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Experimental Analysis of Dependency Factors of Software Product Reliability using SonarQube

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Background

- Current Reliability Models are having limitation due to
  - Assumptions
  - Applicable for certain phases only
  - Not taking holistic view of environment for deriving reliability

- Objective
  - To identify most influential factors making impact on reliability
    - By performing experiments on different software products in diverse domains and developed using diverse technologies.
- These experiments were performed in a large software development organization in India, which has laboratory setup necessary for performing such experiments.

Background

- In this study, we hypothesize reliability to be a function of
  - Process Parameters (Schedule Variance, Effort Variance, Productivity)
  - Technology
  - Design parameters (Commercial Of The Shelf(COTS) complexity, Design Complexity)
  - Testing Parameters (Unit Test Defects, Integration Test Defects, System Test Defects, Defect Leakage and Post Delivery Defects)
  - Operational Parameters (Execution Time, Skill of Developer/ Tester)

(These factors were identified as the most influential ones as perceived by stakeholders)

Research Context

- Experiments involved studying impact of factors (identified during field survey) on reliability
- For each application performed minimum 30 combinations.
- For identifying most influential input factor contributing to reliability
- Capturing reliability for baseline purpose using "SonarQube"

Research Context

- Expected output : Hypothesis run on data obtained and confirm the result
- Independent parameters
  - Skill
  - Design Complexity
  - Technology
  - COTS Complexity
- Dependent parameters
  - UT Defects
  - IT Defects
  - ST Defects
  - Review Efficiency
  - Post Delivery Defects
  - Execution Time
  - Process Metrics
    - Schdule variance
    - Effort variance
    - Productivity
- Design Experiments on controlled environment
  - One parameters is variable and other are kept constant

Experimental Framework

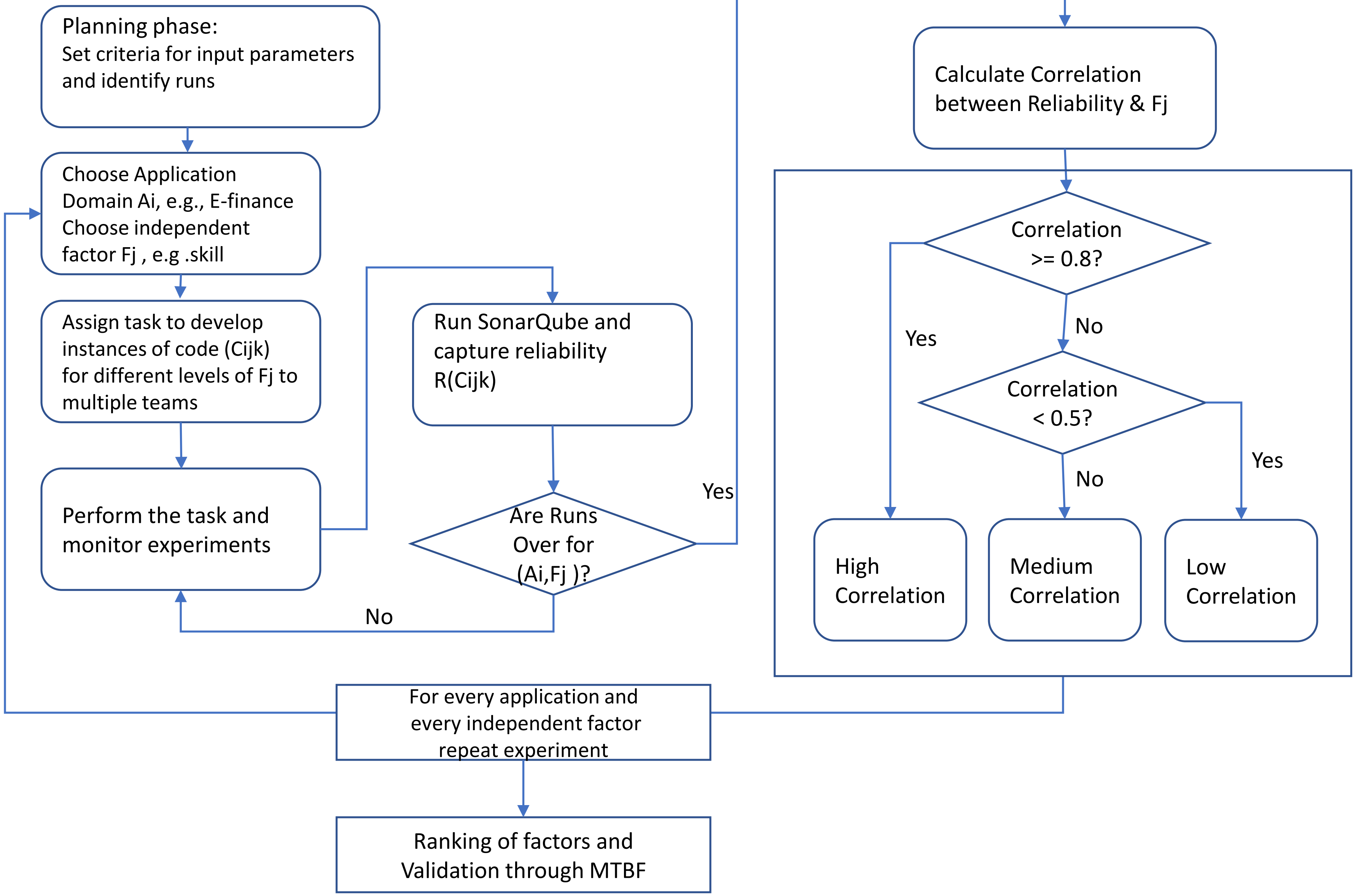
- Application Selection Criteria for Experiments
  - Domain
  - Technology / Platform
  - Criticality
  - Design Complexity
  - Development Methodology
  - Size (KLOC or FP)
- Application Selected (Few examples)
  - Enterprise Risk Management Portal
  - ECG Monitoring System
  - Photoshop Application
  - e-Finance

