# Provenance in Games

**Troy C. Kohwalter,**

*Instituto de Computação – Universidade Federal Fluminense (UFF)*

Introduction
Provenance in Games
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Unity3D Example
Conclusion

# INTRODUCTION

# Context

- Analysis Process
  - Technical Issues
  - Gameplay Mechanics


- Beta Testing
  - Indispensable Source of Data
  - Artisanal
  - Volunteers
  - Superficial Analysis

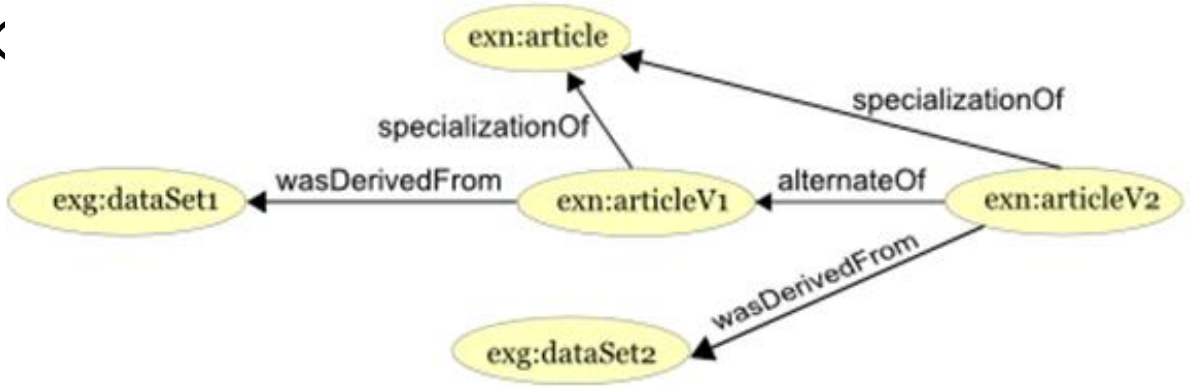
# Motivation

- Cause-and-Effect
  - How to detect?
  - How to display?
- Archeology, Paleontology
  - Provenance

# Provenance

*"Refers to the documented history of an art object, or the documentation of processes in a digital object's life cycle"*

- Provenance Grap
  - Causality Graph




http://www.w3.org/TR/prov-primer/

# Goals

- Cause-and-Effect Relationships
  - Detect
  - Extract
  - Display
- Assist
  - Detect Gameplay Issues
- Visualization
  - Game Session Provenance

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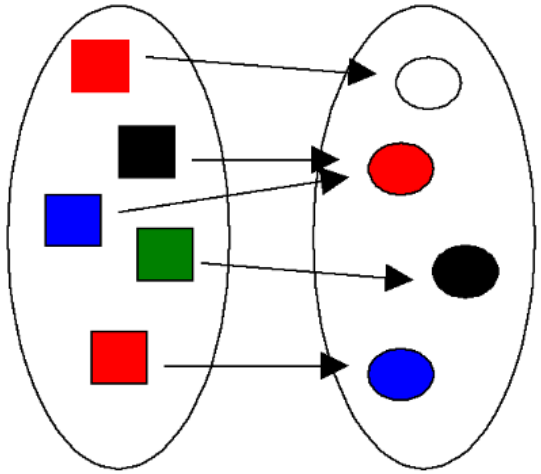
# PROVENANCE IN GAMES

# Provenance in Games

- Conceptual Framework

- Map Domains
  - Provenance to Games



- Gather
  - Provenance Information
  - Causal Relationships

# Provenance Gathering

- Entity
  - Objects
- Activity
  - Actions
  - Events
- Agent
  - NPCs
  - Player

# Provenance Gathering

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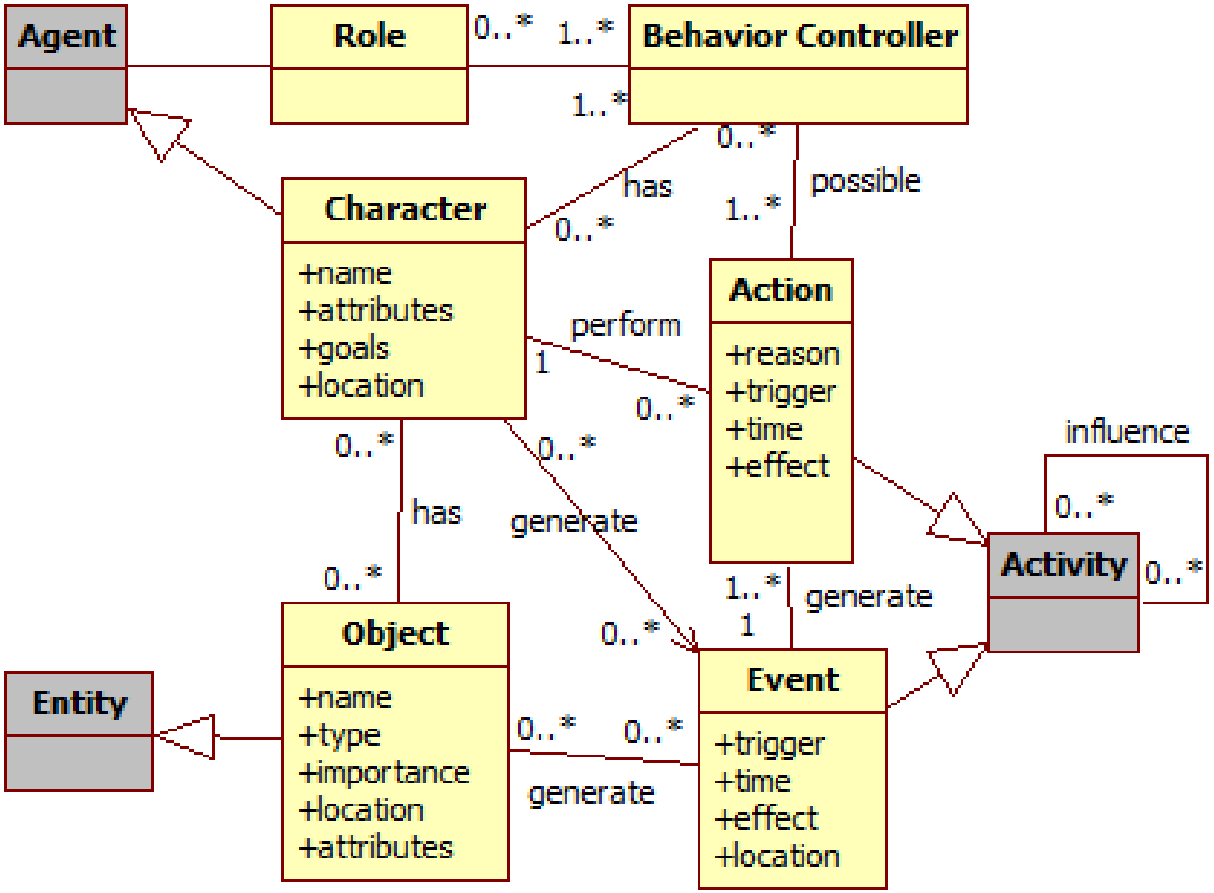
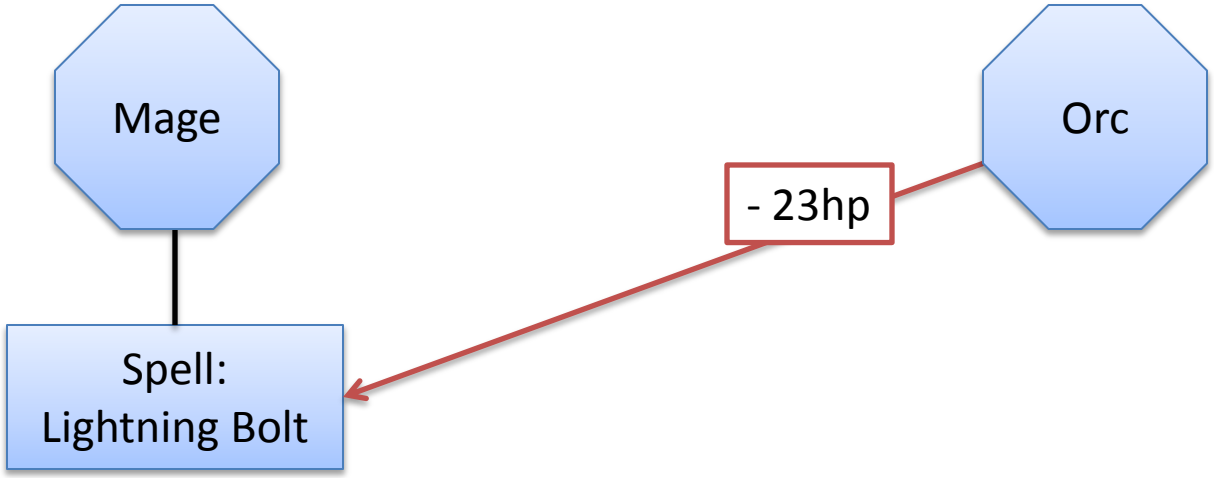
# Provenance to Games



