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Can Clone Detection Support Quality Assessment of Requirements Specifications?

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Motivation

- Requirements specifications pivotal in many projects
- Read by many stakeholders – their quality is important
- IEEE 830-1998: “Modifiability generally requires a requirements specification to […] not be redundant”
- Reviews or inspections employed to assure their quality

Our Experience:

- Some reviews discovered substantial duplication
- Difficult to find manually; can we improve it?

Agenda

Clone Detection

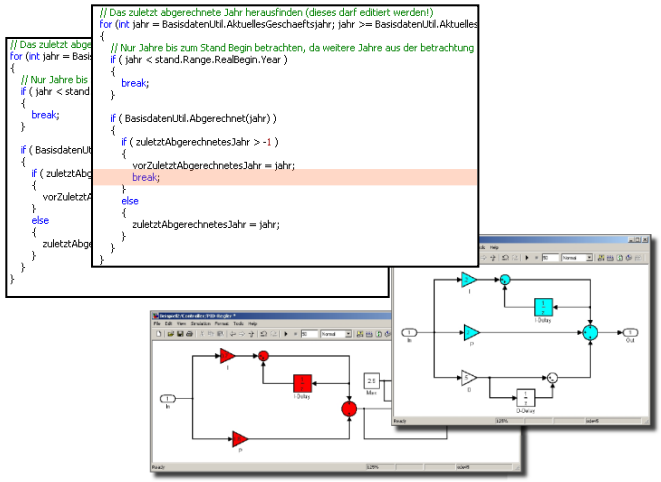
Study Results & Discussion

Detection Approach

Software Cloning

Cloning

- Regions of duplicated code or models
- Mature clone detection tools exist

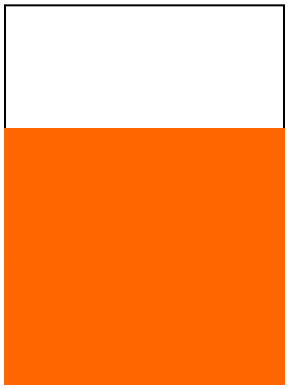


Consequences of Cloning

- Size Increase
- Modification Effort Increase
- Errors through inconsistent modifications

Cloning Measures

- Clone Coverage 66%
- Blow-Up 50%



Terms

Requirements Specification [IEEE 830-1998]:

“specification for a particular software product, program, or set of programs that performs certain functions in a specific environment.”

Clone

- Duplicated specification text of at least 20 words.
- Small differences (e.g. declination) are tolerated
- Must refer to specified system.
- False positives: e.g. page footers with copyright information

Research Questions

RQ1: How much cloning do requirements specifications contain?

RQ2: What kind of information is cloned in requirements specifications?

RQ3: What consequences does cloning in requirements specifications have?

RQ4: Can cloning in requirements specifications be detected accurately using existing clone detectors?

