

Construction Workflow Management System

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Abstract

Workflow management is the coordination of tasks that make up the work an organization does. This mainly focus on the structure of work within some organization and how teams collaborate to complete this work. Workflow management system can replace manual, paper-based quality management systems that are inefficient and prone to error. An automated quality management system increases compliance whether an organization is obliged to regulatory. It can also capture, analyze, track, and document accidents that take place on an active job site according to compliance standards. Using mobile forms, supervisors can easily enter the relevant details of an incomplete task, which is then routed to related employee for rework and action. All activities in the site are tracked with name/data/time and available for reporting to discover trends and key areas of risk. The implemented system intends to perform as a workflow management system mainly focusing on document management and task monitoring. Developed solution mainly has three components; the web-based application for report template designing, the mobile application for report generation and notification system for notify user tasks. It is comprised of several different user levels. This system is used to produce, track, edit, store and manage documents and tasks associated with a business process. The system was implemented using prevailing technologies like .NET, Android Xamarin, SQL Server.

Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

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1. Introduction

Workflow management is the coordination of tasks that make up the work an organization does. This mainly focus on the structure of work within some organization and how teams collaborate to complete this work. Workflow management system can replace manual, paper-based quality management systems that are inefficient and prone to error. The proposed workflow management system focuses on automated document management and task monitoring. This system has two main components. The web application and mobile application. The web application is accessed through a machine and both mobile and web-based solution holds consistent data. There are different users for the system. The roles are Managers, Reporting officers and Supervisors. These users are given different access levels and depending on the role they perform they are permitted to perform certain operations. Main purpose of the system is to generate different types of reports. Depending on the requirement customized reports can also be generated. The formats of reports are pre-defined, and they are drafted in a standard format.

The Manager can create the project. When creating the project, he needs to create it from the project templates. There are pre-defined templates and he can even create a project template if he wishes to have a new template. Since most of the users are not more technical, the process should be a user friendly one. This proposed system introduces drag and drop method for create templates. The project creation includes adding user groups and designing the project template as well. Supervisors can generate the reports according to the tasks of the projects. These reports are generated by entering data. Supervisors can edit them as well. After generating the reports, supervisors can assign the report to their immediate reporting manager to get the approval. The reporting managers will review the reports and pass them after approval. Supervisors can do the changes accordingly and recreate the reports if necessary. Otherwise they can continue their work as intended.

The supervisors and reporting officers can create highly detailed reports of checklists, deviation reports, daily reports, incident reports, package reports, project status reports while they are on site. Each of these reports are different and they are for various purposes as well. All the supervisors might not have the permission to create each report. If the predefined reports do not include all the necessary details, then the supervisors can create their own custom reports according to their need. Manager can view the generated reported as well. These are forwarded to him by relevant reporting officers. Once the reports are generated, managers will be notified through an alert message in the Mobile application. It is a must to have a mobile device, specifically a mobile phone, for all the members of the

organization, to get the real time updates notified. Reporting officer will get a notification once the reports are generated and sent to him.

There is a special feature to make a comment on a report. So, manager can give some feedback for the report by mentioning reasons for his acceptance or rejection. This will make easy to understand the status of report for the next person who in the workflow. As the required amendments are mentioned under the comment section, the supervisor can attend to the work without having any ambiguity about the task. If the reports are approved, they will be sent to the relevant manager and if the reports are rejected and need some revisions, the relevant supervisors will be notified about it. When the reports are approved, the related immediate managers would use it for later reference, or they might forward it to the top management.

Managers can share reports among the group of managers. While sharing the reports they can work on reports together, since it is a synchronized document. So, the updates done by an individual is seen for others at the same time. This leads to less confusion as well. Reports can be modified by adding comments. Reports can be downloaded as PDF and mailed for any third party that the company works with. This is very important when we need to create annual reports and submit a hard copy. Also, it adds the flexibility to attach PDFs to mail threads that are being communicated among different user groups. This system is implemented to overcome the defects of having a manual document maintenance system. With the user-friendly interfaces it provides the users an easy to work environment and they do not require prior expertise knowledge as well.

1.1 Problem

In today's world, most construction businesses have heaps of paperwork involved with day to day business activities and operations. As most of the work happens outside office and it is hard to handle documents in papers because they must do it in an uncomfortable manner. And, there is a great possibility of destroying them due to bad weather conditions and other reasons. Checklists, deviation reports, daily reports, incident reports, package reports, project status reports and more, business operations can be tiresome to handle and document-heavy. Hand written text materials get passed from one division to the other division. These might need either approval or changes at each destination. It requires both effort and time of employees and employer quite a lot. It is also difficult to know workflow status quickly regardless of one's location. Most of the documentation errors can happen due to penmanship and transcription errors. Sometimes the reports could be delivered to the wrong person or documents could be lost or damaged.

Construction organizations without a standardized process often find it hard to keep records of data, since most of their workflow is run on different sites. These informal processes can lead to many issues. Most commonly when trying to access saved documents and when carrying advanced searches for information might be very hard at times. There must be a proper system that ensures that allows authorized individuals, mainly supervisors and top management to easily search what they need at the required time. These searches must not consume excessive time and resources to the project. A proper workflow management system maintains the document material in the company in an organized manner regardless of the format. It also allows proper storing of documents which consumes a less effort when it comes to maintenance as well [1].

Coordination of tasks that builds up the work an organization does, is the main purpose of a workflow management system. The term 'workflow' suggests a series of tasks that belongs to a larger task. The objective of a workflow is to accomplish some outcome. But, the purpose of workflow management is to gain better results according to defined set of goals. The structure of work within an organization is the main emphasis of any workflow management system. And also the way teams in an organization cooperate to complete this work. Workflow management is focused on team work. The way members within teams work together to archive their goal. These tasks may also be automated and performed by digital and other systems computer software. [1].

1.2 Motivation

A properly established workflow management and automation system would replace manual, document-based management systems. These manual systems are usually inefficient and prone to error. An automated quality management system increases compliance whether an organization is obliged to regulatory [2]. It can also capture, investigate, monitor, and document almost every incident that take place on the work premises. At present, most of the systems provides the mobile application support. These mobile solutions allow the employees to easily enter the relevant details of an unfinished task. If these tasks need any revision to be done, then those feedbacks also can be updated and the related employee can take the required actions immediately. All activities in the site are tracked with name/data/time and available for reporting to discover trends and key areas of risk.

Construction companies demand agile, flexible systems to manage the operation and workflow of their business. Maintaining complex approval processes, managing task-based workflow, and interacting with supervisors, employees and managers requires a system that is easily customizable and reliable.

This system provides additional advantage for the management when making decisions. Since they can visualize the progress of the ongoing work it provides them an insight when deciding. As the system is always synced with all the information any user can get updated with the status of the assigned task or project. This proposed solution would address most of the drawbacks of manual documentation maintaining system.

1.3 Project Objective(s)

The proposed system intends to perform as a workflow management system while focusing on document management and task monitoring. Proposed solution mainly has two components; the web-based application and the Mobile application. The objectives of the project are listed as follows.

- This system is used to produce, track, edit, store and manage documents and tasks associated with a business process.
- The proposed system allows to create forms and avoid the problems of paper reports while allowing the worker to create custom, automated workflows that save time and money.
- The system creates more accurate results using highly detailed reports. It helps the employer to learn workflow status at any time with less effort. It will help to minimize the general inefficiencies of dealing with paper documents such as paper documents being damaged or lost, keeping multiple copies of same data that leads to inconsistency and making phone calls to clarify certain data items that are not documented properly.
- Since the proposed solution is comprised of a mobile application, it permits the user to access the system anytime regardless of the time of the day and location.
- Monitor the progress of assigned tasks and make decisions based on those data.
- This proposed solution benefits the management of the organization/company as well. Mostly the management make decisions based on the ongoing progress or status of the current project. For that they require consistent and updated information. This system helps to make decisions in a timely manner.

1.4 Scope of the Project

The workflow management in construction industry is taken into consideration, when developing the system. The system can have three different users as Managers, Reporting Officers and Supervisors with different access levels or permissions. The system comprises of a mobile application and a web-

based application to generate customized reports depending on the task performed in the project. These applications would be having user friendly user interfaces and easy to learn functionalities. The system also allows to generate a set of standardized reports which follow a standard format. These generated reports can be viewed from the immediate managers or other related managers to get approval/rejection.

1.4.1 System runtime environment

Web Application

Operating System - Windows 10

Web browsers – Chrome, IE, Firefox

Connectivity – ADSL

Users – Managers at office

Mobile Application

Type - Native application

Operating System – Android 4.1 or higher

Orientation – Portrait

Connectivity – 3G

Users - Reporting Officers and Supervisors at construction site

1.4.2 Deliverable features

Creating a project

Manager can create the project. When creating the project, he needs to create it from the project templates. There are pre-defined templates and he can even create a project template if he wishes to have a new template. Since most of the users are not more technical, the process should be a user friendly one. This proposed system introduces drag and drop method for create templates. The project creation includes adding user groups and designing the project template as well.

Generate Reports

Supervisors can generate the reports according to the tasks of the projects. These reports are generated by entering data. Supervisors can edit them as well. After generating the reports, supervisors can assign the report to their immediate reporting manager to get the approval. The reporting managers will review the reports and pass them after approval. Supervisors can do the changes accordingly and

recreate the reports if necessary. Otherwise they can continue their work as intended. The supervisors and reporting officers can create highly detailed reports of checklists, deviation reports, daily reports, incident reports, package reports, project status reports while they are on site. Each of these reports are different and they are for various purposes as well. All the supervisors might not have the permission to create each report. If the predefined reports do not include all the necessary details, then the supervisors can create their own custom reports according to their need.

Viewing the Reports

Manager can view the generated reported as well. These are forwarded to him by relevant reporting officers. Once the reports are generated, managers will be notified through an alert message in the Mobile application. Reporting officer will get a notification once the reports are generated and sent to him. There is a special feature to make a comment on a report. So, manager can give some feedback for the report by mentioning reasons for his acceptance or rejection. This will make easy to understand the status of report for the next person who in the workflow. If the reports are approved, they will be sent to the relevant manager and if the reports are rejected and need some revisions, the relevant supervisors will be notified about it.

Monitoring the progress of tasks

Managers can monitor the progress of the tasks performed by workers. Since all the tasks that each employee is assigned is entered to the system, it is easy for the managers to have an idea about the progress. The status of the task can be monitored. So, they can get an idea early as possible about the reasons if some reports get wrong. If any task has been unassigned, it can be assigned to an employee as well.

Sharing Reports

Managers can share reports among the group of managers. While sharing the reports they can work on reports together, since it is a synchronized document. So, the updates done by a particular individual is seen for others at the same time. This leads to less confusion as well. Reports can be modified by adding comments.

Downloading reports

Reports can be downloaded as PDF and mailed for any third party that the company works with. This is very important when we need to create annual reports and submit a hard copy. Also, it adds the flexibility to attach PDFs to mail threads that are being communicated among different user groups.

Alert notifications

This system is composed of a mobile solution as well. Mainly it is there to trigger the required alerts. Reporting officers and managers are notified through a mobile notification, once the reports are generated. Supervisors are notified through an alert message if revisions are needed for the task performed.

1.5 Assumptions of the Project

The project is composed of a web application and a mobile application. The users of the system need to login to the mobile application to update their progress of the assigned task. So, it is assumed that the workers and the supervisors of the organization are provided with related equipment, specifically mobile phones. As this system allows to update or view the dashboard of the application there is always a need of the network connection. With the assumption of having an uninterrupted network connection, the system will function as intended. A network connection with the required bandwidth needs to be existed for the system to perform.

2. Background

Companies who operate in highly regulated industries have further challenges to the usual competition, continuous cost reduction and product development challenges. To address these requirements companies, optimize their business processes and change their applications and information systems to support their evolving way of doing business. Workflow management technology eases the achievement of these necessities by providing methodologies, software and tools to support business process modeling, reengineering and workflow automation [2].

There are workflow and app development platforms that help organizations efficiently and rapidly track, manage and automate critical business processes as well as operational workflows. It makes it easier for the staff to accurately collect data, analyze it in real-time and take appropriate and immediate actions via automated tasks, alerts as well as emails [3]. Creating tasks is very simple and editing all the details is just as well. We can create tasks from a drop-down menu. Delegating tasks is as easy as typing in the name of the team member that one wishes to assign the task at hand.

