

# Particle Systems

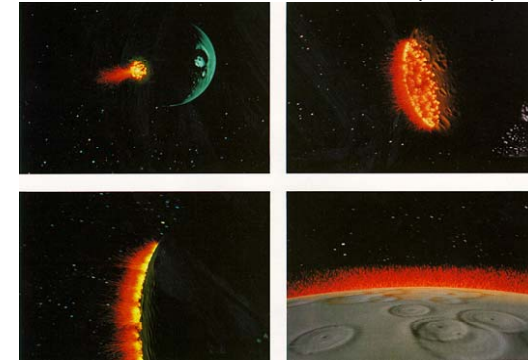
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## Star Trek II (1983)

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- Particle Systems can be utilized to simulate a wide range of phenomena such as fire, rain, smoke, explosions, and projectiles.
- It was first introduced in Star Trek II (1983) "Genesis Effect"



## Particle Systems

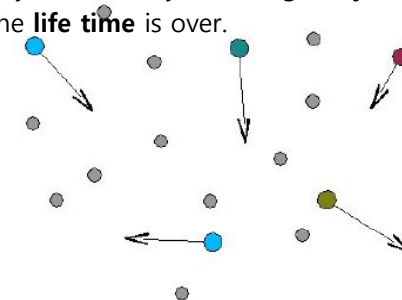
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- Particles (Point Sprite is removed from XNA4.0)
- Particle System Components
- Particle Systems
  - Snow/Rain
  - Explosions
  - Smoke
  - Fire

## Particles

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- Particle
  - A very small object that is usually modeled as a point mathematically.
  - Represented as a point with **position, velocity, and color**.
  - Each particle can be added in the particle system and moved in a physically realistic way (due to **gravity or wind**) and then died after the **life time** is over.



## Particles

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### □ Particle

- Use a **Point Sprite** to represent a particle.
- With point sprites (introduced in DirectX 8), graphics card only needs only one vertex for each particle.
  - Prior to point sprites, game developers had to create a rectangle (quad) and apply a texture to it for each particle.
- Point sprites can be as small as one pixel to as large as we want
  - We can set each particle to be a different texture and/or size.
- XNA automatically maps our texture to the vertex. It also makes sure that the texture is always facing the camera.
- **XNA Game Studio 4.0 no longer supports point sprites**  
<http://blogs.msdn.com/b/shawnhar/archive/2010/03/22/point-sprites-in-xna-game-studio-4-0.aspx>

## Particles

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### □ Creating the ParticleVertex structure

```
public struct ParticleVertex {
    public Short2 Corner; // particle quad's corner
    public Vector3 Position; // particle's starting position
    public Vector3 Velocity; // particle's starting velocity
    public Color Random; // particle's color
    public float Time; // the time at which the particle is created
    public static readonly VertexDeclaration VertexDeclaration = new
        VertexDeclaration (
            new VertexElement(0, VertexElementFormat.Short2,
                VertexElementUsage.Position, 0),
            new VertexElement(4, VertexElementFormat.Vector3,
                VertexElementUsage.Position, 1),
            new VertexElement(16, VertexElementFormat.Vector3,
                VertexElementUsage.Normal, 0),
            // 중간생략...
        );
}
```

## Particle System

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### □ Particle System Engine

- Particle system class manages the multiple particles' creation, initialization, remove, update, and draw.
- This class will be an abstract class that inherits from the DrawableGameComponent class.
- Each individual particle system (smoke, explosion, fire, etc) will inherit from this base ParticleSystem class.

## Particle System

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### □ The particle system fields

```
// 전형적인 particle system을 일반화한 base class
public abstract class ParticleSystem : DrawableGameComponent {
    ParticleSettings settings = new ParticleSettings(); // particle settings
    ContentManager content;
    Effect particleEffect; // for particle animation
    EffectParameter effectViewParameter; // 중간생략 .....
    ParticleVertex[] particles; // a particle array (circular queue)
    DynamicVertexBuffer vertexBuffer; // for GPU
    IndexBuffer indexBuffer; // for particle quads
    int firstActiveParticle; int firstNewParticle;
    int firstFreeParticle; int firstRetiredParticle;
    float currentTime;
    int drawCounter;
    static Random random = new Random();
    ... }
}
```

## Particle System

### □ Initialize the particle settings

```
// initialize particle settings on ParticleSystem
public override void Initialize()
{
    InitializeSettings(settings);
    // Allocate the particle array and fill in the corner (which never change).
    particles = new ParticleVertex[settings.MaxParticles * 4];
    for (int i = 0; i < settings.MaxParticles; i++) {
        particles[i * 4 + 0].Corner = new Short2(-1, -1);
        particles[i * 4 + 1].Corner = new Short2(1, -1);
        particles[i * 4 + 2].Corner = new Short2(1, 1);
        particles[i * 4 + 3].Corner = new Short2(-1, 1);
    }
    base.Initialize();
}
protected abstract void InitializeSettings(ParticleSettings settings);
```

