The Quest for Ubiquity

A Roadmap for Software & Systems Traceability Research

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Outline

• Motivation

• Where are we?

• Where do we want to go?

• How can we get there?

• Are we there yet?
“We're on a road to nowhere ...”

--Talking Heads
Outline

• Motivation

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Traceability @ the center of all things

garyfcox.blogspot.com/2012/07/where-are-we-in-universe-let-me-show.html
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RE 2012
A community vision quest
Outline

• Motivation
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• Are we there yet?
Many ways to climb some mountains

sundayriver.com/TheMountain
Outline

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• Where are we?
• Where do we want to go?
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• Are we there yet?
Progress?

ARE WE THERE YET?!
Grand challenges
Status

Traceability:
www.coest.org/index.php/traceability/glossary

The Quest for Ubiquity
2035

Artwork by Melissa Huang
Challenges & research themes (i)

Σ **Valued**: Strategic priority
(buy-in & commitment to implementation)

P **Purposed**: Requirements-driven & fit for purpose
(prototypical profiles & patterns)

↔ **Portable**: Exchanged, merged & reused
(unified policies, standards & language)

# **Scalable**: Through-life & cross-boundary
(levels of abstraction & granularity)
Challenges & research themes (ii)

$\textbf{Cost-effective}$: Return is adequate in relation to outlay (cost-benefit models for analysis)

$\forall \textbf{Configurable}$: Compliant with changing needs (semantically-rich dynamic specifications)

$\textbf{T Trusted}$: Of dependable quality (systematic quality assessment & assurance)

$\infty \textbf{Ubiquitous}$: Always there when needed (integral to broader processes & tool support)
Goals ($)

- Total cost of traceability throughout a project’s life is computed, along with projected ROI, & is available to assess potential effectiveness of competing traceability solutions (G1)
- Just enough traceability is provided, balancing stakeholder requirements for traceability with resource constraints (G2)
- Perfect middle ground between creating & maintaining traceability early or on demand is attained (G3)
- Lessons learned are capitalized upon, so cost-effectiveness of various traceability techniques, methods & tools are known and improved upon (G4)
- Intuitive user interfaces & interaction mechanisms enable process-related cost decisions to be explored & altered at all stages of traceability process (G5)
Research topics ($$)

• Agree upon metrics for measuring traceability cost-effectiveness (RT1)
• Understand typical cost profile of traceability outlay on a project (RT2)
• Develop means to associate a cost & a benefit profile for individual traces (RT3)
• Create decision support tools & impact analysis tools for making traceability ROI decisions (RT4)
• Develop benchmark studies for evaluating cost-effectiveness of traceability techniques (RT5)
• Decrease costs & improve effectiveness of traceability techniques (RT6)

How 2 get there?

The Quest for Ubiquity
Industry practices ($)

- Consult Traceability Body Of Knowledge (TBOK) for cost-effectiveness of techniques & tools (IP1)
- Use decision support tools to explore cost-benefit of mixed solutions (IP2)
- Track Return On Investment (ROI) of traceability (IP3)
Terrain

- 8 challenges & research themes (one ever so grand)
- 35 associated goals
- 84 derived requirements
- 52 research topics
- 29 industry adoption practices
Thanks for the road! Mike!
Roadmapping

The Quest for Ubiquity

24 of 

How 2 get there?

Specification

Technique

Process

What to trace & why

How to establish & use traces

Who, when & where of tracing

1. Traceability metrics (eg cost-effectiveness, ROI, etc.)
2. Cost profiles for traceability solutions
3. ROI-driven strategic planning
4. Intelligent adaptive link creation & maintenance
5. Benchmark experiments & data (eg cost-effectiveness of techniques, etc.)
6. Cost-benefit of every trace
RE"2012"

The"Quest"for"Ubiquity"

How to get there?

- Specification
- Technique
- Process
- What to trace & why
- How to establish & use traces
- Who, when & where of tracing

Intelligent adaptive link creation & maintenance
- Use decision support tools to explore $ of mixed solutions
- Track ROI of traceability

ROI-driven strategic planning
- Benchmark experiments & data (eg cost-effectiveness of techniques, etc)

Cost profiles for traceability solutions
- Consult TBOK for cost-effectiveness of techniques & tools

Cost-benefit of every trace
- Traceability metrics (eg cost-effectiveness, ROI, etc.)

