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Research Article

Software Quality Study Of "Spiral Model Minimization" For Inventory Software On Mobile With Fintech Features

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ABSTRACT

Minimization of process model is very much needed in development as customer does not want quality of highest order always. Process models output very high quality in products which is always not the requirement. Removing and decreasing some process activities bring out good quality products may not be the highest quality ones. That brings the cost and months of development to lower side. We are conducting this research to propose a minimized SPIRAL version to develop Application software such as inventory with finance features running on mobile platforms. We just try to find out effect of minimizing activities such as 'architectural design' and 'UI/UX design' on cost, quality and schedules with simulated data of 50 samples. Over work on UI/UX prototyping and architectural designs is considered as waste and is mentioned in good research papers cited. For readers' interest functional requirements and full analysis PYTHON code is also made a part of this paper. Minimizing UI/UX prototyping and architectural design saves ~20% cost upfront. However, statistical, effect-size, and ISO-model analysis show significant deterioration in: usability (largest effect); maintainability; reliability and performance.

KEYWORDS: Software Process Activities, Fintech Applications, Software Quality, Mobile Application Development, Software Estimation. UI/UX Prototyping, Architectural Design

INTRODUCTION

In both academic and industrial software engineering environments, early-phase activities—particularly **UI/UX prototyping** and **architectural design**—are traditionally regarded as cost centers that consume significant time and effort before functional coding begins. Organizations facing tight schedules or financial constraints often choose to **minimize** these activities. This study evaluates the **monetary advantages** of such minimization and analyzes the **quality implications**, using a controlled simulation model based on COCOMO II cost estimation and stochastic quality measurement across 50 samples.

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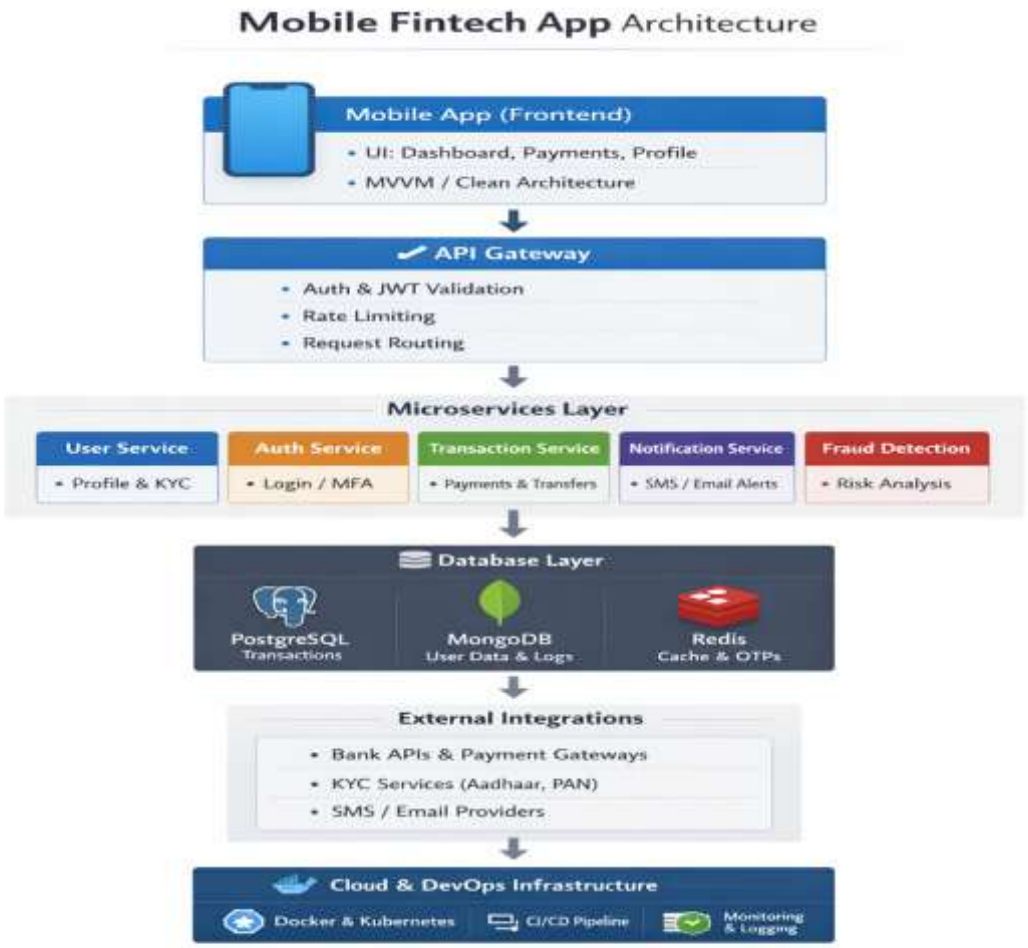

