

gz-unitree: Reinforcement learning en robotique avec validation par moteurs de physique multiples pour le robot *H1v2* d'Unitree

Gwenn Le Bihan <gwenn.lebihan@etu.inp-n7.fr>

7 Novembre 2025

Reinforcement Learning

Et son application à la robotique

Bases du RL

Agent

Environnement

Score

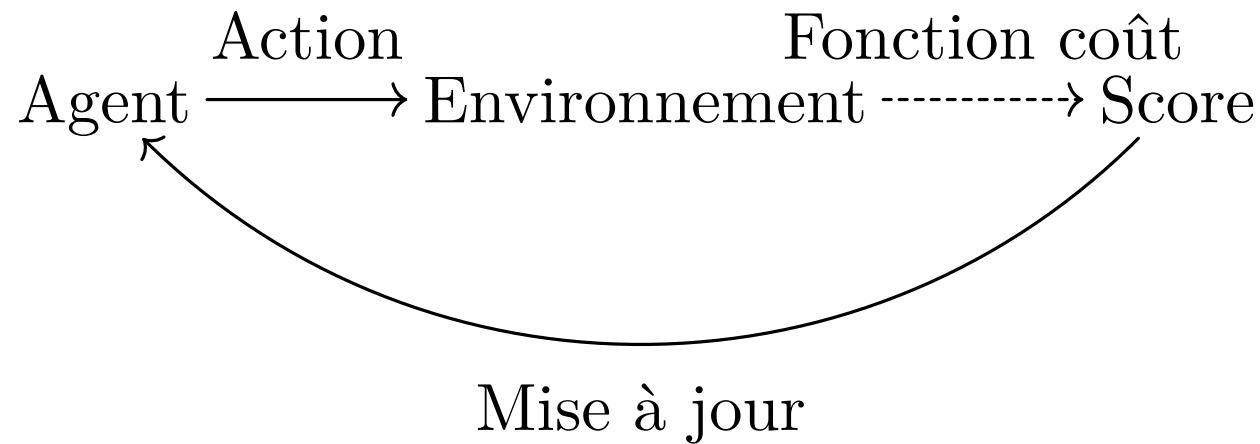
Bases du RL



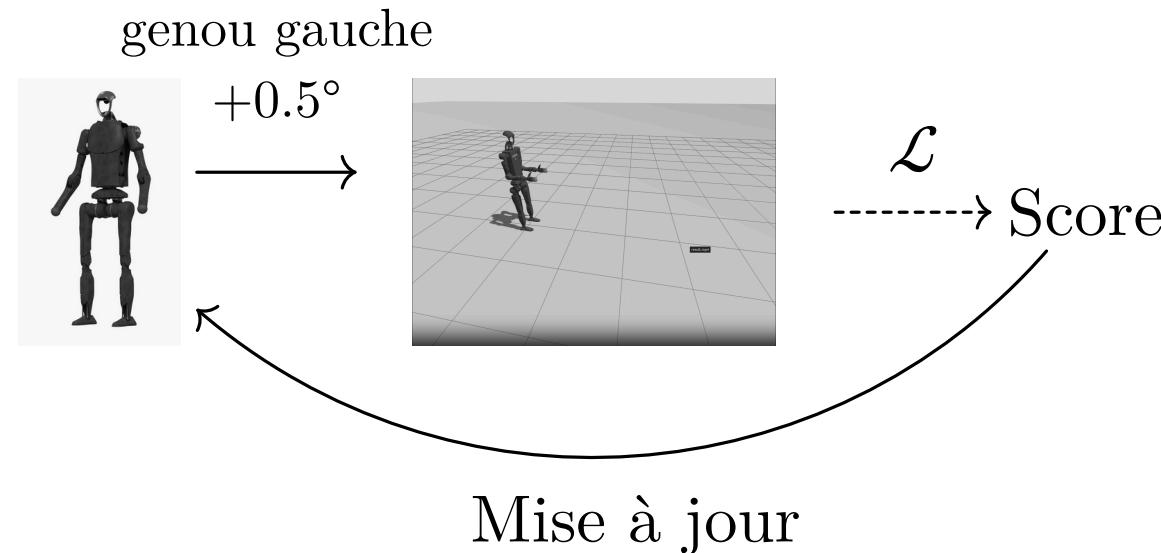
Bases du RL



Bases du RL



RL en robotique



C'est quoi \mathcal{L} ?

C'est très simple:

$$\mathcal{L}_r(\pi', \pi) := \mathbb{E}_{(s_t, a_t)_{t \in \mathbb{N}} \in \mathcal{C}} \sum_{t=0}^{\infty} \frac{Q_{\pi}(s_t, a_t)}{Q_{\pi'}(s_t, a_t)} A_{\pi, r}(s_t, a_t)$$

