Software Quality Engineering

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Testing, Quality Assurance, and Quantiable Improvement
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Chapter 20. Defect Classification and Analysis

- General Types of Defect Analyses
- ODC: Orthogonal Defect Classification
- Analysis of ODC Data

Defect Analysis

- Goal:

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  (actual/potential) defect decrease or quality improve in current and future products
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- General defect analyses
  - Questions: what/where/when/how/why?
  - Distribution/trend/causal analyses
- Analyses of classified defect data
  - Prior: defect classification
  - Use of historical baselines
  - Attribute focusing in 1-way and 2-way analyses
  - Tree-based defect analysis (Chapter 21)

Defect in Quality Data/Models

- Defect data is part of quality measurement data
  - As part of direct Q data
  - Extracted from defect tracking tools
  - Additional (defect classification) data may be available
- Defect data in quality models
  - As results in generalized models (GMs)
  - As r.v. (response/independent variable) in product specific models (PSMs)
    - semi-customized models ~= GMs,
    - observation-based: r.v. in SRGMs,
    - predictive: r.v. in TBDMs
    - (SRGMs/TBDMs in Chapter 22/21.)

General Defect Analysis

- General defect analyses: Questions
    - What? identification (and classification)
        - type, severity, etc.,
        - even without formal classification
    - Where? distribution across location
    - When? discovery/observation
        - what about when injection? harder
        - pre-release: more data
        - post-release: more meaningful/sensitive
    - How/why? related to injection

      => use in future defect prevention
- General defect analyses: Types
    - Distribution by type or area
    - Trend over time
    - Causal analysis
    - Other analysis for classified data

Defect Analysis: Data Treatment

- Variations of defect data
    - Error/fault/failure perspective
    - Pre-/post-release
    - Unique defect?
    - Focus here: defect fixes
- Why defect fixes (DF)
    - Propagation information
    - Close ties to effort (defect fixing)
    - Pre-release: more meaningful

      (post release: each failure occurrence.)

Defect Distribution Analysis

- Distribution: what, where, etc
- What: Distribution over defect types
    - Ties to quality views/attributes (Chapter 2)
    - Within specific view: types/sub-types
    - Defect types (product's "domain"
    - IBM example: CUPRIMDSO
- Important observation
    - Skewed distribution, or 80:20 rule

      => importance of risk identification for effective quality improvement
    - Early indicators needed!

      (Cannot wait after defect discoveries.)
- Web example: Table 20.1 (p.341)

Error Type	Description	# of Errors
A	permission denied	2079
B	no such file or directory	14
C	stale NFS file handle	4
D	client denied by server config.	2
E	file does not exist	28631
F	invalid method in request	0
G	invalid URL in req. connection	1
H	mod_mime_magic	1
I	request failed	1
J	script not found or unable to start	27
K	connection reset by peer	0
all types		30760

    - defect = "error" in web community
    - dominance of type E "missing files"
    - type A: further information needed
    - all other types: negligible
- Further analysis of web example above
    - for dominant type E "missing files"
    - web error distribution by file type
        - Table 20.2 (p.342)
    - again, skewed distribution!

Type	Errors	%
.gif	12489	43.62
.class	4913	17.16
directory	4425	15.46
.html	3656	12.77
.jpg	1323	4.62
other	394	1.38
All	28631	100

DF=	0	1	2	3	4	5	6
module #	771	174	102	63	31	29	23
%	58.8	13.4	7.9	4.9	2.4	2.2	1.8
DF sum	0	174	204	189	124	145	138
%	0	7.4	8.6	8.0	5.2	6.1	5.8

(Table 20.3 continued...)

