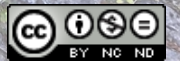


The Need for Context in Software Engineering

Gail C. Murphy
University of British Columbia

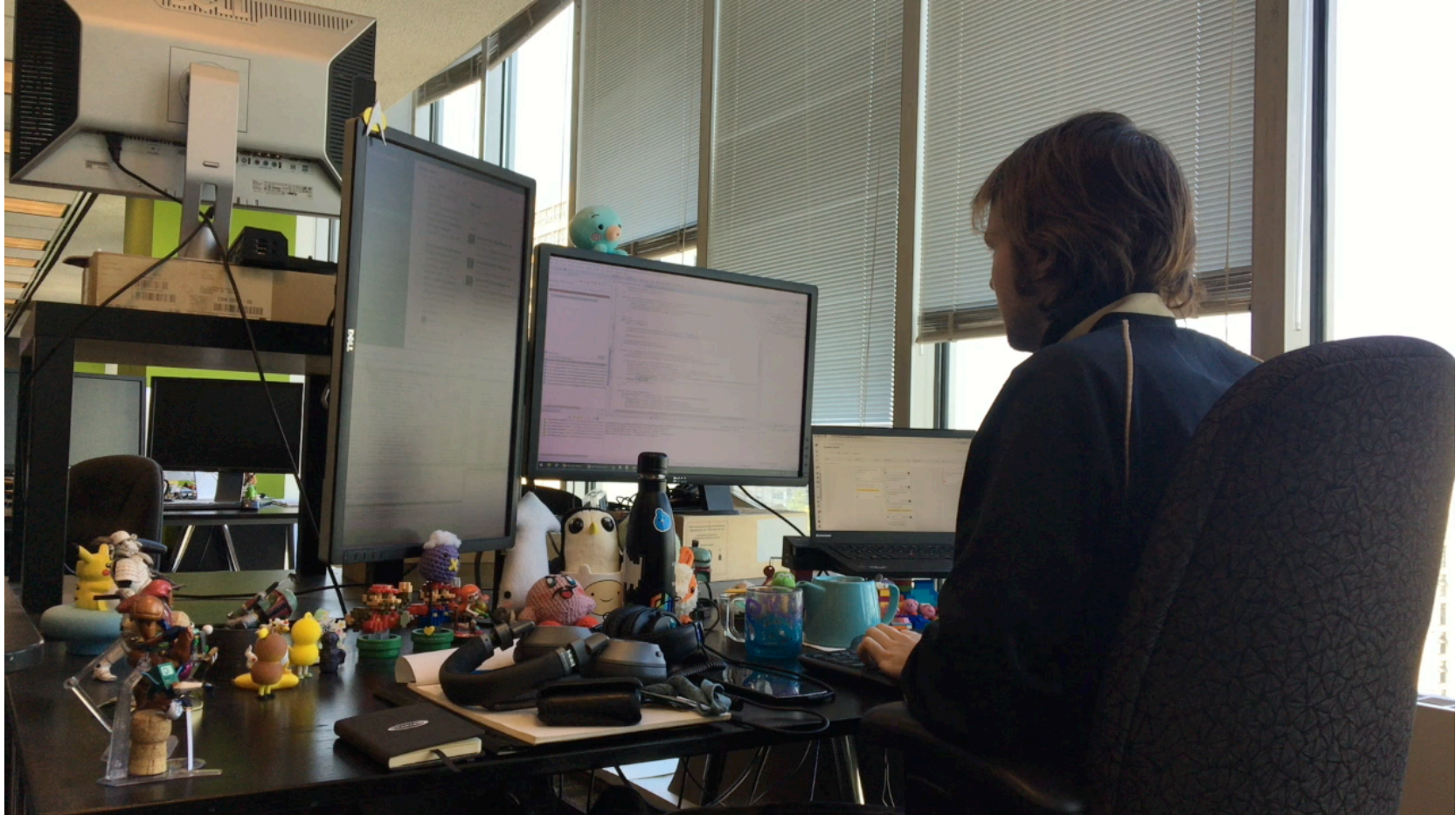
@gail_murphy



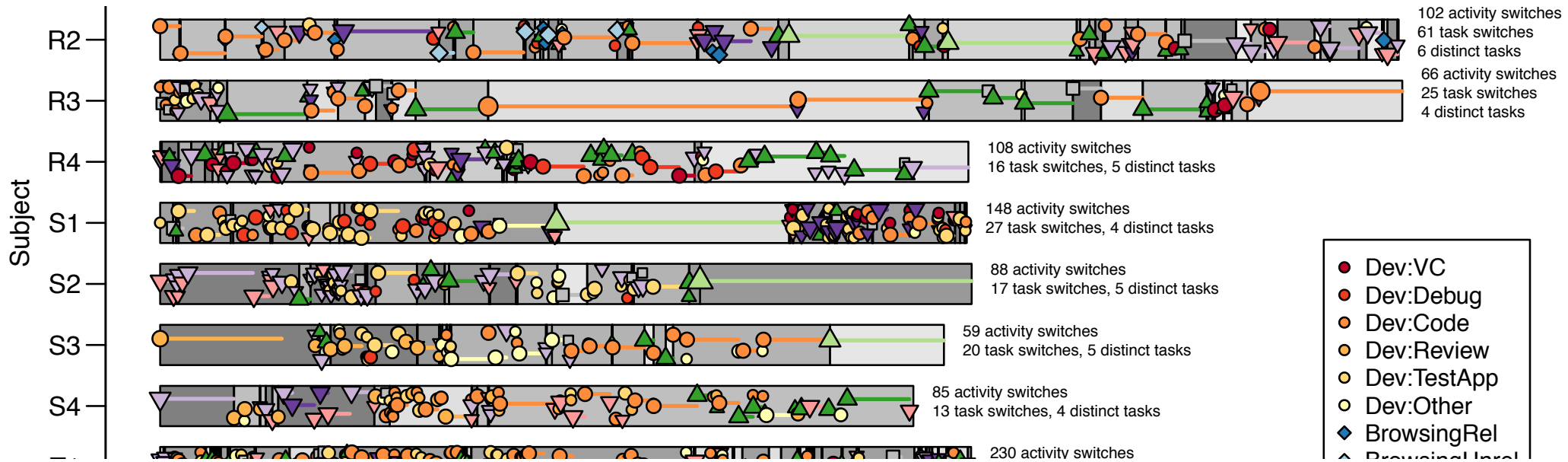
except for images where noted



Software development today



Thanks to Jaxsun McCarthy Huggan, Tasktop, 2018



What do developers do?

[Meyer, Fritz, Murphy, Zimmermann, 2014]

Task Switches:

13.3 (± 8.5) times per hour

Activity Switches:

47 (± 19.8) times per hour

["Software Developers' Perceptions of Productivity", Meyer, Fritz, Murphy and Zimmermann, FSE 2014]

I want to ignite your imagination...



Image attribution: commons.wikimedia.org/wiki/File:Toy_balloons_red_and_blue.jpg

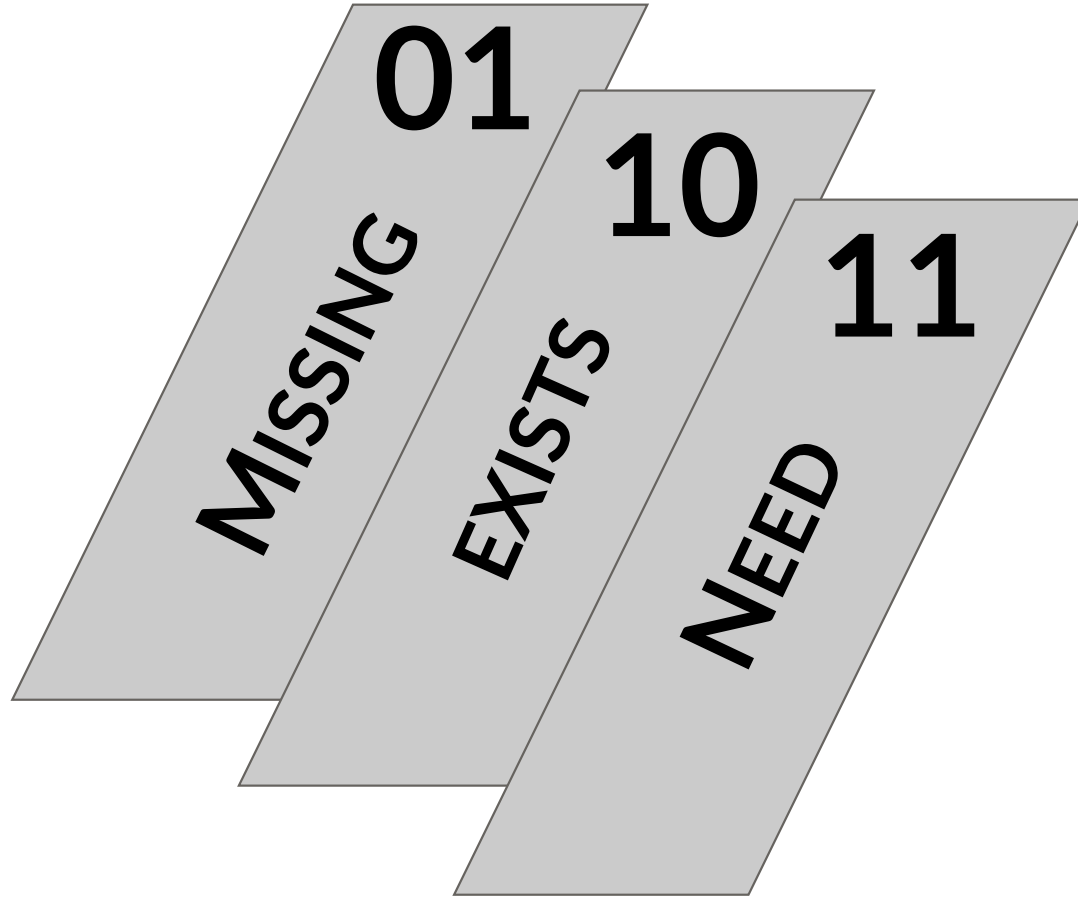
Apple's Knowledge Navigator

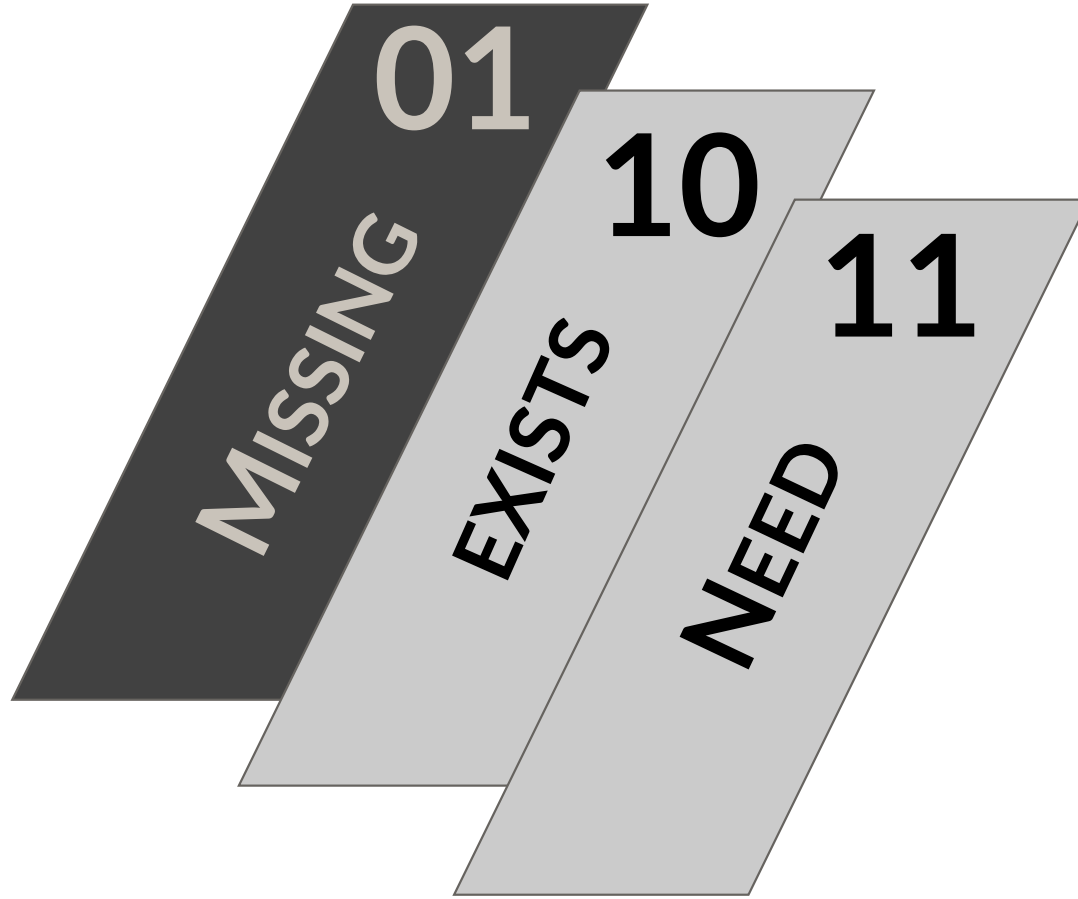
<https://www.youtube.com/watch?v=umJsITGzXd0>

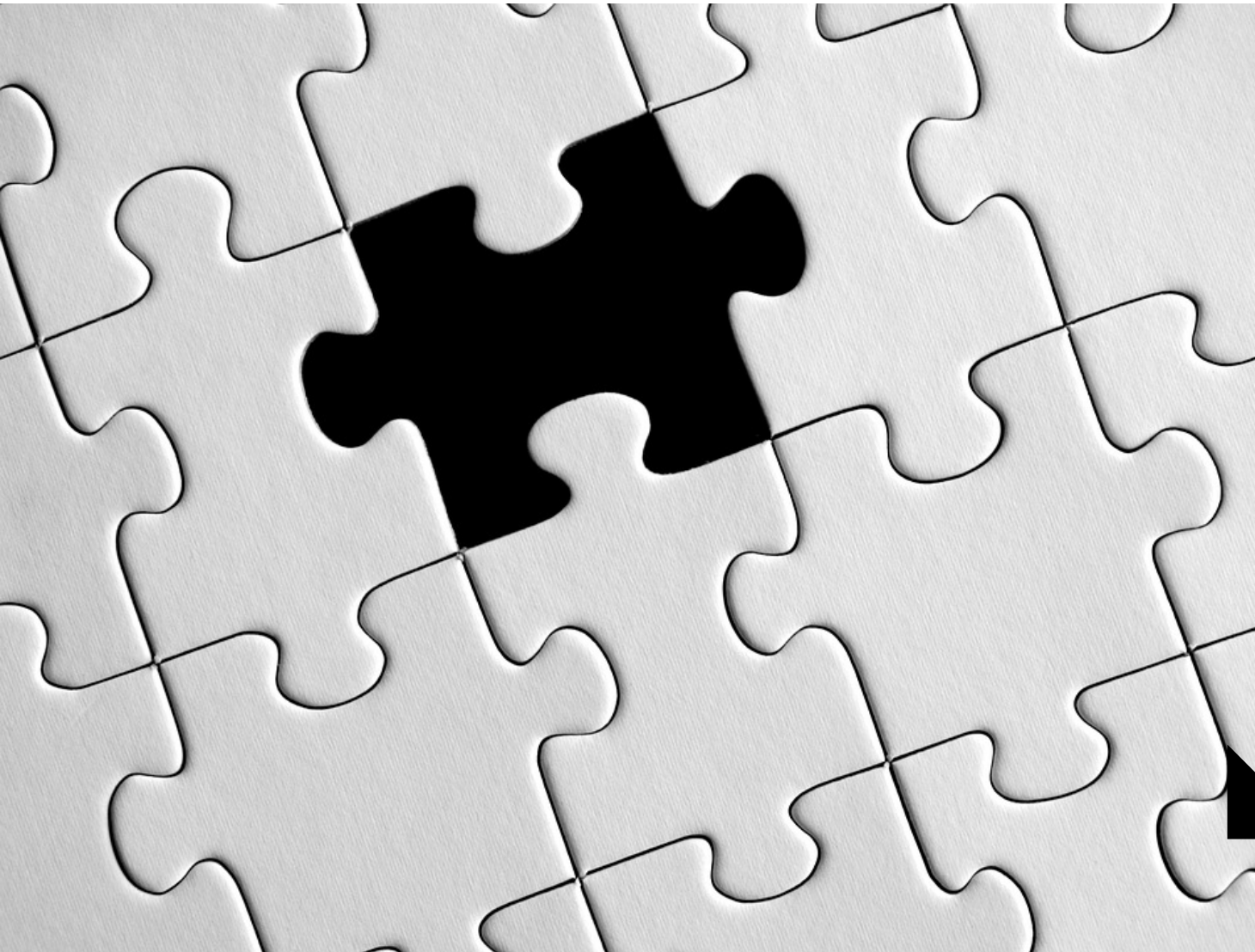


Software development tools are *not* amplifying human intelligence

Study, definition and use of *context* can improve the flow of software development work







01

What's

MISSING

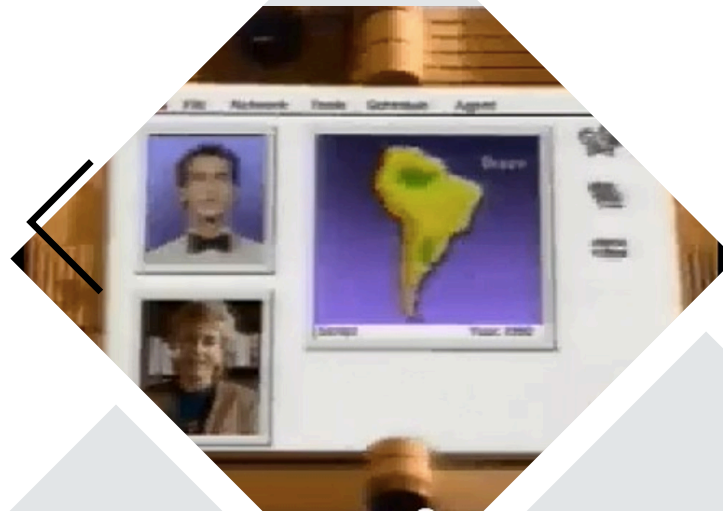
in

Software

Engineering?