# Graph Construction

# Graph Construction



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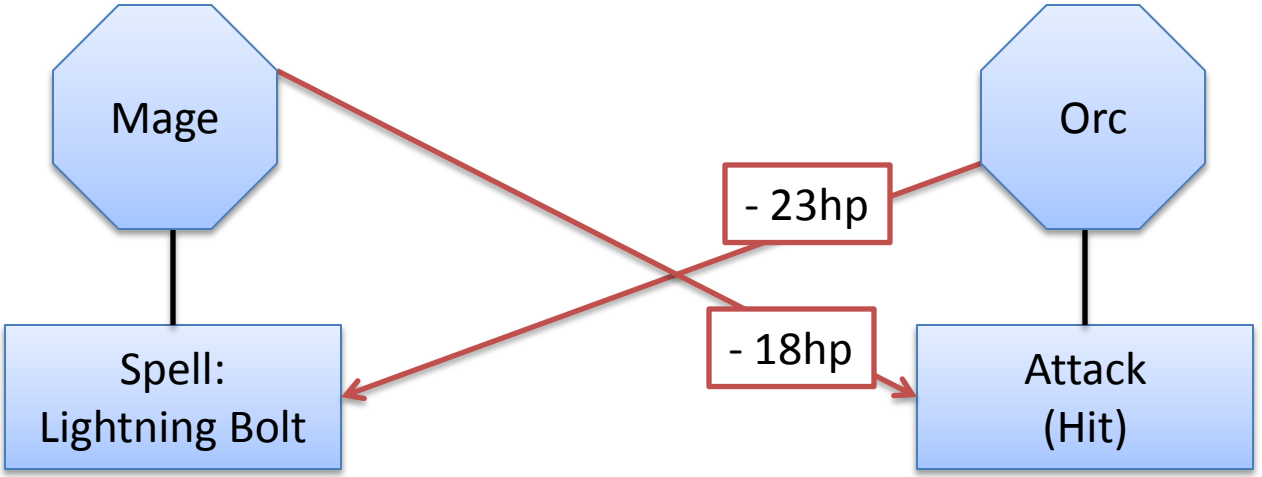

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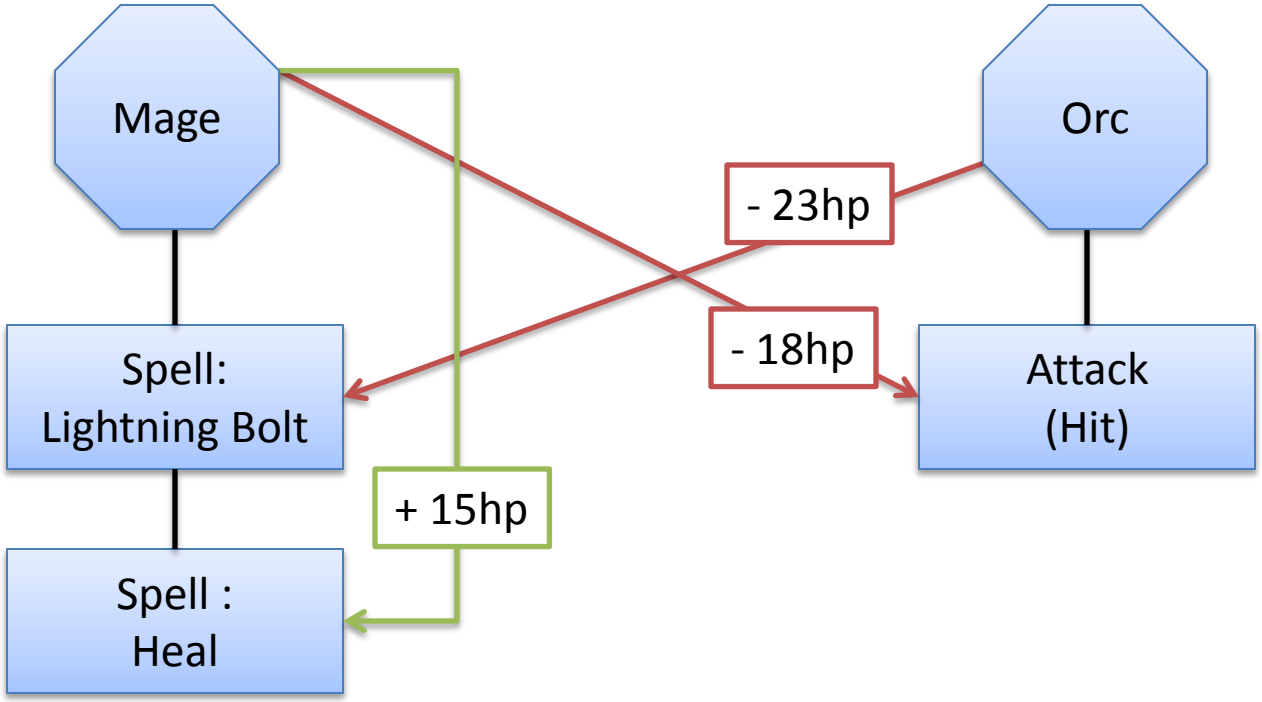

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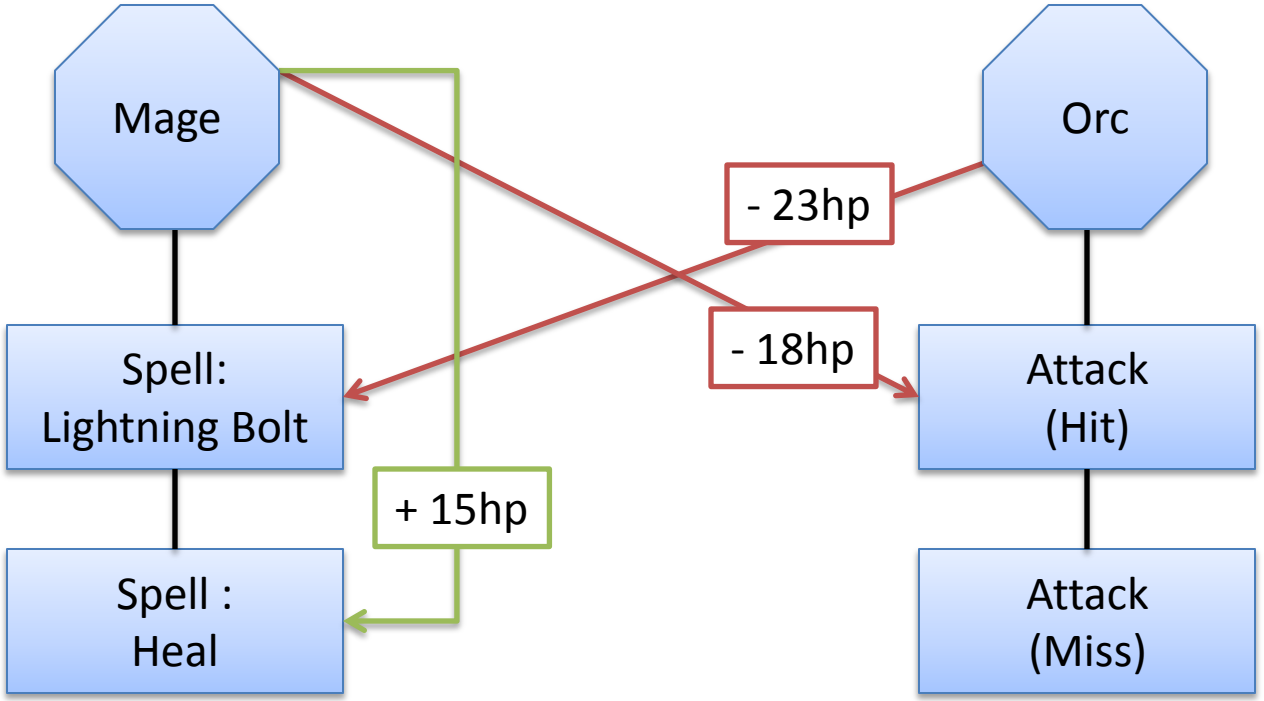

