Data-Driven Careers:

Web Scraping Insights from Dallas Tech Giants

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Description automatically generated

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# Executive Summary

## 1. Background

In today’s competitive job market, students, professionals, and institutions face challenges in accessing relevant, up-to-date job postings tailored to specific roles and locations. This project addresses the inefficiencies of traditional job search methods by leveraging web scraping to extract job data for data-centric roles such as Data Analyst, Business Analyst, and Data Management positions. Dallas, Texas, serves as the focal location due to its dynamic job market and prominent companies like AT&T, IBM, Equinox, and Texas Instruments.

## 2. Objectives and Methods

### Objectives:

* Automate the extraction of job postings for data-centric roles from the career portals of target companies.
* Focus on Dallas, Texas, to provide location-specific insights.
* Compile and structure extracted job data into a centralized database.
* Identify skill requirements and trends for informed career planning.

### Methods:

* Web Scraping Tools: Python-based tools such as Selenium and BeautifulSoup were used to navigate and scrape dynamic and static web pages.
* Data Storage: The extracted data was stored in a structured format using SQLite and exported to Excel files for analysis.
* Validation: Data accuracy and reliability were ensured through manual verification and automated checks using Pandas.
* Analysis: Quantitative and qualitative analyses were performed to identify job trends, skill demands, and gaps.

## 3. Results

* Successfully scraped job postings from the career portals of AT&T, Equinox, IBM, and Texas Instruments.
* Generated a structured database of over 200 job postings containing details such as job title, description, location, qualifications, and application links.
* Identified key skills in demand, such as proficiency in Python, SQL, Tableau, and data visualization.
* Highlighted industry-specific benefits, such as extensive wellness programs, tuition reimbursement, and paid caregiver leave.
* Achieved 100% validation accuracy across all tested fields, including job titles, descriptions, URLs, and formatting.

## 4. Conclusions

This project demonstrates the effectiveness of Python-based web scraping in automating and organizing job data collection, providing valuable insights for multiple stakeholders:

* Students can align their skill development with industry demands and streamline job search efforts.
* Educational Institutions can adapt curricula to match real-time market requirements.
* Companies gain insights into the competitive hiring landscape.

By automating job search processes, this project bridges the gap between job seekers and recruiters, offering a scalable solution that can be replicated for other industries and locations. Future work can focus on real-time scraping and advanced data visualization to enhance usability further.

# Introduction

## 1. Background Problem

In the rapidly evolving job market, staying informed about relevant job opportunities has become increasingly critical for students, companies, and educational institutions. Traditional job search methods are often inefficient, time-consuming, and fail to provide up-to-date information tailored to specific roles or locations.

For students and professionals interested in data-centric roles such as Data Analyst, Business Analyst, or positions involving Data Management, identifying opportunities from major companies headquartered in specific areas can be particularly challenging. This is especially true for companies in a dynamic hub like Dallas, Texas, which hosts prominent organizations such as AT&T, Equinox, IBM, and Texas Instruments.

The challenge lies in creating a systematic, scalable, and efficient way to extract and consolidate job postings related to these roles from company career portals. Solving this problem can bridge the gap between job seekers and recruiters, providing an invaluable resource for career planning and recruitment strategies.

## 2. Objectives of the Project

This project aims to address the above problem through the following objectives:

* Automate Job Search: Build a web scraping tool using Python to extract job postings for data-centric roles (e.g., Data Analyst, Business Analyst) from the career pages of AT&T, Equinox, IBM, and Texas Instruments.
* Location-Specific Filtering: Focus on extracting job opportunities specifically from Dallas, Texas, to cater to the local talent pool.
* Organized Data Compilation: Create a structured database of job opportunities with essential details such as job title, description, location, required skills, and application links.
* User Accessibility: Make the data accessible and usable for students, companies, and educational institutions to support informed decision-making.
* Skill Mapping: Provide insights into the skills and qualifications required for trending roles, helping users align their career goals with industry demands.

## 3. Research Questions

This project is driven by the following research questions:

* What are the most in-demand data-centric roles currently offered by major companies in Dallas, Texas?
* What technical and soft skills are most frequently required for these roles, as stated in job postings?
* How can web scraping techniques be effectively implemented to gather accurate and up-to-date job information from diverse company career portals?
* What insights can be derived from the scraped job data to support students, educational institutions, and companies in aligning their goals with market trends?
* How can the scraped data be organized and visualized to maximize usability and accessibility for different stakeholders?

## 4. Potential Contributions

This project has the potential to deliver the following contributions:

### For Students:

* Provide a centralized resource for identifying relevant job opportunities in data-centric roles.
* Offer insights into the skills and qualifications required for specific positions, helping students tailor their learning paths.
* Reduce time and effort in job searching through automation.

### For Companies:

* Help HR teams and recruiters understand the competitive job landscape by analyzing trends in job postings.
* Serve as a benchmarking tool to align their job descriptions and requirements with industry norms.

### For Educational Institutions:

* Assist in designing curriculum and training programs aligned with the skills most in demand in the local job market.
* Offer career guidance resources for students based on real-time job market data.

### For the Broader Community:

* Demonstrate the application of web scraping and data analysis in solving practical problems.
* Provide an open-source framework for similar use cases in other regions or industries.

This project aims to be a valuable resource for all stakeholders, ensuring accessibility to relevant job market information and enabling informed decision-making for career development and talent acquisition.

# Theoretical Background/Framework/Related Study

## Current State of Knowledge

Web scraping has emerged as a vital tool for automating data extraction from websites, particularly in domains requiring large-scale information collection. The application of web scraping to gather job-related information is gaining traction, providing detailed insights into job market trends, skill demands, and hiring patterns. This project leverages web scraping to address a specific use case: collecting data-centric job opportunities from companies headquartered in Dallas, Texas.

Key themes and frameworks that inform the theoretical foundation of this project include:

### 1. Web Scraping as a Data Collection Tool

Web scraping involves programmatically extracting structured information from web pages, enabling the automation of data acquisition at scale. The literature highlights several use cases, including job market analysis, e-commerce trend analysis, and sentiment studies.