Knowledge Navigator Demo

View the demo as a set
of tools connected by
context



P = Professor
C = Computer

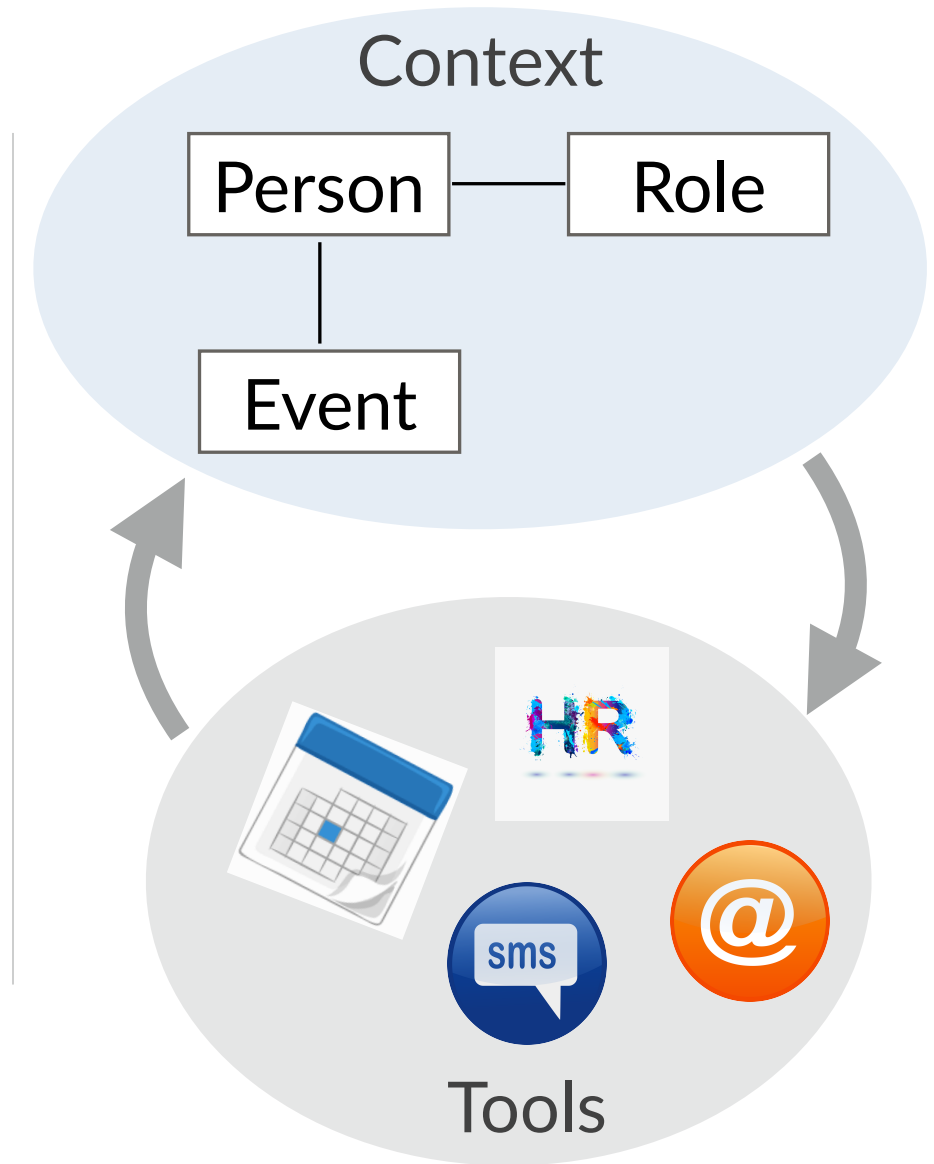
C: You have three messages:

your graduate research team in Guatemala just checking in

Robert Jordan, a second semester junior requesting a second extension on his term paper

and your mother reminding you about your father's (cut off)

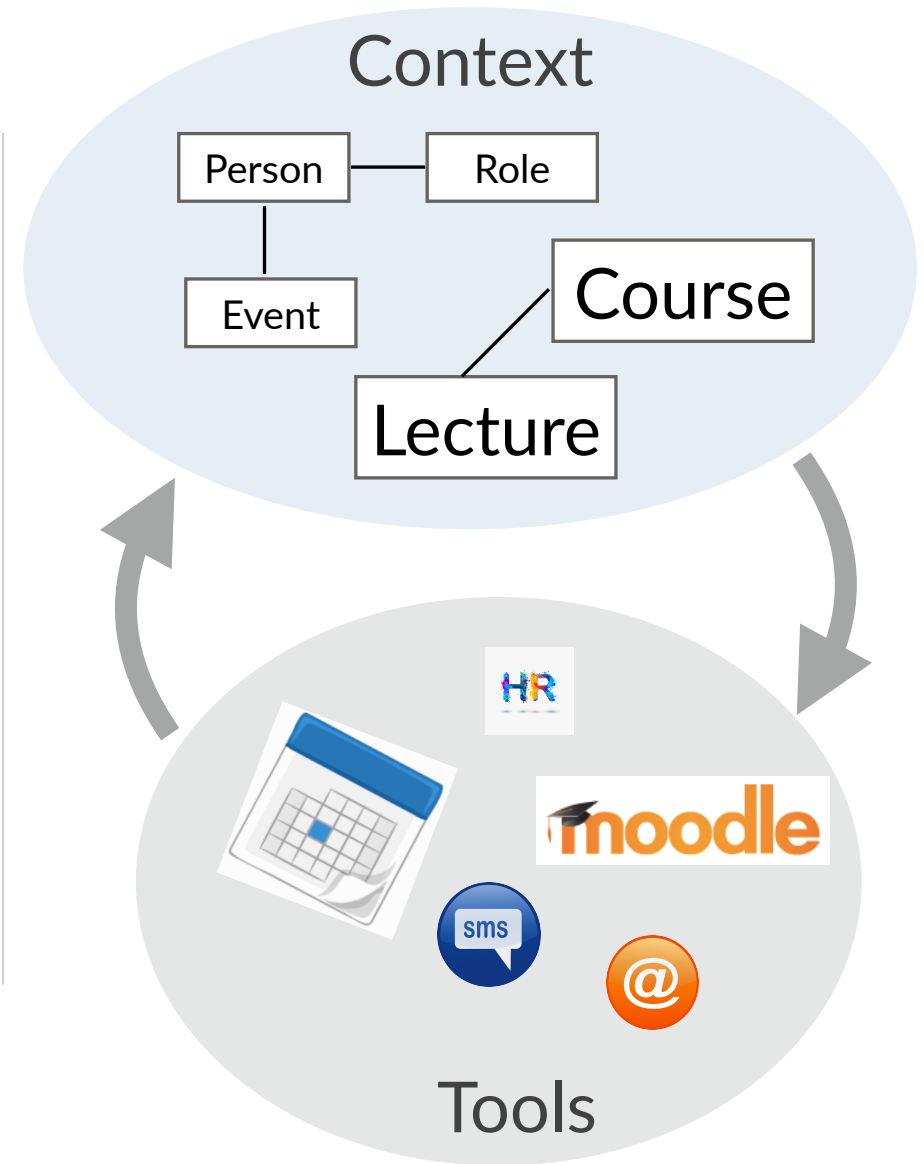
P: (interrupts by touching screen)
surprise birthday party next Sunday



P = Professor
C = Computer

C: Today you have a faculty luncheon at 12:00; you need to take Kathy to the airport by 2; you have a lecture at 4:15 on deforestation in the Amazon rain forest

P: right, let me see the lecture notes from last semester



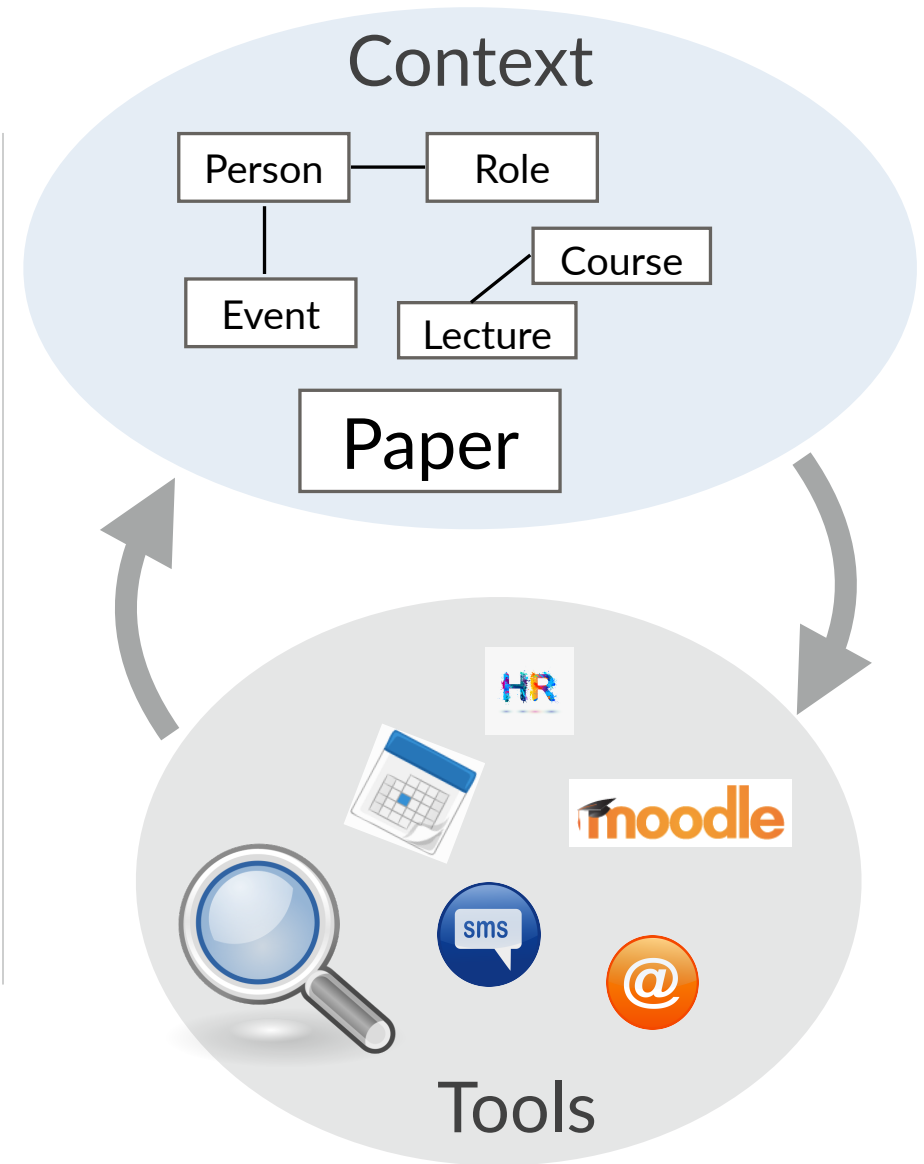
P = Professor
C = Computer

C: (shows notes)

P: No that's not enough. I need to review more recent literature. Pull up the new articles I haven't read yet.

C: Journal articles only?

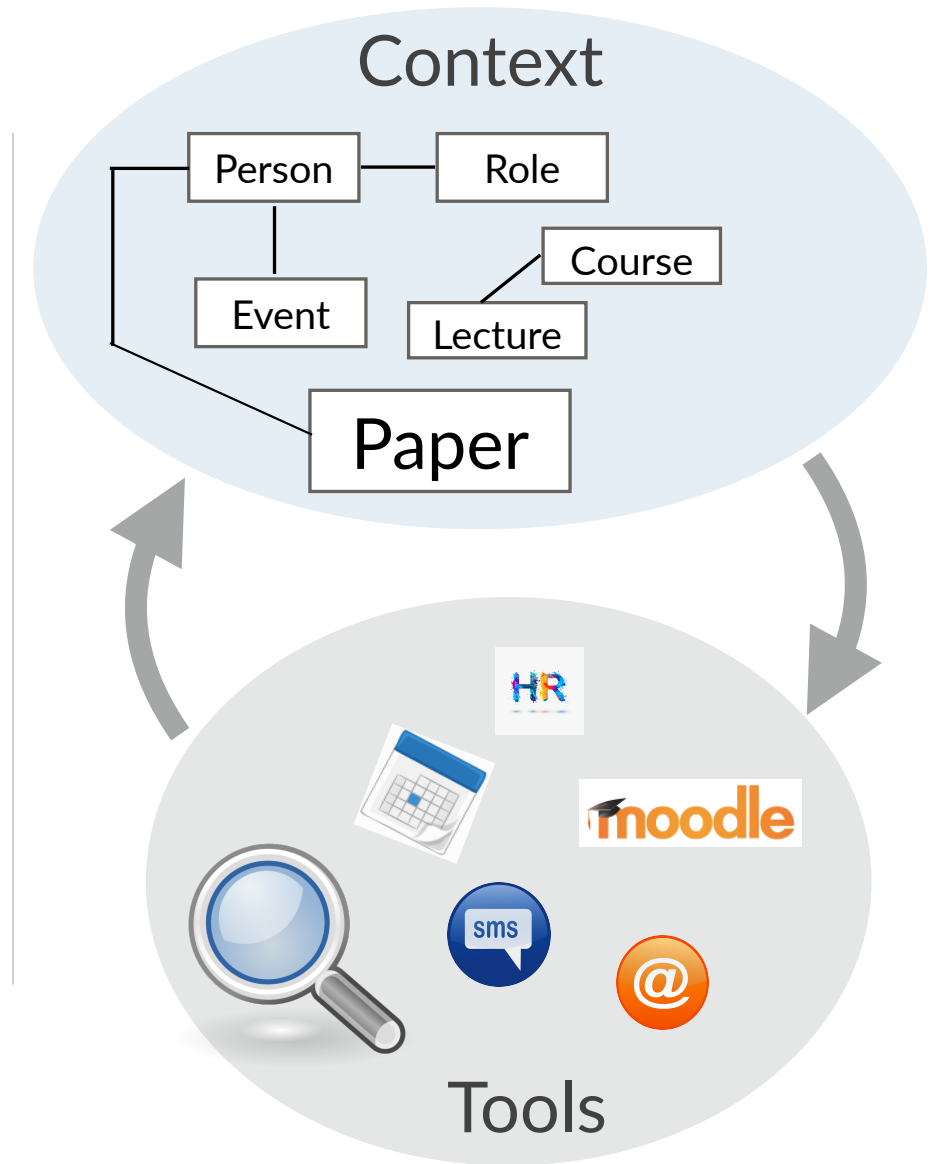
P: Hmmmm. Fine.



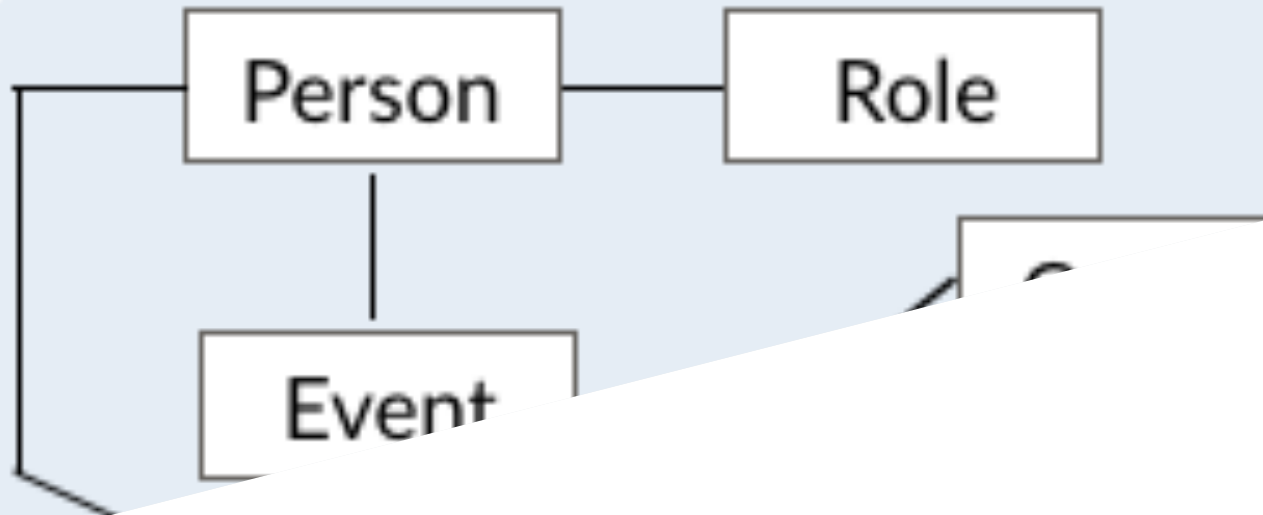
P = Professor
C = Computer

C: Your friend Jill Gilbert has published an article about deforestation in the Amazon and its effects on rainfall in the sub-Saharan. It also covers the drought's effect on food production in Africa and increasing imports of foods.

P: Contact Jill.



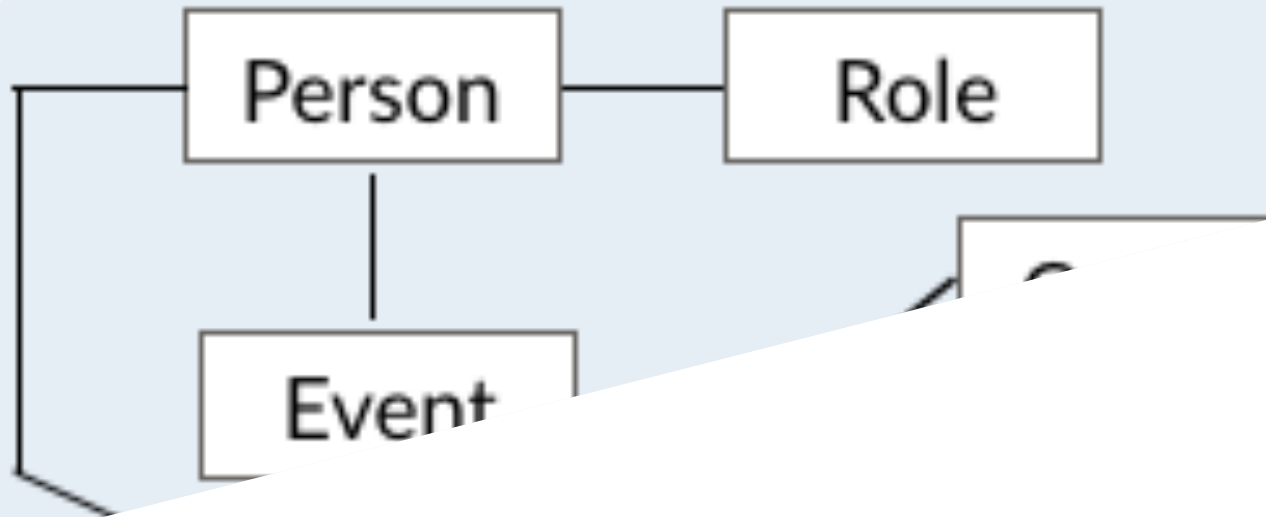
Context



“***Context*** is any information that can be used to characterize the situation of an entity.”