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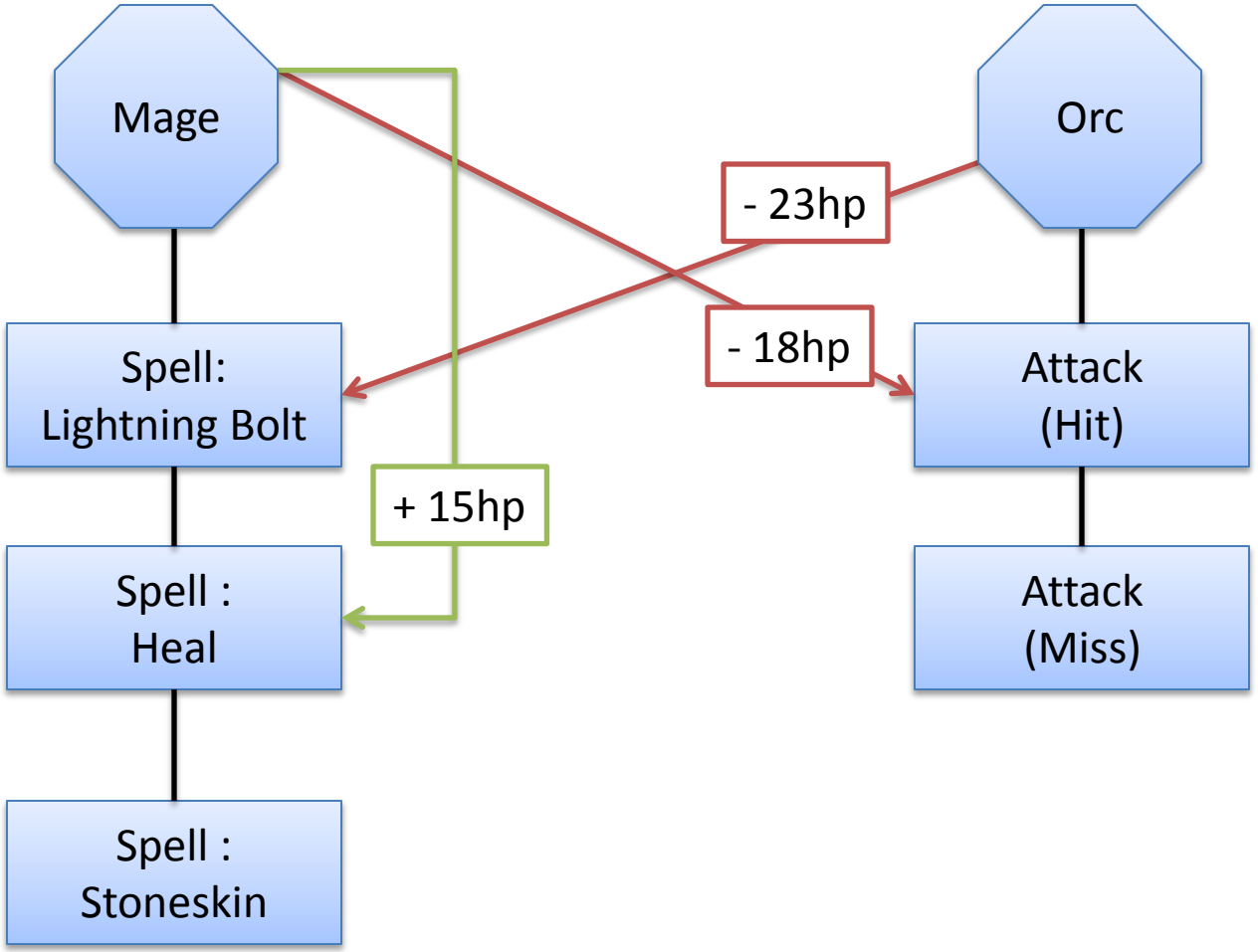
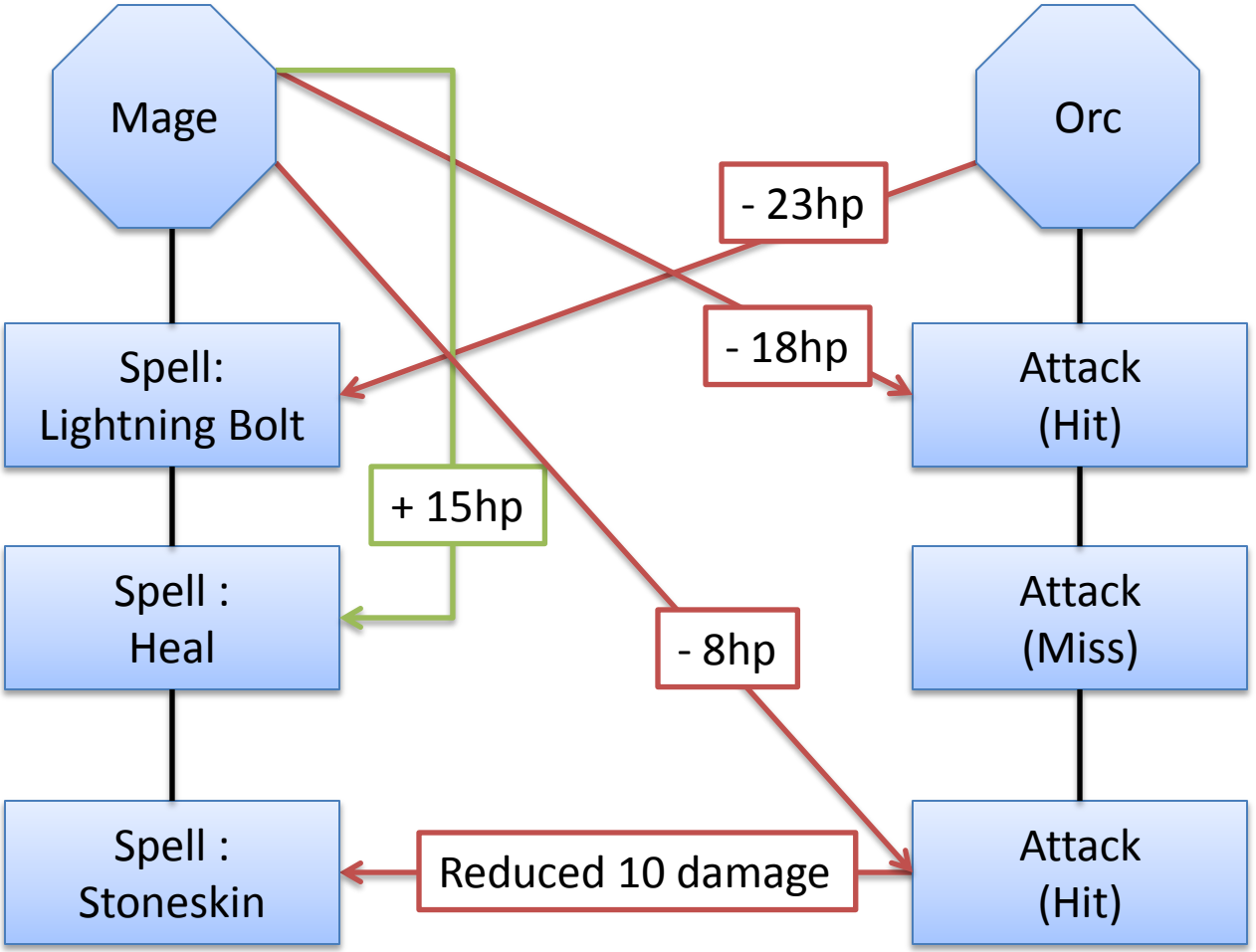


# Graph Construction



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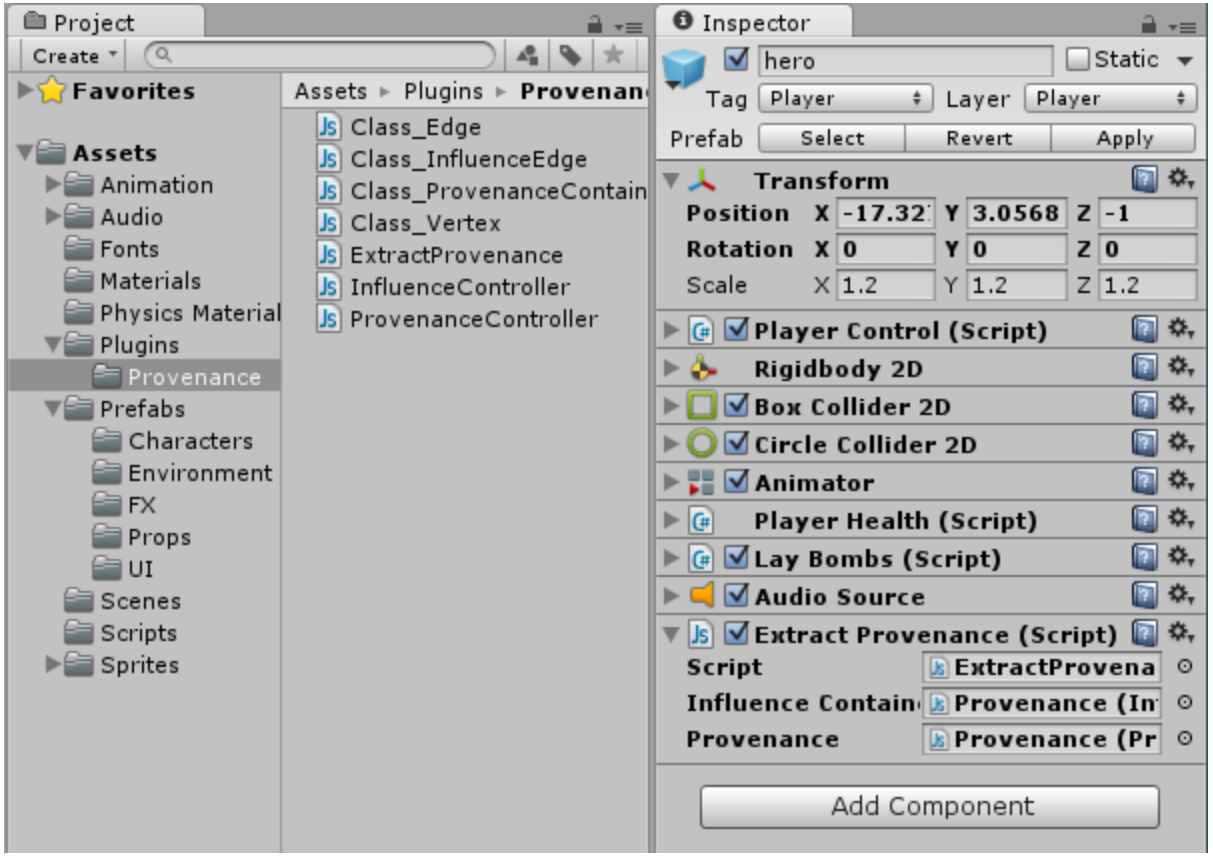
# UNITY3D PROVENANCE SCRIPTS