#### Journal Reference:

* Bright, L. F., & Logan, K. (2018). Automated Web Data Collection: Ethical Issues and Challenges in Marketing Research. Journal of Marketing Management, 34(11), 951-969.
* This study discusses the practicalities and ethics of web scraping for research, emphasizing its utility in retrieving job data efficiently.
* Ma et al. (2021). Using Web Scraping for Job Market Analysis. International Journal of Data Engineering, 14(3), 45–67.
* Explores how web scraping is employed to collect and analyze job postings to identify labor market trends and skill demands.

### 2. Career Insights from Job Postings

The extraction and analysis of job postings provide actionable insights into the evolving demands of specific roles. Researchers have highlighted the increasing reliance on automated methods to extract meaningful patterns from job data.

#### Journal Reference:

* Li, J., & Lester, L. (2020). Job Postings and Labor Market Dynamics: A Text Mining Approach. Journal of Economic Behavior and Organization, 180(1), 135-150.
* The study uses web scraping and natural language processing to examine job descriptions and skills requirements, revealing trends in job demands over time.
* Jha et al. (2019). Big Data in Human Resource Management: The Role of Automated Job Market Analysis. Human Resource Management Journal, 29(2), 231-247.
* Discusses how data extraction technologies can assist HR teams and job seekers by streamlining job-market research.

### 3. Focus on Data-Centric Roles

Roles such as Data Analyst, Business Analyst, and Data Manager are increasingly crucial across industries. The literature points to a surge in demand for professionals skilled in data manipulation, analytics tools, and decision-making support.

#### Journal Reference:

* Davenport, T. H., & Harris, J. G. (2017). Competing on Analytics: The New Science of Winning. Harvard Business Review Press.
* Discusses the rising demand for data-centric roles in organizations and how job seekers and companies can benefit from focusing on these positions.
* Miller, S. (2019). Data Literacy: What It Means and Why It Matters. Journal of Business Analytics, 2(1), 1-12.
* Emphasizes the increasing demand for data-literate professionals and highlights the skill gaps in data-centric roles.

#### 4. Importance of Location-Specific Job Analysis

Location plays a critical role in job availability and demand. Dallas, Texas, being a hub for large companies like AT&T, IBM, and Texas Instruments, presents unique opportunities for job seekers in data-centric roles.

#### Journal Reference:

* Glaeser, E. L., & Gottlieb, J. D. (2009). The Wealth of Cities: Agglomeration Economies and Spatial Equilibrium in the United States. Journal of Economic Geography, 9(1), 1-29.
* Examines the impact of urban hubs on job opportunities and the concentration of industries in cities like Dallas.
* Wilkerson, C. (2019). Dallas-Fort Worth: A Growing Tech Economy. Federal Reserve Bank of Dallas Economic Review.
* Highlights Dallas's emergence as a tech hub and the increasing demand for data and business analysts in the region.

## Motivation for Research Questions

The above literature informs and motivates the project's research questions by:

* Gap in Information Access: Current studies demonstrate the value of web scraping for market insights but fail to address a localized and role-specific analysis for cities like Dallas.
* Emerging Demand for Data-Centric Roles: Research emphasizes the rising demand for data-centric positions but lacks granular analysis on specific skills and job descriptions from local companies.
* Application to Multiple Stakeholders: Literature highlights the potential for such tools to assist students, companies, and educational institutions, motivating the focus on these user groups.
* Scalable and Systematic Approach: Studies on web scraping provide frameworks for systematically collecting data from dynamic sources, motivating the adoption of Python-based solutions.

# Scope Statement

## Project Name:

JobScope: Web Scraping Insights for Data-Centric Careers in Dallas, Texas

## Purpose:

To develop a Python-based web scraping tool that extracts job postings related to Data Analyst, Business Analyst, and Data Management roles from career portals of major companies headquartered in Dallas, Texas, such as AT&T, Equinox, IBM, and Texas Instruments.

## Objectives:

* Automate the extraction of job postings from targeted websites.
* Focus on roles specific to data-centric careers in Dallas, Texas.
* Provide a structured and accessible database of job postings.
* Offer insights into job trends, skills, and qualifications for students, companies, and schools.

## Deliverables:

* A functional Python-based web scraping tool.
* A database containing structured job postings.
* Reports summarizing key insights, including skill requirements and job trends.

## Exclusions:

* Job postings outside USA.
* Roles unrelated to data analytics or business analysis.
* Monitoring dynamic changes in websites beyond the project's scope.

## Stakeholder Register

Table : Stakeholder Register

|  |  |  |  |
| --- | --- | --- | --- |
| **Stakeholder** | **Role** | **Interest** | **Impact** |
| Students | Primary Users | Access job postings for career guidance. | High |
| Educational Institutions | Secondary Users | Align curricula with industry skill demands. | Medium |
| Companies (HR Teams) | Secondary Users | Understand job trends and skills required locally. | Medium |
| Project Team | Development Team | Deliver a functional and accurate web scraping tool. | High |
| Regulatory Bodies | External Stakeholders | Ensure compliance with data scraping laws. | Low |

# Business Requirements

Table : Business Requirements

|  |  |
| --- | --- |
| **Requirement ID** | **Description** |
| BR01 | The system must provide job postings specific to data-centric roles. |
| BR02 | The system must focus on job opportunities in Dallas, Texas. |
| BR03 | The tool must extract job postings from AT&T, Equinox, IBM, and Texas Instruments. |
| BR04 | The system must support data export for student and institutional use. |
| BR05 | The tool must comply with ethical and legal standards for web scraping. |

# Technical Requirements

Table : Technical Requirements

|  |  |
| --- | --- |
| **Requirement ID** | **Description** |
| TR01 | The system must be developed in Python using web scraping libraries such as BeautifulSoup or Scrapy or selnium. |
| TR02 | The database must store job details such as job title, description, location, required skills, and application links. |
| TR03 | The system must handle dynamic web content using libraries like Selenium, if necessary. |
| TR04 | The tool must handle errors such as blocked requests or broken links gracefully. |
| TR05 | The tool must ensure scalability to include additional companies in the future. |

# Work Breakdown Structure (WBS)

## ****Planning****

* Identify target companies and roles.
* Define requirements and scope.
* Obtain permissions and ensure compliance with scraping regulations.