Out of Scope: Reasons for cloning or clone avoidance

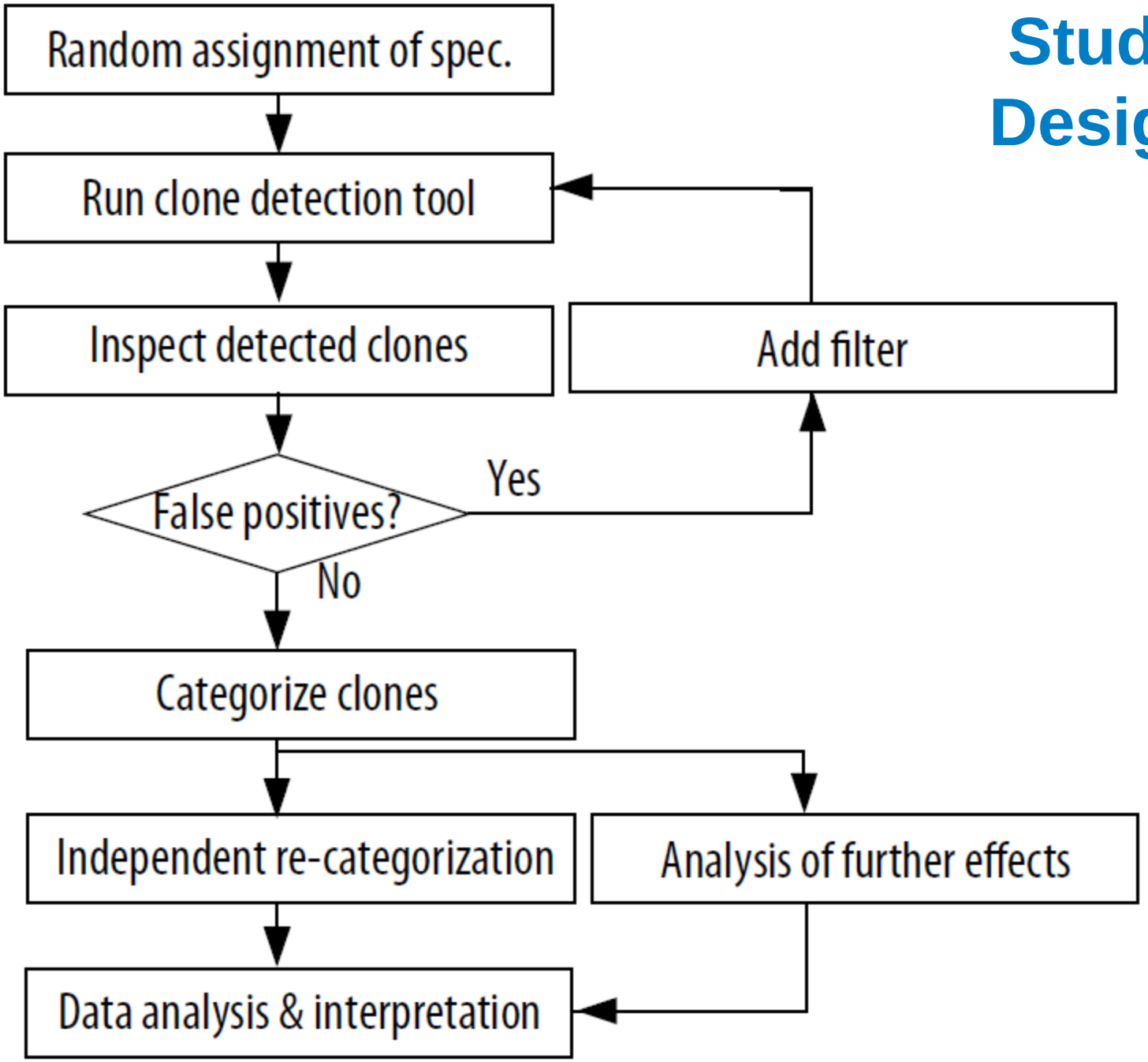
Study Objects

- 28 industrial specs
- English & German
- Domains:

  administration, automotive, convenience, finance, telecommunication, transport
- 11 companies

	Pages	Words		Pages	Words
A	517	41,482	O	184	18,750
B	1,013	130,968	P	45	6,977
C	133	18,447	Q	33	5,040
D	241	37,969	R	109	15,462
E	185	37,056	S	144	24,343
F	42	7,662	T	40	7,799
G	85	10,076	U	n/a	43,216
H	160	19,632	V	448	95,399
I	53	6,895	W	211	31,670
J	28	4,411	X	158	19,679
K	39	5,912	Y	235	49,425
L	535	84,959	Z	n/a	13,807
M	233	46,763	AB	3,100	274,489
N	n/a	103,067	AC	696	81,410
Σ				8,667	1,242,765

Study Design



RQ1: Extent of Cloning

	Pages	Clone cov.	Clone groups	clones	blow-up relative	blow-up words
A	517	35.0%	259	914	32.6%	10,191
B	1,013	8.9%	265	639	5.3%	6,639
F	42	51.1%	50	162	60.6%	2,890
G	85	22.1%	60	262	20.4%	1,704
H	160	71.6%	71	360	129.6%	11,083
O	184	1.9%	8	16	1.0%	182
P	45	5.8%	5	10	3.0%	204
Q	33	0.0%	0	0	0.0%	0
R	109	0.7%	2	4	0.4%	56
S	144	1.6%	11	27	0.9%	228
T	40	0.0%	0	0	0.0%	0
U	n/a	15.5%	85	237	10.8%	4,206
AB	3,100	12.1%	635	1818	8.7%	21,993
Avg		13.6%			13.5%	
Σ			2,631	7,669		100,178

RQ1: Extent of Cloning (4)

