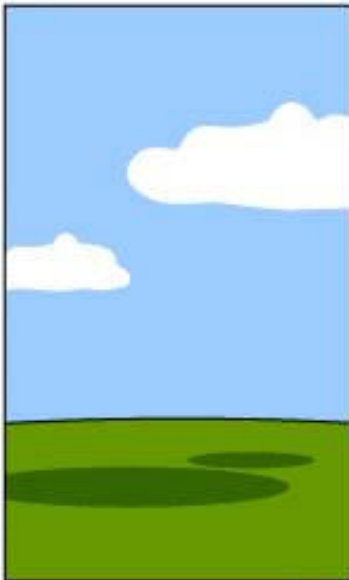
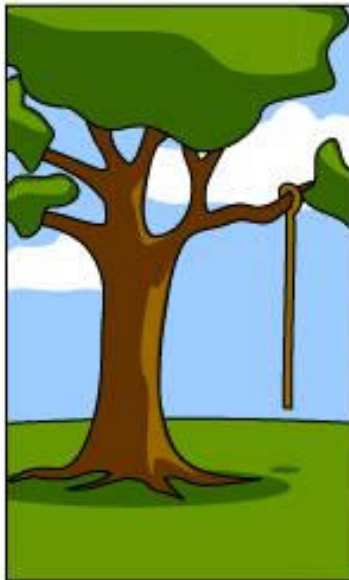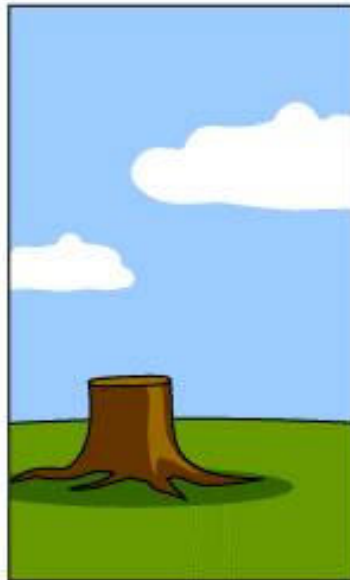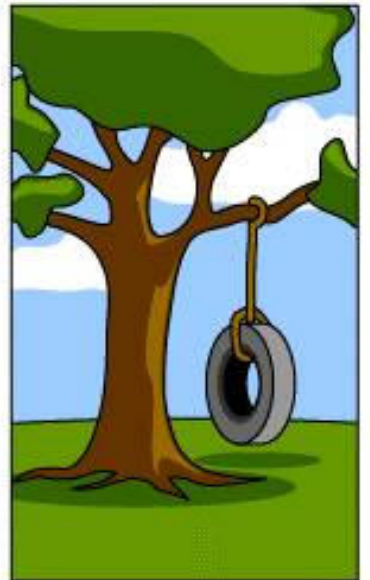| How the customer explained it | How the Project Leader understood it | How the Analyst designed it | How the Programmer wrote it | How the Business Consultant described it |

| How the project was documented | What operations installed | How the customer was billed | How it was supported | What the customer really needed |