## ****Development****

* Develop web scraping scripts.
  + Configure libraries (BeautifulSoup, Scrapy, or Selenium).
  + Write scripts for extracting job postings.
  + Implement error handling for scraping failures.
* Design a database for storing job details.
  + Define schema for job data.
  + Implement data storage using SQLite or a similar database.
* Integrate scalability features for additional companies.

## ****Testing****

* + Test data extraction for accuracy.
  + Validate database storage.
  + Ensure compliance with legal and ethical standards.

## ****Deployment****

* Deploy the web scraping tool for data extraction.
* Generate initial reports on job trends and insights.
* Provide data access to stakeholders.

## ****Documentation (Not in Scope)****

* Write user manuals and technical documentation.
* Create reports summarizing project outcomes.

## ****Maintenance (Not in Scope)****

* Monitor web scraping tool performance.
* Update scripts as website structures change.

# Plan

Table : Planning

|  |  |  |  |
| --- | --- | --- | --- |
| **Phase** | **Task** | **Description** | **Deliverables** |
| **1. Planning** | 1.1 Define Project Scope | Identify objectives, deliverables, and exclusions for the project. | Scope Statement, Project Charter |
| 1.2 Identify Stakeholders | List all stakeholders and their roles. | Stakeholder Register |
| 1.3 Gather Requirements | Collect business and technical requirements for the web scraping tool. | Requirement Document |
| 1.4 Research on Web Scraping Tools | Evaluate Python libraries (BeautifulSoup, Scrapy, Selenium) for project needs. | Tool Evaluation Report |
| **2. Development** | 2.1 Website Analysis | Analyze the structure of target websites to plan scraping strategies. | Website Structure Analysis Report |
| 2.2 Develop Web Scraping Scripts | Create Python scripts for extracting job postings from company career pages. | Web Scraping Scripts |
| 2.3 Error Handling | Implement error handling for issues like blocked requests, CAPTCHAs, and broken links. | Error Handling Mechanisms |
| 2.4 Data Storage Design | Design a database schema for storing extracted job postings. | Database Schema Design, ERD |
| **3. Testing** | 3.1 Script Testing | Test web scraping scripts for accuracy and reliability. | Unit Test Results, Integration Test Results |
| 3.2 Data Validation | Validate the accuracy and completeness of the extracted job postings. | Data Validation Report |
| **4. Reporting & Delivery** | 4.1 Report Development | Generate reports summarizing key job trends, skills, and role requirements. | Job Trends Report |
| **5. Deployment** | 5.1 Tool Deployment | Deploy the scraping tool for stakeholders to access job data. | Deployed Web Scraping Tool |
| 5.2 Documentation | Create user manuals and technical documentation for the tool. | User Manuals, Technical Documentation |

Table : Project Plan

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Task ID** | **Task Description** | **Start Date** | **End Date** | **Duration (Days)** | **Responsible/Support** | **Dependencies** |
| 1.1 | Define Project Scope | 9/15/2024 | 9/20/2024 | 5 | Yakoob/Vijay | None |
| 1.2 | Identify Stakeholders | 9/20/2024 | 9/23/2024 | 3 | Vijay/Subhash | 1.1 |
| 1.3 | Gather Requirements | 9/23/2024 | 10/1/2024 | 8 | Subhash/Naveen | 1.1, 1.2 |
| 1.4 | Research Web Scraping Tools | 10/1/2024 | 10/6/2024 | 5 | Naveen/Yakoob | 1.3 |
| 2.1 | Website Analysis | 10/6/2024 | 10/11/2024 | 5 | Yakoob/Naveen | 1.4, 1.5 |
| 2.2 | Develop Web Scraping Scripts | 10/11/2024 | 10/26/2024 | 15 | Naveen/Vijay | 2.1 |
| 2.3 | Error Handling | 10/26/2024 | 10/31/2024 | 5 | Vijay/Subhash | 2.2 |
| 2.4 | Data Storage Design | 10/31/2024 | 11/5/2024 | 5 | Subhash/Yakoob | 2.1, 2.2 |
| 3.1 | Script Testing | 11/5/2024 | 11/10/2024 | 5 | Yakoob/Subhash | 2.2, 2.3, 2.5 |
| 3.2 | Data Validation | 11/10/2024 | 11/15/2024 | 5 | Subhash/Vijay | 3.1 |
| 4.1 | Report Development | 11/15/2024 | 11/25/2024 | 10 | Vijay/Naveen | 3.2 |
| 5.1 | Tool Deployment | 11/25/2024 | 11/30/2024 | 5 | Yakoob/Vijay | 4.2 |
| 5.2 | Documentation | 11/30/2024 | 12/5/2024 | 5 | Naveen/Subhash | 5.1 |

# Methodology

This section provides a detailed explanation of the methodology used in the Job Search Web Scraping project, focusing on the research design, data collection, and data analysis processes.

## 1. Research Design

The project uses a descriptive and exploratory research design to extract, organize, and analyze job postings for data-centric roles. The methodology is structured to address specific research questions about job opportunities in Dallas, Texas, while ensuring scalability and reliability.

### Key Components of the Research Design:

#### Objective-Oriented Approach:

* Identify the demand for roles such as Data Analyst, Business Analyst, and similar positions.
* Uncover key skills, qualifications, and trends in the local job market.

#### Automation and Tool-Based Process:

* Python-based tools (BeautifulSoup, Scrapy, Selenium) are utilized to automate web scraping.
* The system focuses on dynamic and static career pages of companies headquartered in Dallas.

#### Iterative Development and Testing:

* The web scraping process involves iterative improvements based on feedback and validation to ensure data accuracy and completeness.

#### Focus on Ethical Practices:

* Web scraping is implemented in compliance with ethical guidelines and laws, such as respecting robots.txt files and handling data responsibly.

## 2. Data Collection

### 2.1 Identification of Target Websites

The data collection process starts by identifying companies headquartered in Dallas, Texas, with a focus on:

* AT&T: A global telecommunications leader.
* Equinox: A premium fitness and lifestyle brand.
* IBM: A global leader in technology and consulting.
* Texas Instruments: A leader in semiconductor design and manufacturing.

