HGamer 3D

a toolset for developing games with haskell

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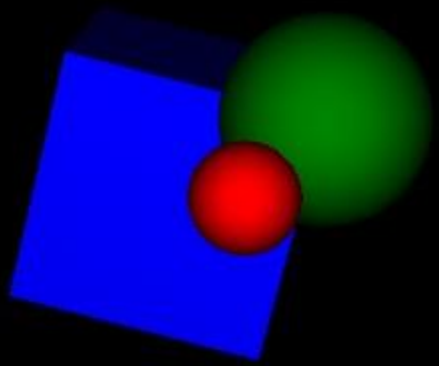
HAL 2016, 14.9., Leipzig

Agenda



Part I – Intro

- History
- Shortcomings
- New Approach

API Technology

Part II – What can I do with

- API Structure
- Showcase Game
  - Demo & Features
  - Architecture
  - HGamer3D API examples
- Feature Coverage of HGamer3D

Part I - History

History

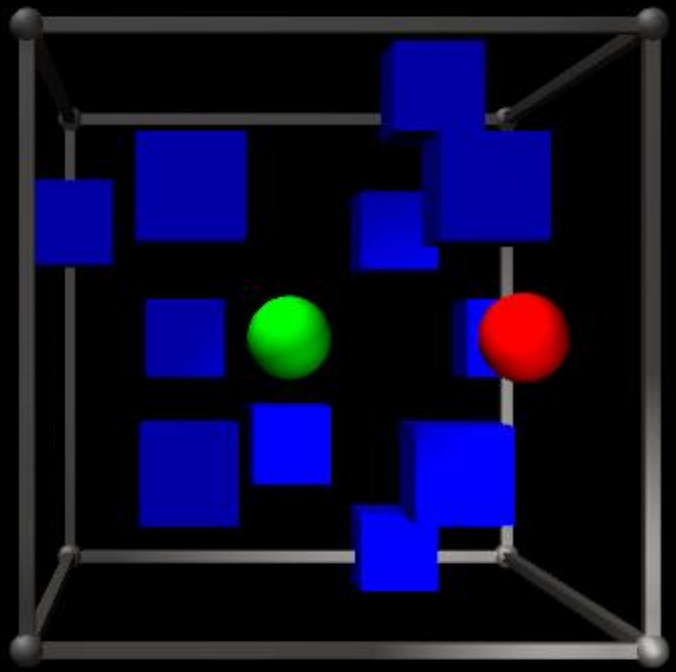
Started with Irrlicht bindings – cumbersome

Then more serious with Ogre3D bindings

Got into trouble

- ❑ *Spent months with API changes, GUI integration, shader libs*
- ❑ *Fragmented build process, not working on other computers*
- ❑ *No binary distribution*
- ❑ *No media tooling*
- ❑ *External C-libs are a nightmare for others to build*

New Approach



New Approach – Fixed It

Integrated Engine: Urho3D

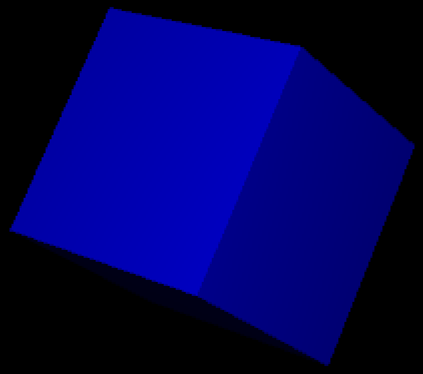
- *All parts integrated, shaders as well, build tooling much better*
- *Media tooling available*

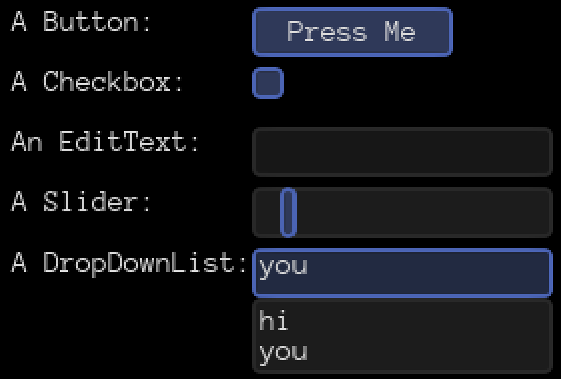
Binary Components, Installer Technology

- *Fixed distribution of programs, C-library problem*

Coarse Grained API Strategy

- *Fixes API stability issues*





API Technology

„Fresco“

Zero Install Tool – Arriccio (Go)

