

GAME DEVELOPMENT WITH RUST

WHY RUST?

RUST MAKES CERTAIN (BAD) PATTERNS MORE PAINFUL THAN OTHERS, WHICH IS A GOOD THING!

- The easiest for Rust are very often the easiest in general
- I had to learn good patterns the hard way, without Rust's help
- For games, one of these is ECS design, but there are OTHERS
- Rust rewards data oriented design with clear

PERSONAL REASONS TO CHOSE RUST FOR GAME DEVELOPMENT

- Code first
- No Heavy Editor
- Easy setup and build and learn incrementally
- My favorite language
- Great community on discord
- Flexible Target Platforms (Browser, Windows, Linux, etc)

WHAT IS ECS?

How many accessors could you possibly need?

```
class Player :
public virtual ToolUserEntity,
public virtual LoungingEntity,
public virtual ChattyEntity,
public virtual DamageBarEntity,
public virtual PortraitEntity,
public virtual NametagEntity,
public virtual PhysicsEntity,
public virtual EmoteEntity {

public:
    Player(PlayerConfigPtr config, Uuid uuid = Uuid());
    Player(PlayerConfigPtr config, Json const& diskStore);
    Player(PlayerConfigPtr config, ByteArray const& netStore);

    ClientContextPtr clientContext() const;
    void setClientContext(ClientContextPtr clientContext);

    StatisticsPtr statistics() const;
    void setStatistics(StatisticsPtr statistics);

    QuestManagerPtr questManager() const;

    Json diskStore();
    ByteArray netStore();

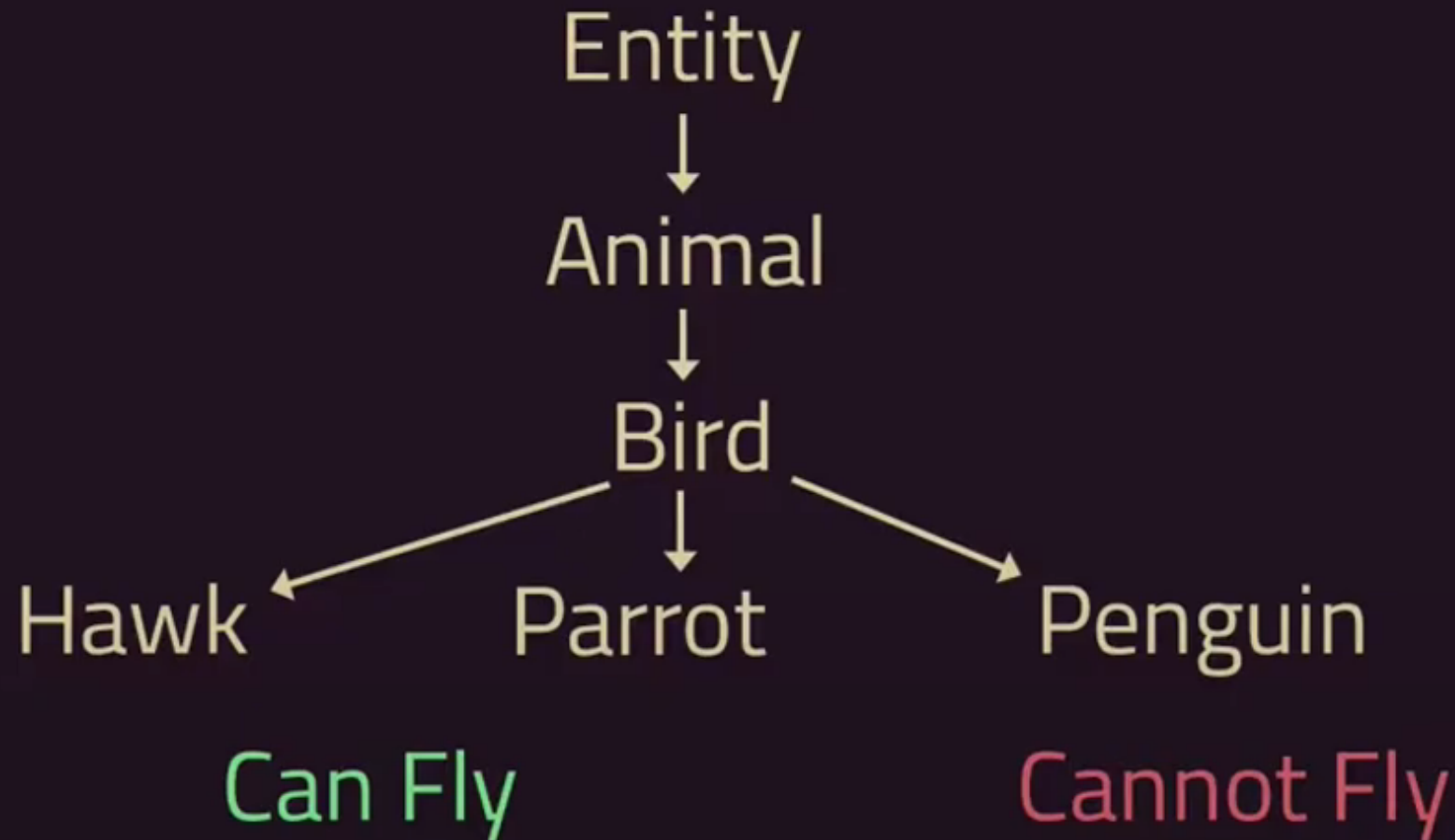
    EntityType entityType() const override;

    void init(World* world, EntityId entityId, EntityMode mode) override;
    void uninit() override;

    Vec2F position() const override;
    Vec2F velocity() const override;

    Vec2F mouthPosition() const override;
    Vec2F mouthOffset() const;
    Vec2F feetOffset() const;
```

