



TP de Especificación

Sudoku

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Algoritmos y Estructuras de Datos I

Grupo 17

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1. Problemas

```

proc sudoku_esTableroValido (in t: seq⟨seq⟨Z⟩⟩, out result: Bool) {
  Pre {True}
  Post {result = esTableroValido(t)}
}

proc sudoku_esCeldaVacía (in t: seq⟨seq⟨Z⟩⟩, in f: Z, in c: Z, out result: Bool) {
  Pre {esTableroValido(t) ∧ 0 ≤ f, c ≤ 8}
  Post {result = (t[f][c] = 0)}
}

proc sudoku_nroDeCeldasVacías (in t: seq⟨seq⟨Z⟩⟩, out result: Z) {
  Pre {esTableroValido(t)}
  Post {result =  $\sum_{i=0}^{|t|-1} (\sum_{j=0}^{|t|-1} \text{if } t[i][j] = 0 \text{ then } 1 \text{ else } 0 \text{ fi})$ }
}

proc sudoku_primeraCeldaVacíaFila (in t: seq⟨seq⟨Z⟩⟩, out result: Z) {
  Pre {esTableroValido(t)}
  Post {esPrimeraFilaConCeldaVacía(t, result) ∨
    (¬(∃i : Z)(0 ≤ i < |t| ∧L filaTieneCeldaVacía(t[i])) ∧ result = -1)}
}

proc sudoku_primeraCeldaVacíaColumna (in t: seq⟨seq⟨Z⟩⟩, out result: Z) {
  Pre {esTableroValido(t)}
  Post {(∃i : Z)(esPrimeraFilaConCeldaVacía(t, i) ∧
    esPrimeraCeldaVacíaEnFila(t[i], result)) ∨
    (¬(∃i : Z)(0 ≤ i < |t| ∧L filaTieneCeldaVacía(t[i])) ∧ result = -1)}
  pred esPrimeraCeldaVacíaEnFila (s: seq⟨Z⟩, k: Z) {0 ≤ k < |t| ∧L s[k] = 0 ∧ (∀i : Z)(0 ≤ i < k →L s[i] ≠ 0)}
}

proc sudoku_valorEnCelda (in t: seq⟨seq⟨Z⟩⟩, in f: Z, in c: Z, out result: Z) {
  Pre {(esTableroValido(t) ∧ 0 ≤ f, c ≤ 8) ∧L t[f][c] ≠ 0}
  Post {result = t[f][c]}
}

proc sudoku_llenarCelda (inout t: seq⟨seq⟨Z⟩⟩, in f: Z, in c: Z, in value: Z) {
  Pre {(esTableroValido(t) ∧ 0 ≤ f, c ≤ 8 ∧ 1 ≤ value ≤ 9 ∧ t = t0) ∧L t[f][c] = 0}
  Post {esTableroValido(t) ∧ t[f][c] = value ∧ (∀i : Z)(∀j : Z)((0 ≤ i, j < |t| ∧ (i ≠ f ∨ j ≠ c)) →L t[i][j] = t0[i][j])}
}

proc sudoku_vaciarCelda (inout t: seq⟨seq⟨Z⟩⟩, in f: Z, in c: Z) {
  Pre {(esTableroValido(t) ∧ 0 ≤ f, c ≤ 8 ∧ t = t0) ∧L t[f][c] ≠ 0}
  Post {esTableroValido(t) ∧ t[f][c] = 0 ∧ (∀i : Z)(∀j : Z)((0 ≤ i, j < |t| ∧ (i ≠ f ∨ j ≠ c)) →L t[i][j] = t0[i][j])}
}

proc sudoku_esTableroParcialmenteResuelto (in t: seq⟨seq⟨Z⟩⟩, out result: Bool) {
  Pre {True}
  Post {result = esTableroParcialmenteResuelto(t)}
}