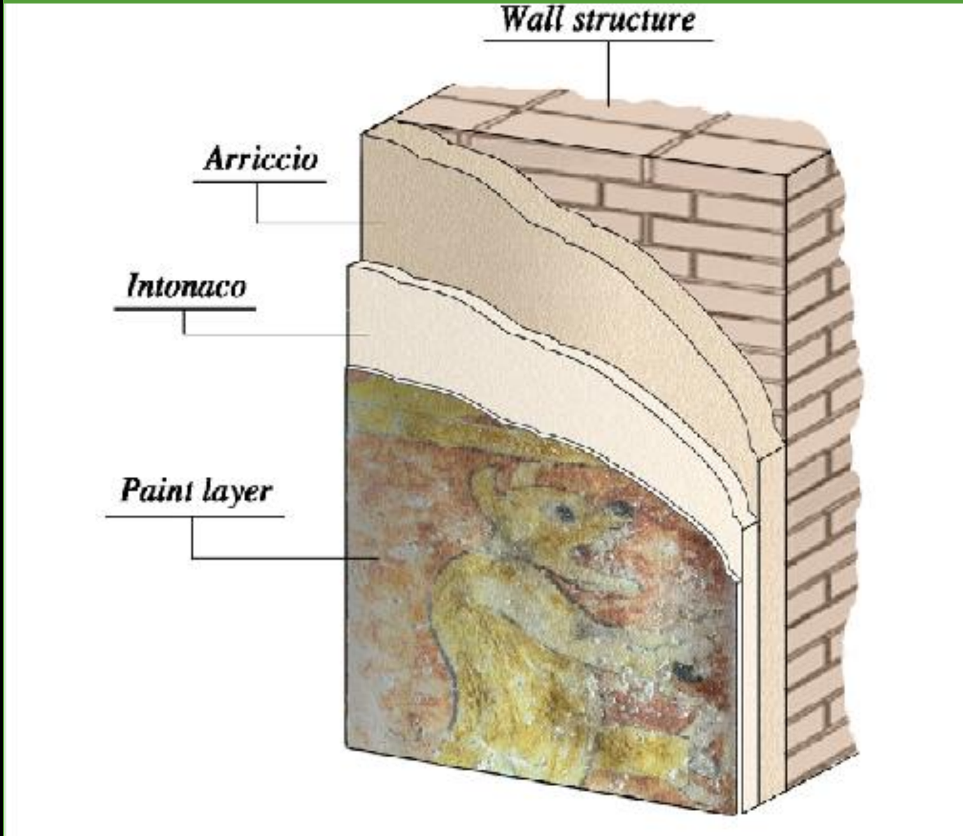
- ❑ *Dependency injection and resolution*
- ❑ *Web download for your platform*

Component Runtime – Intonaco (Rust)

- ❑ *Lock free data-structures for thread abstraction*
- ❑ *Intermediate format: messagepack*
- ❑ *Entity-Component-System*

Data Description Tool – Sinopia (Haskell)

- ❑ *To describe ADT for interface language independent*



Results

Happy Customers!

10 min to install in 5 easy steps:

- ❑ download aio for your platform
- ❑ aio Stack setup –resolver lts-5.8
- ❑ aio CreateProject
- ❑ ./build
- ❑ ./run

