Assignment 1: Ontology Design

Task - 1: A plain text description of the domain of interest and a list of concrete pieces of knowledge you would like to capture in the domain.

The domain of interest is **Financial Modeling**. The goal is to develop a basic ontology model which aids

- **Equity research** by capturing limited details of current and historical information related to given equity instrument in order to assess a security/stock's financial health and also query and filter securities which satisfies certain financial ratio requirements.
- **Portfolio Management** - grouping securities which satisifies certain finacial ratios and market conditions

Developing ontological model will help in framing questions related to equity research in a systematic and concise manner. For example some sample questions are listed below

- Which Stocks are in GrowthStage has high return in last quarter?
- Which Banking stock gave most return in year YYYY?
- Current year Stock price > Last year stock price?
- List stocks that are eligible to be in X portfolio?

Knowledge to be captured:

- **Financial Instrument**
  - Equity - Stock of a **Company** listed in some Market
  - Etf - Collection of stock
  - MutualFund - Collection of one or more Equity or Etf
  - FundofFund - Collection of one or more Mutual Fund
- **Equity**

  An Equity has following properties/relation :

- Name (eg. APPL, SBI)
- Company (eg. Apple Inc, State Bank of India) - equity belongs to a company
- Equity metrics
- Risk metrics
- Balance sheet metrics
- Peers : Companies which are operating in same sectors or industry

- **Equity Metric**
  - Price : price of a stock
  - Return : return over specified period
  - Dividend
- **Risk Metric**
  - beta
  - volatility
  - sharpe ratio
- **Balance Sheet Metric**
  - **Balance Sheet Ratios**
    - Current : Measures solvency
    - Quick : Measures liquidity
    - Debt-to-Worth : Measures financial risk
  - **Efficiency Ratios**
    - Sales-To-Assets : Measures the efficiency of Total Assets in generating sales
    - Return On Assets : Measures the efficiency of Total Assets in generating Net Profit
    - Return On Investment : Measures the efficiency of Net Worth in generating Net Profit
- **Market structure**
  - Category (eg. SmallCap, MidCap, LargeCap, etc)
  - MarketIndex : Index/Equity to which the stock is benchmarked against
  - Sector : market classification of stock (Banking , IT , Manafacturing)
  - Stage : Lifecycle stage at which company is in (DevelopmentStage, GrowthStage, SustainabilityStage, ExpansionStage)
- **Time aspects**
  - Year (FY2022, FY2023 etc)
  - Quarter (Q2023-1, Q2023-2, Q2023-3, ...)

- **Portfolio** - collection of equity
  - Growth
  - Value
  - Balanced

Task - 2 : the DL ontology (TBox)

Now we will model the key concepts and relationships in order to capture above domain knowledge

Classes and Subclasses (Concept Inclusions -Subsumption Axiom)

- Company
  - HoldingCompany
- Name
  - CompanyName
  - StockName
- Category
- BusinessStage
- Sector
- MarketIndex (Nifty, BankNifty)
- Instrument
  - Stock
  - Etf
  - MutualFund
  - FundofFund
- TemporalEntity (referred from FIBO)
  - TimeInterval
    - CalendarPeriod
      - CalendarYear
      - CalendarQuarter
- Metric

- EquityMetric
  - Return
  - Dividend
  - MarketCapitalization
- RiskMetric
  - Beta
  - Volatility (Volatility ⊑ RiskMetric)
  - Sharpe ratio
- MonetaryAmount
  - BalanceStatement
    - Profit
    - Price
    - Income
    - Asset
    - Liability

Some of the Relationships

- Transitive Roles
  - owns : (Company→Company) A company can own other company
  - has: (Instrument → Instrument) A instrument can be part of other instrument
  - hasPeer: (Company→ Company)
- isInStage: (Company→ BusinessStage)
- belongsTo: (Company→ Sector),
- benchmarkedBy: (Instrument→MarketIndex)
- isIn: (Stock→Portfolio)
- holds: (Portfolio→Stock)
- hasPrice : (Stock→ Price)
- hasReturn : (Stock→ Return)
- hasDividend : (Stock→ Dividend)
- hasMarketCapitalization : (Stock → MarketCapitalization)
- observedIn : (Metric→ TimePeriod)
- hasProfit : (Profit → Company)

- hasDividend : (Profit → Company)
- observedIn : (MonetaryAmount→ TimePeriod)
- hasValue : (Metric→ NumericValue)

Axioms

- Company, Stock has always a unique name

> $\text{Company} \sqsubseteq (=1\ \text{hasName.Name})$
> $\text{Stock} \sqsubseteq (=1\ \text{hasName.Name})$

- CompanyName and StockName are disjoint

> $\text{CompanyName} \sqcap \text{StockName} \sqsubseteq \bot$

- Company is part of a sector

> $\text{Company} \sqsubseteq \exists \text{belongsTo.Sector}$

> $\text{Sector} \sqsubseteq \forall \text{has.Company}$

- Company must be in some growth stage

> $\text{Company} \sqsubseteq \exists \text{isInStage.BusinessStage}$

- Heirarchial role of Instruments
  - $\text{Etf} \sqsubseteq \exists \text{has.Stock}$
  - $\text{MutualFund} \sqsubseteq \exists \text{has.Stock} \sqcup \exists \text{has.ETF}$
  - $\text{FundofFund} \sqsubseteq \exists \text{has.ETF} \sqcup \exists \text{has.MutualFund}$
- Portfolio holds at least one stock:

> $\text{Portfolio} \sqsubseteq \exists \text{holds.Stock}$

- A stock must have a price, return, and volatility:

> $\text{Stock} \sqsubseteq \exists \text{hasPrice.Price} \sqcap \exists \text{hasReturn.Return} \sqcap \exists \text{hasVolatility.Volatility}$

- Price, return, and volatility are observed in specific time periods:

> $\text{Price} \sqsubseteq \exists \text{observedIn.TimeInterval}$

> $\text{Return} \sqsubseteq \exists \text{observedIn.TimeInterval}$

> $\text{Volatility} \sqsubseteq \exists \text{observedIn.TimeInterval}$

- Midcap : companies with a moderate market capitalisation ranging from Rs. 5,000 crores to Rs.