DF=	7	8	9	10-19	20-37	all
module #	25	16	7	50	14	1295
%	1.9	1.2	0.5	3.9	1.1	100
DF sum	175	128	63	673	417	2367
%	7.4	5.0	2.7	28.4	17.6	100

- Where: Distribution over locations
  - commonly by product areas
    - sub-product/module/procedure/etc
  - IBM-LS: Table 20.3 (p.342) above
  - again, skewed distribution

DF =	0	1	2	3	4	5	6
module #	23	131	112	120	99	94	68
%	2.3	13.2	11.3	12.1	9.9	9.4	6.8
DF sum	0	131	224	360	396	470	408
%	1.67	2.86	4.60	5.06	6.01	5.21	4.47

(Table 20.4 continued...)

DF =	7	8	9	10-19	20-49	>50	all
module #	50	38	32	147	68	13	995
%	5.0	3.8	3.2	14.8	6.8	1.3	100
DF sum	350	304	288	2109	2040	910	7824
%	3.89	3.68	3.07	26.96	26.07	11.63	100

- IBM-NS: Table 20.4 (p.343) above
  - yet another skewed defect distribution
- Extension: distribution by other locators
  - e.g., types of sources or code, etc

Defect Trend Analysis

- Trend as a continuous function
  - Similar to Putnam model (Chapter 19)
    - but customized with local data
  - Other analysis related to SRE
    - defect/effort/reliability curves
    - more in Chapter 22 and related references
  - Sometimes discrete analysis may be more meaningful (see below)
- Defect dynamics model

- Important variation to trend analysis
- Defect categorized by phase
- Discovery (already done)
- Analysis to identify injection phase

Inj.	Removal Phase						
Phase	R	S	D	C	T	P	All
Requirements	10	22	8	0	5	2	47
Specification		10	20	2	0	1	33
Design			52	120	32	5	209
Coding				198	320	46	564
Testing					58	7	65
Post-release						2	2
All	10	32	80	320	415	63	920

- Defect dynamics model: Table 20.5 (p.344)
  - row: where (phase) injected
  - column: where (phase) removed/discovered
  - focus out-of-phase/off-diagonal ones!

Defect Causal Analysis

- Defect causal analyses: Types
  - Causal relation identified
    - error-fault vs. fault-failure
    - works backwards
  - Techniques: statistical or logical
- Root cause analysis (logical)
  - Human intensive
  - Good domain knowledge
  - Fault-failure: individual and common
  - Error-fault: project-wide effort focused on pervasive problems
- Statistical causal analysis
- risk identification techniques in Chapter 21

ODC: Overview

- Development
  - Chillarege et al. at IBM
  - Applications in IBM Labs and several other companies
  - Recent development and tools
- Key elements of ODC
  - Aim: tracking/analysis/improve
  - Approach: classification and analysis
  - Key attributes of defects
  - Views: both failure and fault

    - Applicability: inspection and testing
    - Analysis: attribute focusing
    - Need for historical data

ODC: Why?

- Statistical defect models
    - Quantitative and objective analyses
    - SRGMs (Chapter 22), DRM (Chapter 19), etc
    - Problems: accuracy & timeliness
- Causal (root cause) analyses
    - Qualitative but subjective analyses
    - Use in defect prevention
- Gap and ODC solution
    - Bridge the gap between the two
    - Systematic scheme used
    - Wide applicability

ODC: Ideas

- Cause-effect relation by type
    - Different types of faults
    - Causing different failures
    - Need defect classification
    - Multiple attributes for defects
- Good measurement
    - Orthogonality (independent view)
    - Consistency across phases
    - Uniformity across products
- ODC process/implementation
    - Human classification
    - Analysis method and tools
    - Feedback results (and followup)

ODC: Theory

- Semantic classification
    - defect classes for a product
    - related-to/explain process
    - akin to event measurement
    - sufficient condition
        - spanning set over process
        - formed by defect attributes
- Classification for cause-effect or views
    - cause: type, trigger, etc
    - effect: severity, impact, etc
    - failure vs fault (internal cause) views

- additional causal-analysis-related: source, where/when injected
- sub-population: environment data

ODC Example

- Table 20.6 (p.347)