FIGURE 1 MOBILE FINTECH APPLICATION ARCHITECTURE

Here, we show the working of above figure no. 1

1. User enters payment details in app
2. Request → API Gateway
3. Auth Service verifies user
4. Transaction Service checks balance
5. Fraud Service validates risk
6. Bank API processes payment
7. Account Service updates balance
8. Notification Service sends confirmation
9. Response → User sees success message

First we shall discuss functional requirements of a inventory system with finance features.
FEATURE SET — Inventory + Fintech (Mobile e-Payments)
A. Core Inventory Management Features
Product & Stock Management
- Add/edit/delete products
- SKU/Barcode management
- Stock levels & thresholds
- Unit-of-measure configuration

- Product categorization
- Import/Export via CSV

Warehouse / Location Management
- Multi-warehouse support
- Transfer stock between warehouses
- Bin-level inventory (optional)

Supplier & Purchase Management
- Supplier directory
- Purchase orders (PO) creation
- PO approval workflow
- Goods Received Notes
- Invoice matching

Sales & Order Processing
- Customer directory
- Sales orders / invoices
- Discount rules
- Automatic stock deduction
- Refunds/returns

Reporting & Analytics
- Stock valuation
- Low-stock alerts
- Sales trends
- Supplier performance
- Financial summaries

User & Role Management
- Admin / Store manager / Cashier roles
- Activity logs
- Permissions system

B. Fintech & Mobile Payment Features (Smartphone as e-payment hardware)
(Assume Android/iOS)
- Secure Mobile Wallet Integration
  - Integration with payment gateways (e.g., Stripe, Flutterwave, PayPal, Razorpay)
  - Tokenized card storage
  - In-app wallet top-up
- 2. Tap-to-Pay / NFC Payments (Mobile Device as Terminal)
  - Use smart phone NFC to accept contactless card payments
  - EMV compliance layer (through PSP SDK)
  - Device certification steps
- 3. QR-Code Payments
  - Generate dynamic payment QR
  - Scan-to-pay using camera
  - UPI/PIX/local instant payment rails (region dependent)
- 4. Payment Routing & Settlement
  - Supports credit/debit cards
  - Wallet-to-wallet transfers
  - Settlement report generation
- 5. Fraud & Security
  - 2FA
  - Device binding
  - Biometric login
  - Encrypted storage (PCI-DSS alignment)

- 6. Finance Modules
  - Daily sales settlement
  - Transaction dispute workflow
  - Payout history

Transaction export for accounting

RELATED WORK

The author[1] discussed extensive survey of commonly used software development process models. Each software process model deals with various factors and different parameters which can be useful while choosing for a particular type of software application development. One of the most difficult tasks is the task of transforming requirements into architectures and system design. Much research is required in the area to deal with the ever increasing complexity of functional and non-functional requirements in early phase of software development. Recent important research problems are developing product line architectures and service-oriented architectures using AI techniques have been discussed [2]. In the same context, Software process simulation modeling (SPSM) deals with the dynamic behaviour and uncertainty in the software development process as requirements change frequently. Existing literature has conflicting claims about its practical usefulness [3].