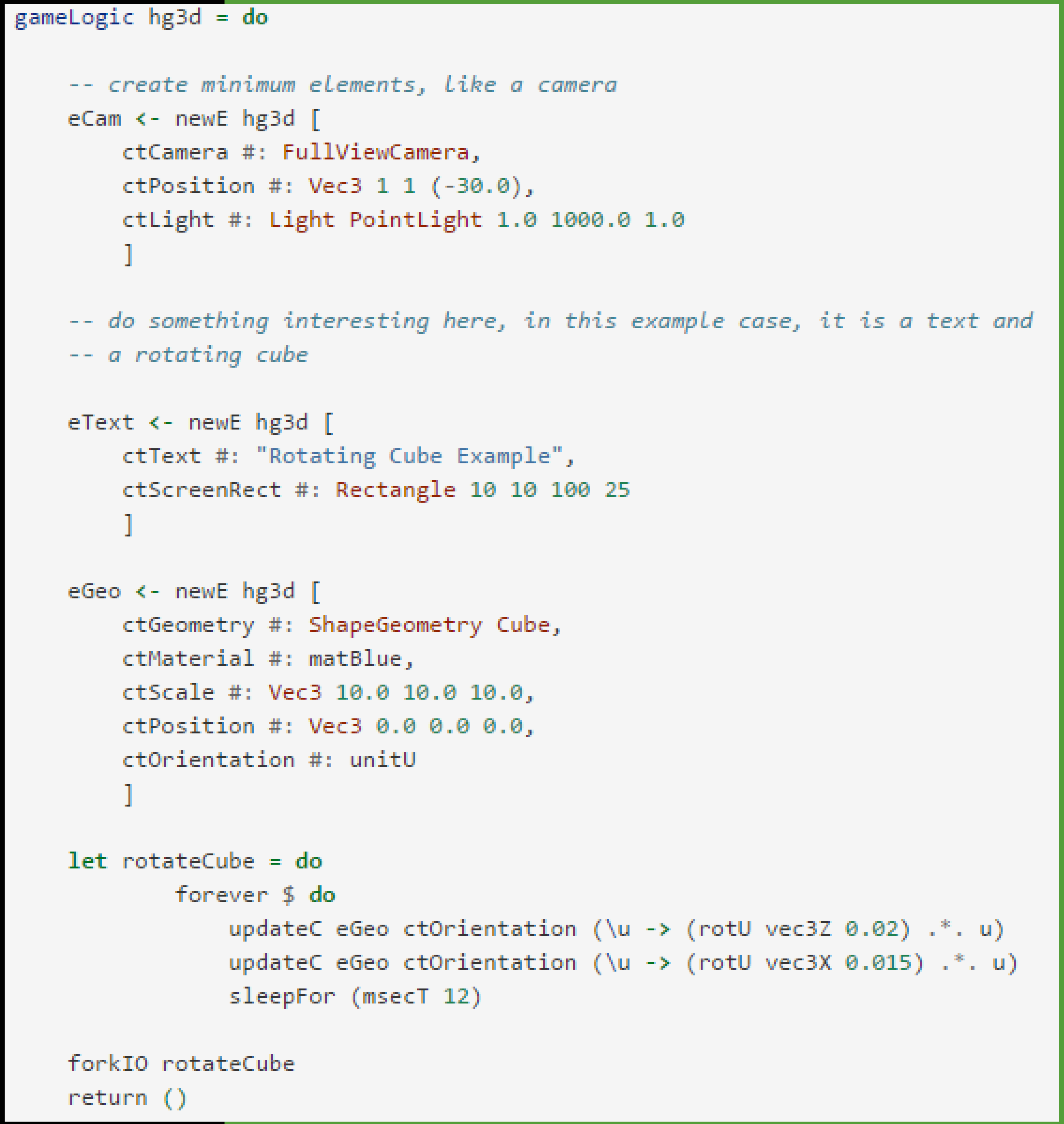
The same Haskell code on:
Windows / Linux / Mac !

Part II
What can I do with it ?