Label	Name	Possible values or categories & labels
`imp`	impact	c=capability, u=usability, p=performance, r=reliability, in=installation, ma=maint., im=implementation, mi=migration, sec=security, ser=service, std=standard
`trig`	trigger	i=installation, m=migration, s=stress, a=ad-hoc, b=backup, c=communications, f=file i/o, co=coexistence, e=exception, ss=startup/shutdown, hc=h/w config., sc=s/w config., o=normal operation
`sev`	severity	range from 1 (highest) to 4 (lowest) in severity
`wk`	week	week detected, from project start
`ftype`	fix type	s=specification, hld=high-level design, lld=low-level design, c=code, b=build process, o=other product
`act`	action	a=add, d=delete, c=change
`src`	code source	b=base, v=vendor, n=new, c=changed, i=incremental, s=scaffolded, p=previous defect fix
`inj`	phase injected	p=previous release, s=specification, hld=high-level design, lld=low-level design, c=coding, ut=unit test, ft=function test, st=system test, d=customer usage

ODC Attributes: Failure-View

- Defect trigger
  - Associated with verification process
    - similar to test case measurement
    - collected by testers
  - Trigger classes
    - product specific
    - black box in nature
    - pre/post-release triggers
- Other attributes
  - Impact: e.g., IBM's CUPRIMDSO

    - Severity: low-high (e.g., 1-4)
    - Detection time, etc

ODC Attributes: Cause/Fault-View

- Defect type
    - Associated with development process
    - Missing or incorrect
    - Collected by developers
    - May be adapted for other products
- Other attributes
    - Action: add, delete, change
    - Number of lines changed, etc
- Key attributes
    - Defect source: vendor/base/new code
    - Where injected
    - When injected
- Characteristics
    - Associated to additional causal analysis
    - (May not be performed.)
    - Many subjective judgment involved

      (evolution of ODC philosophy)
- Phase injected: rough "when"

Adapting ODC for Web Error Analysis

- Continuation of web testing/QA study
- Web error = observed failures, with causes already recorded in access/error logs
- Key attributes mapped to ODC
    - Error type = defect impact
        - types in Table 20.1 (p.341)
        - response code (4xx) in access logs
    - Referring page = defect trigger
        - individual pages with embedded links
        - classified: internal/external/empty
        - focus on internal problems
    - Missing file type = defect source
        - different fixing actions to follow
- May include other attributes for different kinds of web sites

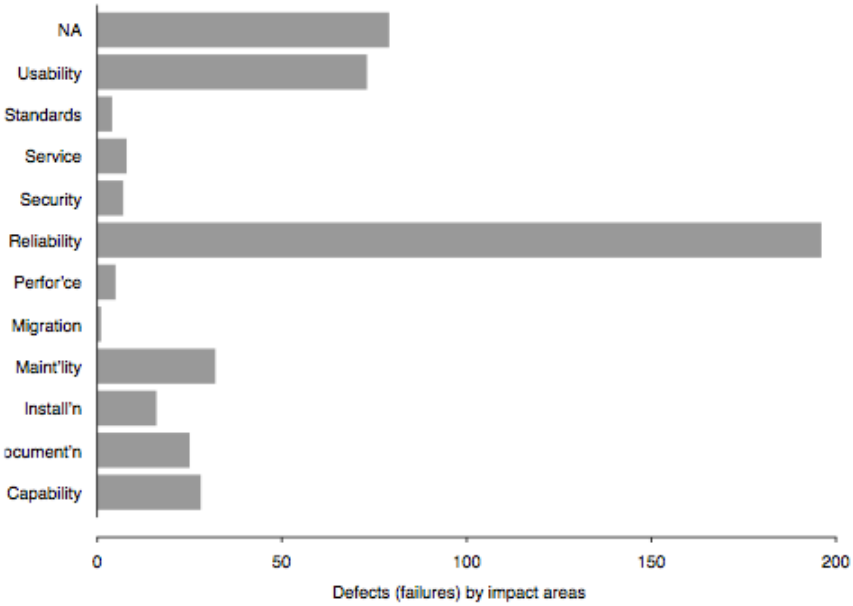
ODC Analysis: Attribute Focusing

- General characteristics
    - Graphical in nature
    - 1-way or 2-way distribution

