A Coding Scheme for Actual Programming Processes

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Contents

Introduction

- Actual process research: Study of what really happens during software development
  - Here: Restricted to programming = coding and related activities
- I will present a *Coding* Scheme = Language to describe what's going on
  - Interpreting videos or basic technical actions
- Aim is to...
  - provide an abstraction for reasoning
  - develop helpful measures
  - allow for discovery of behavior patterns
  - explore possible reasons for making errors

Main Example (1)

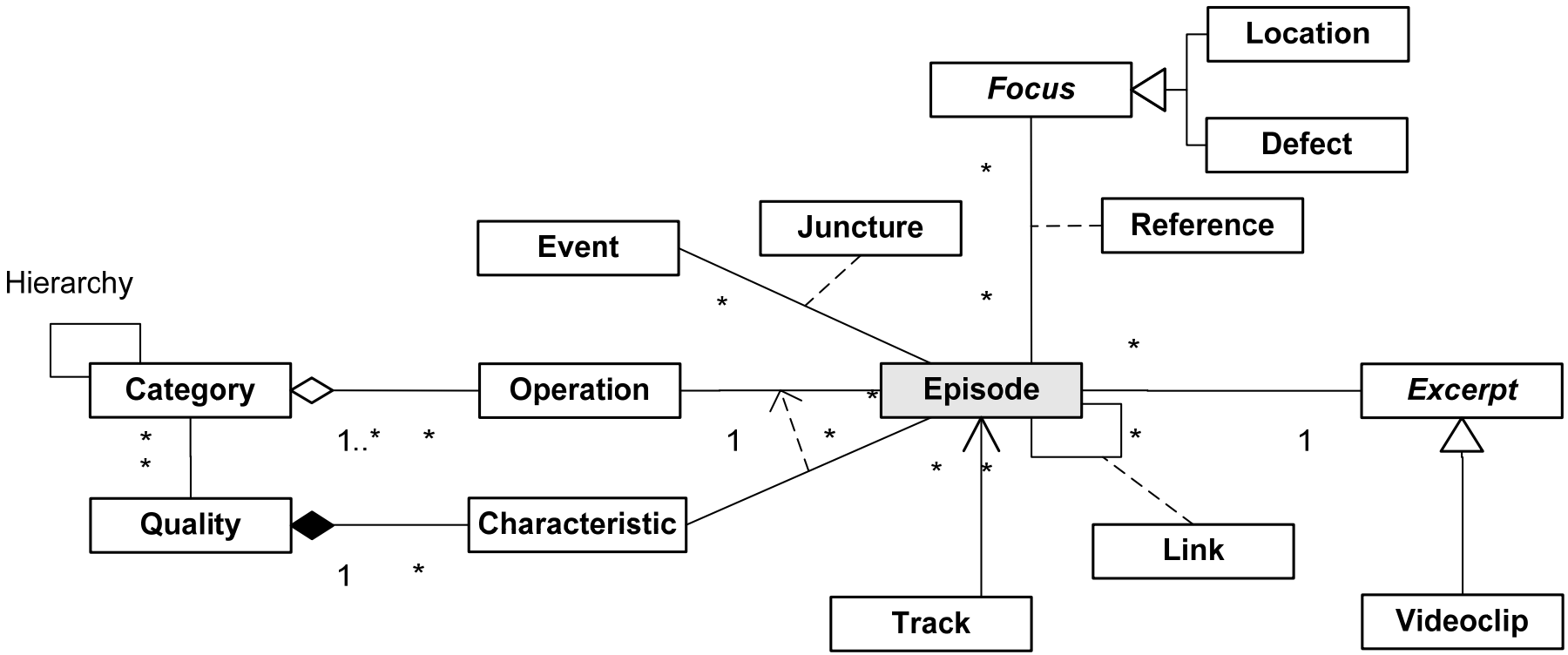
Video:

```
        ConstraintResultList res=filter(r);
        return res.getOutput().getResourcePairList().iterator();
    }

    protected static String[] emptyStringArray=new String[] {};
    public String[] getDetailsKeys() {
        return emptyStringArray;
    }
    public String[] getDetailsDescriptions(ResourcePair r) {
        return emptyStringArray;
    }
```

Basic technical actions:
cursor move, change, change, .. copy, paste, change, .. warning

Interpretation:
Programmer adds a new method called „getDetailsDescriptions“ to class „Base“ via copying previously written code and altering it afterwards. A syntactical defect has been introduced.

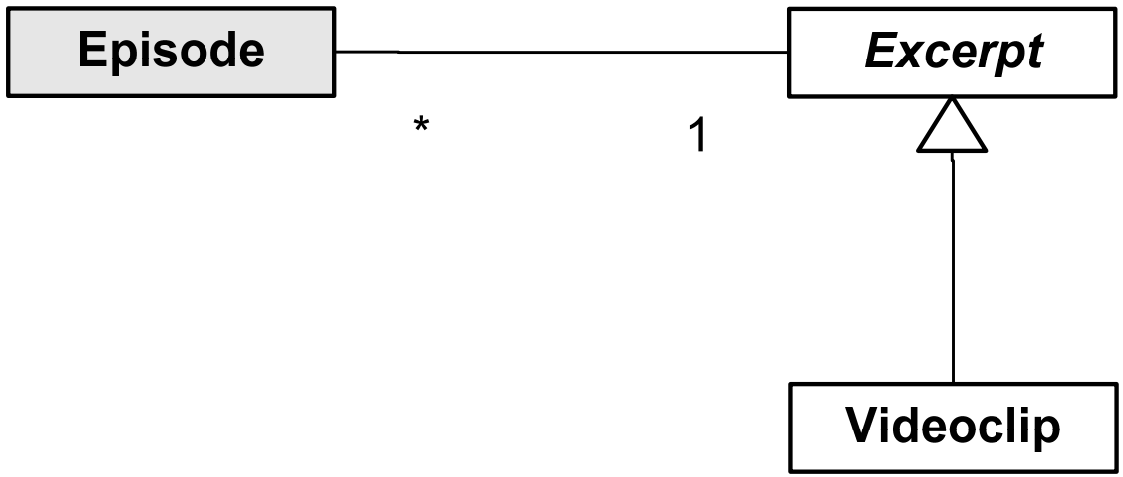
Generic model of representation



Central coding concept

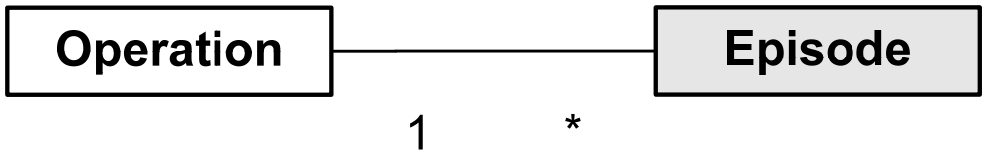
Excerpt (Ausschnitt)

- Excerpt = time frame during development where “one operation” happens
  - video clip excerpts usually contain more than one operation
- Longest possible sequence without any relevant change of situation/status
  - no influencing events, no mental state change, no new action, etc.

