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

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Reinforcement Learning

Et son application à la robotique

Bases du RL

Agent Environnement Score

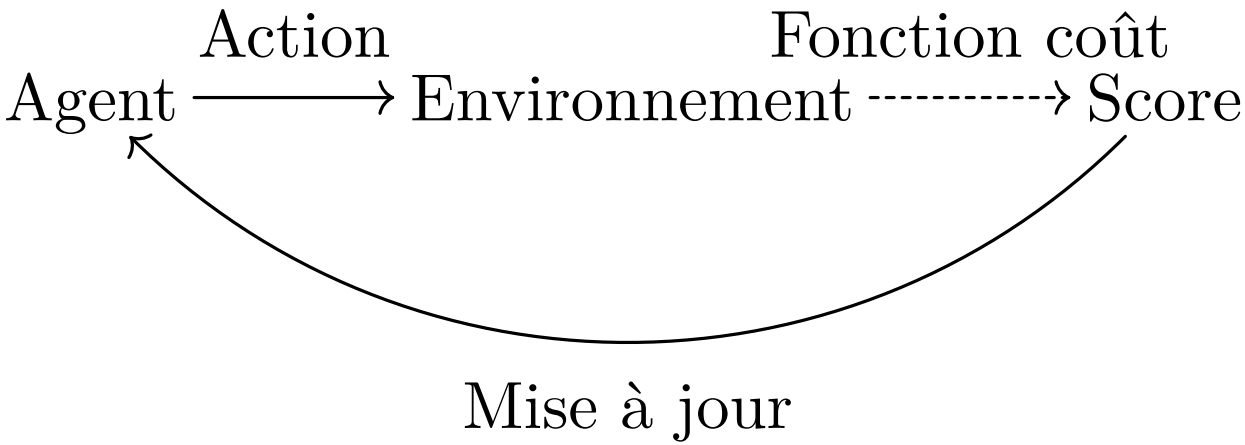
Bases du RL

$$\text{Agent} \xrightarrow{\text{Action}} \text{Environnement} \qquad \text{Score}$$

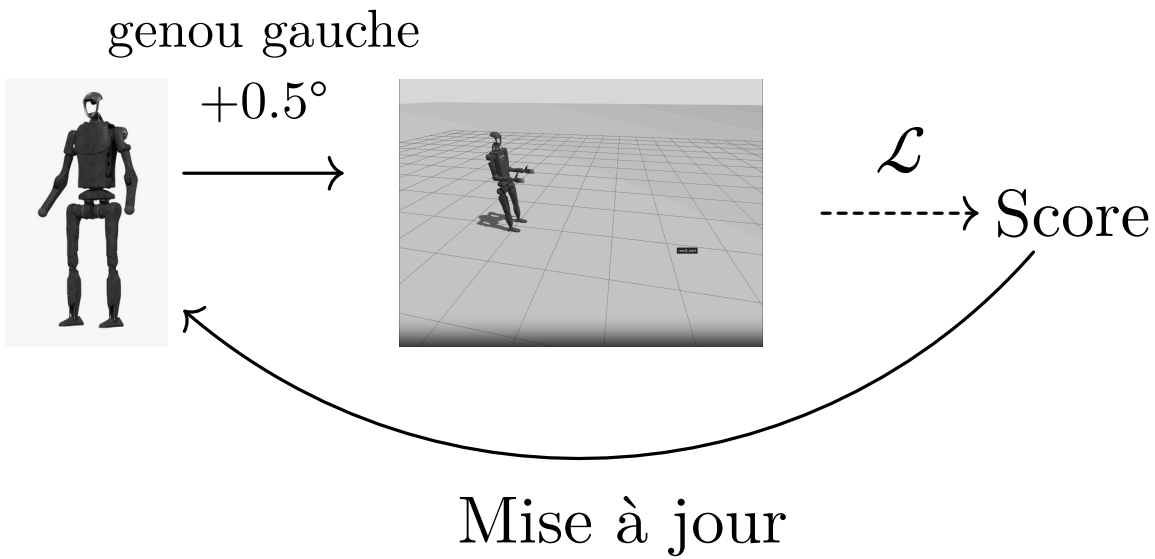
Bases du RL

$$\text{Agent} \xrightarrow{\text{Action}} \text{Environnement} \overset{\text{Fonction coût}}{\dashrightarrow} \text{Score}$$

Bases du RL


Action
Fonction coût
Agent
Environnement
Score
Mise à jour

RL en robotique



C'est quoi $\mathcal{L}$?

C'est très simple:

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

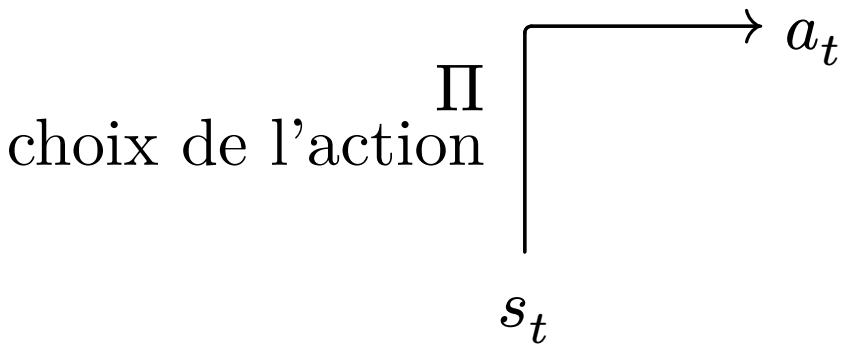
Comparaison des politiques

En Reinforcement Learning

Comparaison des politiques

$$s_t$$

Comparaison des politiques



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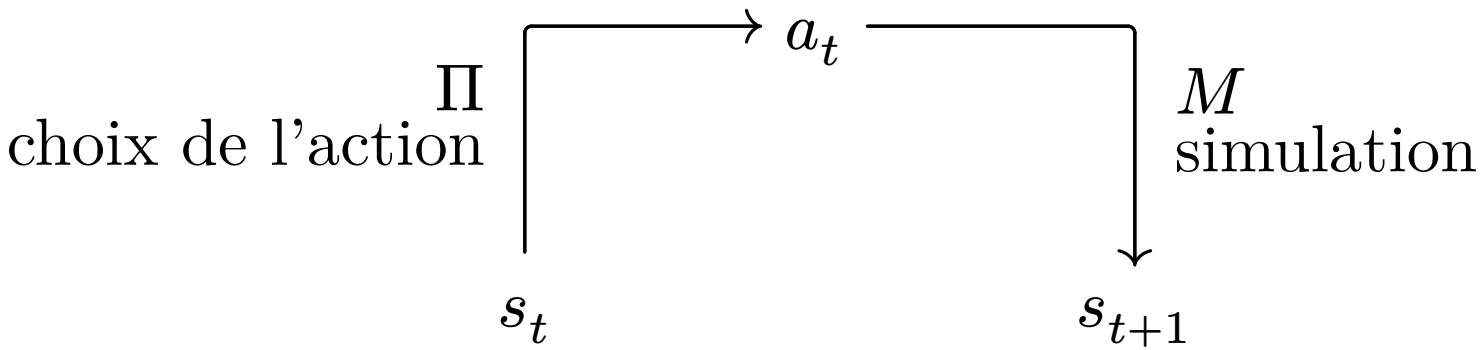