Building Blocks

Groundwork

Foundations

Accelerators

Pervasion

Assurance

Who, when & where of tracing

Process

Technique

Specification

Cost-benefit of every trace

ROI-driven strategic planning

Intelligent adaptive link creation & maintenance

Use decision support tools to explore $ of mixed solutions

Track ROI of traceability

Benchmark experiments & data (eg cost-effectiveness of techniques, etc)

Consult TBOK for cost-effectiveness of techniques & tools

Traceability metrics (eg cost-effectiveness, ROI, etc.)

Cost profiles for traceability solutions

$1

$2

$3

$4

$5

$6

$1, 2, 3

$2, 3

$3

$4

$5

$6
“Well, we know where we're goin’”

--Talking Heads
### Scalable
- Through-life & cross-boundary (levels of abstraction & granularity)

### Cost-effective
- Return is adequate in relation to outlay (cost-benefit models for analysis)

### Configurable
- Compliant with changing needs (semantically-rich dynamic specifications)

### Trusted
- Of dependable quality (systematic quality assessment & assurance)

### Ubiquitous
- Always there when needed (integral to broader processes & tool support)

#### Industry Practices
1. Aware of traceability value, trained & compensated
2. Traceability training & certification sought
3. Traceability demanded of software & systems
4. Traceability integral to college curricula
5. TBOK to determine traceability value propositions

#### Definitions & Standards
- Define & use traceability
- Use a unified representation or language to describe traceability
- Reuse & integrate traceability from other projects
- Professional agreement on policy, standards, representation, terms, etc.

#### Traceability Training & Certification
- Consult TBOK for cost-effectiveness of techniques & tools
- Use decision support tools to explore $ of mixed solutions
- Use & contribute to Traceability

#### Traceability Challenges
- Measure effectiveness of process
- Visualizations to support traceability at different granularity levels
- Datasets contributed to explore scale

#### Traceability Benefits
- Traceability enabled integrated development environments chosen
- Traceability parameters configured, then established & evolved
- Traceability as a by-product of engineering tasks
- The "traceability problem" is no longer spoken of

#### Traceability Metrics
- Motivate & systematize gathering of empirical data
- Generic roles & responsibilities
- Evidence & awareness of traceability
- Traceability consistent on global & distributed projects

#### Traceability Parameters
- Models of traceability process
- Process frameworks
- Quality of traceability process & on-demand

#### Traceability Propositions
- Traceability value propositions
- Cost profiles for traceability solutions
- Link semantics

#### Traceability Use Cases
- How to establish & use traces
- Specification

#### Traceability Tools
- Specification
- Copyright & intellectual property
- Visualizations to support traceability
- Define & use traceability
- Use a unified representation or language to describe traceability
- Reuse & integrate traceability from other projects
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#### Traceability Parameters
- Models of traceability process
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#### Traceability Benefits
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Framework

Ubiquitous ($\infty$)

Trusted (T)

Configurable (V)

Valued ($\Sigma$)

Purposed (P)

Portable ($\leftrightarrow$)

Specified

Pervasion

Assurance

Accelerators

Building Blocks

Groundwork

Foundations

Process

Technique

Cost-effective ($\$$)

How 2 get there?

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The Quest for Ubiquity
The Quest for Ubiquity: A Roadmap for Software & Systems Traceability Research

Key to Road Signs

<table>
<thead>
<tr>
<th>Valued challenge</th>
<th>Focal challenge for research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scalable challenge</td>
<td>Key outcome for industrial practice</td>
</tr>
</tbody>
</table>

Research Topics

- Valued
- Purpose
- Portable
- Scalable

Research Themes

- Cost-effective
- Configurable
- Trusted
- Ubiquitous

Software & Systems Traceability Research

Industry Practices

1. Define & use traceability policies & standards
2. Use a unified representation or language to describe traceability
3. Reuse & integrate traceability from other projects
4. Professional agreement on policy, standards, representation, terms, etc.