OBJECT HIERARCHY



THE ECS WAY 1/2

- Entity - things in the world
- Component - Data of Entities
- System - update entity data

THE ECS WAY 2/2

```
let entity = world.spawn()  
  .insert(Animal)  
  .insert(CanFly)  
  .insert(CanWalk)  
  .insert(AnimalSpecies::Hawk)  
  .insert(AnimalType::Bird)  
  .id();
```

GOAL: AVOID OOP PRACTISES

- Avoid Inheritance
- Avoid Composition
- Avoid Polymorphism
- Avoid Complexity

CORE STRENGTHS

- Flexibility
- Reasonability
- Composability
- Performance (Rendering)

ENTITY

- Just an id

```
let mut world = World::new(); // This is a engine Resource  
let entity: Entity = world.spawn().id();
```

```
let mut map: WorldMap = WorldMap::new(); // This is a game Res  
map.add(entity);
```

BEVY WORLD

```
pub struct World {  
    id: WorldId,  
    pub(crate) entities: Entities,  
    pub(crate) components: Components,  
    pub(crate) archetypes: Archetypes,  
    pub(crate) storages: Storages,  
    pub(crate) bundles: Bundles,  
    pub(crate) removed_components: SparseSet<ComponentId, Vec<  
        /// Access cache used by [WorldCell].  
    pub(crate) archetype_component_access: ArchetypeComponentA  
    main_thread_validator: MainThreadValidator,  
    pub(crate) change_tick: AtomicU32,  
    pub(crate) last_change_tick: u32,  
}
```

COMPONENT EXAMPLES

- Position / Coordinates
- Sprite
- Charakter Health in an RPG

COMPONENT EXAMPLES

```
#[cfg_attr(feature = "debug", derive(bevy_inspector_egui::Insp
#[derive(Debug, Default, Copy, Clone, Eq, PartialEq, Hash, Com
pub struct Coordinates {
    pub x: u16,

    pub y: u16,
}
```

```
#[derive(Component)]
pub struct Coordinates {
    pub x: u16,
    pub y: u16,
}
```