# Unity3D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Class_Vertex
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Box Collider 2D
Circle Collider 2D
Animator
Player Health (Script)
Lay Bombs (Script)
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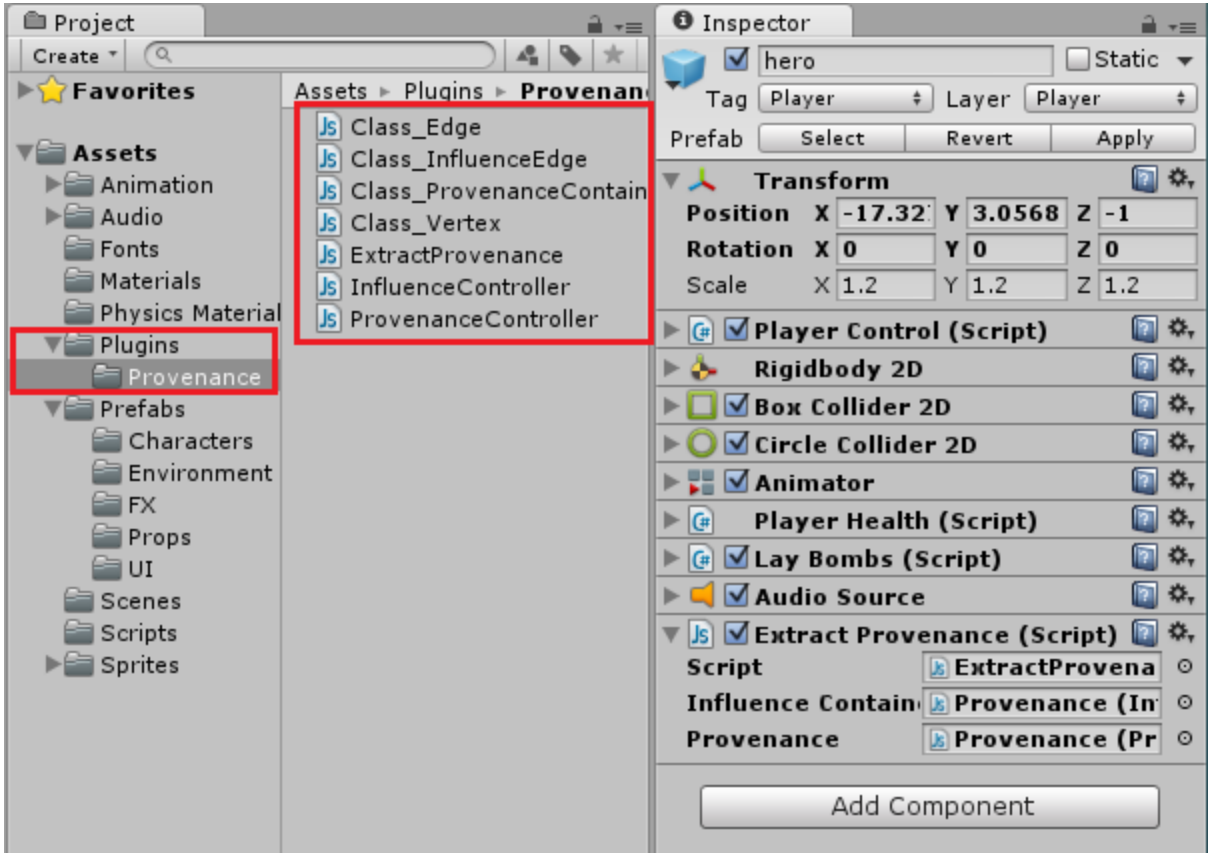
# Unity3D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# Support Classes

```
#pragma strict

//=============================================================================================================
// 'Edge' Class Definition
// This script is to define the Edge class
// Do not attach this script in any GameObject
// It is only necessary to be on your resources folder
// The 'Edge' class is used for the Provenance-Scripts
//=============================================================================================================
```

```
#pragma strict

//=============================================================================================================
// 'InfluenceEdge' Class Definition
// This script is to define the influenceEdge class
// Do not attach this script in any GameObject
// It is only necessary to be on your resources folder
// The 'InfluenceEdge' class is used for the Provenance-Scripts
//=============================================================================================================
```

```
#pragma strict

//=============================================================================================================
// 'ProvenanceContainer' Class Definition
// This script is to define the ProvenanceContainer class
// Do not attach this script in any GameObject
// It is only necessary to be on your resources folder
// The 'ProvenanceContainer' class is used for the Provenance-Scripts
// It is responsible for exporting provenance information into a XML file
//=============================================================================================================
```

```
#pragma strict

//=============================================================================================================
// 'Vertex' Class Definition
// This script is to define the Edge class
// Do not attach this script in any GameObject
// It is only necessary to be on your resources folder
// The 'Vertex' class is used for the Provenance-Scripts
//=============================================================================================================
```

# ExtractProvenance

```
1  #pragma strict
2
3  //=============================================================================================================
4  // Script for creating vertices for the attached GameObject
5  // Attach this script in the desired game object and invoke the functions described below to gather provenance data
6  //
7  // Link it to InfluenceController
8  // Link it to ProvenanceGatherer
9  //-------------------------------------------------------------------------------------------------------------
10 // Brief explanations of each function used to record provenance information:
11 //
12 //  NewActivityVertex(label, details): Creates an Activity type vertex. Custom game attributes must be inserted by 'AddAttribute' function fi
13 //  NewAgentVertex(label, details): Creates an Agent type vertex. Custom game attributes must be inserted by 'AddAttribute' function first
14 //  NewEntityVertex(label, details): Creates an Entity type vertex. Custom game attributes must be inserted by 'AddAttribute' function first
15 //  NewVertex(): Creates an user-defined <type> vertex.
16 //  AddAttribute(name, value): Adds a new attribute to the attribute list.
17 //                  The attribute's name and value are informed by the user and before invoking NewVertex or any of its variants.
18 //  PopulateAttributes(): Add unity-related attributes to the attribute list. Invoked from NewVertex or any of its variants.
19 //  ClearList(): Clean the attribute list for the next vertex. Invoked from NewVertex or any of its variants.
20 //  GenerateInfluence(tag, ID, name, value): Stores information about the current vertex that is used to influenciate other vertices
21 //  HasInfluence(tag): Checks if there is any influence instance of 'tag' for the current vertex and generates their appropriate edges
22 //  HasInfluence_ID(ID): Checks if there is any influence instance of 'ID' for the current vertex and generates their appropriate edges
23 //  RemoveInfluenceTag(tag): Removes all influences that belongs to the group 'tag' defined by the user
24 //  RemoveInfluenceTag(ID): Removes all influences of 'ID' defined by the user
25 //
26 //-------------------------------------------------------------------------------------------------------------
27 // How to use:
28 //
29 // 1) Invoke 'AddAttribute' to add any custom or game specific attributes that is desired to be stored
30 // 2) Invoke the any of the 'NewVertex' typed functions when an action is executed to store provenance information about the action
31 // 3) Then invoke 'HasInfluence' function for each desired 'tag' or 'ID' to check if there is anything stored that influenced the current act
32 // 4) If the current action can influence another action, then invoke 'GenerateInfluence' by defining its 'tag' and influence 'ID'
33 // 5) If any influence effect expired, then invoke 'RemoveInfluenceTag' or 'RemoveInfluenceID' to remove that influence
34 //=============================================================================================================
```

# Influence &Provenance Controller

```
#pragma strict

//=============================================================================================================================
// Script for storing influence edges for the entire game
// Attach this script in an Empty GameObject that is never destroyed during the game
//(In the same GameObject for ProvenanceGatherer)
// Link it to ProvenanceGatherer
//
// Uses ArrayList for influence edges
// All functions are automatically invoked and controlled by 'ExtractProvenance' script script
//
// If you desire to manually clean/erase the influence list, then invoke 'CleanInfluence' function
//=============================================================================================================================
```

```
#pragma strict

//=============================================================================================================================
// Script for storing vertices and edges
// Attach this script in an Empty GameObject that is never destroyed during the game
//(In the same GameObject for InfluenceController)
//
// Uses one ArrayList for vertices and another for edges
// All functions are automatically invoked and controlled by 'ExtractProvenance' script or 'InfluenceController' script
//=============================================================================================================================

