

Univerza v Mariboru
Fakulteta za elektrotehniko, računalništvo in informatiko

Projektna dokumentacija

Dokumentacija pri Prevajanju programskih jezikov

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1 UVOD

Namen dokumenta je predstavitev projekta in značilnosti implementacije, ki je nastajala v okviru projekta v 2. letniku programa RIT UN, predvsem pri predmetu Prevajanje programskih jezikov. V besedilu so povzete zahteve naloge in celotna integracija v projekt, opisane so naše rešitve, ter implementacija, vse omenjeno pa je predstavljeno tudi za čim lažjo uporabo uporabnika.

2 ZAHTEVE IN NAČRTOVANJE

Glavna zahteva celotnega projekta je bila izdelava digitalnega dvojčka mesta Maribor. V naši skupini smo se odločili, da se pri tem osredotočimo na onesnaženost zraka, nevarne delce in njihov grafični prikaz. Celotno delo je bilo razdeljeno na 4 predmete, od katerih smo pri vsakem pokrili del implementacije, ter jih na koncu združili v celoto. Pri ostalih predmetih smo izdelali podatkovno bazo, grafični vmesnik, spletno stran, vzpostavili gostovanje, ter program za pridobivanje podatkov. Pri prevajanju programskih jezikov pa smo izdelali strukturo jezika in njegovo implementacijo v jeziku Kotlin.

Po zahtevah na navodilih, našem modelu aplikacije in dostopnosti orodij smo se nato odločili katera orodja bomo uporabili. Sprva smo naredili primer mesta, ki izpolnjuje vse zahteve za vizualizacijo našega modela mesta, temu je sledil zapisa modela mesta v BNF obliki. Iz BNF modela smo nato implementirali aplikacijo v programskem jeziku Kotlin, ki preveri sintaktično in semantično pravilnost zapisa ter nam v formatu GeoJSON vrne vneseno mesto.

3 PREDSTAVITEV MODELA

Naš model mesta je sestavljen iz cest, stavb ter naprav za merjenje onesnaženosti zraka, naprav za merjenje pretoka prometa in naprav za merjenje vremenskih razmer. Ti objekti pa vsebujejo elemente, ki gradijo točke, ravne črte, ukrivljene črte, kroge in kvadre. Jezik pa podpira tudi spremenljivke v obliki točk za lažje pisanje jezika piscu.

3.1 BNF MODEL

```

<CITY> ::= city <NAME> <LCURL> <CITY_ELEMENT> <CITY_ELEMENTS> <RCURL>
<CITY_ELEMENTS> ::= <CITY_ELEMENT> <CITY_ELEMENTS> | epsilon
<CITY_ELEMENT> ::= <WEATHER_UNIT> | <TRAFFIC_UNIT> | <POLLUTION_UNIT> | <ROAD> | <BUILDING>
WEATHER_UNIT
<WEATHER_UNIT> ::= weather <NAME> <LCURL> <VARIABLES> <UNIT> <RCURL>
TRAFFIC_UNIT
<TRAFFIC_UNIT> ::= traffic <NAME> <LCURL> <VARIABLES> <UNIT> <RCURL>
POLLUTION_UNIT
<POLLUTION_UNIT> ::= pollution <NAME> <LCURL> <VARIABLES> <UNIT> <RCURL>
ROAD
<ROAD> ::= road <NAME> <LCURL> <VARIABLES> <ROAD_ELEMENT> <ROAD_ELEMENTS> <RCURL>
<ROAD_ELEMENTS> ::= <ROAD_ELEMENT> <ROAD_ELEMENTS> | epsilon
<ROAD_ELEMENT> ::= <BEND> | <LINE> | <CIRCLE>