SYSTEM EXAMPLE

```
fn hello_world() {  
    println!("hello world!");  
}  
  
pub fn hide_popup(mut commands: Commands, popup: Res<PopupRef>)  
    commands.entity(popup.0).despawn_recursive();  
    commands.remove_resource::<<PopupRef>>()  
}
```


BEVY GITHUB

LIVE EXAMPLES

Clone the Bevy repo:

```
git clone https://github.com/bevyengine/bevy  
cd bevy  
git checkout latest  
git checkout v0.7.0
```

Try the examples in the examples folder

```
cargo run --example breakout
```

BEVY ENGINE CORE

DEV TOOLS AND EDITORS FOR BEVY

- `bevy_inspector_egui` editor-like inspector window
- `bevy_editor_pls` is an editor-like interface for fly camera, performance diagnostics, inspector panels.
- `bevy_mod_debugdump` is a tool to help visualize your App Schedule (systems and stages)
- `bevy_lint` checks your Bevy code for some common issues

COORDINATE SYSTEM

- Bevy uses a right-handed Y-up coordinate system.
- Bevy uses the same coordinate system for 3D, 2D, and UI, for consistency.

TRANSFORMS

- a Transform is what allows you to place an object in the game world. It is a combination of the object's "translation" (position/coordinates), "rotation", and "scale" (size adjustment).
- You move objects around by modifying the translation, rotate them by modifying the rotation, and make them larger or smaller by modifying the

HIERARCHICAL (PARENT/CHILD) ENTITIES

- Technically, the Entities/Components cannot form a hierarchy (the ECS is a flat data structure).
- Logical hierarchies are a common pattern in games.
- Bevy supports creating logical link between entities, by simply adding Parent and Children components on the respective entities.
- Commands has methods for adding children to

BEVY ENGINE USAGE

APP / MAIN.RS

```
use bevy::prelude::*;
```

```
fn main() {  
    App::new().run();  
}
```

```
cargo run
```

PLUGINS 1/2

- used to organize bevy features
- used to organize a game
- used to create libraries for bevy

```
fn main() {  
    App::new()  
        // This already creates a window  
        // because it contains Core, Input and Window Plugin  
        .add_plugins(DefaultPlugins)  
        .run();  
}
```

PLUGINS 2/2

```
struct MyPlugin;

impl Plugin for MyPlugin {
    fn build(&self, app: &mut App) {
        app
            .init_resource::<MyOtherResource>()
            .add_event::<MyEvent>()
            .add_startup_system(plugin_init)
            .add_system(my_system);
    }
}

fn main() {
    App::new()
        .add_plugins(DefaultPlugins)
```

RESOURCES

Entities and Components are great for representing complex, query-able groups of data. But most Apps will also require "globally unique" data of some kind.

In Bevy ECS, we represent globally unique data using Resources.

- Elapsed Time
- Asset Collections (sounds, textures, meshes)
- Renderers

RESOURCES

```
impl Plugin for HelloPlugin {  
    fn build(&self, app: &mut App) {  
        // the reason we call from_seconds with the true  
        // flag is to make the timer repeat itself  
        app.insert_resource(  
            GreetTimer(Timer::from_seconds(2.0, true))  
        )  
    }  
}
```

- Resources can be added globally or in systems

SYSTEMS

```
fn greet_people(  
    time: Res<Time>, query: Query<&Name, With<Person>>  
) {  
    for name in query.iter() {  
        println!("hello {}!", name.0);  
    }  
}
```

- Systems are called by the Engine each frame
- Parameters of System come from the ECS automatically

SYSTEMS: LOCAL RESOURCES

```
# [derive(Default)]  
struct MyState;  
  
fn my_system1(mut local: Local<MyState>) {  
    // you can do anything you want with the local here  
}
```

- Local is managed by ECS automatically
- ECS creates an instance by calling Default::default()