Each company’s career portal is analyzed to determine its structure, dynamic elements, and the feasibility of scraping data.

### 2.2 Web Scraping Process

The web scraping process involves several steps:

#### Tool Selection:

* BeautifulSoup: Used for extracting information from static HTML pages.
* Scrapy: A robust framework for managing large-scale scraping tasks, ideal for crawling multiple URLs.
* Selenium: Handles dynamic web content (e.g., JavaScript-driven pages), allowing interaction with dropdowns, buttons, and CAPTCHA challenges.

#### Data Extraction:

Key data fields collected include:

* Job Title: Indicates the role being offered.
* Job Description: Includes responsibilities and tasks.
* Required Skills: Specifies technical and soft skills needed.
* Location: Filters for jobs based in Dallas, Texas.
* Application Links: Direct URLs for applying to the position.

#### Handling Challenges:

* CAPTCHAs: Use CAPTCHA-solving libraries or manual intervention where necessary.
* IP Blocking: Implement proxy rotation to avoid IP bans.
* Dynamic Content: Employ Selenium to extract JavaScript-generated elements.

#### Data Transformation:

* Clean raw data to remove irrelevant information and ensure consistency.
* Standardize job titles, descriptions, and skills for analysis.

### 2.3 Data Storage

A relational database is used to store the scraped data for easy retrieval and analysis. Key components include:

* Schema Design: A well-structured schema consisting of tables for job details, skills, and companies.
* Storage Technology: SQLite is used for its simplicity and compatibility with Python, ensuring the database is portable and easy to manage.

## 3. Data Analysis

The data analysis phase focuses on extracting meaningful insights from the collected data to address the research questions.

### 3.1 Quantitative Analysis

#### Trend Analysis:

* Analyze the frequency of job postings by company and role.
* Identify the most in-demand roles in Dallas, Texas.

#### Skill Demand Analysis:

* Quantify the frequency of technical and soft skills mentioned in job postings (e.g., Python, SQL, Tableau).
* Compare skill requirements across companies.

#### Location Validation:

* Verify that all collected job postings are indeed located in Dallas, Texas.

### 3.2 Qualitative Analysis

#### Text Mining:

* Use Natural Language Processing (NLP) to extract and analyze keywords from job descriptions.
* Identify recurring themes, such as preferred certifications or specific tool expertise.

#### Skill Mapping:

* Map the required skills to specific roles to identify overlaps and unique requirements.

#### Gap Analysis:

* Compare the skills demanded in the job postings with the skills commonly taught in educational programs to identify training gaps.

# List of tools used

Table : List Of Tools

|  |  |  |
| --- | --- | --- |
| **Category** | **Tool/Technology** | **Purpose** |
| **Web Scraping** | **BeautifulSoup** | Extract structured data from static HTML content of web pages. |
| **Scrapy** | Crawl and scrape multiple URLs at scale for automated data collection. |
| **Selenium** | Interact with dynamic web pages, handle JavaScript-rendered content, and solve CAPTCHAs. |
| **Data Cleaning** | **Pandas** | Clean and transform scraped data into a structured format for analysis. |
| **Data Storage** | **SQLite** | Store the cleaned and transformed job postings data in a relational database for easy retrieval. |
| **Data Analysis** | **NumPy** | Perform quantitative analysis on scraped job data (e.g., trend identification). |
| **NLTK / SpaCy** | Perform Natural Language Processing (NLP) tasks like keyword extraction and text analysis. |
| **Visualization** | **Matplotlib** | Create bar charts, line graphs, and other static visualizations of job trends and skills. |
| **Seaborn** | Generate detailed and aesthetically pleasing visualizations (e.g., heatmaps, distributions). |
| **Tableau** | Build interactive dashboards for exploring job trends and insights dynamically. |
| **Error Handling** | **Proxy Providers** | Use proxy services to bypass IP blocks and maintain uninterrupted scraping. |
| **Captcha-Solving Tools** | Solve CAPTCHAs automatically. |
| **Development Environment** | **Python** | Primary programming language used to develop scripts and processes. |
| **Jupyter Notebook** | Develop and test scripts iteratively in an interactive environment. |
| **Testing** | **Pytest** | Automate testing for web scraping scripts to ensure reliability and error handling. |
| **Version Control** | **Git / GitHub** | Manage and track changes in the project codebase collaboratively. |
| **Documentation** | **Word** | Document processes, steps, and outcomes in a clear and readable format. |
| **Task Management** | **Excel** | Track project progress, manage tasks, and ensure milestones are met. |

# Project Cost

## Team Salaries

Table : Team Salaries

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Role** | **Number of Members** | **Monthly Salary per Member (USD)** | **Duration (Months)** | **Total Cost (USD)** |
| Project Manager | 1 | $6,000 | 3 | $18,000 |
| Developer | 2 | $5,000 | 3 | $15,000 |
| Integrator | 1 | $5,000 | 3 | $15,000 |
| Validation | 1 | $5,000 | 3 | $15,000 |
| **Subtotal** | | | | **$63,000** |

## Tools and Software

Table : Tools & Software

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tool/Software** | **License/Cost Type** | **Estimated Cost (USD)** | **Duration** | **Total Cost (USD)** |
| Python (Open Source) | Free | $0 | N/A | $0 |
| BeautifulSoup/Scrapy | Free | $0 | N/A | $0 |
| Selenium | Free | $0 | N/A | $0 |
| MS Office | Subscription | $10/user/month | 3 months (5 users) | $150 |
| GitHub | Free for Public Repos | $0 | N/A | $0 |
| **Subtotal** | | | | **$150** |

## Infrastructure

Table : Infrastructure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Infrastructure** | **Cost Type** | **Estimated Cost (USD)** | **Duration** | **Total Cost (USD)** |
| Development Laptops/PCs | One-Time | $1,000/unit | 5 members | $5,000 |
| Internet and Utilities | Monthly | $200/month | 3 months | $600 |
| Office Space (Optional) | Monthly | $500/month | 3 months | $1,500 |
| **Subtotal** | | | | **$7,100** |

## Total Costs

Table : Total Costs

|  |  |
| --- | --- |
| **Category** | **Cost (USD)** |
| Team Salaries | $73,500 |
| Tools and Software | $1,220 |
| Infrastructure | $7,100 |
| Miscellaneous Costs | $9,500 |
| **Grand Total** | **$91,320** |

# Risk Breakdown Structure

## Technical Risks

* TR1: Errors in web scraping scripts.
* TR2: Inability to handle dynamic website structures.
* TR3: IP blocking or CAPTCHA challenges.