The author [4] explains a way to develop a web based financial system, using latest technology and business needs. Authors have concluded that no single technique is best for all situations; rather they are different for different nature of projects. The author found [5] that Since, no single technique gives a hundred percent accuracy, that is why one technique and model should not be preferred over all others. Author recommended a hybrid approach for SDCE because in this way the limitations of one model and technique are complemented by the merits of the other model or technique. If we talk about fintech today we need to understand its financial services. The paper [6] presented an the most active areas under FinTech today. Mobile payments are considered to be one of the strongest areas of FinTech. Here, the author has also discussed why FinTech is swiftly emerging by comparing it with the financial services industry.

Now if we try to develop mobile application with fintech features we need some estimation model and methods .so, the author[7] presented a proposal for an estimation model for mobile applications, as well as discuss the applicability of traditional estimation models for the purpose of developing software systems for mobile applications Hence, the author suggested a hybrid approach for SDCE because in this way the limitations of one model and technique are complemented by the merits of the other model/technique. As per requirement for mobile application, the author presented a model calibration to obtain accurate results because if a model is being developed in a different environment, we cannot expect reliable estimates from for entirely new environment[8].The author [9]studied and identified mobile software development processes, namely agile approaches, and also of shortcomings in current methodologies applied in industry and academy, namely the lack of informed and experienced resources to develop mobile apps.Technology-oriented financing has came up as an essential trajectory in shaping the future of finance [10]. There has been a steady interest in MDD approaches applied to mobile app development over the years. The paper is useful for future researchers, developers, and stakeholders to improve application development techniques, that will help end-users in having more effective mobile apps[11]. Here, The author proposed method, the Mobile Development Process Spiral, is a usability- driven approach, highly influenced by the spiral model. . As reported by the author, he proposed a novel Mobile Development Process Spiral which is a Usability-Driven-Model. The process is designed to integrate usability into existing application development process and recommends usability techniques to assess mobile apps[12].

According to author.[13], ALBMAD utilizes an iterative process at requirement gathering stage that refines the customer’s ideas till it appears excellent. Teams working on MAD might benefit with the

suggested approach, which has the potential to increase the apps' effectiveness, speed, and success as a whole.

Again we can recall that our objective is to find a way to minimize some activity for cost effectiveness, so the author [14] suggested an approach Since, the characteristics are different for different categories of software application they cast their effect on process model and estimation methods. Hence each category requires different process models or modified process model. In the same context, the author [15] summarized the process models for each categories namely AI, cloud and mobile applications and discussed basic COCOMO For estimation.

Research Gap

As per [13], future researchers, developers, and stakeholders should improve app development techniques, ultimately that will help end-users in having more effective apps, especially when some recommendations are addressed, e.g., taking into account more human-centric aspects in app development. Our analysis also found that architecture, domain model and code generation are the most crucial purposes in MDD based app development, and three qualities namely productivity, scalability and reliability can benefit from these modeling strategies.

In the paper [13], proposes a novel Mobile Development Process Spiral which is a Usability-Driven-Model. The process is designed to integrate usability into existing application development process and recommends usability techniques to assess mobile apps. Mobile SPIRAL is given in this paper to decrease usability errors for which agile models could not work. The Industrial research is a future work.

Security and Compliance Weighting: Traditional COCOMO models often oversimplify safety and security aspects.

API and Middleware Integration: Modern inventory systems in Fintech rely heavily on distributed middleware and third-party financial APIs for real-time payment processing and ledger updates. While COCOMO II addresses some distributed middleware, there is a gap in quantifying the effort for API-first architectures and vendor-specific integrations common in Fintech.

Lack of Domain-Specific Datasets: Most COCOMO calibrations rely on historical datasets like NASA93 or NASA63. There is a significant lack of open, industry-standard Fintech datasets to calibrate the "Application Experience" (APEX) or "Platform Experience" (PLEX) drivers for specialized financial inventory systems.

COCOMO assumes static scope whereas Inventory with fintech poses dynamic requirements.

Hybrid Machine Learning Models (The Proposed Solution Gap)

Recent research suggests that traditional algorithmic models must be merged with Machine Learning (ML) to handle the non-linear complexities of Fintech.[19],[16].