```

```

<BEND> ::= bend <LPAREN> <COORDINATES> <COMMA> <COORDINATES> <COMMA> <ANGLE> <RPAREN>
<LINE> ::= line <LPAREN> <COORDINATES> <COMMA> <COORDINATES> <RPAREN>
<CIRCLE> ::= circ <LPAREN> <COORDINATES> <COMMA> <NUMBER> <RPAREN>
    # radius must be >0
    # coordinates for center of circle, number for radius
    BUILDING
<BUILDING> ::= building <NAME> <LCURL> <VARIABLES> <BOX> <RCURL>
<BOX> ::= box <LPAREN> <COORDINATES> <COMMA> <COORDINATES> <RPAREN>
    ## coordinate 1: top left, coordinate 2: bottom right
    UNIT
<UNIT> ::= <POINT> | <POINT> <BOX>
    POINT
<POINT> ::= point <COORDINATES>
    COORDINATES
<COORDINATES> ::= <LPAREN> <NUMBER> <COMMA> <NUMBER> <RPAREN> | <VAR_NAME>
    ## must match VAR_NAME that has been previously found inside same block
    NUMBER
<NUMBER> ::= [-]?[0-9]+([.][0-9]+)?
    NAME
<NAME> ::= "[a-zA-Z\s]+"
    <ANGLE>
<ANGLE> ::= <NUMBER>
    ## number must be between -45 and 45
    ## if 45
    ## if positive, curvature top of circle
    ## if negative, curvature bottom of circle
    VARIABLES
<VARIABLES> ::= <VAR> <VARIABLES> | epsilon
<VAR> ::= let <VAR_NAME> <ASSIGN> <LPAREN> <NUMBER> <COMMA> <NUMBER> <RPAREN>
<VAR_NAME> ::= [a-zA-Z]+[0-9]*
    ## found variables added to stack, once RCURL reached delete saved variables
    ## so each variable exists only inside a block element
<LPAREN> ::= "("
<RPAREN> ::= ")"
<LCURL> ::= "{"
<RCURL> ::= "}"
<COMMA> ::= ","
<ASSIGN> ::= "="

```

3.2 OSNOVNI GRADNIKI

3.2.1 Točka

point(x,y)

Točka vsebuje dve koordinati, "x" za geografsko širino in "y" za geografsko višino.

3.2.2 Ravna črta

line((x1, y1), (x2, y2))

Ravna črta vsebuje podatke o dveh točkah kateri poveže z ravno črto.

3.2.3 Ukrivljena črta

bend((x1, y1), (x2, y2), angle)

Ukrivljena črta vsebuje podatke o dveh točkah ter "angle" oziroma kot, ki da informacijo o ukrivljenosti črte, ki povezuje te točki. Kot je lahko med 45 stopinj in -45 stopinj. V primeru, da je kot 45 stopinj bo črta imela ukrivljenost enako kot četrtnina krožnega loka, ko se pa kot približuje 0 stopinjam pa bo črta vedno bolj ravna in ko doseže negativne stopinje se zamenja stran ukrivljenosti.

3.2.4 Krog

```
circ((x, y), r)
```

Krog vsebuje podatke o točki, ki predstavlja središče kroga in “r” ki predstavlja polmer kroga, ki mora biti večji od 0.

3.2.5 Pravokotnik

```
box((x1, y1), (x2, y2))
```

Kvader vsebuje podatke o zgornji desni točki kvadra in spodnji levi točki.

3.3 Mestni elementi

3.3.1 Stavba

```
building “name” {  
    box((x1, y1), (x2, y2))  
}
```

Element stavba ima podatek o imenu stavbe in vsebuje lahko le en element tipa box.

3.3.2 Naprave za merjenje

```
weather “name” {  
    point(x, y)  
    box((x1, y1), (x2, y2))  
}  
pollution “name” {  
    point(x, y)  
    box((x1, y1), (x2, y2))  
}  
traffic “name” {  
    point(x, y)  
    box((x1, y1), (x2, y2))  
}
```

Naprave za merjenje vsebujejo ime, element točko ter opcijski element kvader, ki predstavljajo zgradbo v primeru večje merilne naprave. Naprave se razlikujejo le v rezervirani besedi (weather, traffic, pollution).

3.3.3 Cesta

```
road “name” {  
    circ((x, y), r)  
    bend((x1, y1), (x2, y2), angle)  
    line((x1, y1), (x2, y2))  
}
```

Cesta vsebuje podatke o imenu, ravni črti, ukrivljeni črti in krogu. Zahtevano je, da vsebuje vsaj enega od elementov za izris, lahko jih pa ima neomejeno.

