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

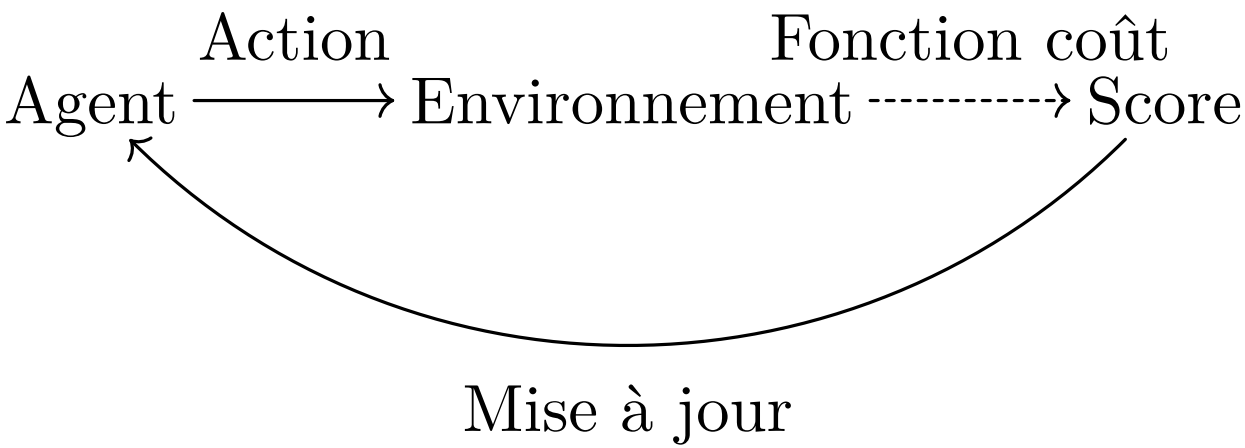
Agent Environnement Score

Bases du RL

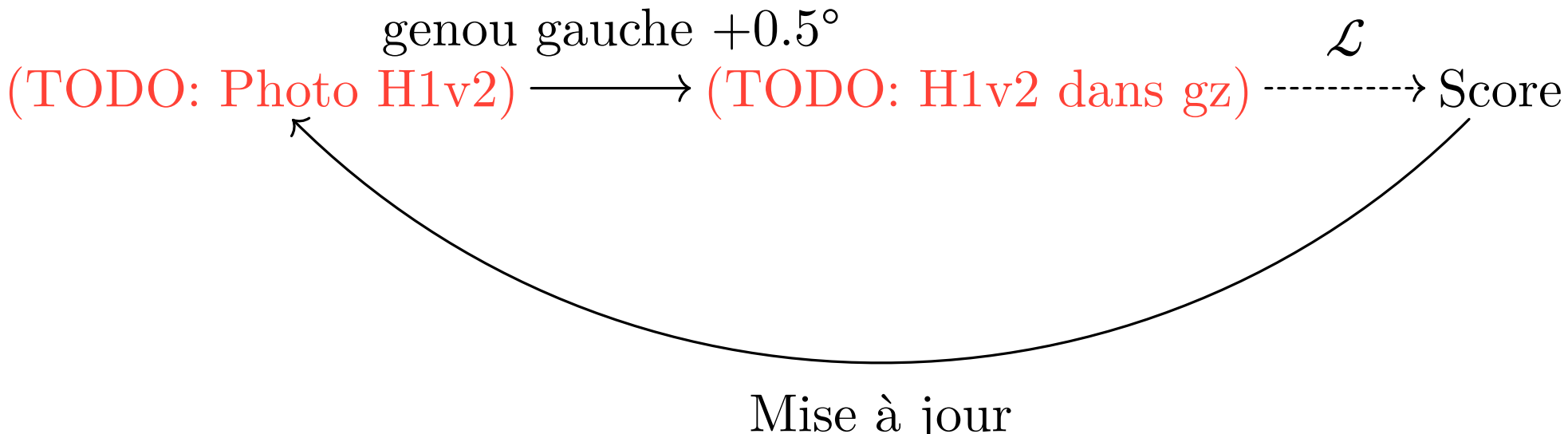
$$\text{Agent} \xrightarrow{\text{Action}} \text{Environnement} \qquad \text{Score}$$

Bases du RL

Bases du RL


Action
Fonction coût
Agent
Environnement
Score
Mise à jour

RL en robotique



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

C'est très simple:

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

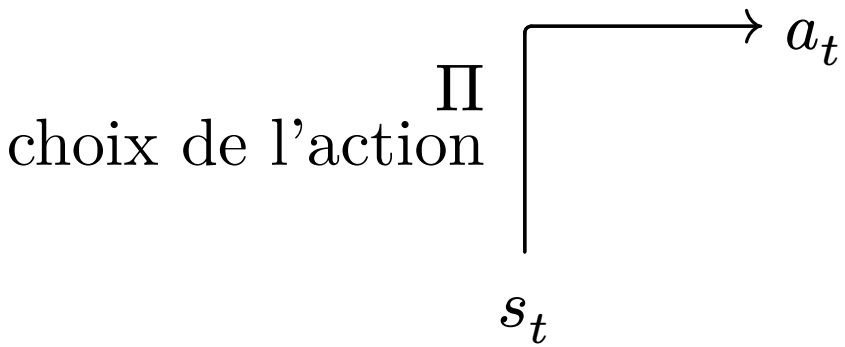
Comparaison des politiques

En Reinforcement Learning

Comparaison des politiques

$$s_t$$

Comparaison des politiques



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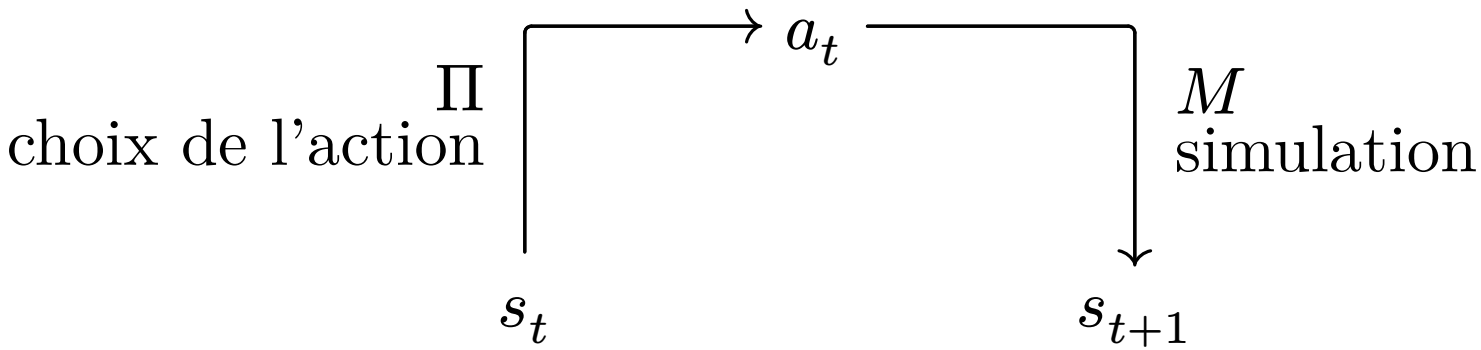

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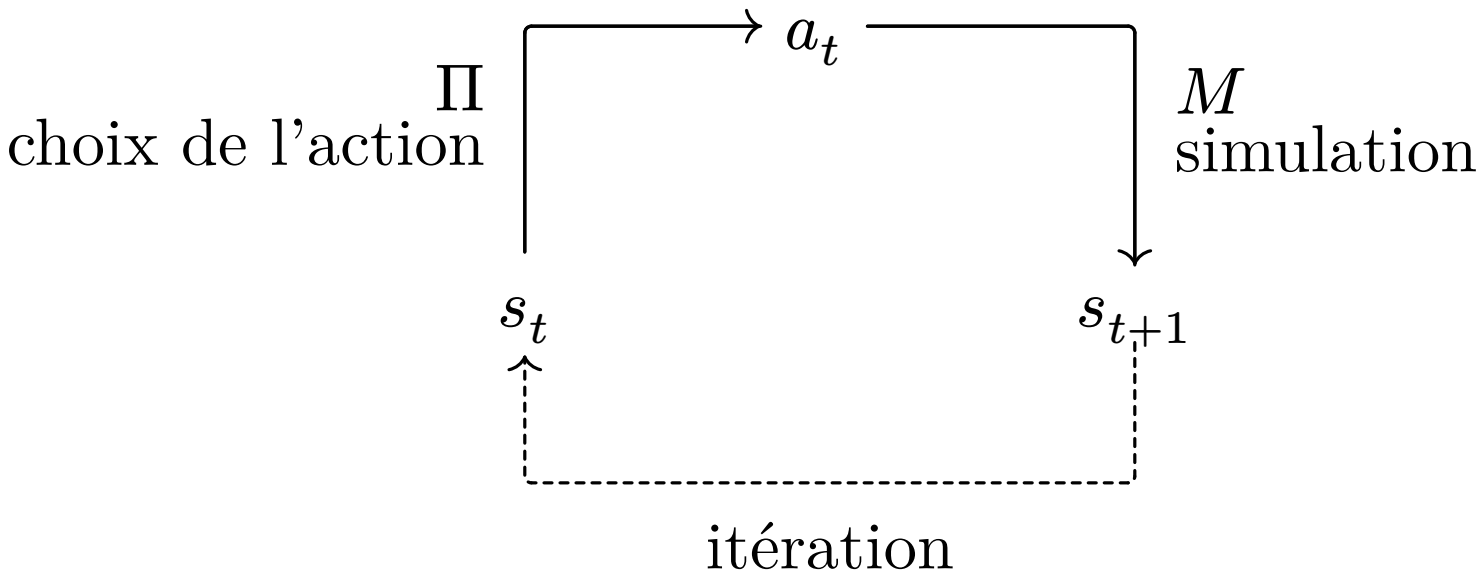

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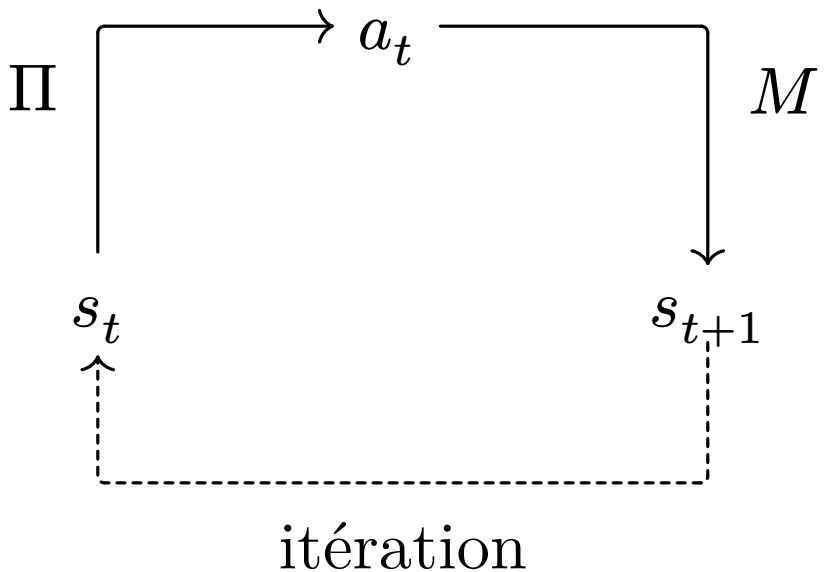
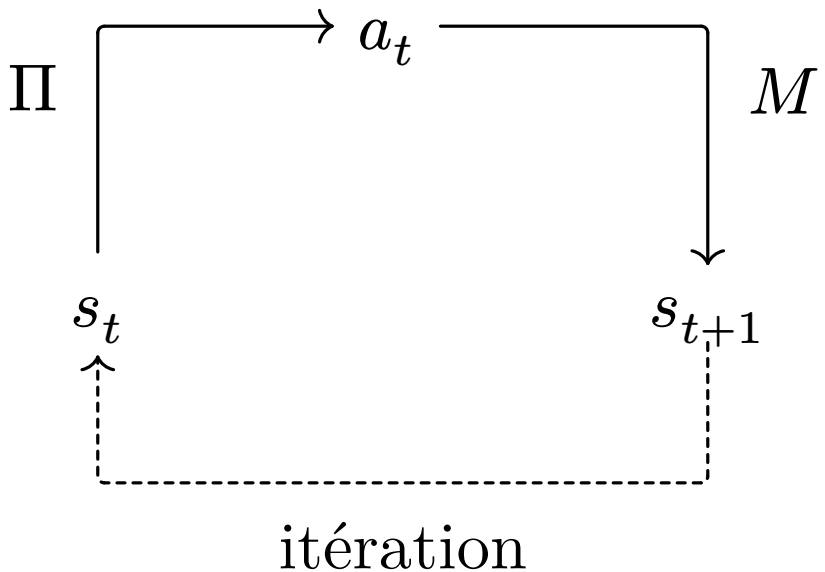


