

CLOUD FEMTOCELL MANAGER (FAP)

A Project Report Phase – II

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Electronics and Communication Engineering

by

SATWIK VINAY TEJA JANGA (39130406)

VISHVESWAR REDDY SUNKIREDDY (39130453)



**DEPARTMENT OF ELECTRONICS AND COMMUNICATIONS ENGINEERING
SCHOOL OF ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHISALAI,
CHENNAI - 600119**

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SATHYABAMA

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Accredited with "A" grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

www.sathyabama.ac.in

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **SATWIK VINAY TEJA JANGA (39130406)** and **VISHVESWAR REDDY SUNKIREDDY (39130453)** who carried out the project entitled "**CLOUD FEMTO CELL MANAGER**" under my supervision from November 2022 to April 2023.



Internal Guide

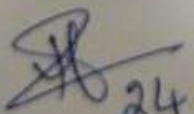
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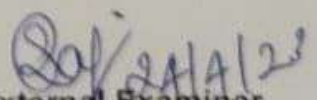
Head of the Department

Dr. T. RAVI M.E., Ph.D.,

Submitted for Viva voce Examination held on 24.4.23



24.4.23
Internal Examiner



24/4/23
External Examiner

DECLARATION

We, **SATWIK VINAY TEJA JANGA** (39130406) and **VISHVESWAR REDDY SUNKIREDDY** (39130453) hereby declare that the Project Report entitled "**CLOUD FEMTOCELL MANAGER**" done by us under the guidance of **Dr.E.LOGASHANMUGAM, M.E.,Ph.D.**, Pro Vice Chancellor, **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY, CHENNAI**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

DATE: 24 - 04 - 23

PLACE: Chennai

SIGNATURE OF CANDIDATES

1. T. Natwik

2. S. Vishweswar

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ABSTRACT

This project is an understanding of the concept known as "Femtocell Management Console" or "femtocells." The current approach is employed mostly in areas where macro cell coverage is poor or non-existent as well as in instances of network congestion. As a result, the speed is frequently disturbed, which causes extra delays. This is why the Femtocell, a tiny cellular base station that expands mobile network service providers' coverage, was designed for this console. A femtocell is a cellular base station with a very short range and little power that can be installed in a home or office. It is offered by a mobile network provider and uses authorised frequency ranges. Femtocells are used to give cellular devices network connectivity in areas where operator base stations or macro cells cannot reach or have poor coverage, such as inside large building complexes, underground construction sites (such as railway stations, basement levels, etc.), aboard buses and trains, etc. The range is the primary distinction between a femtocell and a base station, microcell, or picocell. A base station may have a range of 20 to 30 kilometres, a macro cell 1-2 km, a picocell 200 to 300 metres, and a femtocell as little as 10 metres. The femtocell management console that has been developed will assist in managing and keeping track of the equipment connecting to the femtocells. In contrast to other cellular connectivity options, femtocells connect back over the internet to provide in-home or workplace cellular connectivity.. Femtocells can be installed close to existing hardware arrangements and resemble routers in both appearance and operation. A femtocell can be purchased by anyone to improve cellular connectivity in their home or small company.

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CHAPTER 1

INTRODUCTION

This chapter deals with the brief introduction of the area of work, its significance in the present-day scenario and the motivation to do the project work which includes the shortcomings of the related previous work, importance of the present work and the significance of the results obtained. Also, this chapter deals with the formulation of objectives because of the motivation. This chapter also contains the chapter-wise organization of the project report.

1.1 PROJECT DESCRIPTION

When it comes to Telecommunication, a **femtocell** or small-cell is a tiny modem sized, low in power station, ideally constructed for use at house or small enterprise. A name is more widely spread in the enterprises is small-cell, with femtocells as subsets. The base station is designed typically to support a small number of users simultaneously using actively mobile devices in a setting depending on the serial number, and quite a large number of mobile devices in enterprise settings.

The areas of function which can be used to define the Femtocell network management are Fault, Configuration, Accounting, Provisioning, Performance, and Security. To manage and monitor the Femtocell one need a management console and the project goal is to manage and monitor the femtocell network to determine current status, network performance, percentage utilization to develop the network in order to meet future needs and proactively address performance and health issues affecting femtocell networks.

Here in this project Femtocell management microservice is responsible to activation of femtocell soon after the user is authenticated and the dashboard should render the summary of performance in the form of cards and charts, charts like a pie chart, and column chart. The pie chart is used to show the provisioning percentage, femtocell operational percentage.

The cards are used to display the number of current femtocells, Femto groups, Femto clusters present, and it is also used to display statistical status trends that can show the capacity or reliability issues before they actually start affecting services or systems. An alert that is handled by the team member who handles the fault management process can be set to be triggered by a performance status. In short, the Femtocell management console that was created will aid in managing and monitoring the equipment tethered to the Femtocells.

The adding of the new femtocell includes four steps with the steppers to indicate the operator. The initial step will be the adding of the femtocell type with few options in the form of checkboxes. And the next will be the details of the femtocells with textboxes and text menus. In the end, the femtocell will be added to the network. In short, one can say that the management console shall create a unique feature for the management and monitoring of the femtocells in the network.

The software's management console will give the administrator or operator access to the details of the femtocells as well as the ability to edit and delete any individual femtocell. Dashboards will display graphs for the workflows and an overview of the number of femtocells.

The project consists of one main module with three small sub-modules, and they are explained in detail below. 'Add Femto Cell' is the main module of this project with three sub-modules. It provides the Summary of the femtocells. It has the option to add, edit, and delete options for the femtocell. The operator can add the femtocell using a floating add button or he can delete or edit the existing femtocells. When it comes to Telecommunication, a femtocell or small-cell is a tiny modem sized, low in power station, ideally constructed for use at home or small enterprise.

The base station is designed typically to support a small number of users simultaneously using actively mobile devices in a setting depending on the serial number, and quite a large number of mobile devices in enterprise settings. Femtocells are constructed to reinforce the present 3rd generation, 4th generation, and future generation modular infrastructure.

The word “small cells” is employed to explain the cell size, whereas macrocell covers up to kilo meters in diameter that is the cell divided into a multiple smaller cell and in the reduction of transmission power, with a radius of hundred meters.

1.1.1 Femtocell Hardware Connectivity

Femtocells are individual, small-scale base stations that are deployed on subscriber premises to deliver cellular service inside the home or workplace. A DSL router or cable modem is typically used to link femtocells to the Internet and the cellular operator's network. Any subscriber may have access to a femtocell, only a select group of users may do so, or both with preferred users having priority. Femtocells have advantages for both operators and subscribers. Higher data throughput and enhanced voice service coverage are both experienced by the subscriber. Additional incentives for home use, such as free calls from home, might be offered through special service agreements. The operator can offload traffic from the macro cellular network, which lowers the cost of the infrastructure. Additionally, indoor coverage issues can be overcome without the use of pricey macro base stations. Despite the existence of other technologies (like Wi-Fi), operators also have a stake in seeing that their mobile devices are utilised at home. This "stickiness" with their offerings helps to lower churn. And finally, it encourages switching from wired Internet to only using wireless devices at home.

A femtocell is typically the size of a residential gateway or smaller, and connects to the user's broadband line. Integrated femtocells (which include both a DSL router and femtocell) also exist. Once plugged in, the femtocell connects to the MNO's mobile network, and provides extra coverage. From a user's perspective, it is plug and play, there is no specific installation or technical knowledge required—anyone can install a femtocell at home.

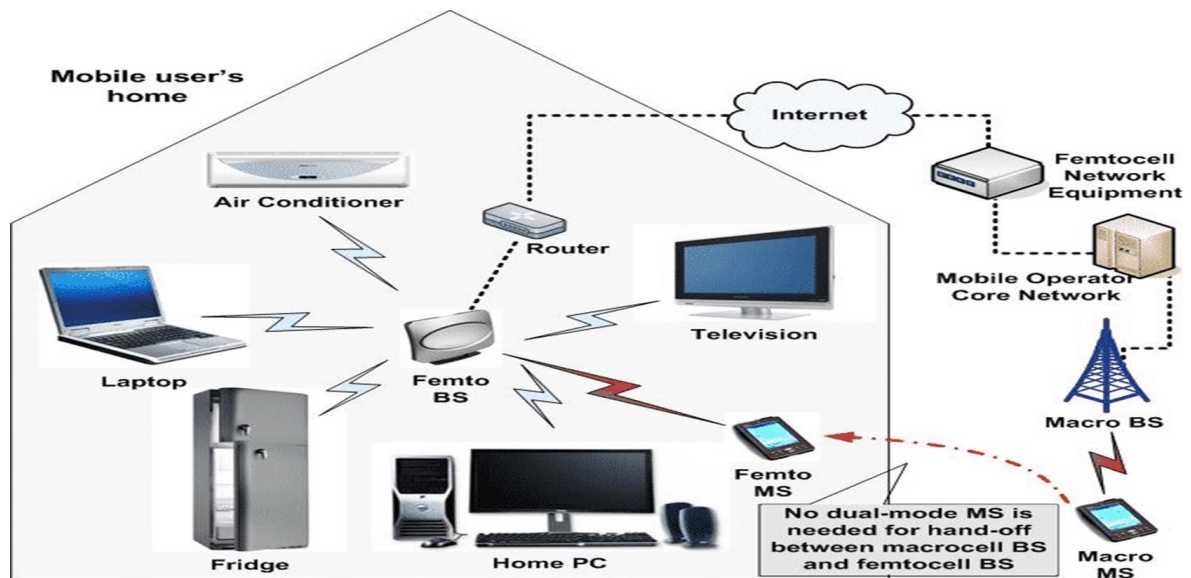


Fig: 1.1 Femtocell Hardware Connectivity

1.1.2 Types of Femtocell

Users can position femtocells next to their existing network hardware arrangements, and they resemble and function like routers. Anyone who desires to buy a femtocell has access to them. There are various types of femtocells based on different standard technologies such as WiMAX, 2G, 3G, 4G(or LTE) etc.

Femtocell Multi-band Residential



Femtocell Multi-band SOHO



Femtocell LTE Residential



Smart Node 4G+5G Multi-standard



Fig: 1.2 Types Of Femtocell

1.1.3 Macro Cell Vs Small Cell Vs Femtocell

For 5G networks and competent devices, small cells will offer new, quick connectivity speeds, but 5G won't stop there. The connection of 5G networks also depends on macro cells and femtocells.

Although tiny cells have been hailed as a significant advancement for 5G networks, there are other base stations that will also provide 5G connection. Macro cells, such as cell towers, will also be used by 5G networks for connectivity; these larger base stations will be able to support lower 5G frequencies than small cells' high-frequency millimetre wave (MM wave) capabilities. Additionally, carriers will offer 5G femtocells to improve in-home or SMB cellular coverage.

The differences between macrocells, small cells, and femtocells are obvious in size, coverage, and cost, according to Michael Finneran, principal analyst and consultant of dBrn Associates Inc., a wireless advisory firm situated in Hewlett Neck, New York. The precise intentions for total 5G coverage are still unidentified, though.

A macrocell is a specific kind of cellular base station that transmits and receives radio signals using large antennas and towers. In particular, cell towers provide km of cellular coverage and can range in height from 50 to 200 feet. According to Finneran, there are already about 200,000 macrocells spread out over the U.S.