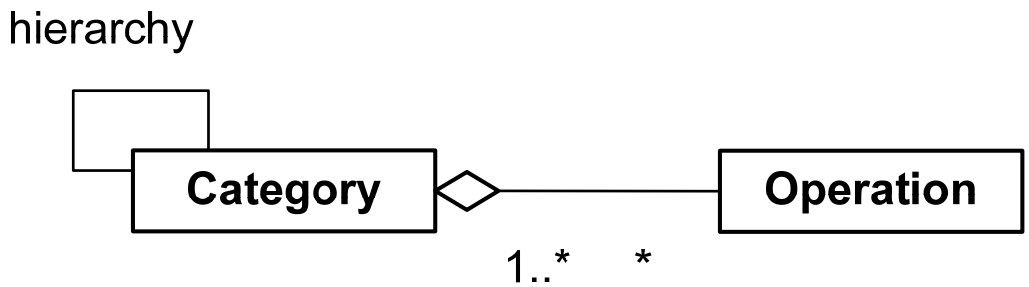


Operation (Vorgang)

- Mostly activities of the programmer
  - includes mental processes and non-actions



- Operations are classified in Categories (Kategorien)
  - which form a hierarchy
- Current high level Operation Categories:
  - Activities
  - Phases



Category „Activities“: Overview

- Core activities
  - Changing code
  - Browsing
  - Reading, Thinking, Pausing
  - Other kind of work
- Inner activities
  - Changing code sideways
  - Eye (=Cursor) movements
- Batch activities
  - Compiling
  - Executing program / Testing

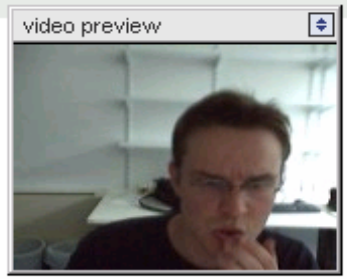
Core activities

- Changing Code:
  - Advancement, Adjustment, Betterment, Complement, Displacement, Document, Embellishment
- Browsing:
  - ForOperator, ForSignature, ForLocation, ForClass
- Reading:
  - Requirements, Reorientation, Reviewing
- Thinking:
  - AboutWhatNextToDo, AboutEvent, AboutProblem
- Pausing:
  - OtherInterest, Waiting, Indifferent
- Other kind of Working:
  - Delivering, ExplainingToOthers, PreparingData, UsingEnvironment, UsingOS, UsingProgram

Core activities, Examples (1)

- ChangingCode.Advancement -> Main Example
- ChangingCode.Complement:

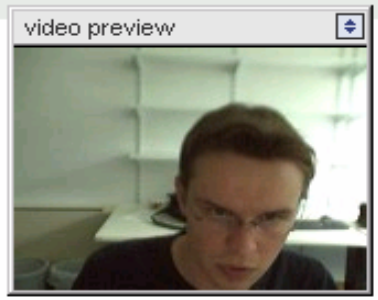
```
public void fstPass(Vector Words)
{
    for (int i=0; i<Words.size(); i++)
    {
        for (int j=i; j<Words.size(); j++)
        {
            String w1 = (String) Words.elementAt(i);
            String w2 = (String) Words.elementAt(j);

            if (w1.indexOf(w2)!=-1)
                Words.remove(w2);
        }
    }
}

public void sndPass(Vector Words)
{
    for (int i=0; i<Words.size(); i++)
    {
        for (int j=i; j<Words.size(); j++)
        {
            String w1 = (String) Words.elementAt(i);
            String w2 = (String) Words.elementAt(j);

            if (w1.indexOf(w2)!=-1)
                Words.remove(w2);
        }
    }
}
```



Core activities, Examples (2)

- ChangingCode.Betterment:

```
public void fstPass(Vector Words)
{
    for (int i=0; i<Words.size(); i++)
    {
        boolean bContinue=true;

        while (bContinue)
        {
            for (int j=i; j<Words.size(); j++)
            {
                String w1 = (String) Words.elementAt(i);
                String w2 = (String) Words.elementAt(j);

                if (w1.indexOf(w2)!=-1)
                {
                    Words.remove(w2);
                    bContinue = true;
                    break;
                }
            }
        }
    }
}

public void sndPass(Vector Words)
{
    for (int i=0; i<Words.size(); i++)
    {
        for (int j=i; j<Words.size(); j++)
```



Inner and Batch activities

Inner activities:

- Code Changing by the way
  - Tag-Along, Re-Spell, Work-Over, Dust-Off, Hold-On, Plan-Aloud, Look-Up, Spruce-Up
- Browsing by the way:
  - Cursor Moving, Scrolling, Selecting

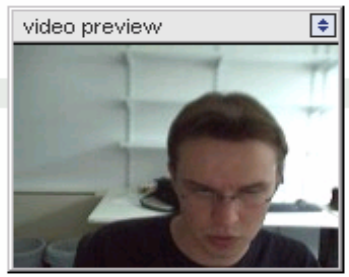
Batch activities:

- Compile, Build
- Run, Debug

Inner activities, Examples

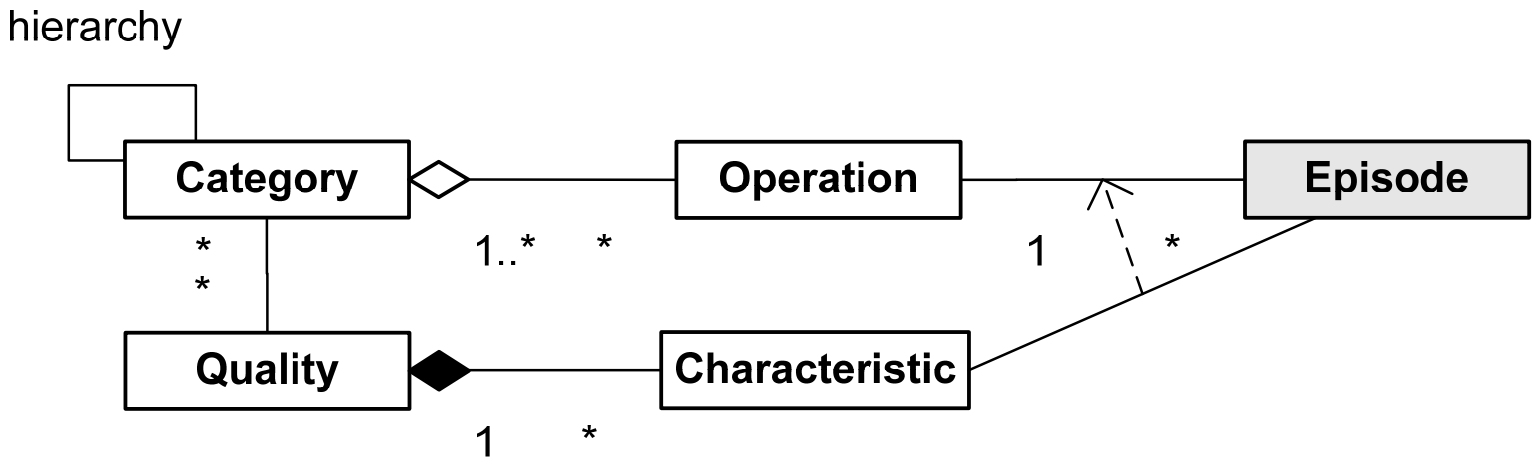
- Re-Spell + Tag-Along:
- Thinking.AboutProblem includes Plan-Aloud:

```
public void fstPass(Vector Words)
{
    for (int i=0; i<Words.size(); i++)
    {
        boolean bContinue=true;

        while (bContinue)
        {

            bContinue=true;
            for (int j=i; j<Words.size(); j++)
            {
                String w1 = (String) Words.elementAt(i);
                String w2 = (String) Words.elementAt(j);

                if (w1.indexOf(w2)!=-1)
                {
                    Words.remove(w2);
                    break;
                }

                bContinue = false;
            }
        }
    }
}

public void sndPass(Vector Words)
{
```