Most software offers users the ability to track due dates, attachments, and reminders. Because of that none of the tasks are missed and everything follows the plan. The Kanban-based software is wholly customizable through add-on extensions. This permits the users to have their own personalized low-cost system. There are also workflow and process management solutions that offer a simple yet robust way to manage recurring procedures and checklists in the business. It is considered one of the simplest ways to manage recurring workflows for any team in a given business environment. Businesses can use these applications to build and track their processes using super powered checklists for better scaling and minimal errors and save money at the same time [4].

But, the existing systems have certain drawback as well. In some systems, there is no good way to use it to prioritize tasks between projects. While in some systems, free version has no calendar functionality or custom reports. So, it is drawback that limits the usability. In most of the systems, the free version is limited in its capabilities. These systems are also not secure enough. Some of the mobile apps have design issues as well, most commonly sorting the tasks in an order. Some systems require internet access. To have many user friendly features in the apps the users need to pay for the application. In some systems, there also aren't task dependencies, time tracking, or attachment features available yet, where as some do not have time tracking, have limited attachment sizes (25MB) for the free version [4].

These applications get started in minutes. For that mostly they import existing projects or use a pre-built template. It is easy to set up the system then. Since most systems allows sharing your work in real-time it adds more value to multiple users. Most of the systems allows to access tasks, calendars, files, and discussions from any device, wherever you are. With the use of interactive Gantt charts, resource management, automated workflows and file sharing, it has made the work load balance of the management and supervisors.

When it comes to the proposed solution it has its own significant features. It helps in visualizing the work and move work through multiple stages quickly, easily, and beautifully. It uses timeline to create a plan that shows how the pieces of the ongoing project fit together, and helps you keep work on track as things change. It keeps track of progress by viewing work on a calendar. By using this solution, it makes easy to spot holes and overlaps in the schedule and quickly adjust. This helps to view how all the projects are progressing in real time with portfolios, so one can proactively address risks and report updates to stakeholders.

We also can use custom fields to track the info that's most important to the team or company, so it stays front and center. It allows to turn common report structures into templates, so projects run smoothly every time. This proposed solution helps to designate admins to control the organization's usage and set security controls, so they feel confident that their info is secure. The user can create workspaces which are basically a way to group a specific set of tasks which can represent the workload that needs to be done for a specific purpose. Report management is a task that usually consumes a lot of time. By using this structuring of reports can be done in no time. Since the proposed solution is comprised of a mobile application as well it adds more flexibility to the user irrespective of where he is.

Generally, when it comes to a workflow management system, versatility is a common characteristic. Usually the user can create projects and assign them to specific people, thus the related personnel can delegate the workload to rest of the employees. Most of the existing solutions offers native clients on all major desktop platforms such as Windows, Mac OS, and Linux and mobile platforms such as iOS and Android. This simple and lightweight desktop client is the way employees get notified of what tasks have been assigned to them. But now the mobile application solution has become more prominent. Evaluating task management software is a top priority for any team with remote members [5].

2.1 Application Review

2.1.1 Aconex

This is consisting with three applications and needs all that three applications to get a final output. Need an installation of Aconex software on a central server to functioning those apps and pricing is user-based, and details are available on request [6].

Features

- Aconex Mobile: For sharing plans, documents, and correspondence on mobile devices (iOS and Android), as well as capturing data on site, and marking up images and documents. Allows users to coordinate bids, permits, RFIs, and change orders.
- Aconex Field: Helps accelerate field inspections and ensure quality and safety across project organizations and in the field. Runs on iOS and Android.
- Aconex Handover: For on-site access and update of operations and maintenance manuals, prior to handover to customers. Supported on Windows 8 devices.

Drawbacks

- Three apps for generating a useful final report.
- Not a fully free solution.
- Pre-defined report templates and can't create a new style.
- External server wants to configure the system.
- Use to appeal for larger construction companies running in a centralized mode.

2.1.2 BuilderStorm

BuilderStorm serves a market of construction companies working on major public sector and private sector projects, and civil engineering organizations across the U.K. This system hasn't a native application and use responsive design for usage of mobile. Instead of offering different versions of its application according to the operating system or device being used, it uses one version that automatically adapts to different screen sizes and browser software. Pricing is quoted on a per-customer basis [6].

Features

- Manage building project schedules
- Access and store drawing files in the cloud
- Manage construction procurement

- Track project RFIs (Requests for Information)
- Send and receive project messages
- Create reports
- Track construction RFIs (Requests for Information)
- Regular backups of project files and data.

Drawbacks

- Can't use native mobile features since this is only a web base solution.
- Not a fully free solution.
- Pre-defined report templates and can't create a new style.

2.1.3 BuilderTREND

The user interface for on-site construction management in BuilderTREND is designed to adapt to the device being used. While desktop users see comprehensive information on their larger screens, Android, iPad and iPhone users see simpler versions, to help keep the screens easy to understand and navigate [6].

Features

- Presales processes: Management of sales leads, bid requests, estimates, and proposals, with CRM (customer relationship management) functions, including automatic email marketing.
- Project management: Scheduling, to-do lists, daily site logs, punch lists, plan markups, warranty, document and photo management, and messaging.
- Customer account management: Client portal, surveys, reviews, and communication.
- Financial tools: Management of budgets, purchase orders, payments, lien waivers, timesheets (mobile clocking in and out for employees) and change orders.
- Mobile touch signatures for creating change orders on site.
- Microphones for logging and then converting voice to text, for daily site logs and other files.
- Cameras for attaching photos directly to files and logs.

Drawbacks

- Not a fully free solution.
- Pre-defined report templates and can't create a new style.
- More complex functionalities for onsite users.

2.1.4 CoConstruct

CoConstruct is targeting a user base of custom builders, remodelers, and design-build firms. Its software comes in web-based and mobile formats (iPhone, iPad, iPod, and Android devices) [6].

Features

- Select materials and designs for custom project change management and enhancement
- Add comments and photos to selections (including photos taken by the smartphone or tablet running the application).
- Manage task lists.
- Adjust and coordinate schedules with subcontractors and clients.
- Communicate with clients to inform them directly of progress and changes, and reply to emails and text messages, all from the application.
- Manage budgets, with automatic updates and information for clients.
- Keep employee time accounts.

Drawbacks

- Not a fully free solution.
- Pre-defined report templates and can't create a new style.
- More complex functionalities for onsite users.
- Less features for mobile users.

2.1.5 e-Builder

E-Builder is a cloud-based product, and therefore everything can be accessed from mobile phones as well. Anyone can directly access e-Builder Enterprise while on the go, so it's like having the e-Builder desktop dashboard available everywhere. This support construction managers throughout the entire project life cycle. It offers features such as business intelligence reporting, which provides real-time data and forecasts, and it can automatically create reports. Users can customize the dashboards to their liking [6].

Features

- Business intelligence reporting, which allows users to visualize performance across a project.
- Tabular reporting similar to Microsoft Excel.
- Workflow manager, which allows users to drag and drop workflows so everyone is accountable.
- Cost management to eliminate cost overruns.

- Document management, putting all documents into a centralized location.

Drawbacks

- Not a fully free solution.
- Pre-defined report templates and can't create a new style.
- More complex functionalities for onsite users.

2.1.6 Fieldwire

Fieldwire provides a solution which people can edit and share drawings in the field. The mobile construction app allows a team to access the latest project information, no matter where they are. It is available for iPhone, iPad, and Android devices. Users can pull up a project on their mobile phone or tablet, even when they're offline. The blueprints are optimized to Fieldwire's servers, so they display instantly on mobile devices, despite being in high resolution [6].

Features

- A blueprint management system that allows you to import a lot of drawings quickly.
- Automatic sheet hyperlinking.
- The ability to add markups, annotations, and progress photos directly on drawings while in the field.

Drawbacks

- Not a fully free solution.
- Pre-defined report templates and can't create a new style.
- More complex functionalities for onsite users.

2.1.7 Newforma

Offering mobile-app-to-central-office synchronization, the Newforma mobile solution uses a modular approach to construction management, organized into the following applications:

- Plans: For viewing project documents (latest version displayed automatically), zooming and panning on documents, and marking up documents to then send them by email, all from the mobile device.
- Capture: For recording task lists, punch lists, building site notes, with possibilities to tag items using information fields such as what, where, and who is responsible for resolution. Photos can be taken, marked up, and added directly to each item.

- **Tasks:** Combines several field and site management functions, including managing task and punch lists, notes, consulting action items (overdue or imminent) for team members, adding photos, and adding comments and consulting the comment history.
- **Project email:** Offers email display (including filed emails), reply, and forward functions.
- **Project teams:** For team contact and project information management.
- **Field notes:** Management functions for audio, video, and photo captures, with automatic association with corresponding projects, and upload to Newforma Project Center Field Notes activity center, for inclusion in site visit documents, daily reports, and action items.
- **Punch list:** download of latest versions of plans, datasheets, and project information from the central server for making a punch list with additional media (audio, photo, video) captures. Can be used online or offline.

Drawbacks

- Not a fully free solution.
- Pre-defined report templates and can't create a new style.
- Features differ on mobile platform and therefore needs to maintain several devices to make task done.

2.1.8 PlanGrid

PlanGrid is specialized for document and drawing management, as well as local and remote construction team collaboration. It does not have the presales, project scheduling, or timesheet functionality but however, it has enough functional variety and scopes [6].

Features

- Rapid plan viewer.
- Remote team collaboration on plans, markups, photos, and reports.
- Life cycle management of RFIs with blueprints attached.
- Issue logging and tracking, with direct input to punch lists of photos, locations, and on-site notes.
- Rolling log for creation and distribution of issue reports.
- Automatic version control of drawings and team syncing on one master version.
- Automatic hyperlinks from plan callouts for faster navigation through drawings.
- Management of progress photos by all team members, with automatic tagging, syncing, and archiving.

- Syncing and backup of mobile data in a cloud application, with download of the data from the cloud to a desktop PC or server.

Drawbacks

- Not a fully free solution.
- Pre-defined report templates and can't create a new style.
- More complex functionalities for onsite users.
- Unnecessary complex features.

2.1.9 Procore

The functionality, interface, and design of Procore Mobile have been specifically designed for iOS (iPad, iPhone) and Android devices. Procore mobile is likely to better suit production builders that specialize in higher volume production of units with fewer construction options [6].

Features

- Review, create, modify, and share project data with team members, locally and remotely.
- Manage RFIs (requests for information, i.e., project technical queries) and construction project submittals on site and in real time.
- Mark up drawings, link RFIs, and manage punch lists.
- Track drawing set versions automatically and prioritize the most recent set.
- Access project directory and schedules.
- Record minutes of meetings.
- Log daily site activities, weather, labor, and productivity.
- Take photos and attach them to drawings and punch list items.
- Scan QR codes to easily locate relevant building project submittals from Procore in the cloud.

Drawbacks

- Not a fully free solution.
- Pre-defined report templates and can't create a new style.
- Only has a mobile client and it's hard to use it for users who are in inside the office.
- Not enough functionality to generate reports.

2.2. Analysis of the Requirements

2.2.1 Functional Requirements

The basic requirement of having a workflow management system is as follows.

- Allows individuals to automate repetitive processes
- Follows up automatically on uncompleted tasks in the process
- Gives an overall picture of the workflow along with performance metrics

Apart from the above-mentioned reasons, there are typical functional requirements that a workflow management system satisfies [7].

- Enables individuals to streamline repetitive processes

Without keeping the records of data in multiple locations, we can have consistent data by having a proper workflow management system.

- Allows creating projects/reports and assigning tasks

By this report generating workflow management system, it allows creating standardized and customized reports depending on the requirement. After creating projects, the defined tasks could be assigned to relevant employee as well. It prevents the overhead of informing the employee verbally.

- Provides an infrastructure where tasks can be defined and executed

The list of tasks can be defined in the project. The manager can assign the task to supervisors and they can change the status of the task (IN Progress, Completed, Revised etc)

- Automatically follows up on unfinished tasks in the process

If there is any task that does not show any progress can be visualized through the dashboard and immediate supervisors can attend to that matter.

- Synchronizes tasks in every stage of the process chain
- Executes and monitor workflows, and adapts to changes along the way

After completing a task, the immediate supervisor would get notified and generated report would be sent for approval or for rejection, then the supervisor can check on it and either approve it or recommend for further revision on the task.

- Coordinates the operation of individual components that constitute the workflow
- Provides tailored solutions to fit your business process

This proposed solution provides the creation of custom reports when needed. The layout and design of those reports can be provided accordingly.

- Allows custom email notifications/ mobile alerts regarding workflow status to concerned individuals

When the task is completed, and a report is generated and sent to the immediate supervisor, then a mobile notification would trigger to alert the user that he has some receivables

- Allows integration of other systems into the process model to reduce errors from manually copying information

2.2.2 Non - Functional Requirements

In any business, a non-functional requirement is one that would not be considered as must-have criteria in which the business will be built, developed and founded upon. They specifically are used as criteria to judge the operation of the business and are typically going to be landmarks that are a long-term. Typical non-functional requirements that you might consider are:

- Data quality and integrity

Quality of data depends on the time and consistency. So, it is important to have consistent data every time.