EXPLICIT SYSTEM ORDERING

```
App::new()  
    // order doesn't matter for these systems:  
    .add_system(particle_effects)  
    .add_system(npc_behaviors)  
    .add_system(enemy_movement)  
    .add_system(input_handling)  
    .add_system(  
        player_movement  
        // `player_movement` must always run before `enemy_movemen  
        .before(enemy_movement)  
        // `player_movement` must always run after `input_handling  
        .after(input_handling)  
    )  
    .run();
```

- Systems can be ordered with `.before` and `.after`

SYSTEM SETS

```
App::new()
.add_plugins(DefaultPlugins)
// group our input handling systems into a set
.add_system_set(
    SystemSet::new()
        .label("input")

        .with_system(keyboard_input)
        .with_system(gamepad_input)
)
// our "net" systems should run before "input"
.add_system_set(
    SystemSet::new()
        .label("net")
        .before("input")
)
```

SYSTEM CHAINING

```
fn main() {  
    App::new()  
        // ...  
        .add_system(net_receive.chain(handle_io_errors))  
  
        // ...  
        .run();  
}
```

- `handle_io_errors` is called with the result of `net_receive`

LIFECYCLE/STAGES 1/2

All systems to be run by Bevy are contained in stages.

Every frame update, Bevy executes each stage, in order. Within each stage, Bevy's scheduling algorithm can run many systems in parallel, using multiple CPU cores for good performance.

LIFECYCLE/STAGES 2/2

```
pub enum StartupStage {  
    PreStartup,  
    Startup,  
    PostStartup,  
  
}  
  
pub enum CoreStage {  
    First,  
    PreUpdate,  
    Update,  
    PostUpdate,  
    Last,  
}
```

CUSTOM STAGE

```
fn main() {  
    // label for our debug stage  
    static DEBUG: &str = "debug";  
  
    App::new()  
        .add_plugins(DefaultPlugins)  
  
        // add DEBUG stage after Bevy's Update  
        // also make it single-threaded  
        .add_stage_after(CoreStage::Update, DEBUG, SystemStage::  
  
        // systems are added to the `CoreStage::Update` stage by  
        .add_system(player_gather_xp)  
        .add_system(player_take_damage)
```

STATES - ONLY FOR PRO'S :D

```
[derive(Debug, Clone, Eq, PartialEq, Hash)]
enum AppState {
    MainMenu,
    InGame,
    Paused,
}

fn main() {
    App::new()
        .add_plugins(DefaultPlugins)

        // add the app state type
        .add_state(AppState::MainMenu)
```

QUERIES AND CHANGE DETECTION

```
/// Print the stats of friendly players when they change
fn debug_stats_change (
    query: Query<
        // components
        (&Health, &PlayerXp),
        // filters
        (Without<Enemy>, Or<(Changed<Health>, Changed<PlayerXp
    >,
) {
    for (health, xp) in query.iter() {
        eprintln!(
            "hp: {}+{}, xp: {}",
            health.hp, health.extra, xp.0
        );
    }
}
```

- Change detection is done with a simple query in the systems for

INPUT

```
fn mouse_button_input (
    buttons: Res<Input<MouseButton>>,
) {
    if buttons.just_pressed(MouseButton::Left) {
        // Left button was pressed
    }
    if buttons.just_released(MouseButton::Left) {
        // Left Button was released
    }
    if buttons.pressed(MouseButton::Right) {
        // Right Button is being held down
    }
    // we can check multiple at once with `.any_*`
    if buttons.any_just_pressed([MouseButton::Left, MouseButton::Right]) {
        // Either the left or the right button was just pressed
    }
}
```

COMMANDS 1/2

- Use Commands to spawn/despawn entities, add/remove components on existing entities, manage resources.
- These actions do not take effect immediately; they are queued to be performed later when it is safe to do so.
- That means your other systems will see them on the