API One

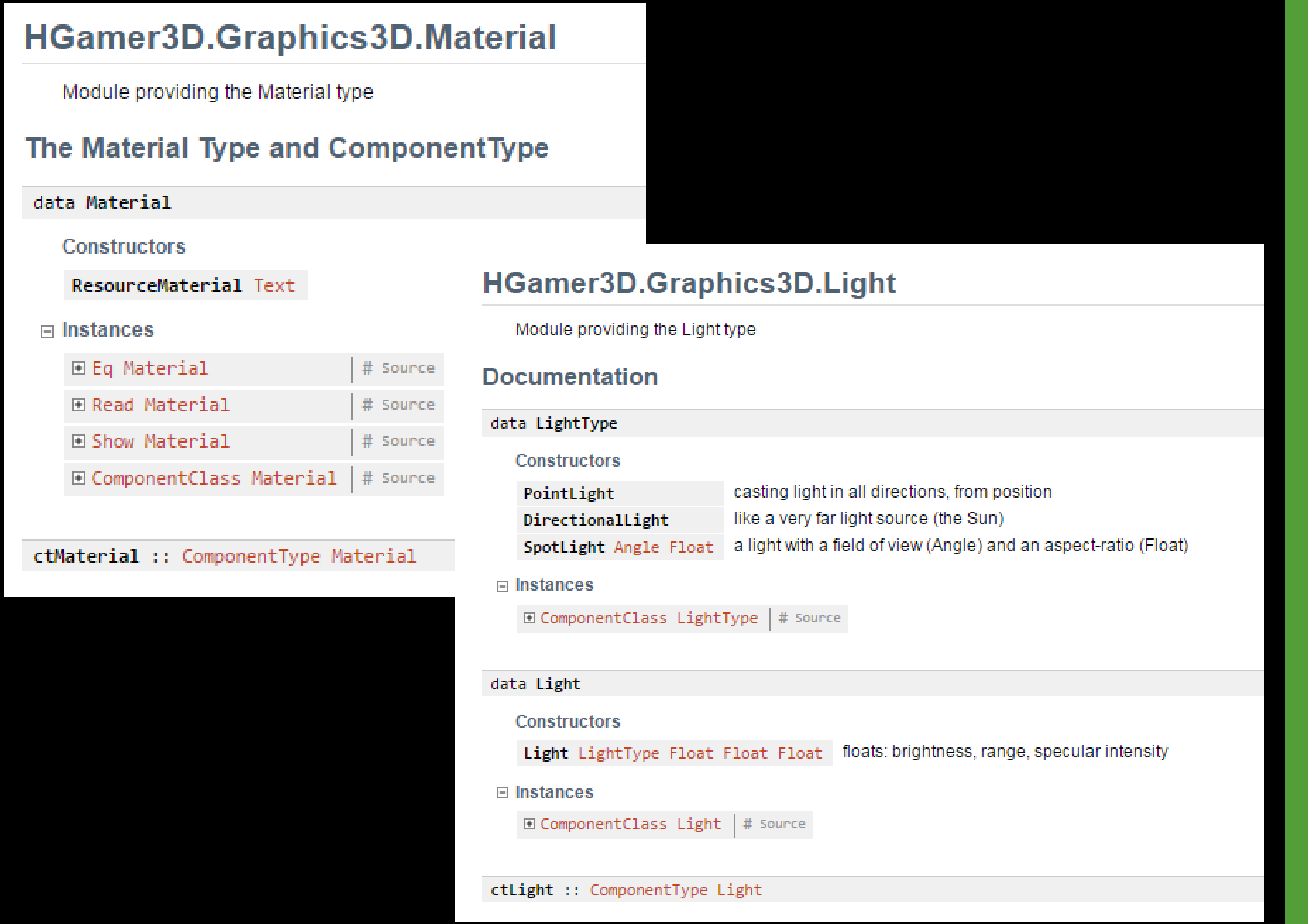
Entities

- ❑ *Composable from components*
- ❑ *Reference style*
- ❑ *CRUD within IO Monad*
- ❑ *Components are regular ADT‘s*
- ❑ *Reading & writing fully thread-safe*
- ❑ *One or more of components are kind-of objects, the other attributes*
- ❑ *Creation with „newE“ and component list*
- ❑ *Attributes modify all objects in Entity*
- ❑ *Threading – behind the scenes*
- ❑ *All you need to know: Data Types*



```
gameLogic hg3d = do

    -- create minimum elements, like a camera
    eCam <- newE hg3d [
        ctCamera #: FullViewCamera,
        ctPosition #: Vec3 1 1 (-30.0),
        ctLight #: Light PointLight 1.0 1000.0 1.0
        ]

    -- do something interesting here, in this example case, it is a text and
    -- a rotating cube

    eText <- newE hg3d [
        ctText #: "Rotating Cube Example",
        ctScreenRect #: Rectangle 10 10 100 25
        ]

    eGeo <- newE hg3d [
        ctGeometry #: ShapeGeometry Cube,
        ctMaterial #: matBlue,
        ctScale #: Vec3 10.0 10.0 10.0,
        ctPosition #: Vec3 0.0 0.0 0.0,
        ctOrientation #: unitU
        ]

    let rotateCube = do