- Management structure and strength
- Service speed and quality
- Recoverability

It mainly considers well is everything protected. If an immediate loss of data happens due to some reason, how can the data be recovered.

- Capacity
- Scalability

It mainly focuses on how things can be improved in the future. Is there any possibility to grow bigger in the future?

- Security strength and consistency
- Environmental responsibility and performance
- Efficiency and Effectiveness
- Extensibility
- Adaptability

It includes adding new features and customization of different functionalities

These are targets that can be met in the long-term, and so long as they are established they can be learned from and improved over time. They tend to be extremely important attributes that every stakeholder will try to improve, as they typically mean that the overall product or service is going to be better in the long run [8].

2.3 Information Flow of the system

Figure 2.1 shows information flow of the system.

Process

The process (function, transformation) is part of a system that transforms inputs to outputs. In this system the data processing part is performed by both web application and mobile application. The element generator and report generator would perform the processing.

Data Flow

Data flow (flow, dataflow) shows the transfer of information from one part of the system to another. The data between two components are transferred through REST API calls. The data from the data base is loaded in to the application through several database/server calls.

Warehouse

The warehouse (datastore, data store, file, database) is used to store data for later use. In this system also, a database has been used to store data.

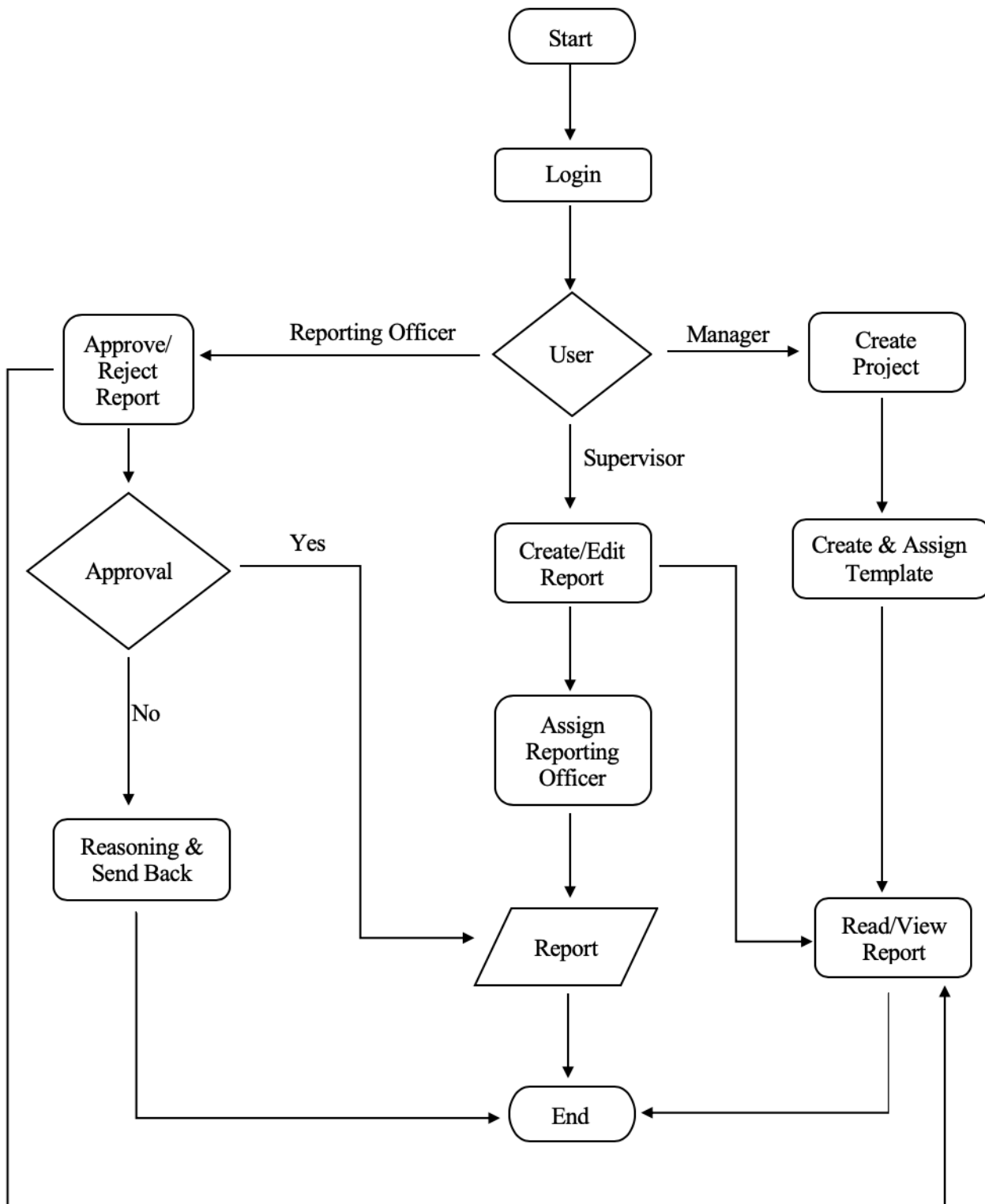


Figure 2.1. Flow Chart of the System

3. Methodology

The proposed system can be used to generate different kinds of reports which in return helps in automating current manual workflow management system. This system has three main components.

- a) Web Based Report Template Designer
- b) Mobile Application of Report Generator
- c) Notification System

3.1 Web-Based Report Template Designer

Managers need various kinds of reports for their analysis. By going through the reports only they can get an idea about the progress of the work. Therefore, this system should be able to generate those different kinds of reports as per the requirement. Manager should be able login to this system and create report templates. The application grants different permissions to different users. There are three user levels in the system. Different views would be created for different types of users.

1. Managers
2. Reporting Officers
3. Supervisors

Managers can design templates. Then can also define in which projects those templates can be used. Managers are also responsible for defining different user groups that can access different templates. A user group might have access to more than one report template. In order to improve the user friendliness of the system, it has been designed to incorporate drag and drop mechanism, where the user can drag the relevant fields and text boxes and create the report in a customized manner. A user-friendly interface would support this.

Managers will have the ability to view the reports which are generated by supervisors/reporting officers. They can provide the feedback for the reports as soon as they view, or they can refer to them later if needed. The managers will also have the option to share the reports among the managerial level when it is important in making a business decision. Sometimes reports may be aggregated to create different types of analytical reports that are required to publish in the annual report of the business organization. Apart from managers, administrator is the other user who will be using this web-based application. Administrator is the person who is responsible for defining user levels and other system configuration tasks. He would maintain the users along with their access levels.

1.2 Mobile Application of Report Generator

This is the mobility section of this system. It is assumed that each person of the organization is provided a mobile phone. There also must be a network connection available within the interested area in order to get the real time updates for the mobile application. Supervisors and Reporting Officers are the main users of this mobile application. Supervisors are responsible for report generating. After logging to the mobile application, supervisor will be able to see different types of project templates that can be generated for a project and then he can be starting to generate report. During the report generation process he can add relevant data for that selected report template and assign a top-level user for acceptance criteria. Once the reports are sent to the related Reporting officers, they are notified through a message.

Reporting officers can view the reports and give their comments or required feedback on that. If he is satisfied with it, he can approve it and forward it to the manager. Otherwise he would reject it and send it back to relevant supervisor to do the alterations. Since most of the supervisors are working in the site it is hard for them to access the reports through a machine. So, it provides them easy access and attend to the needful immediately. Since the report generation also supports attaching images if needed, this mobile application provides the facility to capture images within the site and attach them to the report in no time. It would be helpful for the reporting officers to get an idea about the progress of the work. The assignee of the task can attend to the needful depending on the feedback of the reporting officer. The priority of the task can be mentioned. So, if the issue is very critical to be fixed they can attend immediately or else they can decide to work on it later.

1.3 Notification system

This is another core section of the system and it is responsible to send alerts to relevant users. When the Supervisor generates the report, then an alert message will be sent to the relevant reporting officer. If he approves the report, then the related manager would be notified through an alert message. If the report is approved, then the status of the task can be updated as 'Completed', implying that the task is done. If the reporting officer rejects the generated report due to some reason, then the supervisor will get a notification to rework on the task performed. Then status of the task would be updated as 'InProgress' or 'InRevision'. This notification system would trigger real time notifications and it would be an advantage for the users to attend to the important tasks immediately. This notification system is helpful for the mobile users. The users of the mobile application need to be connected to the

organization network as well. It is assumed that an uninterrupted network connection is available throughout the process.

3.2 Overview Diagram of the System

Figure 3.1 visualizes a sequence of activities in the implemented system. The overview diagram below depicts the available components of the system; the web application, mobile application (including the notification system) and the database. Data which is extracted from the database is rendered in the web application and using different web APIs the data is loaded in to the mobile application. The users of the system are also illustrated as Admin, Manager, Reporting Officer and the Supervisor. The functionalities each of them can perform is also included in the diagram. The tasks that each role can perform differs depending on their level of the organization.