COMMANDS 2/2

```
fn spawn_player(  
    mut commands: Commands,  
) {  
    // manage resources  
    commands.insert_resource(GoalsReached { main_goal: false, bo  
    commands.remove_resource::();  
    // create a new entity using `spawn`  
    let entity_id = commands.spawn()  
        // add a component  
        .insert(ComponentA)  
        // add a bundle  
        .insert_bundle(MyBundle::default())  
        // get the Entity ID  
        .id();  
    // shorthand for creating an entity with a bundle
```

EVENTS

```
struct LevelUpEvent (Entity);

fn player_level_up(
    mut ev_levelup: EventWriter<LevelUpEvent>,
    query: Query<(Entity, &PlayerXp)>,
) {
    for (entity, xp) in query.iter() {
        if xp.0 > 1000 {
            ev_levelup.send(LevelUpEvent(entity));
        }
    }
}

fn debug_levelups(
    mut ev_levelup: EventReader<LevelUpEvent>
```

ENTITIES AND RENDERING

```
pub(crate) fn spawn_tetromino(
    mut commands: Commands,
    board: Res<Board>,
    mut spawn_event_rdr: EventReader<SpawnEvent>,
    mut game_over_event_wtr: EventWriter<GameOverEvent>,
) {
    let translation = Vec3::new(.....);
    for event in spawn_event_rdr.iter() {
        // ...
        commands.entity(board.entity).with_children(|mut parent| {
            for block in blocks.into_iter() {
                // ...
                let entity = parent
                    .spawn()
                    .insert_bundle((body_sprite, bundle, SpriteBundle));
```

TIME

- The Time resource is your main global source of timing information
- Can be accessed from any system
- You should derive all timings from it
- Bevy updates these values at the beginning of every frame

TIMERS 1/3

```
fn asteroids_fly(  
    time: Res<Time>,  
    mut q: Query<&mut Transform, With<Asteroid>>,  
) {  
    for mut transform in q.iter_mut() {  
        // move our asteroids along the X axis  
        // at a speed of 10.0 units per second  
        transform.translation.x += 10.0 * time.delta_seconds()  
    }  
}
```

TIMERS 2/3

```
use std::time::Instant;

/// Say, for whatever reason, we want to keep track
/// of when exactly some specific entities were spawned.
#[derive(Component)]

struct SpawnedTime(Instant);

fn spawn_my_stuff(
    mut commands: Commands,
    time: Res<Time>,
) {
    commands.spawn()
        .insert(SpawnedTime(time.startup() + time.time_since_s
}
```


TIMERS 3/3

```
#[derive(Component)]
struct FuseTime {
    /// track when the bomb should explode (non-repeating time
    timer: Timer,
}

mut commands: Commands,
mut q: Query<(Entity, &mut FuseTime)>,
time: Res<Time>,
) {
    for (entity, mut fuse_timer) in q.iter_mut() {
        // timers gotta be ticked, to work
        fuse_timer.timer.tick(time.delta());

        // if it finished, despawn the bomb
```

TESTS

```
fn headless_mode() {  
    App::new()  
        .insert_resource(WgpuSettings {  
  
            backends: None,  
            ..Default::default()  
        })  
        .add_plugins_with(DefaultPlugins, |group| group.disable:  
        .add_plugin(EguiPlugin)  
        .update();  
}
```

EGUI

- Popular Multiplatform / Target UI Crate
- Used in many crates and plugins in the bevy ecosystem
- Can easily be used to create a game ui

CONCLUSION

- Don't confuse OOP with "Data Oriented Design"
- Getting into Game Development with Rust is easy
- Unity and Unreal Engine removed from personal TODO list
- ECS + Rust feels like a natural fit
- Game Development + Rust feels like a natural fit
- More to come (3D in Space)

RESOURCES

- ECS:
https://www.youtube.com/channel/UCZzs3Umh6sRiYS_IQIQD
- Using RUST FOR GAME DEVELOPMENT: <https://youtu.be/oHYs-UqS458>
- <https://github.com/bevyengine>
- <https://bevyengine.org/learn/book/introduction/>
- <https://bevy-cheatbook.github.io/>

CODING SCORE IMPLEMENTATION