— Dey and Abowd, CHI 2000 Workshop

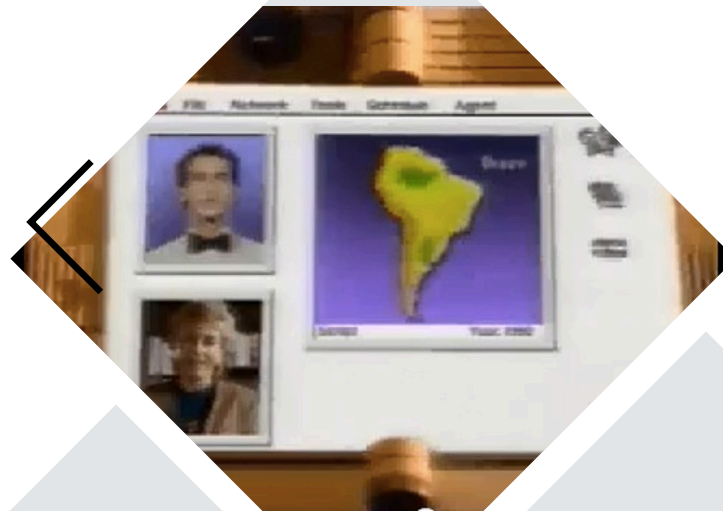
Context



For this talk, think about ***context*** as a semantic plane that tools (components, widgets) can consult when acting

Knowledge Navigator Demo

What is the effect of
context?



P = Professor
C = Computer

C: You have three messages:

your graduate research team in Guatemala
just checking in

Robert Jordan, a second semester junior
requesting a second extension on his term
paper

and your mother reminding you about your
father's (cut off)

P: (interrupts by touching screen)
surprise birthday party next Sunday

What is the professor
focusing on?

the events
(not accessing them)



P = Professor
C = Computer

C: Today you have a faculty luncheon at 12:00; you need to take Kathy to the airport by 2; you have a lecture at 4:15 on deforestation in the Amazon rain forest

P: right, let me see the lecture notes from last semester

What is the professor focusing on?

issue of current interest
(not on how to access history)



P = Professor
C = Computer

C: (shows notes)

P: No that's not enough. I need to review more recent literature. Pull up the new articles I haven't read yet.

C: Journal articles only?

P: Hmmmm. Fine.

What is the professor focusing on?

the question of interest
(not on how to answer it)



P = Professor
C = Computer

C: Your friend Jill Gilbert has published an article about deforestation in the Amazon and its effects on rainfall in the sub-Saharan. It also covers the drought's effect on food production in Africa and increasing imports of foods.

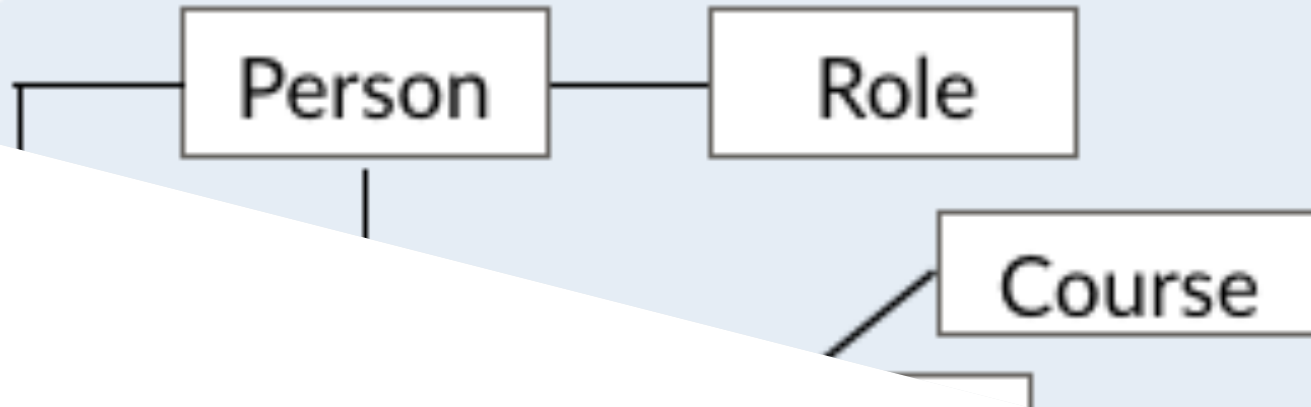
P: Contact Jill.

What is the professor focusing on?

the topic
(not recall, re-reading or lookup)



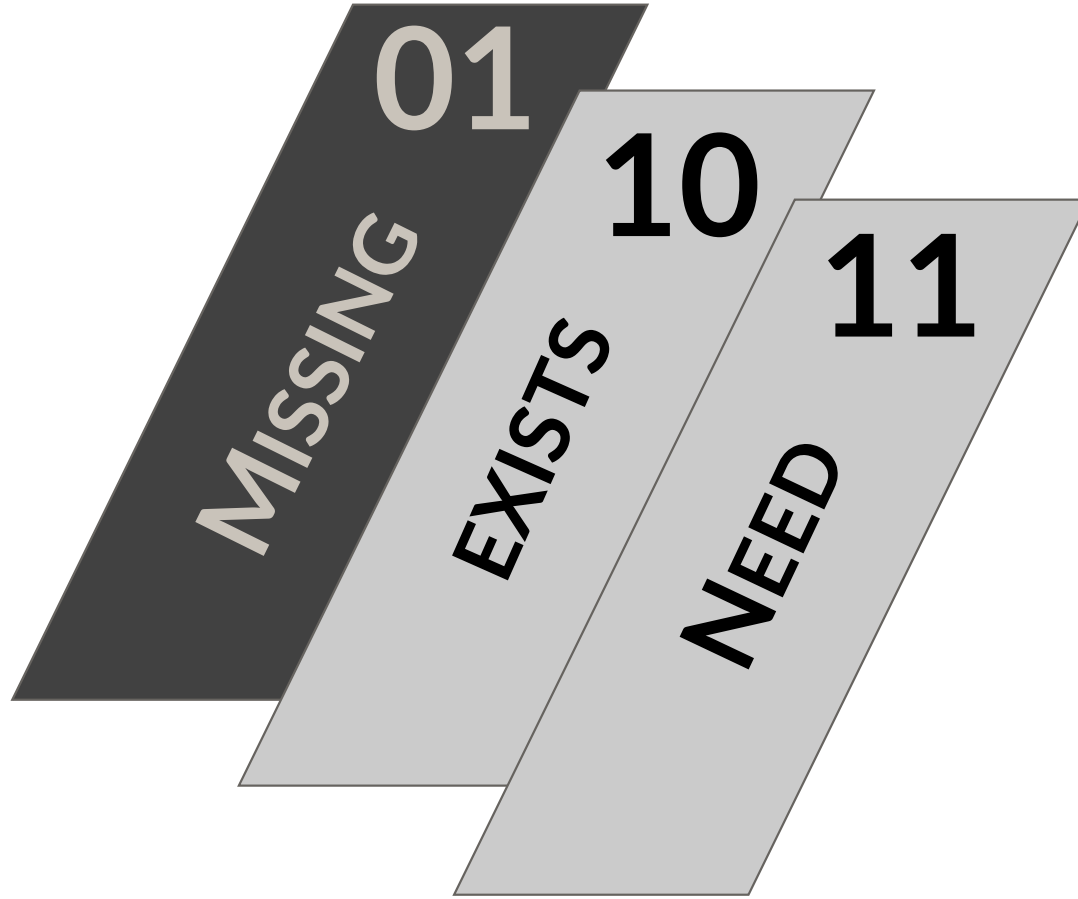
Context

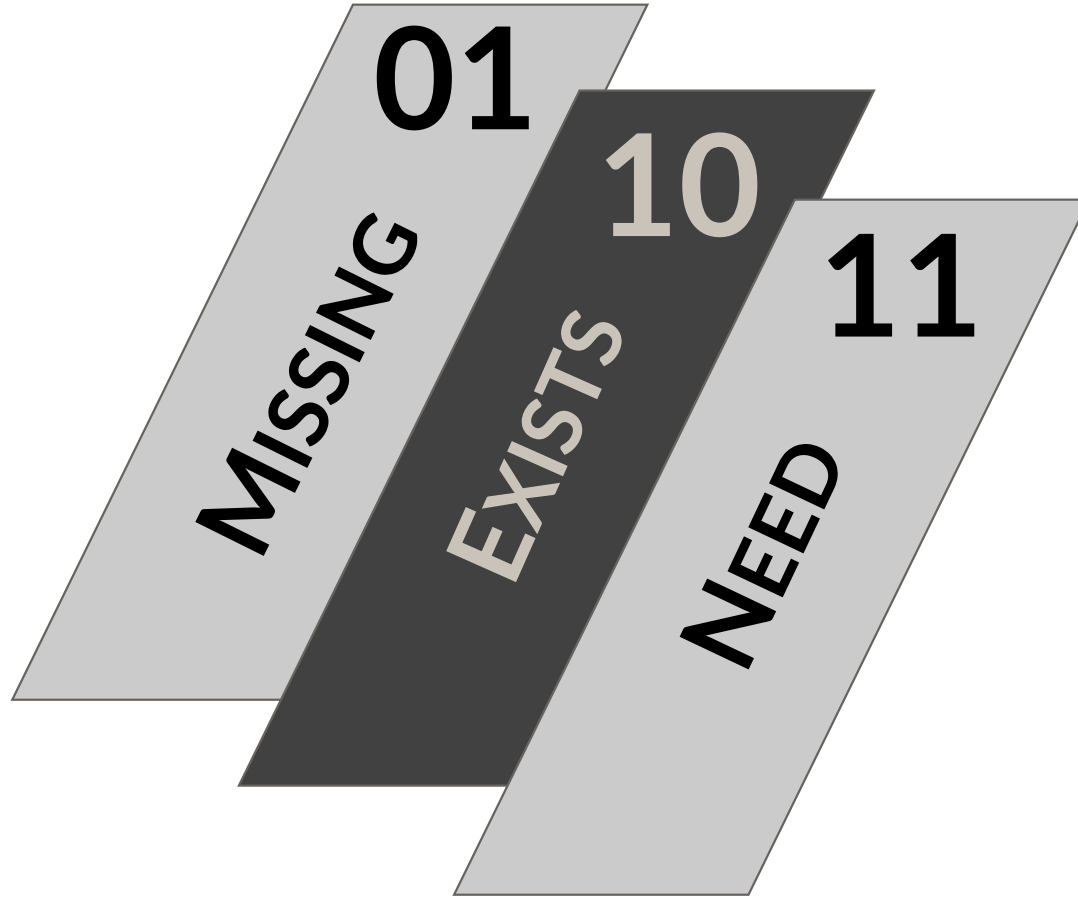


Context can support the *flow* of work...

by reducing the *accidental* complexity
and enabling a focus on the *essential* complexity
of the problem at hand

Where is the
context
in Software Engineering?







10

What
context

EXISTS

in SE?



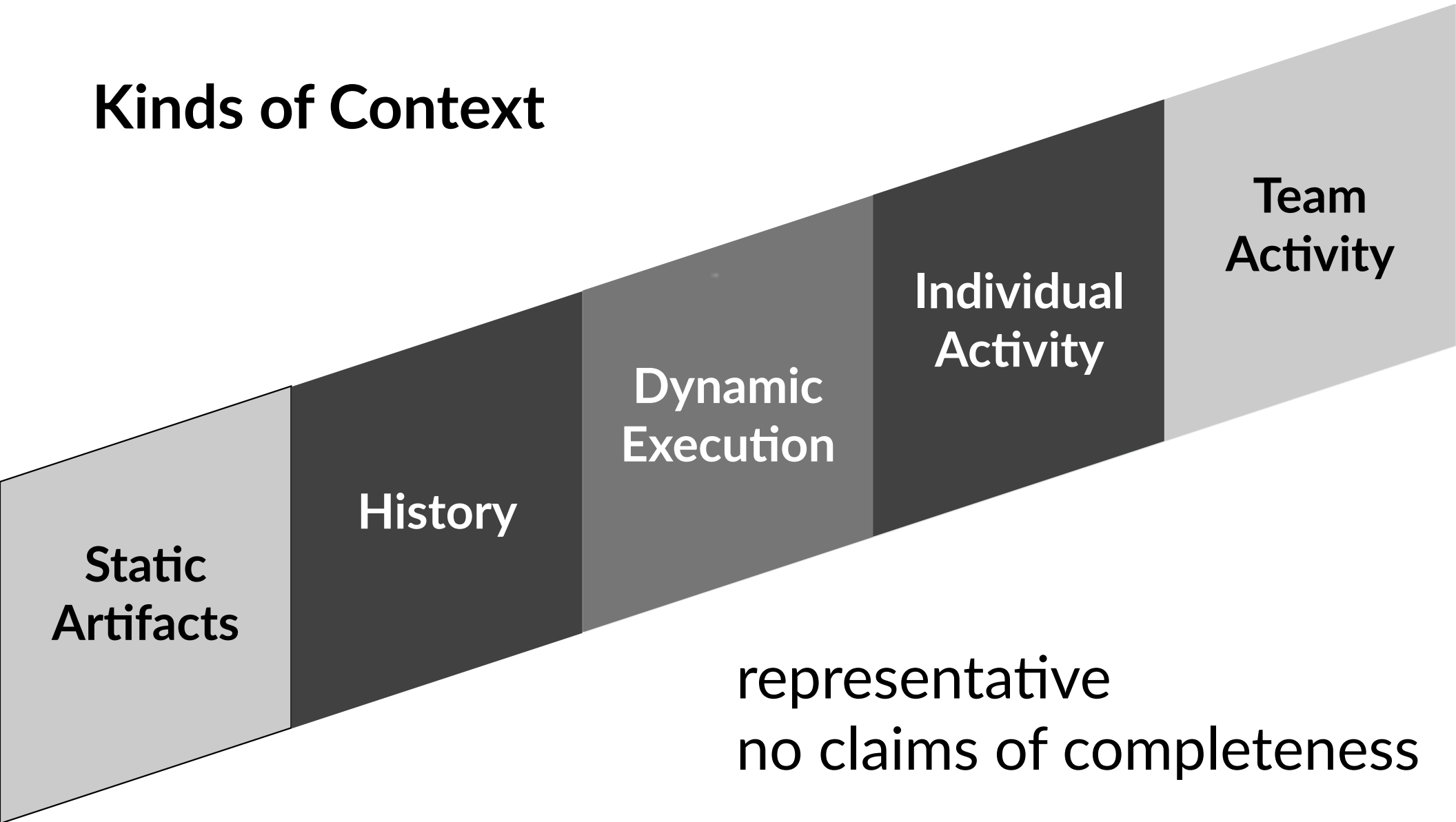
Focus
on tools
where there is human interaction