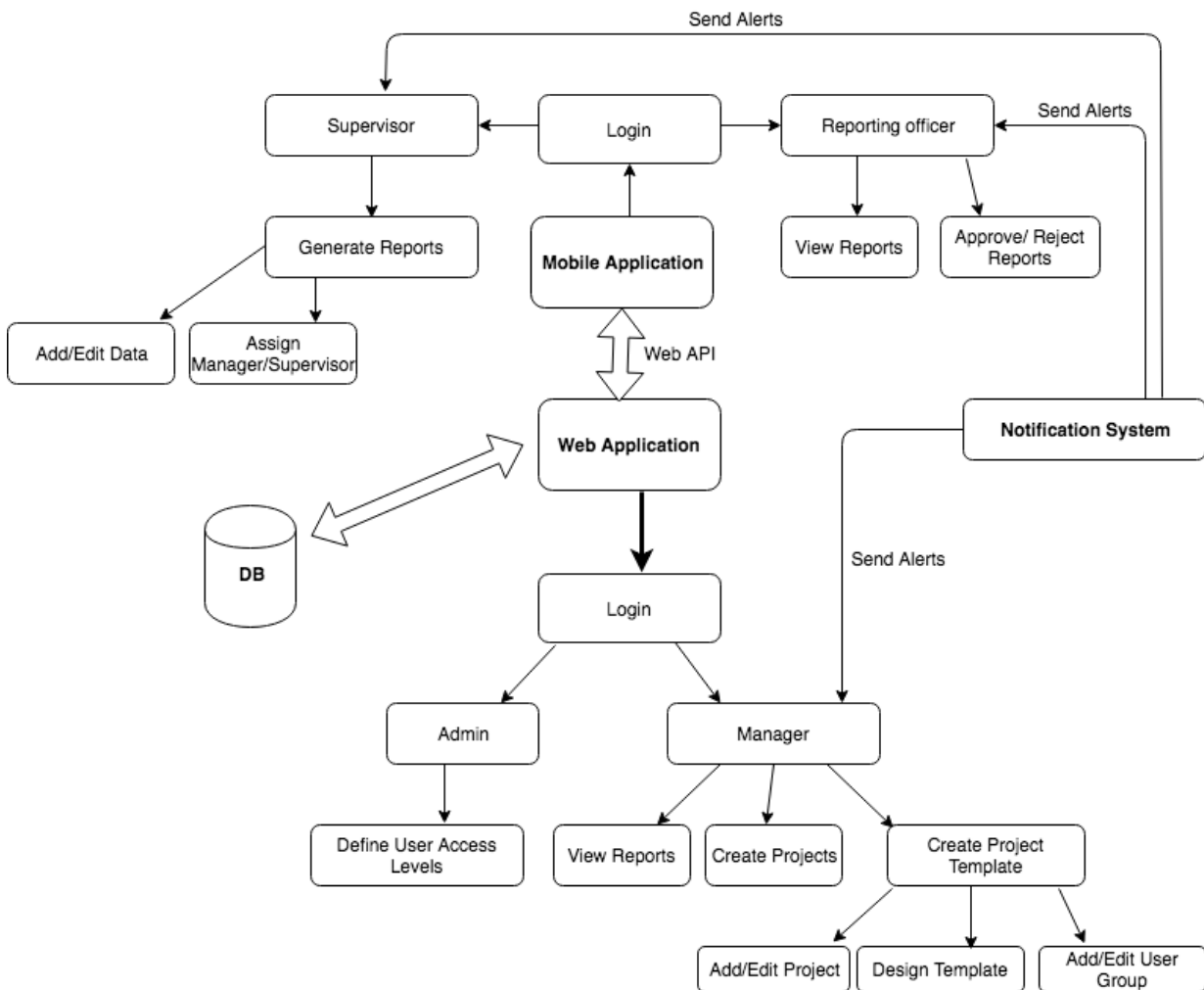


Figure 3.1. Overview Diagram of the System

3.3. Roles in Proposed System

- a) Manager
- b) Reporting officer
- c) Supervisor

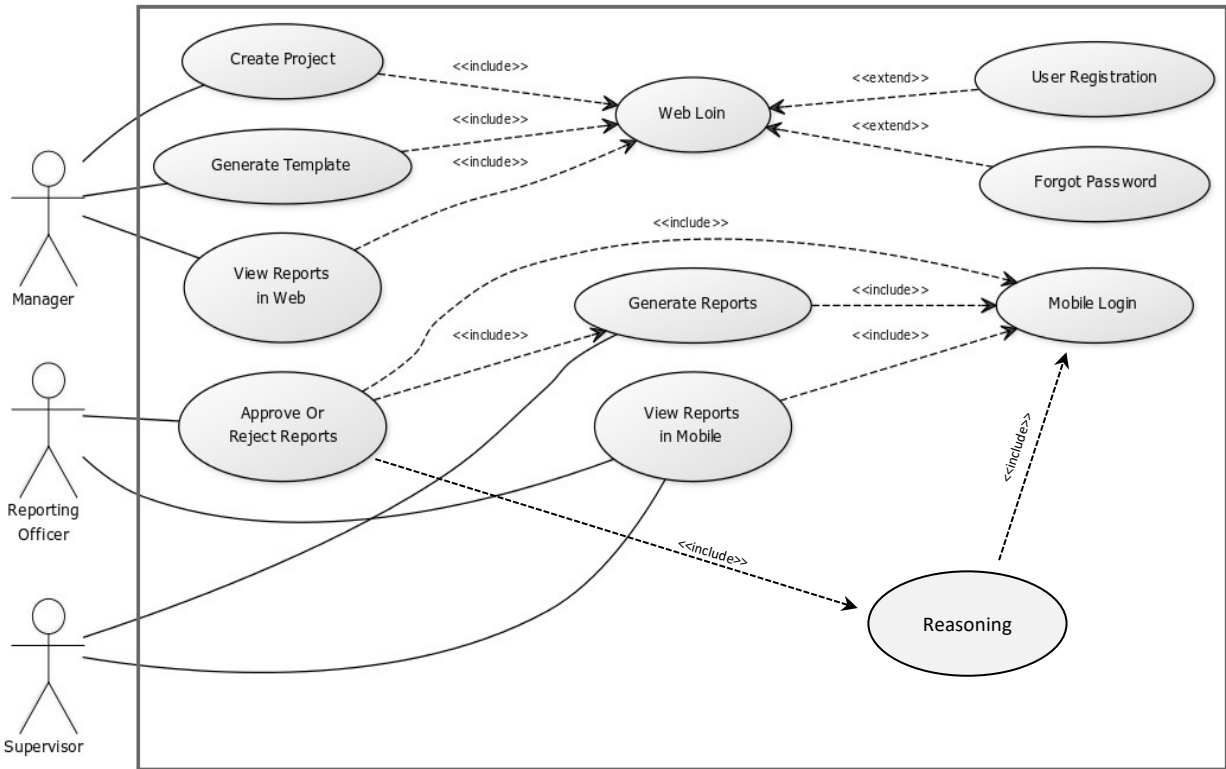


Figure 3.2. Use Case Diagram

The possible actions for each user are depicted in the Figure 3.2. The user roles would be defined by the admin, which is a separate role, outside the system boundary. Every user will be independent from one another. Each user will have different access levels and depending on the user level, accessibility to the mobile and web would be given. The Manger can Create Project, Generate the Project templates, View the reports that are sent by reporting officers. The Reporting Officer can either approve or reject reports that are sent by the supervisors. He can generate reports and view them. The Supervisor can generate the reports and view the generated reports in the mobile. Every user needs to go through either web login or the mobile login, by providing the accurate credentials. If the passwords are forgotten they could be reset again from the system.

3.4 Architectural Design of the Implemented System

The system mainly has two main components.

- a) Web Application
- b) Mobile Application

A notification manager is acting as a common unit for both Web application and Mobile Application. This helps in triggering notifications in real time when needed. The database is used to fetch values in generating reports from the web application. Using both web and mobile application, the generated reports can be viewed.

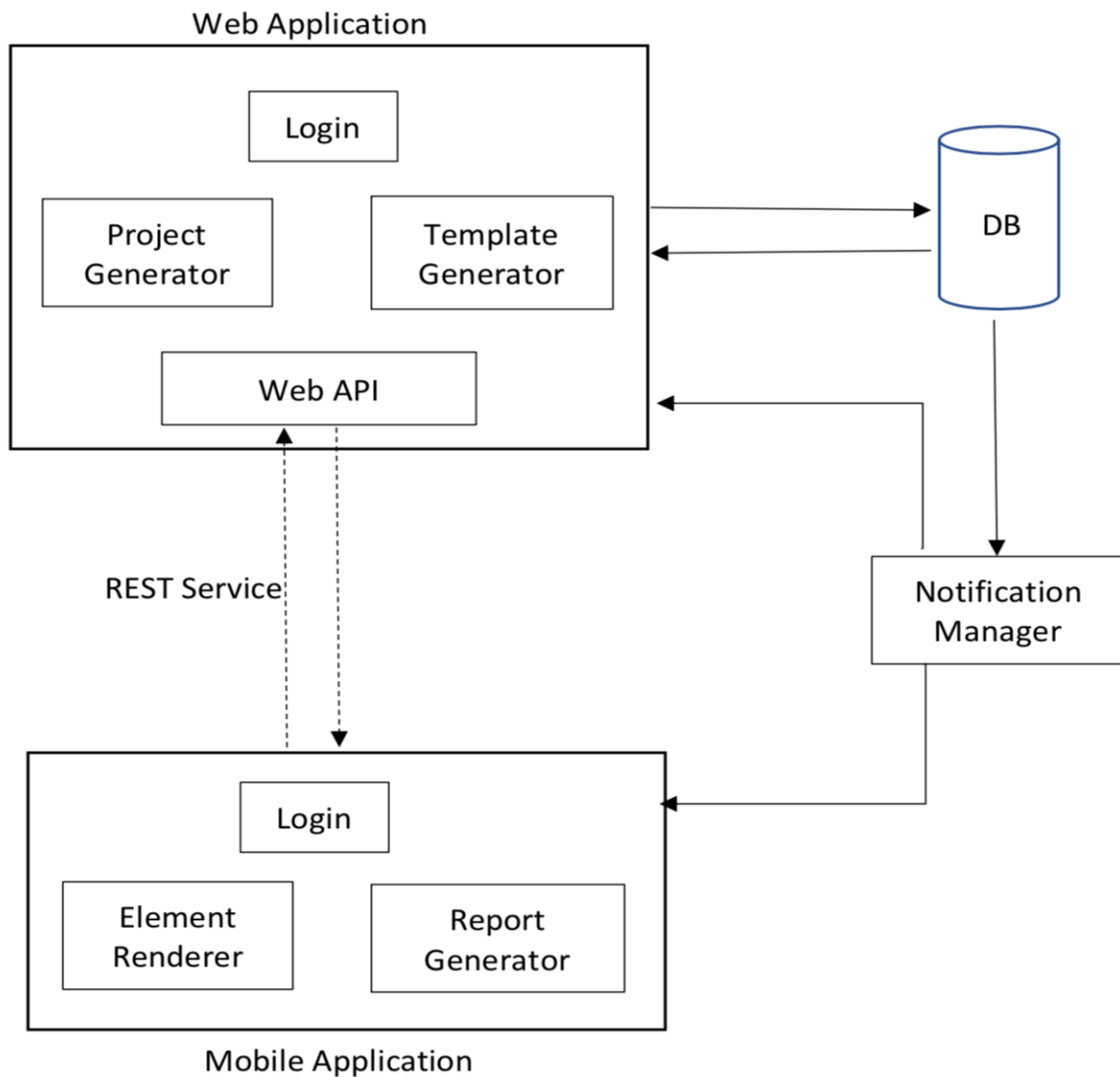


Figure 3.3. Architectural Design of the System

3.4.1 Web application

Web Application is used to display the report templates and trigger the process of report generation. To create the report initially the layout of the design must be finalized. The fields, labels, and other attributes within the report might differ depending on the type of the report generated. So the report creation is dynamic. To fetch the data for the fields in the report, we need to maintain a database connection as well. Different user interfaces need to be designed so that user would find it easy to create the layout and then generate the report.

Web application has two main units as Project Generator and Template Generator. Once the user selects the Project that he wants the available report types for that Project would be shown. Then the user can pick the report type he wants to create. The web application needs to access the database to fetch the relevant values for the fields defined in the report template. Then it also needs to maintain a connection with the mobile application since the reports can be viewed through the mobile applications as well. Through REST calls the communication between mobile application and web application will happen.

3.4.1.1 Connecting to Report Data

Before we start to build a report, we must create at least one data source definition. A data source definition provides details about how to connect to an underlying data source, such as a SQL Server relational database, an Analysis Services database, or an Oracle database. The data source definition specifies the data source type, a connection string, and credentials. Each type of data source requires different connection information. Data source definitions can be saved to a report server and managed as separate files or embedded in the report definition. After we create a data source, we must create at least one dataset. A dataset specifies the fields from the data source that we plan to use in the report, as well as calculated fields that we create. A dataset contains the query and field information, a pointer to the data source definition, query parameters, and data options that include character sensitivities including case, width, accent, and collation information.

3.4.1.2 Creating a Report Dataset

Reporting Services provides data processing extensions to support relational databases, multidimensional databases, report models, and XML-based data. In addition, we can register and

report from standard .NET Framework data providers. Standard .NET Framework data providers do not necessarily support all the features provided by Reporting Services data processing extensions. Data retrieved from a report data source is primarily in the form of a tabular row set. Other retrieved information depends on the type of data source. Data sources can be embedded in a report or defined so that they are shared among multiple reports. A single report can contain any number of data sources, both embedded and shared.

3.4.1.3 Designing the Report Layout

We can interactively position, expand, and contract the initial shape of the report item using snap lines and resizing handles. We can place data regions with different sets of data, or even the same data in different formats, side-by-side. When we place a report item on the design surface, it has a default size and shape and an initial relationship to all other report items. Placing report items in a container helps control the way the report items are displayed on the report page. A report can span multiple pages, with a page header and page footer that are repeated on each page. A report can contain graphical elements such as images and lines, and it can have multiple fonts, colors, and styles, which can be based on expressions.

3.4.1.4 Using the Report Sections

A report consists of three main sections: an optional page header, an optional page footer, and a report body. The report header and footer are not separate sections of the report, but rather are comprised of the report items that are placed at the top and bottom of the report body. The page header and page footer repeat the same content at the top and bottom of each page of the report. We can place images, text boxes, and lines in headers and footers. We can place all types of report items in the report body. We can set properties on report items to initially hide or show them on the page.

We can set visibility properties on rows or columns or groups for data regions and provide toggle buttons to allow the user to interactively show or hide report data. When a report is processed, report data is combined with the report layout elements and the combined data is sent to a report renderer. The renderer follows predefined rules for report item expansion and determines how much data fits on each page. To design an easy-to-read report that is optimized for the renderer that we plan to use, we should understand the rules used to control pagination in Reporting Services.

3.4.1.5 Working with Data Regions

To display data from a report dataset, use a data region. With a data region, you can group, sort, filter, and aggregate data from a single dataset. We use several types of data regions: table, matrix, list, chart etc. The table, matrix, and list data regions are templates based on the Tablix data region, and they can be combined in unique ways to customize data presentation. Charts provide a graphical view of data and aggregates. We can arrange more than one data region in a report. Data regions can be placed side by side in the report body or in a rectangle container or can be nested in other data regions. Multiple data regions can provide different views on the same dataset or similar views on different datasets.

3.4.2 Mobile Application

This system incorporates a mobile application as well. The app enables the users to keep track of their key business metrics, collaborate with other colleagues, and arrive at informed business decisions, all on the go. With this app, user can see all the data, reports and dashboards that he created and have in his own account. User can interact with the reports, favorite those that he likes or views very often, share them with his colleagues and reporting officers. This mobile application is developed in way to support both Android and iOS platforms, where the business logic could be shared irrespective of the operating system. The mobile application will communicate with the web application through REST calls. It would not be necessary for the mobile application to access the database, since already created report is available in the web application.