```

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# UNITY3D EXAMPLE

# Unity3D

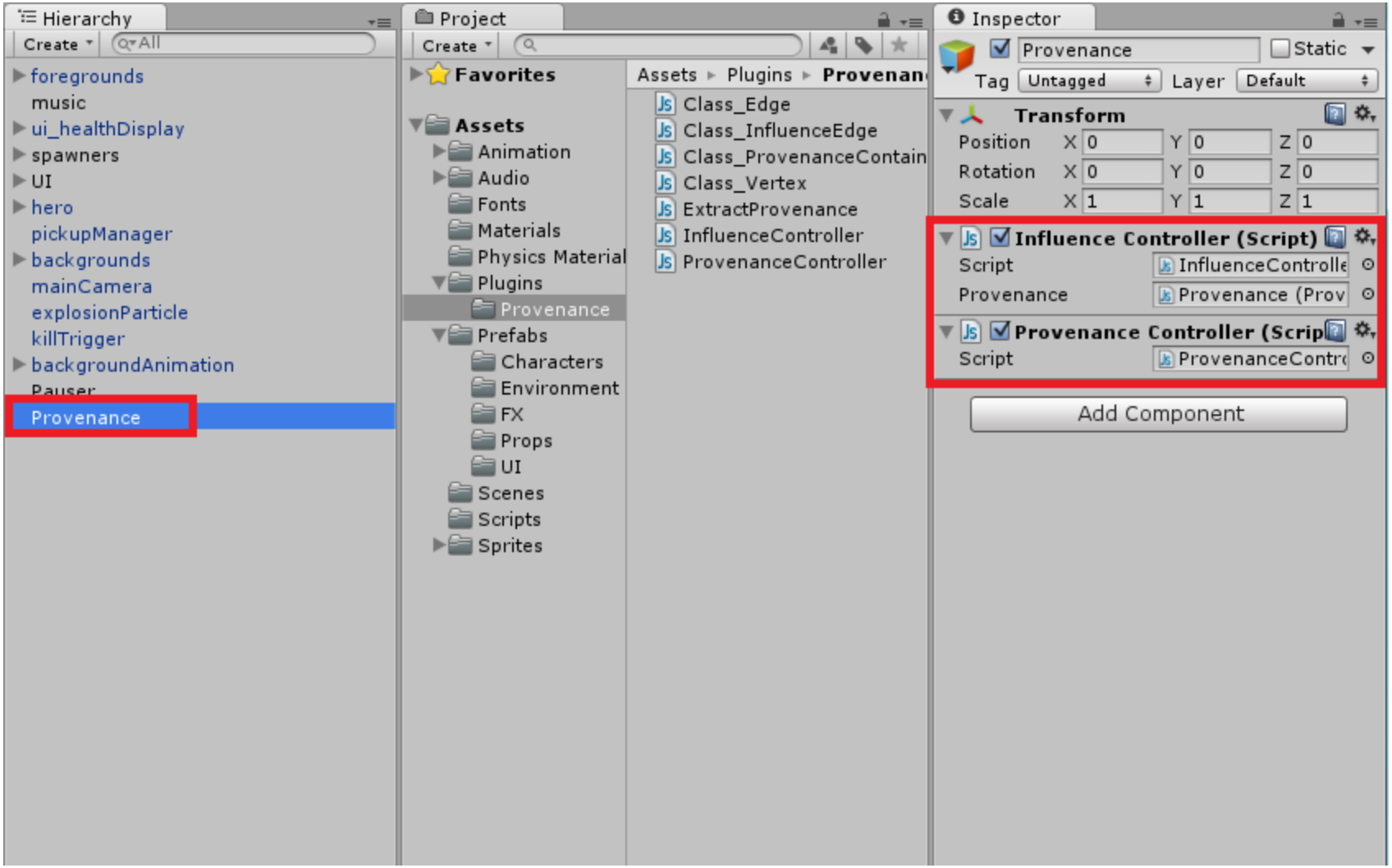

Unity - Level.unity - 2D Tutorial - PC, Mac & Linux Standalone*
File Edit Assets GameObject Component Window Help
Center Local
Layers 2 by 3
Game
Free Aspect
Maximize on Play Stats Gizmos
Score: 0

# Unity3D

- Create an Empty Game Object
  - Attach ***Provenance Controller*** script
  - Attach ***Influence Controller*** script

- For each Character/Agent
  - Attach ***Extract Provenance*** script

# Unity3D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backgrounds
mainCamera
explosionParticle
killTrigger
backgroundAnimation
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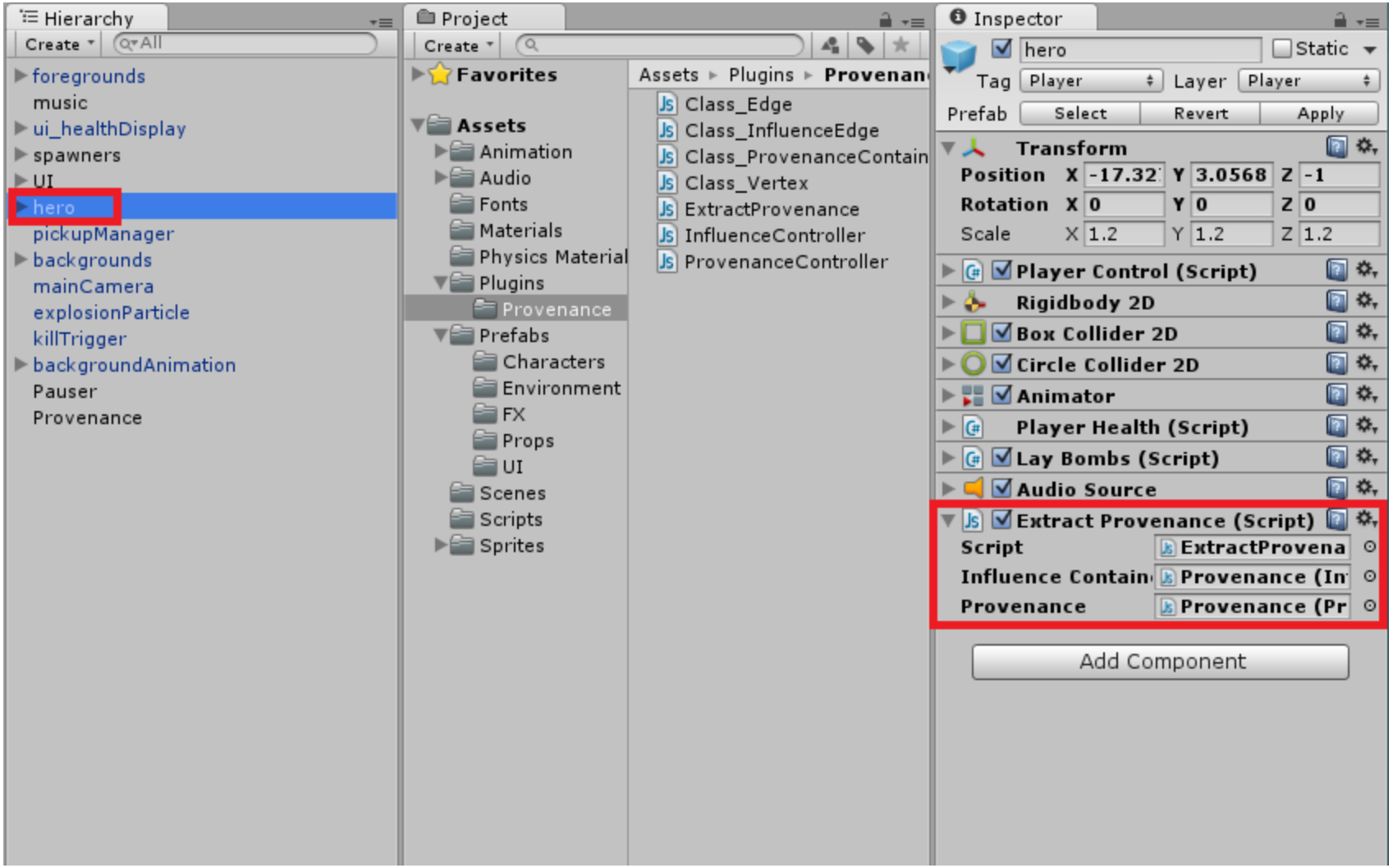
# Unity3D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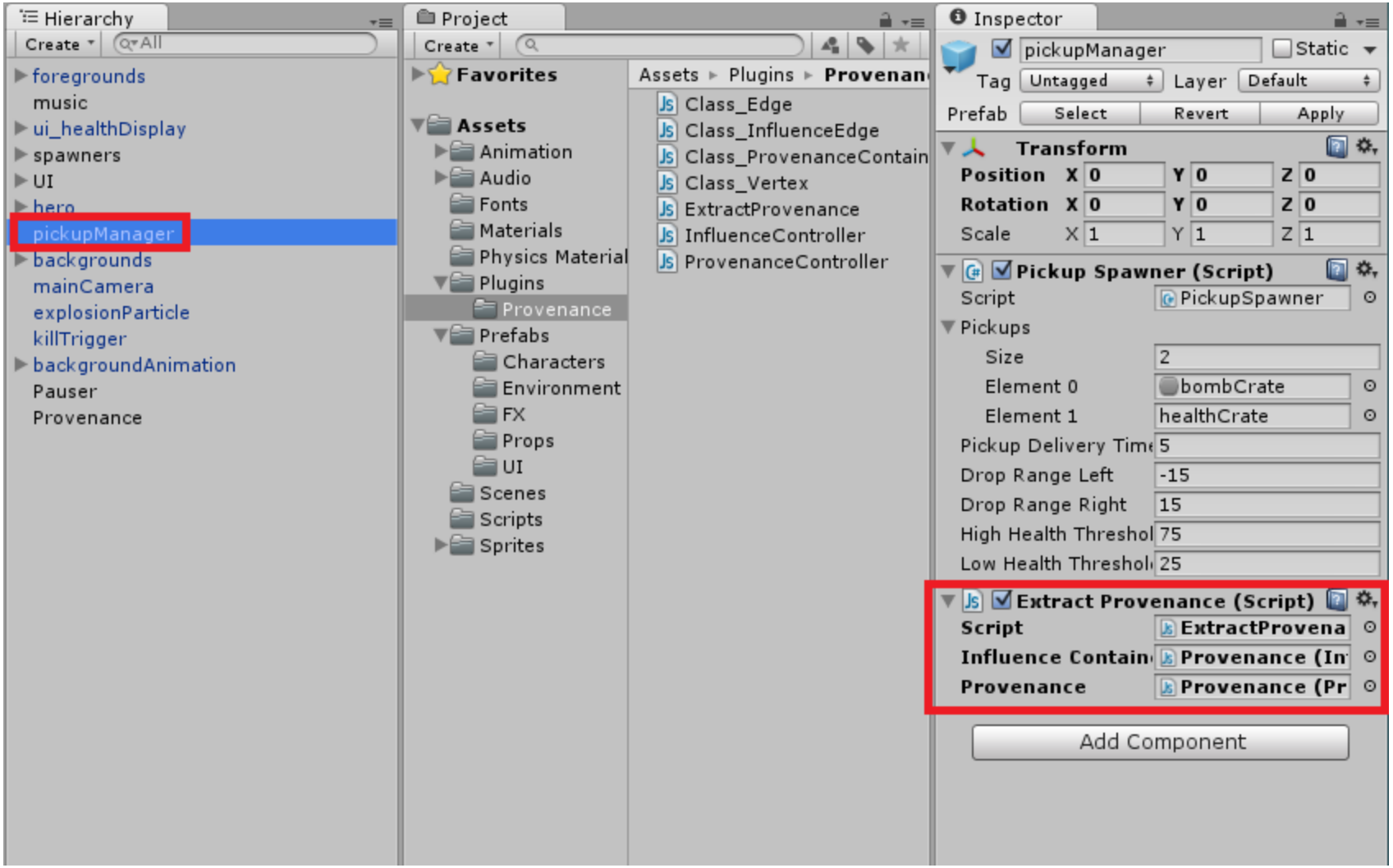
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Pickup Spawner (Script)
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PickupSpawner
Pickups
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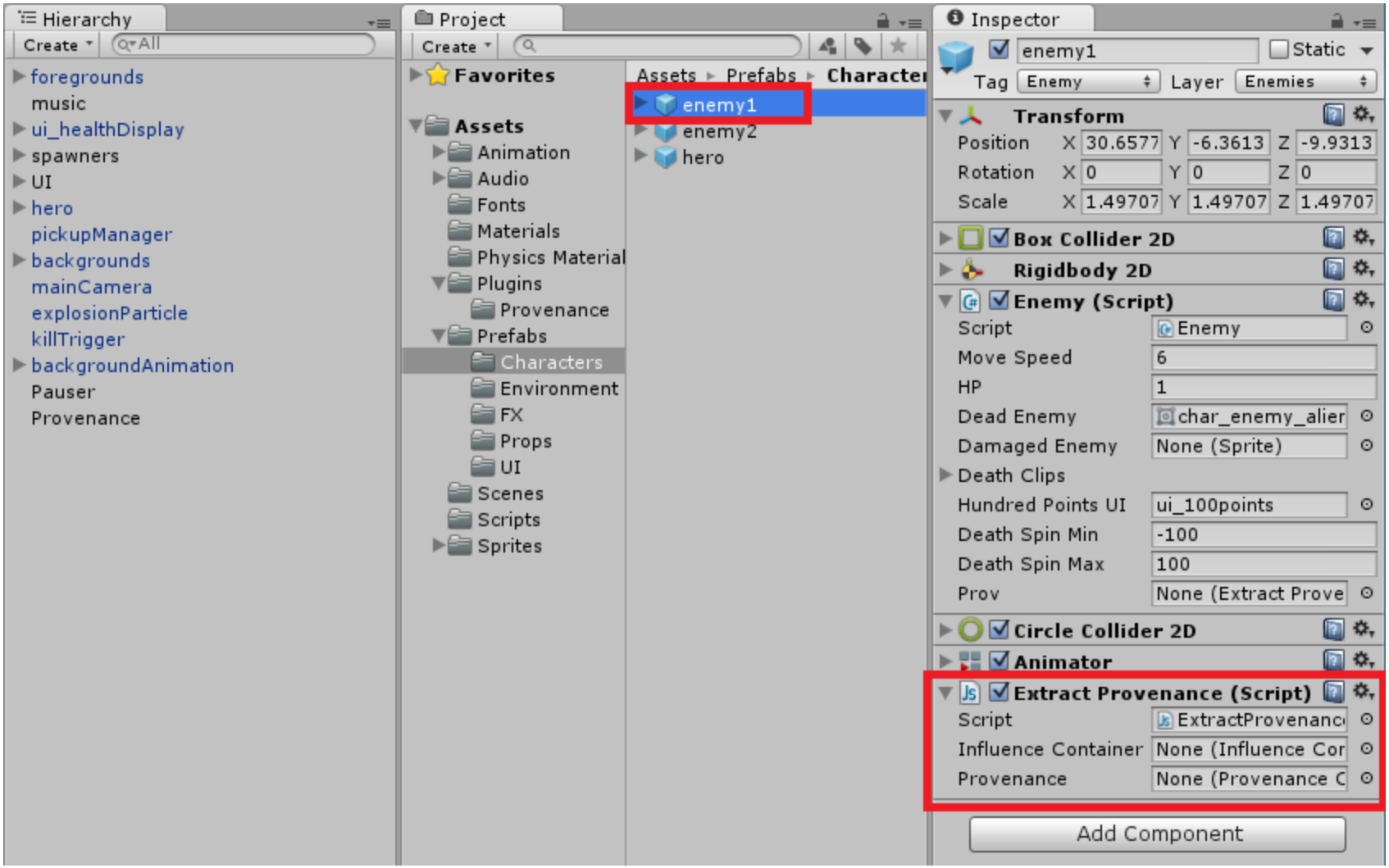
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Script Enemy
Move Speed 6
HP 1
Dead Enemy char_enemy_alier
Damaged Enemy None (Sprite)
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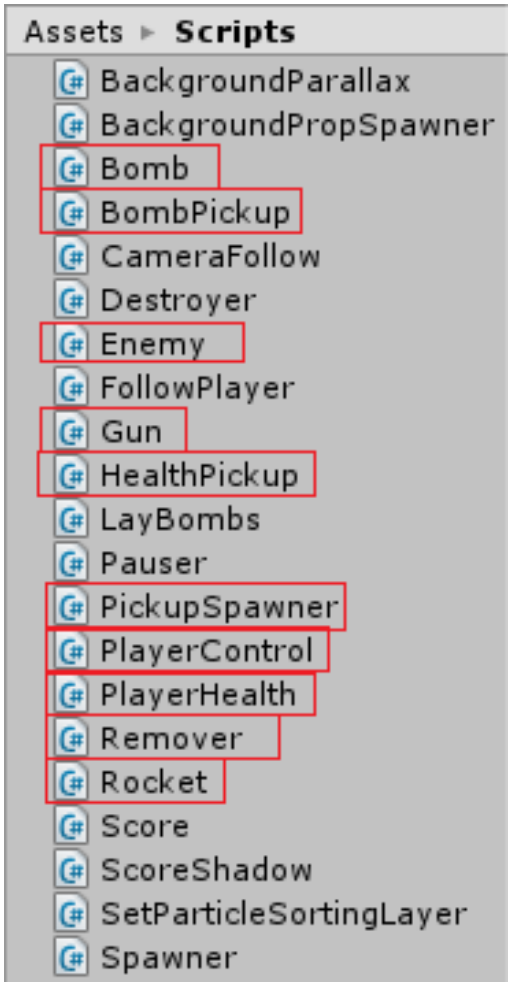
# 2D Platformer Example Scripts Breakdown




