1 Introduction

In this document we present a simply specification of a watergate system where the watergates and pumps of some pools are controlled.

2 Static configuration of the system

Here we describe the components of the system which won't change during the operation of the watergates.

Normally we would specify the pools and gates as given sets. But to simplify the animation of a certain model, we explicit name each pool and gate.

$$POOL ::= pool1 \mid pool2 \mid pool3 \mid pool4 \mid pool5$$
$$GATE ::= gate1 \mid gate2 \mid gate3 \mid gate4$$

2.1 The pools

Every pool has a minimum and maximum gauge. Rivers and canals whose gauge is not under control of the system, have the same maximum and minimum gauge. *mingauge* and *maxgauge* wouldn't are given explicit to simplify animation.

$$\begin{array}{|l}
mingauge, maxgauge : POOL \rightarrow \mathbb{N} \\
\hline
\forall\, p : POOL \bullet mingauge\ p \leq maxgauge\ p \\
mingauge = \{(pool1, 1), (pool2, 1), (pool3, 2), (pool4, 2), (pool5, 3)\} \\
maxgauge = \{(pool1, 1), (pool2, 2), (pool3, 2), (pool4, 3), (pool5, 3)\}
\end{array}$$

2.2 The gates

Every gate connects two pools. As above the explicit connections are given to simplify the animation.

$$\begin{array}{|l}
connect : GATE \rightarrow (\mathbb{P}\, POOL) \\
\hline
\forall\, r : \operatorname{ran} connect \bullet \#\, r = 2 \\
connect = \{(gate1, \{pool1, pool2\}), (gate2, \{pool2, pool3\}), \\
\qquad (gate3, \{pool3, pool4\}), (gate4, \{pool4, pool5\})\}
\end{array}$$

3 State of pools and gates

Each pool has a current gauge which is between the pool's minimum and maximum gauge. We save the set of opened gates, all other gates are closed. If a gate is open, the pools on both sides of the gate must have the same gauge.

$$
\begin{array}{|l}
\hline \textit{State} \\
\quad \textit{gauge} : \textit{POOL} \rightarrow \mathbb{N} \\
\quad \textit{opengates} : \mathbb{P}\, \textit{GATE} \\
\hline
\quad \forall\, p : \textit{POOL} \\
\qquad \bullet\ \textit{mingauge}(p) \leq \textit{gauge}(p) \wedge \textit{gauge}(p) \leq \textit{maxgauge}(p) \\
\quad \forall\, g : \textit{opengates};\ p1, p2 : \textit{POOL} \mid \textit{connect}\ g = \{p1, p2\} \\
\qquad \bullet\ \textit{gauge}(p1) = \textit{gauge}(p2) \\
\hline
\end{array}
$$

4 Operations on the state

4.1 Opening and closing of the gates

An Operation on the gates doesn't change the gauges of the pools. Every Operation takes an gate as an argument.

$$
\begin{array}{|l}
\hline \textit{GateOperation} \\
\quad \Delta \textit{State} \\
\quad \textit{gate?} : \textit{GATE} \\
\hline
\quad \textit{gauge}' = \textit{gauge} \\
\hline
\end{array}
$$

It's possible to close an open gate everytime.

$$
\begin{array}{|l}
\hline \textit{Close} \\
\quad \textit{GateOperation} \\
\hline
\quad \textit{gate?} \in \textit{opengates} \\
\quad \textit{opengates}' = \textit{opengates} \setminus \{\textit{gate?}\} \\
\hline
\end{array}
$$

It's only possible to open closed gates when the gauge of the pools on both sides of the gate is the same.

$$
\begin{array}{|l}
\hline \textit{Open} \\
\quad \textit{GateOperation} \\
\hline
\quad \textit{gate?} \notin \textit{opengates} \\
\quad \textit{opengates}' = \textit{opengates} \cup \{\textit{gate?}\} \\
\quad \forall\, p1, p2 : \textit{POOL} \mid \textit{connect}\ \textit{gate?} = \{p1, p2\} \bullet \textit{gauge}\ p1 = \textit{gauge}\ p2 \\
\hline
\end{array}
$$

4.2 Raising and lowering of the gauges

An Operation on the pools does not change the state of the gates. It's only possible to lower or raise pools, which gates are all closed.

$$
\begin{array}{|l}
\hline \textit{PoolOperation} \\
\quad \Delta \textit{State} \\
\quad \textit{pool?} : \textit{POOL} \\
\hline
\quad \textit{opengates}' = \textit{opengates} \\
\quad \forall\, g : \textit{opengates} \bullet \textit{pool?} \notin \textit{connect}\ g \\
\hline
\end{array}
$$

It's only possible to raise the gauge of a pool if it's maximum is not reached yet.

$$
\begin{array}{|l}
\textit{Raise} \\
\hline
PoolOperation \\
\hline
gauge(pool?) < maxgauge(pool?) \\
gauge' = gauge \oplus \{pool? \mapsto gauge(pool?) + 1\} \\
\hline
\end{array}
$$

It's only possible to lower the gauge of a pool if it's minimum is not reached yet.

$$
\begin{array}{|l}
\textit{Lower} \\
\hline
PoolOperation \\
\hline
gauge(pool?) > mingauge(pool?) \\
gauge' = gauge \oplus \{pool? \mapsto gauge(pool?) - 1\} \\
\hline
\end{array}
$$

5 Initialisation

The systems starts in a state where all gates are closed and all the water gauges are on the minimum.

$$
\begin{array}{|l}
\textit{Init} \\
\hline
State' \\
\hline
gauge' = mingauge \\
opengates' = \varnothing \\
\hline
\end{array}
$$