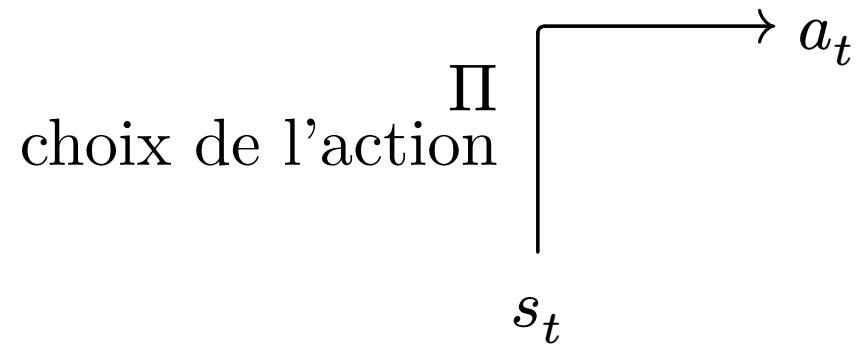
Comparaison des politiques

En Reinforcement Learning

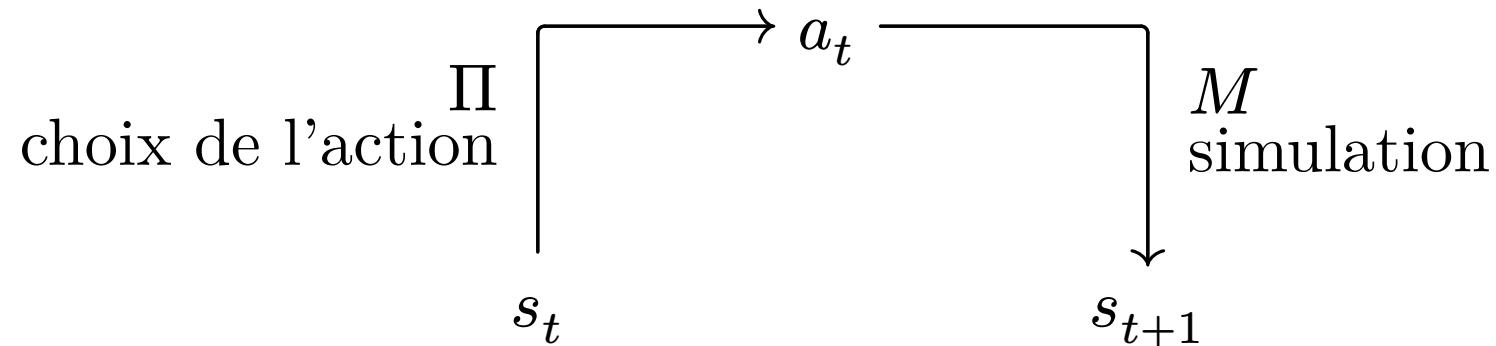
Comparaison des politiques

$$s_t$$

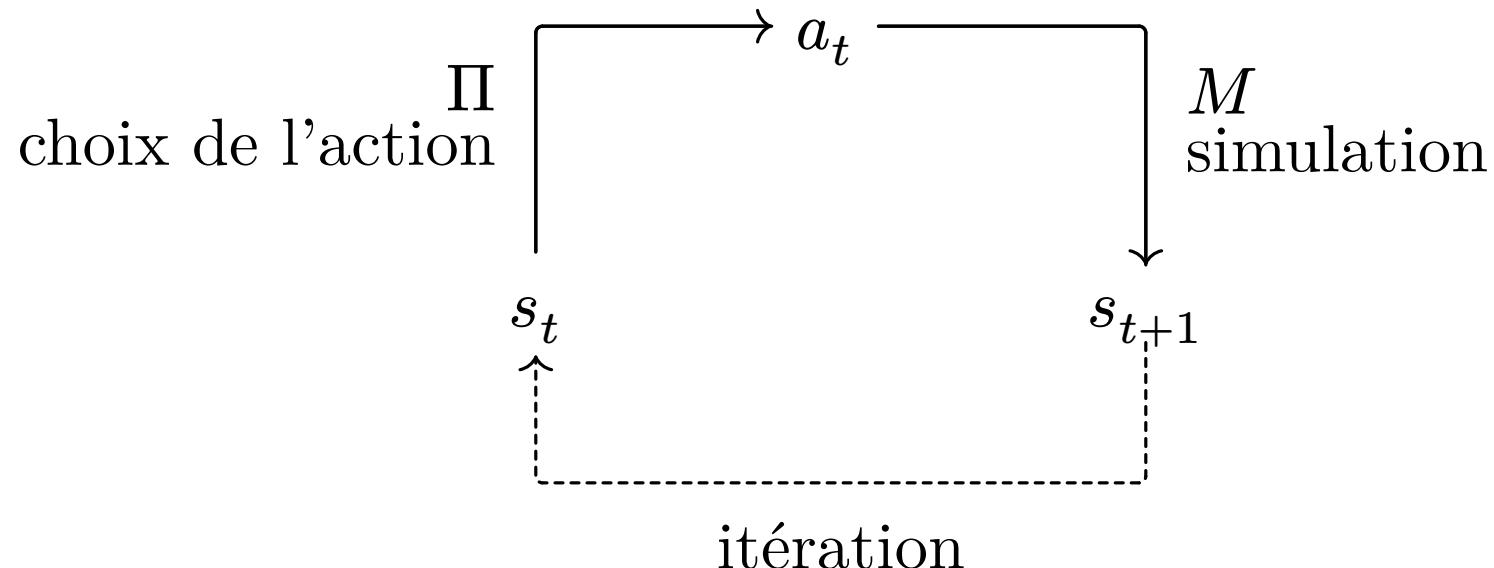
Comparaison des politiques



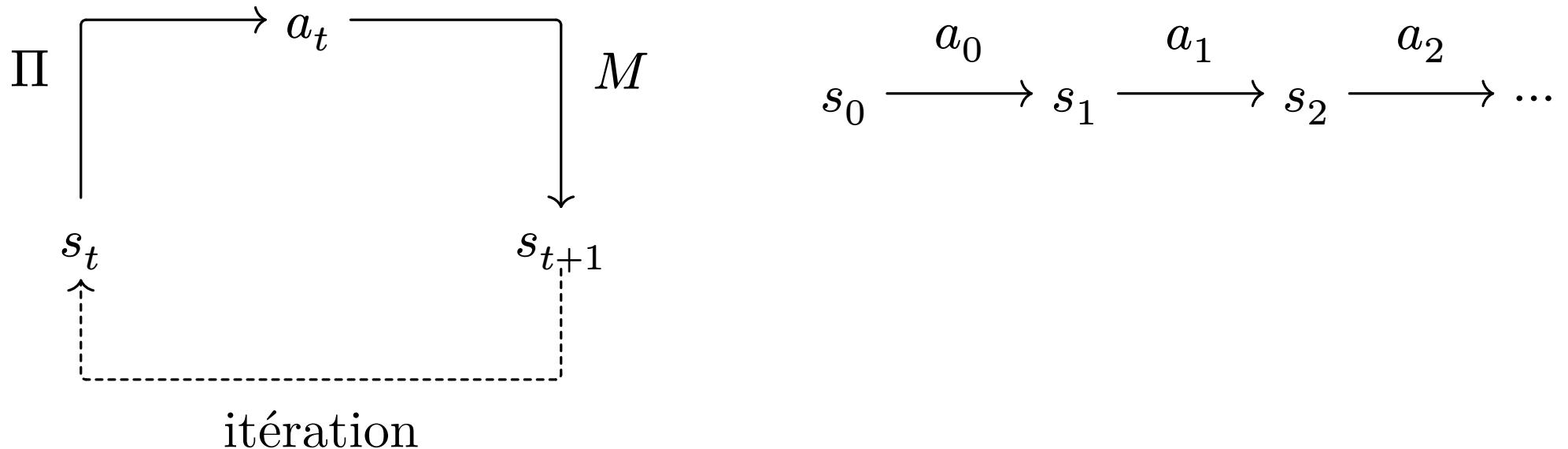
Comparaison des politiques



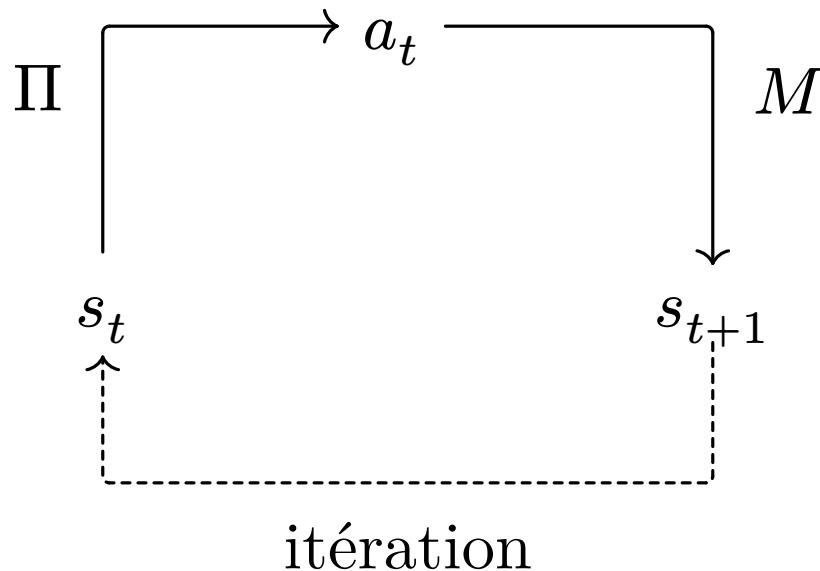
Comparaison des politiques



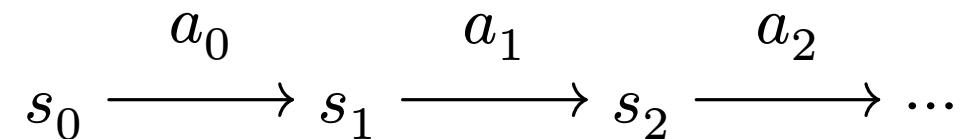
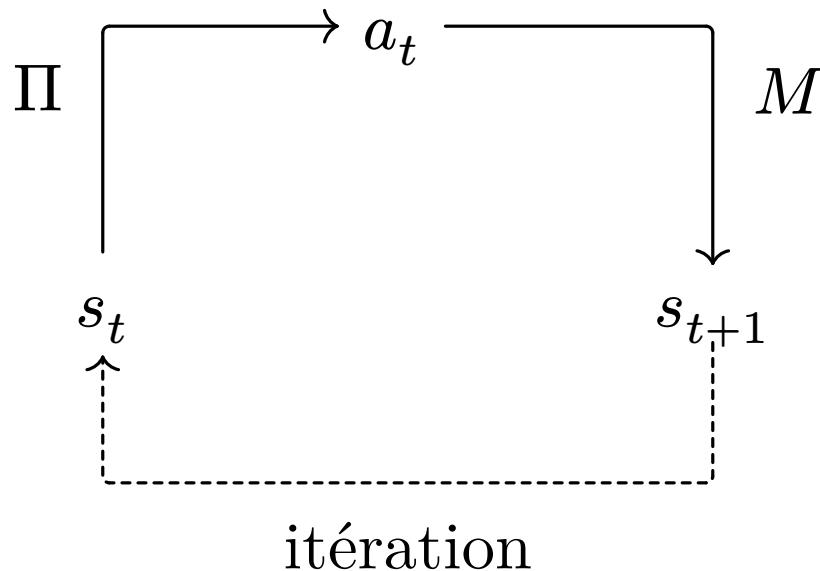
Comparaison des politiques



Comparaison des politiques



Comparaison des politiques



$$((s_0, a_0), (s_1, a_1), (s_2, a_2), \dots) \in \mathcal{C}$$

Comparaison des politiques

A := actions possibles

S := états possibles

$$\mathcal{C} := \left\{ \left\{ \forall t \in \mathbb{N} \quad \begin{array}{l} c_0 = (s_0, a_0) \\ c_{t+1} = (M(c_t), a_t) \end{array} \right| (s_0, a) \in S \times A^{\mathbb{N}} \right\}$$

