TP de Especificación

Sudoku

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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_esCeldaVacia (in t: seq⟨seq⟨Z⟩⟩, in f: Z,in c: Z, out result: Bool)  {
      Pre {esTableroValido(t) ∧_L 0 ≤ f, c < |t|}
      Post {result = (t[f][c] = 0)}
}
```

```
proc sudoku_nroDeCeldasVacias (in t: seq⟨seq⟨Z⟩⟩, out result: Z)  {
      Pre {esTableroValido(t)}
      Post {∑_{i=0}^{|t|-1} (∑_{j=0}^{|t|-1} if t[i][j] = 0 then 1 else 0 fi)}
}
```

```
proc sudoku_primeraCeldaVaciaFila (in t: seq⟨seq⟨Z⟩⟩, out result: Z)  {
      Pre {esTableroValido(t)}
      Post {if (∃i : Z)(0 ≤ i < |t| ∧_L filaTieneCeldaVacia(t[i]) ∧_L (∀j : Z)
          (0 ≤ j < i ⟶_L ¬filaTieneCeldaVacia(t[j])))
          then result = i
          else result = −1 fi}
}
```

```
proc sudoku_primeraCeldaVaciaColumna (in t: seq⟨seq⟨Z⟩⟩, out result: Z)  {
      Pre {esTableroValido(t)}
      Post {if (∃i : Z)(0 ≤ i < |t| ∧_L filaTieneCeldaVacia(t[i]) ∧_L (∀j : Z)(0 ≤ j < i ⟶_L ¬filaTieneCeldaVacia(t[j])))
          then result = indicePrimeraCeldaVaciaEnFila(t[i])
          else result = −1 fi}
      fun indicePrimeraCeldaVaciaEnFila (s: seq⟨Z⟩) : Z = if ((∃i : Z)(0 ≤ i < |s| ∧_L s[i] = 0 ∧_L
          (∀j : Z)(0 ≤ j < i ⟶_L s[j] ≠ 0))) then i else − 1 fi ;
}
```

```
proc sudoku_valorEnCelda (in t: seq⟨seq⟨Z⟩⟩, in f: Z, in c: Z, out result: Z)  {
      Pre {esTableroValido(t) ∧_L 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) ∧_L 0 ≤ f, c ≤ 8 ∧_L t[f][c] = 0 ∧_L 1 ≤ value ≤ 9 ∧_L t = t_0}
      Post {t[f][c] = value ∧_L (∀i : Z)(∀j : Z)((0 ≤ i, j < |t| ∧_L (i ≠ f ∨ j ≠ c)) ⟶_L t[i][j] = t_0[i][j])}
}
```