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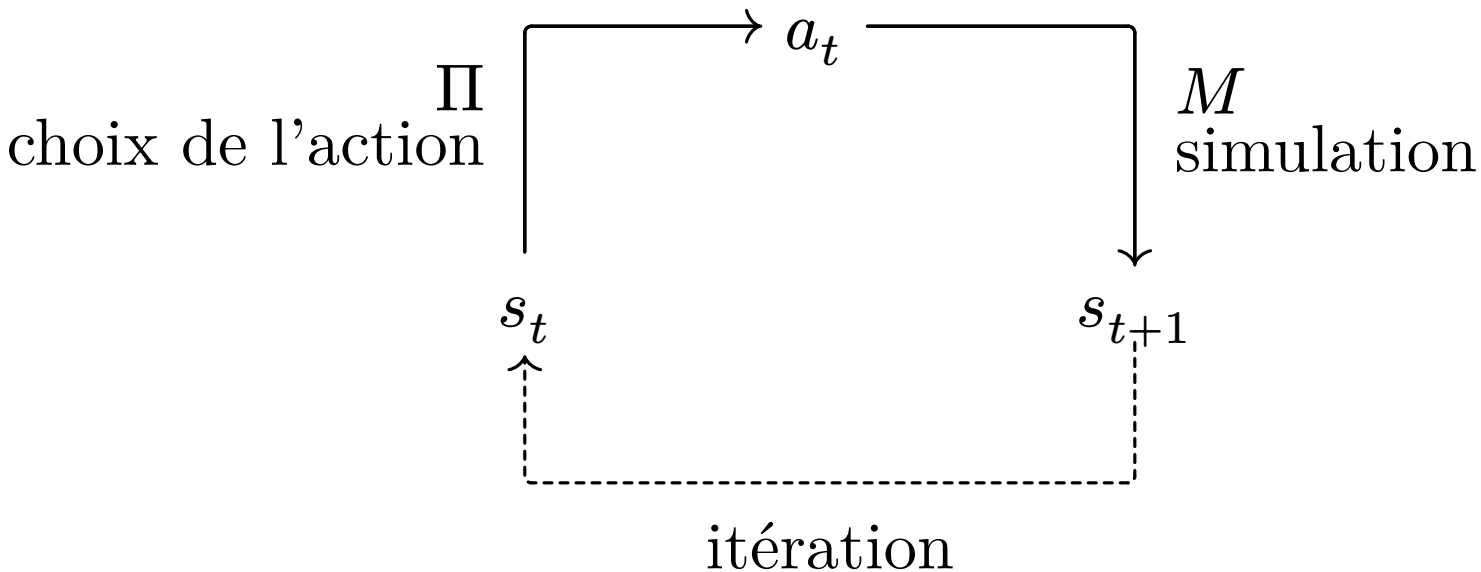

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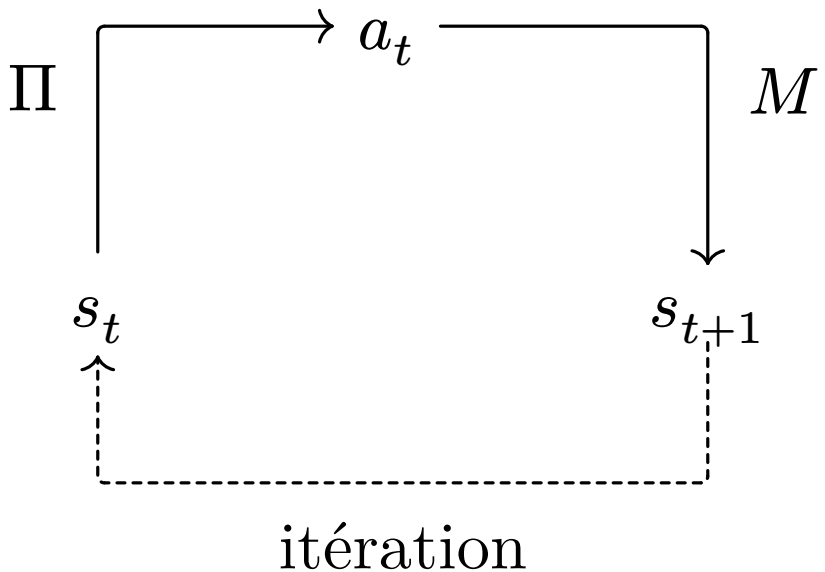
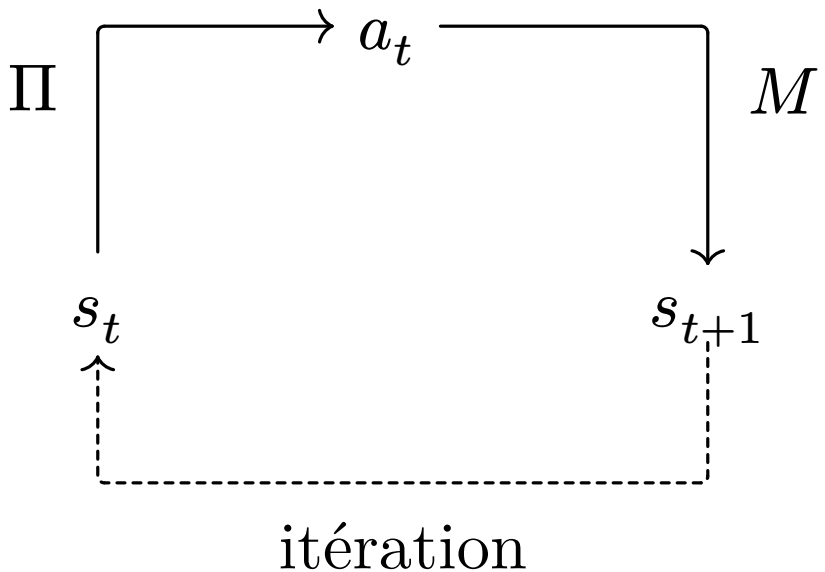


$$s_0 \xrightarrow{a_0} s_1 \xrightarrow{a_1} s_2 \xrightarrow{a_2} \cdots$$

Comparaison des politiques



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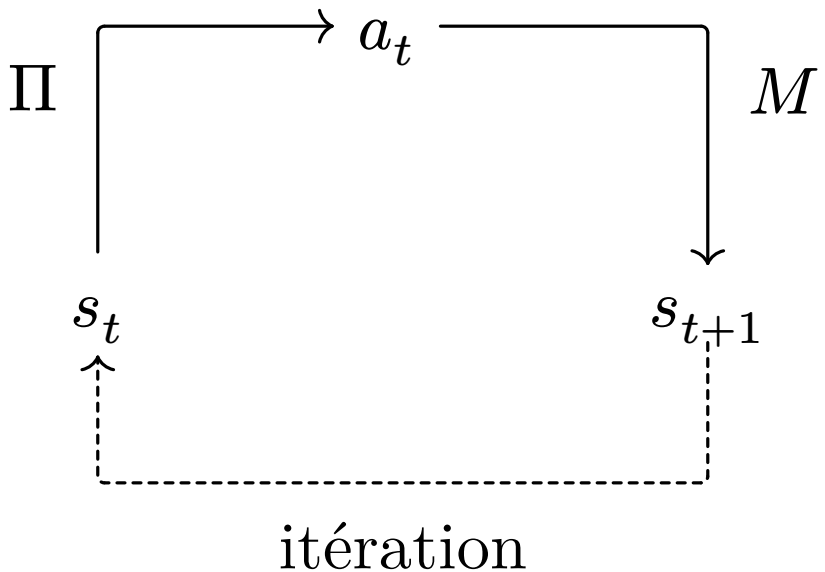
$$((s_0, a_0), (s_1, a_1), (s_2, a_2), ...)$$