3.4 Posebni element – spremenljivka

```
let t = (x, y)
road "name" {
  let t = (x1, y1)
  line((x2, y2), t)
  line(t, (x3, y3))
}
```

Spremenljivka vsebuje podatke o točki in imenu spremenljivke. Spremenljivke se lahko pojavijo v vseh mestnih elementih, morajo pa biti na začetku notranjosti elementa. Na mesto, da je potrebno vpisovati enake koordinate ponovno lahko le definiramo točko kot spremenljivko in na potrebnih mestih vpišemo njeno ime. Spremenljivke obstajajo le znotraj posameznega mestnega elementa.

3.5 Element mesto

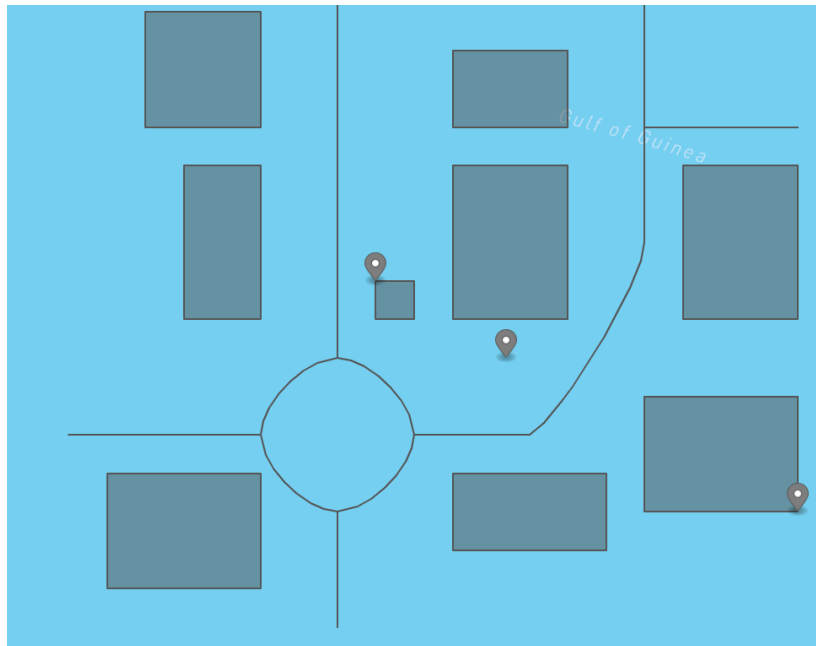
```
city "name" {
  road "name" {...}
  building "name" {...}
  weather "name" {...}
  pollution "name" {...}
  traffic "name" {...}
}
```

Element mesto vsebuje podatek o imenu mesta ter pa mestne elemente. Vsebovati mora vsaj en mestni element, ima pa jih lahko neomejeno.

3.6 Primer mesta

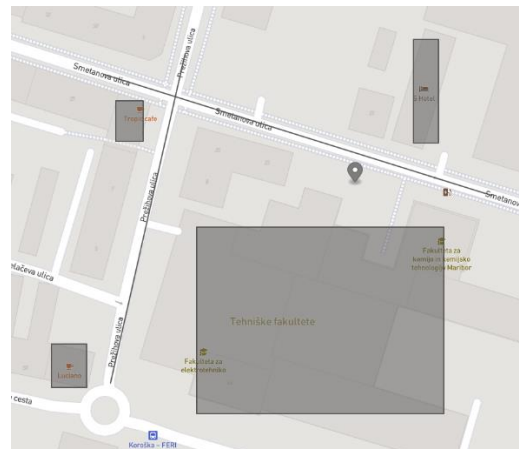
Na spodnji sliki je primer opisa mesta, ki vsebuje vse možne elemente in njegova vizualizacije po pretvorbi v GeoJSON.

```
city "Test A" {
  road "cesta A" {
    let p = (1.5, -1)
    let q = (3, 1.5)
    line((-4.5, -1), (-2, -1))
    circ((-1, -1), 1)
    line((0, -1), p)
    bend(p, q, -35)
    line(q, (3, 5))
  }
  road "cesta B" {
    line((-1, 5.5), (-1, 0))
    line((-1, -2), (-1, -3.5))
  }
  road "cesta C" {
    line((3, 3), (5, 3))
  }
  building "A" {
    box((-3.5, 4.5), (-2, 3))
  }
  building "B" {
    box((-3, 2.5), (-2, 0.5))
  }
  building "C" {
    box((-4, -1.5), (-2, -3))
  }
  building "D" {
    box((0.5, 4), (2, 3))
  }
  building "E" {
    box((0.5, 2.5), (2, 0.5))
  }
  building "F" {
    box((0.5, -1.5), (2.5, -2.5))
  }
  building "G" {
    box((3.5, 2.5), (5, 0.5))
  }
  weather "A" {
    let t = (5, -2)
    point t
    box((3, -0.5), t)
  }
  pollution "A" {
    point(-0.5, 3)
  }
}
```