Quality (Eigenschaft) and Characteristic (Ausprägung) (1)

- Operations have optional Qualities
  - inherited from Category
  - which itself inherits from its Super-Category
- Episodes have Characteristics
  - based on Operation's Qualities



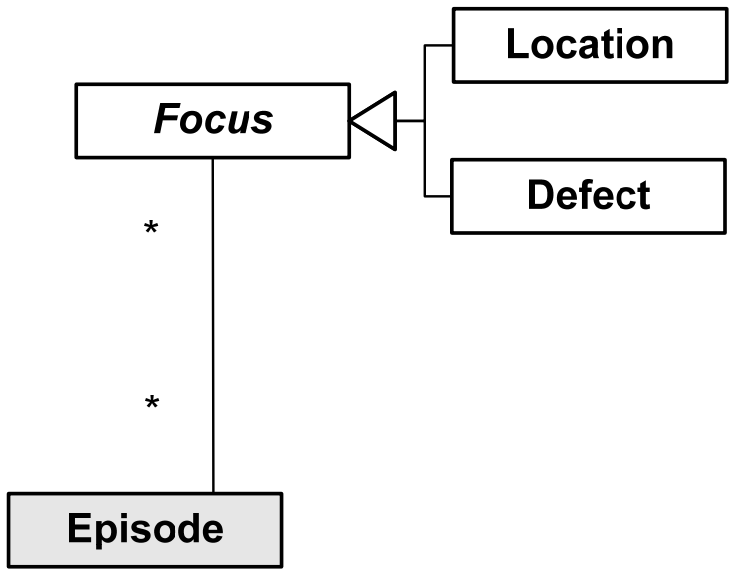
Quality (Eigenschaft) and Characteristic (Ausprägung) (2)

- Examples for Qualities/Characteristics:
  - Source (for Code changes)
    - BrainDump, CopyPaste, TypeWrite
  - Speed (for Core Activities)
    - Slower, Faster
  - Finish (for Code changes)
    - LeavesUncomplete, LeavesOpen
  - Pressure (for Activities)
    - Higher

- *Legend:*
  - Quality (for Category)
    - Characteristics of this Quality

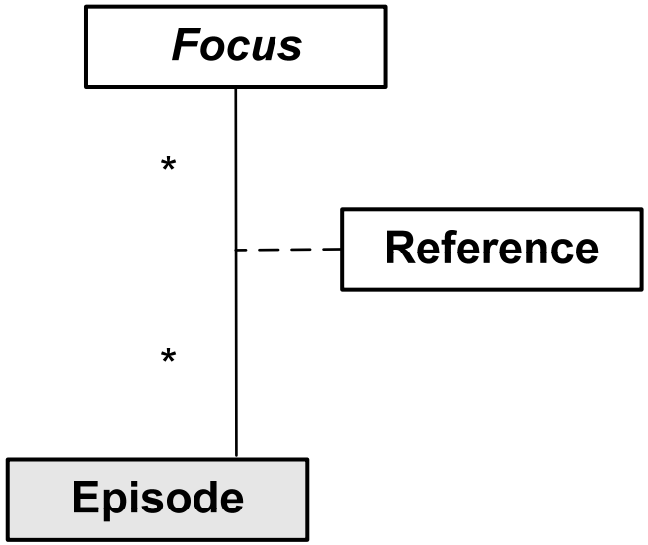
Focus (Fokus)

- Object which the Operation refers to
  - (Code-)Location
  - Defect (semantic, syntactic)
  - others will likely be added
- One Operation may relate to different Foci



Reference (Bezug)

- ... for Locations:
  - creates, changes/corrects, discards, documents/explains, extends, copies
- ... for Defects:
  - introduces, detects, resolves



Focus/Reference/Quality/ Characteristic Example

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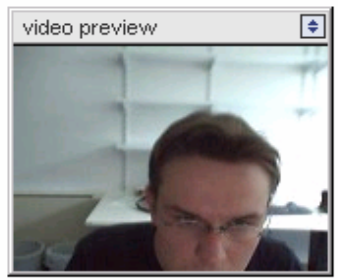
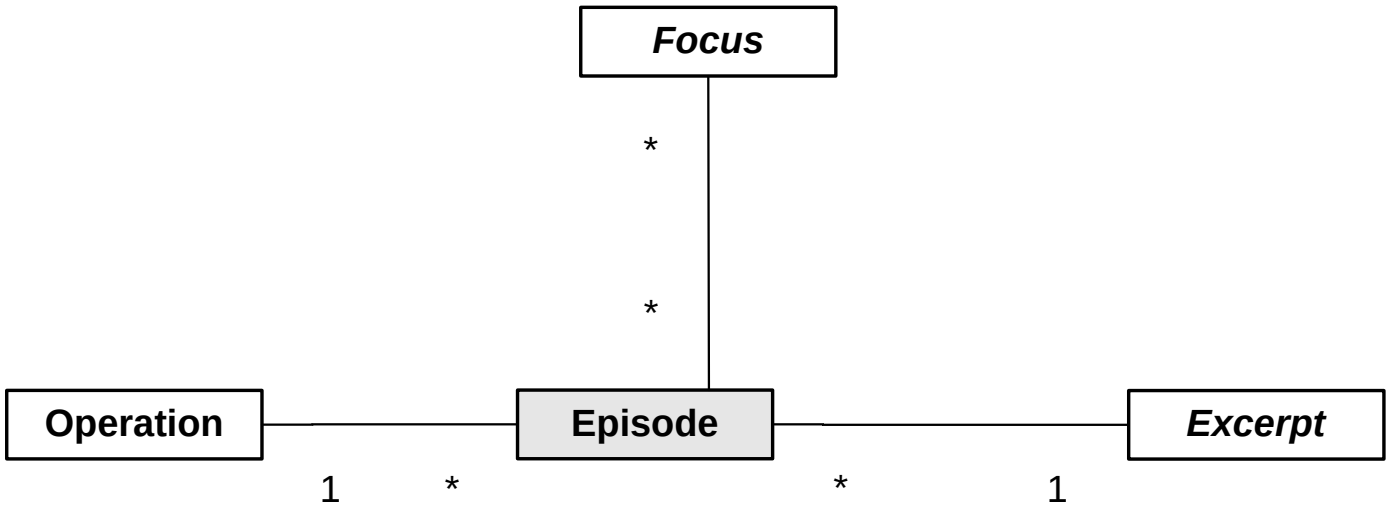
- ChangingCode.Complement {Speed=Slower} changes fstPass(), creates SemanticDefect#1:

```
public void fstPass(Vector Words)
{


    for (int i=0; i<Words.size(); i++)
    {
        boolean bContinue=true;

        while (bContinue)
        {
            for (int j=i; j<Words.size(); j++)
            {
                String w1 = (String) Words.elementAt(i);
                String w2 = (String) Words.elementAt(j);

                if (w1.indexOf(w2)!=-1)
                {
                    Words.remove(w2);
                    j--;
                }
            }
        }
    }
}

public void sndPass(Vector Words)
{
    for (int i=0; i<Words.size(); i++)
    {
```



