RAGE: Real Alive Game Engine

Why does GTA VI feel alive? A smell in a house, boats in rough water and a witness report reveal how game systems interact under a 33-millisecond frame budget.

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The Engineering of Interacting Systems in Grand Theft Auto VI

I haven't played *Grand Theft Auto VI* yet. The thing that makes me want to get my hands on it is a man walking into a house that smells bad. Rockstar's Aaron Garbut told Simon Parkin at *Edge* about a house he had stumbled across while playing that morning. A dog had made a mess. Jason recoiled at the smell. According to Parkin's report, the team had built that reaction for another part of the game, then made it available to designers working on other locations. Fuck, that's cool. Now I want to know what happens in the next house.

Imagine designing that next house. Someone else has already worked out how Jason wrinkles his face and pulls back. You get to decide what he might find behind your door. An animator who has never seen your room could still help you tell a story about the people who live there.

RAGE stands for *Rockstar Advanced Game Engine*. *Real Alive Game Engine* is my own slightly cheeky reading of the initials. By "alive" I mean that feeling you get when a game responds to a question it was your idea to ask. A detail catches your eye, you follow it somewhere, and the world still makes sense when you get there.

What the rain changes

At the same visit, Parkin watched a developer play and asked the team how the world worked. In the weather discussion, Garbut describes the effect of rough water on a boat. Parkin also reports that pedestrians seek shelter as conditions worsen. Those two details make me want to stand on a waterfront in the rain. From one spot, could I watch someone take cover on shore and a boat start pitching out on the water?

Picture the work involved in making that view convincing. A person on the pavement needs somewhere to go. A boat needs time to rise and fall. People can be slow to take cover, and waves can keep running after the rain lets up. Making everything change on the same beat could look oddly mechanical. What I would look for from the shore is whether the person and the boat seem to be responding to the same afternoon, each in their own time. I could watch the timing from the shore. Exactly how Rockstar passes weather information around inside the engine would still be an open question.

The police example adds a wrinkle. In *Edge*'s account, a witness can report that Jason and Lucia were together. If they separate, a person on their own is a poorer match for that description. An ordinary act, walking away from someone, now has a consequence that depends on what a third person saw a few minutes

ago. Parkin describes little icons on the screen that show which details the police have picked up. I like that last piece of design. I could glance at those icons and work out why walking down the very same street alone might go differently this time.

A table, a city and 33 milliseconds

One of the pleasures of following RAGE back through Rockstar's history is finding a table-tennis game. Rockstar released *Table Tennis* in 2006. Co-founder Jamie King later recalled that the game grew out of a demonstration of the engine at Rockstar San Diego. A table gives you a particularly unforgiving audience for the physics. There's one ball, both players are looking straight at it, and if it bounces strangely everyone sees it. In a city, the designer also has to reckon with the player who turns away from the intended spectacle to see what somebody on the pavement is doing.

There are 4,811 days between the original release of *GTA V* on 17 September 2013 and Take-Two's announced date of 19 November 2026 for *GTA VI*. It's a good number for a calendar. The number I find more interesting for the engineering is about 33 milliseconds. Rockstar says it is targeting 30 frames per second on consoles. At that pace, with evenly spaced frames, that is the interval between one picture and the next. While I am deciding where to look, the game already has another picture due.

Imagine I swing the camera from the boat to the covered doorway. The pedestrian who headed for shelter a moment ago ought to have got somewhere plausible by the time I look back. Suppose a game saves time by updating a distant pedestrian less often than the boat in front of me. The tricky moment comes when I turn my head and the pedestrian becomes the one thing I'm paying attention to. Where should they be on that first frame? The 33 milliseconds give me a sense of the time pressure. Finding out how RAGE schedules that work would take measurements from the running game.

It also suggests a good way to think about testing. Say a pedestrian reaches the doorway in rain, and reaches it in dry weather too. Now load the street halfway through the walk, while the rain is stopping. Did the person finish the journey? Each feature can look fine in a test of its own. NIST's work on combinatorial testing explains why it pays to vary a few conditions together. For this imagined street, weather, when the street loads and where the pedestrian is going already give a tester reasons to visit the same doorway several times.

Could a game be harder to build than an operating system?

That was one of the questions that got me interested in this. I can imagine an open-world game giving an engineer a harder timing problem than a particular task in Windows or Linux. Turn the question around and ask what has to happen to a file if the power fails halfway through a write. Suddenly I want to hear from the people who build file systems. Both questions are specific enough to investigate. A ranking of the two entire pieces of software would need a common measure and access to evidence about both. I have neither.

What I do have is a pretty good idea of how I'd like to spend a few minutes in Leonida. If it starts raining near the water, I'd like to let the next mission wait, find a spot where I can see the pavement and the boats, and stay there a while after it clears. Maybe I'll spot a trick. Maybe I'll wait ten minutes for a pedestrian who

never comes. Either way, I'm already looking forward to the ridiculous pleasure of having a whole *Grand Theft Auto* game in front of me and deciding that, for the next few minutes, what I really want to do is watch somebody try to stay dry.

— Dennis Hedegreen, trying to see the structure

Sources

- Simon Parkin reports Aaron Garbut's account of the house, the discussion of weather and the police information shown on screen. Edge, *The State That Never Sleeps* (https://www.gamesradar.com/edge/gtavi-cover/)
- Take-Two gives the engine's official name in the *Innovation* section of its annual report. Take-Two annual report (https://ir.take2games.com/static-files/598df571-75d7-451d-b8f7-ad06a90b80cd)
- Rockstar's announcement dates the North American release of *Table Tennis*. Jamie King recalls its origins in an interview with *Time Extension*. Launch announcement (https://ir.take2games.com/static-files/099bbcb9-6bba-4fdb-aaa8-f4cfe7f9e605) · King's account (https://www.timeextension.com/news/2023/05/rockstar-co-founder-explains-origins-of-rockstar-games-presents-table-tennis)
- The calendar interval uses the original *GTA V* release and the *GTA VI* date announced as of 18 November 2026. Rockstar's 2013 announcement (https://ir.take2games.com/static-files/dd93d264-3d54-404a-ab30-bc6c0fa07ed2) · Take-Two's November 2026 release schedule (https://www.take2games.com/ir/news/take-two-interactive-software-inc-reports-results-fiscal-4)
- Rockstar states its console frame-rate target in the pre-load announcement. Rockstar Games (https://www.rockstargames.com/newswire/article/89834o94713o21/pre-load-grand-theft-auto-vi-now)
- D. Richard Kuhn, Raghu N. Kacker and Yu Lei explain how to design tests around combinations of inputs. NIST, *Practical Combinatorial Testing* (https://csrc.nist.gov/pubs/sp/800/142/final)

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