

Service: Bloc

Types: boolean, enum TypeBloc { VIDE, TERRE, MUR, HERO, SORTIE_FERMEE, SORTIE_OUVERTE, ROCHER, DIAMANT }

Use: Position

Observers:

```

getType: [Bloc] → TypeBloc
getPosition: [Bloc] → Position
isVide: [Bloc] → boolean
isSolide: [Bloc] → boolean
isDeplacable: [Bloc] → boolean
isTombable: [Bloc] → boolean
isSortie: [Bloc] → boolean
isSortieFermee: [Bloc] → boolean
isHero: [Bloc] → boolean
isTerre: [Bloc] → boolean

```

Constructors:

```

init: TypeBloc × Position → [Bloc]

```

Operators:

```

setType: [Bloc] × TypeBloc → [Bloc]

```

Observations:

[invariant]

```

isVide(b)  $\stackrel{min}{=}$  getType(b) = VIDE
isSolide(b)  $\stackrel{min}{=}$  getType(b) \in { SORTIE_FERMEE, MUR, ROCHER }
isDeplacable(b)  $\stackrel{min}{=}$  getType(b) = ROCHER
isTombable(b)  $\stackrel{min}{=}$  getType(b) \in { ROCHER, DIAMANT }
isSortie(b)  $\stackrel{min}{=}$  getType(b) \in { SORTIE_FERMEE, SORTIE_OUVERTE }
isSortieFermee(b)  $\stackrel{min}{=}$  getType(b) = SORTIE_FERMEE
isHero(b)  $\stackrel{min}{=}$  getType(b) = HERO
isTerre(b)  $\stackrel{min}{=}$  getType(b) = TERRE

```

[init]

```

getType(init(tb, pos)) = tb
getPosition(init(tb, pos)) = pos

```

[setType]

```

getType(setType(b, tb)) = tb
getPosition(setType(b, tb)) = getPosition(b)

```

Service: Position

Types: integer, enum Direction { HAUT, BAS, GAUCHE, DROITE }

Observers:

```
const getLargeur: [Position] → integer
const getHauteur: [Position] → integer
getX: [Position] → integer
getY: [Position] → integer
```

Constructors:

```
init: integer × integer × integer × integer → [Position]
  pre init(l, h, x, y) require (l > 0) ∧ (h > 0) ∧ (x ≥ 0) ∧ (y ≥ 0)
```

Operators:

```
deplacerVersDirection: [Position] × Direction → [Position]
```

Observations:

[init]

```
getLargeur(init(l, h, x, y)) = l
getHauteur(init(l, h, x, y)) = h
getX(init(l, h, x, y)) = x % l
getY(init(l, h, x, y)) = y % h
```

[deplacerVersDirection]

```
getX(deplacerVersDirection(p, dir)) =
  if dir = GAUCHE then
    (getX(p) - 1) % getLargeur(p)
  else if dir = DROITE then
    (getX(p) + 1) % getLargeur(p)
  else
    getX(p)

getY(deplacerVersDirection(p, dir)) =
  if dir = HAUT then
    (getY(p) - 1) % getHauteur(p)
  else if dir = BAS then
    (getY(p) + 1) % getHauteur(p)
  else
    getY(p)
```

Service: Terrain

Types: integer, boolean, **Set**, enum Direction { HAUT, BAS, GAUCHE, DROITE }, enum TypeBloc { VIDE, TERRE, MUR, HERO, SORTIE_FERMEE, SORTIE_OUVERTE, ROCHER, DIAMANT }

Use: Bloc, Position

Observers:

```

const getLargeur: [Terrain] → integer
const getHauteur: [Terrain] → integer
getPosSortie: [Terrain] → Position
getPosHero: [Terrain] → Position
getBlocHero: [Terrain] → Bloc
  pre getBlocHero(t) require isHeroVivant(t)
getBlocDepuisPosition: [Terrain] × Position → Bloc
getBloc: [Terrain] × integer × integer → Bloc
getBlocVersDirection: [Terrain] × Bloc × Direction → Bloc
getBlocs: [Terrain] → Set<Bloc>
isHeroVivant: [Terrain] → boolean
isDiamantsRestants: [Terrain] → boolean
isDeplacementBlocPossible: [Terrain] × Bloc × Direction → boolean

```

Constructors:

```

init: integer × integer → [Terrain]
  pre init(l, h) require l > 0 ∧ h > 0