Draw
largely on examples
from my research group ┌

Kinds of Context



**Static
Artifacts**

History

**Dynamic
Execution**

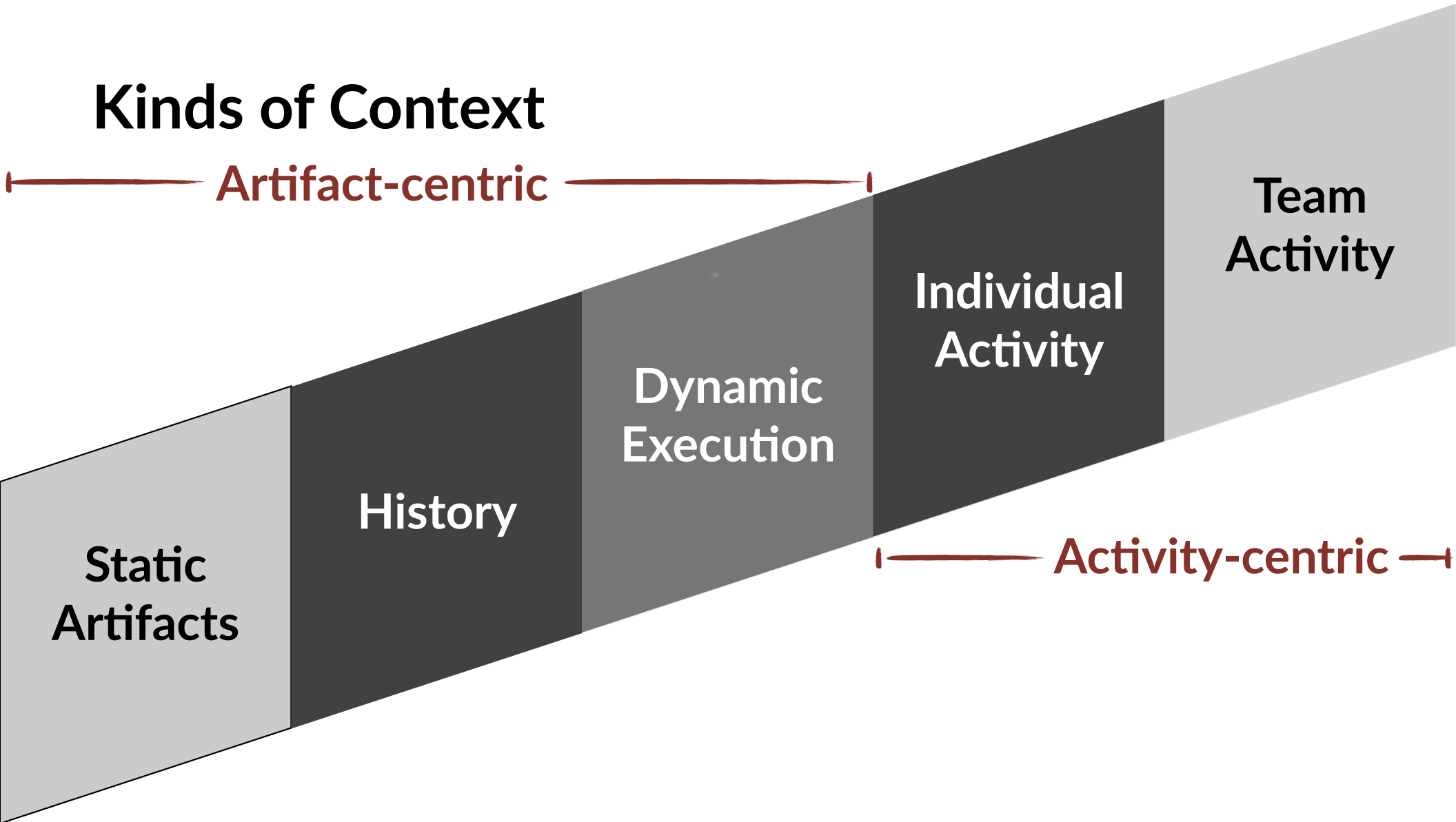
**Individual
Activity**

**Team
Activity**

representative
no claims of completeness

Kinds of Context

Artifact-centric



Individual
Activity

Team
Activity

Static
Artifacts

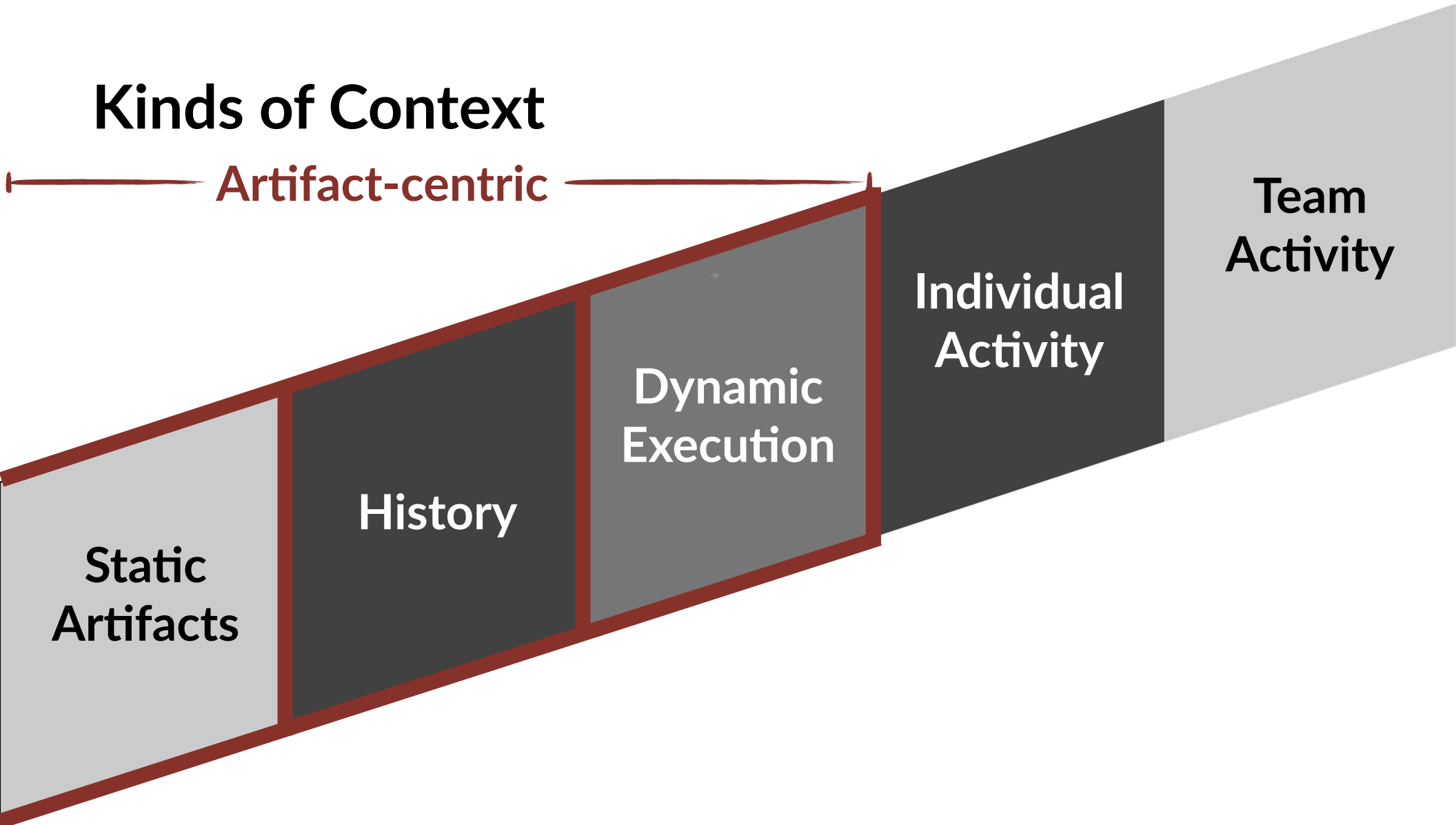
History

Dynamic
Execution

Activity-centric

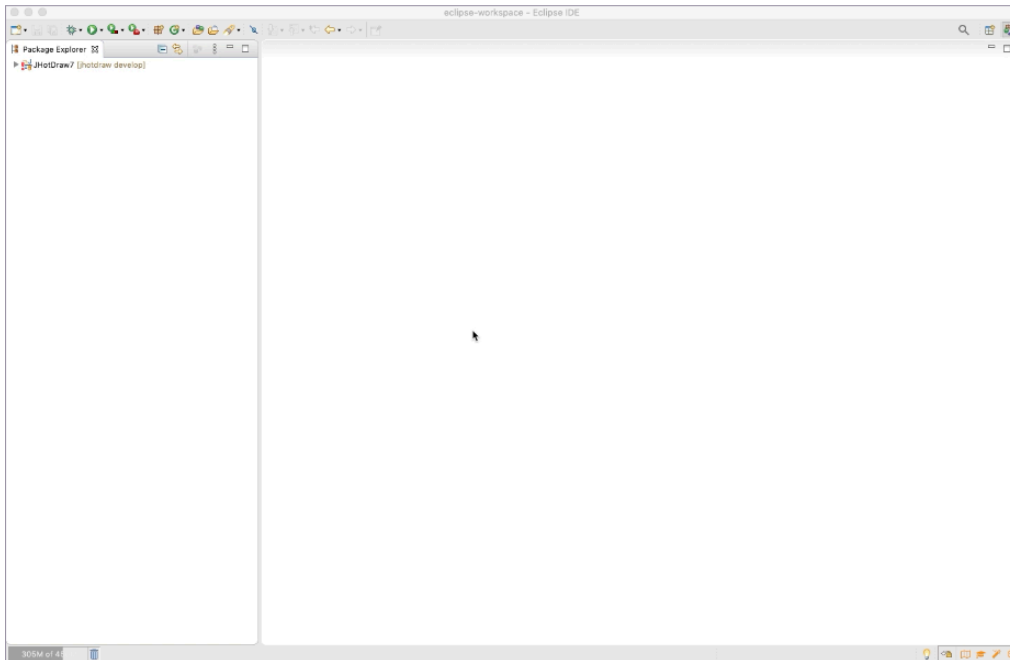
Kinds of Context

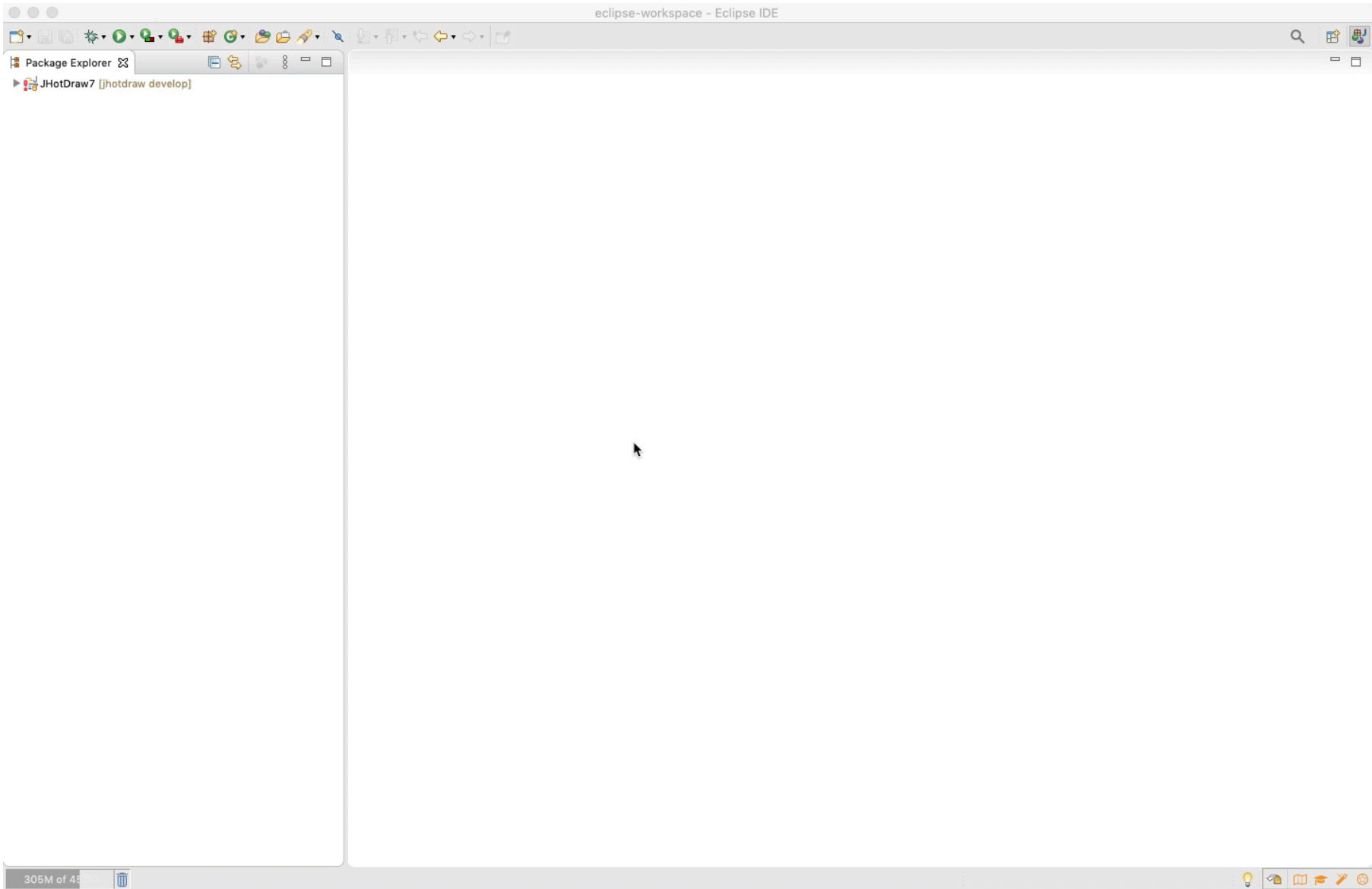
Artifact-centric



Context as Static Artifacts

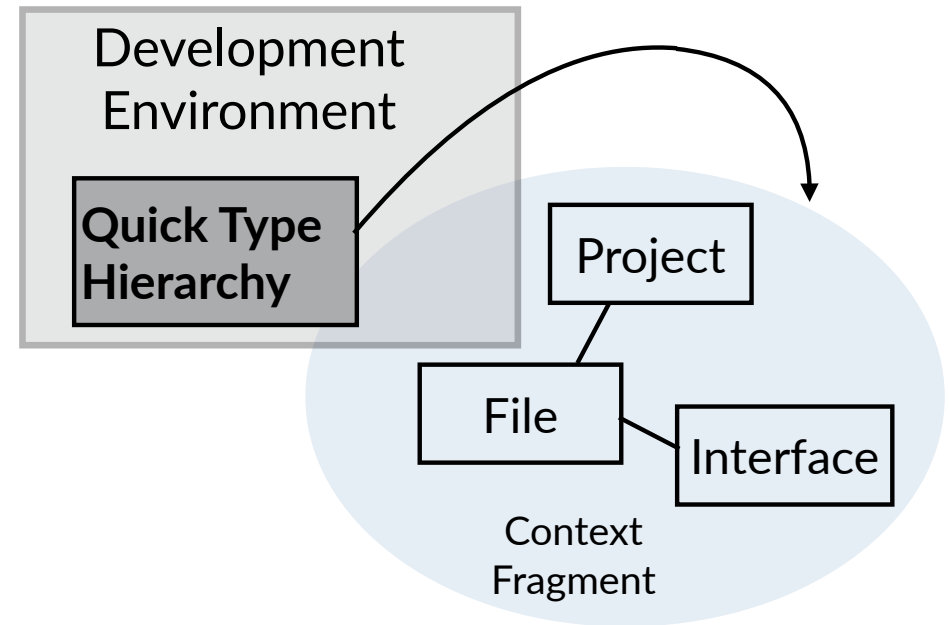
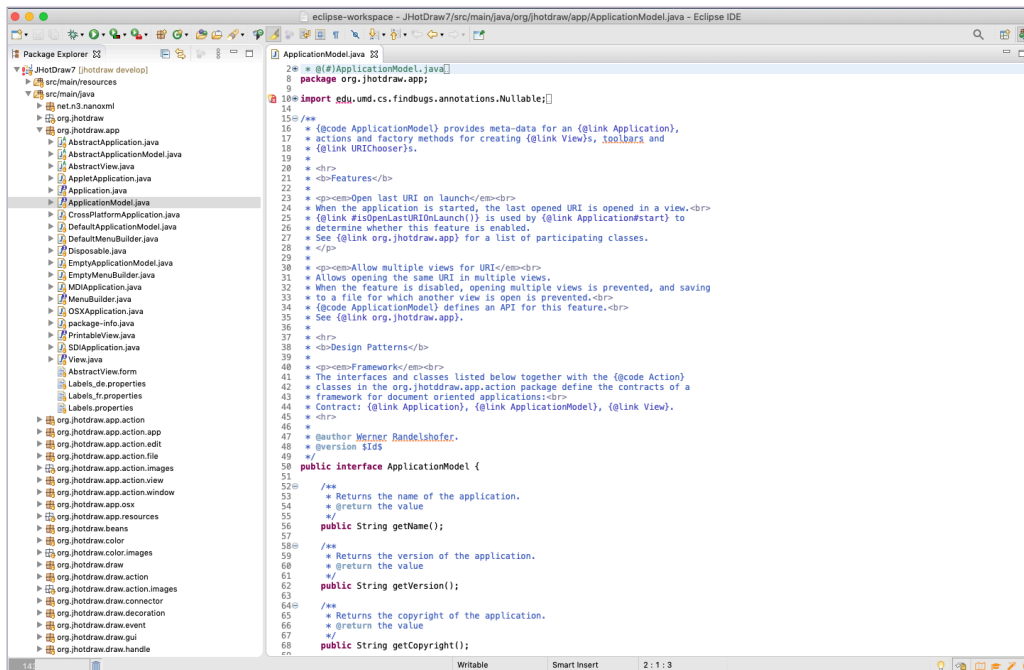
Development Environment





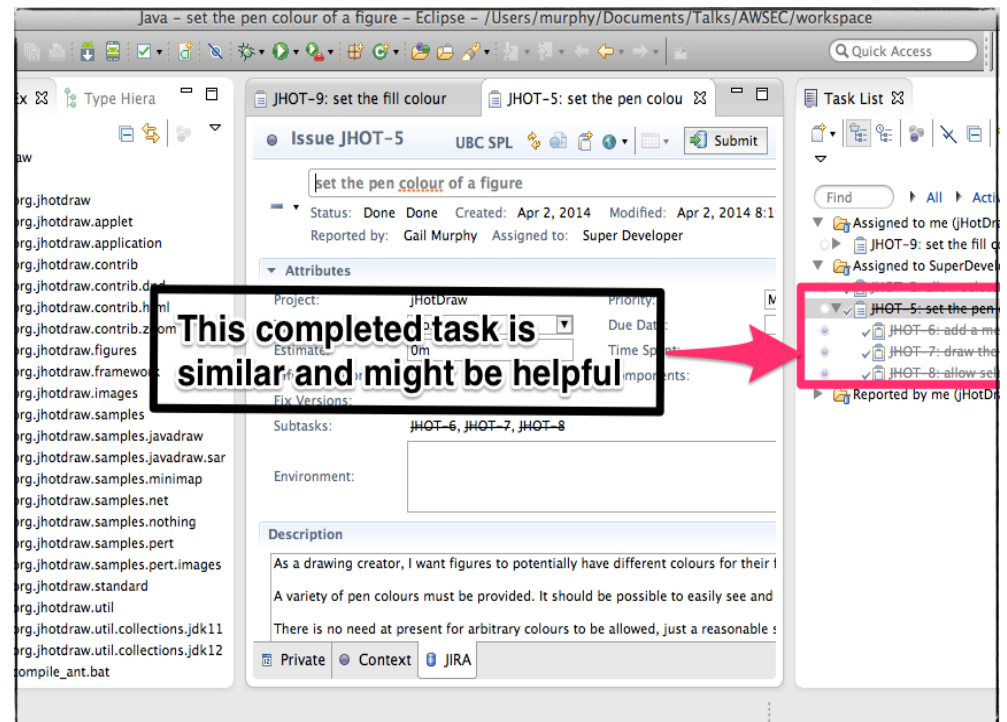
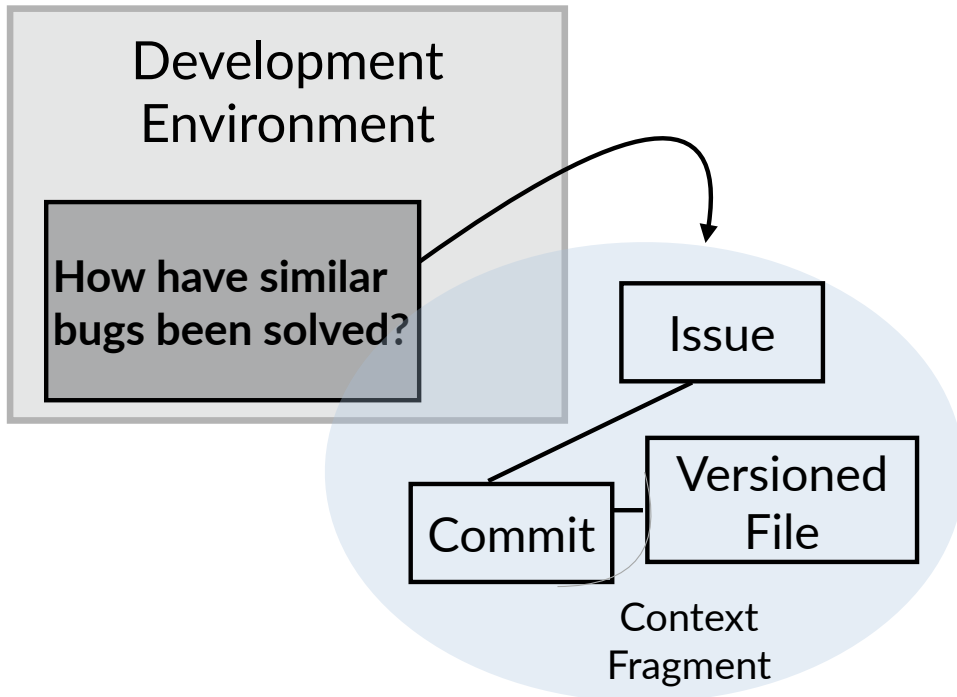
Context as Static Artifacts