Na spodnjih slikah pa je še realen primer, ki opisuje bližnjo okolico FERI-ja in kateremu je dodan namišljena naprava za merjenje pretoka prometa.

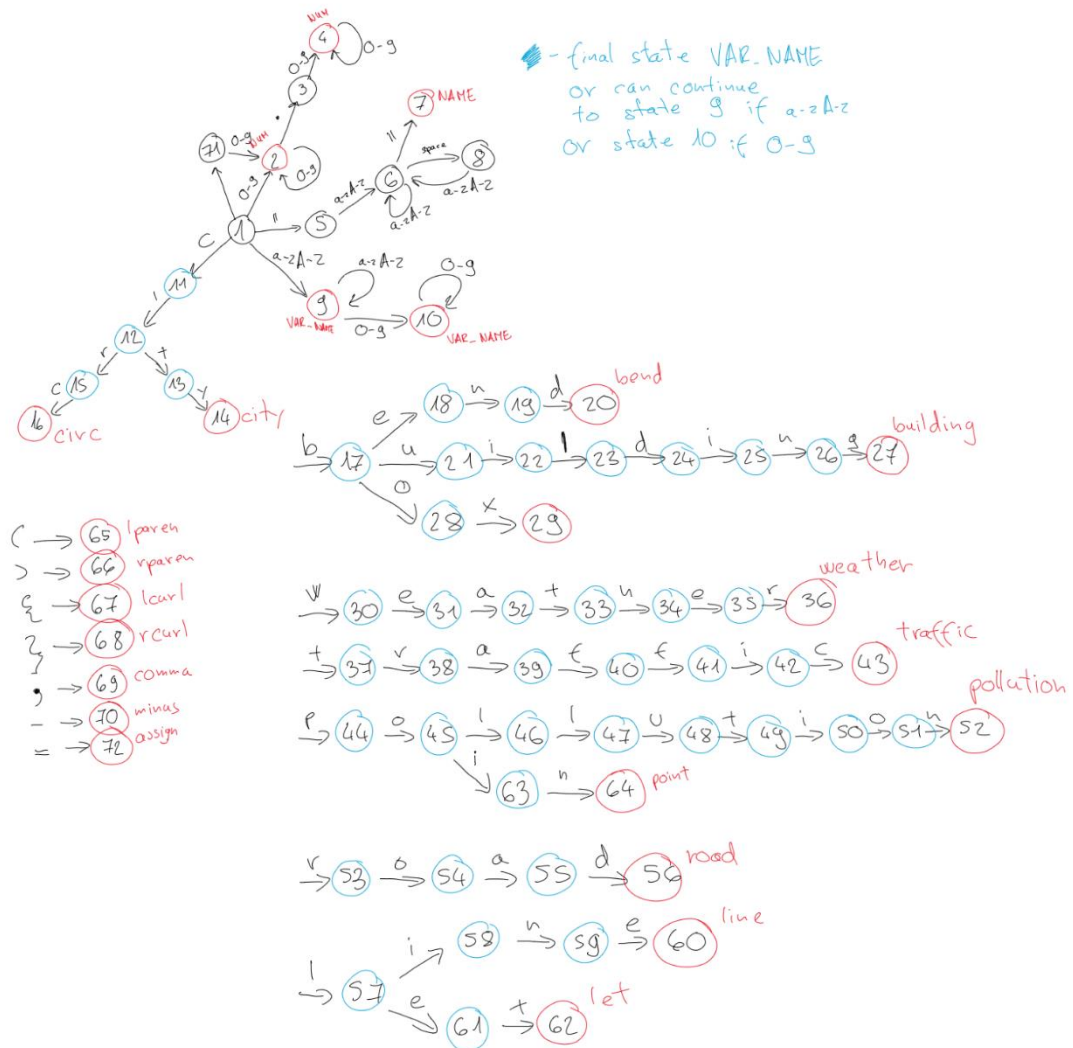
```
city "okolica ferija" {
  building "FERI" {
    box((15.638185143470762, 46.55945970092756), (15.639298260211943, 46.55888243484636))
  }
  building "Luciano" {
    box((15.637529343366621, 46.559099148884406), (15.637688934003009, 46.55896358444285))
  }
  road "Smetanova ulica" {
    line((15.637769401073456, 46.55993183730999), (15.639515519142153, 46.55955744825024))
  }
  road "Prezihova ulica" {
    line((15.638131499290466, 46.55999269834162), (15.637796223163603, 46.558976494594724))
  }
  traffic "stevec prometa FERI" {
    point((15.638898611068726, 46.55959802255885))
  }
  building "S hotel" {
    box((15.639161467552183, 46.56004064940935), (15.63927412033081, 46.5597197453027))
  }
  building "tropic cafe" {
    box((15.637820363044739, 46.55985068916164), (15.637943744659422, 46.55972527814819))
  }
}
```