Typical Clones

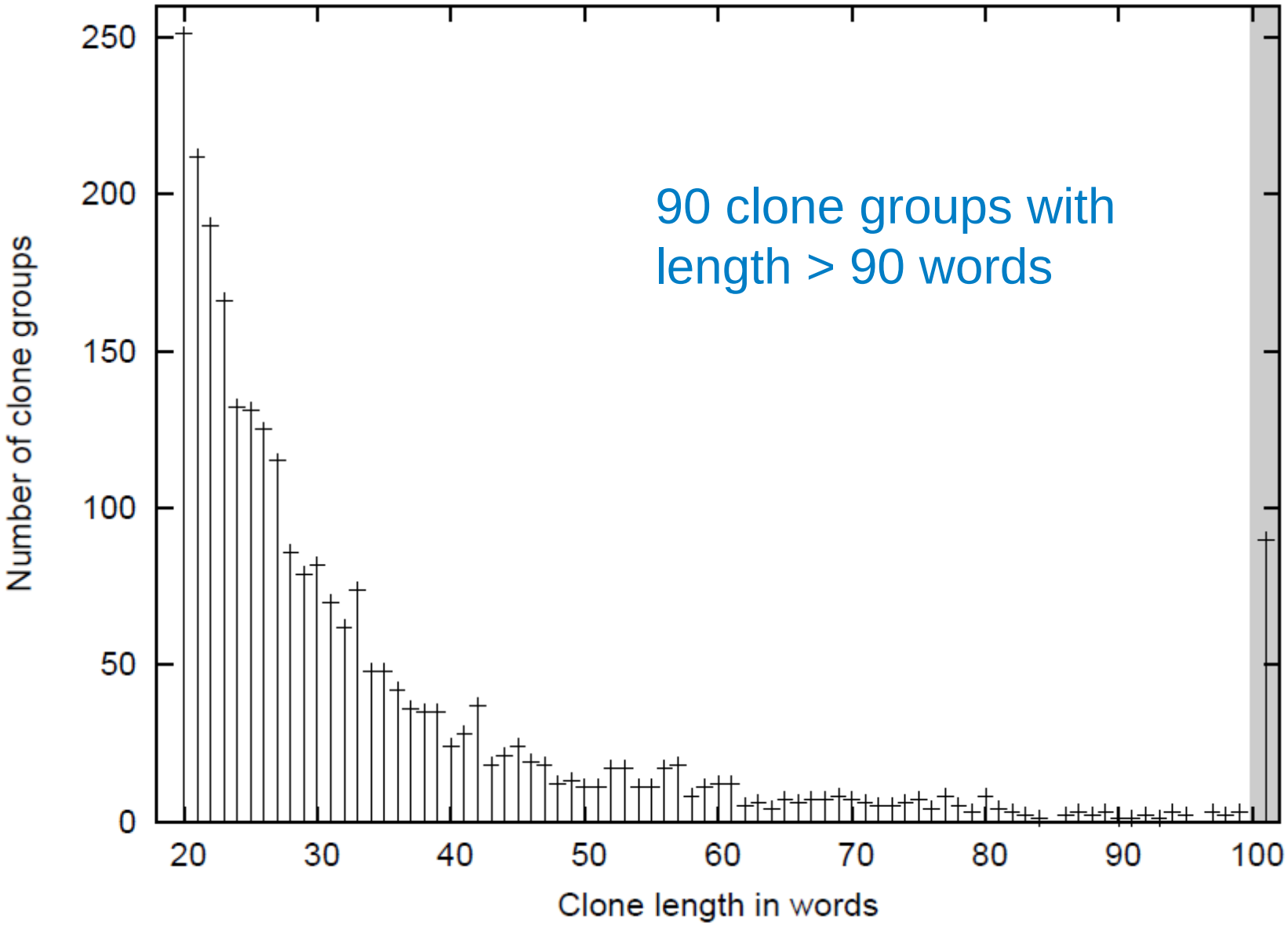
- Entire use cases copied (create / edit XY)
- Similar combinations of pre and post conditions copied
- Descriptions of terms or roles copied