```
proc sudoku_vaciarCelda (inout t: seq⟨seq⟨Z⟩⟩, in f: Z, in c: Z)  {
      Pre {esTableroValido(t) ∧_L 0 ≤ f, c ≤ 8 ∧_L t[f][c] ≠ 0 ∧_L t = t_0}
      Post {t[f][c] = 0 ∧_L (∀i : Z)(∀j : Z)((0 ≤ i, j < |t| ∧_L (i ≠ f ∨ j ≠ c)) ⟶_L t[i][j] = t_0[i][j])}
}
```

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

proc sudoku_esTableroTotalmenteResuelto (in t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$, out result: Bool) {
  Pre {True}
  Post {$result = esTableroTotalmenteResuelto(t)$}
}

proc sudoku_esSubTablero (in $t_0, t_1 : seq\langle seq\langle\mathbb{Z}\rangle\rangle$, out $result$: Bool){
  Pre {True}
  Post {$result = esSubTablero(t_0, t_1)$}
}

proc sudoku_tieneSolucion (in t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$, out tieneSolucion: Bool) {
  Pre {$esTableroValido(t)$}
  Post {$tieneSolucion = (\exists s : seq\langle seq\langle\mathbb{Z}\rangle\rangle)(esTableroTotalmenteResuelto(s) \wedge_L esSubTablero(s,t))$}
}

proc sudoku_resolver (inout t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$, out tieneSolucion: Bool) {
  Pre {$esTableroValido(t) \wedge_L t = t_0$}
  Post {if $(\exists s : seq\langle seq\langle\mathbb{Z}\rangle\rangle)(esTableroTotalmenteResuelto(s) \wedge_L esSubTablero(s,t))$
   then $tieneSolucion = \text{True} \wedge t = s$
   else $tieneSolucion = \text{False}$ fi}
}

proc sudoku_copiarTablero (in src: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$, out target: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) {
  Pre {$esTableroValido(src)$}
  Post {$esTableroValido(target) \wedge_L (\forall i : \mathbb{Z})(\forall j : \mathbb{Z})(0 \leq i, j < |src| \longrightarrow_L target[i][j] = src[i][j])$}
}

2. Predicados y Auxiliares generales

 pred esMatriz (t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) {
$(\forall i : \mathbb{Z})(\forall j : \mathbb{Z})(0 \leq i, j < |t| \longrightarrow_L |t[i]| = |t[j]|)$
}

 pred esMatrizCuadrada (t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) {
$esMatriz(t) \wedge (cantidadFilas(t) = cantidadColumnas(t))$
}

 pred esTableroValido (t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) {$esMatrizCuadrada(t) \wedge_L |t| = 9 \wedge_L$
$(\forall i : \mathbb{Z})(\forall j : \mathbb{Z})(0 \leq i, j < |t| \longrightarrow_L 0 \leq t[i][j] \leq 9)$
}

 pred filaTieneCeldaVacia (f: $seq\langle\mathbb{Z}\rangle$) {
$(\exists i : \mathbb{Z})(0 \leq i < |f| \wedge_L f[i] = 0)$
}

 pred noHayRepetidosEnRegion (t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) {$(\forall i : \mathbb{Z})(\forall j : \mathbb{Z})(\forall k : \mathbb{Z})(\forall l : \mathbb{Z})$
$(0 \leq i, j, k, l < 9 \wedge (i \text{ div } 3 = k \text{ div } 3) \wedge (j \text{ div } 3 = l \text{ div } 3) \wedge (i \neq k \vee j \neq l) \longrightarrow_L (t[i][j] = 0 \vee t[k][l] = 0 \vee t[i][j] \neq t[k][l]))$
}

 pred noHayRepetidosEnFila (s: $seq\langle\mathbb{Z}\rangle$) {$(\forall i : \mathbb{Z})(\forall j : \mathbb{Z})(0 \leq i, j < |s| \wedge j \neq i \longrightarrow_L (s[i] = 0 \vee_L s[j] = 0 \vee_L s[i] \neq s[j]))$
}

 pred noHayRepetidosEnColumna (t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) {$(\forall j : \mathbb{Z})(0 \leq j < |t| \longrightarrow_L (\forall l : \mathbb{Z})(\forall k : \mathbb{Z})$
$(0 \leq l, k < |t| \wedge l \neq k \longrightarrow_L (t[l][j] = 0 \vee_L t[k][j] = 0 \vee_L t[l][j] \neq t[k][j])))$
}

}

    pred esTableroParcialmenteResuelto (t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) $\{esTableroValido(t) \wedge (\forall i : \mathbb{Z})(0 \leq i < |t| \longrightarrow_L$
$noHayRepetidosEnFila(t[i])) \wedge_L noHayRepetidosEnColumna(t) \wedge_L noHayRepetidosEnRegion(t)$
}

    pred esTableroTotalmenteResuelto (t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) $\{esTableroParcialmenteResuelto(t) \wedge (\forall i : \mathbb{Z})(0 \leq i < |t| \longrightarrow_L$
$\neg filaTieneCeldaVacia(t[i]))$
}

    pred esSubTablero ($t_0, t_1 : seq\langle seq\langle\mathbb{Z}\rangle\rangle$)$\{esTableroValido(t_0) \wedge esTableroValido(t_1) \wedge (\forall i : \mathbb{Z})(\forall j : \mathbb{Z})$
$((0 \leq i|t| \wedge_L t_0[i][j] \neq 0) \longrightarrow_L t_0[i][j] = t_1[i][j])$
}
    fun cantidadFilas (t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) : $\mathbb{Z}$ = $|t|$;

    fun cantidadColumnas (t: $seq\langle seq\langle\mathbb{Z}\rangle\rangle$) : $\mathbb{Z}$ = if $cantidadFilas(t) > 0$ then $|t[0]|$ else 0 fi ;