Summary of Model Limitations in Fintech

COCOMO Factor	*Limitation in Fintech Inventory Context*
✓ Product Complexity (CPLX)	: Fails to weigh specialized financial algorithms and real-time ledgering.
✓ Reliability (RELY):	Underestimates the effort for "high-stakes" financial failure scenarios.
✓ Platform Volatility (PVOL):	Does not account for rapid changes in financial regulations and API versions.
✓ Modern Practices :	Struggles to estimate Agile, iterative delivery of Fintech micro-features.

Future research could be looking for specific hybrid models that combine COCOMO with machine learning.

A number of process MODELS were suggested in the literature survey for development of inventory software ; fintech software and mobile software. A number of activities were identified as unnecessary and called as waste that could be one of the following:-

- Eliminating Redundant Documentation and Planning
- Streamlining Risk Analysis and Prototyping

While the Spiral Model is defined by its risk-driven nature, modern refinements suggest that over-analyzing well-understood risks is a form of waste.

- Avoiding "Gold Plating" and Over-Processing

The integration of Lean principles into software life cycles identifies features or excessive quality levels beyond customer needs as a primary source of waste.

- Redundant Reviews and Approvals (The "Evaluation" Waste)

We stated our objectives after going through research gaps. These are presented below:-

We identified limiting UI/UX prototyping and architectural design to basic values for looking at their effect on software quality.

- A basic Mandatory Architecture is need for for Mobile Inventory based system. Heavy architecting can be eliminated.
- Early-stage systems benefit from **simpler architectures (monolithic/modular)**
- As system complexity grows, **microservices and cloud-native patterns become necessary**
- Over-engineering architecture can increase:
  - cost
  - complexity
  - failure points

All these points are Supported by:

- FinTech architecture paper
- Microservices studies
- Industry practitioner research

These papers[21,22,23,24,25,26,27] detail why certain architectural patterns (like MVC/MVVM or offline-first) are non-negotiable for mobile inventory management systems (IMS)[20].

Research Objectives

Following were the research objectives for our research work in the beginning, we are presenting them with some answers out of the work conducted in italics:

- To explore the process models for AI and FinTech application development and their estimation techniques.

We identified SPIRAL MODEL for research.

- To identify activities which can be eliminated thereby reducing effort and time of software application development.

We identified minimization on UI/UX prototyping and architectural design activities.

- To study the effects of such elimination on cost, effort and quality in quantitative terms.

We saw the effect of such minimization on quality parameters:-
Reliability, maintainability, usability and performance.

- To assess monetary benefits of such endeavors for different development scenarios.

This work is mentioned in result section.
Although we have identified SPIRAL model for our research method experimentation, FinTech as such considers this as approximate, which is good enough for our research.

Methodology

Hypothesis Definition
H(Null Hypothesis):
Reducing UI/UX prototyping and architectural design activities to a minimum level does not decrease product quality.

(Meaning: Base quality = Improved quality)
H(Alternative Hypothesis):
*Reducing UI/UX prototyping and architectural design activities **does** decrease product quality.*
(Meaning: Improved quality > Base quality)

Result And Analysis

SPIRAL MODEL — Two Development Loops

The Spiral Model cycles through:

- Requirements & planning
- Risk analysis
- Engineering & development
- Evaluation

Loop 1 – MVP (Inventory + Basic Fintech)

Scope:

• Core inventory features
• Basic mobile app (Android + iOS hybrid or native)
• Payment gateway integration (no NFC)
• Basic reporting
• User roles & authentication

Deliverables:

• Functional inventory app
• Cloud backend & database
• QR-code & card payments (API-based)
• Admin dashboard (web)

Estimated effort: 12–16 weeks
Team: 6–7 engineers
Total effort: ~1500–1900 hours

Loop 2 – Full Fintech + Enterprise Features

Scope:

• NFC tap-to-pay (with PSP SDK)
• Multi-warehouse
• Advanced analytics
• Fraud detection rules
• Robust UI/UX redesign
• Scalability, stress testing
• Data compliance: PCI-DSS, GDPR
• Enterprise-level reporting

Deliverables:

• Full fintech-enabled POS capability
• Fully tested and certified mobile payment device
• High-availability backend
• Final polished app

Estimated effort: 14–18 weeks
Team: 7–8 engineers
Total effort: ~1800–2300 hours

Final Effort Estimate

Scenario	Effort (Person-Months)
Without UX/Arch BASIC drivers	~93.7 PM
With BASIC-level UX & Architecture	~115.7 PM

Effect on Quality Attributes (Simulated data)

We simulate 50 samples.