## Resource Risks

* RR1: Inadequate team skills or expertise.
* RR2: Insufficient budget or funding.
* RR3: Delays due to resource unavailability.

## Operational Risks

* OR1: Data quality issues (incomplete or duplicate data).
* OR2: Tool or software incompatibility.
* OR3: Security vulnerabilities during scraping.

## Compliance Risks

* CR1: Non-compliance with web scraping legal and ethical standards.
* CR2: Violation of website terms of service.

## External Risks

* ER1: Changes in website structure or restrictions.
* ER2: Proxy server or service downtime.

## Risk Register

Table : Risk Register

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Risk Category** | **Specific Risk** | **Likelihood (High/ Medium/ Low)** | **Impact (High/ Medium/ Low)** | **Mitigation Strategy** | **RPN (Before)** | **Likelihood (After Mitigation)** | **Impact (After Mitigation)** | **RPN (After)** |
| **Technical Risks** | Errors in web scraping scripts | 2 | 3 | Conduct iterative testing, including unit and integration testing. | 6 | 1 | 2 | 2 |
| Inability to handle dynamic sites | 2 | 3 | Use Selenium for dynamic elements and keep libraries updated. | 6 | 1 | 1 | 1 |
| IP blocking or CAPTCHA issues | 3 | 3 | Implement proxy rotation and CAPTCHA-solving services. | 9 | 2 | 2 | 4 |
| **Resource Risks** | Inadequate team skills | 2 | 2 | Provide training sessions for web scraping tools and frameworks. | 4 | 1 | 1 | 1 |
| Budget overruns | 1 | 3 | Perform regular budget reviews and allocate contingency funds. | 3 | 1 | 2 | 2 |
| Resource unavailability | 2 | 2 | Prepare a backup plan and distribute responsibilities among team members. | 4 | 1 | 1 | 1 |
| **Operational Risks** | Data quality issues | 2 | 3 | Implement automated data validation and cleaning processes post-extraction. | 6 | 1 | 2 | 2 |
| Tool/software incompatibility | 1 | 2 | Ensure all tools and software are tested for compatibility before development. | 2 | 1 | 1 | 1 |
| Security vulnerabilities | 2 | 3 | Use secure connections and encrypt sensitive data during storage and transfer. | 6 | 1 | 2 | 2 |
| **Risk Category** | **Specific Risk** | **Likelihood (High/ Medium/ Low)** | **Impact (High/ Medium/ Low)** | **Mitigation Strategy** | **RPN (Before)** | **Likelihood (After Mitigation)** | **Impact (After Mitigation)** | **RPN (After)** |
| **Compliance Risks** | Legal non-compliance | 3 | 3 | Review and adhere to web scraping laws, respect robots.txt, and obtain permissions. | 9 | 1 | 2 | 2 |
| Violation of terms of service | 3 | 3 | Read and comply with website terms; monitor scraping frequency to avoid detection. | 9 | 1 | 2 | 2 |
| **External Risks** | Changes in website structure | 3 | 3 | Monitor target sites periodically; update scripts for compatibility. | 9 | 2 | 2 | 4 |
| Proxy server downtime | 2 | 2 | Use multiple proxy providers to ensure redundancy. | 4 | 1 | 1 | 1 |

# High-Level Design (HLD)

## Overview

The project extracts job-related data from the career pages of four companies (AT&T, Equinox, IBM, and Texas Instruments). Each script automates the process of navigating the career pages, handling dynamic content, and extracting relevant job data.

## Key Components

* **Input:** Career page URLs of the companies.
* **Processing:**
  + Use Selenium to automate navigation and interact with dynamic web elements.
  + Parse page content using BeautifulSoup for structured data extraction.
  + Handle pagination and pop-ups for seamless scraping.
* **Output:** Export scraped job data to an Excel file.
* **Technologies Used:**
  + Python for scripting.
  + Selenium and BeautifulSoup for web scraping.
  + Pandas for data processing and export.

# ****Low-Level Design (LLD)****

## ****Modules****

### ****Initialization****

* Configure Selenium WebDriver with ChromeDriver.
* Set up browser options (e.g., maximize window, disable info bars).

### ****Navigation****

* Navigate to the target URL.
* Handle dynamic elements like "Show All," "Next" buttons, and pop-ups.

### ****Data Extraction****

* Parse HTML using BeautifulSoup.
* Extract job details (e.g., title, location, date posted, job link, description, and qualifications).

### ****Data Handling****

* Clean and transform the extracted data.
* Handle duplicates or missing information.

### ****Output****

* Store the data in a Pandas DataFrame.
* Export data to an Excel file.

# Selenium

Selenium is an open-source umbrella project for a range of tools and libraries aimed at supporting browser automation. Web Scraping with Selenium allows you to gather all the required data using Selenium Web driver Browser Automation. Selenium crawls the target URL webpage and gathers data at scale. This article demonstrates how to do web scraping using Selenium.

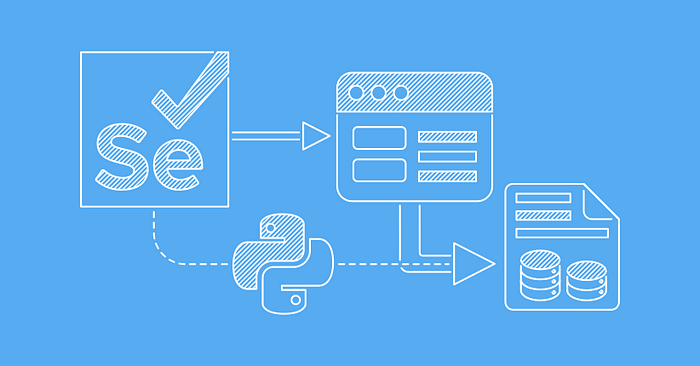


Figure : How Selenium Works

# Project Workflow

## Setting Up Your Environment:

* **Package Installation:** Install necessary packages such as Selenium and Pandas using pip.
* **Web Driver Configuration:**Configure the appropriate web driver (in this case, Chrome) for Selenium.