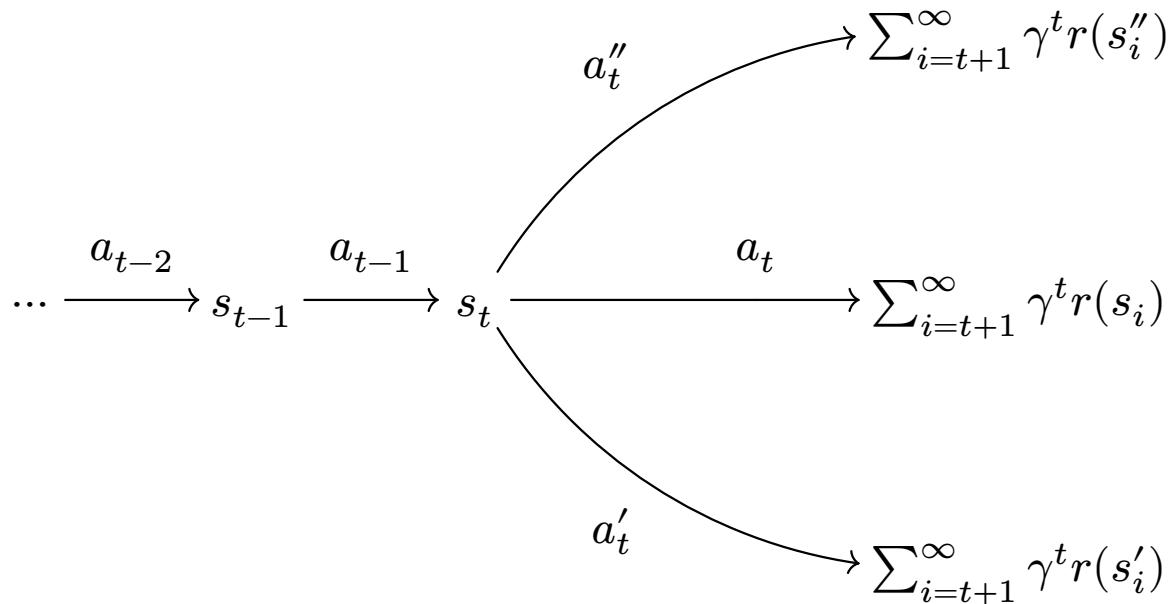
Comparaison des politiques: Avantage A

À quel point est-il mieux de choisir a_t plutôt qu'une autre action?

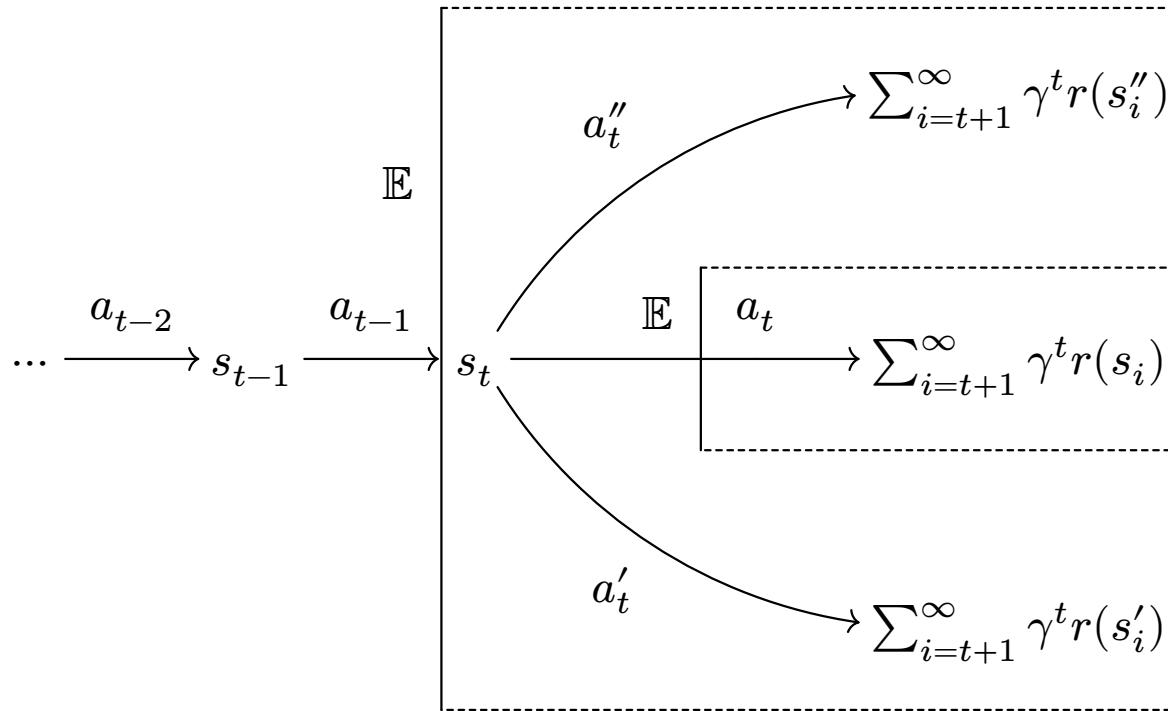
Comparaison des politiques: Avantage *A*

$$\dots \xrightarrow{a_{t-2}} s_{t-1} \xrightarrow{a_{t-1}}$$

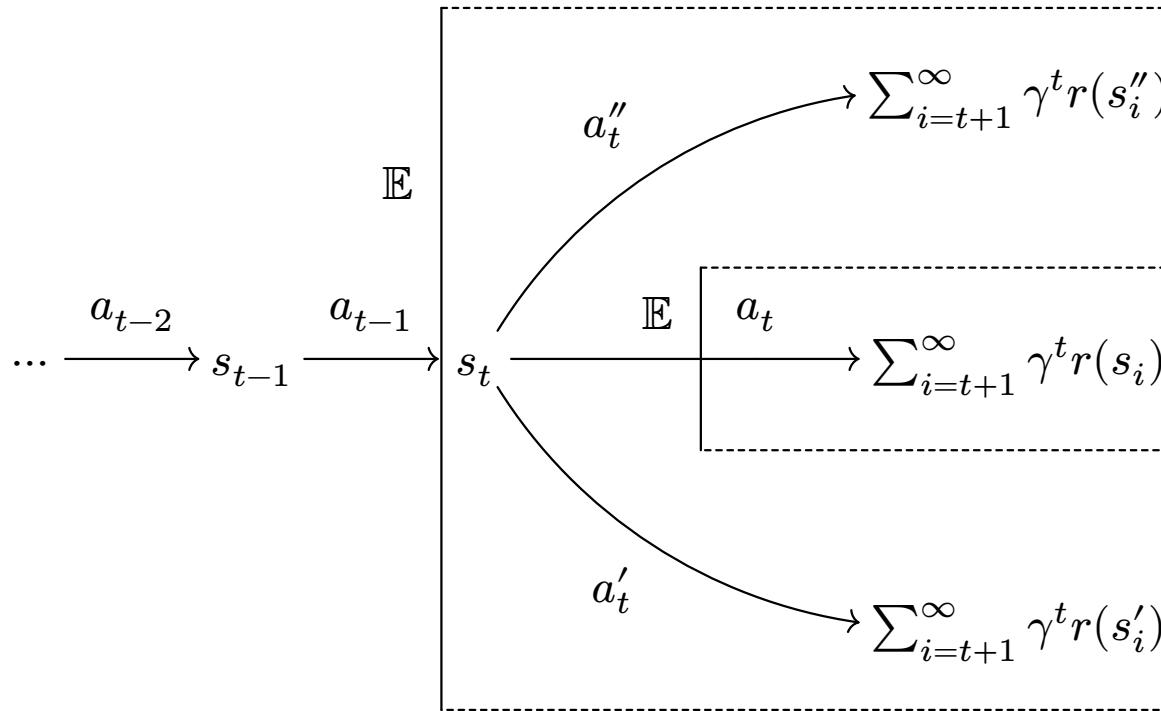
Comparaison des politiques: Avantage A



Comparaison des politiques: Avantage A



Comparaison des politiques: Avantage A



$$A_{\pi,r}(s, a) := \mathbb{E}(\text{avec } a_t) - \mathbb{E}(\text{à } t-1)$$

C'est quoi \mathcal{L} ?

$$\mathcal{L}_r(\pi', \pi) :=$$

C'est quoi \mathcal{L} ?

$$\mathcal{L}_r(\pi', \pi) := \mathbb{E}_{(s_t, a_t)_{t \in \mathbb{N}} \in \mathcal{C}}$$