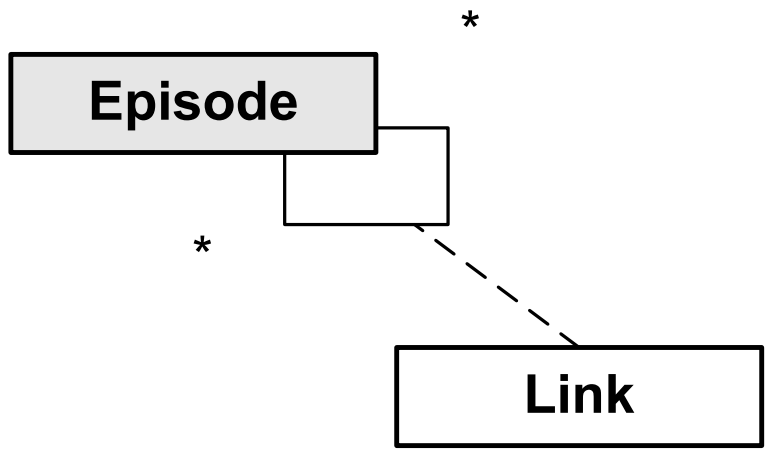
Episode (Episode)

- Connection of Operation and Excerpt
  - with optional Reference to a Focus of Operation
- Should an Excerpt have only one Episode?
  - or: is Excerpt reusable?
- Capturing the actual process = Recognizing Episodes, i.e. Operations in Excerpts



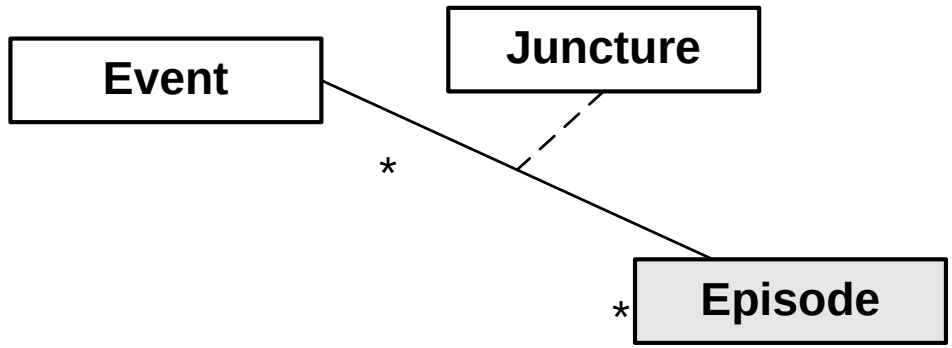
Link (Verknüpfung)

- Operations may resume other Operations
  - telling a story without interruptions and other parallel activities
  - often in Reference to the same Focus
- Currently only:
  - resumes
  - contains?



Event (Ereignis)

- Event = impact on programmer's behavior
  - from outside
    - probably as an effect of her own activity
  - at a point of time
- Examples:
  - Interruptions
  - Result of compilation
  - Result of test

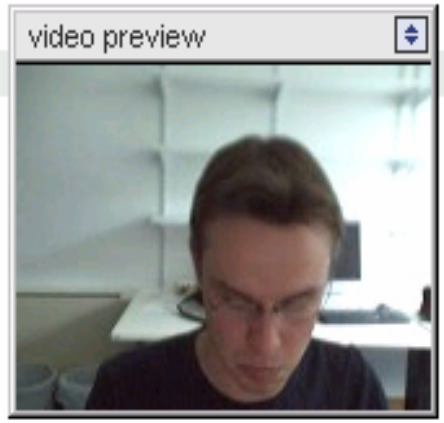


- Juncture (Punkt):
  - „Beginning", „End", „In Between" of an Excerpt

Event Example

- ChangingCode.Advancement {Finish = LeavesOpen} changes sndPass() | Interruption:

```
public void sndPass(Vector Words)
{
    for (int i=0; i<Words.size(); i++)
    {
        if (Words.size()<=i) break;

        for (int j=i; j<Words.size(); j++)
        {
            if (Words.size()<=j) break;

            String w1 = (String) Words.elementAt(i);
            String w2 = (String) Words.elementAt(j);
```

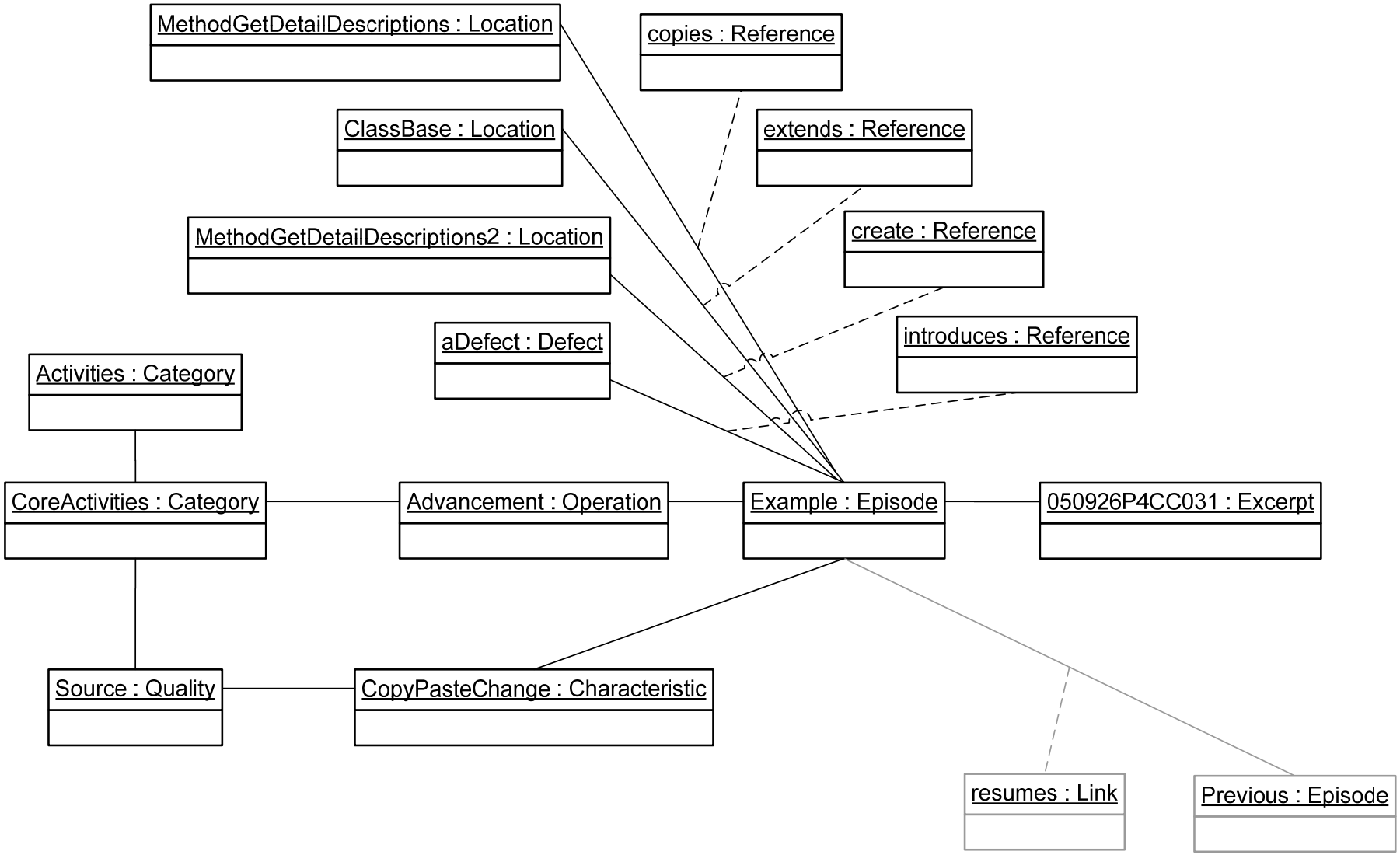


Main Example (2)