Methodology

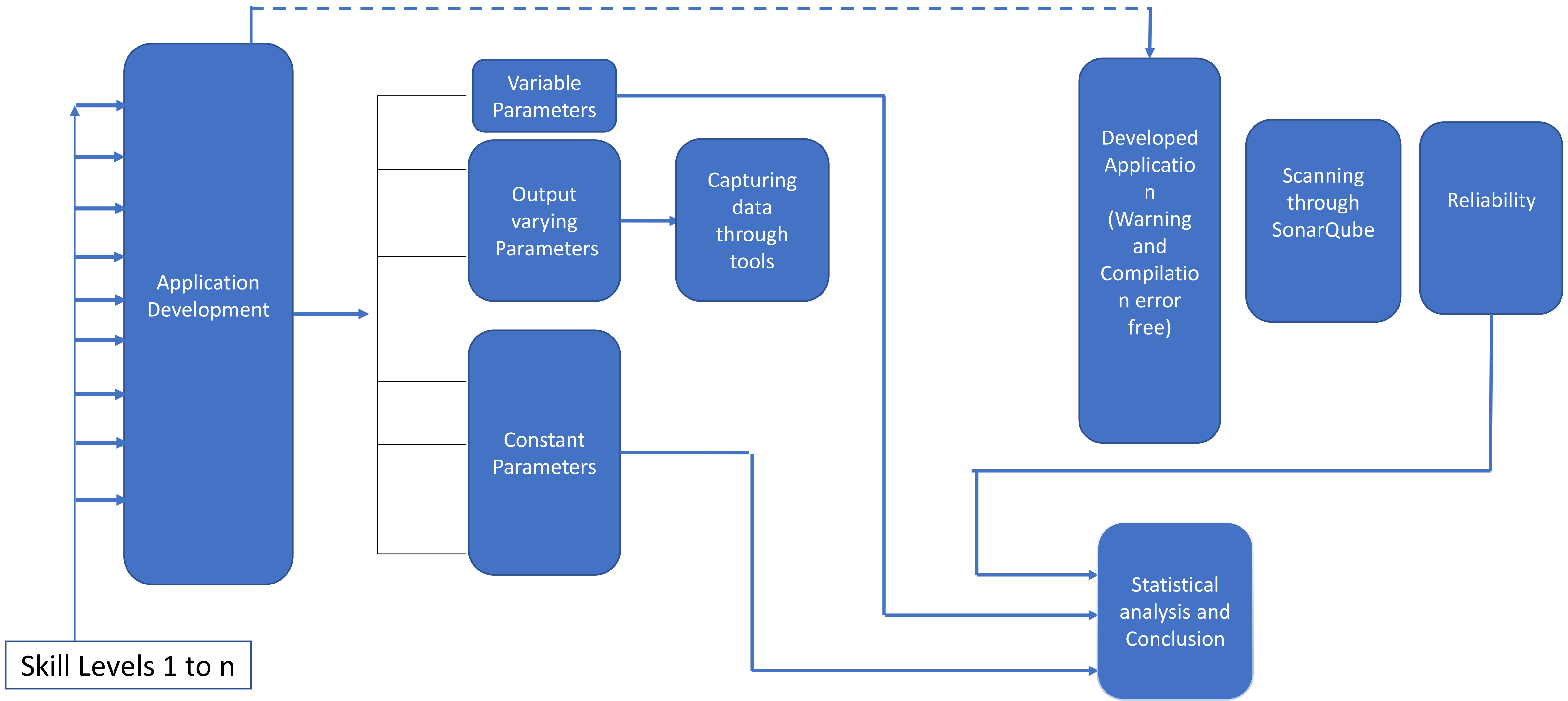
- The main objective of performing experiments is to find cause and effect relationship=> Y= f(x1, x2, x3, x4…………….xn)
- Experiments were conducted in a multinational software product organization having centers across the globe
- Series of experiments were conducted in controlled environment, where one