- **Enemy**
  - PlayerHealth
    - Enemy Attack (Action)
    - Player take Damage (Influence)
- **PlayerControl**
  - Bomb
    - Player Secondary Attack (Action)
    - Enemy take Damage, Area of Effect (Influence)
  - Gun
    - Player Primary Attack (Action)
    - Spawn **Rocket**
  - Remover
    - Player Death (Action)
  - Rocket
    - Enemy Damage (Influence)
- **PickupSpawner**
  - HealthPickup
    - Health Item (Object)
    - Heal (Influence)
  - BombPickup
    - Bomb Ammunition (Object)
    - More Bombs (Influence)

# Enemy

```
//=========================================================
// Provenance
//=========================================================
public void Prov_Enemy()
{
    Prov_GetEnemyAttributes();
    prov.NewAgentVertex("Enemy" + this.GetInstanceID(),"");
    Prov_Idle();
}

public void Prov_GetEnemyAttributes()
{
    prov.AddAttribute("Health", HP.ToString());
}

public void Prov_Hurt(string infID)
{
    Prov_GetEnemyAttributes();
    prov.NewActivityVertex("Taking Hit","");
    prov.HasInfluence_ID(infID);
}

public void Prov_Idle()
{
    Prov_GetEnemyAttributes();
    prov.NewActivityVertex("Walking","");
}

public string Prov_Attack(float damageAmount)
{
    Prov_GetEnemyAttributes();
    prov.NewActivityVertex("Attacking","");
    prov.GenerateInfluence("Player", this.GetInstanceID().ToString(), "Damage", (-damageAmount).ToString(), 1);
    return this.GetInstanceID().ToString();
}

public void Prov_Death()
{
    Prov_GetEnemyAttributes();
    prov.NewActivityVertex("Dead","");
    prov.GenerateInfluence("Player_Score", this.GetInstanceID().ToString(), "Score", "100", 1);
}
```

# Enemy

```
public ExtractProvenance prov = null;

void Awake()
{
    // Setting up the references.
    ren = transform.Find("body").GetComponent<SpriteRenderer>();
    frontCheck = transform.Find("frontCheck").transform;
    score = GameObject.Find("Score").GetComponent<Score>();

    // Provenance
    GameObject provObj = GameObject.Find("Provenance");
    prov = GetComponent<ExtractProvenance>();
    prov.influenceContainer = provObj.GetComponent<InfluenceController>();
    prov.provenance = provObj.GetComponent<ProvenanceController>();
    Prov_Enemy();
}

public void Flip()
{
    // Multiply the x component of localScale by -1.
    Vector3 enemyScale = transform.localScale;
    enemyScale.x *= -1;
    transform.localScale = enemyScale;

    // Provenance
    Prov_Idle();
}
```

# Enemy

```
void Death()
{
    // Find all of the sprite renderers on this object and it's children.
    SpriteRenderer[] otherRenderers = GetComponentsInChildren<SpriteRenderer>();

    // Disable all of them sprite renderers.
    foreach(SpriteRenderer s in otherRenderers)
    {
        s.enabled = false;
    }

    // Re-enable the main sprite renderer and set it's sprite to the deadEnemy sprite.
    ren.enabled = true;
    ren.sprite = deadEnemy;

    // Increase the score by 100 points
    score.score += 100;

    // Set dead to true.
    dead = true;

    // Allow the enemy to rotate and spin it by adding a torque.
    rigidbody2D.fixedAngle = false;
    rigidbody2D.AddTorque(Random.Range(deathSpinMin,deathSpinMax));

    // Find all of the colliders on the gameobject and set them all to be triggers.
    Collider2D[] cols = GetComponents<Collider2D>();
    foreach(Collider2D c in cols)
    {
        c.isTrigger = true;
    }

    // Play a random audioclip from the deathClips array.
    int i = Random.Range(0, deathClips.Length);
    AudioSource.PlayClipAtPoint(deathClips[i], transform.position);

    // Create a vector that is just above the enemy.
    Vector3 scorePos;
    scorePos = transform.position;
    scorePos.y += 1.5f;

    // Instantiate the 100 points prefab at this point.
    Instantiate(hundredPointsUI, scorePos, Quaternion.identity);

    // Provenance
    Prov_Death();
}
```