A femtocell is a type of wireless access point that is used to increase cellular coverage inside of buildings. In contrast to other cellular connectivity options, femtocells connect back over the internet to provide cellular access inside the house or office. Femtocells can be placed adjacent to users' current network hardware configurations, and they look and behave like routers. Anyone who desires to purchase a femtocell can do so.

A small cell is a different kind of cellular base station that transmits radio signals and is physically small, around the size of a pizza box. Small cells can enable MM wave frequencies with high-speed broadband connectivity, which is the purpose of small cells: to increase wireless network coverage in certain locations. According to Finneran, the United States intends to deploy five to ten times as many tiny cells as macrocells.

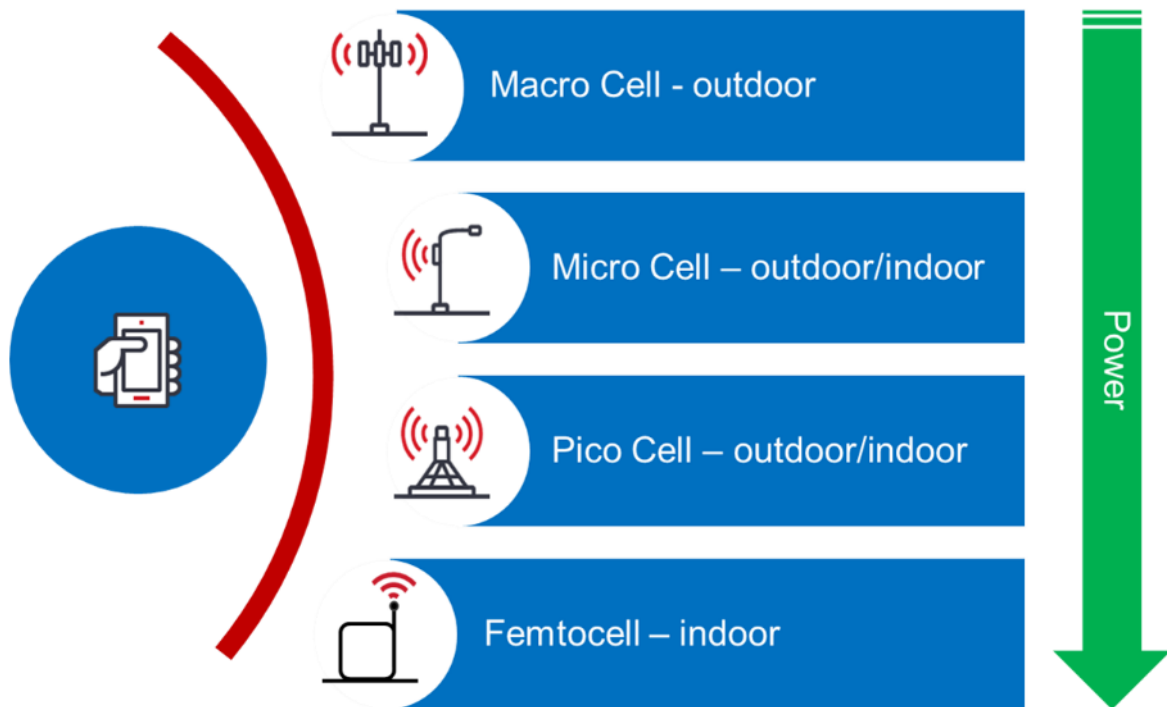


Fig: 1.3 Macrocell, Smallcell, Picocell, Femtocell

By reducing communication distances to user equipment and utilising resources already used in the macrocell network that they overlay, femtocells can dramatically increase wireless cellular network capacity. We take into consideration "cognitive" smart femtocells, which are able to decode the base station control channel and decide on their transmission chances depending on the planning and resource allocation of the overlying macrocell.

The femto access point (FAP) is a hardware component that connects to mobile devices via an over-the-air radio interface and is situated at the customer's premises. A mobile device sees the FAP as an outdoor macrocell, but it emits less power. A broadband interface, such as DSL, fibre, or cable, connects the FAP to

the main mobile network. Mobile devices have better indoor coverage and bandwidth availability when using a FAP to connect to the mobile network. FAP can be divided into two groups based on their capacity: home FAP, which can support 3-5 concurrent users, and enterprise FAP, which can support 8-16 concurrent users. FAP can be divided into UMTS FAP, GSM FAP, WiMAX FAP, and other types depending on the cellular technologies being used. Some FAPs employ a FL interface to regulate broadband access gateway settings. The FL interface is implemented internally by the FAP if it has an integrated access gateway.

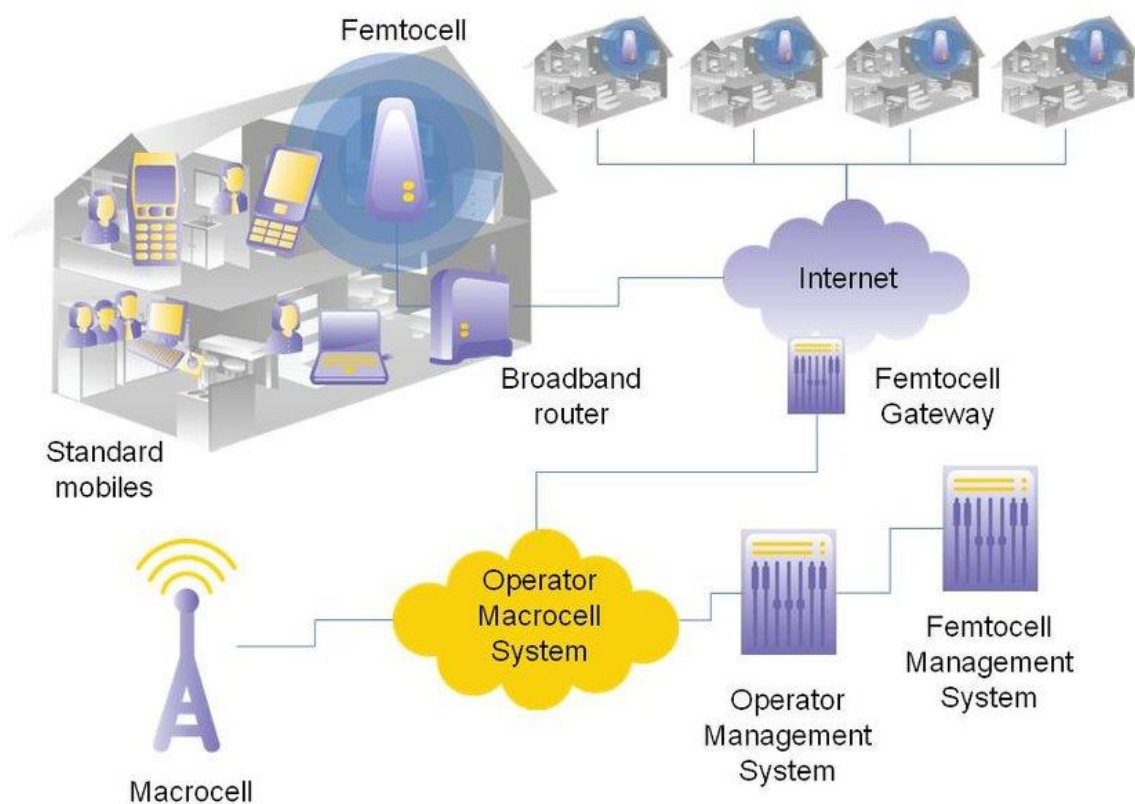


Fig: 1.4 Femtocell Connection With Devices

1.2 PROBLEM STATEMENT

Femtocells are tiny, low-power cellular base stations that link to phone networks over the internet and are mainly used in homes or small businesses.

- Cloud Femtocell Manager(CFCM) is used to configure the femtocell.
- CFCM helps to provision the femtocell i.e, it is used in the registration process of FAP from the client side.

- CFCM is designed using microservices architecture. In this project, I had focused on one of the microservices, Configuration Management.
- This microservice, Configuration Management, used to update a femtocell and create bulkCM file and upload it to file server.

1.3 OBJECTIVE

The main objectives of the cloud femtocell manager are

- To provide same coverage and mobility as macrocell.
- To provision and configure the femtocell which provides indoor cellular connectivity.
- To handle mobile traffic.
- To boost the 5g signals.
- To update the configurations and to handle the notifications.

1.4 COMPANY PROFILE

Nokia Corporation, which serves customers in 130 countries, is a global media transmission company that was founded on May 12th, 1865. Mobile Phones, Multimedia, Enterprise Solutions, and Networks are Nokia's four main divisions. The mobile phones group sells remote voice and information products to consumers and businesses. Portable gaming devices, home satellite systems, and digital TV top boxes are all sold by the multimedia segment. In order to be used by the corporate division, the Enterprise Solutions team develops remote frameworks. The company's Networks section sells gear for remote swapping and transmission. Nokia maintains 15 manufacturing facilities in nine countries and 12 offices for innovative work.

In recent years, the organisation has worked in a variety of industries. It was first built as a mashing plant and had previously been connected to elastic and linkages, but since the 1990s, it has focused on building broad-reaching media communications foundations and advancing innovation and authorising. Nokia has been a key contributor to the development of the GSM, 3G, and LTE standards (as well as currently in 5G), making it a prominent backer of the portable

communication sector. As we prepare to enter the 5G era, Nokia continues to pursue important acquisitions that enhance our reliable start to end item and arrangement arrangements.

1.5 ORGANIZATION OF REPORT

The report is divided into chapters, each dealing with different stages of the project starting from the objective formulation to the results and conclusions and the improvements to be done in the future. Each chapter has a short introduction, explaining the subject and contents of each chapter in brief. The following is a short overview of each chapter.

Chapter 1: This Chapter provides the introduction to the femtocell. The overview on the femtocell hardware connectivity and femtocell management console.

Chapter 2: Outlines the project background and the research made on the project in the initial stage. Background of the project is explained briefly and present developments in the work area is identified, if any. Research gap, if any, are identified because of this step and an analysis is made.

Chapter 3: This chapter gives an overview about the existing methodology and the proposed methodology. The existing methodology is represented in terms of block diagram. The drawback of the existing work is also highlighted.

Chapter 4: This chapter gives an overview about the adapted methodology. The methodology is represented in terms of block diagrams and the call flow of the process is shown. Also, the implementation details about the project are highlighted explaining significance about the implementation done, tools and protocols used.

Chapter 5: This chapter provides the hardware results and performance analysis of the proposed methods and techniques. The performances of proposed mechanism have been discussed.

Chapter 6: This chapter provides the results and discussions of the project.

Chapter 7: This chapter altogether concludes the project. It also gives the scheme of the future work that is how the project could be enhanced further. Finally, the references referred to precede the project are given in brief.

CHAPTER 2

LITERATURE SURVEY

This chapter gives a description of the project and its importance. The discussion regarding the background of the project is done here. Any present or recent developments in the work area is addressed. Theoretical discussions are done and a general analysis regarding the theory is made with the appropriate conclusion.

2.1 LITERATURE SURVEY

Bhanu Ravishankar, Nokia, Small Cells and Wi-Fi, Bangalore(2018), published about Efficient and effective cellular technology: Around 70% of mobile calls and 90% of requests for data services originate from femtocells, which are found inside of buildings. As a result, indoor subscribers use resources in big quantities, which encourages operators to offer satisfactory indoor services. This article provides a thorough discussion of femtocells[1].