parameter is considered as variable and other parameters are taken as constant

Methodology

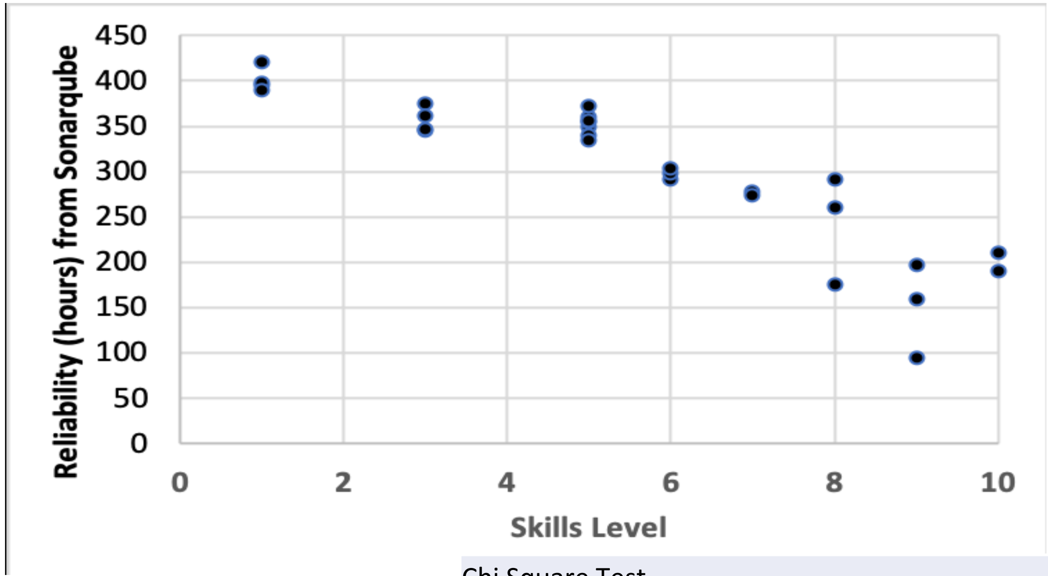
- Minimum of 10K lines of code was the criteria set for developing the application
- The design document was provided to all developers
- SonarQube was run on error free code to give the reliability factor for each skill level