            forever $ do
                updateC eGeo ctOrientation (\u -> (rotU vec3Z 0.02) .*. u)
                updateC eGeo ctOrientation (\u -> (rotU vec3X 0.015) .*. u)
                sleepFor (msecT 12)

    forkIO rotateCube
    return ()
```

Only Data Types to memorize



HGamer3D.Graphics3D.Material

Module providing the Material type

The Material Type and ComponentType

`data Material`

Constructors

`ResourceMaterial Text`

⊟ Instances

```
⊞ Eq Material                 # Source
⊞ Read Material               # Source
⊞ Show Material               # Source
⊞ ComponentClass Material     # Source
```

`ctMaterial :: ComponentType Material`

HGamer3D.Graphics3D.Light

Module providing the Light type

Documentation

`data LightType`

Constructors

`PointLight`	casting light in all directions, from position
`DirectionalLight`	like a very far light source (the Sun)
`SpotLight Angle Float`	a light with a field of view (Angle) and an aspect-ratio (Float)

⊟ Instances

```
⊞ ComponentClass LightType    # Source
```

`data Light`

Constructors

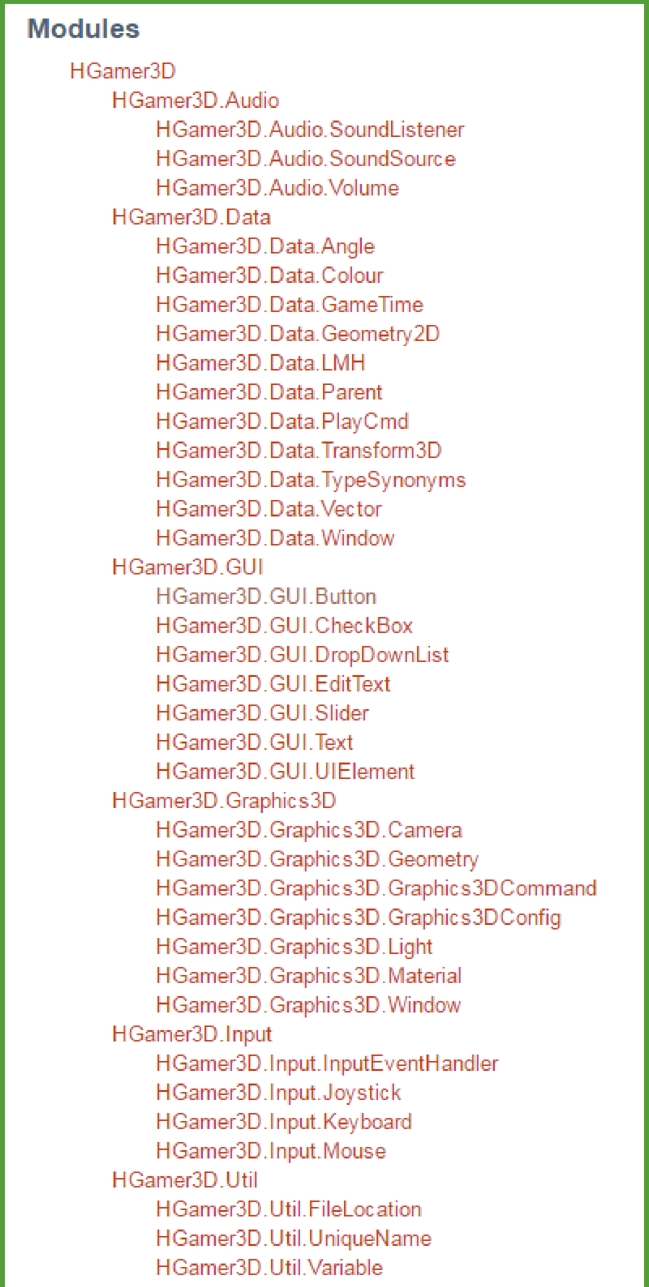
`Light LightType Float Float Float`	floats: brightness, range, specular intensity