Comparaison des politiques



$$s_0 \xrightarrow{a_0} s_1 \xrightarrow{a_1} s_2 \xrightarrow{a_2} \cdots$$

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

Comparaison des politiques

$$A := \text{actions possibles}$$

$$S := \text{états possibles}$$

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

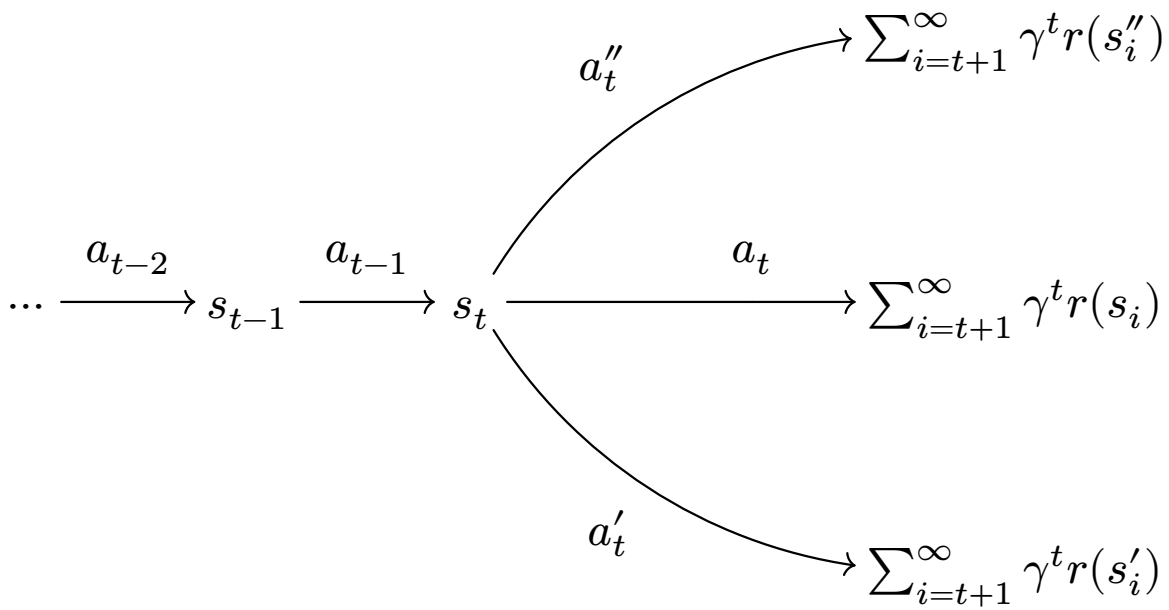
Comparaison des politiques: Avantage A

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

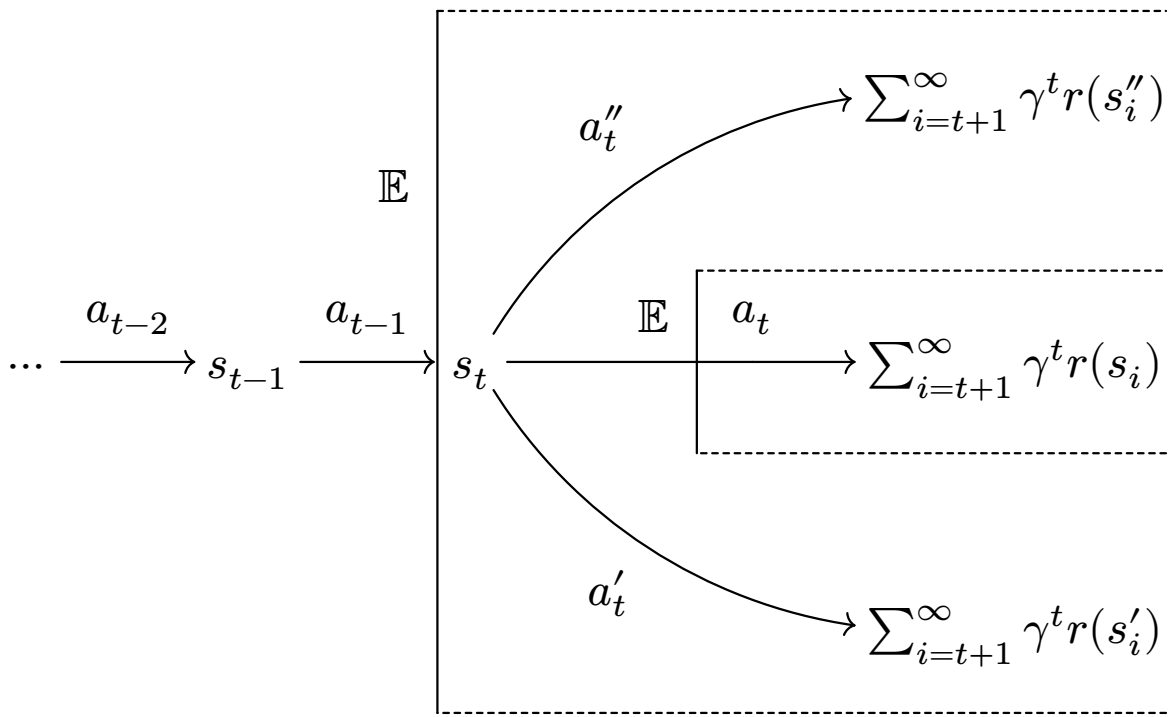
Comparaison des politiques: Avantage A

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

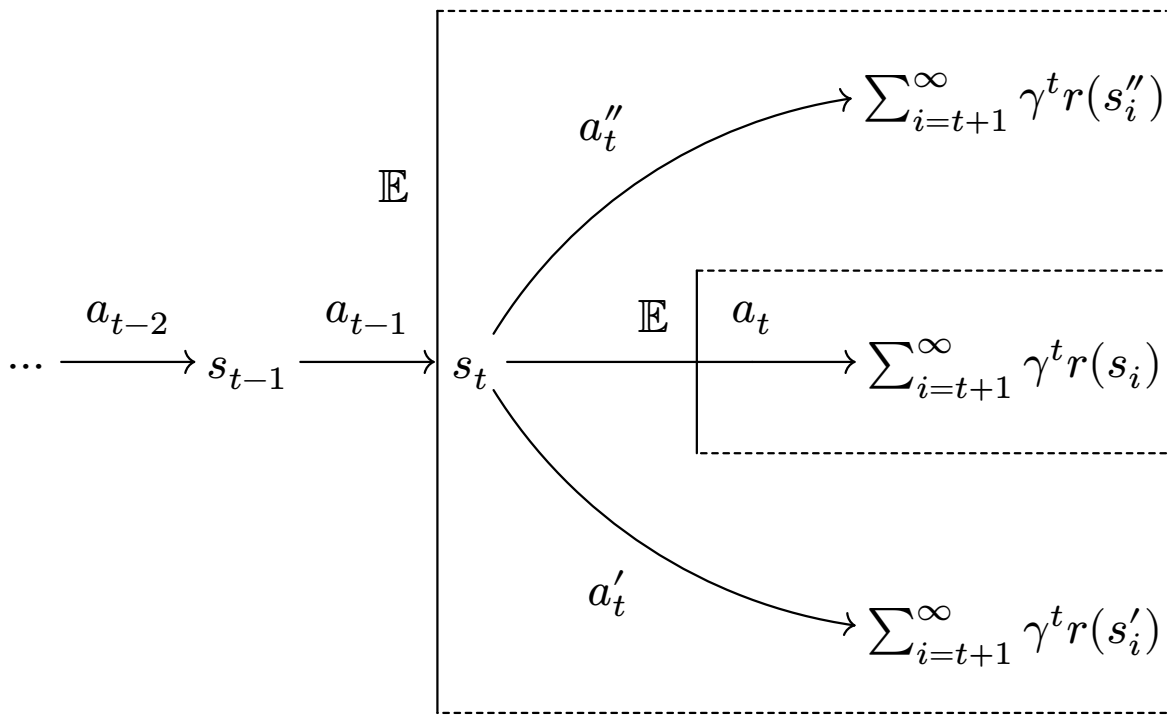
Comparaison des politiques: Avantage A



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 $\mathcal{L}$?

