Worlds: A distributed MMO

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Abstract. A protocol defining how anyone can join or contribute to a completely unbounded universe could allow the flexibility to organically grow an MMO faster and more efficiently then any proprietary closed system. This paper will overview a truly limitless yet fair protocol that allows developers to bolt their code into in common universe.

1 Introduction

For an open software ecosystem to grow organically there should be outlets for people to contribute. In the context of a massively multiplayer online game these currently do not exist. The fairness and security of the game are entirely dependent on the network forming consensus on what is considered to be the truth. It's trivial to solve this using conventional methods. A server maintains a secure connection with a player and the player pipes his actions to the server. The server then provides ground truth for the network. Distributed systems require a very different approach. Blockchains present clear deficiencies, they are too slow and the chain would get too large. A completely alternate consensus method will now be presented...

2 Worlds

2.1 Overview

A world, defined as w_k, is a node that forms consensus among it's own domain. It's possible for any node in the network to be a world. A world can have up to four adjacent worlds determined by itself. Players, defined as P_k, can enter a world one of two ways, the first being a **player genesis**(2.5), and the second being a **world transfer** (2.4). Worlds, just like players have their own RSA key pair.

2.2 Action Ledger

An action ledger, defined as $AL(P_k, w_k)$, is a chronological list of all the signed actions and reactions that has happened to a player in a world. In order to commit an action a player must concatenate current unix time with the action, then sign and sent to the world. If the action is legal, it is entered into the world's action ledger for that player. If reactions are to occur to a player, the world must concatenate current unix time with the reaction then sign and sent to the player. Players are required to keep their actions ledger dating back to their genesis, worlds are only required to keep **transport hashes** (2.3).

2.3 Transport Hash

A transport hash is a hash of an action ledger, $h_s(AL(P_k, w_k))$, these are secured by the worlds and are used to prove a player is presenting an honest action ledger. The transport hash is formed when a player leaves the world. A **Forward Transport Hash** is just a transport hash kept in a special location. This is explained more in the world transfer section, it is defined as $h_{sf}(AL(P_k, w_k))$

2.4 World Transfer

A detailed state machine outlines how players can move about neighboring worlds. Honest worlds must follow this procedure to maintain fairness, if they misbehave they could be risking a **World Disconnect** (3.2) from their neighboring worlds.

Eg: Lets say a player, defined as P_1, wants to move from w_1 to w_2 (Figure 1) and then to w_3, The network values in this scenario are defined as...

Fig. 1. P_1 moving from w_1 to w_2

$$\begin{tikzcd} w_1 \arrow[r, "P_1"] & w_2 \arrow[r, dash] & w_3 \end{tikzcd}$$

	w_1	w_2	w_3
$h_s(AL(P_1, w_k))$	$NULL$	$NULL$	$NULL$
$h_{sf}(AL(P_1, w_k))$	$NULL$	$NULL$	$NULL$
Neighbor	w_2	w_1 & w_3	w_2

1. P_1 sends a signed world entry packet to w_2
2. w_2 insures that w_1 is adjasent to itself
3. w_2 must verify that P_1 currently resides in w_1, this is done by ensuring $h_{sf}(AL(P_1, w_k)) = NULL$. This is found by sending a signed data request to w_1
4. P_1 presents $AL(P_1, w_1)$ to w_2
5. w_1 calculates $h_s(AL(P_1, w_1))$ using the AL on the serverside
6. w_2 calculates $h_s(AL(P_1, w_1))$ using the AL provided by P_1, the hashes must match
7. (Optional) An **Action Ledger Traceback** (3.1) can be complete
8. P_1 is now granted access to w_2 and can submit actions
9. w_1 must store $h_s(AL(P_1, w_1))$, $AL(P_1, w_1)$ can be deleted

Fig. 2. P_1 in w_2

$$w_1 \text{———} w_2,\ P_1 \text{———} w_3$$

	w_1	w_2	w_3
$h_s(AL(P_1, w_k))$	$h_s(AL(P_1, w_1))$	$NULL$	$NULL$
$h_{sf}(AL(P_1, w_k))$	$NULL$	$NULL$	$NULL$
Neighbor	w_2	w_1 & w_3	w_2