⊟ Instances

```
⊞ ComponentClass Light    # Source
```

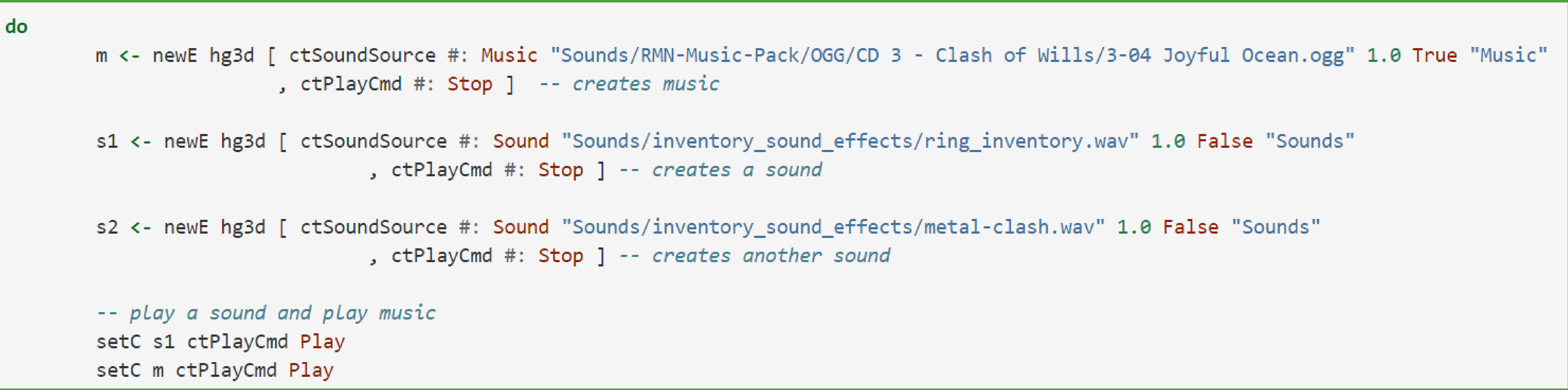
`ctLight :: ComponentType Light`

API Two

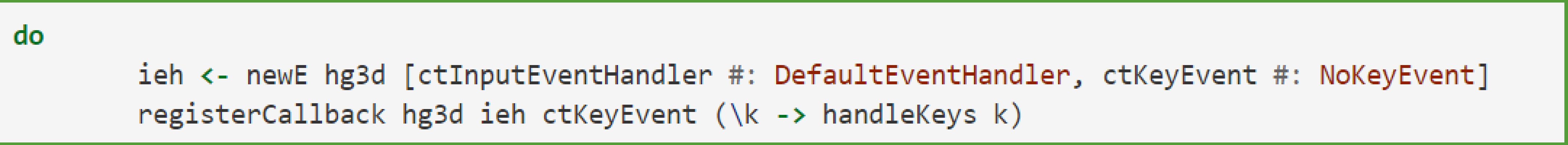


Modules

- HGamer3D
  - HGamer3D.Audio
    - HGamer3D.Audio.SoundListener
    - HGamer3D.Audio.SoundSource
    - HGamer3D.Audio.Volume
  - HGamer3D.Data
    - HGamer3D.Data.Angle
    - HGamer3D.Data.Colour
    - HGamer3D.Data.GameTime
    - HGamer3D.Data.Geometry2D
    - HGamer3D.Data.LMH
    - HGamer3D.Data.Parent
    - HGamer3D.Data.PlayCmd
    - HGamer3D.Data.Transform3D
    - HGamer3D.Data.TypeSynonyms
    - HGamer3D.Data.Vector
    - HGamer3D.Data.Window
  - HGamer3D.GUI
    - HGamer3D.GUI.Button
    - HGamer3D.GUI.CheckBox
    - HGamer3D.GUI.DropDownList
    - HGamer3D.GUI.EditText
    - HGamer3D.GUI.Slider
    - HGamer3D.GUI.Text
    - HGamer3D.GUI.UIElement
  - HGamer3D.Graphics3D
    - HGamer3D.Graphics3D.Camera
    - HGamer3D.Graphics3D.Geometry
    - HGamer3D.Graphics3D.Graphics3DCommand
    - HGamer3D.Graphics3D.Graphics3DConfig
    - HGamer3D.Graphics3D.Light
    - HGamer3D.Graphics3D.Material
    - HGamer3D.Graphics3D.Window
  - HGamer3D.Input
    - HGamer3D.Input.InputEventHandler
    - HGamer3D.Input.Joystick
    - HGamer3D.Input.Keyboard
    - HGamer3D.Input.Mouse
  - HGamer3D.Util
    - HGamer3D.Util.FileLocation