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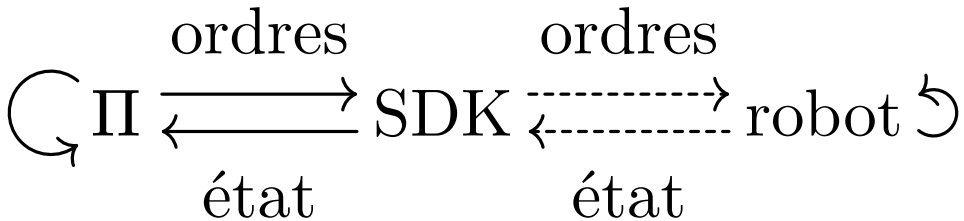
Mise à jour de Π

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

Le *SDK*[1] d'Unitree

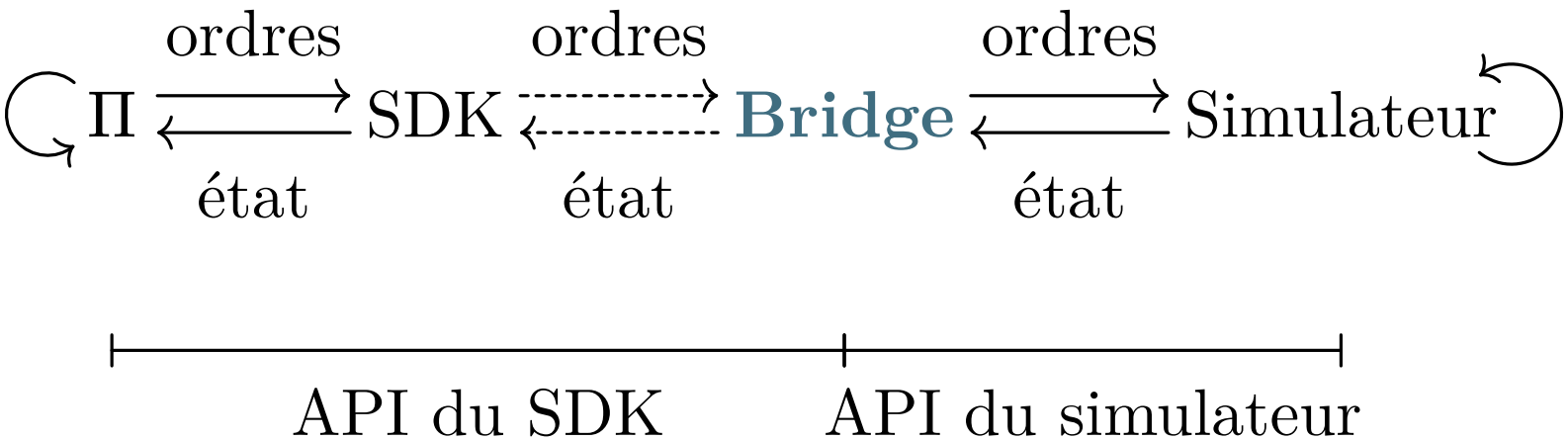
[1]Software Development Kit

Le SDK d'Unitree



⇢ Message DDS

Le SDK d'Unitree



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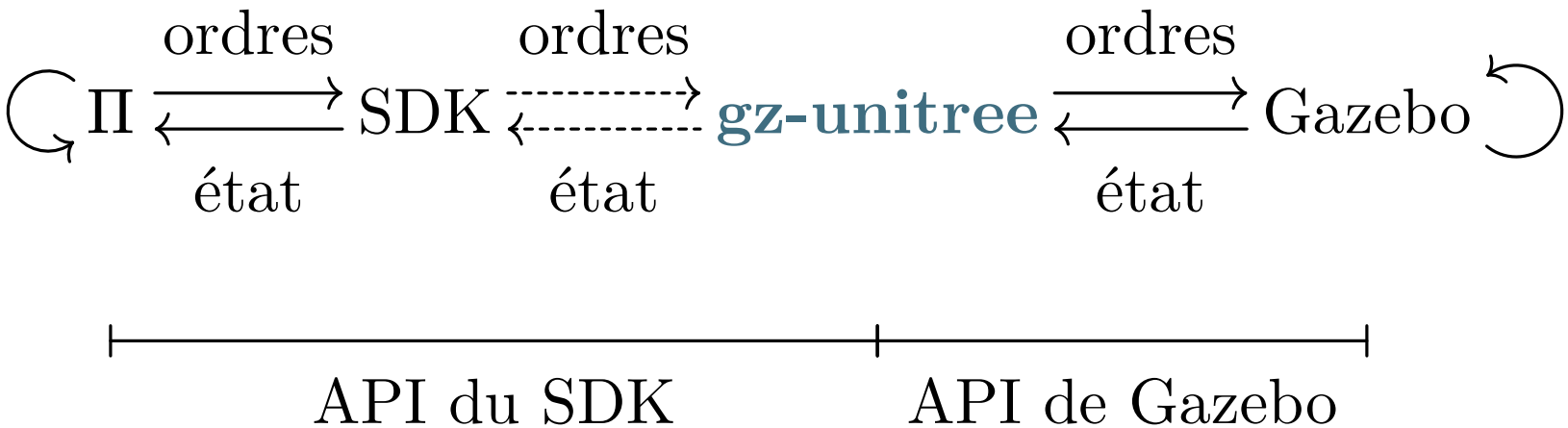
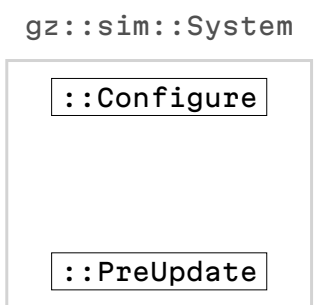
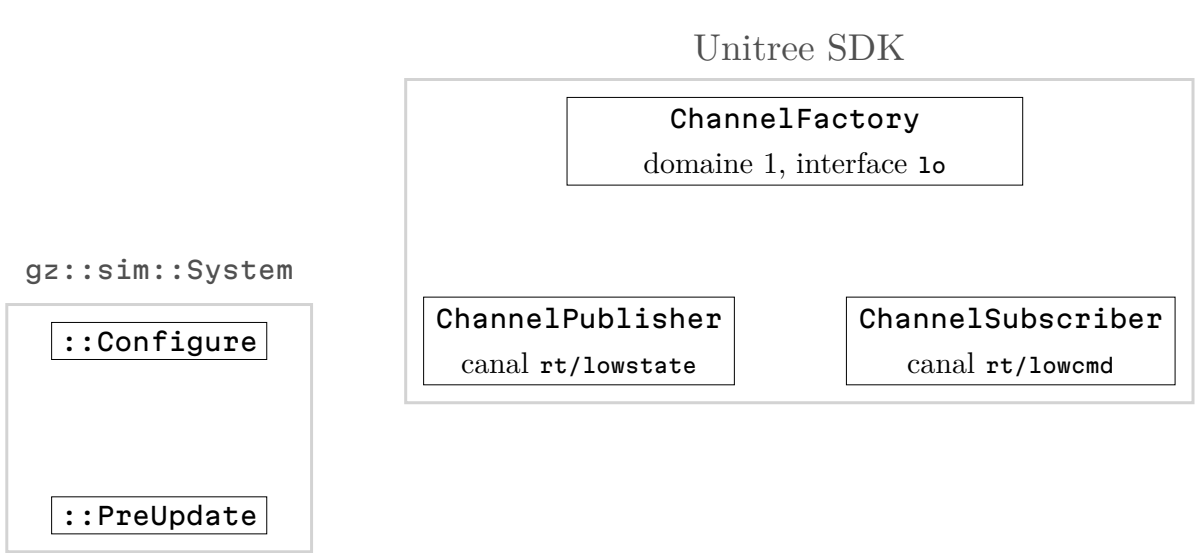



