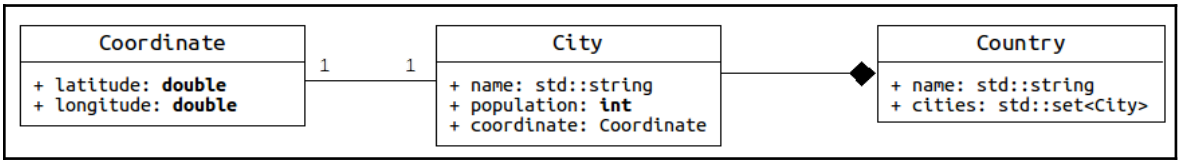
National Research University Higher School of Economics
Faculty of Computer Science
Bachelor's Program in Data Science and Business Analytics (DSBA)

Introduction to Programming
Workshops 18

Part 1. Introduction to Structures in C++



(1) Declare structures `Coordinate`, `City`, and `Country` according to the UML *class diagram* shown above.

(2) Develop a function to fill a *container* of `Country` structures (passed by reference) with the file `cities.csv`.

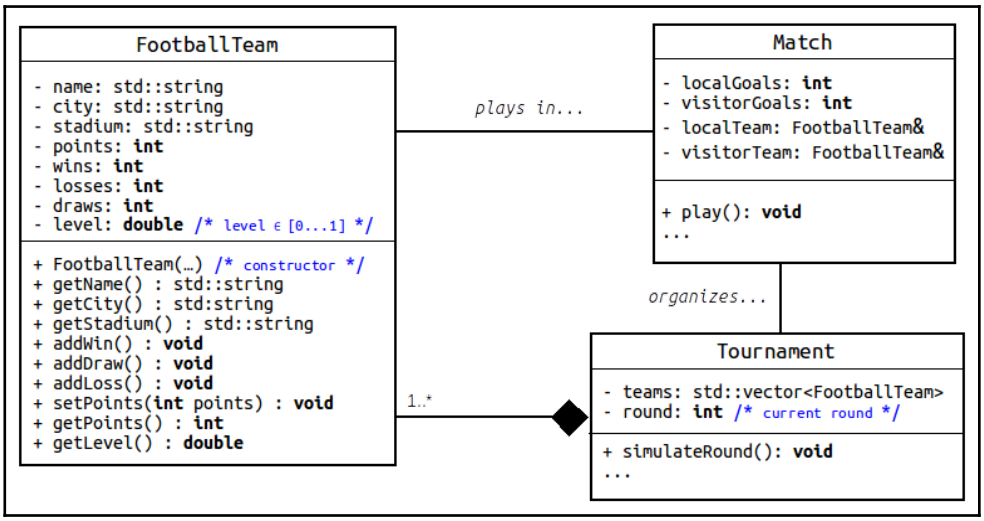
(3) Overload the operator **<<** so that to print a `City` structure as follows:

```
(city = Shanghai, population = 22120000, coordinates = (31.16 , 121.46) )
```

Note: Consider the variant to overload the operator **<<** for `std::set<City>` and/or for `Country`.

(4) Modify the ordering of cities inside the attribute `std::set<City> cities` of a `Country` structure, so that cities are internally ordered by their population ("*bigger cities go first*").

Part 2. Methods in Structures



(1) Implement a structure `FootballTeam` as designed in the UML class diagram shown above.

- Implement a constructor for `FootballTeam` that takes `name`, `city`, `stadium`, and `level` as arguments, whereas attributes `points`, `wins`, `draws` and `losses` are set to zero (0).

Note: Consider constructor variants which make use of default parameters and the constructor delegation feature.

(2) Implement the structure `Tournament` whose attribute `std::vector<FootballTeam> teams` is filled with the data from the file `football.csv`. The attribute `round` is initially set to zero (0) meaning the beginning of the tournament season.

(3) Implement the structure `Match` and its method `play()`.

-The method `play()` *simulates* a match between two football teams, a `localTeam` and a `visitorTeam`, and it updates the attributes of these two structures based on the winner of the match. See the algorithm for this method in the **Appendix 1**, *a*t the end of this file.