- ChangingCode.Advancement {Source = CPC} extends Base, creates getDetailsDescriptions2, copies getDetailsDescriptions, introduces aDefect:

```
        ConstraintResultList res=filter(r);
        return res.getOutput().getResourcePairList().iterator();
    }

    protected static String[] emptyStringArray=new String[] {};
    public String[] getDetailsKeys() {
        return emptyStringArray;
    }
    public String[] getDetailsDescriptions(ResourcePair r) {
        return emptyStringArray;
    }
```

Main Example (3)



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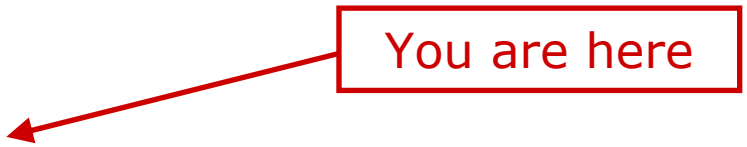

Model, Schema, Actual processes

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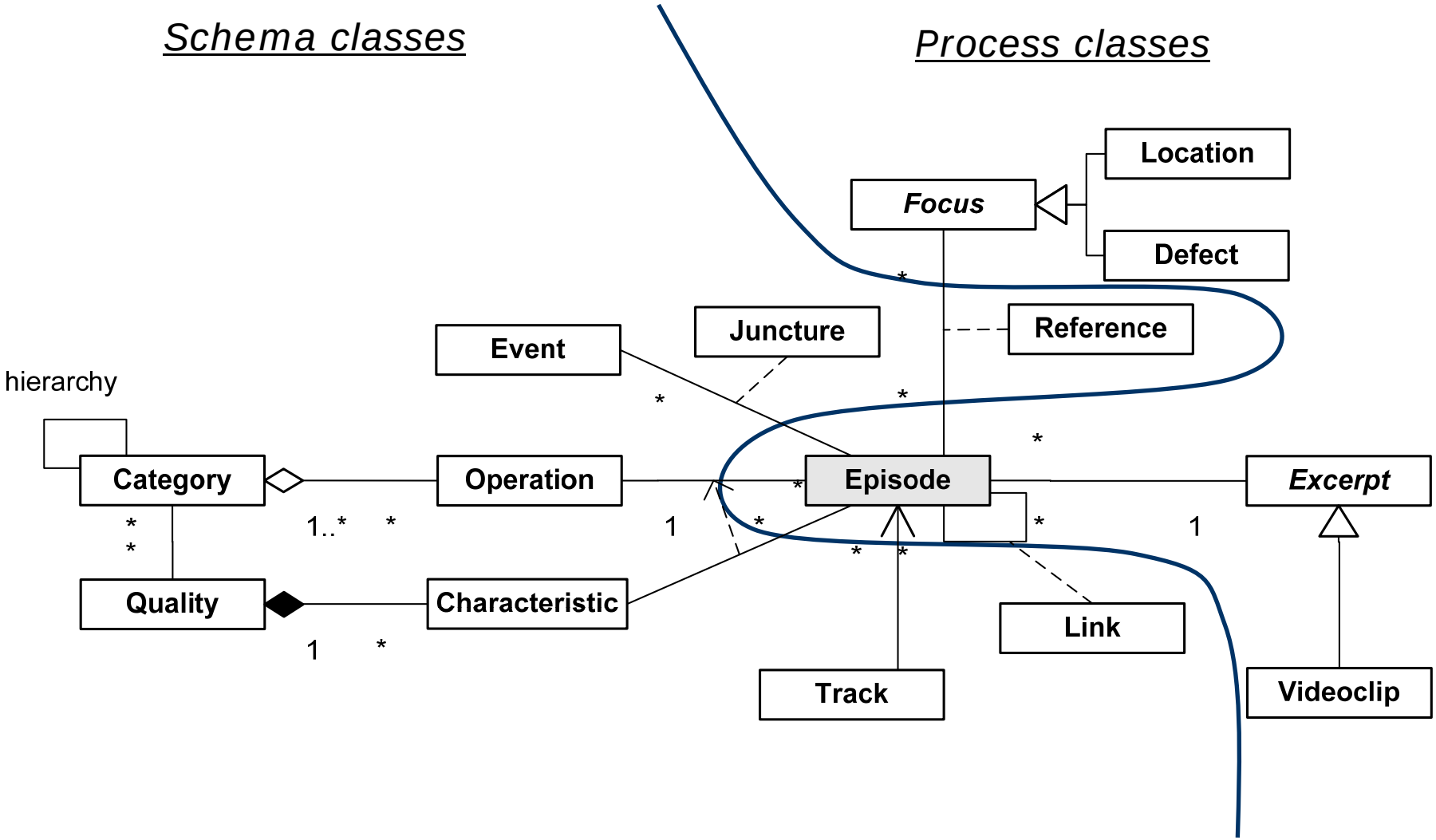
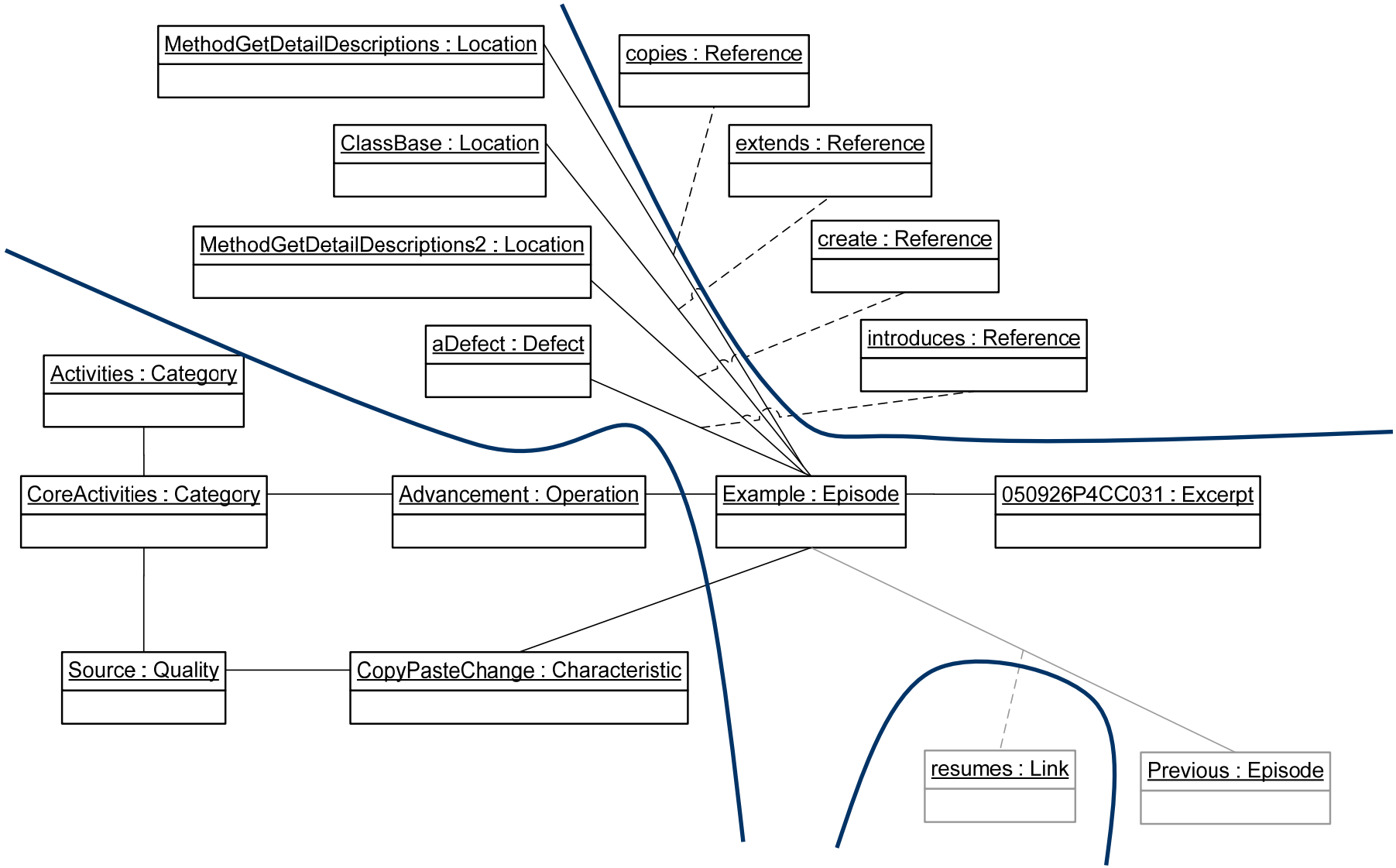
- Model: Contains general, constant concepts (grammar) about work episodes
- Schema: Contains potentially existent concepts for describing programming (vocabulary)
  - Objects of classes Operation, Event, Category, Property, Characteristic, Reference, Link
  - and Associations between them
  - will be extended with further insight
- Actual process: Contains concepts of an observed programming session (sentences)
  - Objects of classes Episode, Focus, Excerpt
  - and its associations among each other, Events and Operations