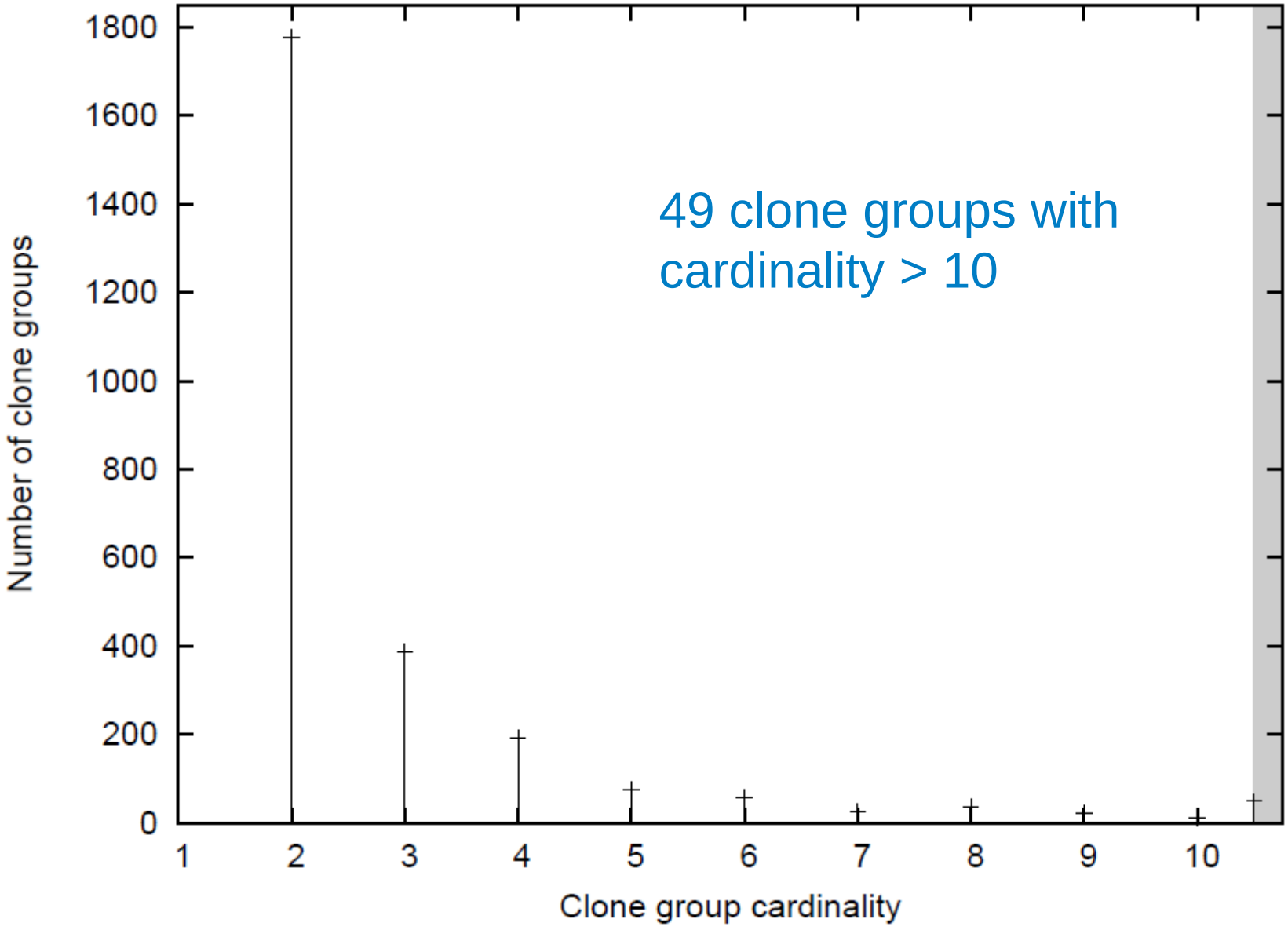
Example*: 42 instances (61 words, 13 instances with > 100 words)

"The contracts with the clients describe the conditions regarding obligatory liabilities that the clients have agreed on with X. The liabilities are calculated from the exposures from Y and the contract conditions from X. The liability-relevant parts of the contracts thus need to be managed in system Z."