Knisely D et al (2009) presented the different deployment models of femtocells in microcell. The standardization of femtocells in 3GPP2 and a legacy network's CDMA2000 femtocell design is shown [3].

Evans J.B (2008) published in IEEE Communications Magazine, vol.46, October 2008 about the WIMAX Femto cells : A perspective on Network Architecture, Capacity and Coverage. Security and performance wise more sophisticated registration and authentication. Femtocell AP shall be a plug and play device in the network without the intervention of the user.

Louis G. Samuel, Alcatel-Lucent's Europe and North region(2016) , published about an overview of the femtocell concept which describes, The femtocell concept combines fixed-line Internet access with cellular telephony by installing incredibly low-cost, low-power third generation (3G) base stations in users' homes or places of business.

M.Z. Chowdhury et al (2011) proposed a neighbouring list creation scheme for femto-femto handover in a dense femtocell network. The neighbouring list contains small number of nearby femtocells. These nearby femtocells are selected based on their signal level, the frequency and the location information [5].

S.A. Rubaye et al (2011) published about cognitive femtocell sub-network (CFS) provides services like profile management, user rights and services provision. CFBS controls interface between macrocell and femtocell [9].

V. Chandrasekhar et al (2008) presented a paper in IEEE Communications Magazine, vol.46, September 2008 about the Femtocell Networks. The overall conclusion of the survey was Consumer installed wireless data access point inside homes, which backhauls data through a broadband gateway (DSL/cable/Ethernet/WiMAX) over the Internet to the cellular operator network. The benefits of the wireless Access points are Lower cost, better coverage, and prolonged handset battery life from shrinking cell-size [10].

2.2 EXISTING SYSTEM

Femtocells are constructed to reinforce the present 3rd generation, 4th generation, and future generation modular infrastructure. The three baseline features for Femtocells are, the primary is that the Femtocells are indeed corrected. However, our deployment might not succeed from getting to location registration failures, which may be tolerated. Second, the information and audio performances indeed improve with Femtocells, especially in areas with poor or limited Macrocell coverage or instances of network congestion. As a result, speed is frequently disrupted, which causes extra delays.

The word “small cells” is employed to explain the cell size, whereas macrocell so as to kilometres in diameter is that the cell divided into a multiple smaller cell and in the reduction of transmission power, with a radius of hundred meters. Boosters or Cellular repeaters were referred to as the choice to small base stations.

These devices were meant to enhance the standard of the signal in regions with poor signal coverage. and therefore, the cost is reduced because the backhaul wasn't required. However, the achievable throughput is restricted due to their licensed spectrum reuse for backhaul. Therefore, these repeaters were neither simple to deploy nor helpful to the system capacity.

For the indoor users, the Femtocell has the capacity to supply top quality network access for lower cost, while the burden on the entire network traffic is reduced. Nevertheless, femtocells would have to face many issues or issues on weak deployment. Issues like timing and synching up, mobility management, security and self-organization, and interference are still put a threat to realizing a gain on femtocells.

Femtocells can be used or utilized to give work in an open-air remote help. Versatile system administrators use them to broaden their administration inclusion and extend the organize limit. System inclusion is additionally a fundamental market that has created as portable administrators have begun to introduce free metrocells in remote and provincial zones which has just 2G inclusion or where there is no inclusion by any means. The money-saving advantages of femtocells, when contrasted and full-scale cells make it financially conceivable to give inclusion to littler networks – from two or three ten to two or three hundred.

The Femtocell Forum has distributed a white paper about the innovation and business case statements. So, our project Femtocell Configuration management provides provisioning of Femtocells.

The femtocell configuration management which is designed will help to draw and manage the workflow diagrams related to the Femtocells. The software, configuration management microservice will provide the admin or the operator for the provisioning of the Femtocells.

CHAPTER 3

REQUIREMENTS ANALYSIS

This chapter describes about feasibility study and software requirements which are needed for the project Cloud Femtocell Manager.

3.1 FEASIBILITY STUDY

The main purpose of this study is to check the feasibility before proceeding with the design phase. This study lets us know whether the proposed system is performing better than the existing system in every aspect and whether the proposed system or application is technically and financially clear to develop.

Based on these aspects we can classify the feasibility study into the following parts

- * Financial feasibility
- * Technical feasibility
- * Operational feasibility

Financial Feasibility: Financially feasibility is estimating the budget of this Femtocell Configuration Management before beginning with the development. The financial estimation for Femtocell configuration management under telecommunication is economically feasible and its financial estimation is worth the efforts.

Technical Feasibility: Technically feasibility study is performed to know whether this Femtocell Configuration Management can be technically implemented on given requirements and whether it is possible to implement the required features to it in each time period and how this user interface can be implemented in an efficient manner.

Operational Feasibility: Operationally feasibility is a study that will help in studying how our application will solve the problem of the existing system and whether the Femtocell Management Console user interface will be easy to perform tasks without facing any difficulties.

3.2 SOFTWARE AND HARDWARE REQUIREMENTS

The software and hardware requirements which are used in this project are described below in the tables.

We can see the hardware requirements in the table 3.1. These are the system hardware requirements like processor, RAM, CPU and Hard disk of the system.

Table: 3.1 Hardware Requirements

COMPONENT	REQUIREMENT
Processor	Intel Core 2
Ram	4 GB
CPU	2.54 GHz
Hard Disk	20 GB

We can see the software requirements in the table 3.2. These are the software frontend applications like React JS that are used while developing this project.

Table: 3.2 Software Requirements

COMPONENT	REQUIRED
Operating System	Windows 7 and above
Scripting language	React Script
Front End	React JS
Framework	CCFK client framework
Browser	Firefox, google chrome

CHAPTER 4

DESCRIPTION OF PROPOSED SYSTEM

This chapter gives an overview about the existing methodology and the proposed methodology. The proposed methodology is shown clearly in the block diagram and images.

4.1 PROPOSED METHODOLOGY

The Proposed Methodology compensates the cloud femtocell manager and its architecture. Femtocell Simplified OAM Solution is an evolution of Nokia's Femto management solution, utilising HDM's device management. This Centralized OAM entity to manage Femtocell & Femto Gateway elements in femtocell network. Integrates to OSS and external systems, Orchestrates pre-provisioning and activation workflows. Software infrastructure for virtualization and management of compute, storage and networking, providing flexibility, performance, robustness, security, visibility and operational efficiency. Microservice Architecture is truly Independent, Highly focused capability, Linear Scalability and Resilient.

- Femtocell API – This service provides REST interface for external system integration.
- Management Console – Femtocell management console based on CSF UI framework.
- Configuration management – Provides intelligent workflow engines for configuration management of Femtocell and Femto Gateway network elements.
- Alarm Management – Provides Fault management capabilities for Femto and Femto Gateway network elements alarms.
- Event Listener – Collection and processing of notifications from device management.
- Audit logger – Keeps record of activities performed (operation history) in Femtocell solution - TODO
- Call back Server – provides capability to forward notification to external call back systems. The notification can be forwarded as RES notifications.

- **SNMP Manager** - collection and processing of notifications from Femto Gateway network element.

4.1.1 Common Services

Common services are the services provided by cFCM which are common for every API call. Each common service provides different functionality.

- **MetaLB**: For bare metal Kubernetes clusters, MetaLB is a load-balancing implementation that makes use of common routing protocols.
- **Nginx**: Load balancing across several application instances to ensure fault-tolerant configurations, maximise throughput, cut down on latency, and optimise resource utilisation.
- **RabbitMQ**: open-source and extensible message queuing solution
Message Broker - an intermediary for messaging. It provides a unified platform for your applications to send and receive messages, as well as a secure storage location for your messages until they are received.
Reliability - RabbitMQ offers a variety of features including persistence, delivery acknowledgements, publisher confirms.
Highly Available Queues - Your messages will be protected even in the case of a failure thanks to the ability to mirror queues across a number of machines in a cluster.
- **Redis : Distributed Cache**
Redis is a free and open source distributed cache that stores data in memory. Redis has a wide range of data structures to match your application demands, unlike simple key-value data stores that only offer a few data structures.
High availability and scalability - Redis Sentinels is the most popular HA solution included with Redis. Redis Sentinels are a collection of independent processes that, when combined, provide automatic failover and reconfiguration, monitor Redis master slave sets, and operate independently.
- **Camunda - BPMN Workflow Engine**
Automate BPMN process diagrams for human job flows, (micro-)service orchestration, or both. To launch process instances, finish tasks, and much more, you can access the Workflow Engine over REST. You can entirely

divorce the development and operation of your (micro-)services from the Workflow Engine and fetch work through REST whenever it's convenient. The Camunda Workflow Engine moves at breakneck speed. As the engine is stateless, clustering for horizontal scalability is simple because numerous instances can share the same database.

- *MariaDB* - SQL based Relational Database Management System.
- *Key cloak* - Identity and Access management.
- *BTEL Telemetry* - The following CSF assets will be incorporated in the the BTEL container as inherited services:
- CPRO (System monitoring and alerting toolkit and visual dashboard to display metrics)
- BELK (Log collection, analysis and display) - TODO
- CALM (Alarm management)

4.2 CFCM ARCHITECTURE

CFCM architecture is made up of microservice architecture, microservices communicate with each other using API.

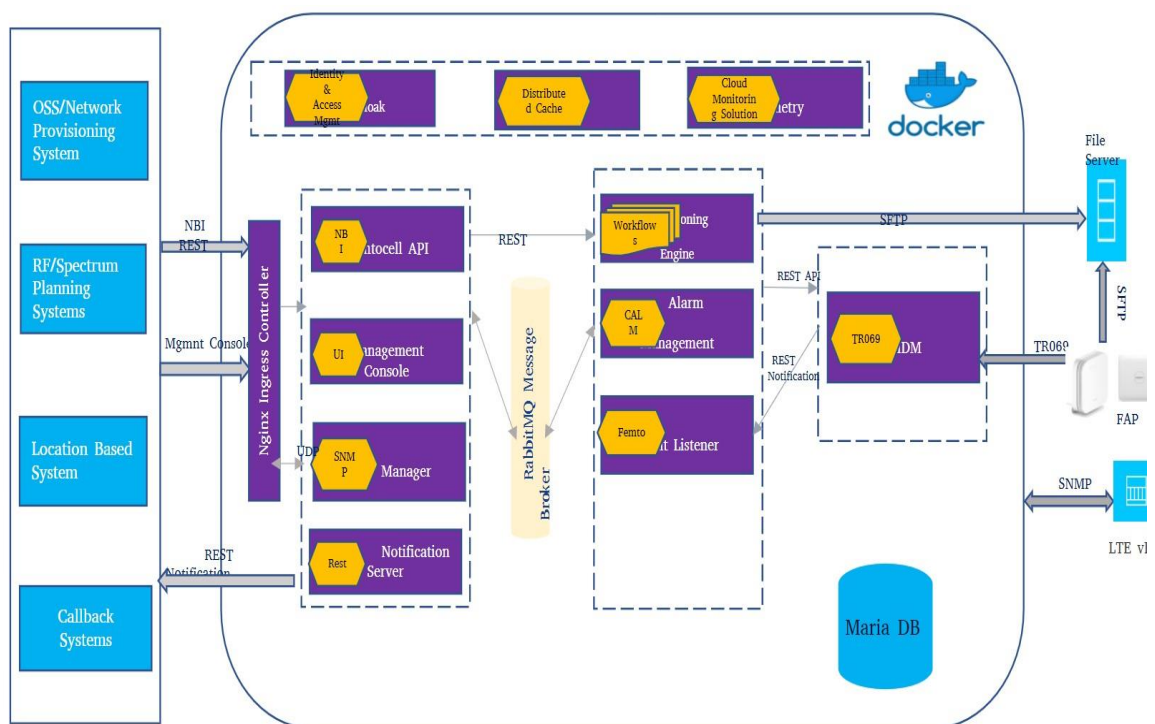


Fig: 4.1 CFCM Architecture

4.2.1 Microservices

CFCM follows microservices architecture. Following Femto cell microservices are organised around business capabilities, Highly maintainable and scalable, loosely coupled and Independently deployable.