$$s_0 \xrightarrow{a_0} s_1 \xrightarrow{a_1} s_2 \xrightarrow{a_2} \cdots$$

Comparaison des politiques



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

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

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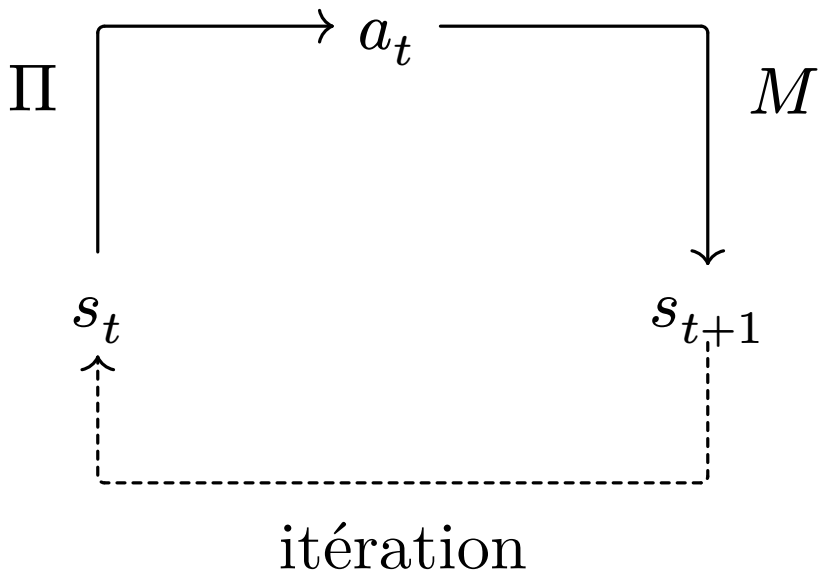

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$$((s_0, a_0), (s_1, a_1), (s_2, a_2), ...) \in \mathcal{C}$$

