Considering weight

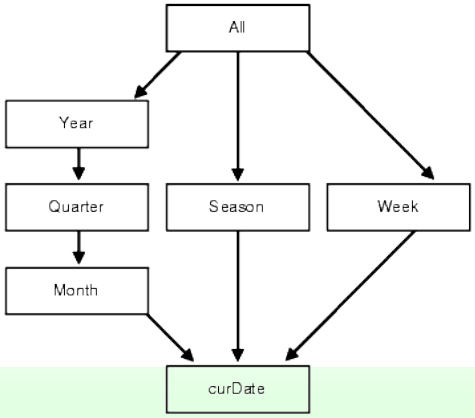
- Items may be characterized by different importance within a transaction
  - Example: product quantity or price in transactions
- Transactions may be weighted
  - Example: discount on entire market basket
- Weighted dataset
  - Each item is assigned a weight measuring its relevance in the corresponding transaction

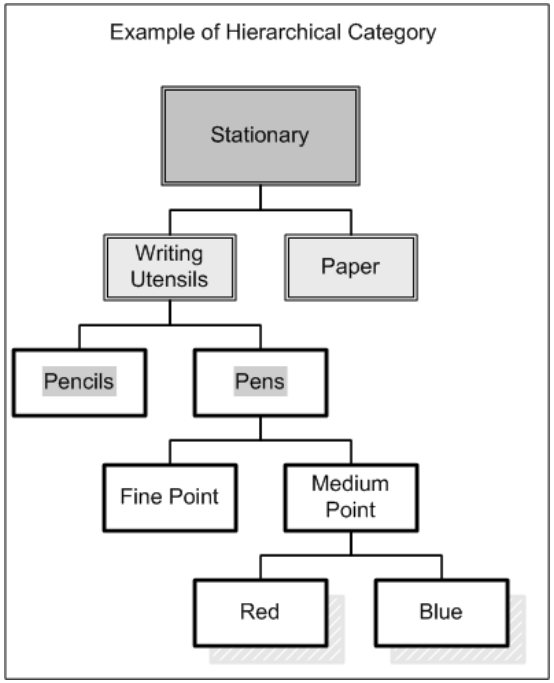
Weighted association rules

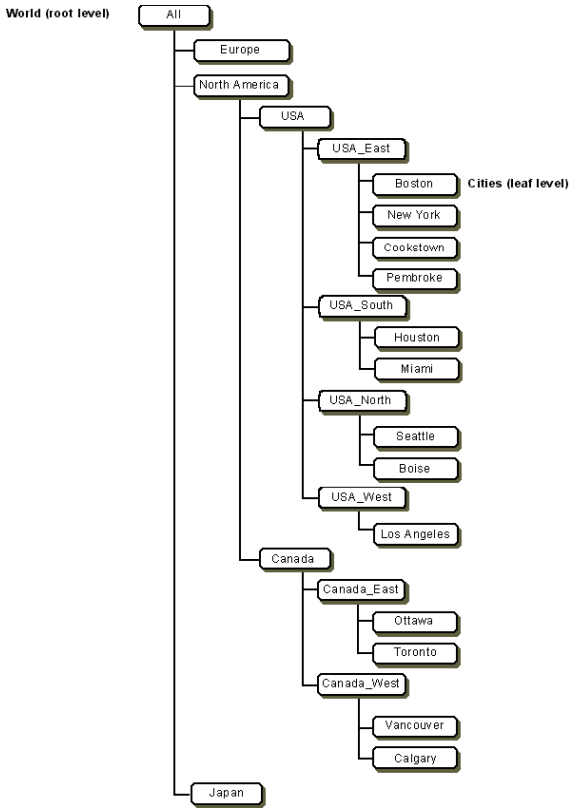
- Consider item/transaction weights during association rule extraction
- Extend rule quality measures
  - E.g., weighted support, weighted confidence
- Apply ad-hoc weight aggregation functions
  - E.g., min, max, avg

Considering hierarchies

- Generalization hierarchies
  - Aggregation over attributes in a dataset
  - Typically user provided
- Examples
  - Time hierarchy
  - Product category
  - Location hierarchy
  - …

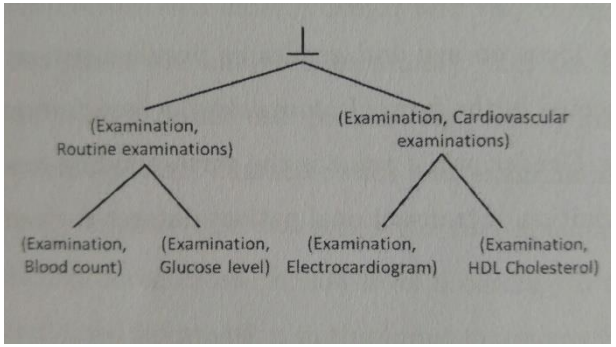






Taxonomy

- A taxonomy is a set of is-a hierarchies that aggregate data items into higher-level concepts
- Data item
  - Instance in the (transactional) dataset
  - Represents detailed concepts
- Generalized item
  - Aggregation in higher-level concepts
  - Represents abstractions on instances