- Femtocell API – This service provides REST interface for external system integration.
- Management Console – Femtocell management console based on CSF UI framework.
- Configuration management – Provides intelligent workflow engines for configuration management of Femtocell and Femto Gateway network elements.
- Alarm Management – Provides Fault management capabilities for Femto and Femto Gateway network elements alarms.
- Event Listener – Collection and processing of notifications from device management.
- Audit logger – Keeps record of activities performed (operation history) in Femtocell solution - TODO
- Call back Server – provides capability to forward notification to external call back systems. The notification can be forwarded as RES notifications.
- SNMP Manager - collection and processing of notifications from Femto Gateway network element.

4.2.2 CFCM Design Aspects

CFCM is developed based on microservices architecture, which are highly maintainable and scalable. Below is the description of different microservices like provisioning engine, management console etc;

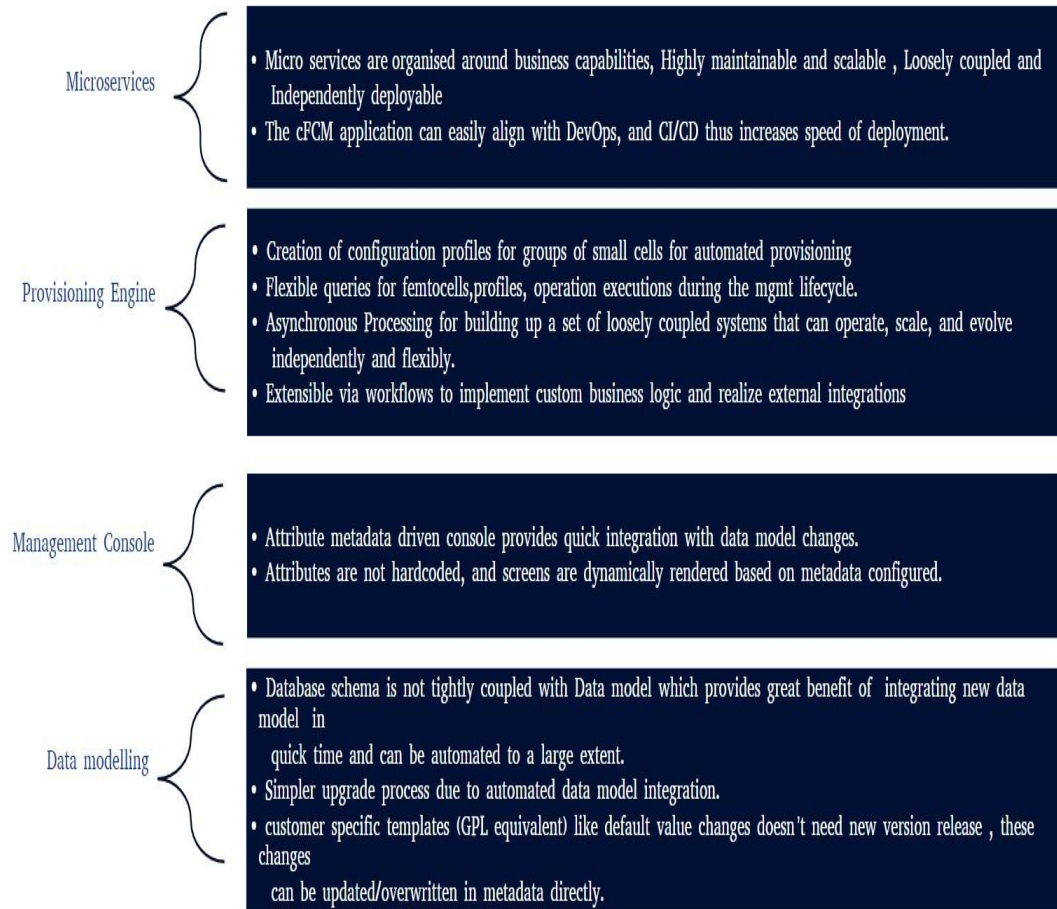


Fig: 4.2 Microservices

4.3 SOFTWARE IMPLEMENTATION

Below is the flow of the API request starting from different microservices. The cFCM NBI microservices are the frontend interface to the cFCM application. The request may come from management console.

- Client applications invoke NBI Application Programming Interface.
- After validation, it generates correlation ID which sent back to the client and the validation output will be orchestrated in message queue.
- Based on the message, it will interpret whether it is add or update or delete request.
- If the request is add or delete, it will access database and do the needful operations like adding or deleting a femtocell.
- If the request is update, then it will invoke the configuration management microservice which generates bulkCM file as part of updating a femtocell.
- Then the bulkCM file will be moved to file server using SFTP protocol.

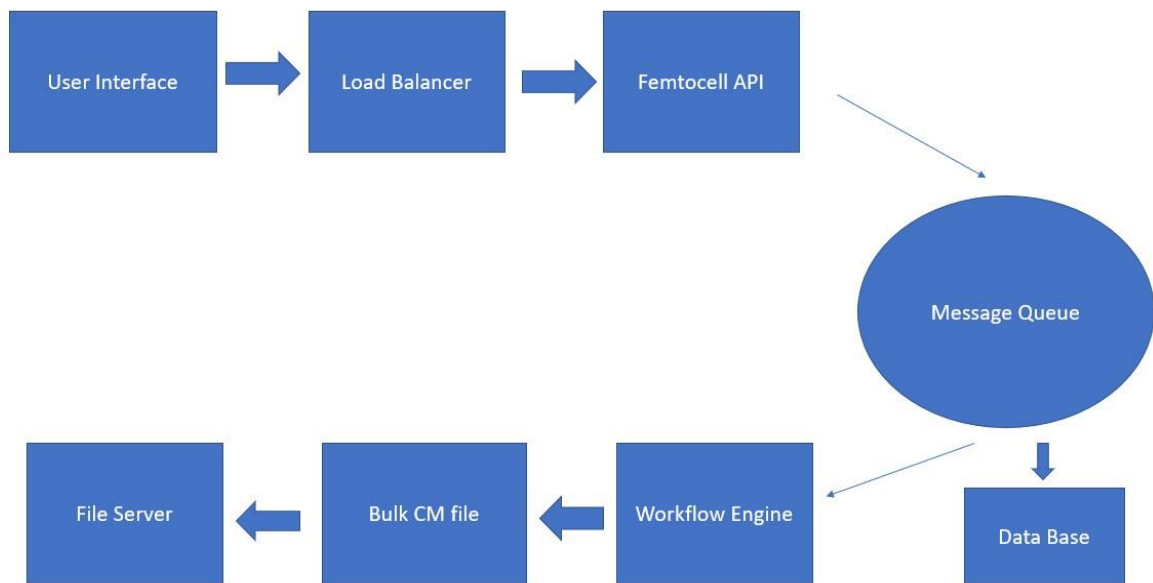


Fig: 4.3 Architecture Flow

4.3.1 Femtocell Rest API Interface

This design is mainly for Femtocell Northbound Interface Micro service to Integrate with external system.

- Pre-provisioning of Femtocells in the FCM database .
- Creation of configuration profiles for groups of femtocells for automated provisioning .
- Flexible queries for femto cells, operation executions during the management lifecycle .
- Ease of integration .
- Asynchronous Processing, which can be used to create a collection of loosely coupled systems that can function, scale, and evolve in an autonomous and flexible manner.
- Concurrency control is the activity of coordinating the simultaneous execution of transactions in a multiprocessing system. The objective of concurrency control is to ensure the serializability of transactions in a distributed system. This microservice will offer REST based Web Services to perform CRUD operation on cFCM objects.

4.4 PROJECT MANAGEMENT PLAN

Below are the steps for the process of femtocell activation status when the user buys it and tries to activate the femtocell.

- Pre-provisioning of Femtocells in the FCM database .
- Creation of configuration profiles for groups of femtocells for automated provisioning .
- Flexible queries for femto cells, operation executions during the management lifecycle .
- Asynchronous Processing, which can be used to create a collection of loosely coupled systems that can function, scale, and evolve in an autonomous and flexible manner.
- Concurrency control is the activity of coordinating the simultaneous execution of transactions in a multiprocessing system. The objective of concurrency control is to ensure the serializability of transactions in a distributed system.

4.4.1 *Femtocell Management Console*

The software's management console will give the administrator or operator access to the details of the femtocells as well as the ability to edit and delete any individual femtocell. Dashboards will display graphs for the workflows and an overview of the number of femtocells.

- The femtocell management console was created to aid in managing and monitoring the equipment syncing with the Femtocells.
- Femtocell Management Console designed will provide the user interface for Administrator to view the performance in the Dashboard like the number of femtocells, Femto groups, Femto clusters available at present, he will view the alarms that indicate the thread rate which can be managed later by the Fault management team, he can view the provisioning status, operational status in the form of a pie chart and he can also view the transactions per day in the form of a column chart.
- Administrators can add, delete, edit operations that is, basically a dashboard for monitoring the devices connecting to the Femtocell and the workflows.

- The summary will provide the details of femtocells so that it enables the Operator with either editing or deleting of the Femtocells.

4.4.2 BPMN Workflow Engine

Using Camunda engine we can develop workflows to automate business processes.

- Using the tool Camunda Modeler, we can draw workflows.
- Automate and coordinate crucial company procedures. Automate business operations from beginning to end across a range of components and endpoints.
- Below is the workflow diagram of updating a femtocell.