# Player Health

```
//============================================================
// Provenance
//============================================================
void Prov_TakeDamage(GameObject enemy)
{
    string infID = enemy.GetComponent<Enemy>().Prov_Attack(damageAmount);
    playerControl.Prov_TakeDamage(infID);
}
```

# Player Health

```
void OnCollisionEnter2D (Collision2D col)
{
    // If the colliding gameobject is an Enemy...
    if(col.gameObject.tag == "Enemy")
    {
        // ... and if the time exceeds the time of the last hit plus the time between hits...
        if (Time.time > lastHitTime + repeatDamagePeriod)
        {
            // ... and if the player still has health...
            if(health > 0f)
            {
                // ... take damage and reset the lastHitTime.
                TakeDamage(col.transform);
                lastHitTime = Time.time;

                // Provenance
                Prov_TakeDamage(col.gameObject);
            }
            // If the player doesn't have health, do some stuff, let him fall into the river to reload the level.
            else
            {
                // Find all of the colliders on the gameobject and set them all to be triggers.
                Collider2D[] cols = GetComponents<Collider2D>();
                foreach(Collider2D c in cols)
                {
                    c.isTrigger = true;
                }

                // Move all sprite parts of the player to the front
                SpriteRenderer[] spr = GetComponentsInChildren<SpriteRenderer>();
                foreach(SpriteRenderer s in spr)
                {
                    s.sortingLayerName = "UI";
                }

                // ... disable user Player Control script
                GetComponent<PlayerControl>().enabled = false;

                // ... disable the Gun script to stop a dead guy shooting a nonexistant bazooka
                GetComponentInChildren<Gun>().enabled = false;

                // ... Trigger the 'Die' animation state
                anim.SetTrigger("Die");
            }
        }
    }
}
```

# Player Control

```
//============================================================
// Provenance
//============================================================
public void Prov_Jump()
{
    Prov_GetPlayerAttributes();
    prov.NewActivityVertex("Jump","");
    prov.HasInfluence("Player_Score");
}

public void Prov_Player()
{
    Prov_GetPlayerAttributes();
    prov.NewAgentVertex("Player","");
}

public void Prov_Walking()
{
    Prov_GetPlayerAttributes();
    prov.NewActivityVertex("Walking","");
    prov.HasInfluence("Player_Score");
}

public void Prov_Shoot()
{
    Prov_GetPlayerAttributes();
    prov.NewActivityVertex("Shooting","");
    prov.HasInfluence("Player_Score");
    //Generated Influence in the ammo instantiation (Rocket)
}

public void Prov_TakeDamage(string infID)
{
    Prov_GetPlayerAttributes();
    prov.NewActivityVertex("Being Hit","");
    // Check Influence
    prov.HasInfluence_ID(infID);
}
```

```
public void Prov_Death()
{
    Score score = GameObject.Find("Score").GetComponent<Score>();

    prov.AddAttribute("Health", "0");
    prov.AddAttribute("Score", score.score.ToString());
    prov.NewActivityVertex("Death","Drowned");
    Prov_Export();
}

public void Prov_GetPlayerAttributes()
{
    PlayerHealth hp = GetComponent<PlayerHealth>();
    Score score = GameObject.Find("Score").GetComponent<Score>();
    LayBombs laybomb = GetComponent<LayBombs>();

    prov.AddAttribute("Health", hp.health.ToString());
    prov.AddAttribute("Score", score.score.ToString());
    prov.AddAttribute("Bombs", laybomb.bombCount.ToString());
}

public void Prov_PickUp(string infID)
{
    Prov_GetPlayerAttributes();
    prov.NewActivityVertex("PickedUp","");
    // Check Influence
    prov.HasInfluence_ID(infID);
}

public void RemoveBombInfluence(string bomb)
{
    prov.RemoveInfluenceID(bomb);
}
public void Prov_LayBomb(string bomb)
{
    Prov_GetPlayerAttributes();
    prov.NewActivityVertex("LayingBomb","");
    prov.HasInfluence("Player_Score");
    prov.GenerateInfluence("Enemy", bomb, "Damage", "-2");
}

void Prov_Export()
{
    Debug.Log ("Exported");
    GameObject ProvObj = GameObject.Find("Provenance");
    ProvenanceController prov = ProvObj.GetComponent<ProvenanceController>();
    prov.Save("2D_Provenance");
}
```

# Player Control

```
// Provenance
public ExtractProvenance prov;

 void Awake()
 {
     // Setting up references.
     groundCheck = transform.Find("groundCheck");
     anim = GetComponent<Animator>();

     // Provenance
     Prov_Player();
 }


void Flip ()
{
    // Switch the way the player is labelled as facing.
    facingRight = !facingRight;

    // Multiply the player's x local scale by -1.
    Vector3 theScale = transform.localScale;
    theScale.x *= -1;
    transform.localScale = theScale;

    // Provenance
    Prov_Walking();
}
```

```
void FixedUpdate ()
{
    // Cache the horizontal input.
    float h = Input.GetAxis("Horizontal");

    // The Speed animator parameter is set to the absolute value of the horizontal input.
    anim.SetFloat("Speed", Mathf.Abs(h));

    // If the player is changing direction (h has a different sign to velocity.x) or hasn't reached maxSpeed yet...
    if(h * rigidbody2D.velocity.x < maxSpeed)
        // ... add a force to the player.
        rigidbody2D.AddForce(Vector2.right * h * moveForce);

    // If the player's horizontal velocity is greater than the maxSpeed...
    if(Mathf.Abs(rigidbody2D.velocity.x) > maxSpeed)
        // ... set the player's velocity to the maxSpeed in the x axis.
        rigidbody2D.velocity = new Vector2(Mathf.Sign(rigidbody2D.velocity.x) * maxSpeed, rigidbody2D.velocity.y);

    // If the input is moving the player right and the player is facing left...
    if(h > 0 && !facingRight)
        // ... flip the player.
        Flip();
    // Otherwise if the input is moving the player left and the player is facing right...
    else if(h < 0 && facingRight)
        // ... flip the player.
        Flip();

    // If the player should jump...
    if(jump)
    {
        // Set the Jump animator trigger parameter.
        anim.SetTrigger("Jump");

        // Play a random jump audio clip.
        int i = Random.Range(0, jumpClips.Length);
        AudioSource.PlayClipAtPoint(jumpClips[i], transform.position);

        // Add a vertical force to the player.
        rigidbody2D.AddForce(new Vector2(0f, jumpForce));

        // Make sure the player can't jump again until the jump conditions from Update are satisfied.
        jump = false;

        //Prov Extraction
        Prov_Jump();
    }
```

# Bomb

```
//============================================================
// Provenance
//============================================================
void Prov_LayBomb()
{
    PlayerControl playerControl = GameObject.FindGameObjectWithTag("Player").GetComponent<PlayerControl>();
    playerControl.Prov_LayBomb(this.GetInstanceID().ToString());
}
void PROV_Boom(GameObject enemy)
{
    enemy.GetComponent<Enemy>().Prov_Hurt(this.GetInstanceID().ToString());
}

void Prov_RemoveBomb()
{
    PlayerControl playerControl = GameObject.FindGameObjectWithTag("Player").GetComponent<PlayerControl>();
    playerControl.RemoveBombInfluence(this.GetInstanceID().ToString());
}
```

# Bomb

```
IEnumerator BombDetonation()
{
    // Provenance
    Prov_LayBomb();

    // Play the fuse audioclip.
    AudioSource.PlayClipAtPoint(fuse, transform.position);

    // Wait for 2 seconds.
    yield return new WaitForSeconds(fuseTime);

    // Explode the bomb.
    Explode();
}
```

```
public void Explode()
{
    // The player is now free to lay bombs when he has them.
    layBombs.bombLaid = false;

    // Make the pickup spawner start to deliver a new pickup.
    pickupSpawner.StartCoroutine(pickupSpawner.DeliverPickup());

    // Find all the colliders on the Enemies layer within the bombRadius.
    Collider2D[] enemies = Physics2D.OverlapCircleAll(transform.position, bombRadius, 1 << LayerMask.NameToLayer("Enemies"));

    // For each collider...
    foreach(Collider2D en in enemies)
    {
        // Check if it has a rigidbody (since there is only one per enemy, on the parent).
        Rigidbody2D rb = en.rigidbody2D;
        if(rb != null && rb.tag == "Enemy")
        {
            // Find the Enemy script and set the enemy's health to zero.
            rb.gameObject.GetComponent<Enemy>().HP = 0;

            // Provenance
            PROV_Boom(rb.gameObject);

            // Find a vector from the bomb to the enemy.
            Vector3 deltaPos = rb.transform.position - transform.position;

            // Apply a force in this direction with a magnitude of bombForce.
            Vector3 force = deltaPos.normalized * bombForce;
            rb.AddForce(force);
        }
    }

    // Provenance
    Prov_RemoveBomb();

    // Set the explosion effect's position to the bomb's position and play the particle system.
    explosionFX.transform.position = transform.position;
    explosionFX.Play();

    // Instantiate the explosion prefab.
    Instantiate(explosion,transform.position, Quaternion.identity);

    // Play the explosion sound effect.
    AudioSource.PlayClipAtPoint(boom, transform.position);

    // Destroy the bomb.
    Destroy (gameObject);
}
```