    - Phases and progression
    - Historical data necessary
    - Focusing on big deviations
- Representation and analysis
    - 1-way: histograms
    - 2-way: stack-up vs. multiple graphics
    - Support with analysis tools

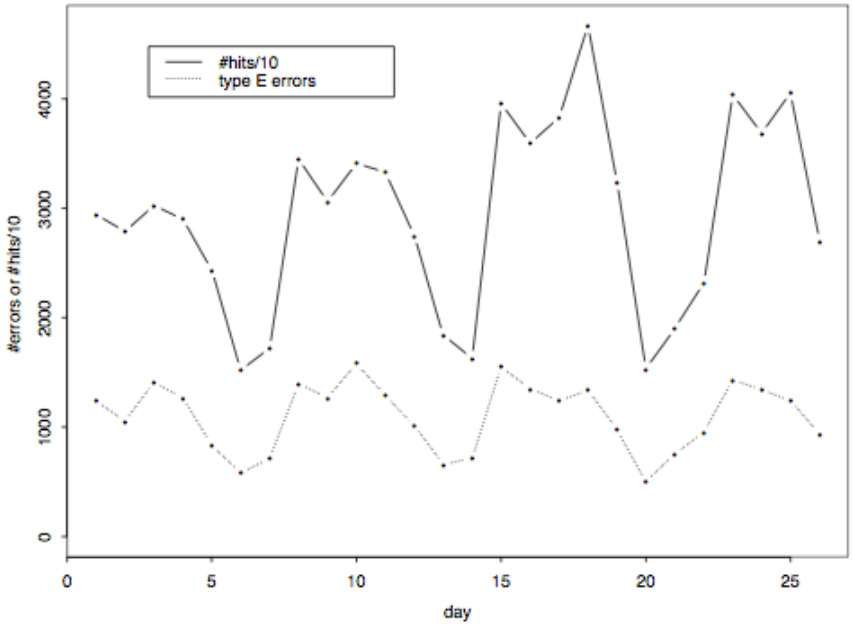
ODC Analysis Examples

- 1-way analysis: Fig 20.1 (p.349)



    - Defect impact distribution for an IBM product
    - Uneven distribution of impact areas!

      => risk identification and focus



- 1-way analysis: Fig 20.2 (p.350)
    - web error trend analysis
    - context: compare to usage (reliability)
    - stable operational reliability

Impact	Severity			
	1	2	3	4
Capability	2	12	13	1
Documentation	0	1	14	10
Installability	0	6	6	4
Maintainability	0	6	19	7
Migration	0	0	0	1
Performance	1	1	3	0
Reliability	27	96	66	7
Security	1	3	3	0
Service	0	0	4	4
Standards	0	1	2	1
Usability	0	10	44	19

- 2-way analysis: Table 20.7 (p.351)
    - Defect impact-severity analysis
    - IBM product study continued
    - Huge contrast: severity of reliability and usability problems!

ODC Process and Implementation

- ODC process
    - Human classification

        - defect type: developers,
        - defect trigger and effect: testers,
        - other information: coordinator/other
    - Tie to inspection/testing processes
    - Analysis: attribute focusing
    - Feedback results: graphical
- Implementation and deployment
    - Training of participants
    - Data capturing tools
    - Centralized analysis
    - Usage of analysis results

Linkage to Other Topics

- Development process
    - Defect prevention process/techniques
    - Inspection and testing
- Testing and reliability
    - Expanded testing measurement
        - Defects and other information
        - Environmental (impact)
        - Test case (trigger)
        - Causal (fault)
    - Reliability modeling for ODC classes