Development Environment



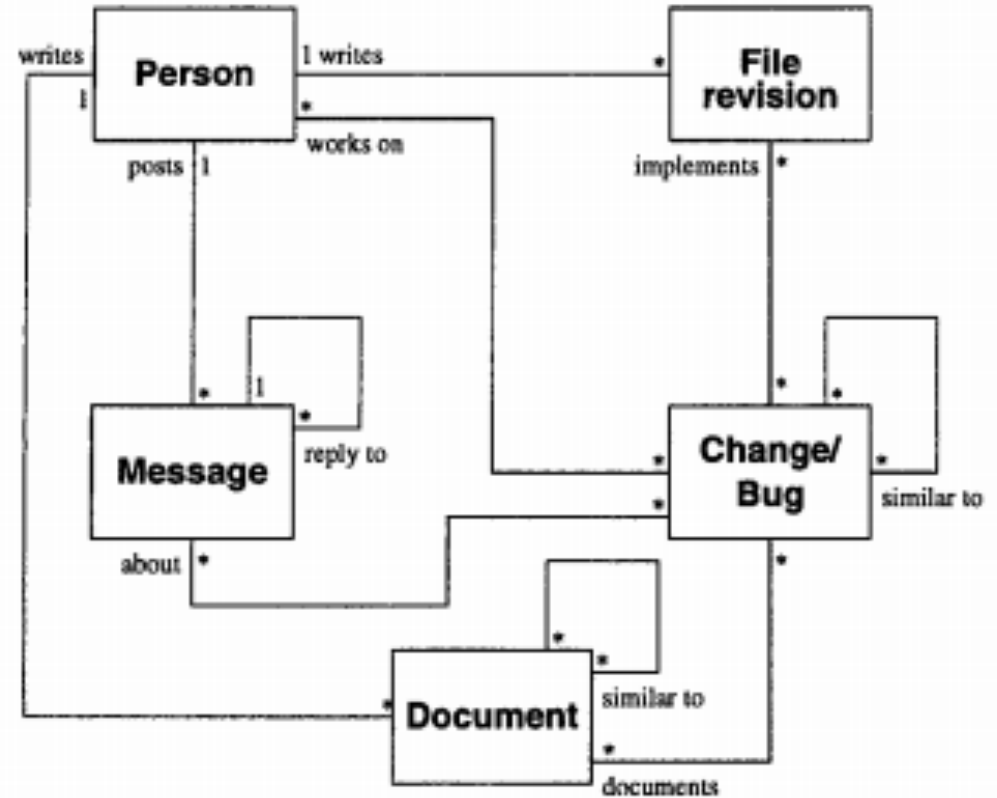
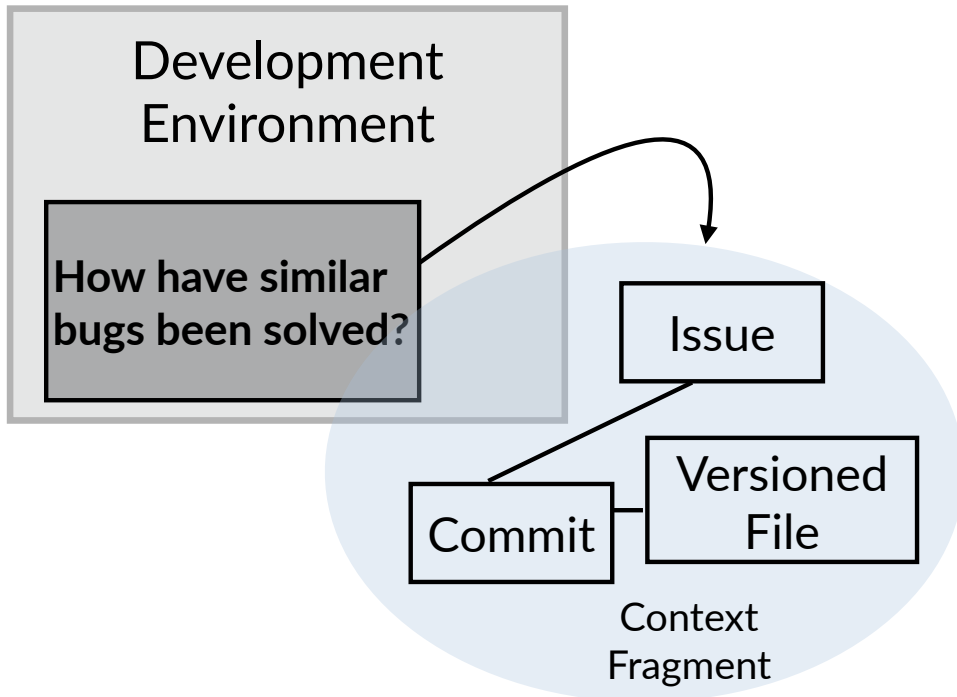
Context as History

Hipikat [Čubranić & Murphy, 2003]



["Hipikat: Recommending Pertinent Software Artifacts", Čubranić and Murphy, ICSE 2003]

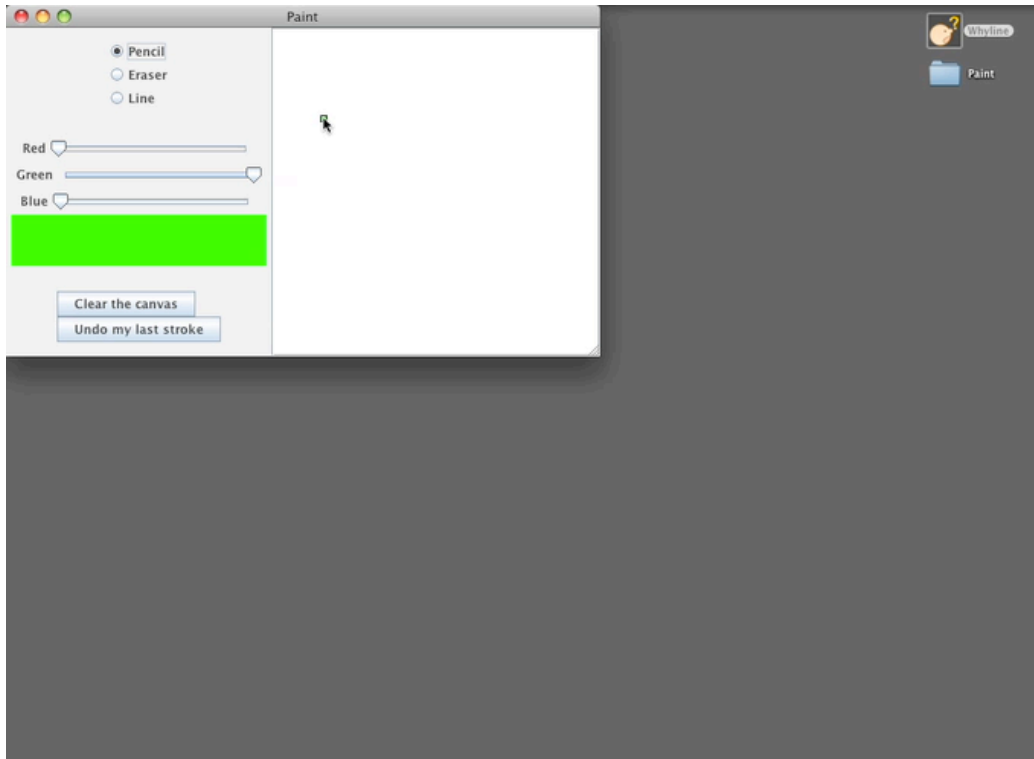
Context as History



["Hipikat: Recommending Pertinent Software Artifacts", Čubranić and Murphy, ICSE 2003]

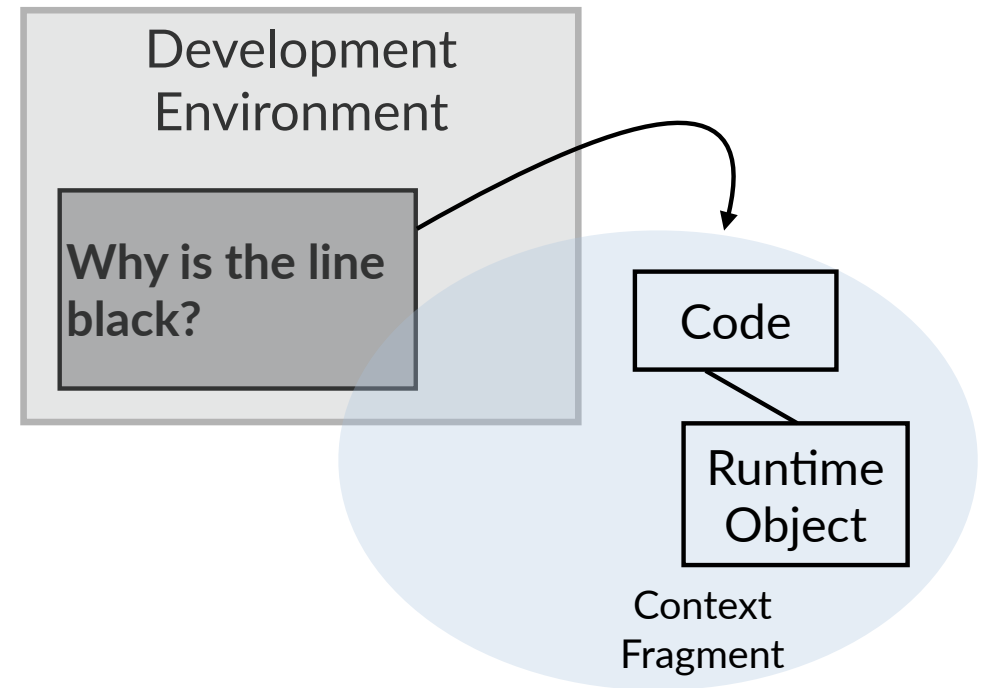
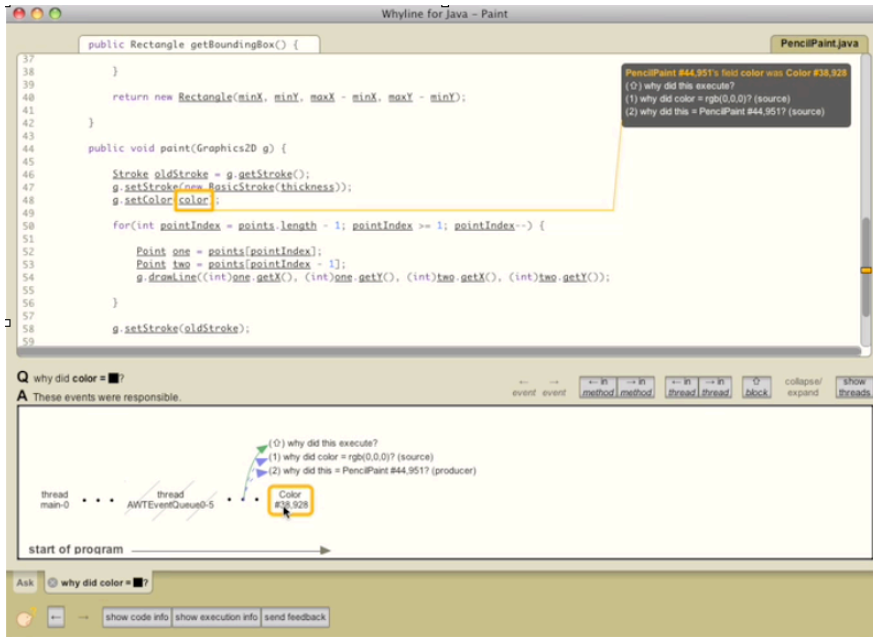
Context as Dynamic Execution

WhyLine [Ko & Myers, 2004]

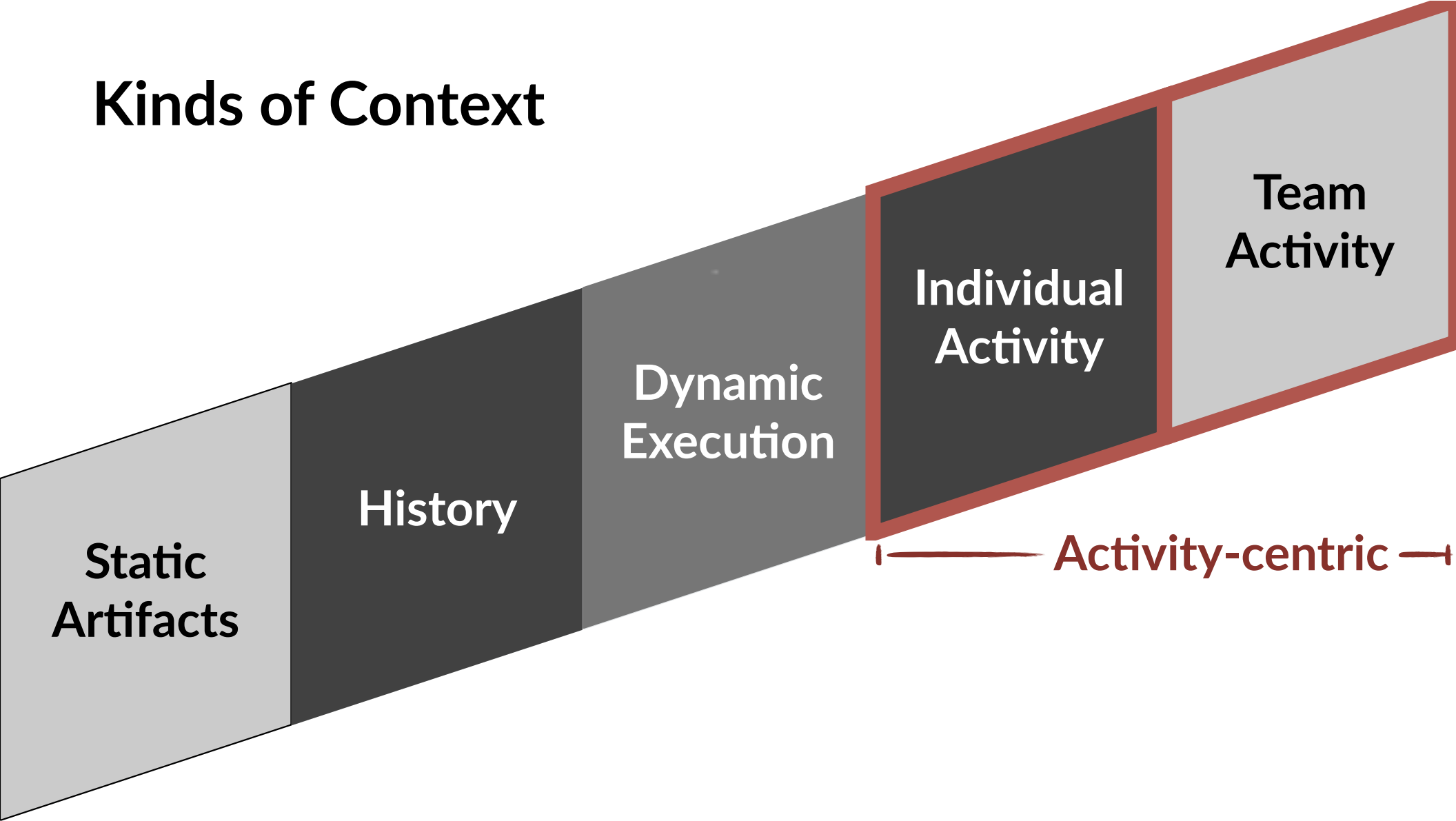


Context as Dynamic Execution

WhyLine [Ko & Myers, 2004]