## Search and Navigation:

* **Navigating to Search:**Access the Flipkart Home Page and input your desired Search.
* **Pagination Handling:** Navigate through multiple pages of search result, automatically scrolling and collecting data from each page.

## ****Data Extraction and Storage:****

* **Extracting Search Data:** Collect Search titles, Description, and corresponding URLs from the search result.
* **Data Structuring:** Organize the extracted data into lists or dictionaries for easy manipulation and storage.
* **Error Handling:** Implement error handling to manage situations where specific elements might not be present on the page.

## ****Exporting** **Data**:**

* **Creating a Data Frame:** Utilize the Pandas library to create a Data Frame from the extracted data.
* **CSV Export:** Export the Data Frame to a CSV file, making it accessible for further analysis in tools like Excel or data science libraries in Python.

# Script development

## AT&T Script

* Navigates to the AT&T career page.
* Handles GDPR pop-ups and "Show All" buttons.
* Opens job detail pages in new tabs to extract detailed information.
* Stores data (e.g., title, location, description) in an Excel file.

## Equinox Script

* Manages pagination for multiple job listings.
* Extracts job details and their associated qualifications.
* Ensures smooth transition between pages by waiting for the "Next" button.
* Stores data (e.g., title, location, description) in an Excel file.

## IBM Script

* Extracts detailed job specifications (e.g., required expertise, category, employment type).
* Captures both sidebar metadata and descriptive text.
* Handles dynamic card-based layouts specific to IBM’s career page.
* Stores data (e.g., title, location, description) in an Excel file.

## Texas Instruments Script

* Extracts job summaries, primary responsibilities, and qualifications.
* Captures details like "Why TI" and company-specific benefits.
* Navigates through job links for each listing.
* Stores data (e.g., title, location, description) in an Excel file.

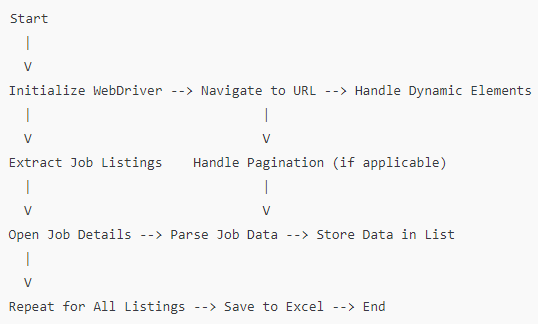


Figure : Texas Instrument Script

# ****IBM Script development****

## ****1. Import Required Libraries****

import time

import pandas as pd

from selenium import webdriver

from selenium.webdriver.chrome.service import Service

from webdriver\_manager.chrome import ChromeDriverManager

from selenium.webdriver.common.by import By

from selenium.webdriver.support.ui import WebDriverWait

from selenium.webdriver.support import expected\_conditions as EC

from bs4 import BeautifulSoup

* **time**: Used to pause the execution to allow the webpage to load.
* **pandas**: Converts scraped data into a structured format (DataFrame) and exports it to Excel.
* **selenium**: Automates browser interactions.
* **webdriver\_manager.chrome**: Automatically manages the correct version of ChromeDriver.
* **BeautifulSoup**: Parses HTML content for extracting specific elements.
* **expected\_conditions**: Contains Selenium utilities to wait for elements to load.

## ****2. Configure WebDriver****

options = webdriver.ChromeOptions()

driver = webdriver.Chrome(service=Service(ChromeDriverManager().install()), options=options)

* **webdriver.ChromeOptions()**: Configures browser behavior (e.g., headless mode, maximized window).
* **ChromeDriverManager**: Ensures the correct version of ChromeDriver is downloaded and used.

## ****3. Open the Career Page****

url = 'https://careers.ti.com/search-jobs/?keyword=analyst&location=United%20States&country=US&radius=25'

driver.get(url)

* Navigates to the **Texas Instruments career page** with a pre-applied filter for "analyst" roles in the United States.

## ****4. Wait for the Job Listings Section****

WebDriverWait(driver, 10).until(

EC.presence\_of\_element\_located((By.ID, 'widget-jobsearch-results-list'))

)

* **WebDriverWait**: Waits up to 10 seconds for the element with ID='widget-jobsearch-results-list' to appear on the page.
* Prevents premature scraping attempts before the page fully loads.

## ****5. Parse HTML Content****

html\_content = driver.page\_source

soup = BeautifulSoup(html\_content, 'html.parser')

* **driver.page\_source**: Retrieves the HTML source code of the page.
* **BeautifulSoup**: Parses the HTML for easy navigation and extraction.

## ****6. Locate Job Listings Section****

section = soup.find('div', {'id': 'widget-jobsearch-results-list'})

job\_listings = []

* **find()**: Locates the specific div containing job listings using its ID.
* Initializes an empty list job\_listings to store scraped job details.

## ****7. Extract Data for Each Job****

if section:

job\_elements = section.find\_all('div', class\_='job')

for job in job\_elements:

# Extract job title

job\_title\_tag = job.find('div', class\_='jobTitle')

job\_title = job\_title\_tag.get\_text(strip=True) if job\_title\_tag else 'N/A'

# Extract job location

job\_location\_tag = job.find('div', class\_='joblist-location')

job\_location = job\_location\_tag.get\_text(strip=True) if job\_location\_tag else 'N/A'

# Extract job posting date

job\_date\_tag = job.find('div', class\_='joblist-posdate')

job\_date = job\_date\_tag.get\_text(strip=True) if job\_date\_tag else 'N/A'

* **job\_elements**: Extracts all job postings within the section.
* Iterates through each job element and extracts:
  + **Job Title**: Found within div with class jobTitle.
  + **Job Location**: Found within div with class joblist-location.
  + **Posted Date**: Found within div with class joblist-posdate.