Some of the key features of the mobile application are listed below.

- Apply filters and see filtered data.
- See the underlying data, or drill-down any point in the report.
- Segregate reports based on type, folders and related views.
- Quickly access/ select reports using Favorites and Recent Items.
- Export and share reports with the colleagues and reporting officers

3.4.3 Notification Manager

The notification manager will trigger notifications when needed. It will facilitate the web users and mobile users as well. When the Reporting officer approves the report the status of it could be updated as 'Completed'. If the reporting officer marks it for rejection or further amendments are required, then

the status of the task could be updated to 'InProgress'. Depending on the criticality of the task, the related personal can attend to the task. This will add the real time notification benefit and attend to the needful tasks.

Some of the instances where notifications are triggered are

- When a report is created and assigned to a Reporting officer, the assignee (Reporting officer) would be notified
- When a report is updated, then the assignees would be notified with the relevant changes

3.5 Interfaces of the Application

The web application looks as below. In the login page, the user needs to provide the required credentials to login.

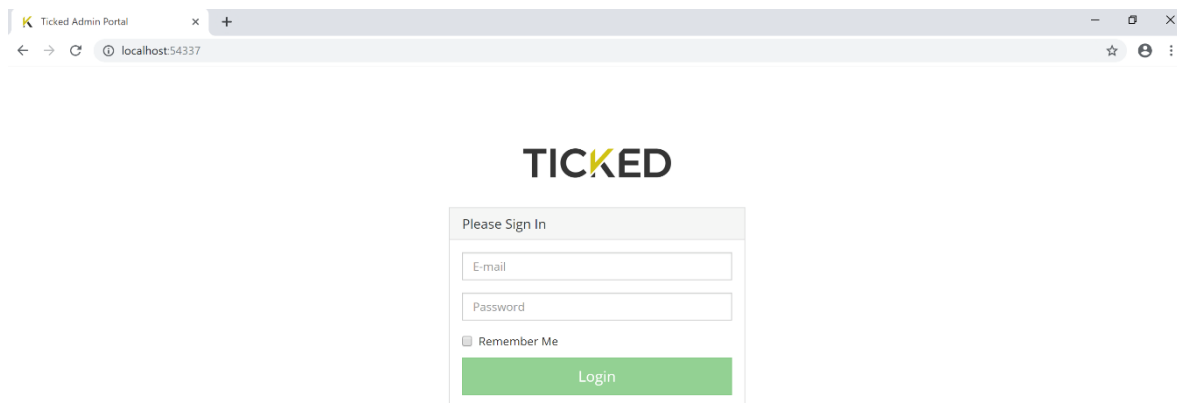


Figure 3.4. Web Login Page

When the login is successful, the user would be directed to the page where projects can be created. Projects can be created using web application only. Information like Project Id, Title, Description, Location can be filled in the columns. By pressing the 'Create Project' button, the new project will get created. Later, if there's any change to be done, it is also assisted by this page.

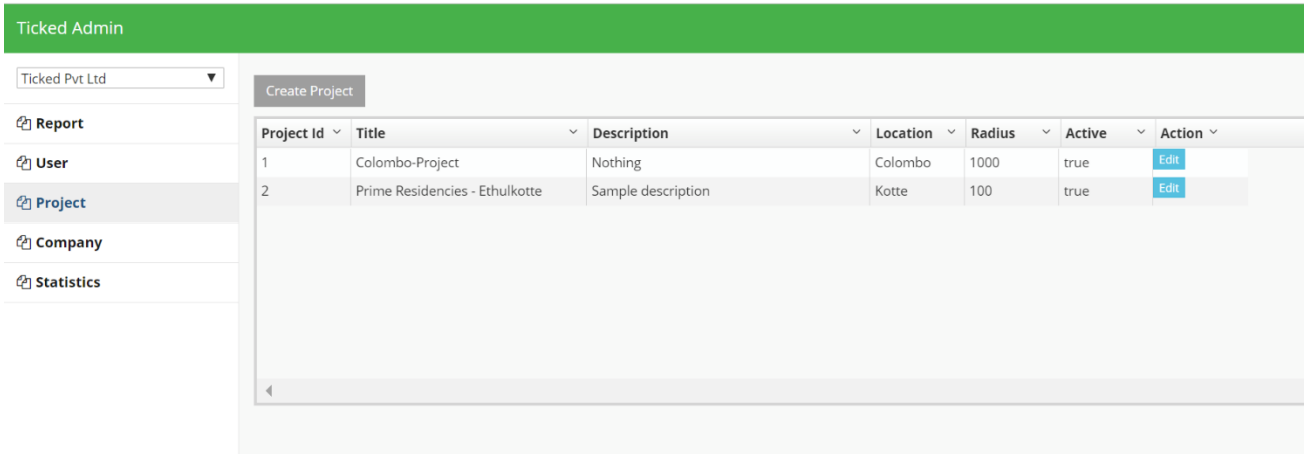


Figure 3.5. Create Project Page

When creating the project, the properties page is important. If there's any change required after the initial data entry, then the user can alter the values here.

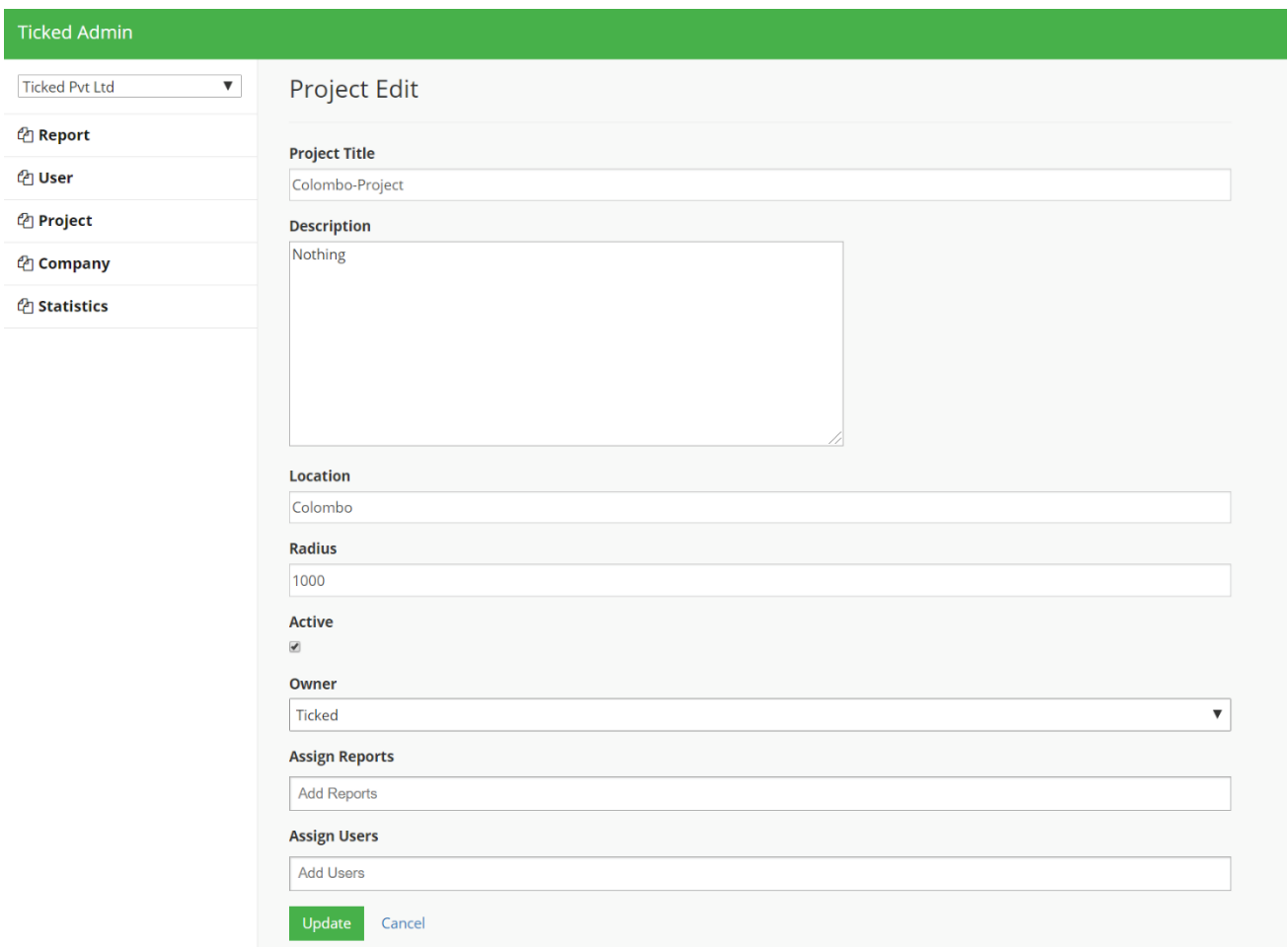


Figure 3.6. Project Properties Page

In here, the user can (mostly the manger) assign the users for the created project also assign the required reports for the project. So, when an assigned user logs with his mobile application, he would get notified that a new project has been created and he has been assigned to it. From the mobile application, every user cannot see all the projects that are created, instead only the ones they are assigned to. “Assign Reports” and “Assign Users” fields plays an important role in filtering the data. When the user has created the project, then the project related report templates could be created from the web application. Report template generation is also, limited to the web application. Later, they can be viewed from the mobile application as well.

The screenshot shows the 'Create Report' page in the Ticked Admin interface. The page has a green header with 'Ticked Admin' and a sidebar on the left with navigation options: Report, User, Project, Company, and Statistics. The main content area is titled 'Create Report' and contains the following fields and panels:

- Report Name:** A text input field containing 'Sample Report'.
- Category:** A dropdown menu with '--Select--' selected.
- Standard:** A checkbox that is currently unchecked.
- Elements:** A panel containing a list of form components: Text Field, Text Field (Number), Slider, Yes/No, Multiline Text, Date, Time, Camera, GPS, Signature, Check Box, Drop Down, Up Down Arrow, Main and Sub Field, and Tabular Form.
- Header:** A panel that is currently empty.
- Details:** A panel that is currently empty.

At the bottom of the form, there are two buttons: 'Save Form' (in green) and 'Reset' (in grey).

Figure 3.7. Report Template Creating page

The users of the application who are given access to the system can also be viewed from the web application as shown in Figure 5. The user id, user name, contact details, role within the application, status of the user (active/inactive) can be seen from the page.

User Id	Display Name	User Name	Phone	Role	Company	Active	Action
1		ticked@ticked.com	0778675467	SuperAdmin	Ticked Pvt L...	true	Edit
11		dilshan@ticked.com	0714775295	SuperAdmin	Ticked Pvt L...	true	Edit
12		kamal@ticked.com	0773456732	Normal	Ticked Pvt L...	true	Edit
13		nalin@ticked.com	0714887563	Admin	Ticked Pvt L...	true	Edit

Figure 3.8. Users of the Application

The interfaces of the mobile application

The Mobile Application interfaces are shown below. This mobile application supports both Android and iOS devices. In the home page, the user specific information would be displayed. Some of the information are the name of the owner, contact details and address. In the login interface, by providing the mail address and the password, the user can log in to the system.