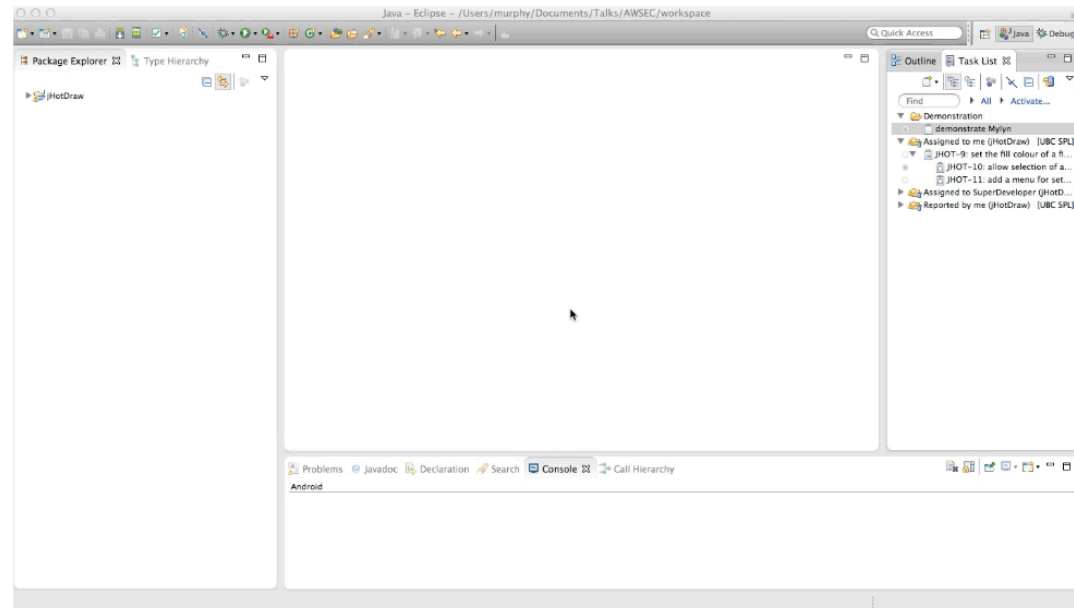
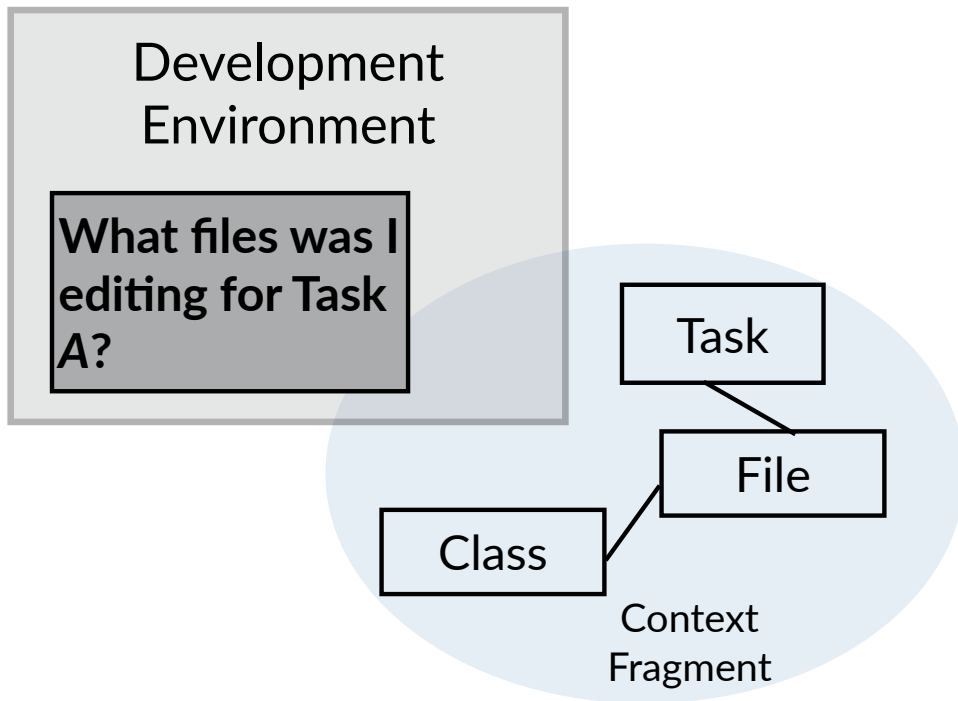


Kinds of Context

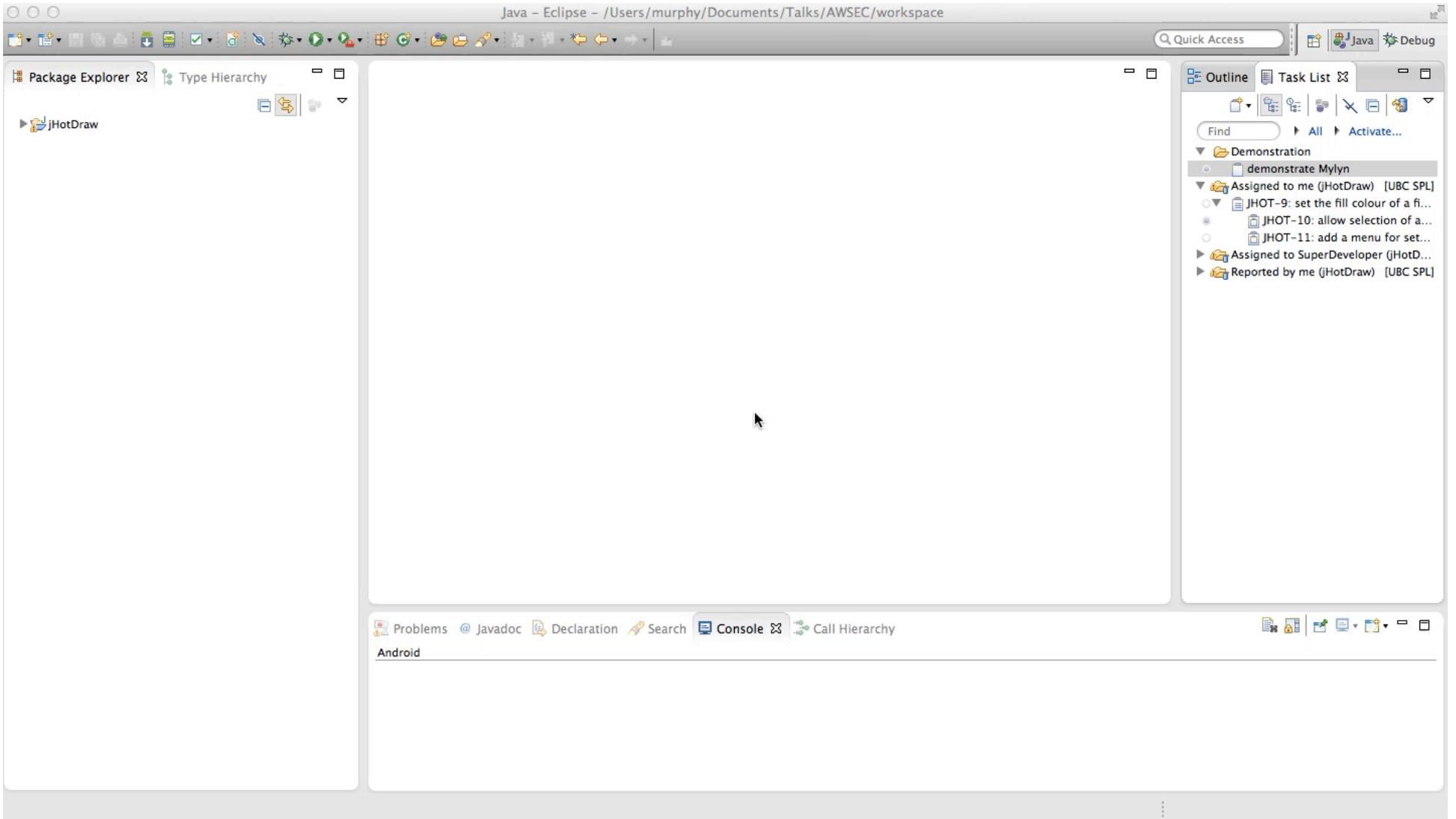


Context as Individual Activity

Mylyn [Kersten & Murphy 2006]

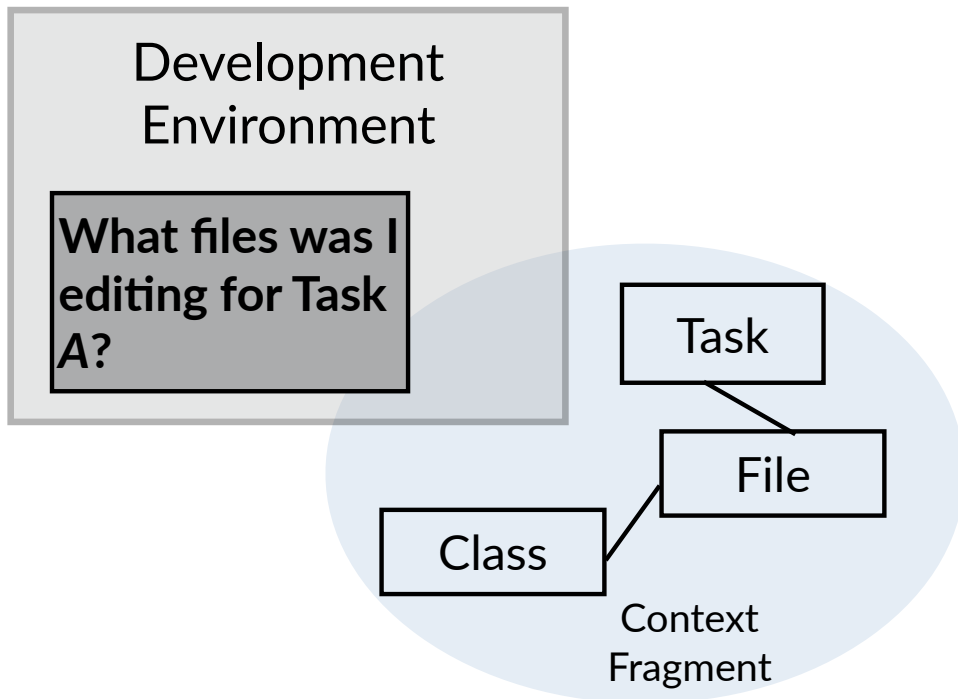


[“Using Task Context to Improve Programmer Productivity, Kersten and Murphy, FSE 2006]



Context as Individual Activity

Mylyn [Kersten & Murphy 2006]



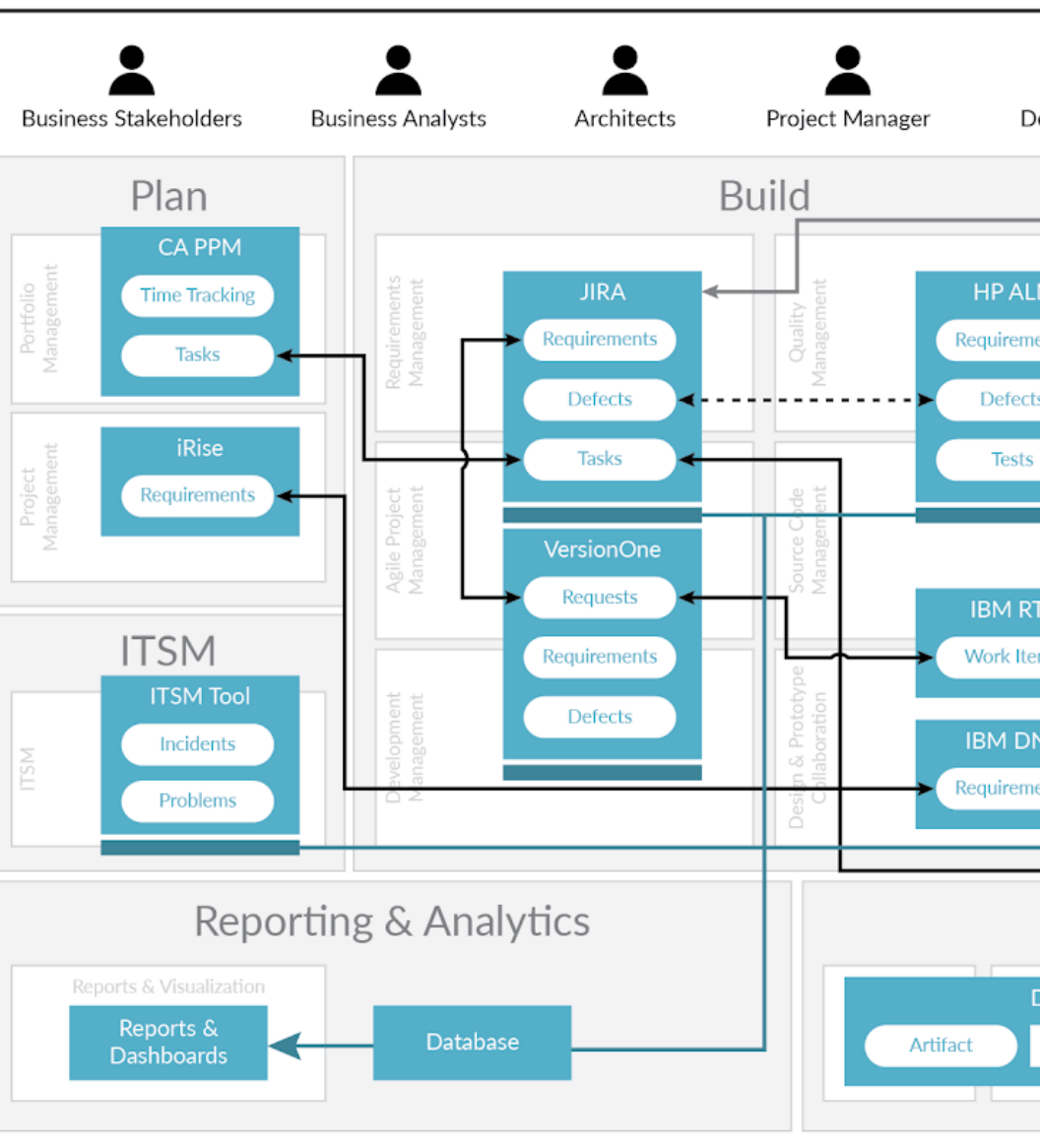
```
textChangeSetM... x ChangeSetManagerTes... ChangeSetManager.class  
  
private void initContextChangeSets() {  
  
    * For testing.  
    public void clearActiveChangeSets() {  
        activeChangeSets.clear();  
    }  
  
    public IResource[] getResources()  
  
    public void contextActivate()  
  
    public void contextDeactivate()  
  
    public List<ContextChangeSet>  
  
    private ITask getTask(IMylarC
```

- interestChanged(List<IMylarElement> elem
- clearActiveChangeSets() void - ContextCha
- getTask(IMylarContext context) ITask - Co
- activeChangeSets Map<java.lang.String,
- CHANGE_SET_LISTENER IChangeSetChar
- collectors List<org.eclipse.team.internal.c
- isEnabled boolean - ContextChangeSetMa
- TASK_ACTIVITY_LISTENER ITaskActivityL

Press 'Ctrl+Space' to show Template P

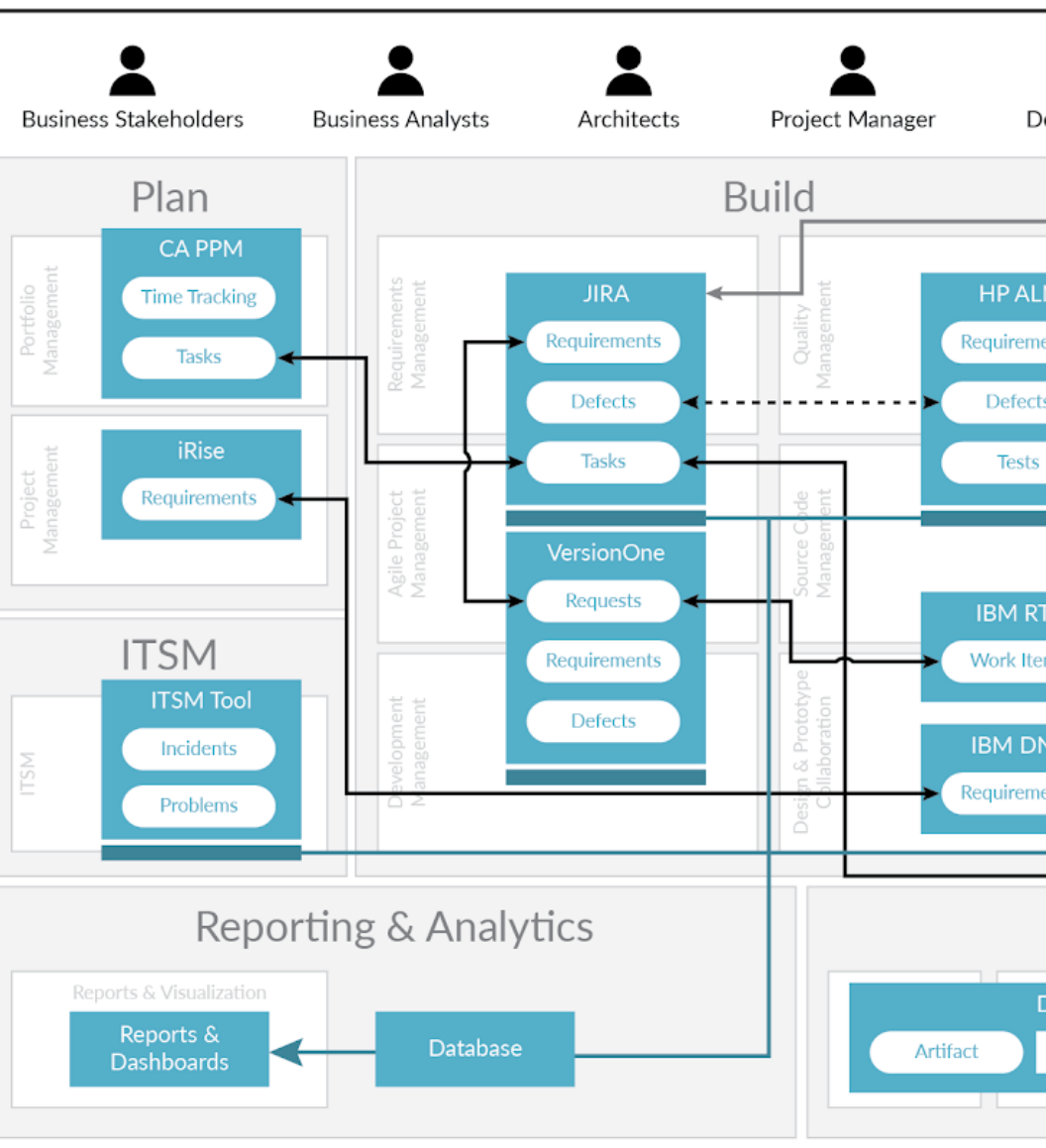
content assist based on interest derived from activity

[“Using Task Context to Improve Programmer Productivity, Kersten and Murphy, FSE 2006]