4 Implementacija

Jezik implementiran v jeziku Kotlin je sestavljen iz dveh delov. Avtomata, ki nam vrne žetone s pomočjo katerih lahko preverimo pravilnost zapisa elementov in navzdol razpoznavalnika, ki preveri sintaktično pravilnost jezika ter gradi objektni model, ki se nato pretvori v GeoJSON in le tega vrne v terminalu, če je sintaktično pravilen.

Sprva smo za Avtomat naredili graf avtomata za lažjo predstavo.



Pred implementacijo v navzdol razpoznavalnika pa smo le tega načrtovali v psevdokodi.

```

procedure main
  nextToken
  call CITY
  if token <> eof then error

procedure CITY
  if token = "city" then nextToken
  if token = "name"
    var GeoCity(token.val)
    nextToken
    if token = "{" then nextToken
      call CITY_ELEMENT(GeoCity)
      call CITY_ELEMENTS(GeoCity)
      if token = "}" then nextToken
    else error
  else error
else error

procedure CITY_ELEMENTS(GeoCity)
  if token = "road" | "building" | "weather" | "traffic" | "pollution"
    call CITY_ELEMENT(GeoCity)
    call CITY_ELEMENTS(GeoCity)

```

Spodaj primer izpisa v primeru pravilne sintakse.

```

{"type":"FeatureCollection","features":[{"type":"Feature","geometry":{"type":"MultiLineString","coordinates":[[[-4.5,-1.0],[-2.0,-1.0],[0.0,-1.0],[-0.00758603075653331,-0.9150940519480357],[-0.029446721265125084,-0.826959243778868],[-0.0642354901218218,-0.736741920487317],[-0.1104099987089431,-0.6463887135138568],[-0.16721180095412702,-0.556458241304764],[-0.2327864940365487,-0.4698976105482293],[-0.30574365945162674,-0.3849748806312894],[-0.3769748806312894,-0.30574365945162674],[-0.4498976105482293,-0.2327864940365487],[-0.520446721265125084,-0.16721180095412702],[-0.594458241304764,-0.092446721265125084],[-0.6698976105482293,-0.029446721265125084],[-0.736741920487317,-0.0642354901218218],[-0.80574365945162674,-0.1104099987089431],[-0.8769748806312894,-0.16721180095412702],[-0.9498976105482293,-0.2327864940365487],[-1.02446721265125084,-0.30574365945162674],[-1.099458241304764,-0.3849748806312894],[-1.1769748806312894,-0.4698976105482293],[-1.256959243778868,-0.556458241304764],[-1.338959243778868,-0.6463887135138568],[-1.422959243778868,-0.736741920487317],[-1.508959243778868,-0.826959243778868],[-1.596959243778868,-0.9150940519480357],[-1.686959243778868,-1.0040940519480357],[-1.778959243778868,-1.0920940519480357],[-1.872959243778868,-1.1790940519480357],[-1.968959243778868,-1.2650940519480357],[-2.066959243778868,-1.3510940519480357],[-2.166959243778868,-1.4370940519480357],[-2.268959243778868,-1.5230940519480357],[-2.372959243778868,-1.6090940519480357],[-2.478959243778868,-1.6950940519480357],[-2.586959243778868,-1.7810940519480357],[-2.696959243778868,-1.8670940519480357],[-2.807959243778868,-1.9530940519480357],[-2.920959243778868,-2.0390940519480357],[-3.035959243778868,-2.1250940519480357],[-3.152959243778868,-2.2110940519480357],[-3.271959243778868,-2.2970940519480357],[-3.392959243778868,-2.3830940519480357],[-3.515959243778868,-2.4690940519480357],[-3.640959243778868,-2.5550940519480357],[-3.767959243778868,-2.6410940519480357],