gz::sim::System
::Configure
::PreUpdate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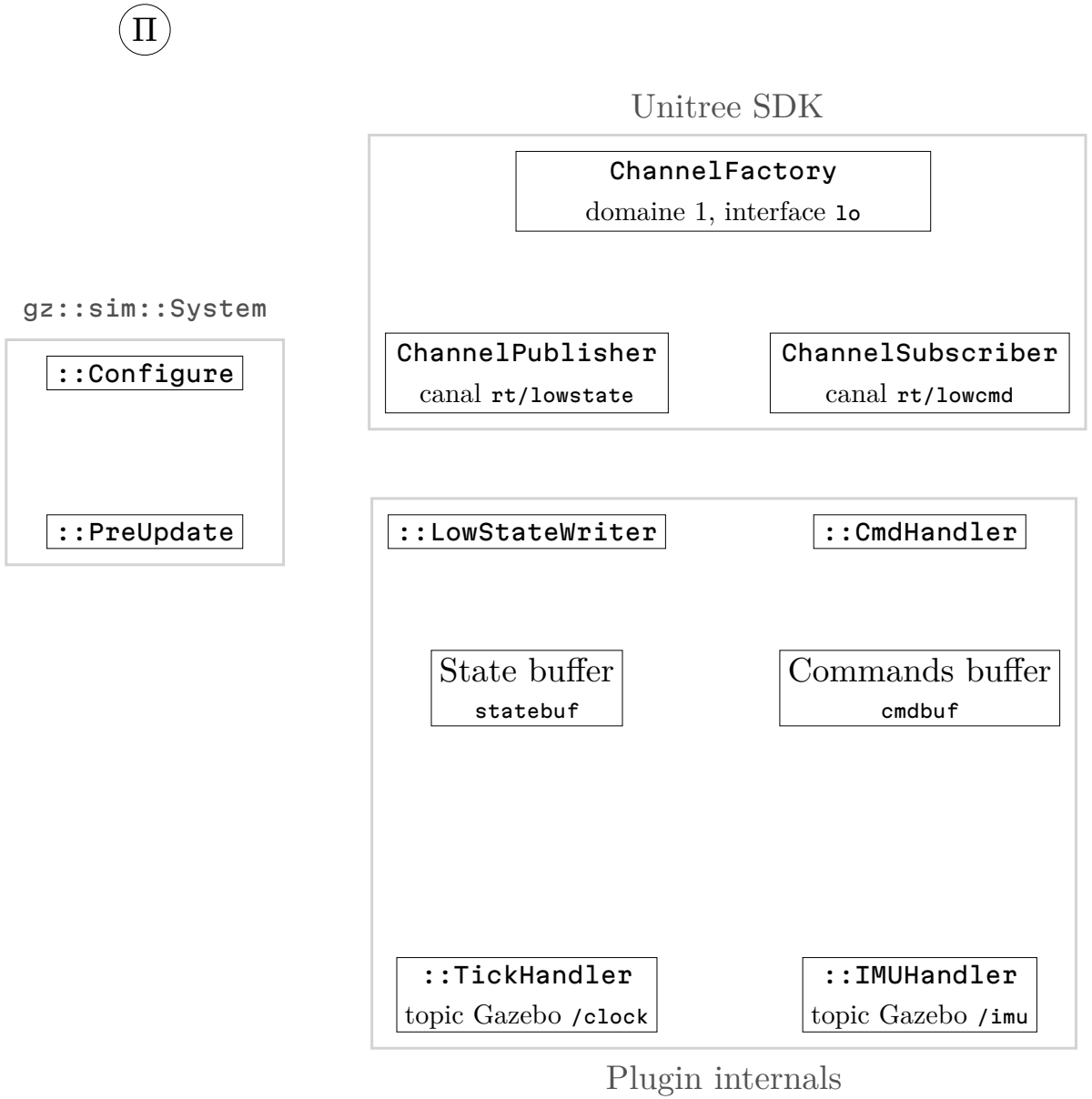
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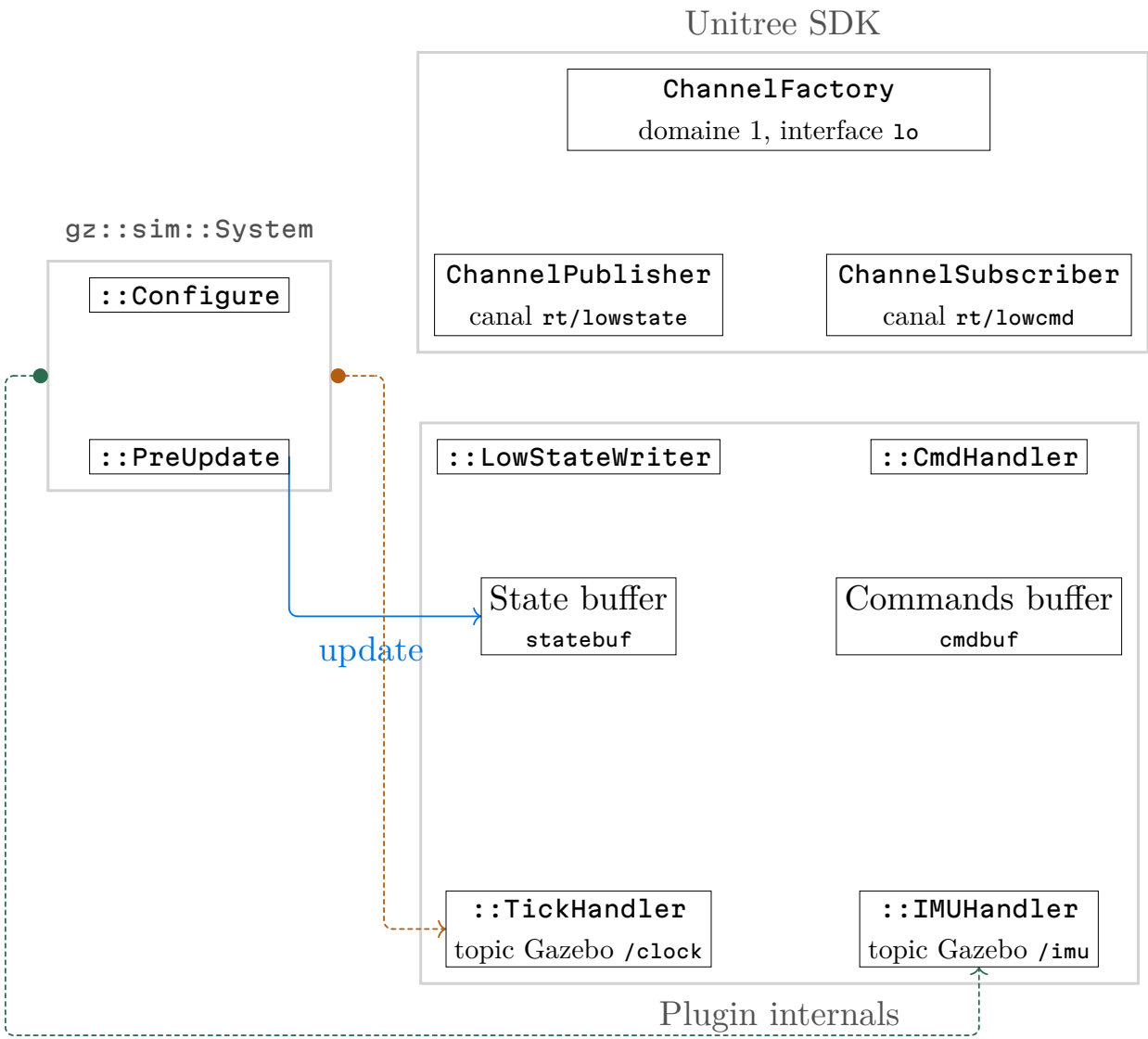