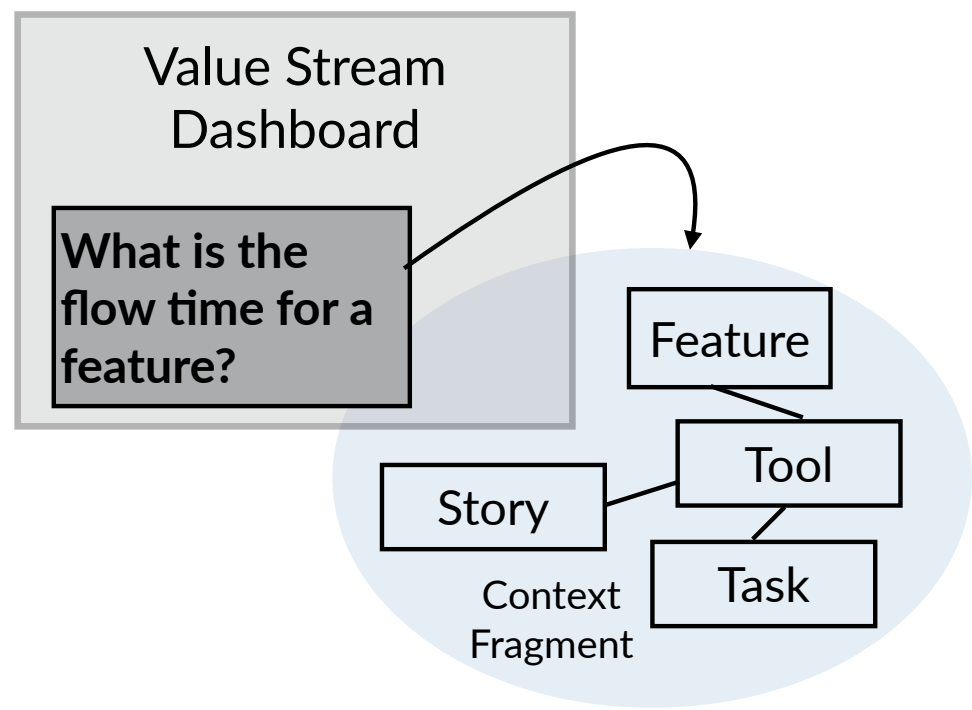
Context as Team Activity

Tasktop



Context as Team Activity

Tasktop



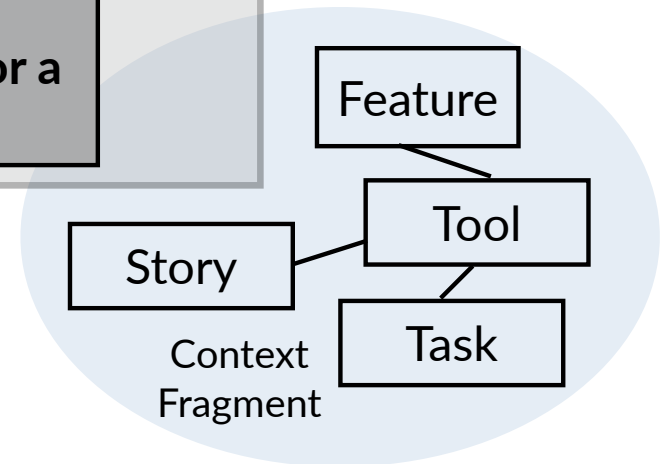
Context as Team Activity

Tasktop



Value Stream Dashboard

What is the flow time for a feature?



Kinds of Context

**Static
Artifacts**

History

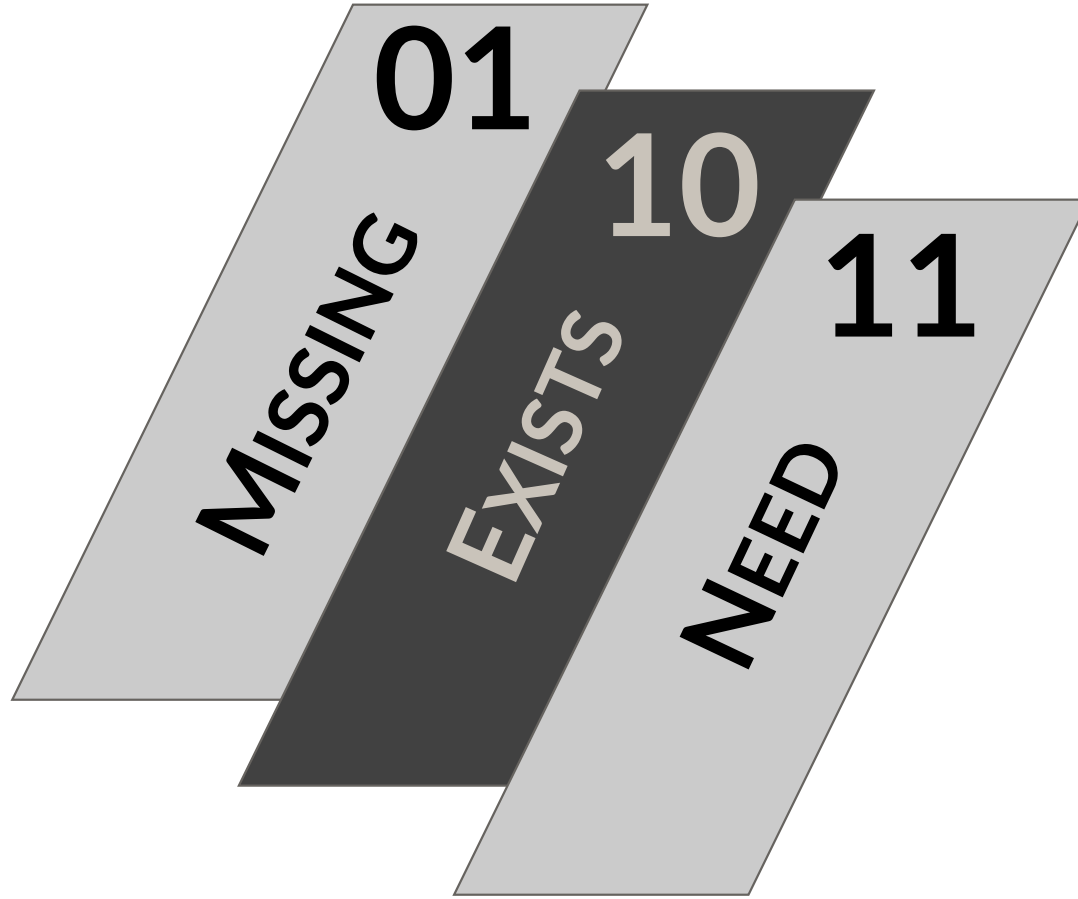
**Dynamic
Execution**

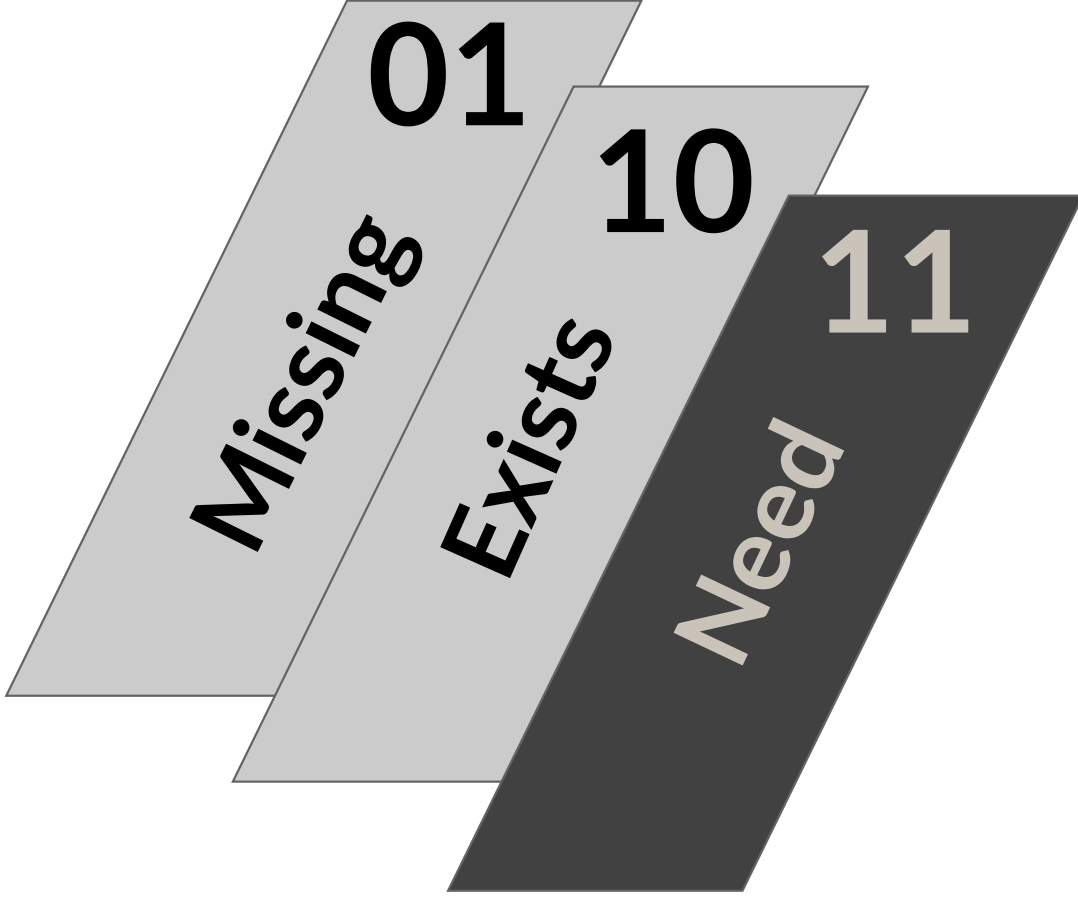
**Individual
Activity**

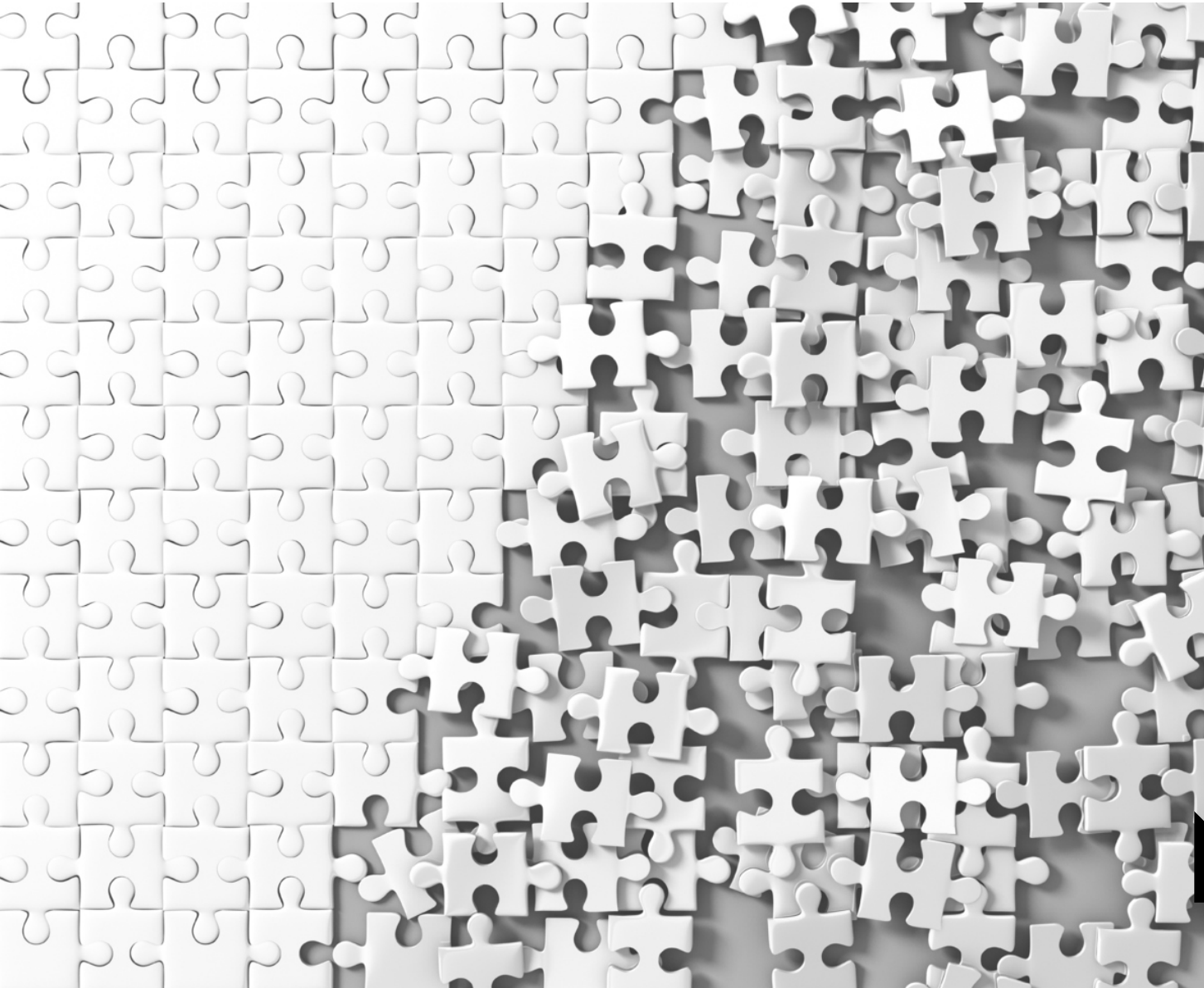
**Team
Activity**

representative
no claims of completeness

What is needed to effectively use
context
in Software Engineering?







11

What do we

NEED

in

SE to make

context

effective?

**The fundamental
need is to augment
human intelligence
not...**



Four Steps

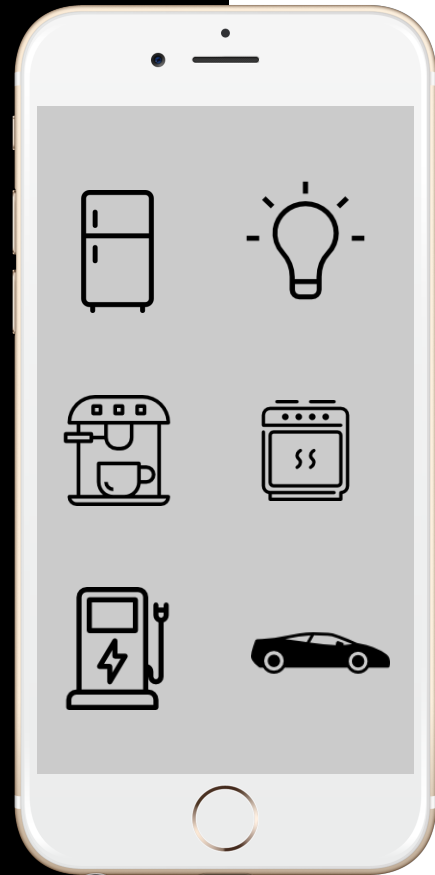
Recognize

Explain

Experiment

Build

Recognize



Context exists
in other
communities...

Papers

CHI 99 15-20 MAY 1999

**The Context Toolkit:
Aiding the Development of Context-Enabled Applications**

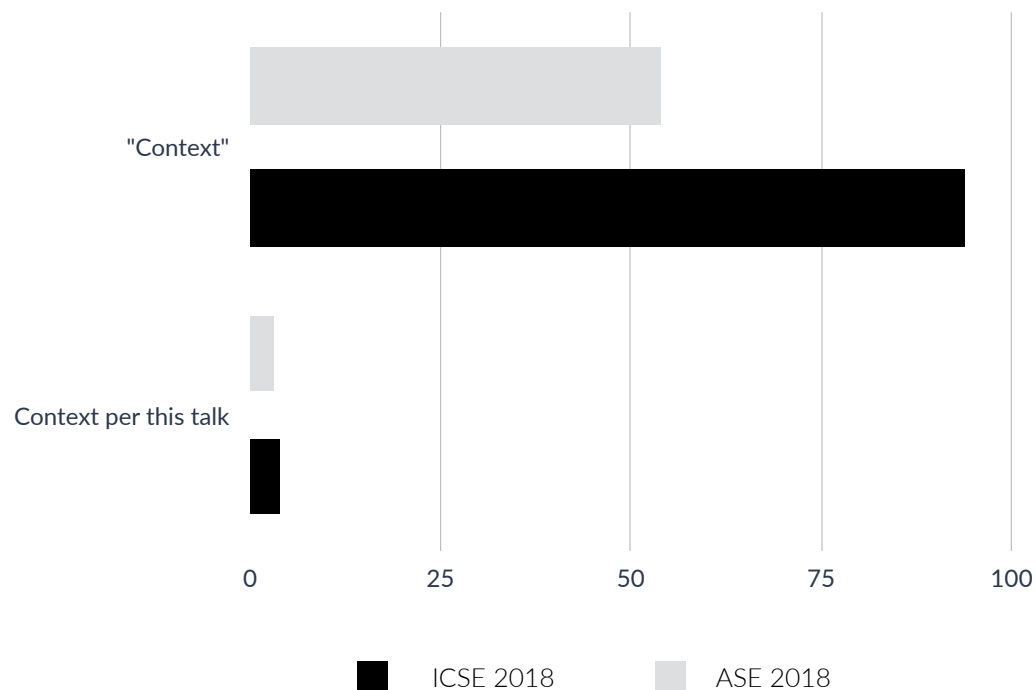
Daniel Salber, Anind K. Dey and Gregory D. Abowd

Mobile Netw Appl (2007) 12:113-127
DOI 10.1007/s11036-007-0017-1

Pervasive Healthcare and Wireless Health Monitoring

Upkar Varshney

Recognize



Paper Analysis

Approximate analysis of recent papers in major SE conferences

Most uses of "context" are in program analysis sense

Use of "context" as in this talk are rare

Explain

Who Should Fix This Bug?