[-3.896959243778868,-2.7270940519480357],[-4.027959243778868,-2.8130940519480357],[-4.160959243778868,-2.9000940519480357],[-4.295959243778868,-2.9870940519480357],[-4.432959243778868,-3.0740940519480357],[-4.571959243778868,-3.1610940519480357],[-4.712959243778868,-3.2480940519480357],[-4.855959243778868,-3.3350940519480357],[-4.999959243778868,-3.4220940519480357],[-5.145959243778868,-3.5090940519480357],[-5.293959243778868,-3.5960940519480357],[-5.443959243778868,-3.6830940519480357],[-5.595959243778868,-3.7700940519480357],[-5.749959243778868,-3.8570940519480357],[-5.905959243778868,-3.9440940519480357],[-6.063959243778868,-4.0310940519480357],[-6.223959243778868,-4.1180940519480357],[-6.385959243778868,-4.2050940519480357],[-6.549959243778868,-4.2920940519480357],[-6.715959243778868,-4.3790940519480357],[-6.883959243778868,-4.4660940519480357],[-7.053959243778868,-4.5530940519480357],[-7.225959243778868,-4.6400940519480357],[-7.399959243778868,-4.7270940519480357],[-7.575959243778868,-4.8140940519480357],[-7.753959243778868,-4.9010940519480357],[-7.933959243778868,-4.9880940519480357],[-8.115959243778868,-5.0750940519480357],[-8.299959243778868,-5.1620940519480357],[-8.485959243778868,-5.2490940519480357],[-8.673959243778868,-5.3360940519480357],[-8.863959243778868,-5.4230940519480357],[-9.055959243778868,-5.5100940519480357],[-9.249959243778868,-5.5970940519480357],[-9.445959243778868,-5.6840940519480357],[-9.643959243778868,-5.7710940519480357],[-9.843959243778868,-5.8580940519480357],[-10.045959243778868,-5.9450940519480357],[-10.249959243778868,-6.0320940519480357],[-10.455959243778868,-6.1190940519480357],[-10.663959243778868,-6.2060940519480357],[-10.873959243778868,-6.2930940519480357],[-11.085959243778868,-6.3800940519480357],[-11.299959243778868,-6.4670940519480357],[-11.515959243778868,-6.5540940519480357],[-11.733959243778868,-6.6410940519480357],[-11.953959243778868,-6.7280940519480357],[-12.175959243778868,-6.8150940519480357],[-12.400959243778868,-6.9020940519480357],[-12.627959243778868,-6.9890940519480357],[-12.856959243778868,-7.0760940519480357],[-13.087959243778868,-7.1630940519480357],[-13.320959243778868,-7.2500940519480357],[-13.555959243778868,-7.3370940519480357],[-13.792959243778868,-7.4240940519480357],[-14.032959243778868,-7.5110940519480357],[-14.275959243778868,-7.5980940519480357],[-14.520959243778868,-7.6850940519480357],[-14.767959243778868,-7.7720940519480357],[-15.017959243778868,-7.8590940519480357],[-15.270959243778868,-7.9460940519480357],[-15.526959243778868,-8.0330940519480357],[-15.785959243778868,-8.1200940519480357],[-16.046959243778868,-8.2070940519480357],[-16.310959243778868,-8.2940940519480357],[-16.577959243778868,-8.3810940519480357],[-16.847959243778868,-8.4680940519480357],[-17.120959243778868,-8.5550940519480357],[-17.396959243778868,-8.6420940519480357],[-17.675959243778868,-8.7290940519480357],[-17.957959243778868,-8.8160940519480357],[-18.242959243778868,-8.9030940519480357],[-18.530959243778868,-8.990094051948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