Plugin internals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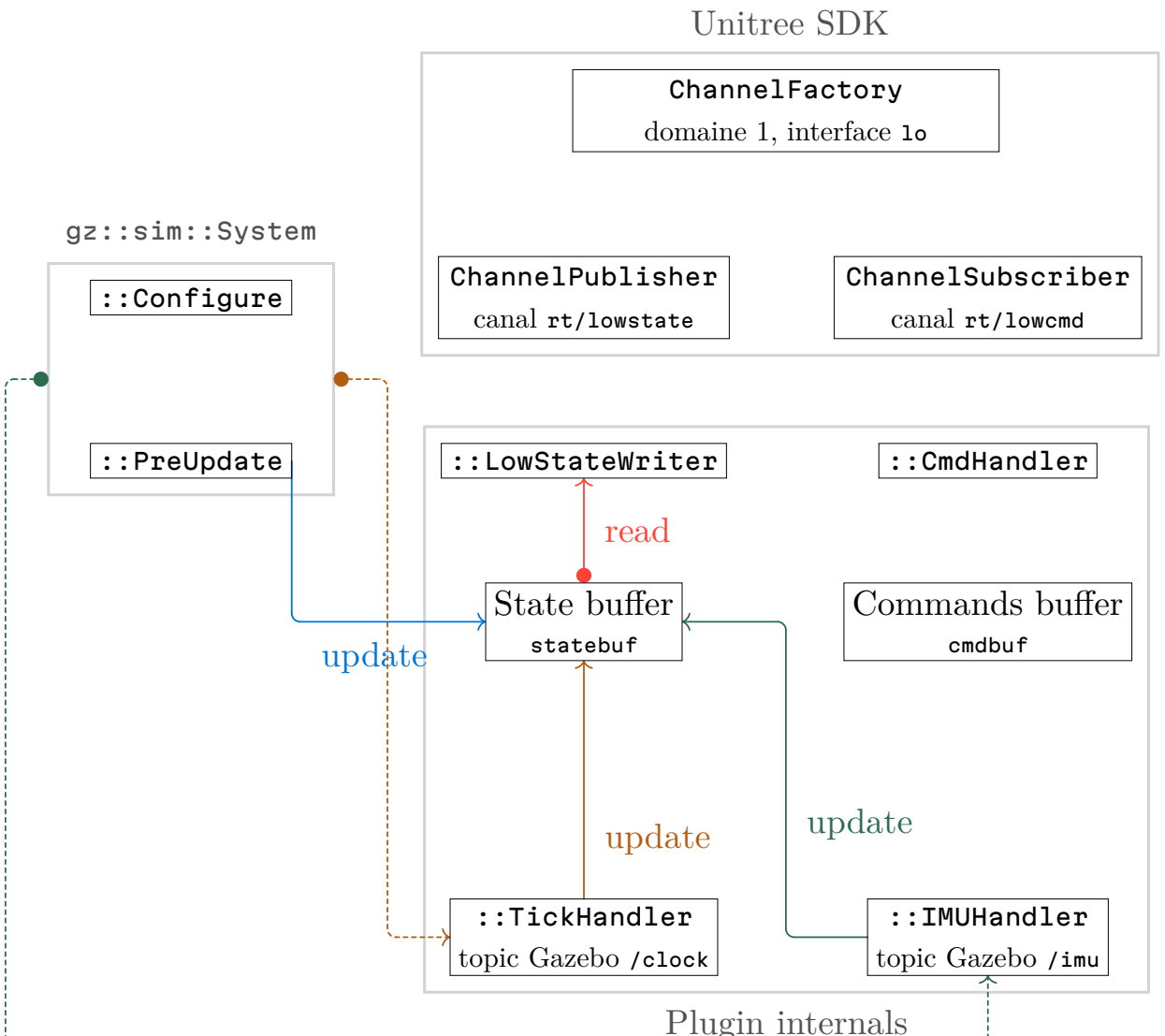
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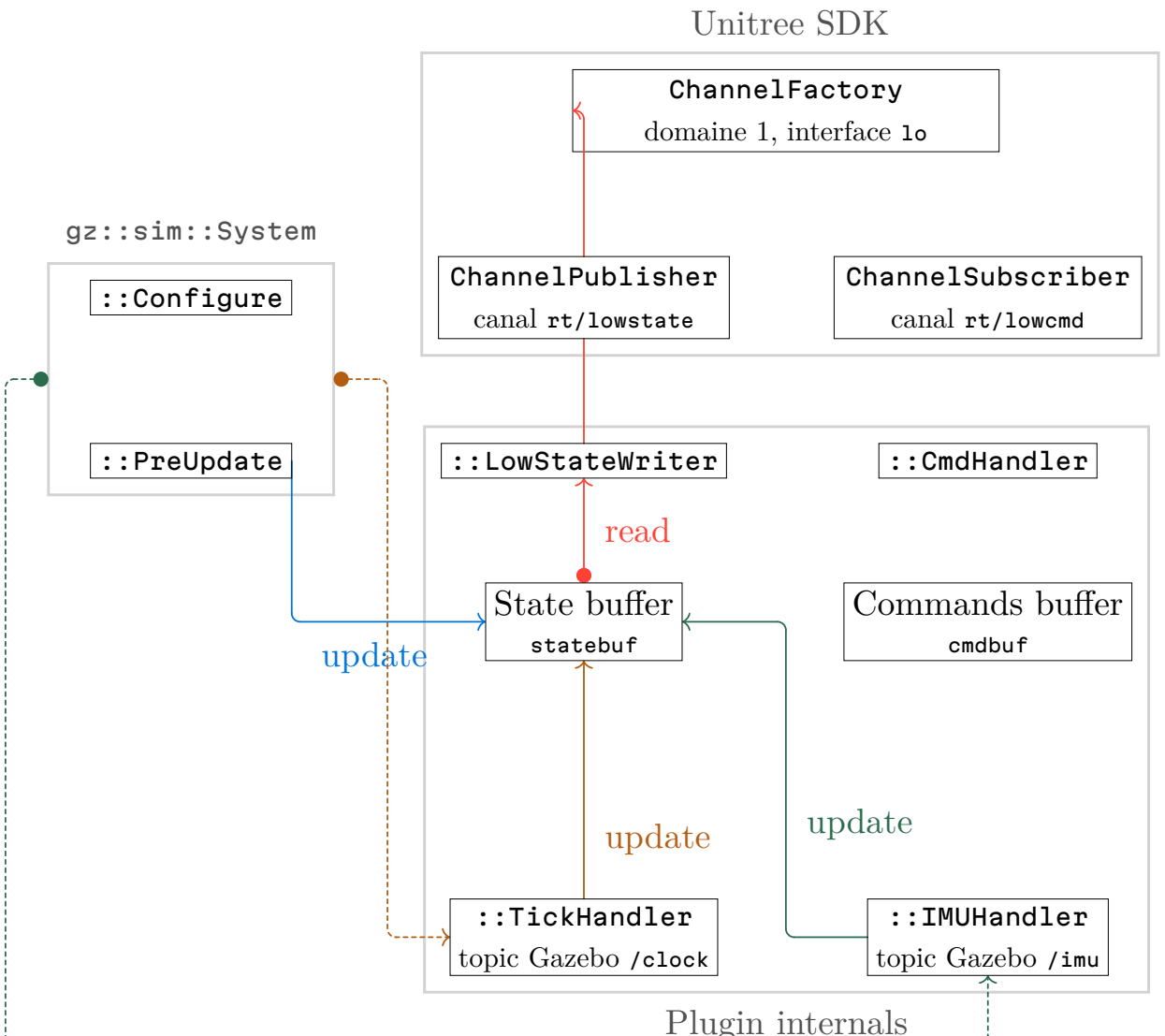
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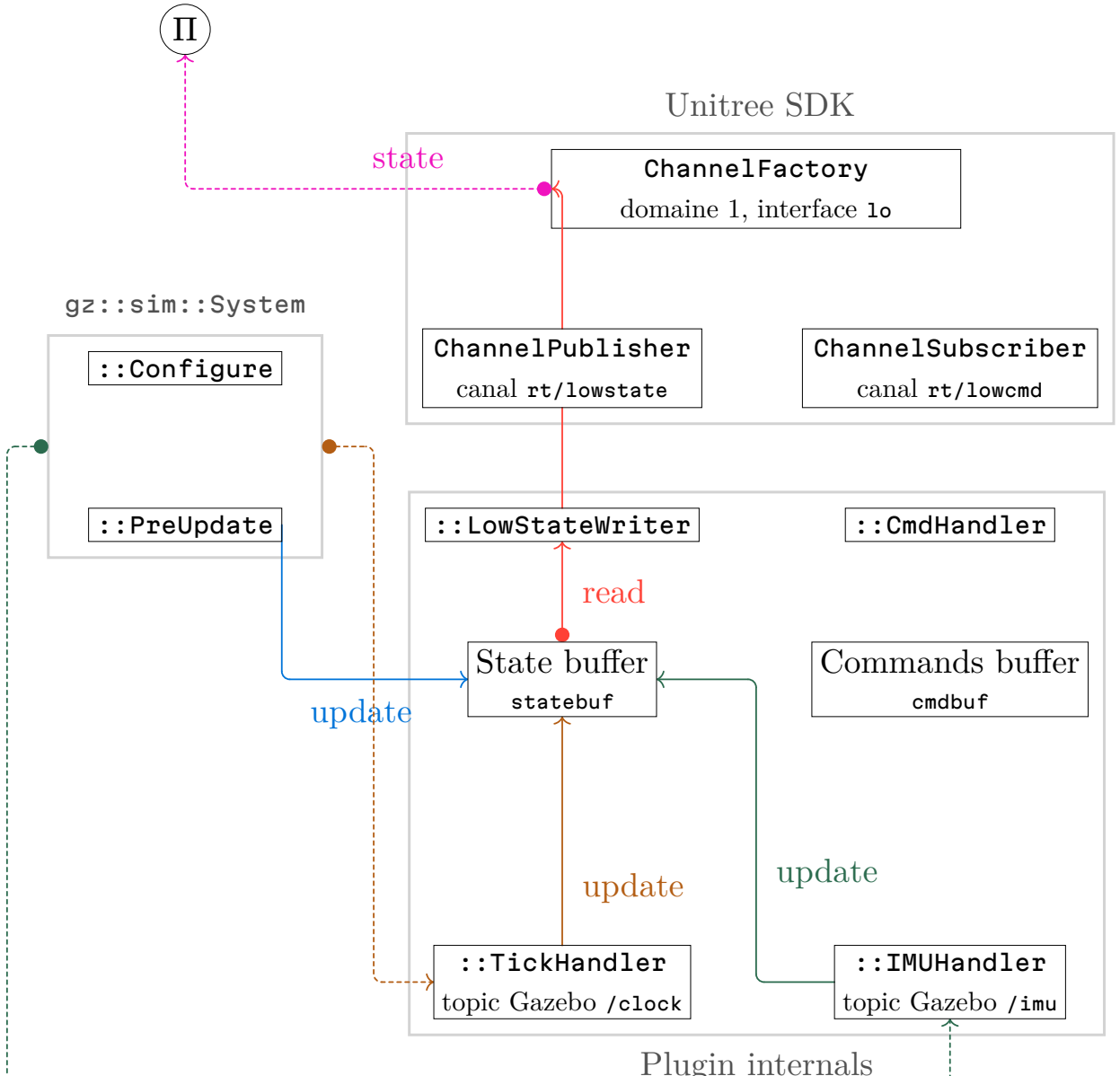