John Arvik, Lyndon Hiew and Gail C. Murphy
Department of Computer Science
University of British Columbia
{jarvik, lyndonh, murphy}@cs.ubc.ca

ABSTRACT

Open source development projects typically support an open bug repository to which both developers and users can report bugs. The reports that appear in this repository must be triaged to determine if the report is one which requires attention and if it is, which developer will be assigned the responsibility of resolving the report. Large open source developments are burdened by the rate at which new bug reports appear in the bug repository. In this paper, we present a semi-automated approach intended to ease one part of this process, the assignment of reports to a developer. Our approach applies a machine learning algorithm to the open bug repository to learn the kinds of reports each developer resolves. When a new report arrives, the classifier produced by the machine learning technique suggests a small number of developers suitable to resolve the report. With this approach, we have reached precision levels of 57% and 64% on the Eclipse and Firefox development projects respectively. We have also applied our approach to the gcc open source development with less positive results. We describe the conditions under which the approach is applicable and also report on the lessons we learned about applying machine learning to repositories used in open source development.

Categories and Subject Descriptors: D.2 [Software]: Software Engineering

General Terms: Management.

Keywords: Problem tracking, issue tracking, bug report assignment, bug triage, machine learning

1. INTRODUCTION

Most open source software developments incorporate an open bug repository that allows both developers and users to post problems encountered with the software, suggest possible enhancements, and comment upon existing bug reports. One potential advantage of an open bug repository is that it may allow more bugs to be identified and solved, improving the quality of the software produced [12].

However, this potential advantage also comes with a significant cost. Each bug that is reported must be triaged to determine if it describes a meaningful new problem or enhancement, and if it does, it must be assigned to an appropriate developer for further handling [13]. Consider the case of the Eclipse open source project¹ over a four month period (January 1, 2005 to April 30, 2005) when 3426 reports were filed, averaging 29 reports per day. Assuming that a triager takes approximately five minutes to read and handle each report, two person-hours per day is being spent on this activity. If all of these reports led to improvements in the code, this might be an acceptable cost to the project. However, since many of the reports are duplicates of existing reports or are not valid reports, much of this work does not improve the product. For instance, of the 3426 reports for Eclipse, 1190 (36%) were marked either as invalid, a duplicate, a bug that could not be replicated, or one that will not be fixed.

As a means of reducing the time spent triaging, we present an approach for semi-automating one part of the process, the assignment of a developer to a newly received report. Our approach uses a machine learning algorithm to recommend to a triager a set of developers who may be appropriate for resolving the bug. This information can help the triage process in two ways: it may allow a triager to process a bug more quickly, and it may allow triagers with less overall knowledge of the system to perform bug assignments more correctly. Our approach requires a project to have had an open bug repository for some period of time from which the patterns of who solves what kinds of bugs can be learned. Our approach also requires the specification of heuristics to interpret how a project uses the bug repository. We believe that neither of these requirements are arduous for the large projects we are targeting with this approach. Using our approach we have been able to correctly suggest appropriate developers to whom to assign a bug with a precision between 57% and 64% for the Eclipse and Firefox² bug repositories, which we used to develop the approach. We have also applied our approach to the gcc repository, but the results were not as encouraging, hovering around 6% precision. We

What if...

any paper with a tool includes a section explicitly describing context?

Explain

Inputs:

Recent issue history (~>300)

Outputs:

Developer recommendations

Context

Requires:

Active developers

Provides:

<N/A>

eclipse

Bugzilla Bug 193787 Unnecessary scrollbars in preferences

Bug List: (This bug is not in your last search results) [Show last search results](#) [Search page](#) [Enter new bug](#)

[Eclipse] Bug#: 193787

Product: Platform (2) Component: UI (3) (Choose Subcomponent)

Status: NEW

Resolution:

Assigned To: Platform-UI-Inbox <Platform-UI-Inbox@eclipse.org> Target Milestone: --

Hardware: PC OS: Windows XP Version: 3.3 Priority: P3 Severity: normal

- Leave as NEW
- Accept bug (change status to ASSIGNED)
- Resolve bug, changing resolution to FIXED (1)
- Resolve bug, mark it as duplicate
- Reassign bug to (Choose Developer) Platform-UI-Inbox@eclipse.org
- Reassign bug to default assignee and QA contact of selected component

[View Bug Activity](#) | [Format For Printing](#) | [NML](#) | [Clone This Bug](#)

Description: [reply](#) **Opened:** 2007-06-21 12:51

I've noticed when I click through the preferences pages, sometimes pages have vertical scrollbars even though they don't need one. The extra scroll bar isn't too bad, but it also puts the Restore and Apply buttons off the bottom of the page (requiring a scroll), even though there is usually plenty of room.

Explain

Context-Aware Conversational Developer Assistants

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Thomas Fritz

Department of Informatics
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Reid Holmes

Department of Computer Science
University of California, Berkeley

ABSTRACT

Building and maintaining modern software systems requires developers to perform a variety of tasks. These tasks often require information sources that are not directly available to the developer. This paper describes a context-aware conversational developer assistant that can help developers with these tasks. The assistant is designed to be used in a variety of contexts, including in a code editor, a terminal, or a chat window. It can help developers with tasks such as finding code, running commands, and debugging. The assistant is designed to be context-aware, meaning it can understand the current state of the development environment and the developer's current task. This allows the assistant to provide more relevant and helpful assistance. The assistant is implemented as a chatbot that can be accessed via a web interface or a mobile app. It is currently being used by developers at the University of California, Berkeley and the University of Zurich.

Human: Devy, I'm done

Devy: You have uncommitted changes.
Should I commit them?

Human: Ok

Devy: OK, I'm about to open a pull request,
should I assign Alice?

Human: OK

Explain

Context-Aware Conversational Developer Assistants

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Reid Holmes

Department of Computer Science
University of Toronto

ABSTRACT

Building and maintaining modern software systems requires developers to perform a variety of tasks. These tasks often require information sources that are distributed across multiple systems and require

Table 2: Context Model elements.

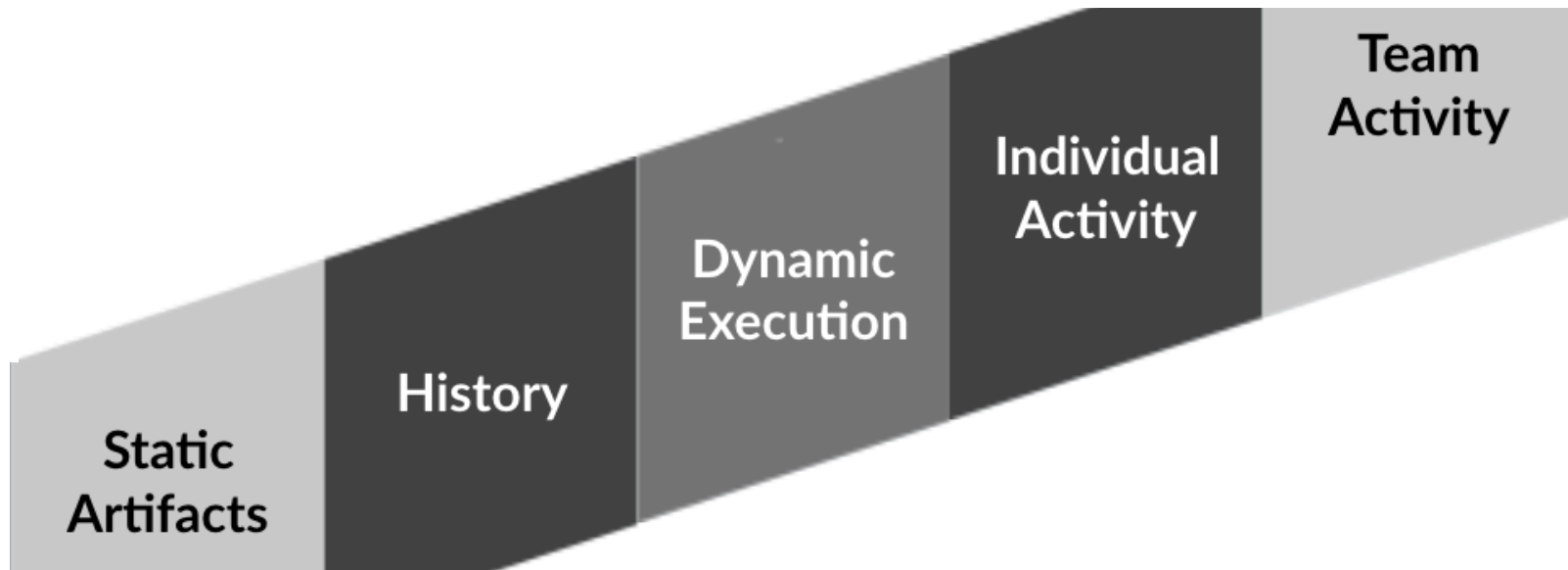
Current Focus
ActiveFile
Each Local Repository
Path
Version Control Type
OriginURL
UserName
CurrentBranch
FileStatus
Each Remote Repository
OpenAssignedIssues[]
Collaborators[]

Other Services

BlameService
TestService
ReviewerAssignmentService

Experiment

Are there other kinds of context?



Determining what context matters to a tool...

A context model for IDE-based recommendation systems



Marko Gasparic^{a,*}, Gail C. Murphy^b, Francesco Ricci^a

^aFree University of Bozen-Bolzano, Dominikanerplatz 3, 39100 Bolzano, Italy

^bUniversity of British Columbia, 201-2366 Main Mall, V6T 1Z4 Vancouver BC, Canada

ARTICLE INFO

Article history:

Received 19 September 2015

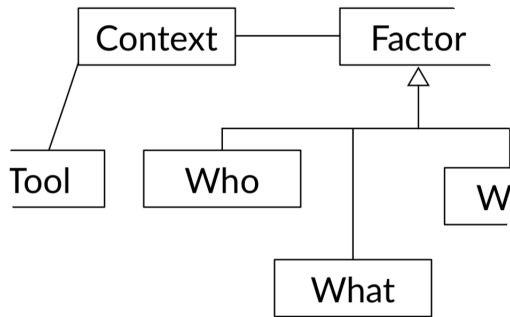
Revised 30 August 2016

Accepted 10 September 2016

ABSTRACT

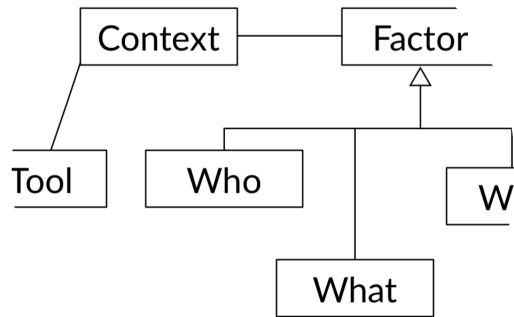
Context, as modeled through variables called contextual factors, can improve human-computer interaction. To date, in applications supporting software development, such as integrated development environments (IDEs) and recommendation systems for software engineering (RSSEs), contextual factors have

Build



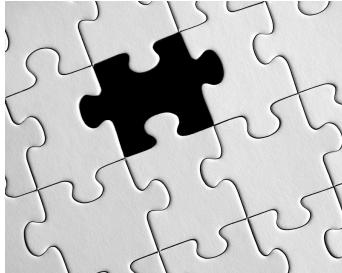
What tool/system architecture will best accommodate context?

Build



How does
context relate
to ontologies?

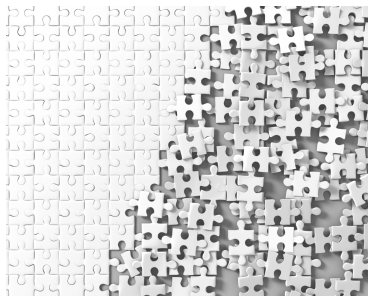
So there is lots to do....



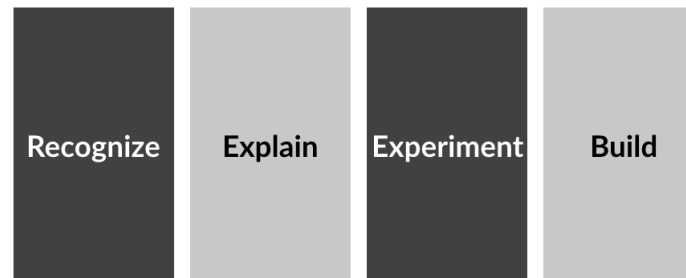
01 MISSING



10 HAVE



11 NEED

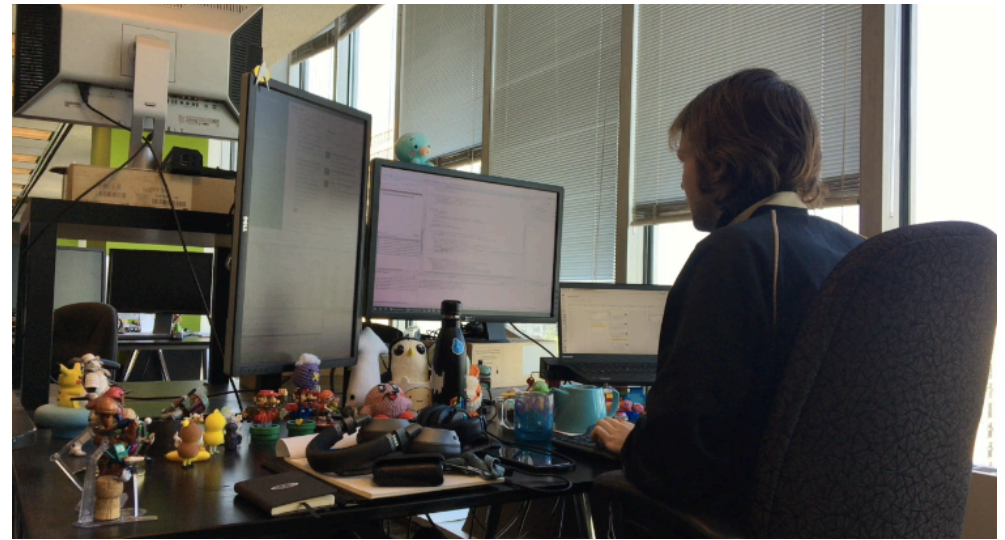




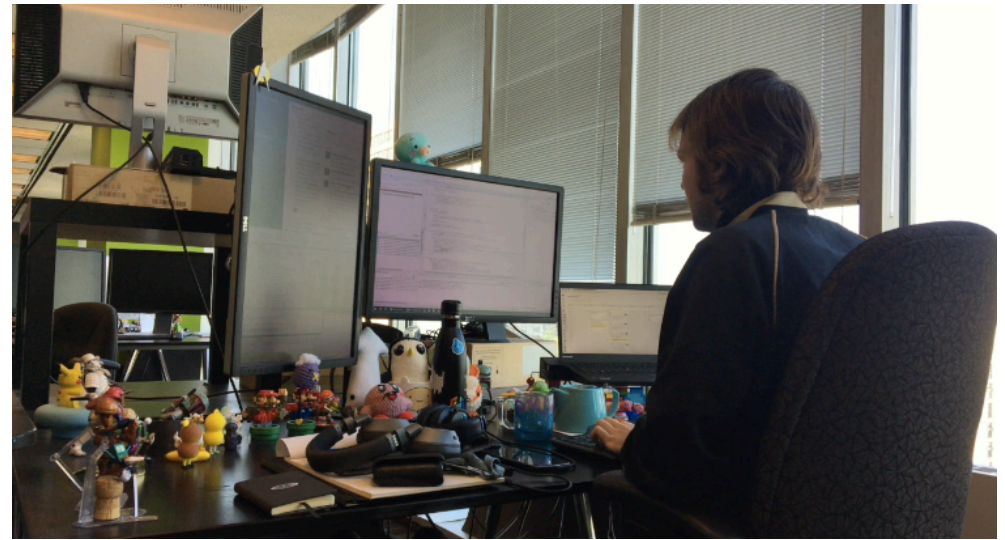
Thanks

to my fantastic academic and industrial colleagues, post-doctoral fellows, graduate and undergraduate students, to Mik Kersten and Robert Elves (my co-founders at Tasktop Technologies) and to the fantastic team at Tasktop from whom I have learned so much.

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Current tools often cause software professionals to do as much work for the tools as the tools do work for them.



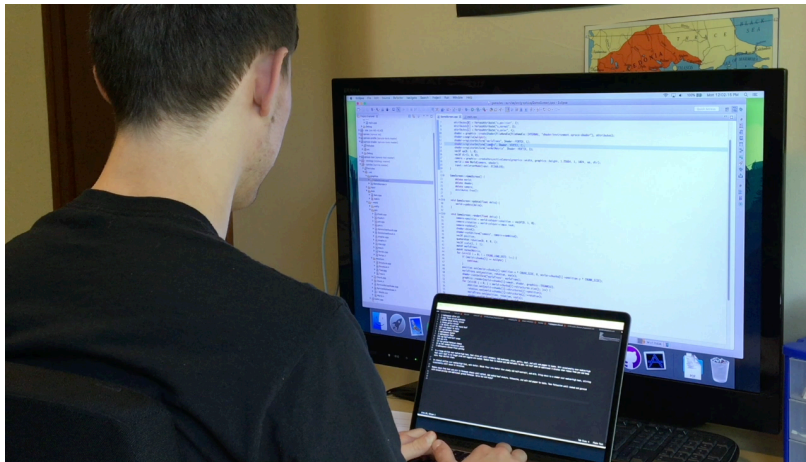
We are passing too much of the *accidental* complexity to the humans decreasing the cognitive power they have for the real problems.

We can do more to enable the humans to focus on the *essential* complexity.

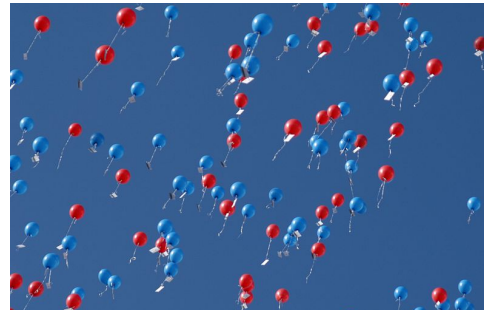


Image attribution: commons.wikimedia.org/wiki/File:Toy_balloons_red_and_blue.jpg

One possible future...



What do you imagine to help bridge the gap?



Thanks to Jason Murphy and Kieran Murphy Vancouver 2018



Software development tools are *not* amplifying human intelligence

Study, definition and use of *context* can improve the flow of software development work

@gail_murphy