Comparaison des politiques

$A :=$ actions possibles

$S :=$ états possibles

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

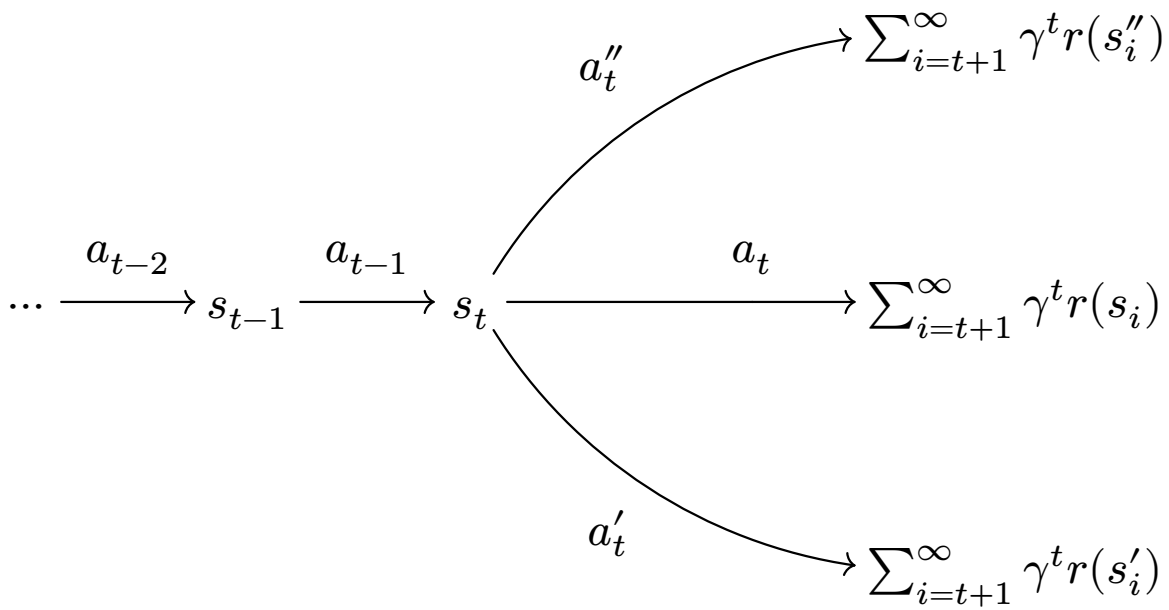
Comparaison des politiques: Avantage A

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



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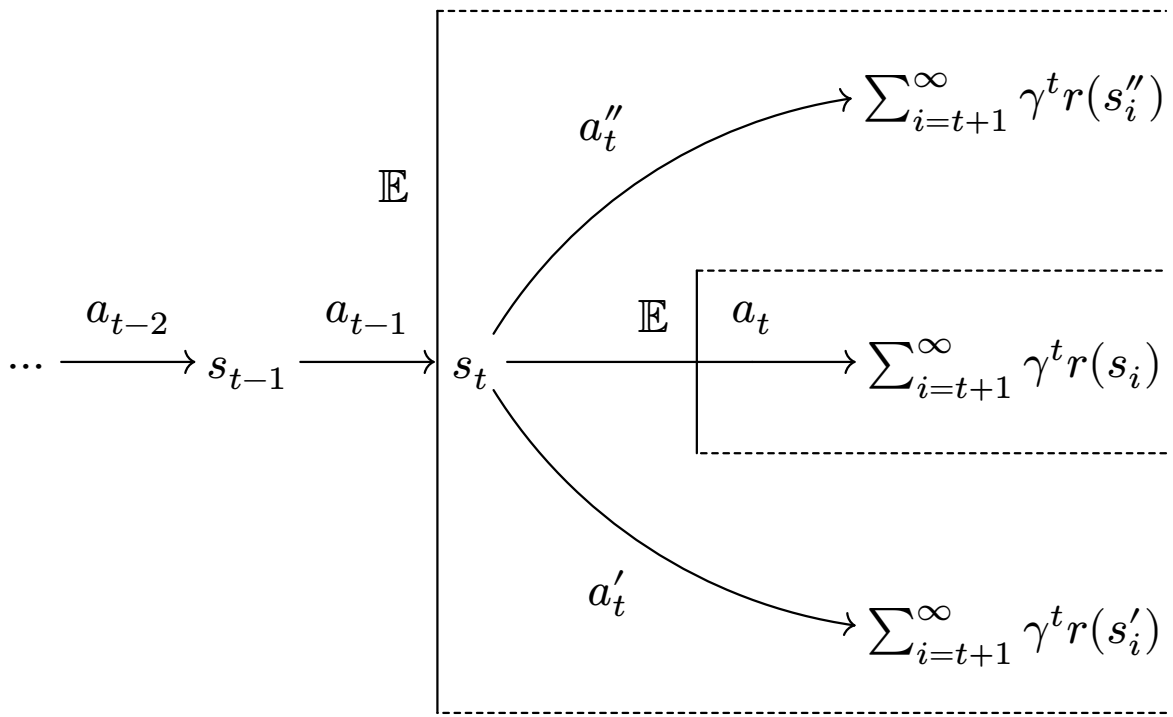

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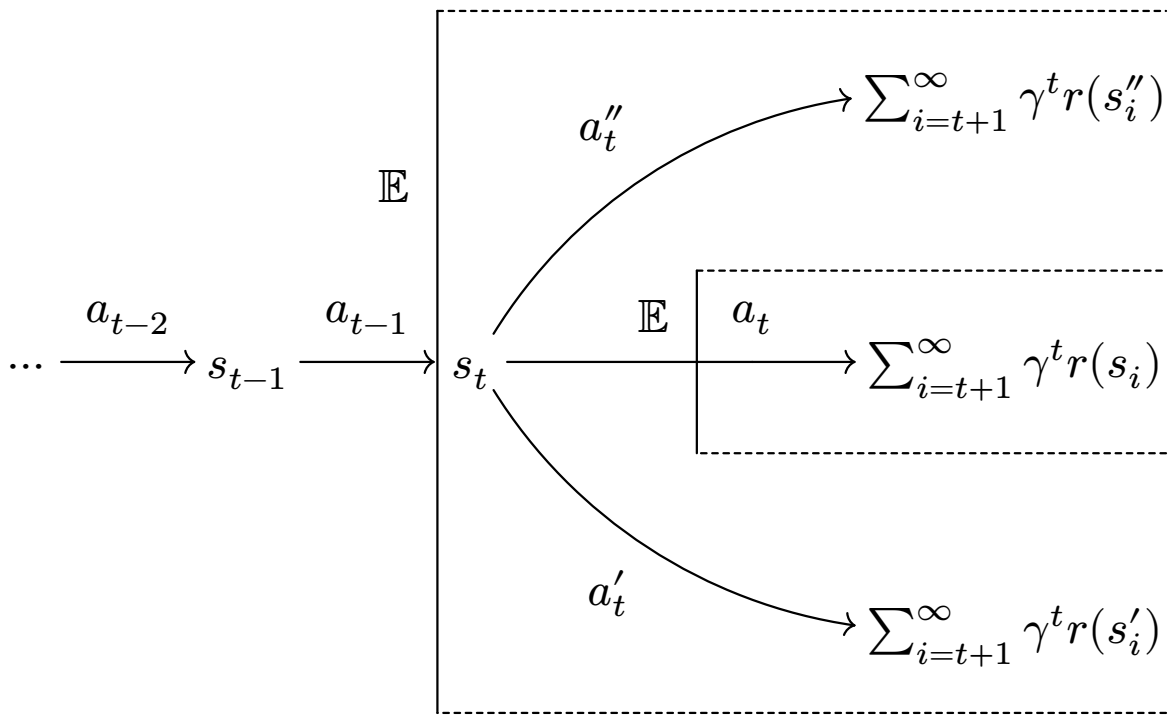

$$A_{\pi,r}(s,a) := \mathbb{E}(\text{avec } a_t) - \mathbb{E}(\text{à } t-1)$$

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Mise à jour de Π

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

Mise à jour de Π: distance entre politiques

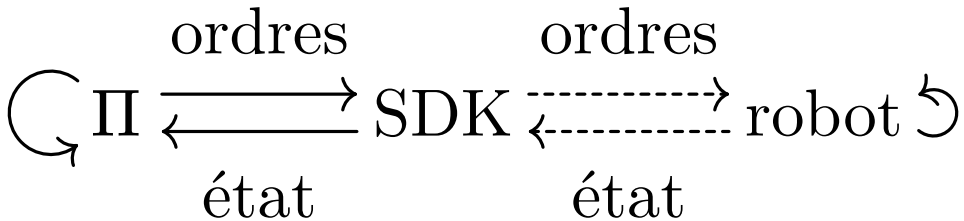
$$\text{distance}(\Pi', \Pi) := \max_{s \in S} D_{\text{KL}}(Q_{\Pi'}(s, \cdot) \parallel Q_{\Pi}(s, \cdot))$$

$$D_{\text{KL}}(P \parallel P') := \sum_{x \in \mathcal{X}} P(x) \log \frac{P(x)}{P'(x)}$$