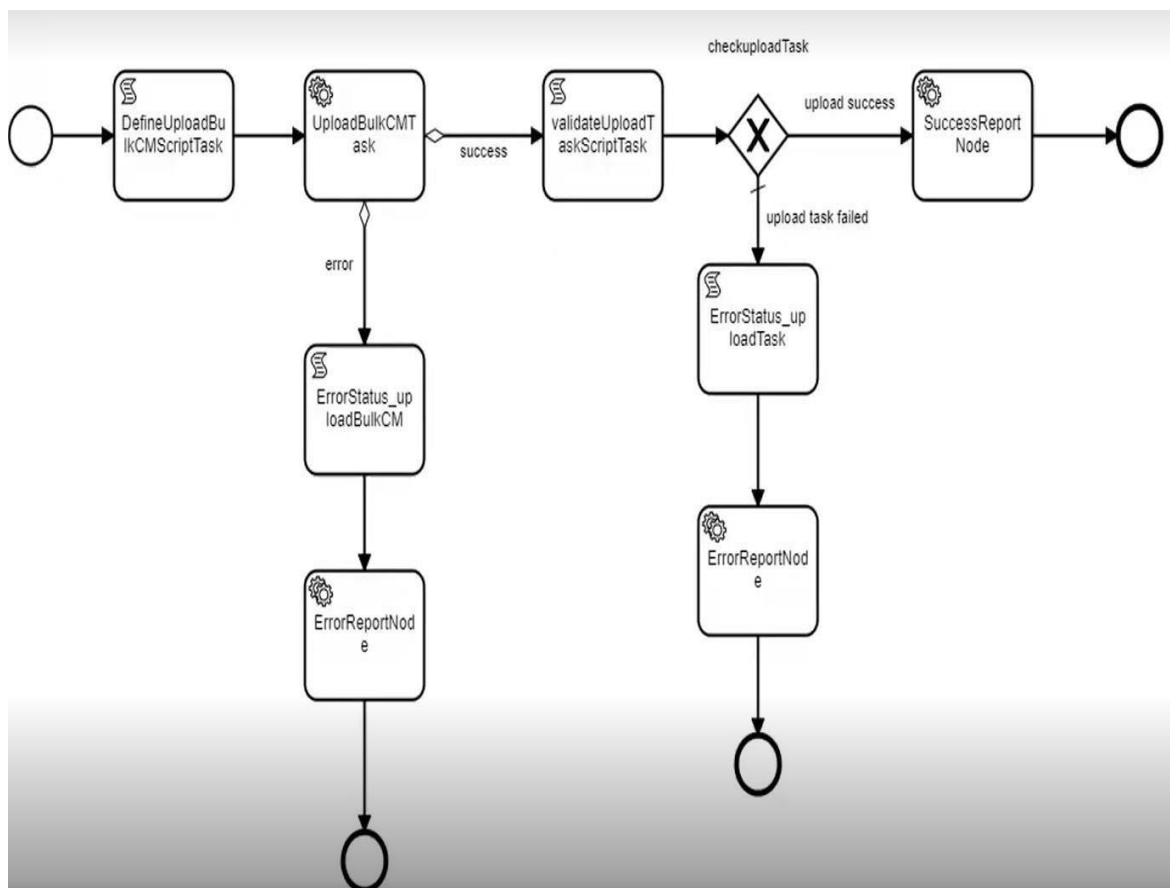


Fig: 4.4 Update Workflow

CHAPTER 5

IMPLEMENTATION DETAILS

This chapter gives an overview about the adapted methodology. The methodology is represented in terms of block diagrams and the call flow of the process is shown. Also, the implementation details about the project are highlighted explaining significance about the implementation done, tools and protocols used here.

5.1 DEVELOPMENT AND DEPLOYMENT SETUP

Femtocells Management Console where it renders about the structural part of the console. It consolidates the entertainers, use cases of the project, functionalities, and classes related to the undertaking. It likewise adds the utilization of the case graph, moves mental chart, and the database chart of the femtocells console.

5.1.1 Use Case Diagram

The use case chart portrays the connection between admin and the console. It shows how the admin has the access to the dashboard, femtocells, and transaction, within femtocells he can also add, edit, and delete by following the steps designed in the form of the progress bar. The on-screen character is the administrator of the console. Use Cases are the functionalities given by the console to its admin.

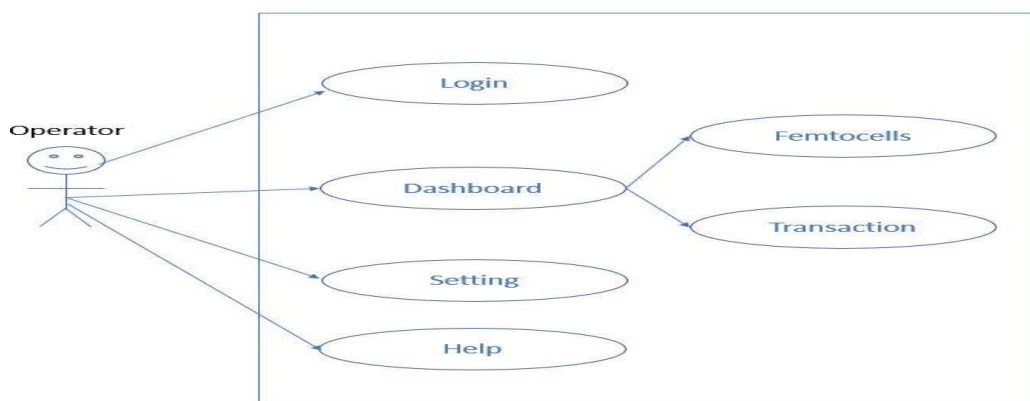


Fig: 5.1 Use Case Diagram Of Femtocell Management Console

5.1.2 Login Use Case

At first, the administrator needs to login to the console using the login credentials. In the wake of logging, the administrator chooses the required number of focuses from the rundown. For the authentication purpose, we set the auth token when the user logs in and the auth token unset automatically when the user logs out.

5.1.3 Femtocell Use Case

It provides a summary of the existing femtocells with the options of edit and delete. This module also has a Search option for the searching of the femtocells through the attributes. The summary of the existing femtocells will be displayed on the table and the data is retrieved from the JSON file with the help of API calls.

- a) Add Femto Cell Type use case which provides a checkbox with the femtocell types like WCDMA, MS-LTE
- b) Add Femto Cell Details, which provides several text boxes and labels to provide the details for the femtocell to add. The details are divided into two pages to give a better user interface. It also includes back and a cancel button.

5.1.4 Dashboard Use Case

Tree Graphical user interface which provides a glance of KPI(Key Performance Indicator).The dashboard will display the provisioning status, operational status, alarms to notify the user before any component affect the services and transactions per day. In simple words, it's used to display the performance of the femtocell's management console.

5.1.5 Sequence Diagram

Sequence Diagram is graphical representations of the interaction between the system and actors and other components of the System. The actor Operator

and the components Management console and the JSON files interaction is shown in the below diagram. JSON file forms the backend where the object is retrieved for displaying the attributes for the add option and the data for the summary table.

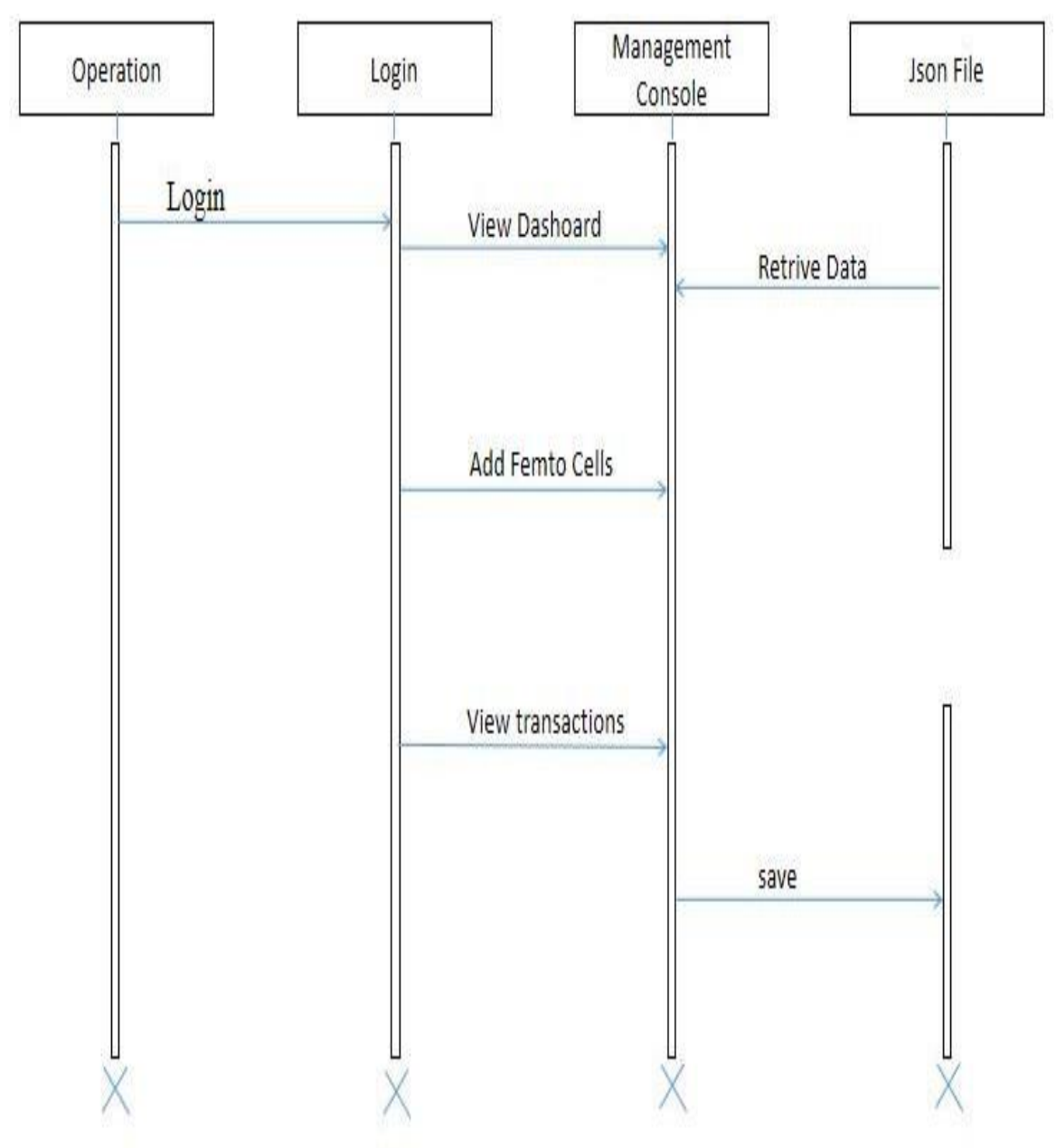


Fig: 5.2 Sequence Diagram Of Femtocell Management Console

5.1.6 Activity Diagram

Activity Diagrams are diagram representations of activities and performing actions of the user in the System. The operator does Add, Delete, and Edit activities in the Femtocell Management console. At that point, the administrator enters the console or required page and he can view the Femtocell management performance in the dashboard and make decisions according to it, he can add femtocells in the femtocell module, any changes made by the users will automatically reflect in the dashboard. Our application will display the provisioning status, operational status, alarms to notify the user before any component affect the services and transactions per day.