Fig. 3. P_1 in w_3

$$w_1 \text{———} w_2 \text{———} w_3,\ P_1$$

	w_1	w_2	w_3
$h_s(AL(P_1, w_k))$	$h_s(AL(P_1, w_1))$	$h_s(AL(P_1, w_2))$	$NULL$
$h_{sf}(AL(P_1, w_k))$	$h_s(AL(P_1, w_2))$	$NULL$	$NULL$
Neighbor	w_2	w_1 & w_3	w_2

2.5 Player Genesis

Player Genesis is the creation of a new player, for this to occur a player must digitally sign a genesis package with the current nuance of the world. The world must ensure there are no existing values entered for that player. The player is then instated into the world with all the initial player values set to zero.

3 Trust

The system is not entirely trustless, the neighboring worlds need to trust each other. It's possible for neighboring worlds to have disagreements and still function. For instance, w_1 might introduce an item w_2 consider to be too powerful. In a case like this w_1 world can just neglect it. Actions presented using that item would be considered illegal and not entered into the action ledger of the w_1.

Worlds that have rules that are considered to be completely egregious can be neglected, consider Figure 4

Fig. 4. Three adjacent worlds

$$w_1 \text{———} w_2 \text{———} w_3$$

It's entirely possible that w_1 might have conflicts with the rules of w_3. During the worlds transfer, w_1 would not get the action ledger from w_3. Completely illegal action could have been committed in w_3 (eg. free money). In this case w_1 can required an Action **Action Ledger Traceback**(3.1).

3.1 Action Ledger traceback

Depending on the required security of a world, an Action Ledger Traceback (ALT) may be requested upon a world transfer. If this is requested, the player must provide a list of action ledgers that date back to either the player genesis or to the last entry of the world committing the audit. The world then needs to obtain $h_s AL(P_k, w_{k:n})$ from w_k to w_n. If the hashes match then the players history has been confirmed.

It's still entirely possible for the $AL(P_k, w_{k:n})$ to contain actions considered illegal by the world doing the audit. In this case the rewards and actions committed in the offending world are neglected in the world. An ALT should not often return illegal actions as it will result in **Action Ledger Fragmentation** (6.1), if this is seen often the world should consider a disconnect from the offending world.

3.2 World Disconnects

It's possible a world may issue a disconnect of an adjacent world, this means that players can no longer travel back and fourth through these worlds and they are no longer considered adjacent. This could leave players orphaned in the disconnected world. It would be logical for the world that issued the disconnect to accept the player back into the world in an earlier state.

4 Action Listing

A clear data construct containing possible player outcomes is used to form consensus from world to world.

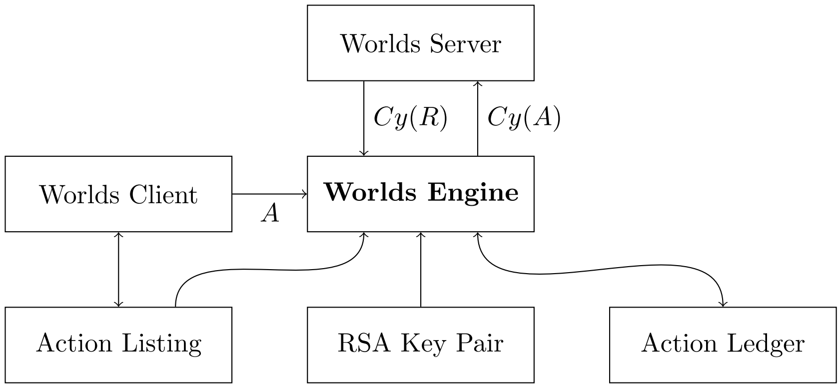
Legal Actions are action that a world will accecpt into a players action ledger if presented.

Illegal Actions are actions that a world does not consider to be legal. Illegal actions will simply not show up on a worlds action listing.

Acceptable Actions are action that are to be performed in other worlds. Results from these actions are respected.

5 System Architecture

A: Action
$Cy(A)$: Encrypted Action
R: Response
$Cy(R)$: Encrypted Response



6 Outstanding Issues

6.1 Action Ledger Fragmentation

Action ledger fragmentation is when a significant portion of a players action ledger has become 'neglected' due to worlds with action disagreements.