Le *SDK*[1] d'Unitree

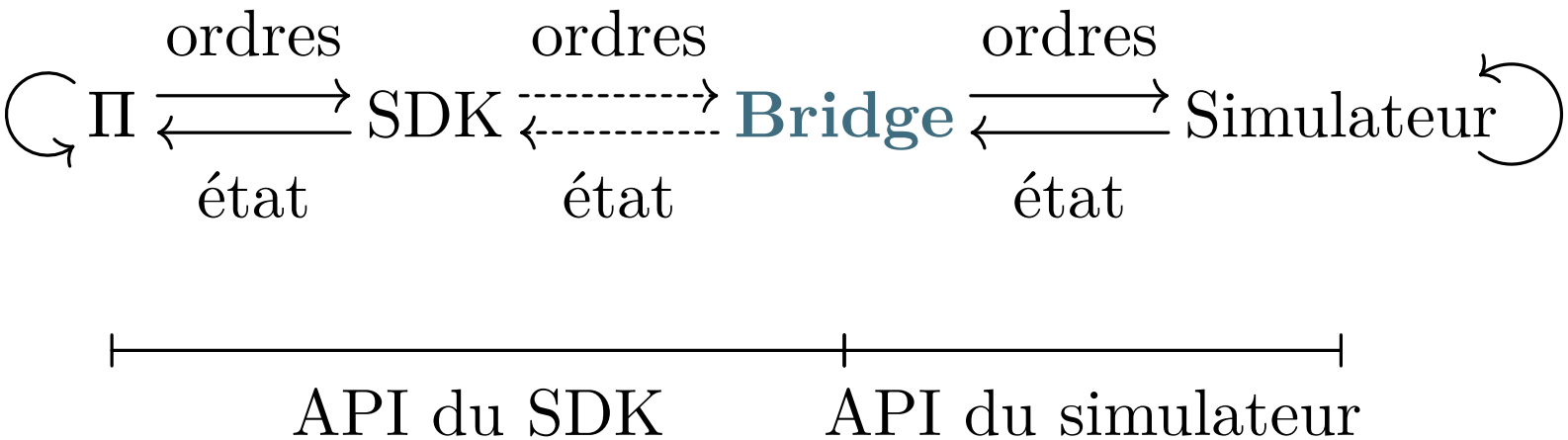
[1]Software Development Kit

Le SDK d'Unitree

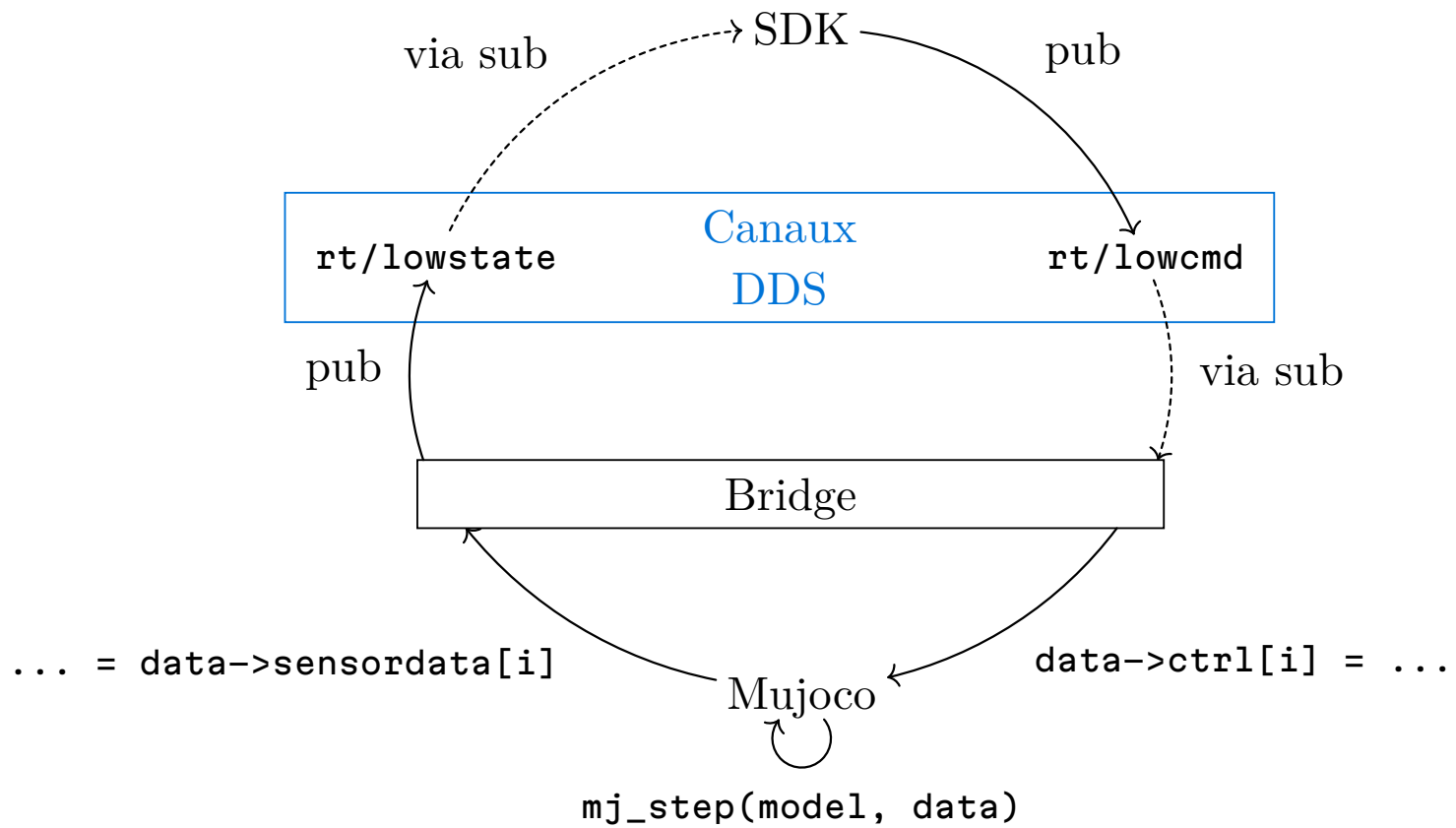


⇢ Message DDS

Le SDK d'Unitree



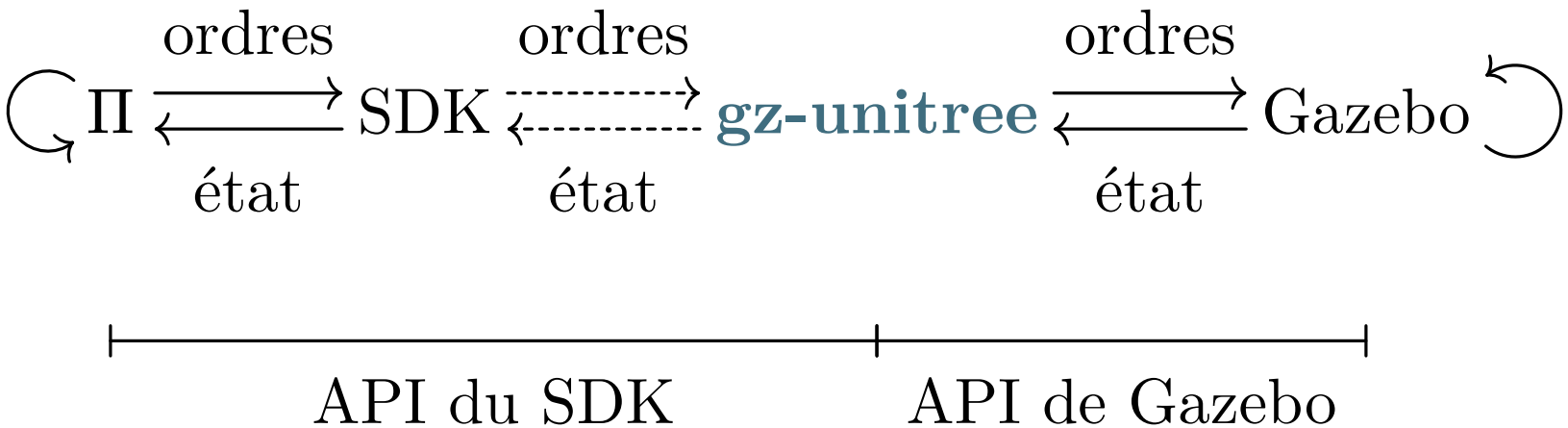
unitree_mujoco



Développement de *gz-unitree*

Un bridge pour Gazebo

Développement de *gz-unitree*



Développement de *gz-unitree*

```
#include <gz/sim/System.hh>
namespace gz_unitree
{
    class UnitreePlugin :
        public gz::sim::System,
        public gz::sim::ISystemPreUpdate
    {
    public:
        UnitreePlugin();
    public:
        ~UnitreePlugin() override;
    public:
        void PreUpdate(const gz::sim::UpdateInfo &_info,
                       gz::sim::EntityComponentManager &ecm) override;
    };
}
```