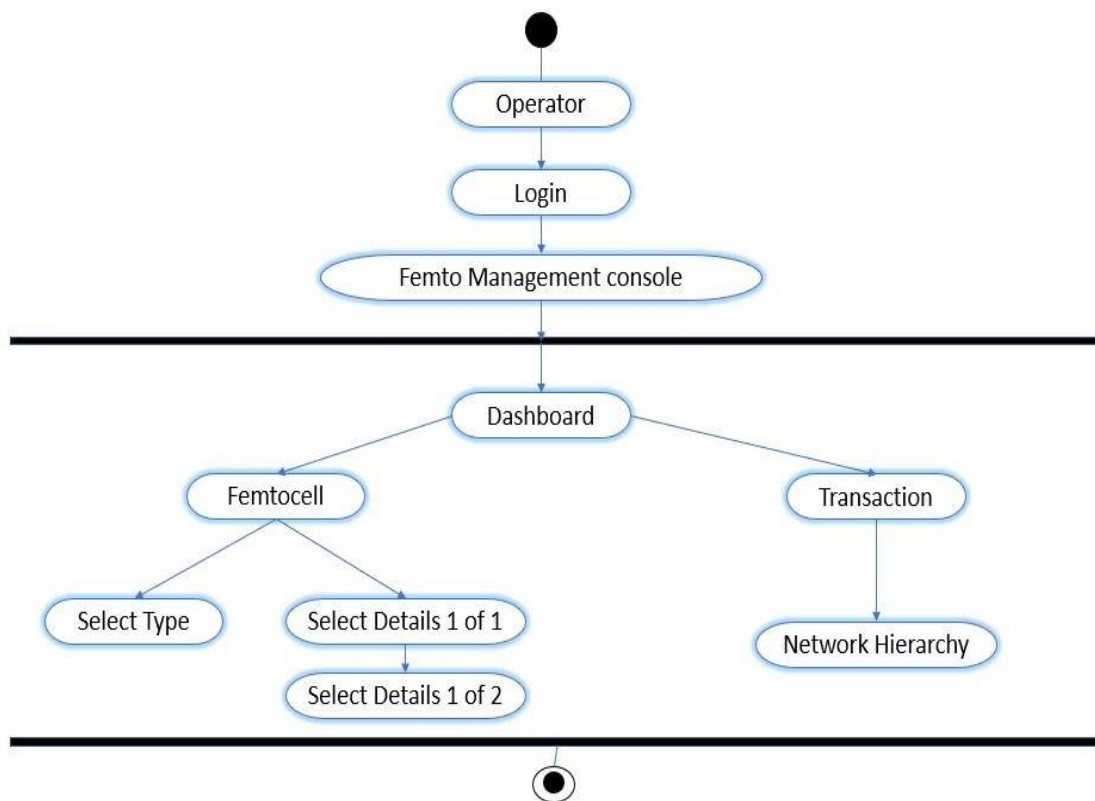


Fig: 5.3 Activity Diagram For The Femtocell Management Console

5.2 ALGORITHMS AND TECHNOLOGIES USED

In the development of femtocell UI, we have used many technologies from both frontend and backend like react is library in this project.

5.2.1 React Js

React is a library of JavaScript which is used for constructing interactive and intuitive front-end applications. This library is created and maintained on Facebook. We can use this Framework for developing basic UI and other front-end applications as well as mobile applications. This is used for designing the UI layer of web and mobile applications. Also, ReactJS is very simple to use because of component-based and well-defined lifecycles. Apparently, react is only worries with rendering and showing information to the DOM. We may require additional libraries that are provided by various sources for managing the states and routing to the different pages etc. Also, DOM(Document Object Modal) creates the memory cache to store the changes which are made in the component and update the same in the browser window. The main feature of ReactJS is Lightweight and injectability. Other features are as follows:

1. The virtual document object model is a programming concept, real document object by a library like React DOM.
2. Props which are also known as Properties are variables that are passed by the parent component.
3. The state is also variables, but the State is directly initialized and managed by the component.
4. Components form the main feature of ReactJS, and it's can be a Class or a function that takes inputs which are known as properties(props) and output an element that explains how user Interface should be displayed.
5. Hooks are the functions that let us hook into the React state and life cycle from the functional components.

5.2.2 CSS

Cascading Style Sheets implanted with the HTML is utilized to make the website pages sleek and appealing. CSS controls the format and introduction of numerous pages at the same time and makes it simpler to plan a lovely User Interface. It is easier to learn and understand and it provides powerful control over the presentation of HTML documents. It helps the developer by saving their time and also page loader faster.CSS is a platform-independent which can support the latest browsers as well.

5.2.3 Visual Studio Code

Visual studio code IDE is a source code editor for a developer which is developed by Microsoft company which is a cross-platform i.e. that will work on Windows, Linux and Mac operating system. It allows developers to edit and debug the code and also it contains the embedded git. It has a great ecosystem of plugins for supporting other languages such as C, C++, python, etc. The performance of VScode is good. Some of the features such as embedded git, code refracting, shortcuts, etc.

5.2.4 Client Common Software(Nokia Specific)

Client Framework is a library of UI components for developing modern web-based applications that are styled to meet Nokia standards of excellence for user experience and branding guidelines. Built using ReactJS (a JavaScript UI library), the Client Common Software(Nokia specific) the library provides a wide range of functionality for building enterprise-level web applications that can contain forms, charts, data tables as well as navigation and layout components.

As a component-based framework, every UI element is treated as an individual component, including those which are assembled together to create more complex components, such as an application banner or a login screen. These components are compatible with all major browsers.

One can implement the user interface by importing the components to the project and calling the imported components inside the component's return statement.

➤ Domain Components:

- *Client Framework* – provide effective UXR technology, components, consulting, and template artefact to Product Units and Services for the inclusion of these capabilities.
- *Common Look and Feel* – This is an approach to covering logo, colour schemes, and style sheet standards for both native and Web clients. It leverages existing UI components as well as the development of new components based on free form UXR design principles.

- *Graphical User Feature Set* – This set includes tabular and graphical rendering, form/data entry, drill down, interactive panel presentation, geographical integration (with the ability to explore eventual integration to 3D/Virtual Reality capabilities) and any other requirement as identified by constituents within the business line.
- *Consumable Components include:*
 - *Icons, Patterns, and Styles* - A common library of icons and themes will be made available to all production units. The core icons will be based on Google Material Design with Nokia styling. Product-specific icons will be based on the same design concepts. These items are provided without dependence upon any other UXR component. Based on availability, UXR Design resources can be made available to product units to assist in the development of consistent and efficient designs that incorporate the evolving Nokia brand.
 - *Common Software(Nokia specific) widgets* – CSF widgets provide a set of base-level visual and non-visual client-side components that will be consumable and made available to all production units. It will include visual components such as drop-downs, tabs, tables, etc. as well as non-visual components such as client-side databases, web workers, etc. These component(s) will be based on ReactJS and leverage third-party and open-source libraries such as Widgets (Enterprise license in place) and ag-Grid. More complex components will be developed to address recurring patterns across product unit applications.
 - *Framework Support* – Guidance on techniques for the consumption of CSF widgets by utilizing client-side frameworks and libraries.
- *Supported Application and Library Framework:*
 - *React (Library)* - The ReactJS library provides rendering and UI state management. At its core, it only supports the 'V' of the MVC paradigm. If this is the library of choice for the Product Unit application, it will require the addition of the following technologies:
 - *State/data management* - RedUXR has been selected as the 'predictable state container' implementing the FIUXR architecture.

- *Redux/Flux support* – For product units to fully employ ReactJS-based assets of Client Framework, additional components would be required to handle the client-side data workflow for the web view designed for their particular application. Consulting services are available from the UXR domain based on Redux/Flux architecture for such a workflow. Redux/Flux-based web application assets or templates will not be developed and would not be available within the CSF repository.
- *Remote data integration (Ajax, REST)* - Currently under review. Options being considered:
 - Axios (front runner) - currently in use within other A&A products
 - Request
- *Routing* - Currently under review. Options being considered:
 - react-router
 - Junctions

5.2.5 Gerrit

Git is an appropriated adaptation control framework apparatus intended to deal with everything from little to exceptionally enormous ventures with speed and effectiveness. Git has the usefulness, execution, security, and adaptability that most groups and individual engineers need.

It likewise fills in as a significant circulated rendition control DevOps instrument. Gerrit is a code audit apparatus for the Git variant control framework. It is an electronic code audit framework, encouraging on the web code surveys for ventures. Gerrit is a Git server that includes a fine-grained get to control framework and a code survey framework and work process. We have created the “Femtocell” team name for the FCM project in Nokia IT Gerrit systems (this is a one-time activity for the product - Create an IT ticket, component EE Gerrit system to create a new team.

5.2.6 Eclipse

Our Java Integrated Development Environment (IDE) makes the Eclipse IDE famous. An integrated development environment (IDE) for computer programming is called Eclipse. The environment can be customised using an extendable plug-in

system and a base workspace. It is currently the second-most popular IDE for Java development and was the top choice up until 2016.

5.2.7 IntelliJ

One of the most effective and well-liked Integrated Development Environments (IDE) for Java is IntelliJ. It comes in community and ultimate editions and is created and maintained by JetBrains. RAPId development is made possible by this feature-rich IDE, which also aids in enhancing code quality.

5.2.8 Junit

A free testing tool for the Java programming language is called Junit. It offers assertions to distinguish test methodology. Data is tested with this tool before being entered into the piece of code.

5.2.9 Jmockit

JMockit is a free tool for unit testing. Line and path metrics are included in this code coverage tool. With recording and verification syntax, it permits API mimicking. Line, Path, and Data coverage are all provided by this tool.

5.3 SOFTWARE TESTING

Testing is the way toward running the application or the program to check whether it is giving the normal yields or not and furthermore to discover the blunders in it. And every one of the prerequisites ought to be met and every one of the functionalities should work appropriately to do the day by day task adequately. Testing helped in finding the mistakes and blames that could later prompt the disappointment of the application is fixed. This application experiences different sorts of testing.

This is a practical come execution testing where the application is tried for the best possible yield gave the best possible information sources. Discovery testing is a kind of programming testing where just an application's usefulness is tried. While testing the analysers will give a number of contributions to checks for the relating

results. The principal objective here is to test whether the necessities of the application are met or not.

Analysers will give both substantial and invalid contributions to check whether the framework is working appropriately or not. This will occur at every single dimension. The objective is here to acquire the normal yield for every one of the functionalities in the given necessities.

5.3.1 Functional Testing

The useful testing is done to check the weather all the utilitarian necessities are giving normal outcomes or not. This application is tried for the different contributions for every one of the functionalities and yield is watched. Testing is finished by giving both the substantial and invalid sources of information and checking whether for the legitimate it's diverting to the next page and for the invalid data sources it's appearing warning messages.

5.3.2 Regression Testing

This testing discovers how the application carries on after certain adjustments and fixing the blunders. In the wake of fixing the blunders, this application is acting true to form the progressions made are not influencing the yields of different functionalities and the application is giving appropriate yields for all the substantial data source.

5.3.3 White Box Testing

This testing is additionally called open box testing, which is utilized to test the punctuation, structure, and semantics in the code that may cause some mistakes in the framework. These are the blunders that are brought about by the rationales and superfluous code. This testing used to test how the inward structure is associating with the sources of info, how the special case is happened because of the blunders, and so on.

5.3.4 Integration Testing

This is likewise one of the testing done after the unit testing, this testing is utilized to check all the modules together. Subsequent to joining every one of the modules together whether the application is working appropriately or not, for that we utilize the reconciliation testing. To check whether the connection between the modules is giving the normal yield or not.

5.3.5 Unit Testing

This sort of testing is utilized to test the modules of the application freely for legitimate tasks. This test is utilized to test the code stream in the application. This testing is finished by every single module here module is only the units or segments of the application. This testing is finished by the engineer who builds up the application. This testing finds the blunders each early. Just to test the function, a developer adds some code to the application. When the programme is deployed, they will eventually remove the test code once it has been commented out.

A developer may isolate the function and run more thorough tests on it. This is a more extensive method of unit testing that entails copying and pasting code into a testing environment apart from the code's original environment. UNIT TESTING is a sort of software testing in which certain software units or components are tested. As you can see, unit testing can encompass a lot of different things. Depending on the application being tested, the testing methodologies, tools, and philosophies employed, it may be sophisticated or very easy. On some level, unit testing is always important. It is certain that.