C'est quoi \mathcal{L} ?

$$\mathcal{L}_r(\pi', \pi) := \mathbb{E}_{(s_t, a_t)_{t \in \mathbb{N}} \in \mathcal{C}} \sum_{t=0}^{\infty}$$

C'est quoi \mathcal{L} ?

$$\mathcal{L}_r(\pi', \pi) := \mathbb{E}_{(s_t, a_t)_{t \in \mathbb{N}} \in \mathcal{C}} \sum_{t=0}^{\infty} \frac{Q_{\pi}(s_t, a_t)}{Q_{\pi'}(s_t, a_t)} A_{\pi, r}(s_t, a_t)$$

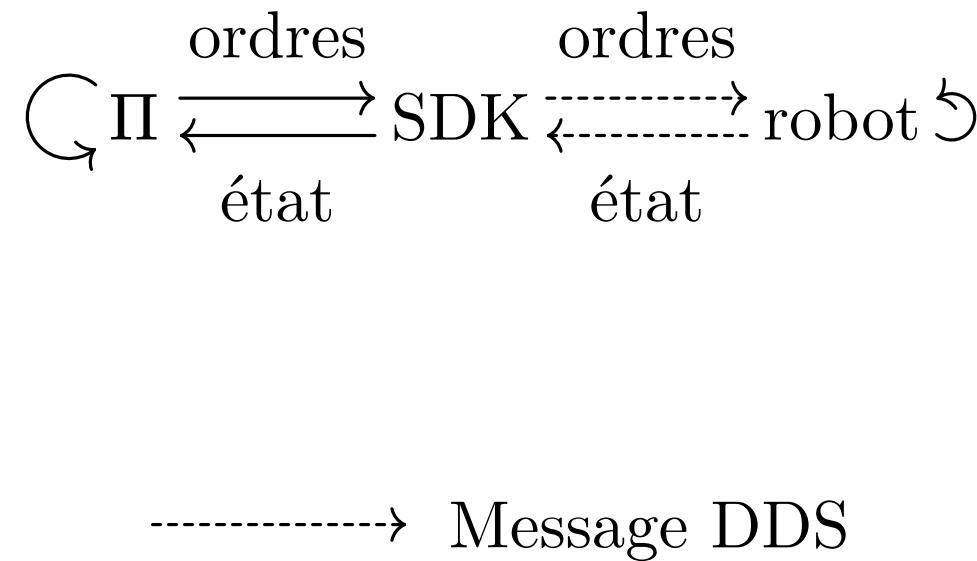
Mise à jour de Π

$$\Pi' = \begin{cases} \operatorname{argmax}_{\pi} \mathcal{L}_r(\pi, \Pi) \\ \text{s.c. } \operatorname{distance}(\Pi', \Pi) < \delta \end{cases}$$

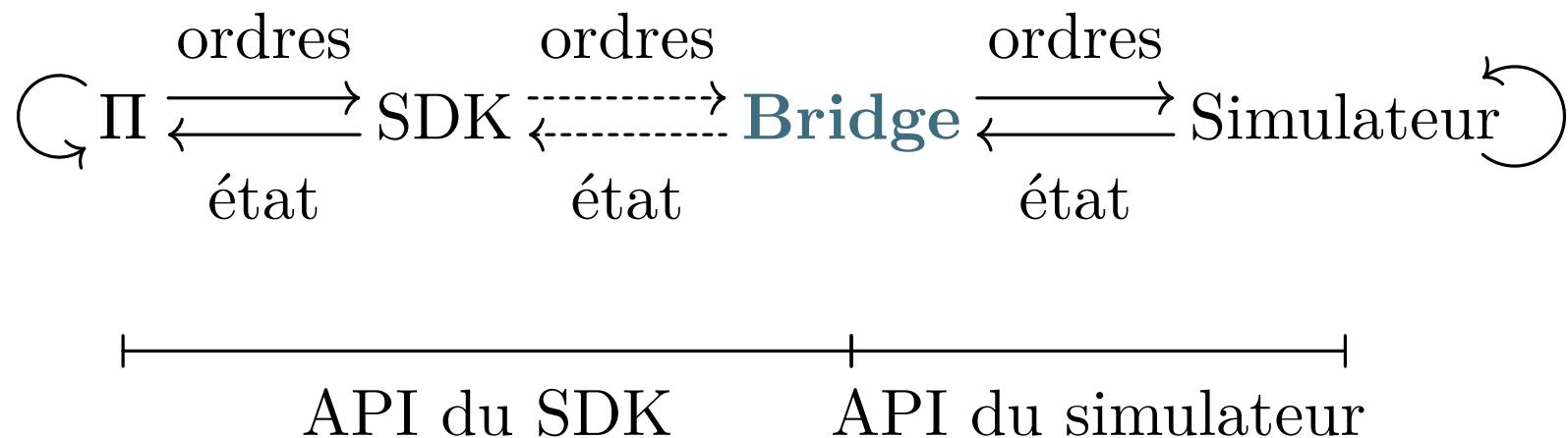
Le *SDK*¹ d'Unitree

¹Software Development Kit

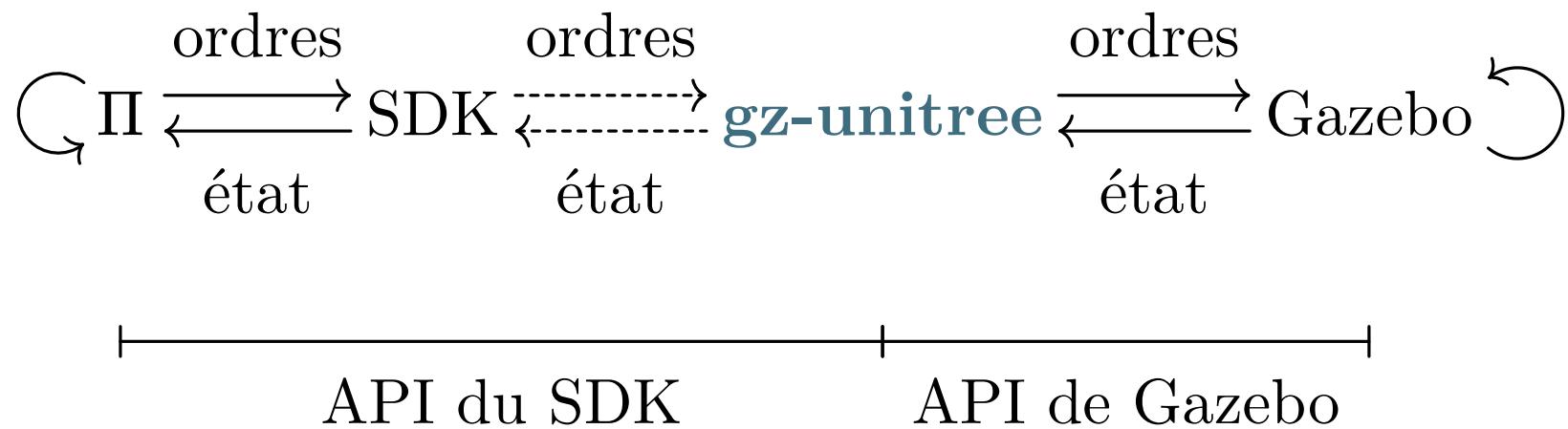
Le SDK d'Unitree



Le SDK d'Unitree



Le SDK d'Unitree



(Π)

Π

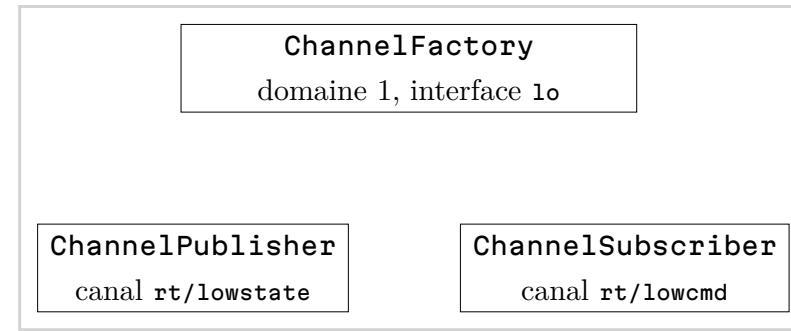
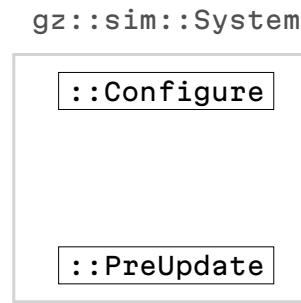
gz::sim::System