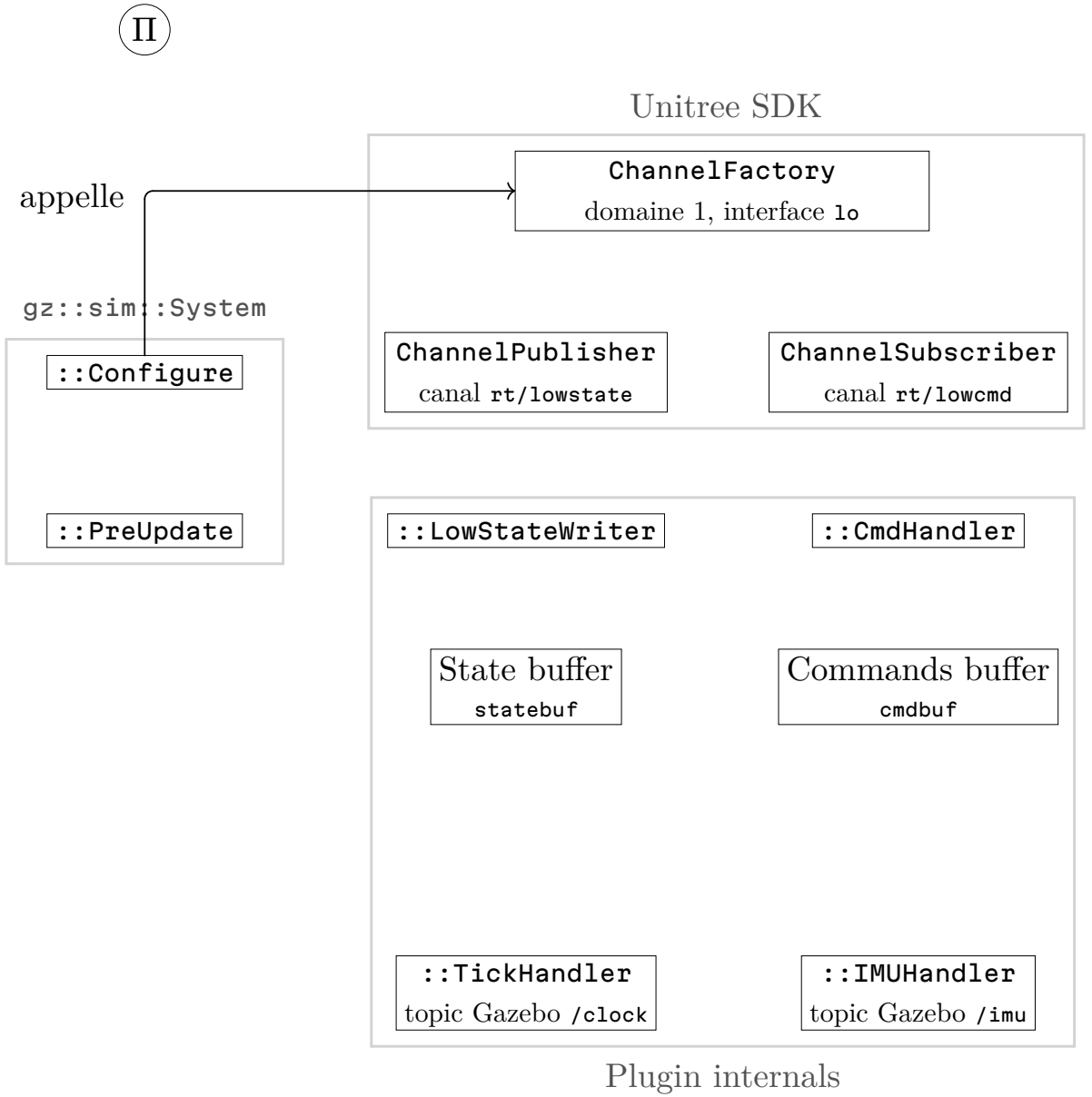
Développement de *gz-unitree*

```
#include <gz/plugin/Register.hh>

... // class implementation

GZ_ADD_PLUGIN(
    UnitreePlugin,
    gz::sim::System,
    UnitreePlugin::ISystemPreUpdate)
```

```
<sdf version='1.11'>
<world name="default">
  <plugin filename="gz-unitree"