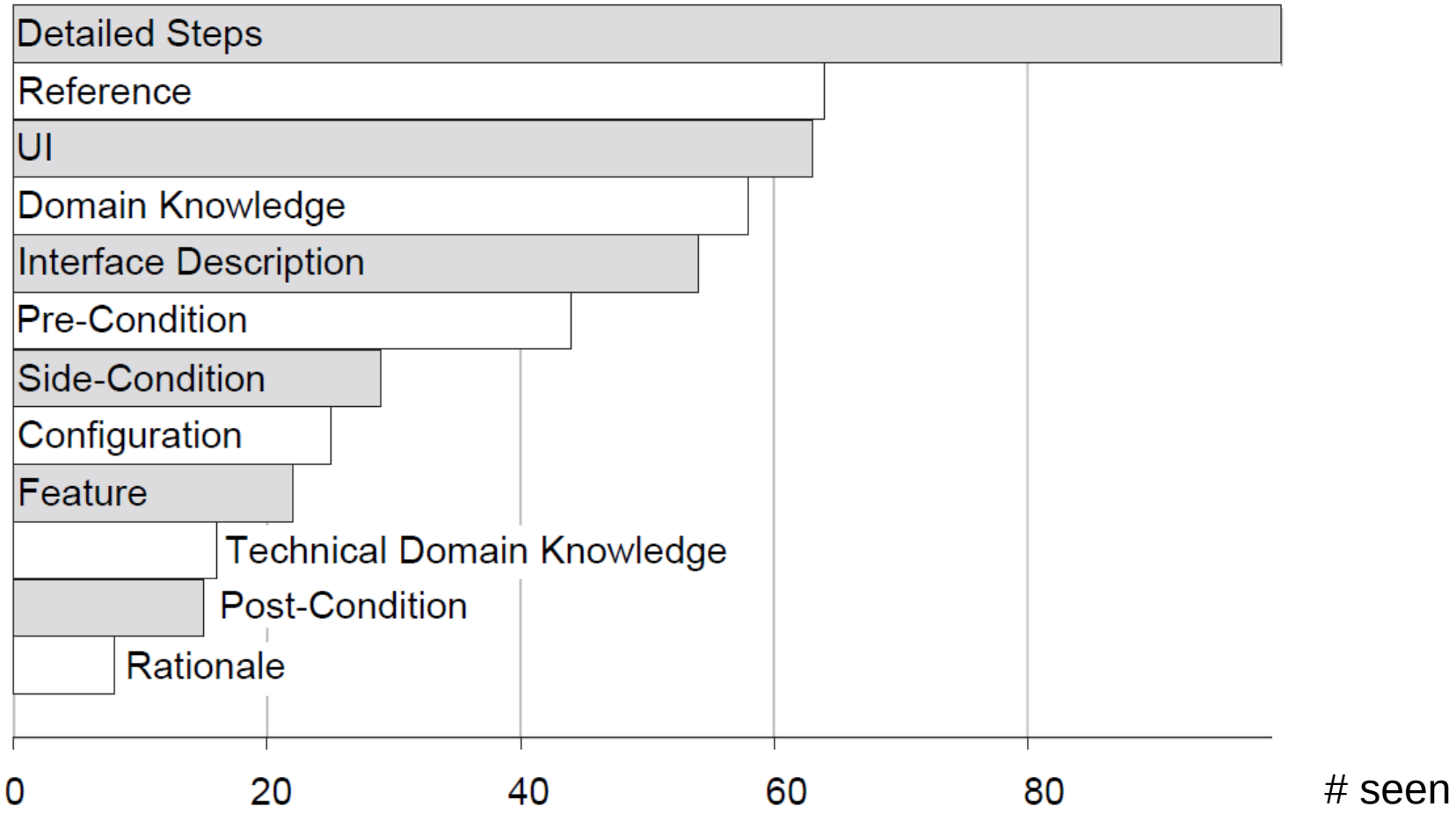
…

*Translated from German


90 clone groups with
length > 90 words
Number of clone groups
Clone length in words
0
50
100
150
200
250
20
30
40
50
60
70
80
90
100


1800
1600
1400
1200
1000
800
600
400
200
0
Number of clone groups
1
2
3
4
5
6
7
8
9
10
Clone group cardinality
49 clone groups with
cardinality > 10

RQ2: Kind of Cloned Information



Cloning not limited to a specific kind of information

RQ3: Consequences

Reading

- Reading speed: 220 words/minute [Gould et al, ‘87]
- Average blow-up: 3578 words: ~16 minutes reading overhead
- Many stake holders read a specification, often several times

Inspections

- Substantially slower recommended reading speed!
- 600 words/hour maximum rate [Gilb & Graham, ‘93]
- Time increase (single): 6 hours (avg), 4.5 person days (max)
- Time increase (3 persons): 2.5 person days (avg), 13 p. days (max)