::Configure

::PreUpdate

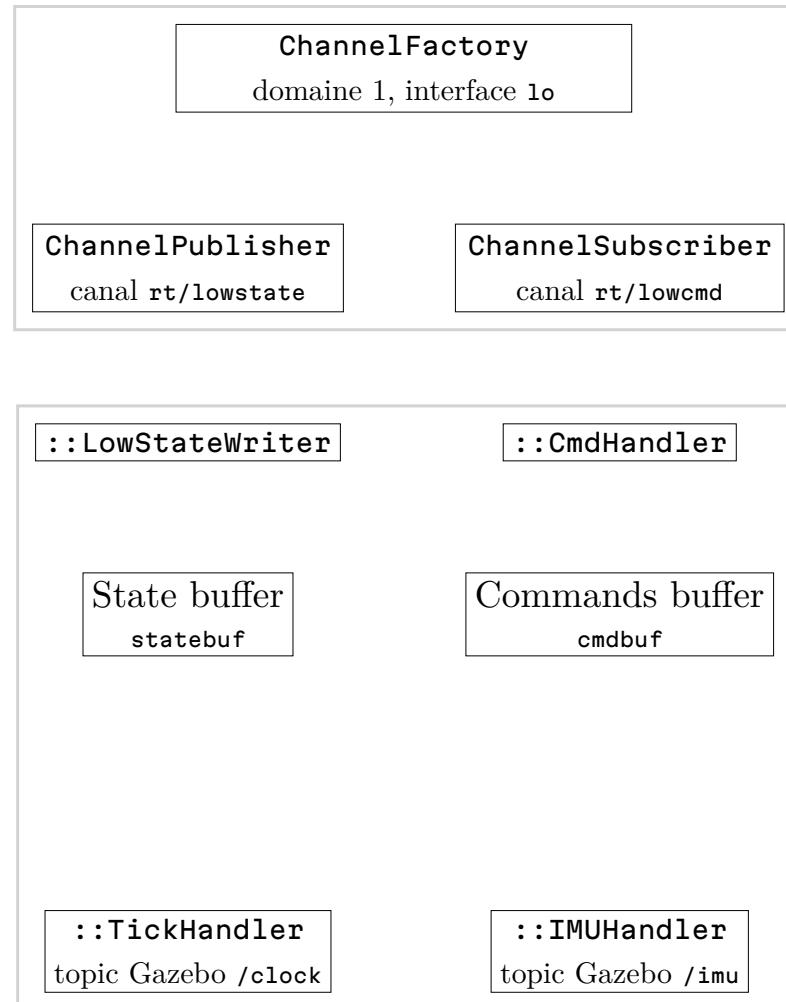
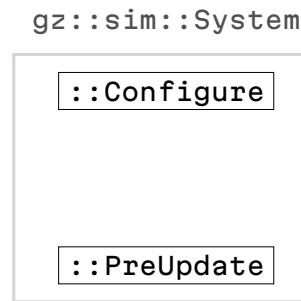
II