# Gun

```
void Update ()
{
    // If the fire button is pressed...
    if(Input.GetButtonDown("Fire1"))
    {
        // ... set the animator Shoot trigger parameter and play the audioclip.
        anim.SetTrigger("Shoot");
        audio.Play();

        // If the player is facing right...
        if(playerCtrl.facingRight)
        {
            // ... instantiate the rocket facing right and set it's velocity to the right.
            Rigidbody2D bulletInstance = Instantiate(rocket, transform.position, Quaternion.Euler(new Vector3(0,0,0))) as Rigidbody2D;
            bulletInstance.velocity = new Vector2(speed, 0);
        }
        else
        {
            // Otherwise instantiate the rocket facing left and set it's velocity to the left.
            Rigidbody2D bulletInstance = Instantiate(rocket, transform.position, Quaternion.Euler(new Vector3(0,0,180f))) as Rigidbody2D;
            bulletInstance.velocity = new Vector2(-speed, 0);
        }

        // Provenance
        playerCtrl.Prov_Shoot();
    }
}
```

# Remover

```
//=============================================================
// Provenance
//=============================================================
void Prov_Death(GameObject player)
{
    PlayerControl playerControl = player.GetComponent<PlayerControl>();
    playerControl.Prov_Death();
}
```

# Remover

```
void OnTriggerEnter2D(Collider2D col)
{
    // If the player hits the trigger...
    if(col.gameObject.tag == "Player")
    {
        // .. stop the camera tracking the player
        GameObject.FindGameObjectWithTag("MainCamera").GetComponent<CameraFollow>().enabled = false;

        // .. stop the Health Bar following the player
        if(GameObject.FindGameObjectWithTag("HealthBar").activeSelf)
        {
            GameObject.FindGameObjectWithTag("HealthBar").SetActive(false);
        }

        // ... instantiate the splash where the player falls in.
        Instantiate(splash, col.transform.position, transform.rotation);
        // ... destroy the player.
        Destroy (col.gameObject);

        //Provenance Death
        Prov_Death(col.gameObject);

        // ... reload the level.
        StartCoroutine("ReloadGame");
    }
    else
    {
        // ... instantiate the splash where the enemy falls in.
        Instantiate(splash, col.transform.position, transform.rotation);

        // Destroy the enemy.
        Destroy (col.gameObject);
    }
}
```

# Rocket

```
//============================================================
// Provenance
//============================================================
void Prov_generateInfluence()
{
    GameObject heroObj = GameObject.FindGameObjectWithTag("Player");
    PlayerControl playerControl = heroObj.GetComponent<PlayerControl>();
    playerControl.prov.GenerateInfluence("Enemy", this.GetInstanceID().ToString(), "Damage", "-1", 1);
}

void Prov_DamageEnemy(GameObject enemy)
{
    Prov_generateInfluence();
    enemy.GetComponent<Enemy>().Prov_Hurt(this.GetInstanceID().ToString());
}
```

# Rocket

```
void OnTriggerEnter2D (Collider2D col)
{
    // If it hits an enemy...
    if(col.tag == "Enemy")
    {
        // ... find the Enemy script and call the Hurt function.
        col.gameObject.GetComponent<Enemy>().Hurt();

        // Call the explosion instantiation.
        OnExplode();

        // Provenance
        Prov_DamageEnemy(col.gameObject);

        // Destroy the rocket.
        Destroy (gameObject);
    }
    // Otherwise if it hits a bomb crate...
    else if(col.tag == "BombPickup")
    {
        // ... find the Bomb script and call the Explode function.
        col.gameObject.GetComponent<Bomb>().Explode();

        // Destroy the bomb crate.
        Destroy (col.transform.root.gameObject);

        // Destroy the rocket.
        Destroy (gameObject);
    }
    // Otherwise if the player manages to shoot himself...
    else if(col.gameObject.tag != "Player")
    {
        // Instantiate the explosion and destroy the rocket.
        OnExplode();
        Destroy (gameObject);
    }
}
```

# Pickup Spawner

```
//============================================================
// Provenance
//============================================================
private void Prov_SpawnAgent()
{
    ExtractProvenance prov = GetComponent<ExtractProvenance>();
    prov.NewAgentVertex("ItemSpawner","");

}

public void Prov_SpawnPickup(string type, string infID, float value)
{
    ExtractProvenance prov = GetComponent<ExtractProvenance>();
    prov.NewEntityVertexFromAgent(type,"");
    prov.GenerateInfluence("Player", infID, type, value.ToString(), 1);

}
```

# Pickup Spawner

```
void Awake ()
{
    // Setting up the reference.
    playerHealth = GameObject.FindGameObjectWithTag("Player").GetComponent<PlayerHealth>();

    // Provenance
    Prov_SpawnAgent();
}
```

# Bomb & Health Pickup

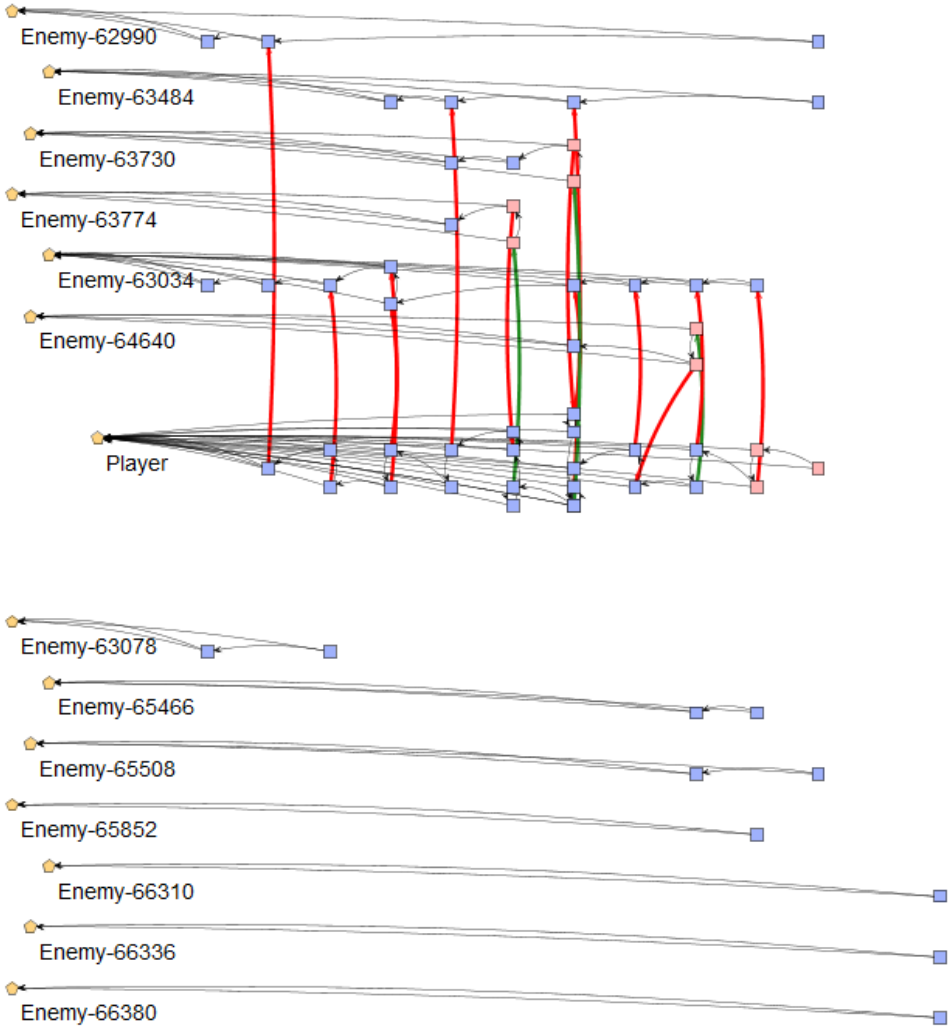
```
//============================================================
// Provenance
//============================================================

private void Prov_SpawnPickup()
{
    PickupSpawner pickupSpawner = GameObject.Find("pickupManager").GetComponent<PickupSpawner>();
    pickupSpawner.Prov_SpawnPickup("Bomb", this.GetInstanceID().ToString(), 1);
}

private void Prov_Pickup()
{
    PlayerControl playerControl = GameObject.FindGameObjectWithTag("Player").GetComponent<PlayerControl>();
    playerControl.Prov_PickUp(this.GetInstanceID().ToString());
}
```

```
//============================================================
// Provenance
//============================================================

private void Prov_SpawnPickup()
{
    pickupSpawner.Prov_SpawnPickup("LifeBox", this.GetInstanceID().ToString(), healthBonus);
}

private void Prov_Pickup()
{
    PlayerControl playerControl = GameObject.FindGameObjectWithTag("Player").GetComponent<PlayerControl>();
    playerControl.Prov_PickUp(this.GetInstanceID().ToString());
}
```

# Bomb & Health Pickup

```
void Awake()
{
    // Setting up the reference.
    anim = transform.root.GetComponent<Animator>();

    // Provenance
    Prov_SpawnPickup();
}


void OnTriggerEnter2D (Collider2D other)
{
    // If the player enters the trigger zone...
    if(other.tag == "Player")
    {
        // ... play the pickup sound effect.
        AudioSource.PlayClipAtPoint(pickupClip, transform.position);

        // Increase the number of bombs the player has.
        other.GetComponent<LayBombs>().bombCount++;

        // Provenance
        Prov_Pickup();

        // Destroy the crate.
        Destroy(transform.root.gameObject);
    }
    // Otherwise if the crate lands on the ground...
    else if(other.tag == "ground" && !landed)
    {
        // ... set the animator trigger parameter Land.
        anim.SetTrigger("Land");
        transform.parent = null;
        gameObject.AddComponent<Rigidbody2D>();
        landed = true;
    }
}
```

# Provenance Graph Example



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# CONCLUSION

# Conclusion

- Contributions
  - Rich Data Extraction
    - Broader Range of Analysis
  - Cause-and-Effect Relationships
  - Game Provenance Visualization
- Future Work
  - Automatic Inferences
  - Pattern Detection
  - Graph Layouts

# Provenance in Games

**Troy C. Kohwalter,**

*Instituto de Computação – Universidade Federal Fluminense (UFF)*