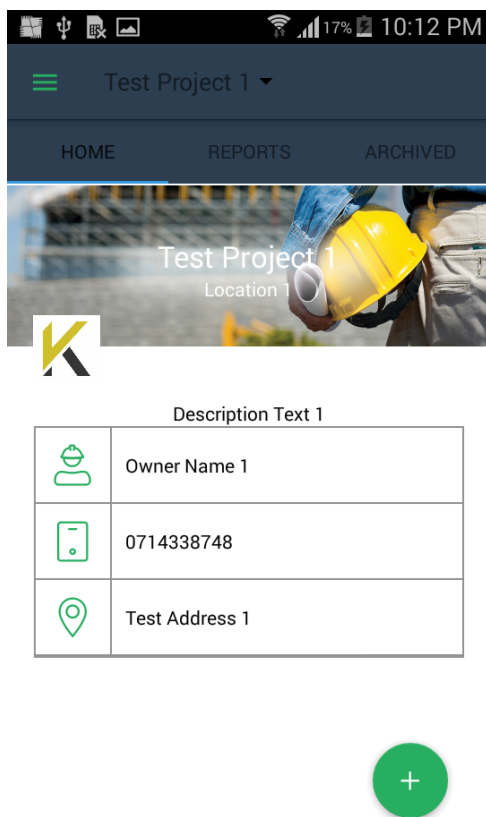


Figure 3.9. Home Page of Mobile Application

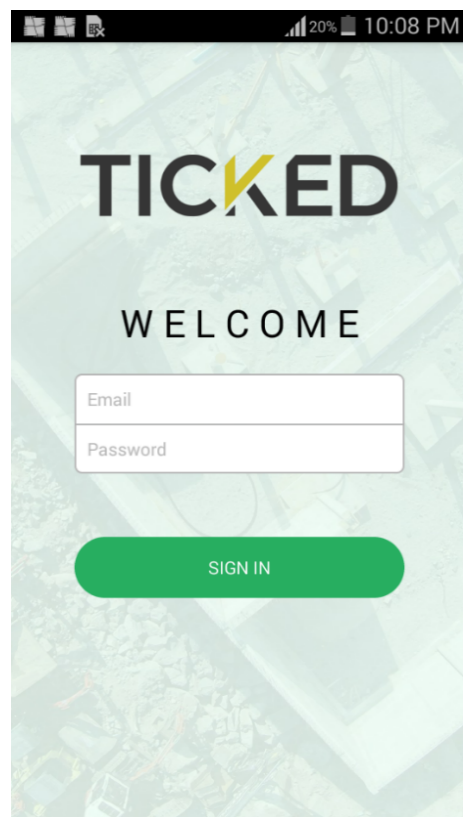


Figure 3.10. Login Page

The related code implementation for home page is as below

```
private void InitializeElements()
{
    CreateActionBar();

    mDrawerLayout = FindViewById<DrawerLayout>(Resource.Id.new_drawer_layout);
    mLeftDrawer = FindViewById<ListView>(Resource.Id.leftDrawerReport);

    List<string> mleftDrawerItems = new List<string>();
    mleftDrawerItems.Add(Resources.GetString(Resource.String.logout));
    mDrawerToggle = new ActionBarDrawerToggle(this, mDrawerLayout, Resource.Drawable.menu_navbar_ham_new, Resource.String.open_drawer, Resource.String.close_drawer);
    mLeftDrawerAdapter = new ArrayAdapter<this, Android.Resource.Layout.SimpleListItem1, mleftDrawerItems>;
    mLeftDrawer.Adapter = mLeftDrawerAdapter;
    mDrawerLayout.SetDrawerListener(mDrawerToggle);
    mLeftDrawer.ItemClick += ListView_ItemClick;

    pager = FindViewById<ViewPager>(Resource.Id.pager);
    pager.OffscreenPageLimit = 2;
    tabLayout = FindViewById<TabLayout>(Resource.Id.tabLayout);

    floatingActionButton = FindViewById<FloatingActionButton>(Resource.Id.fab);
    floatingActionButton.Click += FloatingActionButtonClick;

    InitializePagerAdapter();
}

2 references
private void InitializePagerAdapter()
{
    pagerAdapter = new MainPagerAdapter(SupportFragmentManager, this);
    pager.Adapter = pagerAdapter;
    tabLayout.SetupWithViewPager(pager);
}
```

When implementing the login page, following code segment was written

```
if (Utility.IsInternetAvailable(this))
{
    var progress = new ProgressDialog(this);
    progress.Indeterminate = true;
    progress.SetProgressStyle(ProgressDialogStyle.Spinner);
    progress.SetMessage(Resources.GetString(Resource.String.LoadingMessage));
    progress.SetCancelable(false);
    progress.Show();

    try
    {
        var userSession = await loginService.GetValidUserAsync(new LoginUser
        {
            Email = textEmail.Text,
            Password = textPassword.Text
        });
        if (userSession != null)
        {
            var projectList = await projectService.GetProjectList(userSession.UserId);
            sharedPreferencesEditor.PutString(Resources.GetString(Resource.String.user_session), JsonConvert.SerializeObject(userSession));
            sharedPreferencesEditor.PutString(Resources.GetString(Resource.String.current_project), JsonConvert.SerializeObject(projectList[0]));
            sharedPreferencesEditor.Commit();
            GoToMainActivity();
        }
        else
        {
            Utility.DisplayToast(this, Resources.GetString(Resource.String.LoginFailed));
        }
    }
    catch (Exception ex)
    {
        Log.Debug(ComponentName.ClassName, ex.ToString());
    }
    progress.Dismiss();
}
else
{
    Utility.DisplayToast(this, Resources.GetString(Resource.String.NoInternet));
}
```

When the user logs in to the mobile application, then he would be able to view the projects that he has been assigned. The list of assigned projects can be viewed as Figure 3.11. The report templates related to the project can also be viewed from the mobile application as Figure 3.12. (report templates are created from the web application) Depending on the type of the project, report templates may differ. For implementing every list, (as the reports list, report template list) same pattern has been followed. Basically, the ‘ViewHolder’ pattern has been used.

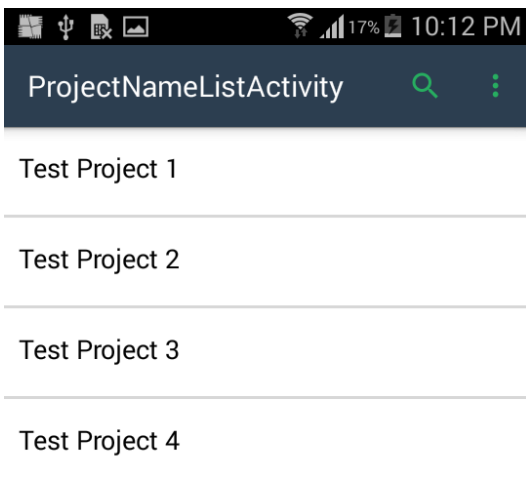


Figure 3.11. Project List Interface

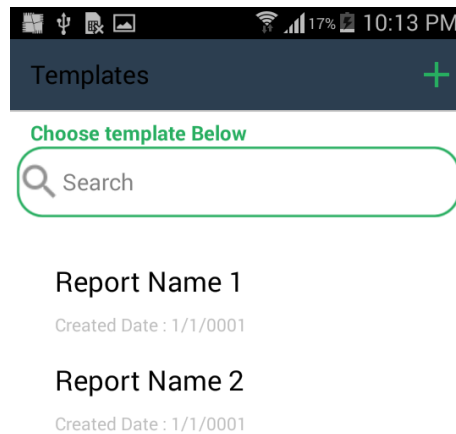


Figure 3.12. Report Template List Interface

Using the report templates, reports can be generated. Then reports can be viewed from the report list as Figure 3.13. For a project, set of different reports would be available. The report list displays the received set of reports and the reports which have been sent for feedback.

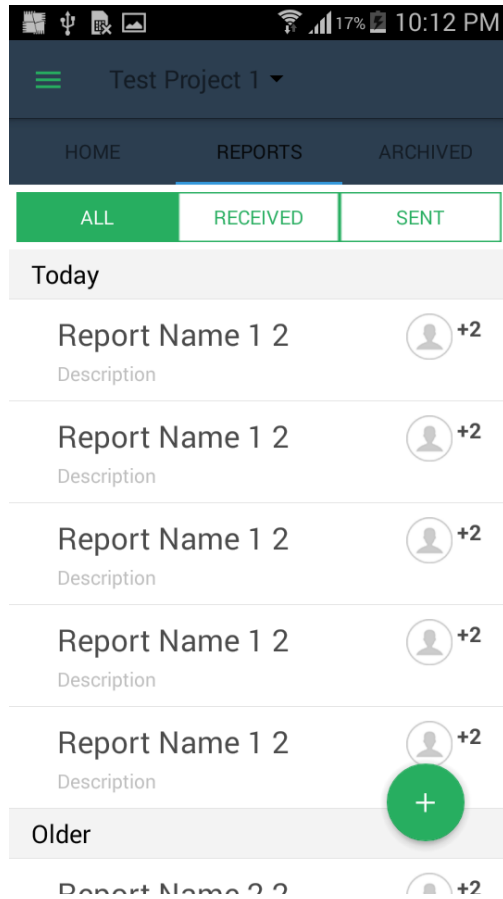


Figure 3.13. Report List Interface

When populating the project List, the below attached code segment is used.

```

4 references
public override View GetView(int position, View convertView, ViewGroup parent)
{
    var view = convertView;
    ViewHolder holder;
    if (view == null)
    {
        holder = new ViewHolder();
        view = LayoutInflater.From(context).Inflate(Resource.Layout.item_project_name_list, parent, false);
        holder.ProjectName = view.FindViewById<TextView>(Resource.Id.lblProjectListName);
        view.Tag = holder;
    }
    else
    {
        holder = (ViewHolder)view.Tag;
    }

    var item = this[position];
    holder.ProjectName.Text = item.Title;
    return view;
}

3 references
public class ViewHolder : Java.Lang.Object
{
    2 references
    public TextView ProjectName { get; set; }
    0 references
    public TextView Location { get; set; }
    0 references
    public TextView CreatedDate { get; set; }
    0 references
    public TextView Count { get; set; }
}

```

Apart from the above implementations regarding to the main functionalities of the application, there are many other considerations as well. Among them, the triggering of validations is playing a major role. When the network connection is not established properly when connecting to the application, that would be displayed using a toast as below.

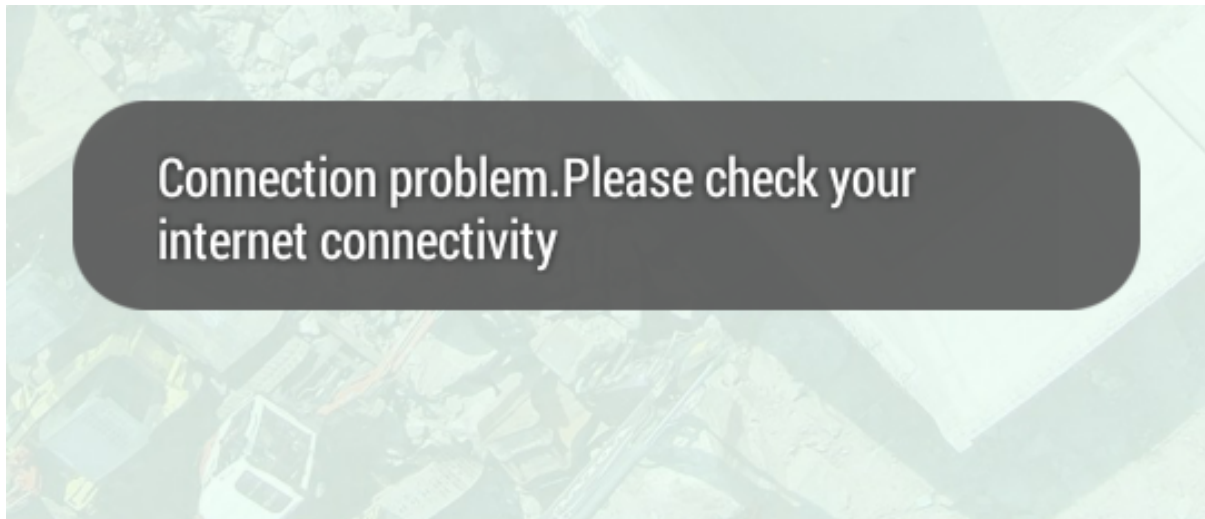


Figure 3.14. Toast for Network Disconnection

3.6 Technologies used for the Implementation

3.6.1 Web Application

When developing a web application, we need to consider both the client side and the server side. The client side is also called the front end. Server-side programming involves an application (and a backend programming language that powers it), a database, and the server itself.

3.6.2 Client-Side Programming

Frontend web development involves everything that users see on their screens. In this project JavaScript (JS) is mainly used to develop the frontend. JavaScript was chosen since it makes web pages interactive and there are many JavaScript libraries (such as jQuery, React.js, and Zepto.js) and frameworks (such as Angular, Vue, Backbone, and Ember) for faster and easier web development.

3.6.3 Server-Side Programming

The server side isn't visible to users, but it powers the client side. When developing the backend, the challenge lies mainly in the choice of server-side technologies for developing the web application. As for server-side programming languages, they are used to create the logic of websites and applications. Frameworks for programming languages offer lots of tools for simpler and faster coding. Throughout the development process PHP(Laravel) is used to handle the server-side programming.

3.6.4 Database

The web application needs a place to store its data, and that's what a database is used for. There are two types of databases: relational and non-relational. Each has its pros and cons. For this system, I have considered the MySQL (relational) as per the database due to the below features.

- MySQL is a fast, easy-to-use RDBMS being used for many small and big businesses.
- MySQL is released under an open-source license.
- It handles a large subset of the functionality of the most expensive and powerful database packages.
- MySQL uses a standard form of the well-known SQL data language. MySQL works on many operating systems and with many languages including PHP, PERL, C, C++, JAVA, etc.