Unitree SDK



II

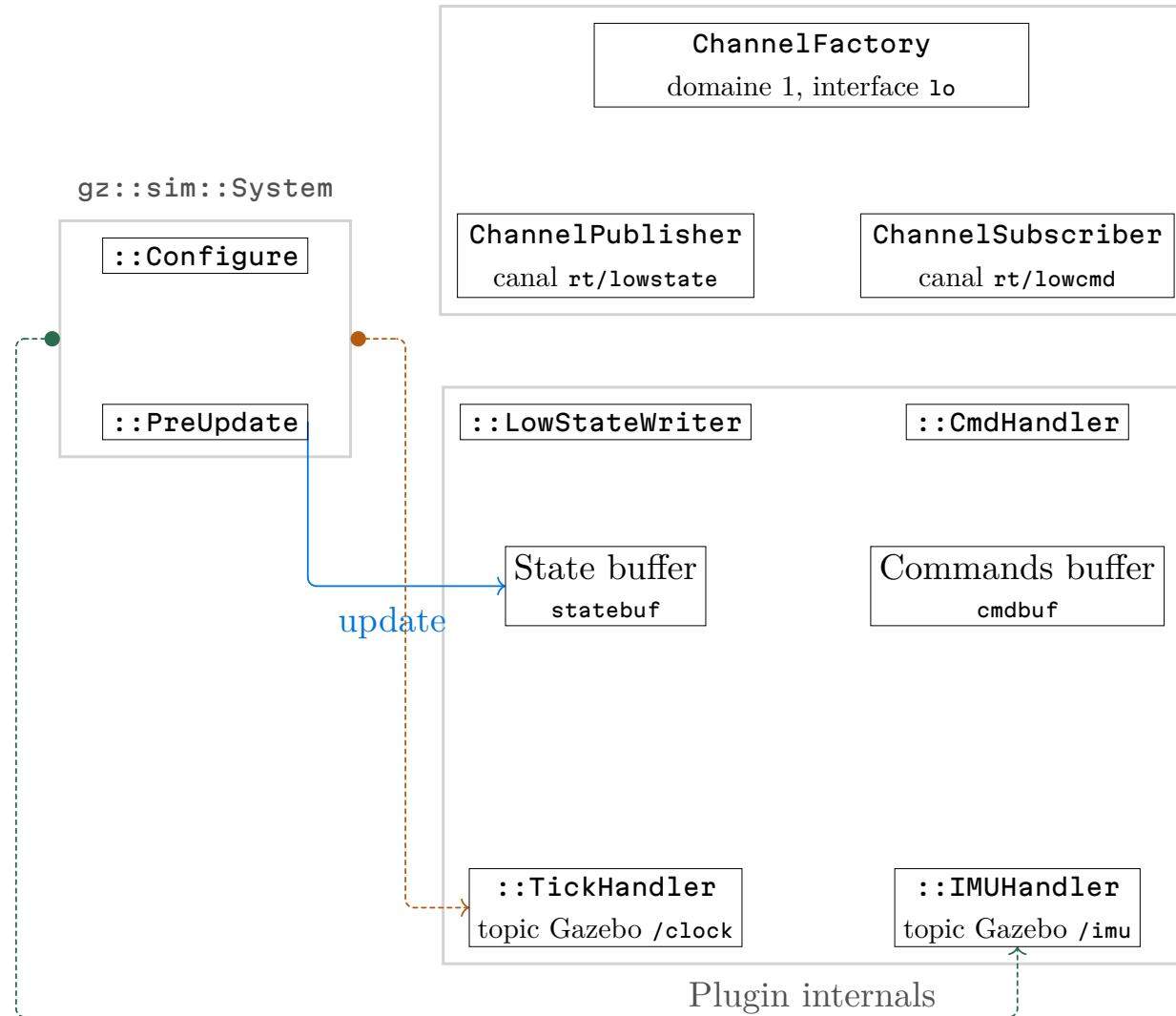
Unitree SDK



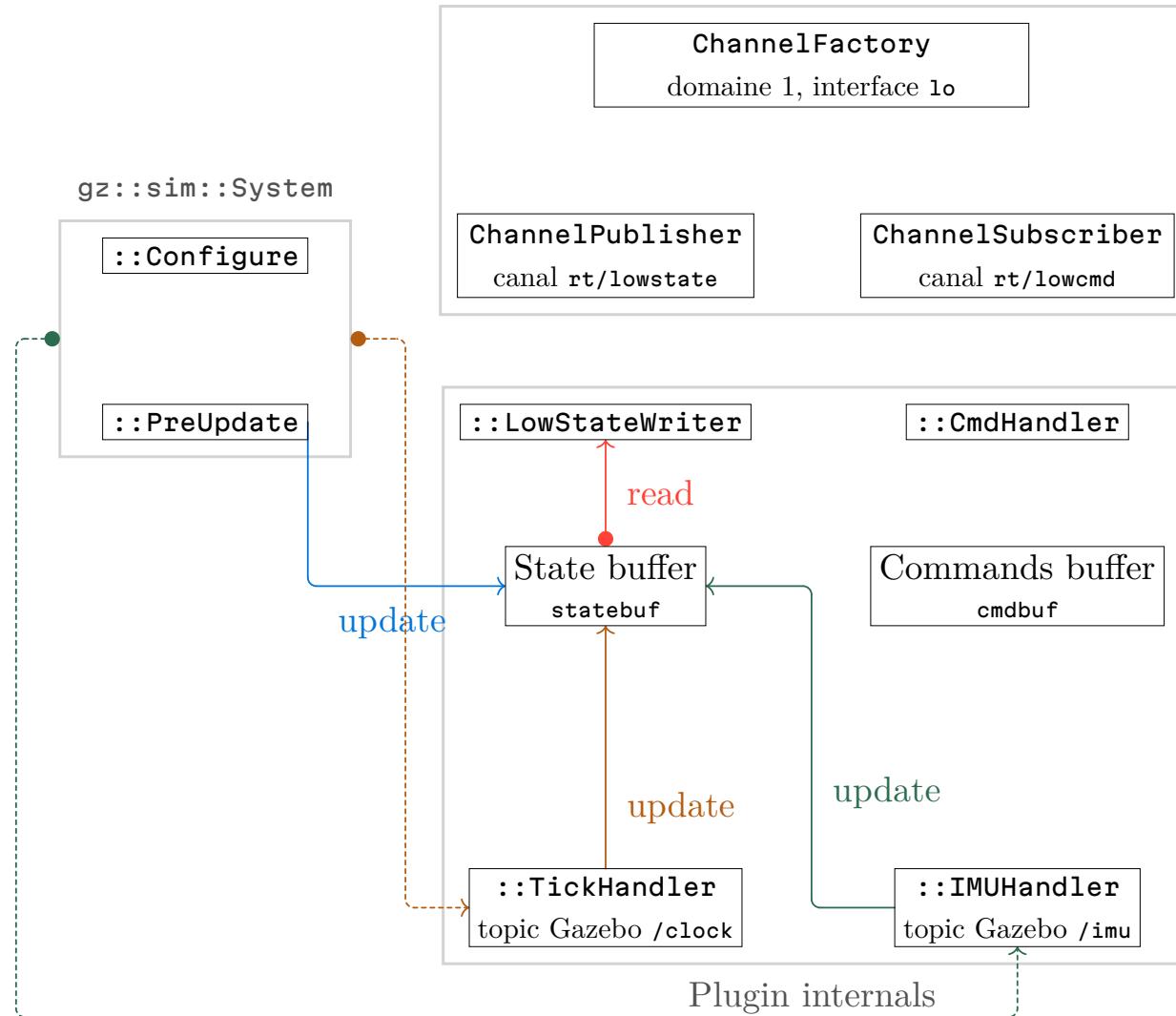
Plugin internals

II

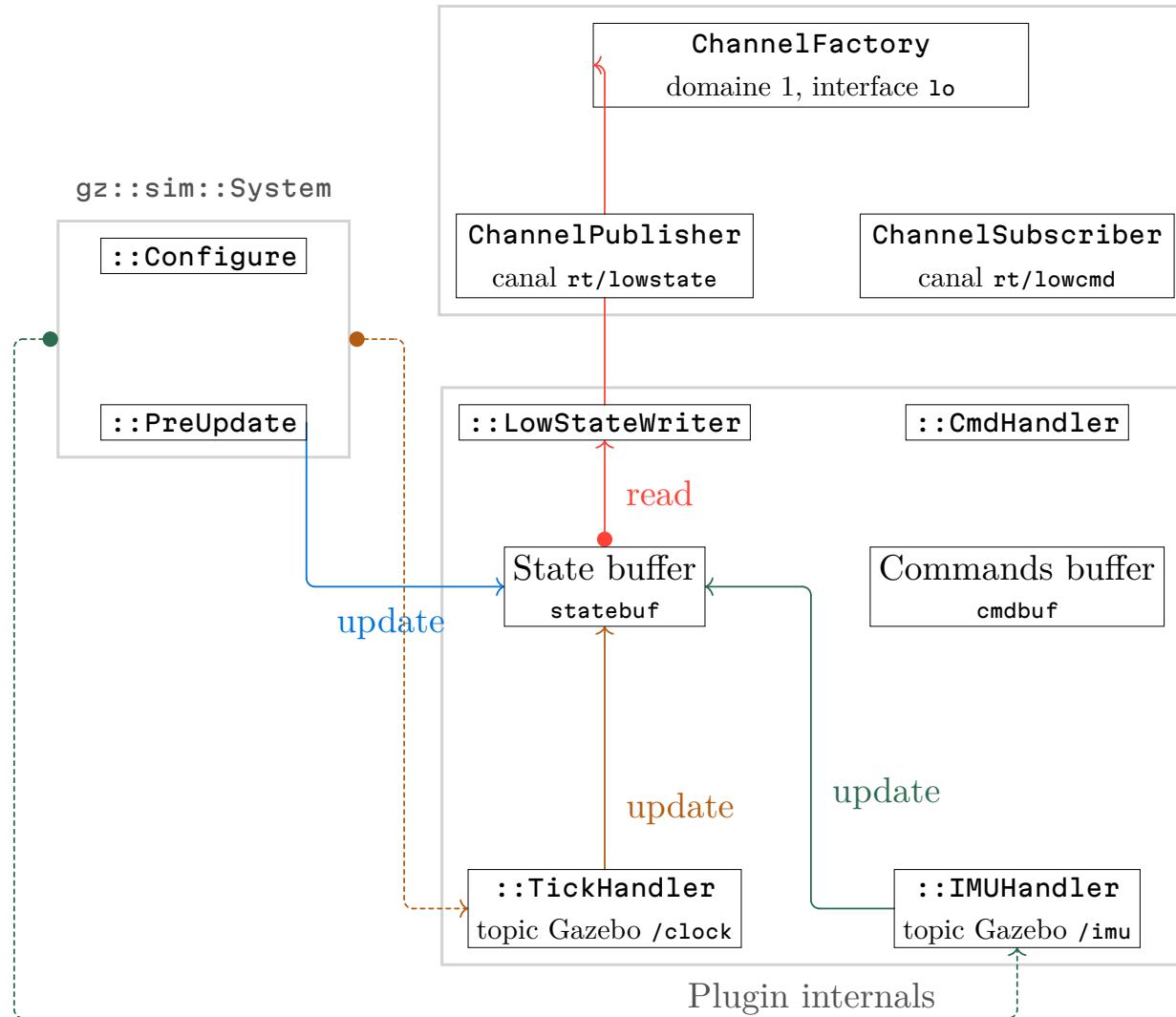
Unitree SDK

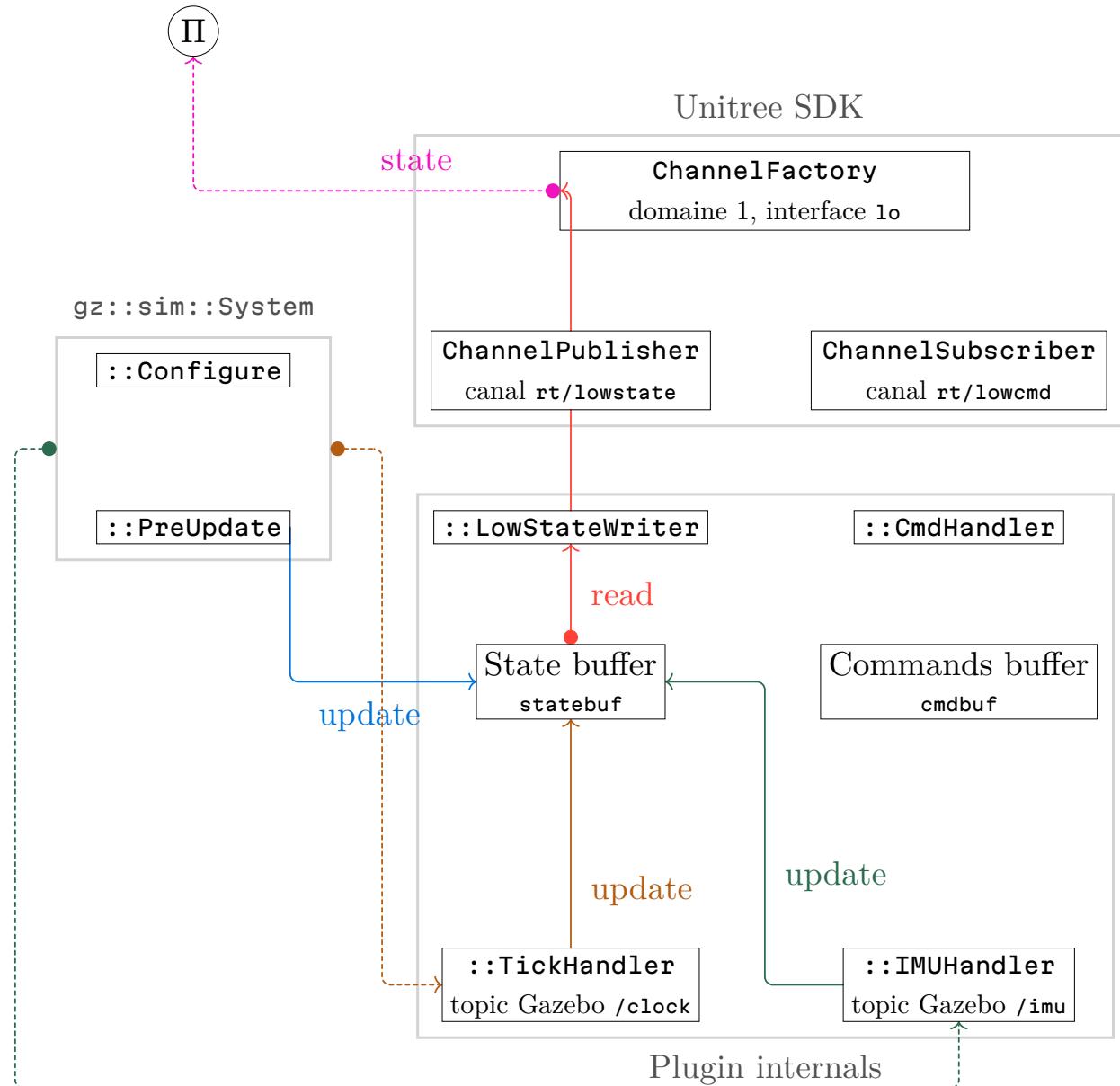