```

Operators:

```

setBloc: [Terrain] × TypeBloc × integer × integer → [Terrain]
deplacerBlocVersDirection: [Terrain] × Bloc × Direction → [Terrain]
  pre deplacerBlocVersDirection(t, bloc, dir)
  require isDeplacementBlocPossible(t, bloc, dir)
fairePasDeMiseAJour: [Terrain] → [Terrain]

```

Observations:

[invariants]

$\text{getBlocHero}(t) \stackrel{\text{min}}{=} \text{getBlocDepuisPosition}(\text{getPosHero}(t))$

$\forall \text{bloc} \in \text{getBlocs}(t), \text{dir} \in \text{Direction}, \text{getBlocVersDirection}(t, \text{bloc}, \text{dir}) \stackrel{\text{min}}{=} \text{getBloc}(t, \text{Position}::\text{deplacerVersDirection}(\text{Bloc}::\text{getPosition}(\text{bloc}), \text{dir}))$

$\text{isHeroVivant}(t) \stackrel{\text{min}}{=} \exists \text{bloc} \in \text{getBlocs}(t), \text{Bloc}::\text{getType}(\text{bloc}) = \text{HERO}$

$\text{isDiamantsRestants}(t) \stackrel{\text{min}}{=} \exists \text{bloc} \in \text{getBlocs}(t), \text{Bloc}::\text{getType}(\text{bloc}) = \text{DIAMANT}$

$\forall \text{bloc} \in \text{getBlocs}(t), \text{dir} \in \text{Direction}, \text{isDeplacementBlocPossible}(t, \text{bloc}, \text{dir}) \stackrel{\text{min}}{=}$

```

    ¬Bloc::isSolide(getBlocVersDirection(t, bloc, dir))

getBlocDepuisPosition(t, pos)  $\stackrel{min}{=}$ 
    getBloc(t, Position::getX(pos), Position::getY(pos))

getBlocs(t)  $\stackrel{min}{=}$ 
     $\sum x \in [0..getLargeur() - 1], y \in [0..getHauteur() - 1], \text{getBloc}(t, x, y)$ 

[init]
    getLargeur(init(l, h)) = l
    getHauteur(init(l, h)) = h
    getPosSortie(init(l, h)) = null
    getPosHero(init(l, h)) = null

    getBlocHero(init(l, h)) = null
     $\forall x \in [0..getLargeur() - 1], y \in [0..getHauteur() - 1],$ 
        let* bloc = getBloc(init(l, h), x, y)
        and blocPos = Bloc::getPosition(bloc)
        in Bloc::isVide(bloc)  $\wedge$  Position::getX(blocPos) = x
             $\wedge$  Position::getY(blocPos) = y

[setBloc]
    getPosSortie(setBloc(t, type, x, y)) =
        if type \in { SORTIE_FERMEE, SORTIE_OUVERTE } then
            Bloc::getPosition(getBloc(t, x, y))
        else
            getPosSortie(t)

    getPosHero(setBloc(t, type, x, y)) =
        if type = HERO then
            Bloc::getPosition(getBloc(t, x, y))
        else
            getPosHero(t)

     $\forall x' \in [0..getLargeur() - 1], y' \in [0..getHauteur() - 1],$ 
        getBloc(setBloc(t, type, x, y), x', y') =
            if x = x'  $\wedge$  y = y' then
                Bloc::setType(getBloc(t, x, y), type)
            else
                getBloc(t, x', y')

[deplacerBlocVersDirection]
    getPosSortie(deplacerBlocVersDirection(t, bloc, dir)) = getPosSortie(t)

    getPosHero(deplacerBlocVersDirection(t, bloc, dir)) =
        if bloc = getBlocHero(t) then
            Bloc::getPosition(getBlocVersDirection(t, bloc, dir))
        else