20,000 crores

> $Midcap \sqsubseteq Stock \sqcap (hasMarketCapitalization \geq 5000) \sqcap (hasMarketCapitalization \leq 20000)$

- Smallcap : company whose market capitalization is less than Rs 5,000 crores are known as small-cap companie

> $Smallcap \sqsubseteq Stock \sqcap (hasMarketCapitalization < 5000)$

- Largecap : company with market caps of ₹20,000 crore or more

> $Largecap \sqsubseteq Stock \sqcap (hasMarketCapitalization > 20000)$

- Balanced portfolios cannot hold more than 30% of equities from the same sector:

> $BalancedPortfolio \sqsubseteq \exists holds.(Stock \sqcap (hasVolatility \geq 0.3)) \sqcap (\geq 3\ holds.Stock)$

- LowVolatile portfolios holds more than 3 equities each having volatility lesser than 0.3:

> $LowVolatile \sqsubseteq \exists holds.(Equity \sqcap (hasVolatility < 0.3)) \sqcap (\geq 3\ holds.Stock)$

Task - 3 : a write-up about the design choices made and the details of the design - the explanations for classes, properties, DL axioms, motivating situations/examples - of terms in the ontology.

Classes

- Company - A registered business according to laws.
- CompanyName - Represents the name of the company
- StockName - Represents the name of the stock of the company
- Category - Classification of financial instruments based on characteristics like market capitalization (e.g., SmallCap, MidCap, LargeCap).
- BusinessStage - Represents the lifecycle stage of a company, such as DevelopmentStage, GrowthStage, SustainabilityStage, ExpansionStage.
- Sector - Represents the industry sector to which a company belongs, such as Technology, Finance, or Healthcare.
- MarketIndex - A statistical measure representing the performance of a segment of the stock market. Eg. NIFTY, BankNifty
- Instrument

- Stock - Represents an equity that signifies ownership in a company.
- ETF - An exchange-traded fund that holds a collection of stocks or other assets and is traded on an exchange.
- MutualFund - A fund that pools money from multiple investors to invest in a diversified portfolio of stocks, bonds or other assets.
- FundofFund - An investment fund that holds shares in other investment funds.

- TemporalEntity
  - TimeInterval - Represents a period of time during which a metric or event is measured.
  - CalenderPeriod -
    - CalenderYear - Represents a full year.
    - CalenderQuarter - Represents a quarter of a year.
- Metric
  - EquityMetric - Measures specific attributes of equity investments.
    - Return - The profit or loss from an instrument.
    - Dividend - The portion of a company's earnings distributed to shareholders (who owns stocks).
    - MarketCapitalization - The total market value of a company's stocks.
  - RiskMetric - Measures the risk associated with investments.
    - Beta - A measure of an investment's volatility relative to the market.
    - Volatility - The degree of variation of a trading stock price over time.
    - Sharpe ratio - A measure of risk-adjusted return, comparing the return of an investment to its risk.
- MonetaryAmount
  - BalanceStatement - Represents financial metrics
    - Profit - The net income of a company after expenses.
    - Price - The current trading value of instrument.
    - Income - Earnings generated by a company from its operations and sales.
    - Asset - Resources owned by a company that have economic value.
    - Liability - Financial obligations or debts owed by a company.

Properties

- owns - (Company→Company) A company can own other company.
- has - (Instrument → Instrument) A instrument can be part of other instrument.

- hasPeer - (Company→ Company) A company which is in similar sector (IT, Banking etc.) as another company.
- isInStage - (Company→ BusinessStage) Links a company to the specific stage of its business lifecycle (e.g., growth stage, maturity stage).
- belongsTo - (Company→ Sector) Indicates the sector or industry to which a company belongs (e.g., technology, finance).
- benchmarkedBy - (Instrument→MarketIndex) Relates an instrument to the market index against which it is benchmarked.
- isIn: (Stock→Portfolio) Describes the inclusion of a stock within a specific investment portfolio.
- holds - (Portfolio→Stock) Represents the relationship where a portfolio holds a stock.
- hasPrice - (Stock→ Price) The price of the stock.
- hasReturn - (Stock→ Return) The return (profit/loss) on a stock.
- hasDividend : (Stock→ Dividend) The dividend distributed by the company per stock to its shareholders.
- hasMarketCapitalization - (Stock → MarketCapitalization) Relates a stock to its total market capitalization.
- observedIn - (Metric→ TimePeriod) Links metrics to the time period during which they are observed.
  (MonetaryAmount→ TimePeriod) Links monetary amount to the time period during which they are observed.
- hasProfit - (Profit → Company) Indicates the profit generated by the company.
- hasValue - (Metric→ NumericValue) Describes the value of a specific metric as a numerical value.

Design choices

- Use of Transitive roles : The company can have ownership chain say Company A can own Company B and Company B owns Company C which was captured by transitive role `owns`. Similar transitive role `has` also captures relation like Etf has Stock and Mutual fund can have both Stock and ETFs.
- Concept Disjointness : The company and stock name should be disjoint to represent different entities. Stock is a financial instrument representing the company's business.
- Inverse Role :
  - (Company $\sqsubseteq \exists$belongsTo.Sector) A company will definitely belong to a sector but (Sector $\sqsubseteq \forall$ has.Company) a sector can have 0 or many companies.