- Note: Attributes `localTeam` and `visitorTeam` of the Match structure are reference variables (&). T

(4) Implement the method `simulateRound()` of a Tournament structure.

- This method *simulates* a round of `N/2` matches between the `N` teams of the tournament.
- The `N/2` matches between teams as exemplified below: "*team k plays with team* `N-k+1`"

1	2	3	4	5	6	7
14	13	12	11	10	9	8

Example of a round with N = 14 teams.
Team #1 plays with team #14; team #2 plays with team #13, etc.

- After executing the `N/2` matches of a round, teams inside `std::vector<FootballTeam> teams` are re-ordered as exemplified below: Team #1 in the first position is always fixed, whereas the other teams inside the vector are *rotated clockwise one position*.

1	14	2	3	4	5	6
13	12	11	10	9	8	7

Re-ordering of teams in a vector teams after the round.

This rotation scheme allows that in the next round, different matches are organized, i.e., team #1 will play in the next round with team #13, team #14 will play with team #12, etc.

Additional exercises

(5) Overload the operator **<<** for the structure `Match` so that to print the result of a match between two teams. For example, the `Match` structure may be printed as follows:

```
(localTeam=PFC Sochi, visitorTeam=CSKA Moscow, stadium=Fisht Olympic Stadium, result=0-3)
```

(6) At the end of the program, sort the vector `std::vector<FootballTeam> teams` by the attribute `point`. Then, print the vector to know the results of the tournament, i.e., the position of each team.

Appendix #1: *Simple match simulation algorithm* to implement the `play()` method of a `Match` structure.

Step 1. Calculate the number of goals in the match.

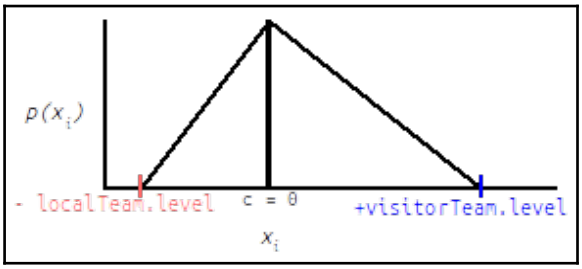
- Generate a random number *k uniformly distributed* in the range depicted below:

```
k ∈ [ 0,  ceil( abs(localTeam.level - visitorTeam.level) ) * 10 ]
```

"The bigger the difference between two teams, then bigger the chance to have more goals in a match"

Step 2. Distribute the number of goals between the teams.

- Generate *k* random numbers ("the goals") {X_1, X_2, ... , X_k} using a *triangular distribution* in the range: `[-localTeam.level, +visitorTeam.level]` with center ("peak of the triangle") `c = 0`.



Example of a triangular probabilistic distribution in the range `[-localTeam.level, +visitorTeam.level]` *with* `peak = 0`.
"The bigger of one of the two sizes of the triangle determines who scores more goals in average"

For each **X**i (1 ≤ i ≤ n):

- if **X**i < 0, then count a goal for the *local team i*n the match, i.e., `this->localGoals++`.
- Otherwise, then count a goal for the *visitor team* in the match, i.e., `this->visitorGoals++`.

Step 3. Decide the winner of the match to update the attributes of the `FootballTeam` structures. We shall assume that a *victory* gives 3 points to the winner, and 0 points to the loser. If both teams have a draw, i.e., then each team is granted with 1 point.

Thus, structures `localTeam` and `visitorTeam` are updated as follows:

Case 1:
`localGoals > visitorGoals`
"local wins, visitor losses"

```
localTeam.addWin();
localTeam.setPoints(3);
visitorTeam.addLoss();
```

Case 2:
`visitorGoals > localGoals`
"visitor wins, local losses"

```
visitorTeam.addWin();
visitorTeam.setPoints(3);
localTeam.addLoss();
```

Case 3:
`visitorGoals == localGoals`
"draw"

```
visitorTeam.addDraw();
visitorTeam.setPoints(1);

localTeam.addDraw();
LocalTeam.setPoints(1);
```