## Particle System

```
class FireParticleSystem : ParticleSystem {
protected override void InitializeSettings(ParticleSettings settings) {
    settings.TextureName = "Particle\\fire";
    settings.MaxParticles = 2400;
    settings.Duration = TimeSpan.FromSeconds(2);
    settings.DurationRandomness = 1;
    settings.MinHorizontalVelocity = 0; settings.MaxHorizontalVelocity = 15;
    settings.MinVerticalVelocity = -10; settings.MaxVerticalVelocity = 10;
    settings.Gravity = new Vector3(0, 15, 0);
    settings.MinColor = new Color(255, 255, 255, 10);
    settings.MaxColor = new Color(255, 255, 255, 40);
    settings.MinStartSize = 5;
    settings.MaxStartSize = 10;
    settings.MinEndSize = 10;
    settings.MaxEndSize = 40;
    settings.BlendState = BlendState.Additive; // Use additive blending.
    } }
```

## Particle System

```
class ExplosionParticleSystem : ParticleSystem {
protected override void InitializeSettings(ParticleSettings settings) {
    settings.TextureName = "Particle\\explosion";
    settings.MaxParticles = 100;
    settings.Duration = TimeSpan.FromSeconds(2);
    settings.DurationRandomness = 1;
    settings.MinHorizontalVelocity = 20; settings.MaxHorizontalVelocity = 30;
    settings.MinVerticalVelocity = -20; settings.MaxVerticalVelocity = 20;
    settings.EndVelocity = 0;
    settings.MinColor = Color.DarkGray; settings.MaxColor = Color.Gray;
    settings.MinRotateSpeed = -1; settings.MaxRotateSpeed = 1;
    settings.MinStartSize = 7;
    settings.MaxStartSize = 7;
    settings.MinEndSize = 70;
    settings.MaxEndSize = 140;
    settings.BlendState = BlendState.Additive; // Use additive blending.
    } }
```

## Particle System

```
public override void Update(GameTime gameTime) {
    currentTime += (float)gameTime.ElapsedGameTime.TotalSeconds;
    // if active particles have reached the end of their life, move to retired section
    RetireActiveParticles();
    // if retired particles have been kept long enough, move old particle to free
    FreeRetiredParticles();
    // If we let our timer go on increasing for ever, it would eventually
    // run out of floating point precision, at which point the particles
    // would render incorrectly. An easy way to prevent this is to notice
    // that the time value doesn't matter when no particles are being drawn,
    // so we can reset it back to zero any time the active queue is empty.
    if (firstActiveParticle == firstFreeParticle)
        currentTime = 0;
    if (firstRetiredParticle == firstActiveParticle)
        drawCounter = 0;
    }
```

## Particle System

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```
public override void Draw(GameTime gameTime) {
    if (firstActiveParticle != firstFreeParticle) { // if active particle, draw
        device.BlendState = settings.BlendState;
        device.DepthStencilState = DepthStencilState.DepthRead;
// 중간 생략.. effect.SetParameters
        // Set the particle vertex and index buffer.
        device.SetVertexBuffer(vertexBuffer);
        device.Indices = indexBuffer;
        // Activate the particle effect.
        foreach (EffectPass pass in particleEffect.CurrentTechnique.Passes) {
            pass.Apply();
            if (firstActiveParticle < firstFreeParticle) {
                device.DrawIndexedPrimitives(PrimitiveType.TriangleList, 0,
                    firstActiveParticle * 4, (firstFreeParticle - firstActiveParticle) * 4,
                    firstActiveParticle * 6, (firstFreeParticle - firstActiveParticle) * 2);
            }
        }
    }
}
```

## Particle System

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```
else {
    device.DrawIndexedPrimitives(PrimitiveType.TriangleList, 0,
        firstActiveParticle * 4, (settings.MaxParticles - firstActiveParticle) * 4,
        firstActiveParticle * 6, (settings.MaxParticles - firstActiveParticle) * 2);
    if (firstFreeParticle > 0) {
        device.DrawIndexedPrimitives(PrimitiveType.TriangleList, 0,
            0, firstFreeParticle * 4, 0, firstFreeParticle * 2);
    }
}
// Reset some of the renderstates that we changed,
// so as not to mess up any other subsequent drawing.
device.DepthStencilState = DepthStencilState.Default;
}
drawCounter++;
}
```