```

```

    getPosHero(t)

 $\forall x \in [0..getLargeur() - 1], y \in [0..getHauteur() - 1],$ 
getBloc(deplacerBlocVersDirection(t, bloc, dir), x, y) =
    let* blocPos = Bloc::getPosition(bloc)
    and blocX = Position::getX(blocPos)
    and blocY = Position::getY(blocPos)
    and blocDest = getBlocVersDirection(t, bloc, dir)
    and blocDestPos = Bloc::getPosition(blocDest)
    and blocDestX = Position::getX(blocDestPos)
    and blocDestY = Position::getY(blocDestPos)
    in
        if blocX = x  $\wedge$  blocY = y then
            Bloc::setType(bloc, VIDE)
        else if blocDestX = x  $\wedge$  blocDestY = y then
            Bloc::setType(blocDest, Bloc::getType(bloc))
        else
            getBloc(x, y)

[fairePasDeMiseAJour]
getPosSortie(fairePasDeMiseAJour(t)) = getPosSortie(t)
getPosHero(fairePasDeMiseAJour(t)) = getPosHero(t)

 $\forall x \in [0..getLargeur() - 1], y \in [0..getHauteur() - 1],$ 
getBloc(fairePasDeMiseAJour(t), x, y) =
    let bloc = getBloc(t, x, y)
    in
        if Bloc::isSortieFermee(bloc)  $\wedge$   $\neg$ isDiamantsRestants(t) then
            Bloc::setType(bloc, SORTIE_OUVERTE)
        else if Bloc::isTombable(bloc)
 $\wedge$  Bloc::isVide(getBlocVersDirection(t, bloc, BAS))
            Bloc::setType(bloc, VIDE)
        else if Bloc::isVide(bloc)
 $\wedge$  Bloc::isTombable(getBlocVersDirection(t, bloc, HAUT))
            Bloc::setType(bloc,
                Bloc::getType(getBlocVersDirection(t, bloc, HAUT)))
        else
            getBloc(t, pos)

```

Service: MoteurJeu

Types: integer, boolean, enum Direction { HAUT, BAS, GAUCHE, DROITE }, enum TypeBloc { VIDE, TERRE, MUR, HERO, SORTIE_FERMEE, SORTIE_OUVERTE, ROCHER, DIAMANT }

Use: Terrain, Bloc, Position

Observers:

```
getTerrain: [MoteurJeu] → Terrain
getPasRestants: [MoteurJeu] → integer
isDeplacementHeroPossible: [MoteurJeu] × Direction → boolean
isPartieTerminee: [MoteurJeu] → boolean
isPartieGagnee: [MoteurJeu] → boolean
```

Constructors:

```
init: Terrain × integer → [MoteurJeu]
pre init(t, nbPas) require nbPas > 0
```

Operators:

```
deplacerHero: [MoteurJeu] × Direction → [MoteurJeu]
pre deplacerHero(mj, dir) require ¬isPartieTerminee(mj) ∧
isDeplacementHeroPossible(mj, dir)
```

Observations:

[invariant]

```
isPartieTerminee(mj)  $\stackrel{min}{=}$ 
  getPasRestants(mj) = 0
  ∨ ¬Terrain::isHeroVivant(getTerrain(mj))
  ∨ Terrain::getPosSortie(getTerrain(mj)) = Terrain::getPosHero(getTerrain(mj))
```

```
isPartieGagnee(mj)  $\stackrel{min}{=}$  isPartieTerminee(mj) ∧ Terrain::isHeroVivant(getTerrain(mj))
```

```
∀dir ∈ Direction, isDeplacementHeroPossible(mj, dir)  $\stackrel{min}{=}$ 
  let* terrain = getTerrain(mj)
  and blocHero = Terrain::getBlocHero(terrain)
  and blocDest = Terrain::getBlocVersDirection(terrain, blocHero, dir)
  in
    if dir \in { GAUCHE, DROITE } then
      ¬Bloc::isSolide(blocDest) ∨ (Bloc::isDeplacable(blocDest)
      ∧ Bloc::isVide(Terrain::getBlocVersDirection(terrain, blocDest, dir))
    else
      ¬Bloc::isSolide(blocDest)
```

[init]

```
getTerrain(init(t, nbPas)) = t
```

```
getPasRestants(init(t, nbPas)) = nbPas
```

```
[deplacerHero]
```

```
getTerrain(deplacerHero(mj, dir)) =  
  let* terrain = getTerrain(mj)  
  and blocHero = Terrain::getBlocHero(terrain)  
  and blocDest = Terrain::getBlocVersDirection(terrain, blocHero, dir)  
  in  
    if ¬Bloc::isSolide(blocDest) then  
      Terrain::deplacerBlocVersDirection(terrain, blocHero, dir)  
    else if Bloc::isDeplacable(blocDest) and dir \in GAUCHE, DROITE then  
      let terrain' = Terrain::deplacerBlocVersDirection(terrain, blocDest, dir)  
      in Terrain::deplacerBlocVersDirection(terrain', blocHero, dir)  
getPasRestants(deplacerHero(mj, dir)) = getPasRestants(mj) - 1
```