1. Traceability established from project onset & throughout
2. Traceability accounts for any type of media & project artifact
3. Visualizations to support traceability at different granularity levels
4. Datasets contributed to explore scale

Cost-effectiveness of techniques & tools
Use decision support tools to explore $ of mixed solutions
Track ROI of traceability

1. Consult TBOK for cost-effectiveness of techniques & tools
2. Use decision support tools to explore $ of mixed solutions
3. Track ROI of traceability

1. Use traceability information models to specify intent
2. Traceability consistent on global & distributed projects
3. Individual practices heterogeneous yet compatible

1. Specify levels of traceability quality for user tasks
2. Data provided to determine trust of traceability & its analyses
3. Supply feedback on traceability quality unobtrusively
4. The "traceability problem" is no longer spoken of
Navigating the roadmap

• Near-term: Foundations & Groundwork (<3 Years)
  • Short-term: Building Blocks (<5 Years)
  • Mid-term: Accelerators (<15 Years)
  • Long-term: Assurance (15+ Years)
• Final Destination: Pervasion (2035?)
The Quest for Ubiquity: A Roadmap for Software & Systems Traceability Research

**Research Topics**
- **Valued**: Strategic priority (buy-in & commitment to implementation)
- **Purposed**: Requirements-driven & fit for purpose (prototypical profiles & patterns)
- **Portable**: Exchanged, merged & reused (unified policies, standards & language)
- **Scalable**: Through-life & cross-boundary (levels of abstraction & granularity)

**Roadmap Framework**
- **Ubiquitous**
- **Configurable**
- **Trustworthy**
- **Value-added**

**Challenges**
- 

**Key to Road Signs**
- Valued challenge
- Scalable challenge
- Focal challenge for research
- Key outcome for industrial practice

**Research Themes**
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- **Trusted**: Of dependable quality (systematic quality assessment & assurance)
- **Ubiquitous**: Always there when needed (integral to broader processes & tool support)

**Research Practices**
- **Use & contribute to Traceability Body of Knowledge (TBOK)**
- **Use profiles, contexts & patterns to design traceability solutions**
- **Measure effectiveness of process**

**Valued in practice & strategic priority; commitment & training**

**On the road to traceability that is purposed & portable**

**Understanding**
- What is essential groundwork

**Aim to traceability**
- Stakeholder commitment & training

**Agile**
- Changes & adaptations

**Support for end-use & interaction**
- Process & tools

**Foundations**
- Terms & concepts

**Emergence of a TBOK**
- Traceability metrics (quality, cost, effectiveness, ROI, etc.)
- Motivate & systematize gathering of empirical data

**Industry Practices**
- **Use decision support tools to explore $ of mixed solutions**
- **Use profiles, contexts & patterns to design traceability solutions**
- **Balance continuous adaptive link & process data**

**Traceability issues**
- **TBOK to determine traceability value propositions**
- **Supply feedback on traceability**
- **Professional agreement on policy, standards, etc.**

**TBOK**
- **Use profiles, contexts & patterns to design traceability solutions**
- **Supply feedback on traceability**
- **Professional agreement on policy, standards, etc.**

**Support for end-use & interaction**
- Process & tools

**Download from www.coest.org**
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Practitioners expect traceability “inside” all projects. When traceability is configured as

Researchers focus on fully executable traceability specifications, making traceability pervasive to all SSE processes, & ensuring its techniques are integral to tool support.
Interim paths

• Specific research agendas

sundayriver.com/TheMountain

RE 2012
You have arrived @ your destination

- 1st attempt to map terrain for traceability research (& to carve a road through it)
- Priority (value & difficulty) of research topics – triage
- Measuring progress – classify research contributions
- Other ways to organize terrain
- Different terrain entirely
On the road to traceability ubiquity ...

A community needs to pursue research that fits together to take us toward a shared vision of the future.

Research communities need to think more about the use of roadmaps & the role they could play.
Acknowledgments

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Resources

The Grand Challenge of Traceability (v1.0)
Center of Excellence for Software Traceability Technical Report
#CoEST-2011-001
June 14, 2011

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