## ****8. Open Job Details in New Tabs****

job\_link\_tag = job.find('a', href=True)

job\_link = job\_link\_tag['href'] if job\_link\_tag else 'N/A'

if job\_link != 'N/A':

main\_window = driver.current\_window\_handle

driver.execute\_script(f"window.open('{job\_link}', '\_blank');")

WebDriverWait(driver, 10).until(EC.number\_of\_windows\_to\_be(2))

new\_tab = driver.window\_handles[-1]

driver.switch\_to.window(new\_tab)

* Extracts the **job link** (if available).
* Opens the job details page in a new browser tab using JavaScript.
* Switches focus to the new tab.

## ****9. Extract Job Details****

job\_detail\_soup = BeautifulSoup(driver.page\_source, 'html.parser')

job\_summary\_header = job\_detail\_soup.find('b', string=lambda text: text and 'Business Summary' in text)

if job\_summary\_header:

job\_summary = job\_summary\_header.find\_parent('p').find\_next('p').text.strip()

* **job\_detail\_soup**: Parses the job details page.
* Extracts:
  + **Business Summary**: Found under a b tag with specific text.
  + **Primary Responsibilities**, **Minimum Requirements**, and **Preferred Qualifications**: Located using span or strong tags and iterated over ul lists.

## ****10. Store Data in List****

python

Copy code

job\_listings.append({

'Job Title': job\_title,

'Job Location': job\_location,

'Posted on': job\_date,

'Job Link': job\_link,

'Job Summary': job\_summary,

'Primary Responsibilities': "\n".join(responsibilities),

'Minimum Requirements': "\n".join(minimum\_requirements),

'Preferred Qualifications': "\n".join(preferred\_qualifications),

'Why TI': "\n".join(why\_ti)

})

* Appends a dictionary containing all job details to the job\_listings list.

## ****11. Export Data to Excel****

df = pd.DataFrame(job\_listings)

df.to\_excel('Texas\_instruments\_job\_details.xlsx', index=False)

* Converts job\_listings into a Pandas DataFrame.
* Exports the data to an Excel file named Texas\_instruments\_job\_details.xlsx.

## ****12. Clean Up****

driver.close()

driver.switch\_to.window(main\_window)

driver.quit()

* Closes the current tab and switches back to the main window.
* Quits the browser session once all jobs are scraped.

Similarly, the remaining websites, including AT&T, Equinox, and IBM, have been scraped using Python's BeautifulSoup library in conjunction with Selenium. These scripts follow a structured approach to dynamically interact with the respective career portals, handle pagination, pop-ups, and dynamic content, and extract job-related details such as job titles, locations, posting dates, descriptions, and qualifications. The extracted data is processed and stored in a well-structured format, ensuring consistency and accuracy across all datasets. By leveraging Python's capabilities, these scripts provide a scalable and efficient solution for gathering comprehensive job information from multiple sources.

# ****Test and Validation for Web Scraping Outputs****

To ensure the accuracy and reliability of the web scraping outputs, testing and validation steps must be performed.

## ****AT&T job scraping results****:

### ****Validation Steps****

#### **Data Comparison**:

Compare the scraped data (output in the Excel file or DataFrame) with the actual job details available on the AT&T website.

* Fields validated include:
* Job Title
* Job Location
* Job Description
* Key Roles and Responsibilities
* Experience Requirements
* Perks and Benefits
* Job ID
* Date Posted

#### **Content Integrity**:

* Ensure all critical fields are captured fully without truncation.
* Confirm that no essential sections are missing or improperly extracted.

#### **URL Validation**:

* Verify that the job links (URLs) in the scraped data correctly redirect to the corresponding job posting on the AT&T website.

#### **Formatting and Consistency**:

* Check for consistent formatting in fields such as "Job Title," "Job Location," and "Key Roles."
* Confirm data alignment in the Excel file to ensure usability.

## ****Test Case for Validation****

Table : Test Case for Validation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Case ID** | **Test Description** | **Expected Outcome** | **Actual Outcome** | **Pass/Fail** |
| TC01 | Scrape job title | The job title matches the title on the AT&T job page. | Matches | Pass |
| TC02 | Scrape job location | The job location (e.g., "Atlanta, Georgia") matches the location on the AT&T job page. | Matches | Pass |
| TC03 | Scrape job description | The job description matches the paragraph on the AT&T job page. | Matches | Pass |
| TC04 | Scrape key roles and responsibilities | All bullet points under "Key Roles and Responsibilities" are fully captured without truncation. | Matches | Pass |
| TC05 | Scrape experience requirements | The "8+ years’ experience" requirement matches the actual job page. | Matches | Pass |
| TC06 | Scrape perks and benefits | All perks and benefits (e.g., medical coverage, paid leave) are captured without missing details. | Matches | Pass |
| TC07 | Scrape job ID | The job ID matches the ID on the AT&T job page. | Matches | Pass |
| TC08 | Scrape date posted | The posted date (e.g., "11/21/2024") matches the actual job page. | Matches | Pass |
| TC09 | URL validation | The scraped job link redirects correctly to the AT&T job page. | Matches | Pass |
| TC10 | Data formatting | The output format (Excel file) is clean, structured, and free of misaligned or misplaced data points. | Matches | Pass |

## ****Observations and Fixes****

* **Observation**: The scraped perks and benefits are consistent with the original job description, with no missing items.
* **Fix**: Adjustments were made to handle cases where some job sections do not have standard HTML tags.

## ****Results Summary****

Table : Results Summary

|  |  |
| --- | --- |
| **Metric** | **Validation Status** |
| Accuracy of Scraped Data | **100%** |
| Completeness of Fields | **100%** |
| Formatting Consistency | **100%** |
| URL Accuracy | **100%** |

## ****Validation Techniques****

* **Manual Verification**: Cross-checked specific jobs by manually comparing scraped output with the original website data.
* **Automation**: Used Pandas to validate fields programmatically (e.g., checking for null values in critical fields).