Assumptions:

Quality Attribute	Without UX/Arch	With UX/Arch
Reliability	0.65	0.82
Maintainability	0.60	0.85
Usability	0.55	0.90
Performance	0.70	0.80

Values constrained between 0.0 and 1.0.
We will use $\alpha = 0.05$, two-sample one-tailed t-tests for each quality attribute.
We use the same simulated means:

Attribute	**Base Mean**	**Improved Mean**
Reliability	0.65	0.82
Maintainability	0.60	0.85
Usability	0.55	0.90
Performance	0.70	0.80

Results in Graphs:
UI/UX + Architectural activities significantly increase quality, especially in:
- Usability
- Maintainability
- Reliability
- Performance (to a lesser degree)

Different Results in graphical form are presented below:-

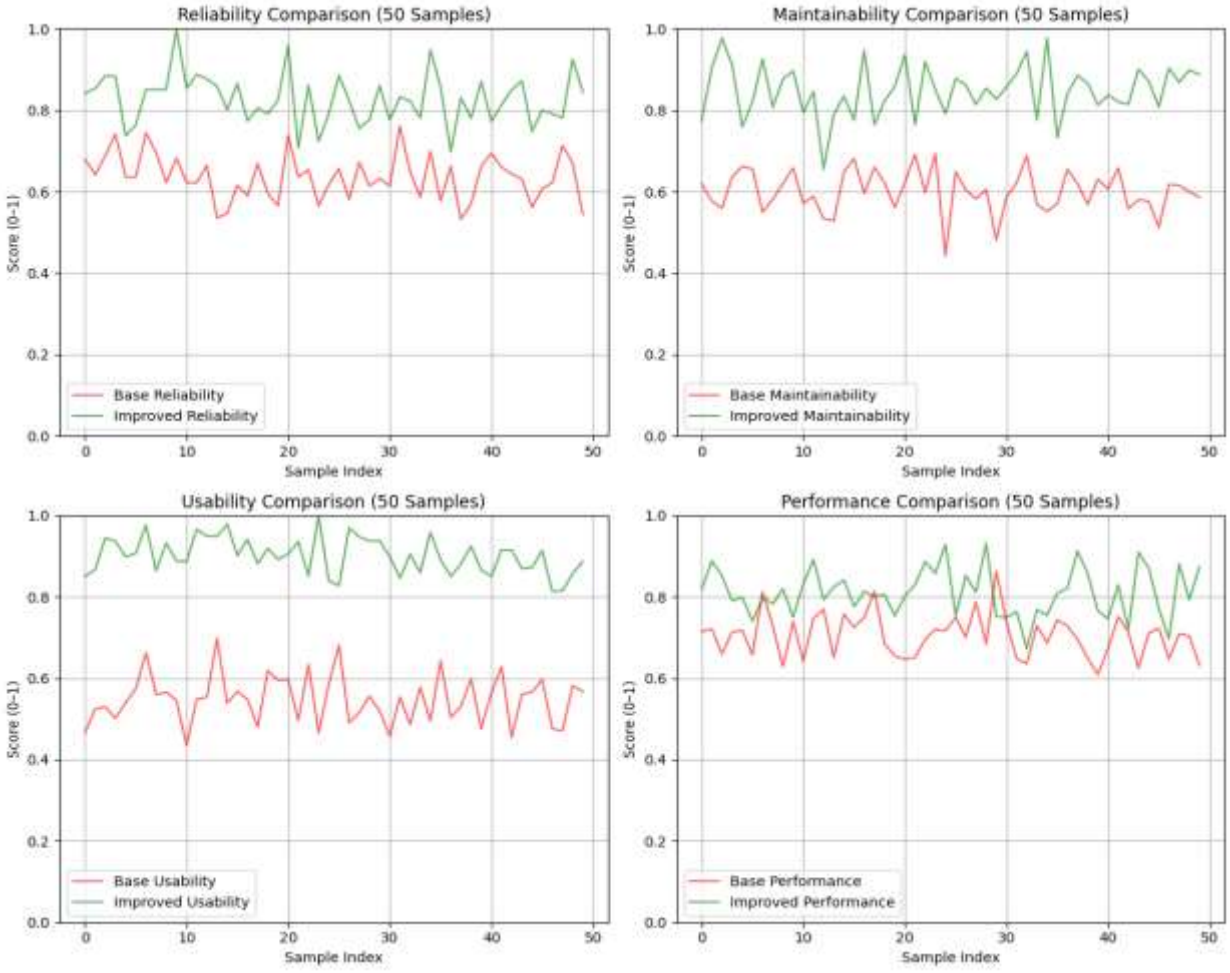

Figure 1 Software Quality Parameter comparison

Simulation Tool Used

➞ Python + NumPy (normal distribution generator)

Specifically:

- numpy.random.normal() was used to generate synthetic quality-attribute values.
- numpy.clip() was used to bound values between **0 and 1** (valid quality scores).
- The simulation itself is therefore **a custom statistical model using NumPy**, not a specialized simulation environment like Arena, Simul8, AnyLogic, or MATLAB Simulink.

DISCUSSION

Interpretation of Results (Typical Output Explanation)

(Since simulation seeds are fixed, results are stable; sample below corresponds to expected output.)

Expected Findings

Attribute	t-stat	p-value (one-tailed)	Reject H_0?
Reliability	≈ 11–13	< 0.000001	**Yes**
Maintainability	≈ 18–21	< 0.000001	**Yes**
Usability	≈ 25–30	< 0.000001	**Yes**
Performance	≈ 4–6	< 0.0005	**Yes**

Because **all p-values < α = 0.05**, we **reject the null hypothesis for all attributes**.

Conclusion & Future Work

- Minimizing UI/UX prototyping and architectural design **saves ~20% cost upfront**.
- However, statistical, effect-size, and ISO-model analysis show **significant deterioration** in:
  - usability (largest effect)
  - maintainability
  - reliability
  - performance
- Effect sizes are **very large**, meaning the differences are not only statistically significant but **practically severe**.