Substantial impact on inspection effort

RQ3: Consequences (2)

Modification

- Multiple inconsistent specification clones identified
- Differences suspected to be unintentional

⇒ Indication that inconsistent updates happen in practice

Implementation

Traced specification clone groups to implementation. 3 cases:

- Shared abstraction
- Cloned code
- Independent reimplementation of similar functionality

⇒ Indication that spec. cloning causes redundancy in implementation

Threats to Validity

Internal

- Pairs of researchers to reduce errors during manual steps
- Reading speeds for cloned vs non-cloned text? Assumed similar. Further research required
- Recall unclear. But: does not affect study results

External

- Substantial differences between requirements specifications (format, organization, language, …)

But: large amount of study objects from different companies, domains

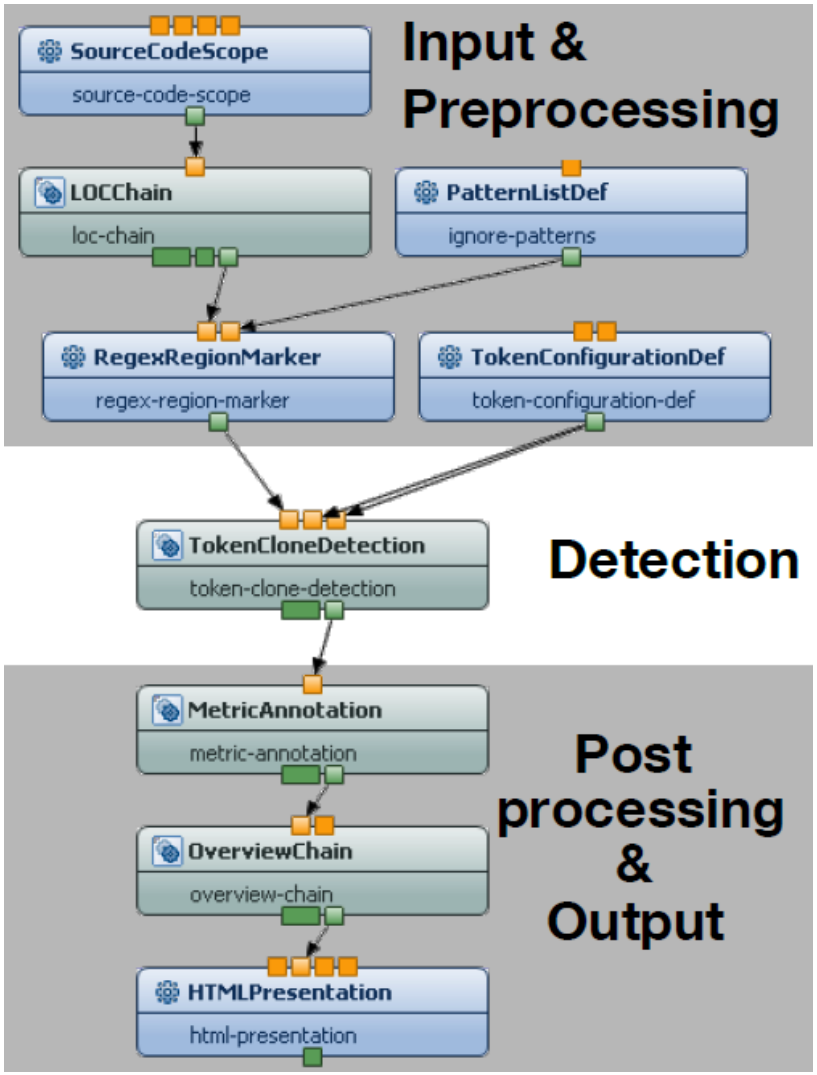
RQ4: Suitability of Existing Detectors

Clone Detector

- ConQAT (open source)
- Extensible through visual configuration language
- Word stemming, stop-word Removal

Precision

- Before tailoring: worst 2%
- After tailoring: avg 99%
- Tailoring: 33min max, <10 avg



Conclusion

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Lessons Learned

- Many specs contain a lot of cloning
- Negative impact on reading and inspection effort
- Indication for corresponding redundancy in source code
- Cloning not necessary – many specs contain none
- Tailoring required but feasible: effort small w.r.t. inspection overhead

Future Work

- How can cloning be avoided or removed?
- What are the causes for cloning? Different than for code clones?
- Further studies on consequences for implementation