Generic Model, revisited



Example, revisited



Capturing the actual process

1. On the lowest level, actual processes are streams of basic technical events
   - File change, clicking Run, etc.
2. Group events to excerpts = time frames
   - Events are not necessarily in one consecutive row
   - But still without status changing during the episode
3. Assign Excerpt an Interpretation as an Operation
   - leading to an Episode
4. Add Foci and Links

- "Process Disassembling": It's like reconstructing the chicken out of the chicken soup!
- Can it be done automatically?

Comparison with Stephan's model

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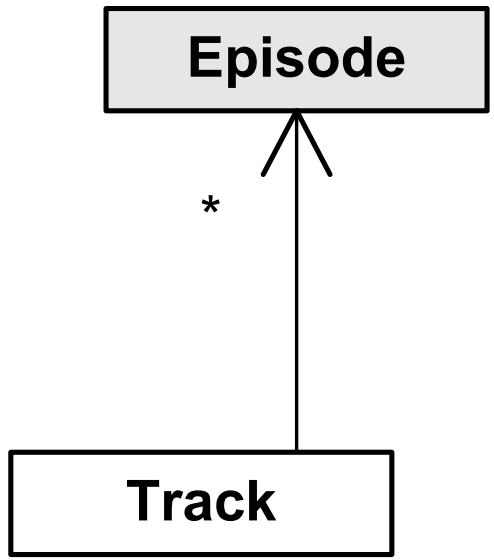
- Episode = Annotation
- Operation ≤ Concept, Category = Concept Class
- Excerpts may contain different Concepts
- Properties, Characteristics and Events are Concepts
  - of Classes "Properties", "Characteristics" and "Event"
- Foci (Locations, Defects) are Excerpts as well
  - which do have a range, but not necessarily in time
  - Links and References become synonyms
- Multiplicities of associations change accordingly
- Stephan's model contains no concept class hierarchy
  - but Inheritance of Annotations, Primary annotations
  - and Concepts in more than one Classes

➢ Stephan's model is more suitable for manual annotation

Contents

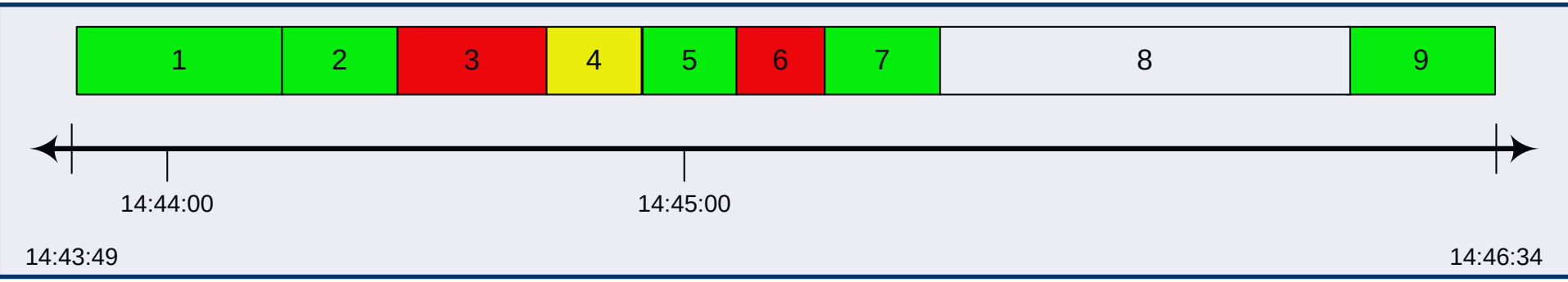
Visualization: Track (Spur)

- Tracks is view/filter/selection of Episodes, i.e. parts of the actual process
- Visualization = showing Tracks
- Selection criteria are Episode's attributes, i.e.
  - Excerpt (i.e. time, people, project)
  - Operation (out of Categories)
  - Reference (to Focus)
  - Link (to other Episodes)
  - Characteristics

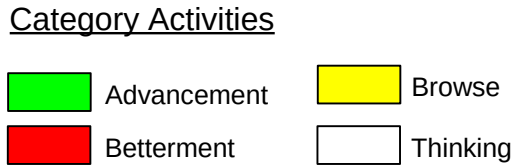


Visualization: Example (1)

- First example of a Track:

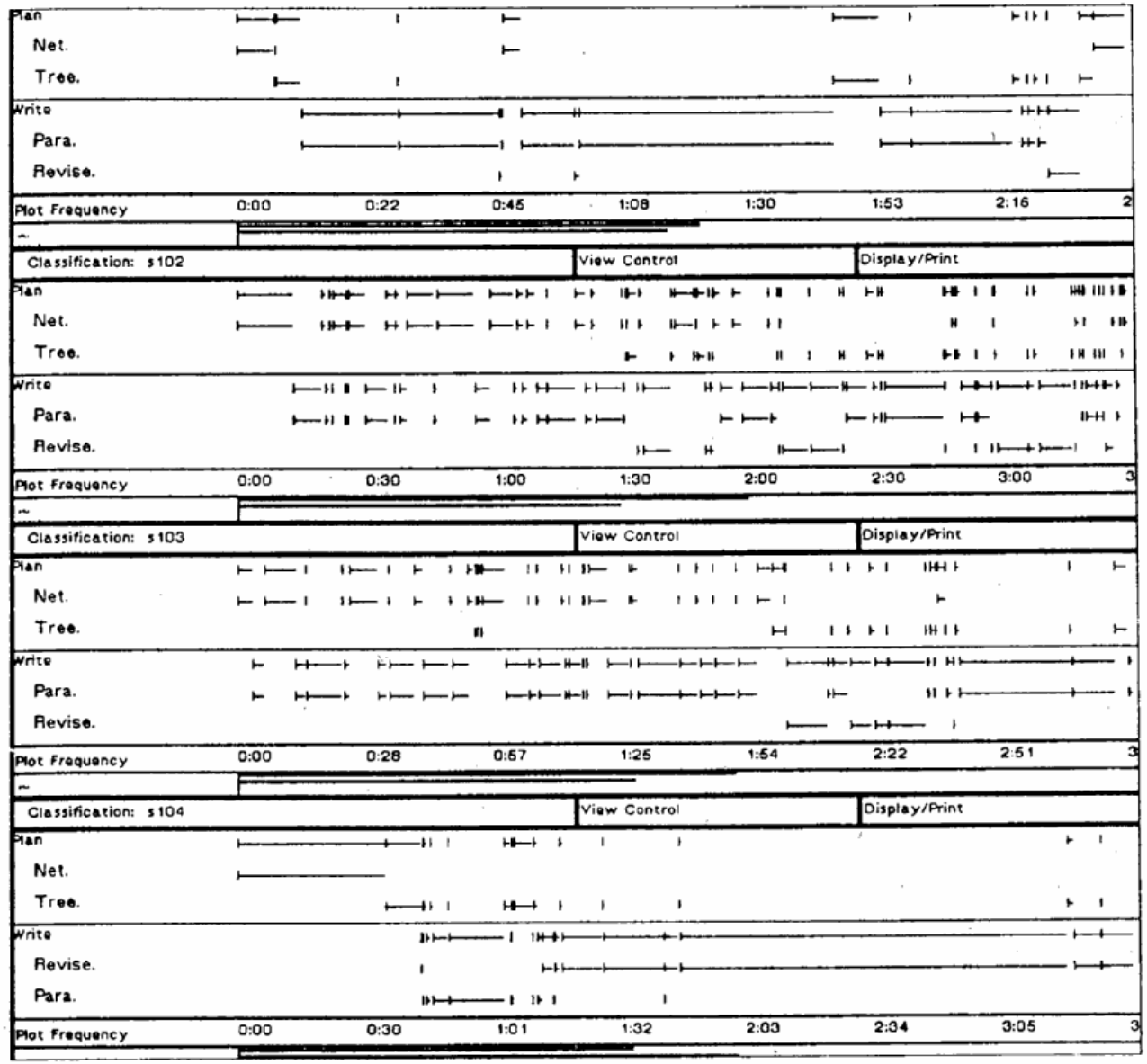


- Legend:



- Missing: 1 introduces defect and creates location, 5 leaves location open, 8 includes cursor moving, etc.
- 9 is main example

Figure 7. **Abbreviated events-time displays for four subjects, permitting comparison of their different planning and writing strategies.**



from **Smith**, John B., **Smith**, Dana K., Kupstas, Eileen (**1993**): Automated Protocol Analysis. In **Human-Computer Interaction**, 8 (2), pp. 101-145

Creating a visualization

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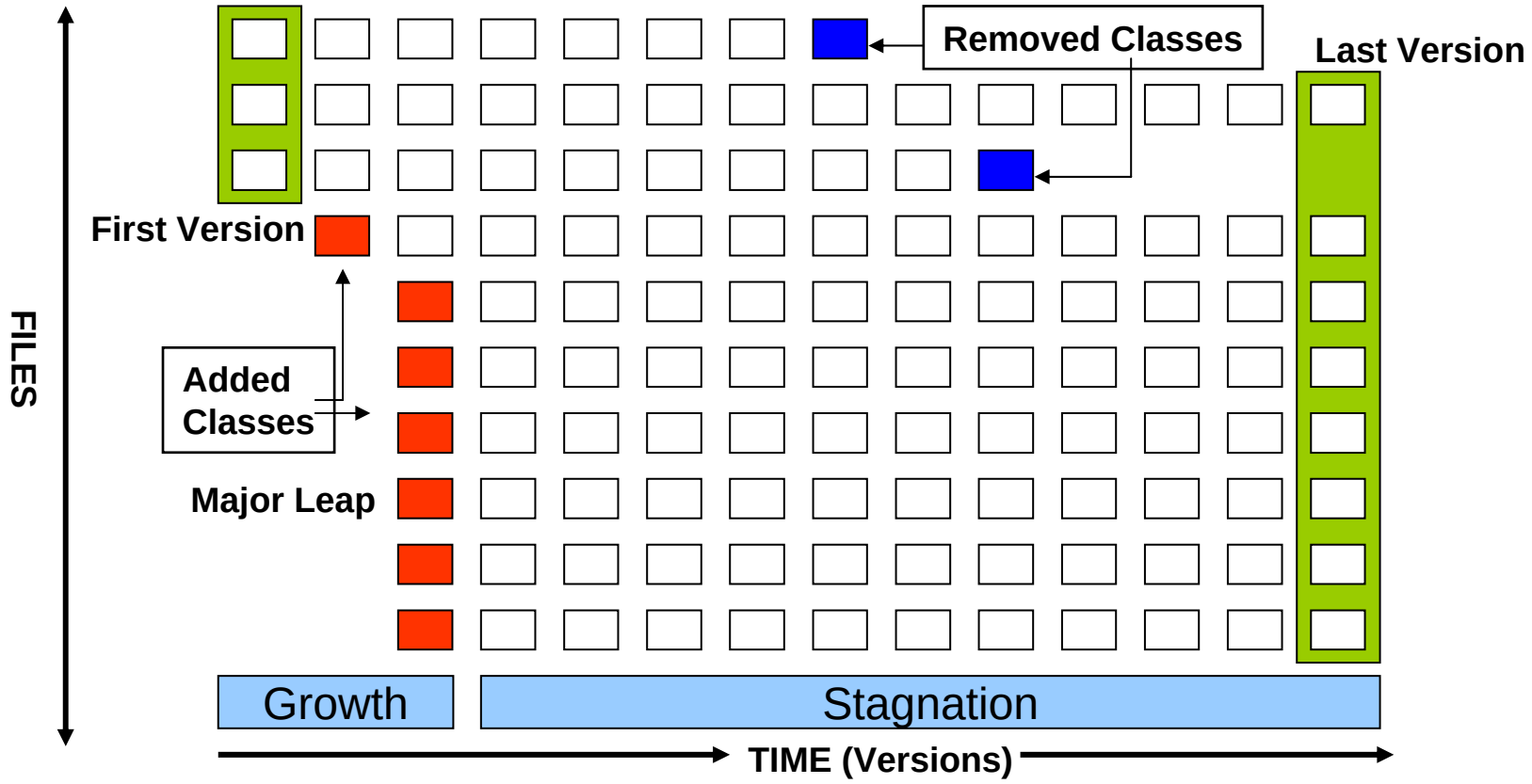
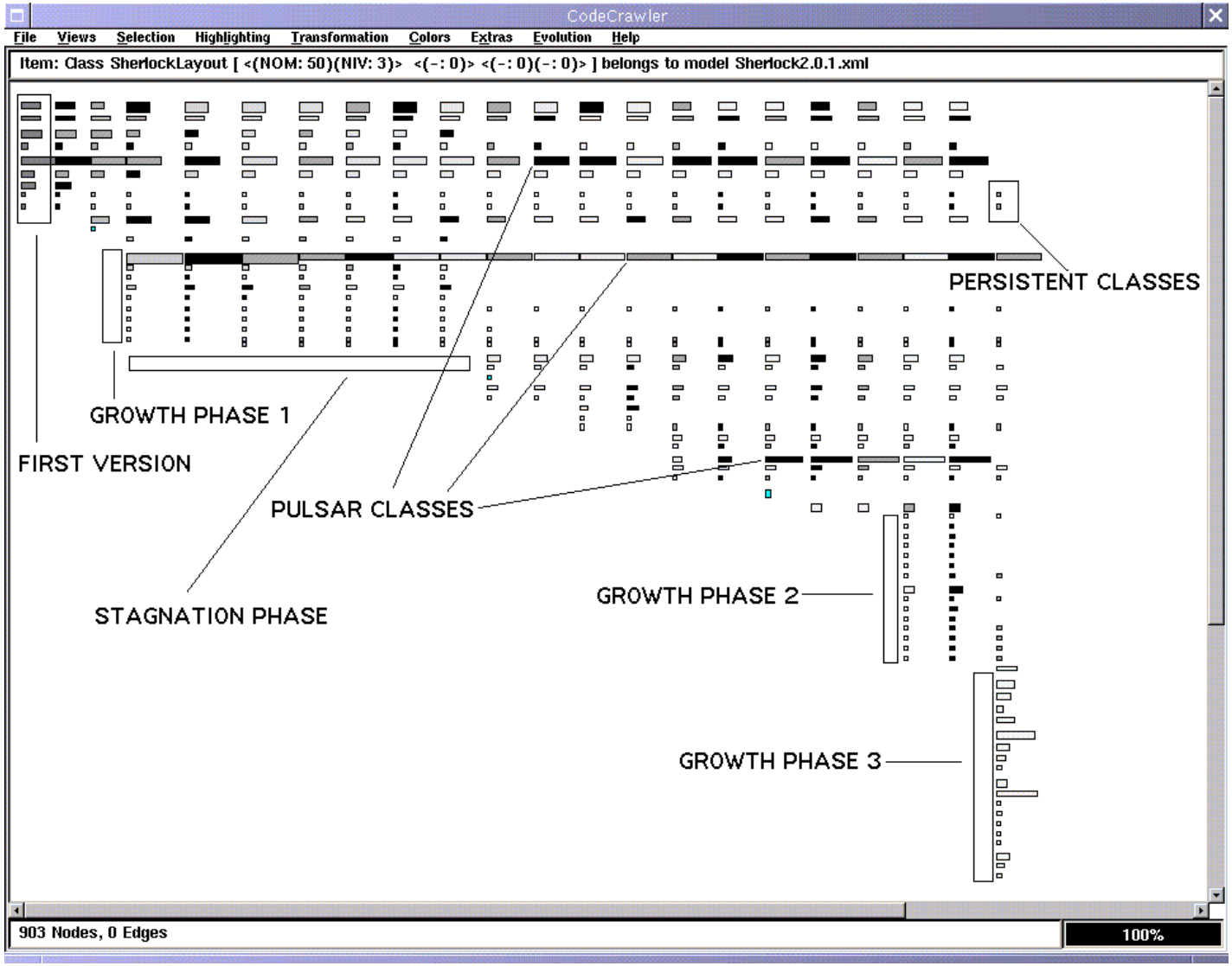
1. Selection = Define Track (i.e. set of Episodes)
2. Projection = Choose attributes to be displayed
3. Decoration = Specify how to display the attributes
   - i.e. type of view
     - Bars (height/width), Text, Colors (Base + Brightness), Texture, Symbols, etc.
   - ... of each dimension
     - Characteristics, Activity, Excerpt length, etc.
4. Repetition = Different Tracks can be viewed one below the other
   - for similar time frame
   - especially different projections for the same selection