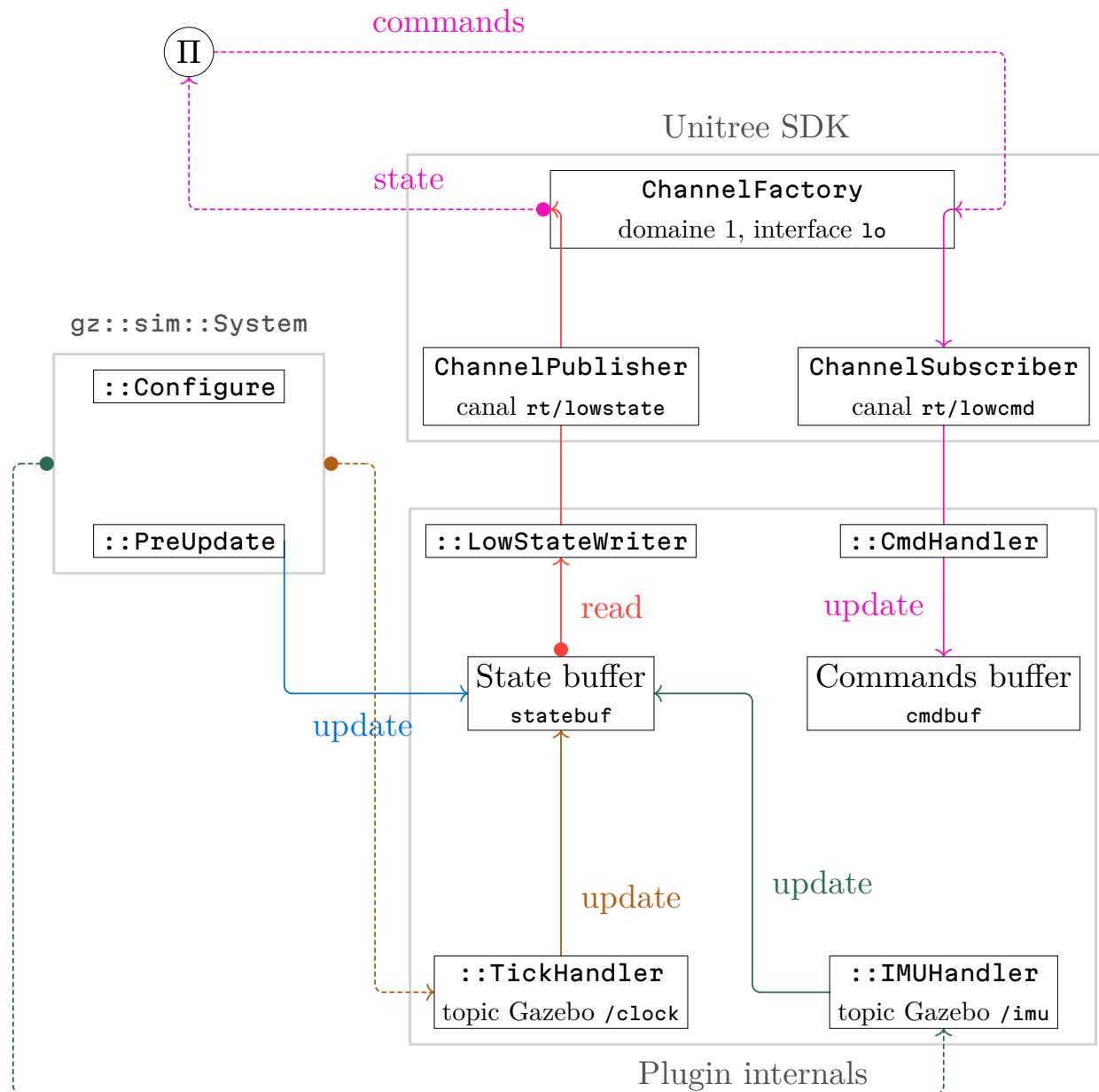
Unitree SDK

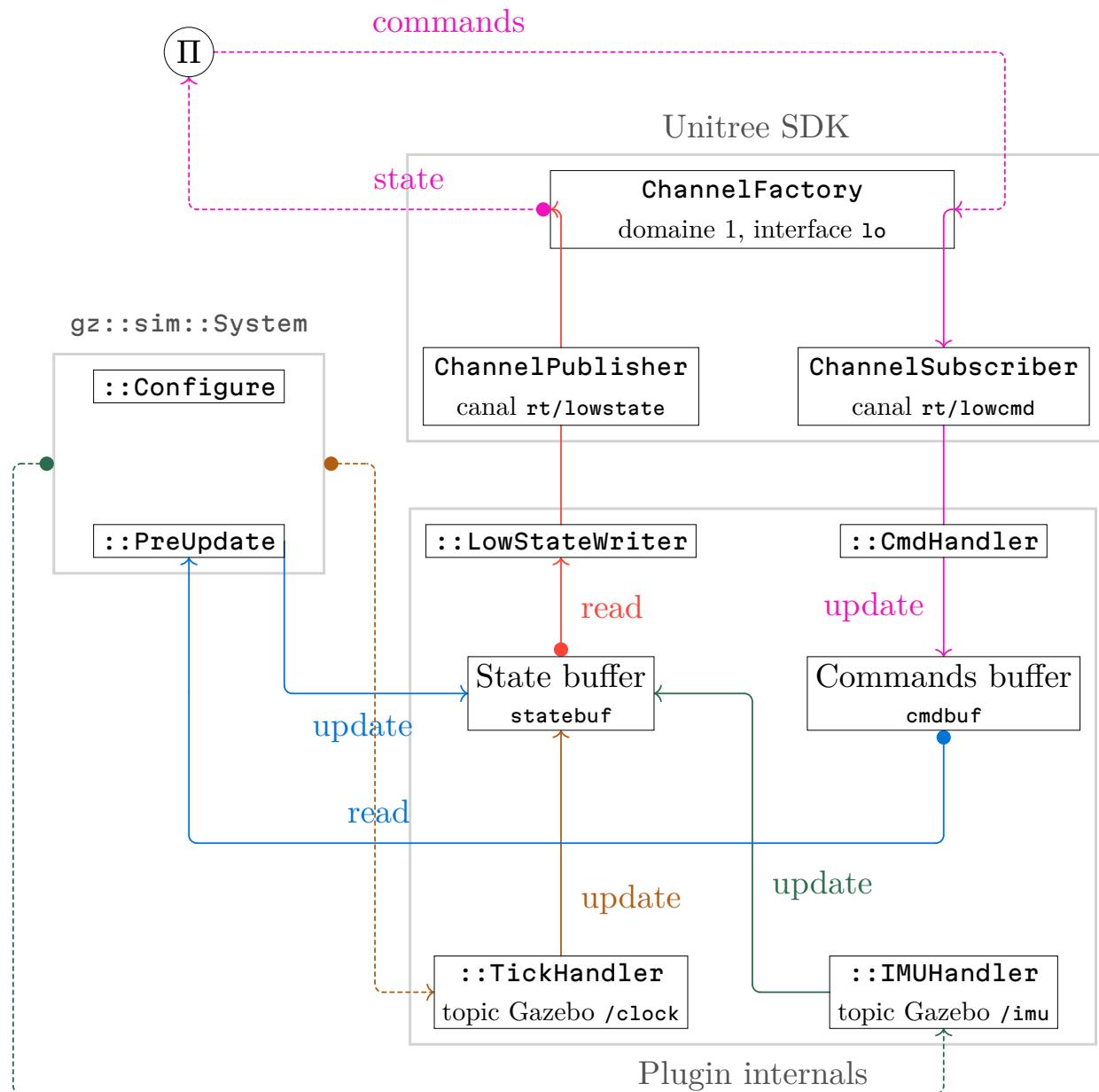


Unitree SDK









Reproductibilité

Avec Nix

Reproductibilité

```
from datetime import date

def f(a):
    return date.today().year + a
```

