UNIVERSITÉ DE RENNES 1

Direction de la Recherche et de l'Innovation

Appel à projets - Année 2023

Contrats doctoraux «Ordinaires»

ECOLE DOCTORALE : **POLE DE RECHERCHE :**

Unité de recherche d'accueil

Unité de Recherche : IRISA (UMR 6074)

Equipe : WIDE (The World is Distribued)

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Sujet

Titre : Byzantine-Tolerant Netcodes For Tomorrow's Metaverse

Mots clés : Metaverse, Virtual World, Decentralization, Replication, Byzantine Fault- Tolerance, Distributed Algorithms, Middleware

Cotutelle internationale (oui/non) : non **Si oui, préciser l'établissement et le pays de rattachement** :

Descriptif (15-30 lignes) :
Contexte socioéconomique et scientifique ; Les hypothèses et questions posées ; Les grandes étapes de la thèse et démarche ; Approches méthodologiques et techniques envisagées

Although there is no consensus on an exact definition yet, the metaverse is generally understood as an open virtual world in which users can interact, contribute content, and engage in monetized transactions (both over user-created content and out-of-metaverse services and goods). Interactions are usually understood as taking place in a three-dimensional world (possibly experienced through a virtual reality device), but earlier online experiments (including textual MMORPGs of the 80's) have shown that other modes of interactions are possible.

As these virtual experiences progressively combine gaming elements, monetary transactions, and monetized content (either provided by the game's developer, but also increasingly by other users and actors acting as content creator), the reliability of such platforms is becoming increasingly important.

Unfortunately, the robustness and fault tolerance that ensures the consistency, replication, and persistence of a metaverse's state over multiple machines have been little studied. Distributed 3D and VR games today are typically built on industrial engines (two leading examples are the Unity and Unreal engines, which power some of the most visible games in the industry). These engines typically embark some distributed logic (known as a netcode) to distribute a game's state across multiple machines. Netcodes either follow a client-server (the most common) or P2P logic and rely on heuristics and optimization (such as delays and rollbacks) to ensure an acceptable level of quality of experience (e.g. high reactivity and low latency), even in a degraded network.

In the past, weaknesses in the security of netcodes have been exploited to obtain an unfair advantage over other players, using a variety of attacks. The problem, however, has been little studied by the research community and is poised to grow in importance with the growth of decentralized metaverse applications beyond simple gaming. In particular, we anticipate that metaverse operators will have to reconcile the need to replicate content (for reliability, availability, and performance reasons), possibly reusing earlier research on P2P games, and the need to ensure some consistency between the copies of the world-state in spite of potentially rogue participants. Such a context directly chimes in with research Byzantine-Fault-Tolerant

(BFT) algorithms that are able to withstand the corruption of a proportion of the devices they run on. BFT replication protocols are however not usually designed with the needs of a metaverse world in mind. In particular, BFT replication protocols are usually very costly, do not scale well, and induce high delays. These limits directly conflict with the soft real-time constraints put on on metaverse virtual world to support seamless and high-quality user interactions.

To address these challenges, this PhD aims to develop novel Byzantine-tolerant replication mechanisms that espouse the unique requirements of a metaverse's virtual world, notably in terms of responsiveness and latency. In particular the PhD will explore how Byzantine-Fault-Tolerant techniques can be accelerated using two central strategies: (i) by using adaptive levels of protection for different parts of a meta- verse world, and (ii) by allowing for optimistic local decisions coupled with micro-rollbacks in case malicious discrepancies are later discovered.