Related work: Evolution Matrix (1)

- What about Foci? Idea: A Track per Focus.
- Similar design: Evolution Matrix

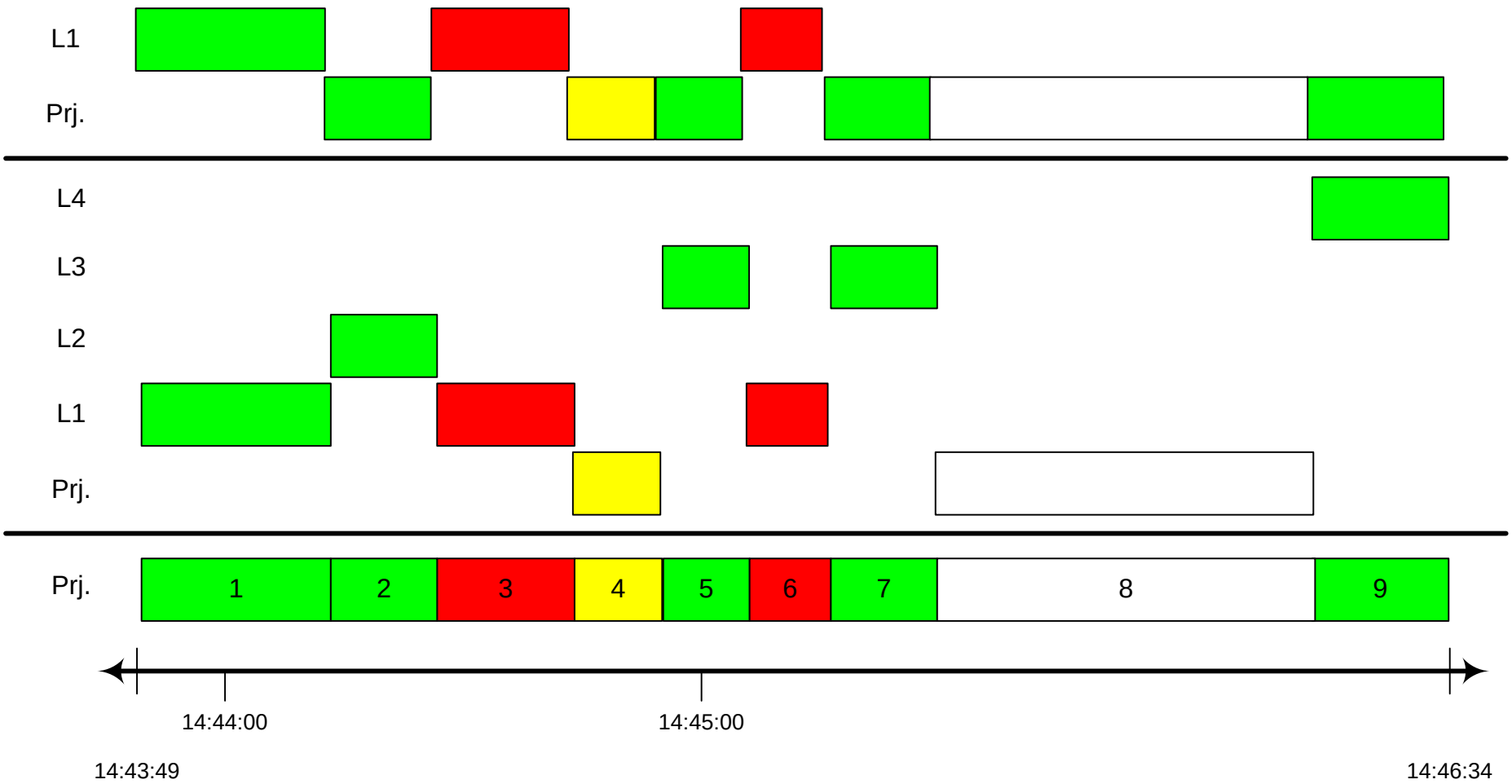


Related work: Evolution Matrix (2)



from:
Michele Lanza:
The Evolution Matrix:
Recovering Software Evolution using Software Visualization Techniques, 2001

Visualization Example (2)



Thank you!