name="gz_unitree::UnitreePlugin">
  </plugin>
</world>
<model name='h1_description'>
  <link name='pelvis'>
    <inertial>
    ...
```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ChannelFactory
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::LowStateWriter
::CmdHandler
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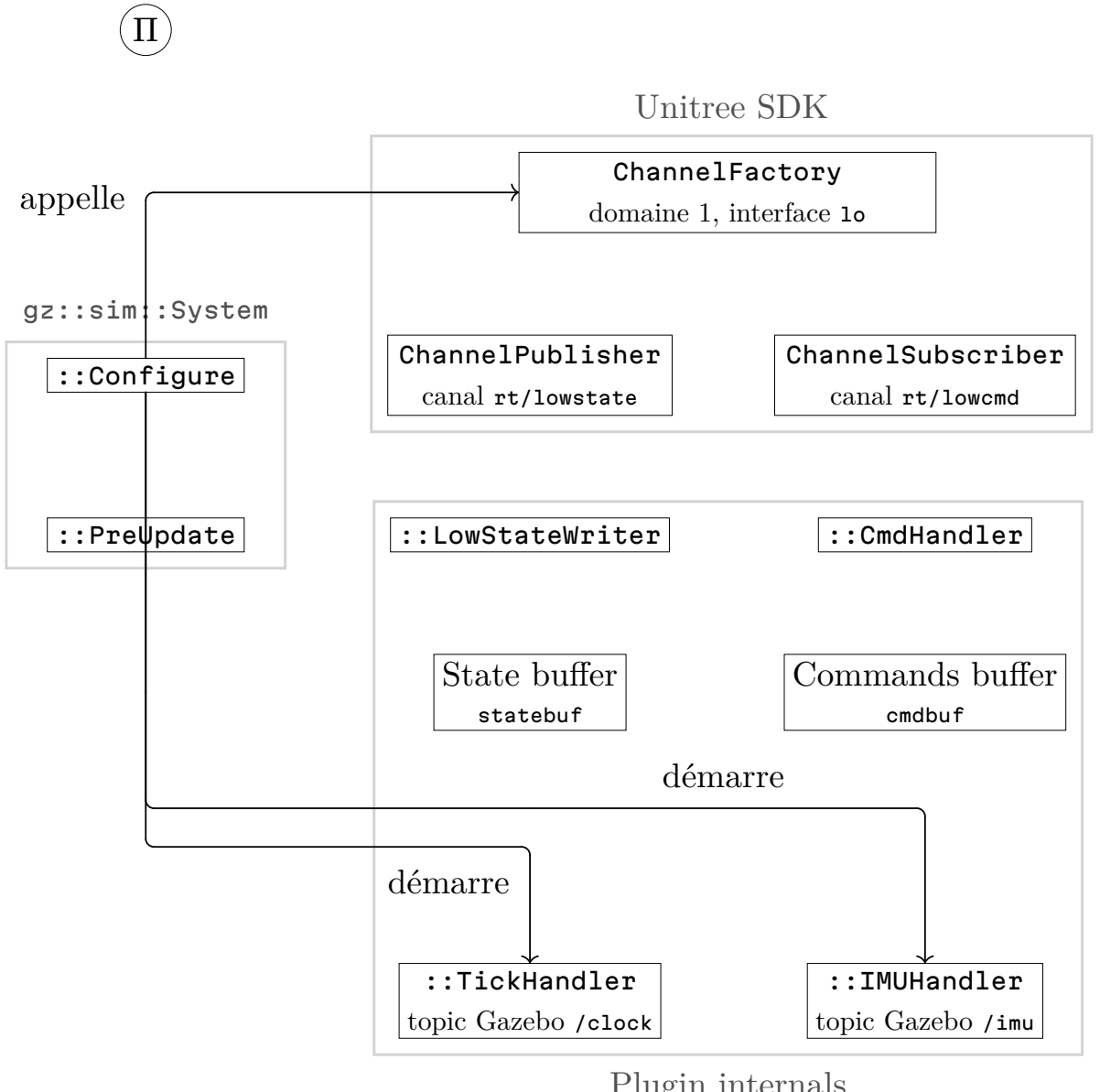
Plugin internals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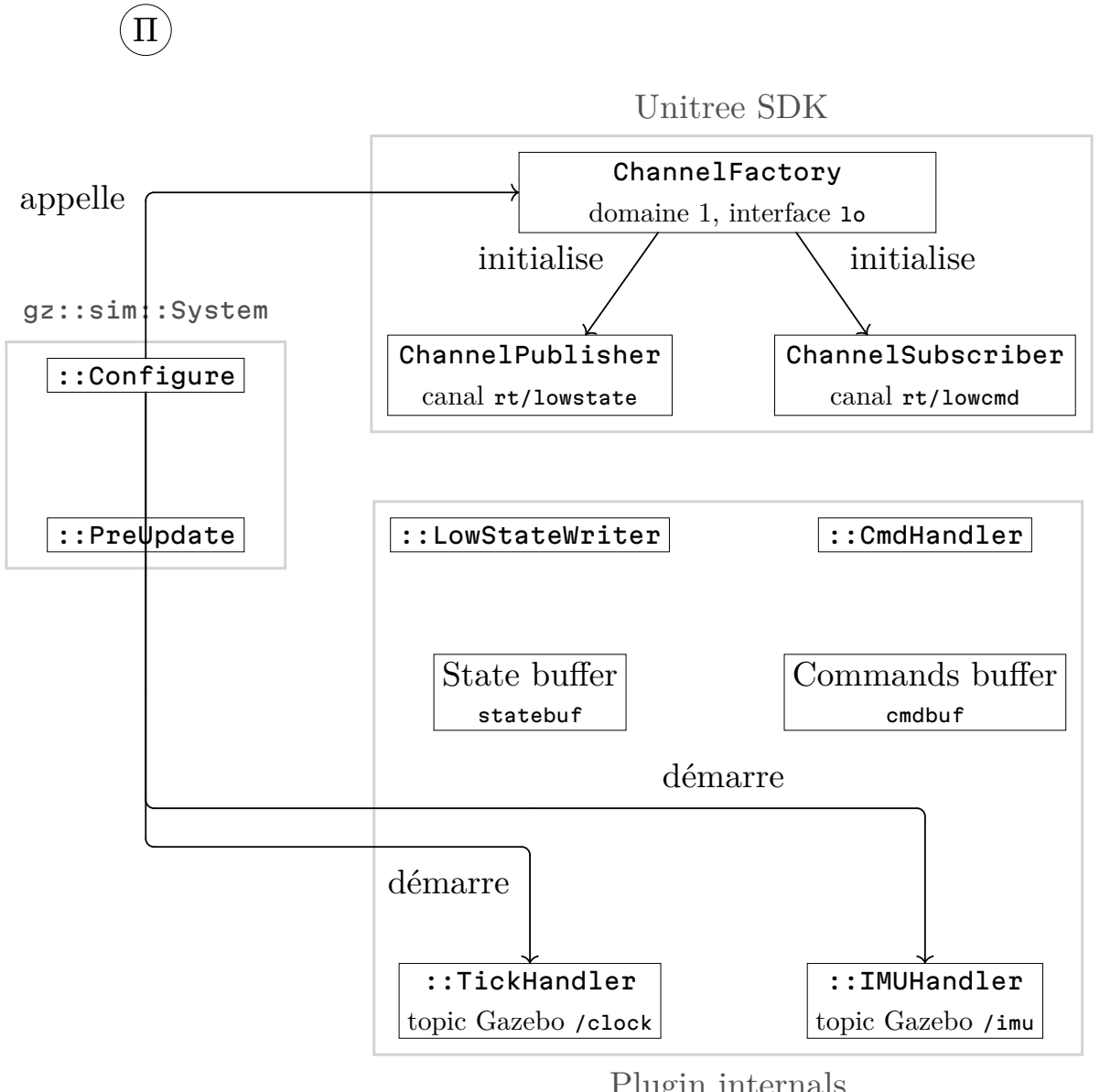
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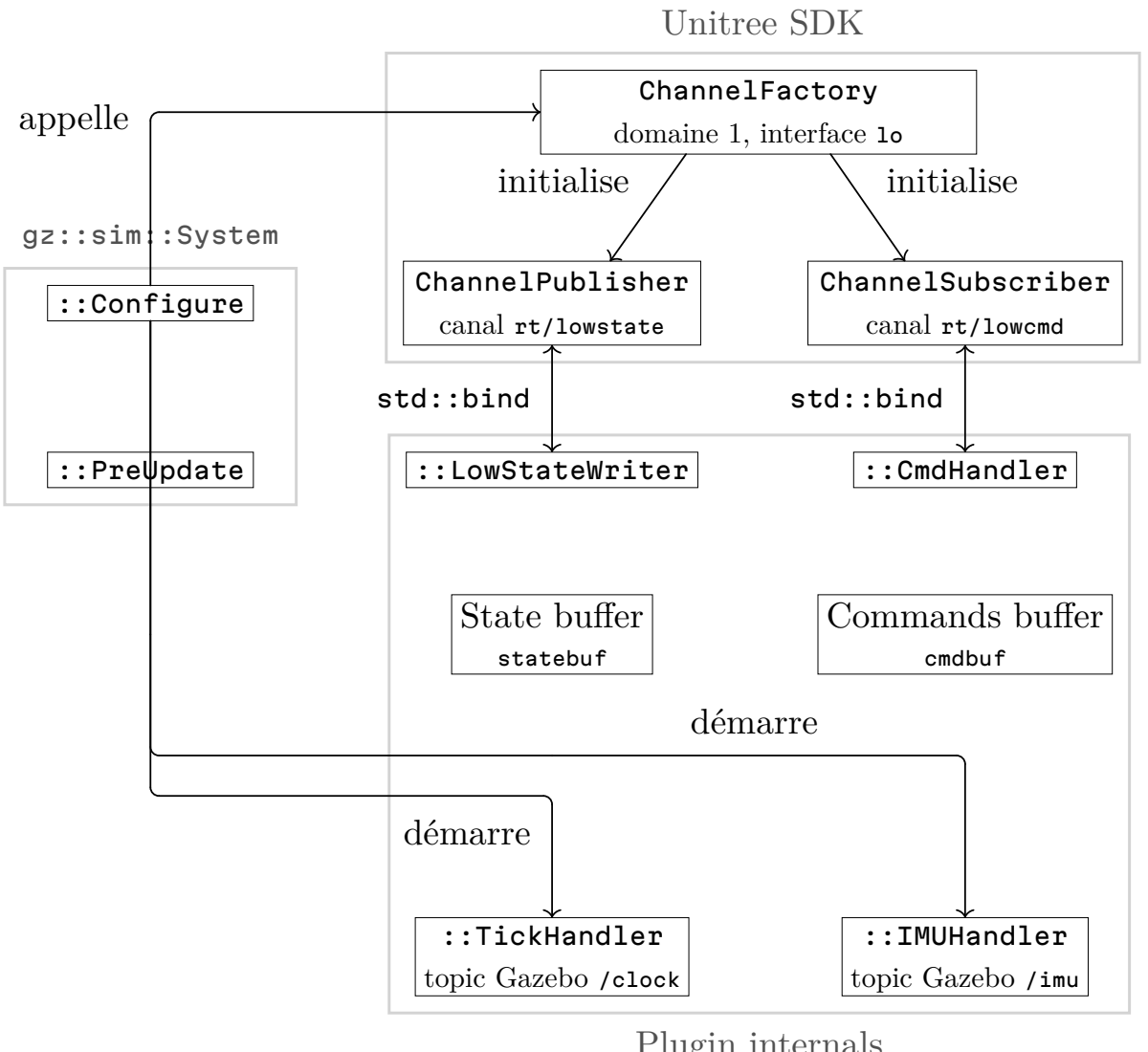
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