3.6.5 Web Server

The web application also needs a server to handle requests from clients' computers. For that I have chosen 'Apache' as the web server by considering the following reasons.

- Apache has become a keystone in website hosting infrastructure. Because of this adoption and popularity, significant resources have been dedicated to the web server's evolution, upkeep and enhanced functionality
- Apache creates new processes (or threads) for additional connections on the server
- Apache is easier to develop for, which has fostered its own development and expanded its functionality and application
- Apache offers outstanding support for many scripting languages using modules

3.6.6 Web API

As per for this system, RESTFUL APIs are used for backend communication. This was selected as it has the below discussed features. RESTful APIs are also cacheable. This means that the client has the

capability of storing all of the responses within a cache. As a result, the API has an improved performance. When request transfers are being processed, no data gets stored on the server. Instead, the data is stateless, which means the session is saved on the client's end. RESTful APIs implement REST principles as well HTTP protocols. Component interfaces are standardized following specific REST guidelines. The REST architectural style makes use of hierarchical layers as well.

3.6.7 Mobile Application

For developing the mobile application, I have selected Xamarin. Of all cross-platform development tools, Xamarin is considered the most powerful and popular one. This tool is fully .NET and allows building iOS and Android applications, using just one programming language. It allows building native applications for iOS and Android. While the code related to business logic, database access, and network communication can be shared across all platforms, Xamarin allows us to create platform-specific UI code layer. Thus, Xamarin cross-platform apps look 100% native on any device, providing better user experience, as compared to generic hybrid apps.

3.6.8 Notification Manager

This is implemented using Firebase Cloud Messaging (FCM). It is a free cloud service from Google that allows to send notifications and messages to users across a variety of platforms, including Android, iOS and web applications. FCM allows to send push notifications for their applications to end users through an application programming interface (API). Using message targeting, FCM is able to deliver messages to applications in three ways: to single devices, to groups of devices, or to devices subscribed to topics.

4. Evaluation

The purpose of evaluation is to discover errors. Evaluation is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub-assemblies, assemblies and a finished product. It is the process of exercising software with the intent of ensuring that the software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of evaluation methods which can be used for this system. The list of considered factors are listed below

4.1 Facts considered when evaluating the system

- Template design ease and speed
 - Do the reports contain large chunks of data that would be best organized in highly configurable tables? It is necessary to organize data in a proper manner.
 - Do the users need headers, footers and tables of contents to enhance multi-page documents? In here headers and footers have been applied for easy navigation of the user.
 - Are charts and graphs the optimal format for displaying some of the information? Graphs and charts have been included into the places to indicate the amount of task completed/remaining

- Data and Database connectivity

Getting the data into a report template is often one of the most confusing or elaborate processes in the report generation cycle. So, the following scenarios were evaluated

- What data sources can be used in the reports?
- How many different data sources can be used at one time?
- What types of data (e.g., XML, Big Data) can be included? In here we have mostly used XML, JavaScript and some other web specific languages.
- Does the package ensure data security?
- Does the software allow to filter data categories, easily sum totals, and perform other necessary calculations? Using different queries data has been filtered in the system

- Production Speed

The time spent for different operations must be considered.

- How long does it take to design a template? The designing time may differ depending on the requirement.

- How long does it take to add data to that template? Adding data to the template is just a matter of sending server calls from the web through APIs.
- How long does it take to run the report?
- How long does it take to modify a template and re-run the report?

- Infrastructure and Cost
- System Compatibility
 - What programming languages are required?
 - How long will it take to embed the solution into your software product?

- Implementation Costs
 - What will be the expenditures in terms of time spent and resources devoted to implementation?

- Hardware and Software Costs
 - How much up-front investment will be needed to make in software?
 - Will it be needed to upgrade any related software?

4.2 Achieving Project Objectives

The main objective of the system was to perform as a report generating system while focusing on document management and task monitoring. At the end of the project I was able to implement a successful application that generates intended reports in a construction-based organization. Proposed solution mainly had two components; the web-based application and the Mobile application. The remaining objectives of the project were as follows.

- This system is used to produce, track, edit, store and manage documents and tasks associated with a business process. With the implemented system, monitoring of the tasks can be done.
- The proposed system allows to create forms and avoid the problems of paper reports while allowing the worker to create custom, automated workflows that save time and money. The implemented application allows to create a standard set of reports and custom reports based on the requirement.
- The system creates more accurate results using highly detailed reports. It helps the employer to learn workflow status at any time with less effort. It will help to minimize the general inefficiencies of dealing with paper documents such as paper documents being damaged or lost, keeping multiple copies of same data that leads to inconsistency and making phone calls to clarify certain data items

that are not documented properly. Since the Supervisor can update the progress the status of the task, everyone knows the status of the task when they log to the mobile or the web application.

- Since the proposed solution is comprised of a mobile application, it permits the user to access the system anytime regardless of the time of the day and location. The mobile application has been developed and it plays a major role in the whole application.
- Monitor the progress of assigned tasks and make decisions based on data. The implemented application allows to get notifications to the mobile phone whenever there is an update for the assigned task. Depending on the criticality of the issue, the related personal can attend to the task (if a revision is needed/ the report had been rejected)
- This proposed solution benefits the management of the organization/company as well. Mostly the management make decisions based on the ongoing progress or status of the current project. For that they require consistent and updated information. This system helps to make decisions in a timely manner.

4.3 Project Objectives that could not be achieved

The mobile notification system could not be implemented. It could not be implemented with the time constraint given. It requires some tutorials to follow and my knowledge related to mobile notification system needs to be improved as well. It is not technically infeasible, but it requires some background work to be done. So, with the time I had I could not figure out some extra time to spend on that. So that part is missing in the developed application.

4.4 Lessons learnt during the project

- Xamarin android development

I have been developing android applications for some time. But I had not worked quite a lot related to Xamarin implementation. It was useful to learn Xamarin since it is a cross platform framework, which would be quite useful in most of the developments. It brings .NET and C# to both android and iOS platforms. As it was open source it was easy to learn and use. I have followed tutorials in the internet and referred to some videos as well. For developing the mobile application, I have used Xamarin. My knowledge related to Xamarin was sharpened and improved when implementing this mobile application.

- Asynchronous service calls

A multithreaded application has multiple threads residing in memory at a instant of time. One of these threads would be in the running or execution state, while all other threads would be in the ready or runnable state. In the running state a thread has access to all resources including the processor. In a ready or runnable state, a thread doesn't have access to the processor and waits for its turn in a ready queue to be scheduled. The threads are scheduled by the operating system. Support for parallel programming was introduced in .NET Framework 4.0. The support for asynchronous operations in WCF 4.5 makes it very flexible as far as throughput is concerned. The ability to call a WCF 4.5 service asynchronously enables an application to continue its other operations as the main thread (the application thread) is not blocked and so it doesn't need to wait for the service operation to be complete. This concept was learnt in a practical manner when implementing this project.

- .NET web development

Though I have done some basic web development related projects, I was not quite through with the web development earlier. When implementing the web application, .NET was mainly used. Along with-it C# has been used. These are secure and fast. The scalability is also an added advantage of using .NET and C#. The knowledge on developing websites was improved. .NET was chosen to develop the web application, since it was open source server-side web application framework designed for web development to produce dynamic web pages. I had to read some articles related and follow some videos and tutorials related to the implementation of web applications. Knowledge on developing web application has been smoothed after implementing the web application.

- Web API development

Web API as the name suggests, is an API over the web which can be accessed using HTTP protocol. It is a concept and not a technology. The ASP.NET Web API is an extensible framework for building HTTP based services that can be accessed in different applications on different platforms such as web, windows, mobile etc. It works the same way as ASP.NET MVC web application except that it sends data as a response instead of html view. It is like a webservice or WCF service, but the exception is that it only supports HTTP protocol. When implementing those projects, I had to refer some tutorials and videos to understand how these APIs work and how to implement them. Knowledge on working with web APIs was improved from this.

- Apply Custom styling on android components

Styles and themes on Android allow to separate the details of the app design from the UI structure and behavior, like stylesheets in web design. A style resource defines the format and look for a UI. A style

can be applied to an individual View (from within a layout file) or to an entire Activity or application (from within the manifest file). A style is defined in an XML resource that is separate from the XML that specifies the layout. When designing the mobile application, I had to refer some tutorials and sample codes to understand how to apply different custom styles for the application. The ‘Android Developers’ documentation was helpful when referring. I was able to improve my knowledge on adding custom styles for android applications.

- Managing time to complete the tasks

Within the given time frame, I had to develop the project. So, prioritizing the tasks were important. Then breaking down the tasks into sub tasks made to improve the progress, as it helps to complete the task with less stress. When implementing the application, I had to allocate more time for reading other’s work and enhance my knowledge on areas that I was not competent enough. I had to follow several videos and go through sample codes to understand the concepts before applying them to my context. Time management was hard to do. But I was able to complete most of the expected project objectives. Only one task was not able to complete due to the lack of time I had. Apart from that most of the important tasks have been completed.

4.5 Challengers found when implementing the system

- Drag and drop fields when creating a custom template

Drag and drop feature was necessary to be added as it was a user-friendly feature. But this feature was difficult to be added. It took a lot of time to go through some materials to understand how it can be used. Anyway, that feature was developed. To apply it to my context, I had to refer some documentation as well. I needed to follow some tutorials to understand how to implement it. I had not developed anything related to drag and drop functionality earlier. So, I had to commit some time and effort to get it done. I have included that feature to the proposed application. It makes the application user – friendly. So that feature adds value to the application.

- Generating custom reports in mobile application

This was complex to handle. The json manipulation was difficult to work on. It took some time to refer some of the online documentation and then map to it to the context that I use. The supervisor can make customer reports depending on the requirement. The design or the layout of the report can be defined

and then the report would be generated. This feature helps the organization in designing their own reports.

- Images Handling (Uploading/Downloading)

In the mobile application there was a necessity to attach the image. For example, if the task was related to some damage happen to certain equipment or cracking of a wall or breaking a part of some other item, it was clear to attach an image of the incident rather than explain it in words. So that adds value to get an understanding for the reporting officer as well as for the supervisor. So, after the fixing has been done the related assignee can again capture the image from the mobile phone and attach it to the task. I had to refer some tutorials and go through some sample codes to understand how the implementation has been done. I have added that feature in the application and it adds value to the system. The viewer can download the image as well and keep it for later reference as well. Image uploading and downloading is very user-friendly feature in most of the mobile applications today.

- Creating Connectivity between Server APIs and Mobile Application

This is very important section of the system because without a connectivity, mobile application can't get any data from the server side. Since I hosted the server locally, I had to make some alterations on mobile application side for making connectivity success. It got more worse because I developed the system on a virtual machine. First of all, had to configure host machine network settings and do some modifications even on virtual machine. There were some code modifications when connected to a local host rather than a hosted web site. For all these changes, I followed some online materials.

4.6 Test Plan

Testing is a major activity component of the system. This is used to identify bugs/defects before deliver the system to client. Since this system has two components, at the beginning it took single component and tested. Then executed the test for combined solution.

4.6.1 Tested Features

Web Application

- Login
- Project creation
- Template creation
- Template assigning
- View summary

Mobile Application

- Login
- Project detail
- Report generation
- Report assigning
- Accept/Reject report
- View reports

4.6.2 Testing Criteria

Unit Testing

Unit tests involve the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application. It is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. perform basic tests at component level and test a specific business process, application, and system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

Below are some of the scenarios where unit testing was performed

- Login to the system – both mobile and web application (validations for username and password)
- Adding users to the system
- CRUD operations for Project
- Creating Report Templates (CRUD operations for reports)
- Assigning the defined tasks to employees
- Updating the status of the assigned tasks
- Viewing and editing reports from the mobile application
- Creating custom reports for various designs
- Approving/Rejecting the reports

Integration Testing

Integration tests are designed to test integrated software components to determine if they run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown

by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination of components.

The following list defines some of the test case scenarios for integration testing.

- Generating report templates from the web application and viewing them from mobile application Both web application and mobile application functionalities are tested together.
- Updating the task with approval/rejection from the web application and getting the updated information in the mobile application as well.
- Defining the required fields for the custom report in the and creating the report

System Testing

System testing is the testing of a complete and fully integrated software product. Usually software is only one element of a larger computer-based system. Ultimately, software is interfaced with other software/hardware systems. The whole system comprising both web and mobile solution is tested from end to end covering all the functionalities and performance is taken into consideration.