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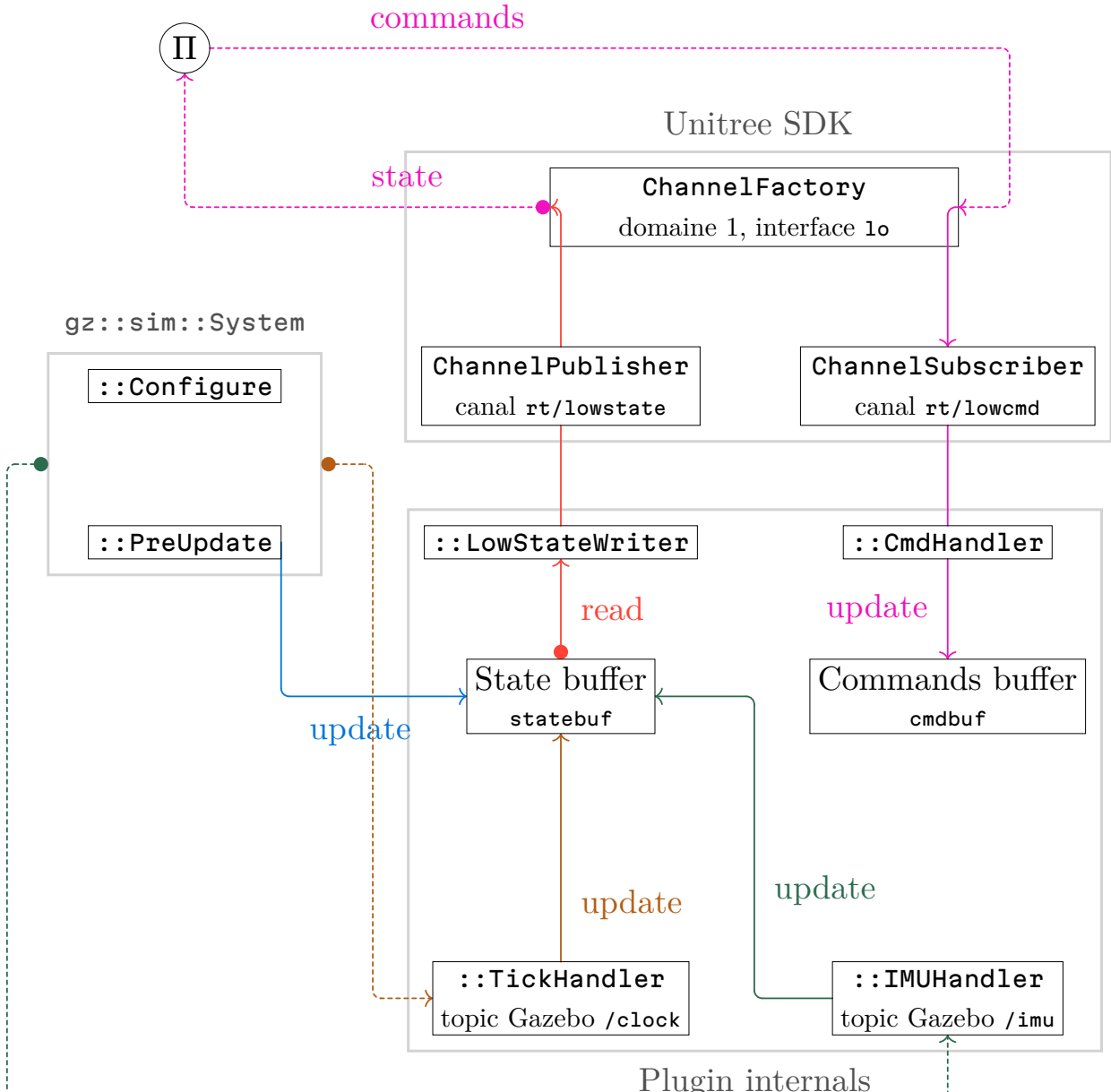
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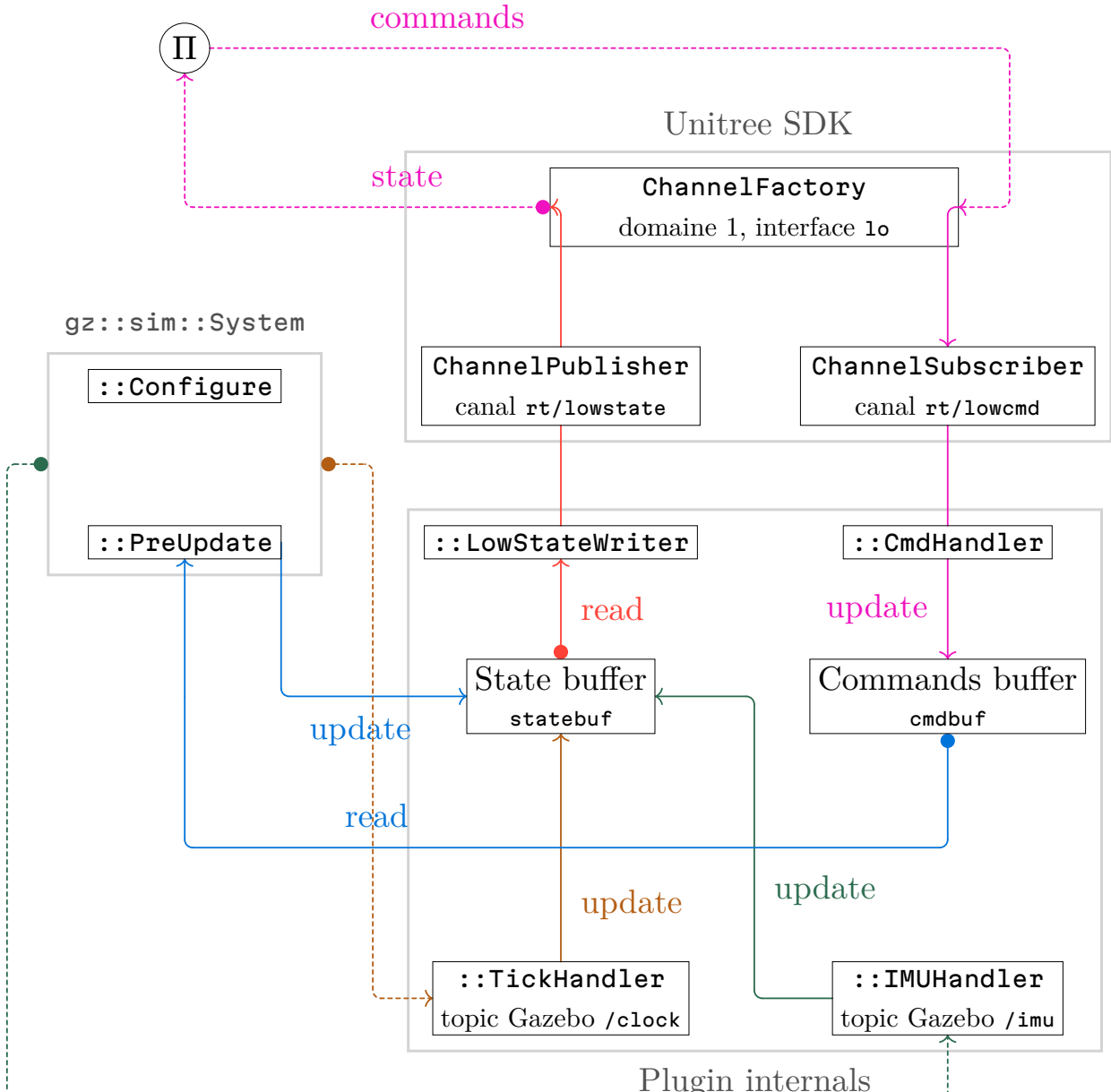
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Reproductibilité