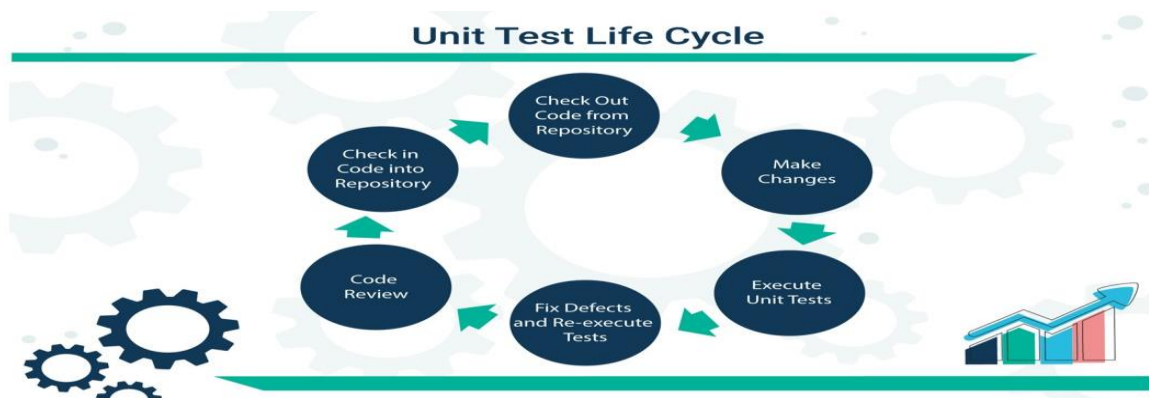


Fig: 5.4 Unit Testing Life Cycle

5.3.6 Test Cases

Table 5.1 describes about the regression testing of dashboard component. We will perform the testing on each and every inch of the UI to check whether it is functioning fully as expected.

Table: 5.1 Dashboard

Test ID	Test Case	Test Input	ExpectedOutput	Actual Output	Result
TC1	Login	check username and password	Successfully log into the application	Successfully login to the application	Pass
TC2	Login	Invalid Username and Password	Invalid User Name andpassword Warring message, redirect to login page.	Invalid User Name And password Warring message, redirect to the loginpage.	Pass
TC3	Cards	Count	Display count automatically	Display count automatically	Pass
TC4	Alarms	Errors and faults	Notify user onhigh thread	Notify user on highthread	Pass
TC5	Provisionin gStatus	Count	Display statusin percentage	Display status inpercentage	Pass
TC6	Operational Status	Count	Display statusin percentage	Display status inpercentage	pass
TC7	Transaction perday	Count	Display data inthe form of a graph	Display data in theform of a graph	pass

Table 5.2 describes about the regression testing of femtocell summary component. We will perform the testing on each and every inch of the UI to check whether it is functioning fully as expected.

Table: 5.2 Test Case of Femtocell Summary

Test ID	Test Case	Test Input	Expected Output	Actual Output	Result
TC1	Table data are to be fetched from the JSON file and displayed.	JSON file with key-value pairs	Rows and columns populated with values from JSON file	Rows and columns populated with values from JSON file	Pass
TC2	Delete options on each row of the table for deleting of the Femtocells	Femtocell on the selected row	Deleting of the row with a warning dialog box	Deleting of the row with a warning dialog box	Pass
TC3	Search for the entire Femto Cells from the table	Search = 'demoFAP1'	Displays the row with the serial number = demoFAP1	Displays the row with the serial number = demoFAP1	Pass

Table 5.3 describes about the regression testing of femtocell summary component. We will perform the testing on each and every inch of the UI to check whether it is functioning fully as expected.

Table 5.3 : Test case of femtocell details

Test ID	Test Case	Test Input	Expected Output	Actual Output	Result
TC1	Attributes for the Femtocell should be displayed from the selected Femtocell Type	JSON file with the array of objects as attributes	Attributes should be displayed	Attributes should be displayed	Pass
TC2	Dynamic display of attributes with form type	JSON file with 'form type' object	Attributes are displayed on the basis of form type	Attributes are displayed on the basis of form type	Pass

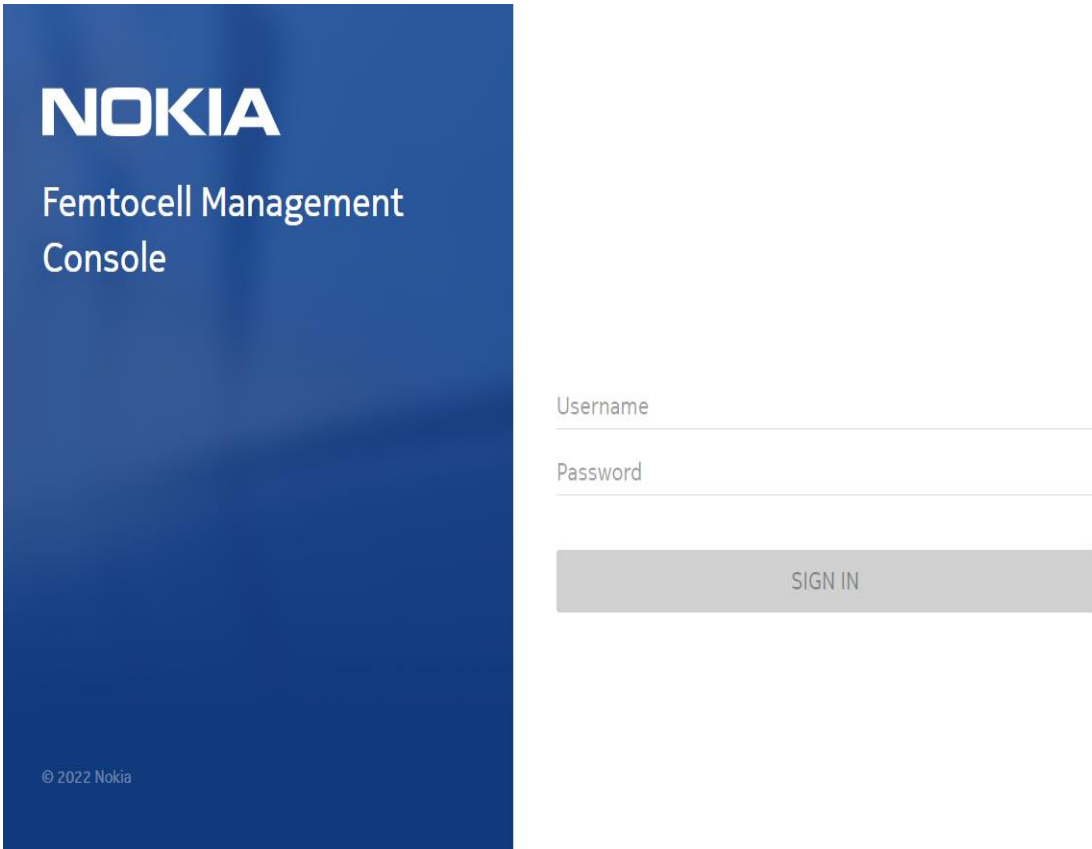
All the experiments written in the above table are effectively tried and forms engaged with building up the application are working flawlessly with no mistake.

CHAPTER 6

RESULTS AND DISCUSSION

This chapter shows and describes the results obtained with the use of methodologies adapted in the project. The findings are analysed, and a suitable conclusion is provided. Any variation in result is noted and further analysed.

6.1 IMPLEMENTATION SCREENSHOTS



The screenshot displays the login interface for the Nokia Femtocell Management Console. On the left, a dark blue vertical banner contains the 'NOKIA' logo in white, followed by the text 'Femtocell Management Console' and a copyright notice '© 2022 Nokia' at the bottom. To the right of the banner, there are two input fields: 'Username' and 'Password', each with a light gray underline. Below these fields is a gray rectangular button with the text 'SIGN IN' in white capital letters.

Fig: 6.1 Login Page

Fig 6.1 represents the Login page(company-specific theme) for femtocell management console. If we provide correct username and password then the page loads to display the dashboard. If we provide wrong login credentials then the error code will display as shown in the fig: 6.1.2 and we cannot move forward until we provide correct login credentials.

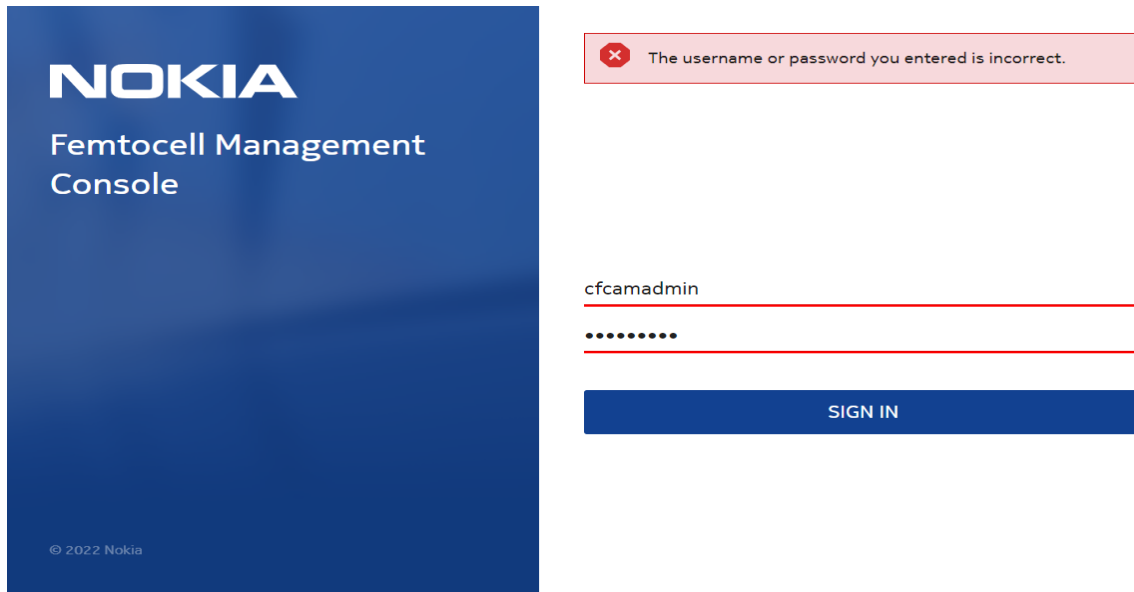


Fig: 6.2 Login Page With An Error Notification

Fig 6.2 shows the error notification when the user credentials are wrong. User can not enter inside the UI unless he provides the correct login details. We can create our own usernames and passwords for the login page.