Planning phase:
Set criteria for input parameters and identify runs
Choose Application Domain Ai, e.g., E-finance Choose independent factor Fj , e.g .skill
Assign task to develop instances of code (Cijk) for different levels of Fj to multiple teams
Perform the task and monitor experiments
Run SonarQube and capture reliability R(Cijk)
Are Runs Over for (Ai,Fj)?
Yes
No
Prepare graph of R versus independent factor Fj (e.g. Skill)
Calculate Correlation between Reliability & Fj
Correlation >= 0.8?
Yes
No
Correlation < 0.5?
Yes
No
High Correlation
Medium Correlation
Low Correlation
For every application and every independent factor repeat experiment
Ranking of factors and Validation through MTBF

Experiments (Setup)



Experimental Findings



Pearson's Chi2 Test

Technology (major)	*Chi2*	*Df*	*p value*	*Less than 0.05*
C#	393.75	336	0.0163	Yes
Sharepoint	441.15	344	0000304	Yes
ASP.NET	196	144	0.002588	Yes
Java	226.65	180	0.0105	Yes

Chi Square Test

```
> a7 <- table(data_skill7$Skill.Level,data_skill7$Reliability)
> chisq.test(a7)

    Pearson's Chi-squared test

data:  a7
X-squared = 157.89, df = 120, p-value = 0.01162
```

Chi Square Test

```
> a <- table(data_skill3$Skill.Level,data_skill3$Reliability)
> chisq.test(a)

    Pearson's Chi-squared test

data:  a
X-squared = 178.25, df = 147, p-value = 0.04044
```

Chi Square Test

```
> a4 <- table(data_skill4$Skill.Level,data_skill4$Reliability)
> chisq.test(a4)

    Pearson's Chi-squared test

data:  a4
X-squared = 196, df = 144, p-value = 0.002588
```

Experimental Findings

Technology V/s Parameters	C#	Sharepoint	ASP.NET	Java	Inference	Average	Rank
Skill	0.890	0.9191	0.981	0.950	Strong	0.935025	2
UT defects	0.231	0.040	0.224	0.233	No	0.182	9
IT defects	0.295	0.230	0.262	0.260	No	0.26175	8
ST defects	0.6840	0.820	0.910	0.985	Good	0.84975	7
On time	0.040	0.201	0.040	0.105	No	0.0965	13
Load	0.833	0.789	0.980	0.820	Good	0.8555	6
Design Complexity	0.990	0.771	0.913	0.911	Good	0.89625	4
COTS	0.846	0.843	0.921	0.900	Good	0.8775	5
Review Efficiency	0.997	0.910	0.870	0.960	Strong	0.93425	3
Post Delivery Defects	0.936	0.990	0.960	0.966	Strong	0.963	1
SV	0.170	0.170	0.010	0.215	No	0.14125	11
EV	0.190	0.230	0.065	0.224	No	0.17745	10
Productivity	Productivity	0.160	0.190	0.051	No	0.124275	12

Sample Data – Skill (EXCEL FILE)

MWSM_Data

Conclusion

One of the noteworthy findings from these experiments are factors contributes significantly towards software product reliability

- Post-Delivery Defects,
- Skill
- Review Efficiency

With the help of this exercise, we could also eliminate some parameters such as

- Process metrics (Schedule Variance, Effort Variance and Productivity)
- Unit Test Defects, Integration Test Defect, System Test Defects

These experiments also indicate that following input parameters could make significant impact

- Load Condition
- Design Complexity
- COTS

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Thank You