Reproductibilité

```
from datetime import date

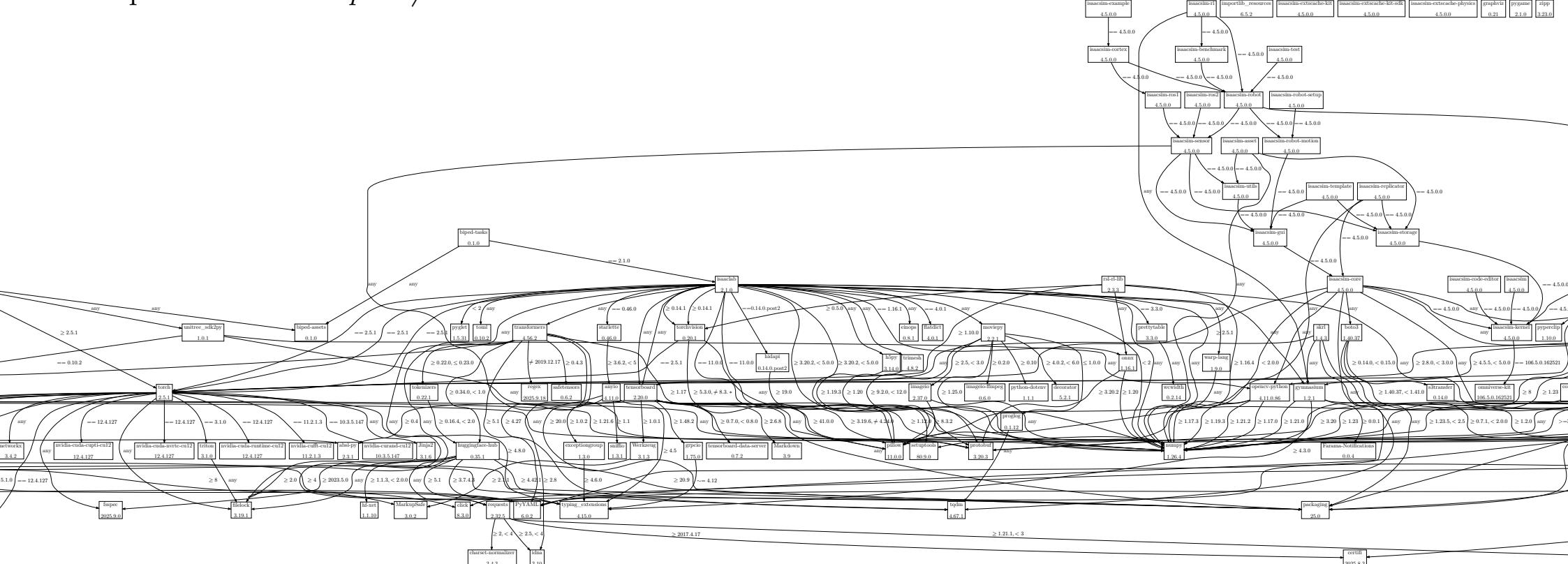
def f(a):
    return date.today().year + a
```

Reproductibilité

Au *compile-time*

Beaucoup de dépendances!

Dépendances de *Gepetto/h1v2-Isaac*



Reproductibilité

```
./program.c
int main()
{
    printf("Built at %s\n", BUILT_AT);
}
```

puis

```
gcc -DBUILT_AT=$(date) program.c
```

Nix, le langage

Pour des paquets reproductibles

Définition de gz-unitree

```
{ lib, stdenv, fetchFromGitHub, cmake, eigen }:

stdenv.mkDerivation {
  pname = "unitree-sdk2";
  version = "0.1.0";

  src = fetchFromGitHub {
    owner = "unitreerobotics";
    repo = "unitree_sdk2";
    rev = version;
    hash = "sha256-r05zwhZW36+VOrIuTCr2HLf2R23csmnj33JFzUqz62Q=";
  };

  nativeBuildInputs = [ cmake ];
  buildInputs = [ eigen ];
  meta = { ... };
}
```

Définition de gz-unitree

```
{ lib, stdenv, fetchFromGitHub, cmake, eigen }:
```

```
stdenv.mkDerivation {  
  pname = "unitree-sdk2";  
  version = "0.1.0";  
  
  src = fetchFromGitHub {  
    owner = "unitreerobotics";  
    repo = "unitree_sdk2";  
    rev = version;  
    hash = "sha256-r05zwhZW36+VOrIuTCr2HLf2R23csmnj33JFzUqz62Q=";  
  };  
  
  nativeBuildInputs = [ cmake ];  
  buildInputs = [ eigen ];  
  meta = { ... };  
}
```

Définition de gz-unitree

```
{ lib, stdenv, fetchFromGitHub, cmake, eigen }:

stdenv.mkDerivation {
  pname = "unitree-sdk2";
  version = "0.1.0";

  src = fetchFromGitHub {
    owner = "unitreerobotics";
    repo = "unitree_sdk2";
    rev = version;
    hash = "sha256-r05zwhZw36+V0rIuTCr2Hlf2R23csmnj33JFzUqz62Q=";
  };

  nativeBuildInputs = [ cmake ];
  buildInputs = [ eigen ];
  meta = { ... };
}
```

Définition de gz-unitree

```
{ lib, stdenv, fetchFromGitHub, cmake, eigen }:

stdenv.mkDerivation {
  pname = "unitree-sdk2";
  version = "0.1.0";

  src = fetchFromGitHub {
    owner = "unitreerobotics";
    repo = "unitree_sdk2";
    rev = version;
    hash = "sha256-r05zwhZW36+VOrIuTCr2HLf2R23csmnj33JFzUqz62Q=";
  };

  nativeBuildInputs = [ cmake ];
  buildInputs = [ eigen ];
  meta = { ... };
}
```

Définition de nixpkgs#eigen

```
{ lib, stdenv, fetchFromGitLab, cmake }:

stdenv.mkDerivation {
  pname = "eigen";
  version = "3.4.0-unstable-2022-05-19";

  src = fetchFromGitLab {
    owner = "libeigen";
    repo = "eigen";
    rev = "e7248b26a1ed53fa030c5c459f7ea095dfd276ac";
    hash = "sha256-uQ1YYV3ojbMVfHdqjXRyUymRPjJZV3WHT36PTxPRius=";
  };
}

nativeBuildInputs = [ cmake ];
patches = [ ./include-dir.patch ];
postPatch = ''substituteInPlace Eigen/src/SVD/BDCSVD.h --replace-fail "if (l == 0) {" "if (i
>= k && l == 0) {"';
meta = { ... };

}
```

Définition de nixpkgs#cmake

```
{  
    lib,  
    stdenv,  
    fetchurl,  
    replaceVars,  
    buildPackages,  
    bzip2,  
    curlMinimal,  
    expat,  
    libarchive,  
    libuv,  
    ncurses,  
    openssl,  
    pkg-config,  
    ps,  
    sysctl,  
    rhash,  
    sphinx,  
    texinfo,  
    xz,  
    zlib,  
    darwin,  
    isBootstrap ? null,  
    isMinimalBuild ? (  
        if isBootstrap != null then  
            lib.warn "isBootstrap argument is deprecated and will be  
            removed; use isMinimalBuild instead" isBootstrap  
        else  
            false  
    ),  
    useOpenSSL ? !isMinimalBuild,  
    useSharedLibraries ? (!isMinimalBuild && !  
        stdenv.hostPlatform.isCygwin),  
    uiToolkits ? [ ], # can contain "ncurses" and/or "qt5"  
    buildDocs ? !(isMinimalBuild || (uiToolkits == [ ])),  
    libsForQt5,  
    gitUpdater,  
}:  
}
```