```

```

proc sudoku_esTableroTotalmenteResuelto (in t: seq⟨seq⟨ℤ⟩⟩, out result: Bool) {
  Pre {esTableroValido(t)}
  Post {result = esTableroTotalmenteResuelto(t)}
}

proc sudoku_esSubTablero (in t0, t1 : seq⟨seq⟨ℤ⟩⟩, out result : Bool){
  Pre {esTableroValido(t0) ∧ esTableroValido(t1)}
  Post {result = esSubTablero(t0, t1)}
}

proc sudoku_tieneSolucion (in t: seq⟨seq⟨ℤ⟩⟩, out tieneSolucion: Bool) {
  Pre {esTableroValido(t)}
  Post {tieneSolucion = (∃s : seq⟨seq⟨ℤ⟩⟩)(esTableroTotalmenteResuelto(s) ∧ esSubTablero(t, s))}
}

proc sudoku_resolver (inout t: seq⟨seq⟨ℤ⟩⟩, out tieneSolucion: Bool) {
  Pre {esTableroValido(t) ∧ t = t0}
  Post {(∃s : seq⟨seq⟨ℤ⟩⟩)(esTableroTotalmenteResuelto(s) ∧ esSubTablero(t, s)
    ∧ (tieneSolucion = True) ∧ (t = s)) ∨ (¬(∃s : seq⟨seq⟨ℤ⟩⟩)(esTableroTotalmenteResuelto(s) ∧
    esSubTablero(t, s)) ∧ (tieneSolucion = False) ∧ (t = t0))}
}

proc sudoku_copiarTablero (in src: seq⟨seq⟨ℤ⟩⟩, out target: seq⟨seq⟨ℤ⟩⟩) {
  Pre {esTableroValido(src)}
  Post {esTableroValido(target) ∧ (∀i : ℤ)(∀j : ℤ)(0 ≤ i, j < |src| →L target[i][j] = src[i][j])}
}

```

2. Predicados y Auxiliares generales

```

pred esMatriz (t: seq⟨seq⟨ℤ⟩⟩) {
  (∀i : ℤ)(∀j : ℤ)(0 ≤ i, j < |t| →L |t[i]| = |t[j]|)
}

pred esMatrizCuadrada (t: seq⟨seq⟨ℤ⟩⟩) {
  esMatriz(t) ∧ (cantidadFilas(t) = cantidadColumnas(t))
}

pred esTableroValido (t: seq⟨seq⟨ℤ⟩⟩) {esMatrizCuadrada(t) ∧L |t| = 9 ∧
  (∀i : ℤ)(∀j : ℤ)(0 ≤ i, j < |t| →L 0 ≤ t[i][j] ≤ 9)}

pred filaTieneCeldaVacía (f: seq⟨ℤ⟩) {
  (∃i : ℤ)(0 ≤ i < |f| ∧L f[i] = 0)
}

pred esPrimeraFilaConCeldaVacía (t: seq⟨seq⟨ℤ⟩⟩, i: ℤ) {0 ≤ i < |t| ∧L filaTieneCeldaVacía(t[i]) ∧
  (∀j : ℤ)(0 ≤ j < i →L ¬filaTieneCeldaVacía(t[j]))}

pred noHayRepetidosEnRegion (t: seq⟨seq⟨ℤ⟩⟩) {(∀i : ℤ)(∀j : ℤ)(∀k : ℤ)(∀l : ℤ)
  ((0 ≤ i, j, k, l < |t| ∧ (i div 3 = k div 3) ∧ (j div 3 = l div 3) ∧ (i ≠ k ∨ j ≠ l)) →L (t[i][j] = 0 ∨ t[k][l] = 0 ∨ t[i][j] ≠ t[k][l]))}

pred noHayRepetidosEnFila (s: seq⟨ℤ⟩) {(∀i : ℤ)(∀j : ℤ)((0 ≤ i, j < |s| ∧ i ≠ j) →L (s[i] = 0 ∨ s[j] = 0 ∨ s[i] ≠ s[j]))}

```

```

    pred noHayRepetidosEnColumna (t: seq<seq<Z>>) { (∀j : Z) (0 ≤ j < |t| →L (∀l : Z) (∀k : Z)
    ((0 ≤ l, k < |t| ∧ l ≠ k) →L (t[l][j] = 0 ∨ t[k][j] = 0 ∨ t[l][j] ≠ t[k][j])))
}

```

```

    pred esTableroParcialmenteResuelto (t: seq<seq<Z>>) { esTableroValido(t) ∧ (∀i : Z) (0 ≤ i < |t| →L
noHayRepetidosEnFila(t[i])) ∧ noHayRepetidosEnColumna(t) ∧ noHayRepetidosEnRegion(t)
}

```

```

    pred esTableroTotalmenteResuelto (t: seq<seq<Z>>) { esTableroParcialmenteResuelto(t) ∧ (∀i : Z) (0 ≤ i < |t| →L
¬filaTieneCeldaVacía(t[i]))
}

```

```

    pred esSubTablero (t0, t1 : seq<seq<Z>>) { (∀i : Z) (∀j : Z)
((0 ≤ i, j < |t| ∧L t0[i][j] ≠ 0) →L t0[i][j] = t1[i][j])
}

```

```

fun cantidadFilas (t: seq<seq<Z>>) : Z = |t|;

```

```

fun cantidadColumnas (t: seq<seq<Z>>) : Z = if cantidadFilas(t) > 0 then |t[0]| else 0 fi;

```