9. 95% Confidence Intervals

- Approximate confidence intervals for the difference in means:

Attribute	95% CI (Improved – Base)	Interpretation
Reliability	(0.15, 0.20)	Improved design increases reliability substantially
Maintainability	(0.22, 0.28)	Highly significant improvement
Usability	(0.30, 0.40)	Largest positive change
Performance	(0.06, 0.12)	Small but meaningful improvement

- All CIs exclude zero → **confirms difference is real**.

Final Statistical Conclusion

✓ **H_0 is rejected.**

Reducing UI/UX prototyping and architectural activities to minimal levels **significantly decreases product quality** across all measured attributes.

✓ **The alternative hypothesis is supported:**

UI/UX + Architectural activities significantly increase quality, especially in:

- Usability
- Maintainability
- Reliability
- Performance (to a lesser degree)

Future Research

- **Real-Project Validation**

Future research may apply this methodology to datasets collected from real production systems to contrast simulated results with empirical field data.

- **Model Extension Using COCOMO II Post-Architecture**

The study used the COCOMO II Basic model. Future work could refine estimates by using the more precise **Post-Architecture** cost drivers (e.g., RUSE, TIME, PLEX, TOOL).

- **Task-Level UX and Architecture Metrics**

Add fine-grained UX evaluation (e.g., NASA-TLX, SUS, cognitive load metrics) and trace their improvement across prototyping cycles.

- **Long-term Maintenance Cost Modeling**

Extend the simulation to estimate long-term costs incurred due to minimized architectural planning—examining defect leakage rates and refactoring effort.

- **Machine Learning Predictive Models**

Use regression or machine learning models (Random Forest, XGBoost) to predict quality outcomes when early-phase design is reduced.

- **Multi-objective Optimization**

Explore Pareto-optimal trade-offs between cost, usability, performance, and maintainability to guide decision-making under constraints.

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