Generalized itemsets

- Sets of items at different generalization levels
  - May contain data items together with generalized items defined in the taxonomy
  - Summarize knowledge represented by a set of lower-level descendants
    - Both frequent and infrequent
- A generalized itemset covers a transaction when all
  - its generalized items are ancestors of items included in the transaction
  - its data items are included in the transaction
- Generalized itemset support
  - ratio between number of covered transactions and dataset cardinality

Context-aware data analysis

- Context data provided by different, possibly heterogeneous, sources
  - Mobile devices provide information on
    - the user context (e.g., GPS coordinates)
    - the supplied services
      - temporal information
      - service description
      - duration
  - Additional information available
    - demographics of the user requesting the service

Generalized itemset example

user: **John,** ***time:*** **6.05 p.m.,** ***service:*** **Weather**
(s = 0.005%)

- A very low support
  - The itemset may be discarded
- By generalizing
  - the time attribute on a time period
  - the user on a user category

user: **employee,** ***time:*** **6 p.m. to 7 p.m.,** ***service:*** **Weather**
(s = 0.2%)

- May discover interesting properties generalizing *infrequent* items

Generalized association rules

- Extension of "classical" association rules

$$X \rightarrow Y$$

- X and Y are either generalized or not generalized itemsets
  - Extract associations among data items at multiple abstraction levels
  - Support, confidence and lift are defined accordingly

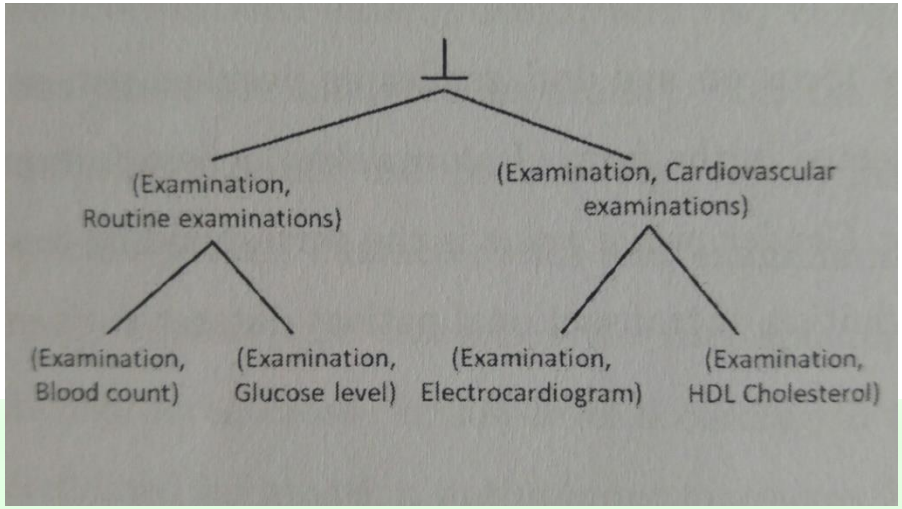
Patient data analysis

- Analysis of multiple level correlations on patient treatment historical data
  - Dataset collected by an Italian Local Health Center
    - Diabetes complications at various severity levels
    - 95K records, 3.5K patients
  - Features
    - Prescribed examinations (26 examinations, 7 categories)
    - Prescribed drugs (200 drugs, 14 categories)
    - Census patient data (gender, age discretized in age groups)
- Sparse dataset
  - Difficult setting of support threshold
    - Low: generates too many rules
    - High: interesting information at lower levels of abstraction may remain hidden

High level rules

- Only generalized itemsets
  - Represent general knowledge
    - May be too high level to perform targeted analyses
- Example

  (Examination, Liver) -> (Examination, Kidney)
  - Frequently prescribed together
  - May be used for examination scheduling



Cross level rules

- Different abstraction levels (generalized items and data items)
  - Combine detailed and general information
- Example

  (Examination, Liver) -> (Examination, Uric acid)
  - Insight into specific kidney examinations correlated with liver examinations
    - Confidence: 74.8%

Low-lewel rules

- Only not generalized itemsets (only data items)
  - Very detailed knowledge
    - Covered by high and cross-level rules
  - Large rule set
    - Challenging exploration task
  - Drill down exploration based on formerly extracted high and cross-level rules