Avec Nix

Reproductibilité

```
from datetime import date

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

Reproductibilité

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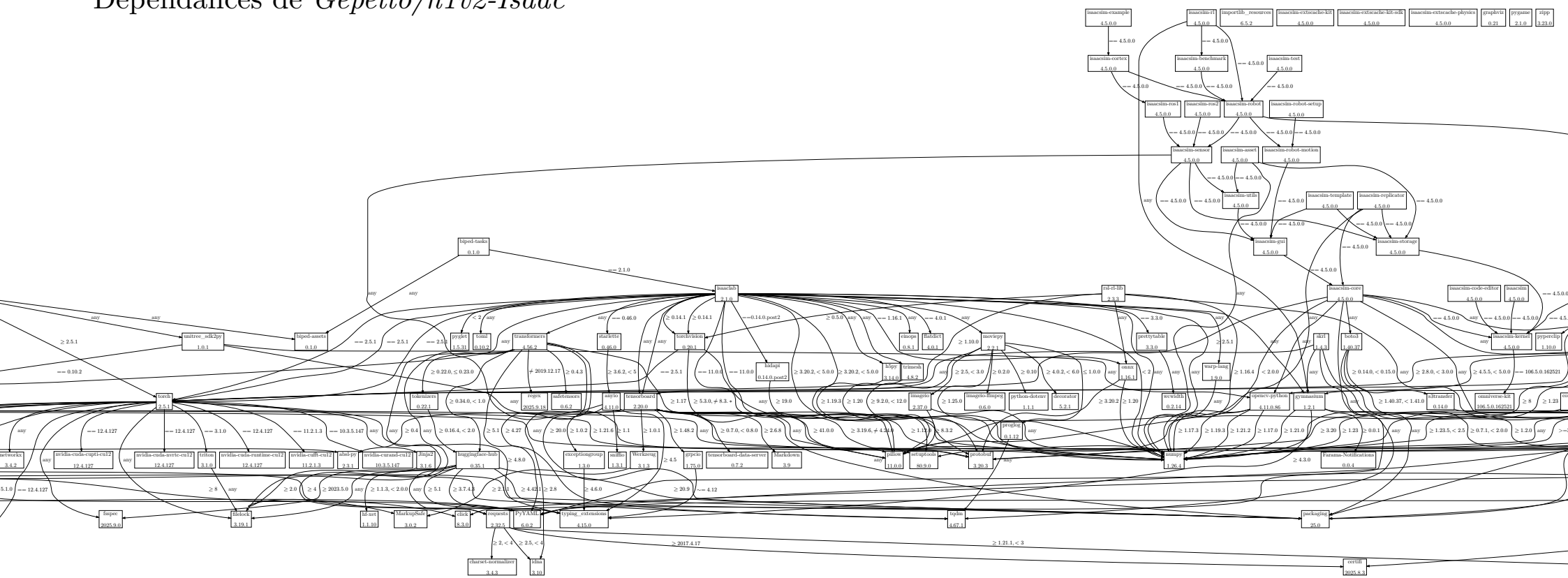
Reproductibilité

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 = { ... };
}
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  };

  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,
}:
```