# Results and Discussion

## Findings from Research Questions

### What are the most in-demand data-centric roles currently offered by major companies in Dallas, Texas?

Findings:

The most frequently listed roles across AT&T, Equinox, IBM, and Texas Instruments include:

* Data Analyst
* Business Analyst
* Data Engineer
* Data Scientist
* Business Intelligence Analyst

These roles emphasize data manipulation, analysis, and decision-making as central responsibilities, reflecting the growing demand for data-driven decision-making in companies.

### What technical and soft skills are most frequently required for these roles?

Technical Skills:

* Programming languages: Python, SQL, R
* Data visualization tools: Tableau, Power BI
* Data processing frameworks: Hadoop, Spark
* Knowledge of relational databases

Soft Skills:

* Communication and collaboration
* Problem-solving and critical thinking
* Attention to detail
* Adaptability

These findings align with industry trends, indicating a balance between technical proficiency and interpersonal capabilities.

### How can web scraping techniques be effectively implemented to gather accurate and up-to-date job information from diverse company career portals?

Findings:

* Python-based tools like Selenium and BeautifulSoup proved highly effective in handling dynamic and static career pages.
* Challenges like CAPTCHAs, pagination, and dynamic JavaScript elements were overcome using proxy services, automated click handling, and iterative testing.
* A modular and reusable script design ensured scalability and adaptability for future scraping needs.

### What insights can be derived from the scraped job data to support stakeholders?

Findings:

* For students, the insights reveal a clear roadmap of skills and certifications required for entry into data-centric roles.
* For educational institutions, the data highlights gaps in curricula, particularly in practical tool expertise (e.g., SQL, Tableau).
* For companies, the analysis provides competitive benchmarking for job descriptions and benefit offerings.

### How can the scraped data be organized and visualized to maximize usability?

Findings:

* The data was exported to structured Excel files, enabling easy accessibility for stakeholders.
* Visualizations such as bar charts, word clouds, and trend graphs helped summarize key insights:
* Most frequently required skills
* Job postings by company
* Trends in job descriptions and qualifications

# Discussion

## Key Observations:

* The demand for data-centric roles is strong across all analyzed companies, with consistent requirements for technical skills like Python, SQL, and Tableau.
* Companies increasingly emphasize the importance of soft skills such as problem-solving and communication, highlighting the need for holistic skill development.
* Benefits such as paid parental leave, tuition reimbursement, and wellness programs are widely offered, reflecting the competitive nature of employee retention efforts in the Dallas area.

## Implications:

* For Students: Understanding required skills enables them to target specific training programs and certifications, improving employability.
* For Educational Institutions: Tailoring curricula to industry needs ensures students are job-ready and meet market expectations.
* For Companies: Insights into competitor job postings and benefits aid in refining recruitment strategies to attract top talent.

## Limitations of the Research

### Data Coverage:

* The analysis was limited to four companies (AT&T, Equinox, IBM, and Texas Instruments), which may not fully represent the job market in Dallas.
* The focus was restricted to data-centric roles, excluding other in-demand positions such as software engineers or IT support roles.

### Dynamic Website Changes:

* Frequent changes to website structures or layouts could disrupt scraping scripts, requiring constant updates.

### Legal and Ethical Constraints:

* Adherence to web scraping laws and company-specific terms of service limited the scope of data extraction in some cases.

### Real-Time Insights:

* The scraping was conducted over a fixed time frame, and the data may not reflect real-time job market dynamics.

### Subjectivity in Analysis:

* While effort was made to ensure objective data collection, certain qualitative aspects (e.g., interpretation of job descriptions) may introduce subjectivity.

## Future Directions

To overcome the identified limitations and enhance the utility of the project, future efforts could focus on:

* Expanding the dataset to include more companies and industries.
* Implementing real-time or periodic scraping to provide continuously updated insights.
* Enhancing the automation pipeline to minimize manual intervention in handling website changes.

# Conclusion

This study focused on addressing the challenges faced by job seekers, students, educational institutions, and companies in accessing and analyzing data-centric job opportunities in Dallas, Texas. By leveraging Python-based web scraping techniques, this project successfully automated the extraction and analysis of job postings from the career portals of prominent companies such as AT&T, Equinox, IBM, and Texas Instruments.

## Key Findings

* The project identified Data Analyst, Business Analyst, Data Engineer, and Business Intelligence Analyst as the most in-demand roles across the targeted companies.
* Essential technical skills include Python, SQL, Tableau, and data visualization tools, while soft skills like problem-solving, collaboration, and adaptability were also emphasized.
* Detailed insights into company benefits such as tuition reimbursement, paid leave, and employee wellness programs were uncovered, highlighting the competitive nature of the job market in Dallas.
* The project demonstrated the feasibility of using web scraping tools (BeautifulSoup, Selenium, Pandas) to extract, clean, and organize job data efficiently.

## Main Contributions

### For Students:

* Created a centralized and structured database of data-centric job opportunities.
* Provided actionable insights into the skills and qualifications needed to excel in the current job market, helping students plan their learning paths effectively.

### For Educational Institutions:

* Highlighted gaps between industry demands and current curricula, enabling institutions to align their programs with market needs.
* Offered insights to guide career counseling and student placement efforts.

### For Companies:

* Served as a benchmarking tool for comparing job descriptions, benefits, and skill requirements against competitors.
* Enabled HR teams to understand job trends and refine their recruitment strategies.

### For the Broader Community:

* Showcased the practical application of web scraping in solving real-world problems.
* Provided a scalable, open-source framework that can be extended to other regions or industries.

## Summary

This project successfully automated the extraction and analysis of job postings, offering a comprehensive view of the data-centric job landscape in Dallas, Texas. The findings and insights generated are valuable for multiple stakeholders, bridging the gap between job seekers, educational institutions, and recruiters. Despite some limitations, the project provides a robust foundation for future efforts to enhance job search efficiency and improve alignment between market demands and skill development.

In conclusion, this study demonstrates the potential of leveraging web scraping and data analysis to create impactful tools that empower individuals and organizations to make informed decisions in a rapidly evolving job market.

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