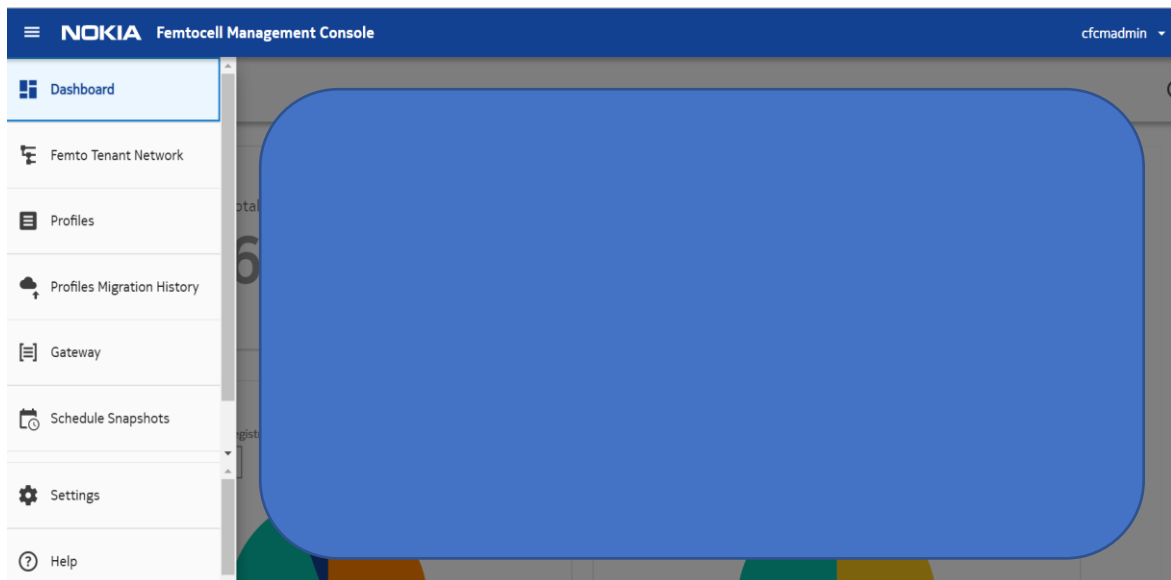


Fig: 6.3 Side Drawer

Fig 6.3 is the view of all the components that are present in the UI like dashboard, femto tenant network, snapshots and settings. We can move from one component to other using this side drawer.

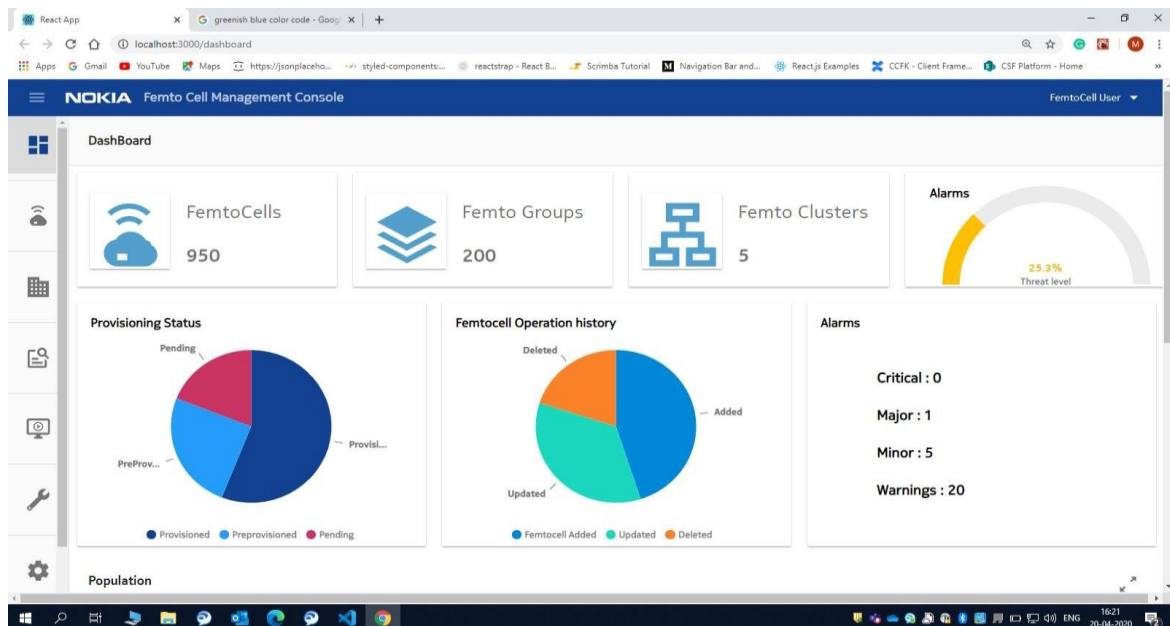


Fig: 6.4 Dashboard Console

Fig 6.4 is the dashboard console where user can see the femtocell registration status and gps status data in the form of pie chart.

The screenshot displays the Nokia Femtocell Management Console, specifically the 'Femto Tenant Network' section. The left sidebar shows a tree view of the network structure, including 'Femto Tenant Network' and 'Femto Clusters'. The main area shows a table of femtocells with the following columns: Serial number, Linked Serial N..., BSR ID, FemtoCluster ID, FemtoGroup ID, and Registration S.

Serial number	Linked Serial N...	BSR ID	FemtoCluster ID	FemtoGroup ID	Registration S
☐ araj		12	1		registered
☐ araj2		13	1		registered
☐ sram1		15	1		pending
☐ abc		14	1		pending
☐ raman11		11	1		registered
☐ femto01		5	1		registered
☐ femto07		10	1		awaitingTrans
☐ test_dualcell		9	1		pending

Fig: 6.5 Femto Tenant Network

The fig 6.5 shows the user can able to see the list of femtocells they have created and they can able to edit the attributes of femtocell if needed. They can also create new clusters, new groups and new femtocells according to the requirement.

Fig: 6.6 Adding a Femtocell

In the figure 6.6, we can see the adding of the femtocell. In this component, user can able to add the number of femtocells according to the requirement.

Fig: 6.7 Migrating Profile

We can migrate profiles from one version to another version. Here target version is SC22 and we can see that in figure 6.7. If the profile is in SC21 version, we can migrate to SC22 and if it is already SC22 we cannot migrate.

Schedule Snapshot

Merge Default Value ?
☒ False ☐ True

Periodicity *
WEEKLY

Start date *
YYYY-MM-DD hh:mm 

On Going ?
☐ False ☒ True

Periodicity Parameters

Day *
Select

CANCEL SAVE

Fig: 6.8 Scheduling Snapshots

In the figure 6.8, we can see scheduling the snapshots. User can schedule the snapshot hourly, daily, weekly, monthly.

CHAPTER 7

CONCLUSION

7.1 CONCLUSION

Femtocell Configuration Management will provide the bulkCM file which is used by the femtocell for the registration process and the design will provide the user interface for Administrator to view the performance in the Dashboard like the number of femtocells, Femto groups, Femto clusters available at present, he will view the alarms that indicate the thread rate which can be managed later by the Fault management team, he can view the provisioning status, operational status in the form of a pie chart and he can also view the transactions per day in the form of a column chart. Administrators can add, delete, edit operations that is, basically a dashboard for monitoring the devices connecting to the Femtocell and the workflows. The software, management console will provide the admin or the operator with the details of the Femtocells and an option for each of the Femtocells to edit and delete. The summary will provide the details of femtocells so that it enables the Operator with either editing or deleting of the Femtocells. Essentially this project is designed to ease the work of admin manage the overall performance of the Femto management system.

REFERENCES

- [1] Bhanu Ravishankar et al “Efficient and effective cellular technology”, Nokia, Small Cells and Wifi, Bangalore, Page. No. 754-759, 2016.
- [2] IEEE 802.16 Broadband Wireless access working group, “IEEE 802.16m System Description Document.
- [3] Jeffrey G. Andrews et al “Femtocells: Past, Present, and Future”, IEEE Journal on Selected Areas in Communications, Vol. 30, No. 3, April 2012.
- [4] Knisely D et al, Standardization of Femtocell in 3GPP IEEE Communications Magazine, Page No .68-75, September 2009.
- [5] M.E. Sahin et al CCI and ICI in OFDMA femtocell networks through frequency scheduling IEEE Transactions on Consumer Electronics, 55 (4) (2009), pp. 1936-1944 November, 2009.
- [6] M.Z. Chowdhury et al Neighbour cell list optimization for femtocell to femtocell Handover in dense femto cellular networks, 2011 Third International Conference on Ubiquitous and Future Networks (ICUFN) (2011), pp. 241-245, 2011.
- [7] Perez D.L et al OFDMA femtocells: A roadmap on Interference avoidance IEEE communications magazine, 47 (9) (2009), pp. 41-48 September 2009.
- [8] Pérez D.L, et al JieOFDMA Femtocells: Intracell Handover for Interference and Handover Mitigation in Two-Tier Networks, IEEE Wireless Communications and Networking Conference (WCNC) (2010), pp. 1-6, 2010.
- [9] S. Huan et al Jianhua Interference avoidance in OFDMA-based femtocell network, IEEE Youth Conference on Information, Computing and Telecommunication (2009), pp. 126-129 20–21 Sept.
- [10] S.A. Rubaye et al Cognitive Femtocell IEEE Vehicular Technology magazine, 6 (1) (2011), pp. 44-51 March 2011.
- [11] V Chandrasekhar et al “Femtocell Networks: A Survey”, IEEE Communications Magazine, vol. 46, no. 9, pp. 59-67, September 2008.
- [12] Zhuoran Li et al , “Understand and Diagnose Real-World Femtocell Performance Problems”, International Research Journal of Engineering and Technology, Page. No. 1-9, 2017.

APPENDIX

A. IEEE STANDARDS OF FEMTOCELL

Femtocell is a type of small-scale base station that provides enhanced wireless coverage and capacity in indoor or outdoor environments. It is typically used in residential or small business settings to improve cellular network connectivity. The Institute of Electrical and Electronics Engineers (IEEE) has published several standards related to femtocell technology. Some of the relevant IEEE standards for femtocells are:

- [1] IEEE 802.16e: This standard, also known as WiMAX (Worldwide Interoperability for Microwave Access), includes provisions for femtocells as part of its wireless broadband access system. It defines the air interface and network architecture for broadband wireless communication systems operating in the 10-66 GHz frequency range.
- [2] IEEE 802.11f: This standard, also known as Inter-Access Point Protocol (IAPP), specifies the protocol for communication between access points in a wireless local area network (WLAN) system. It has been used as a basis for femtocell deployments in some cases.
- [3] IEEE 802.11u: This standard, also known as Next Generation Hotspot (NGH), provides enhancements to the IEEE 802.11 WLAN standard to enable seamless and secure access to public Wi-Fi networks, including femtocells. It includes features such as network discovery, selection, and authentication.
- [4] IEEE 802.20: This standard, also known as Mobile Broadband Wireless Access (MBWA), specifies the air interface for a broadband wireless communication system designed for mobile and nomadic access. It includes provisions for femtocells as part of the overall system architecture.

B. CONSTRAINTS

There are some of the general constraints for femtocells based on IEEE standards. It is important to note that femtocell technology is continuously evolving, and specific constraints may vary depending on the specific IEEE standard, regulatory requirements, and implementation choices made by different stakeholders.

Frequency bands: Femtocells operate in licensed frequency bands, and their deployment must comply with the regulatory requirements of the respective frequency bands as defined by IEEE and other regulatory bodies. For example, in the United States, femtocells typically operate in the licensed frequency bands such as PCS (Personal Communications Service) or AWS (Advanced Wireless Services), as defined by the Federal Communications Commission (FCC).

Power limits: Femtocells are subject to power limits defined by IEEE and regulatory bodies to prevent interference with other wireless networks. These power limits may vary depending on the frequency band, deployment scenario, and interference mitigation techniques employed.

Backhaul connectivity: Femtocells require a reliable backhaul connectivity to connect to the core network of the cellular operator. IEEE standards may define requirements for the type of backhaul connectivity, such as Ethernet, DSL, or fiber, and their performance characteristics, such as latency, jitter, and bandwidth, to ensure reliable communication between femtocells and the core network.

Security: Femtocells must implement security measures to protect against unauthorized access, data breaches, and other security threats. IEEE standards may specify requirements for authentication, encryption, and other security mechanisms to ensure the confidentiality, integrity, and availability of communications over the femtocell network.