- This process was started from creating a user and defining his role.
- Then a new project instance was created, and project template was created.
- New user groups were assigned to the project.
- Managers and Supervisors generated reports and assigned the tasks and updated the status of the tasks while working on them.
- After completing the tasks, the generated reports were sent for approval. Depending on the approval/rejection, the tasks were revised.
- Management could make decisions based on the generated reports.

Acceptance Testing

After the developer has completed all rounds of testing and he is satisfied with the system, then the user takes over and re-tests the system from his point of view to judge whether it is acceptable according to some previously identified criteria (Requirement Specification). The complete system will be installed in a practical environment in a hospital and run to identify the real-world issues that the application face.

Apart from those tests verification and validation is also considered when evaluating the product. The main purpose of verification and validation activities is to assess and improve the quality of the product. Quality depends upon various attributes like correctness, completeness, consistency,

reliability, usefulness, usability, efficiency and conformance to standards. Verification activities include proving, testing, and reviews. Validation is the process of evaluating software at the end of the software development to ensure compliance with the software requirements.

4.6.3 Test Cases

Web Application		
	Steps	Expected Result
Login	Tap login button without enter credentials	Toast message should display by mentioning empty fields
Create Project	1.Login to application 2.Click on project tab 3.Click create project 4.Fill necessary fields 5.Click create button	Successfully create a project on database and successful toast message should display.
Create Template	1.Login to application 2.Click on project template tab 3.Click create template 4.Drag & drop fields 5.Click create button	Successfully create a template on database and successful toast message should display.
Assign Template	1.Login to application 2.Click on project template tab 3.Click create template 4.Drag & drop fields 5.Click create button	Toast message should display by mentioning empty fields
Mobile Application		
Login	Tap login button without enter credentials	Toast message should display by mentioning empty fields
View Report	1.Login to application 2.Tap report tab	There should be three tabs with report list (Sent, Received, Archived)
Create Report	1.Login to application 2.Click on floating button 3.Fill all the fields 4.Tap complete button	Alert window should show with two option buttons (Assign Verifier, Send to Archive)
Assign Verifier	1.Login to application 2.Click on floating button 3.Fill all the fields 4.Tap complete button 5.Select Assign Verifier option 6.Select verifier 7.Tap Ok button	Successfully create a report and successful toast message should display.
View Report Status	1.Login to application 2.Click on archive tab 3.Select a report	Alert popup should display with report details

Table 4.1. Test Cases

4.7 User Feedback

I have used a form to getting user feedback for current system evaluation. This form distributed among managers, project officers and supervisors and got their feedback. Figure 4.1 indicates that form which I used to getting feedback from users and Figure 4.2 indicates the overall result of their feedback.

User Feedback Form

Please take a few moments to provide us with some important feedback about Construction Workflow Management System. This information will be used to improve the application features.

Web Application

Feature	Rating				
	1	2	3	4	5
I can login to the system every time without any issue					
Forget password give me an option to retrieve my password					
I can create new project with all required details					
I can easily add new user to the system					
I can create new project template easily					
I can assign users and projects to templates very efficient manner					
I can view overall summary of all templates					
I can see the reports current status					
Application responsiveness					
Overall satisfaction					

Mobile Application

Feature	Rating				
	1	2	3	4	5
I can login to the application every time without any issue					
I can see my current project details on home page					
I can switch between projects easily					
Easy to understand report status					
I can create report easily					
I can send report to necessary parties for approval					
I can clearly see reasons for report approval/rejection					
Application responsiveness					
Application connectivity					
Overall satisfaction					

Figure 4.1. User Feedback Form

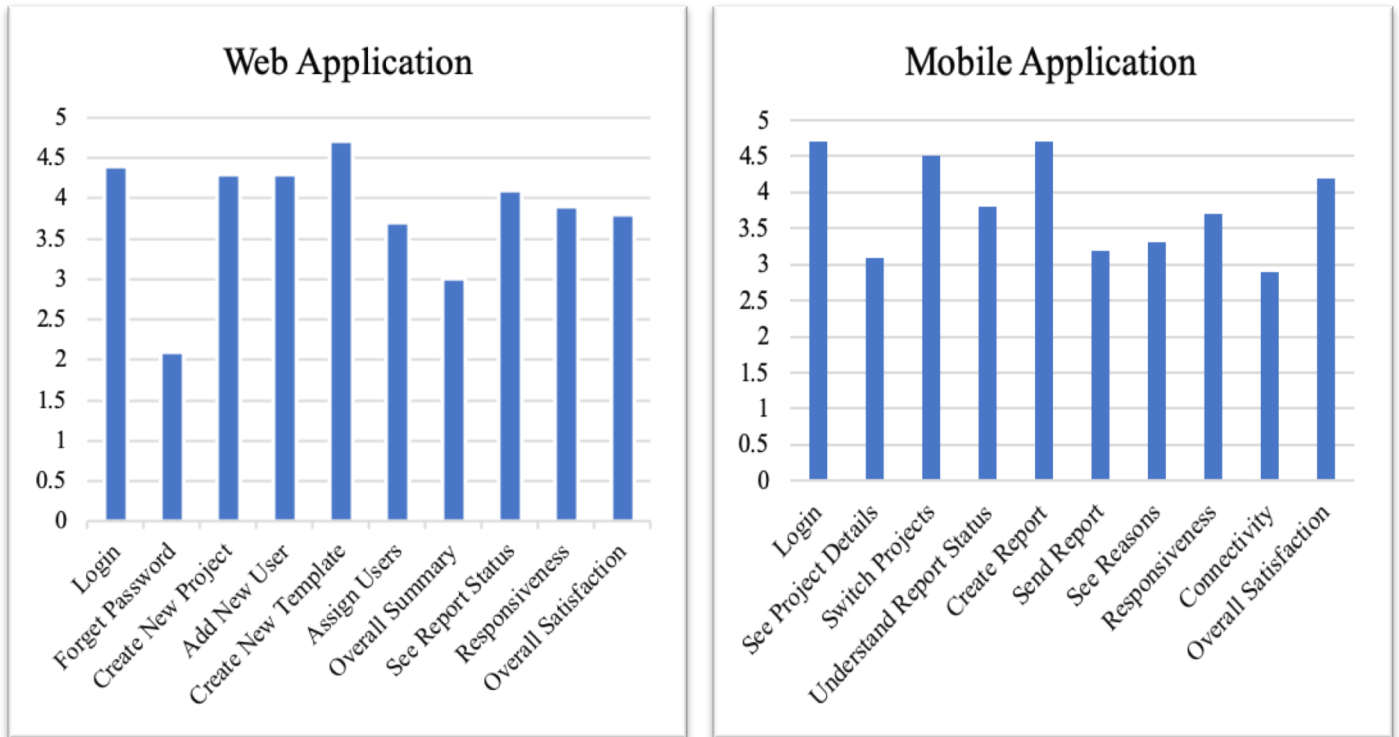


Figure 4.2. User Feedback Results

5. Conclusion

In this project I have implemented a construction workflow management system. There are many reasons to have a construction workflow management system. Today most construction businesses have many paperwork involved with daily operations. Maintaining paperwork is difficult and most of the time it requires an additional effort when referring to past information and in storing as well. Checklists, deviation reports, daily reports, incident reports, package reports, project status reports and more, business operations can be tiresome to handle and document heavy. Data inconsistency can take place as the records cannot be updated immediately and the value of information may be lost with time. In construction organizations, most of the work happen in sites and employees in sites need to check the work and update the status of the tasks. So, if they happen to carry files or related document with them it would be a burden for them as well. Losing of documents can also take place, since there is no proper place to handle the paperwork in construction sites. Reasons would substantiate the need to have an automated workflow management system for a construction site.

Workflow management and automation can replace manual, paper-based quality management systems that are inefficient and prone to error. It would save both time and space of maintain documents. This would also give the ease of having updated data for the employees and the management as well. Up to date information will be available at any time. It can also capture, analyze, track, and document tasks that take place on an active job site. Using mobile devices, supervisors can easily enter the relevant details of an incomplete task, which is then routed to related employee for rework or attend to related action. All activities in the site are tracked with name/data/time, which would give a reference for later. Visualizing the progress of different tasks can be made with the use of this application which in turn helps in making decisions for the management.

This system intends to perform as a workflow management system while focusing on document management and task monitoring. This system mainly has two components. A web-based application and mobile application. The mobile application is used to produce, track, edit, store and manage documents and tasks associated with the construction site. Web application allows to create forms and avoid the problems of paperwork while allowing the worker to create custom, automated workflows that save time and money. It helps the employer to get an overall idea of the workflow status at any time with less effort. It will help to minimize the general inefficiencies of dealing with paper documents such as documents being damaged or lost, keeping multiple copies of data that leads to data inconsistency.

There are different users for the application. Mainly the manager, supervisor and worker would be the roles. Admin would be a different role that allocates permission to different users. Depending on the role, the users would be given the approval to perform certain actions. Manager can create the project. When creating the project, he needs to create it from the project templates. There are pre-defined templates and he can even create a project template if he wishes to have a new template. This system has drag and drop method for creating templates. The project creation includes adding user groups and designing the project template as well. Supervisors can generate the reports according to the tasks of the projects. These reports are generated by entering data. Supervisors can edit them as well. After generating the reports, supervisors can assign the report to their immediate reporting manager to get the approval. The reporting managers will review the reports and pass them after approval. Supervisors can do the changes accordingly and recreate the reports if necessary. Otherwise they can continue their work as intended.

The supervisors and reporting officers can create different reports. All the supervisors might not have the permission to create each report. If the predefined reports do not include all the necessary details, then the supervisors can create their own custom reports according to their need. Manager can view the generated reported as well. These are forwarded to him by relevant reporting officers. Manager would either reject or approve the report. If the reports are approved, they will be sent to the relevant manager and if the reports are rejected and need some revisions, the relevant supervisors will be notified about it. Managers can monitor the progress of the tasks performed by workers. Since all the tasks that each employee is assigned is entered to the system, it is easy for the managers to have an idea about the progress. If any task has been unassigned, it can be assigned to an employee as well.

There are certain special features of the system as well. Among them the ability of the Managers to share reports among the group of managers is prominent. While sharing the reports they can work on reports together, since it is a synchronized document. So, the updates done by a individual is seen for others at the same time. This leads to less confusion as well. Another feature is that, the reports can be downloaded as PDF and mailed for any third party that the company works with. This is very important when there is a need to create annual reports and submit a hard copy. Also, it adds the flexibility to attach PDFs to mail threads that are being communicated among different user groups.

Future Improvements

In the proposed implementation there was a feature to have mobile notification system where the managers are notified when the supervisors send them a report. With the time constraint it could not be implemented. Other implementations consumed more time and other functionalities were having more priority. But it would be a useful feature if the application had it, since managers could get notified immediately. This would be a feature that could be achieved in further implementation.

Apart from that the performance of the application could be further improved. Even the slight delays when loading the data could be avoided by doing so. This workflow management application would be useful for many users out there working in construction sites and who require visualizing the progress of the work going on in site without physically being in the site.

6. Annexures

Web Application Test Results

Login	
Steps	Tap login button without enter credentials
Expected Result	Toast message should display by mentioning empty fields
Status	PASS

Create Project	
Steps	1.Login to application 2.Click on project tab 3.Click create project 4.Fill necessary fields 5.Click create button
Expected Result	Successfully create a project on database and successful toast message should display.
Status	PASS

Create Template	
Steps	1.Login to application 2.Click on project template tab 3.Click create template 4.Drag & drop fields 5.Click create button
Expected Result	Successfully create a template on database and successful toast message should display.
Status	PASS

Assign Template	
Steps	1.Login to application 2.Click on project template tab 3.Click create template 4.Drag & drop fields 5.Click create button
Expected Result	Toast message should display by mentioning empty fields
Status	PASS

Mobile Application Test Results

Login	
Steps	Tap login button without enter credentials
Expected Result	Toast message should display by mentioning empty fields
Status	PASS

View Reports	
Steps	1.Login to application 2.Tap report tab
Expected Result	There should be three tabs with report list (Sent, Received, Archived)
Status	PASS

Create Report	
Steps	1.Login to application 2.Click on floating button 3.Fill all the fields 4.Tap complete button
Expected Result	Alert window should show with two option buttons (Assign Verifier, Send to Archive)
Status	PASS

Assign Verifier	
Steps	1.Login to application 2.Click on floating button 3.Fill all the fields 4.Tap complete button 5.Select Assign Verifier option 6.Select verifier 7.Tap Ok button
Expected Result	Successfully create a report and successful toast message should display.
Status	PASS

View Report Status	
Steps	1.Login to application 2.Click on archive tab 3.Select a report
Expected Result	Alert popup should display with report details
Status	PASS

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