    - HGamer3D.Util.UniqueName
    - HGamer3D.Util.Variable



```
do
        m <- newE hg3d [ ctSoundSource #: Music "Sounds/RMN-Music-Pack/OGG/CD 3 - Clash of Wills/3-04 Joyful Ocean.ogg" 1.0 True "Music"
                        , ctPlayCmd #: Stop ]  -- creates music

        s1 <- newE hg3d [ ctSoundSource #: Sound "Sounds/inventory_sound_effects/ring_inventory.wav" 1.0 False "Sounds"
                                , ctPlayCmd #: Stop ] -- creates a sound

        s2 <- newE hg3d [ ctSoundSource #: Sound "Sounds/inventory_sound_effects/metal-clash.wav" 1.0 False "Sounds"
                                , ctPlayCmd #: Stop ] -- creates another sound

        -- play a sound and play music
        setC s1 ctPlayCmd Play
        setC m ctPlayCmd Play
```



```
do
        ieh <- newE hg3d [ctInputEventHandler #: DefaultEventHandler, ctKeyEvent #: NoKeyEvent]
        registerCallback hg3d ieh ctKeyEvent (\k -> handleKeys k)
```

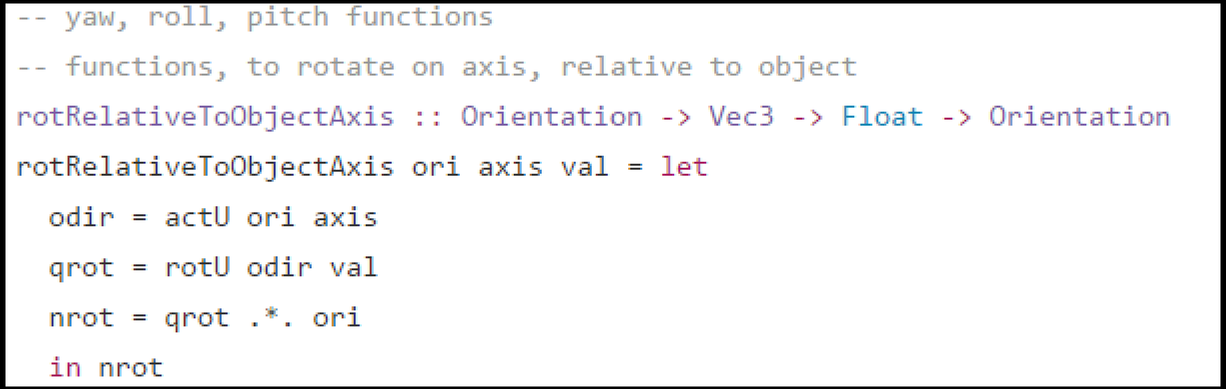
API Three

Examples for Sound and Event Handling

API Four

Vector Arithmetics with Vect package from Balázs Kőműves

- *Vector substraction, addition, scaling, rotation ...*
- *Quaternion arithmetics*
- *Examples:*
    - Rotation around an axis: „updateC eGeo ctOrientation (\u -> (rotU vec3Z 0.02) .*. u)“
    - Implementation of yaw, roll, pitch:

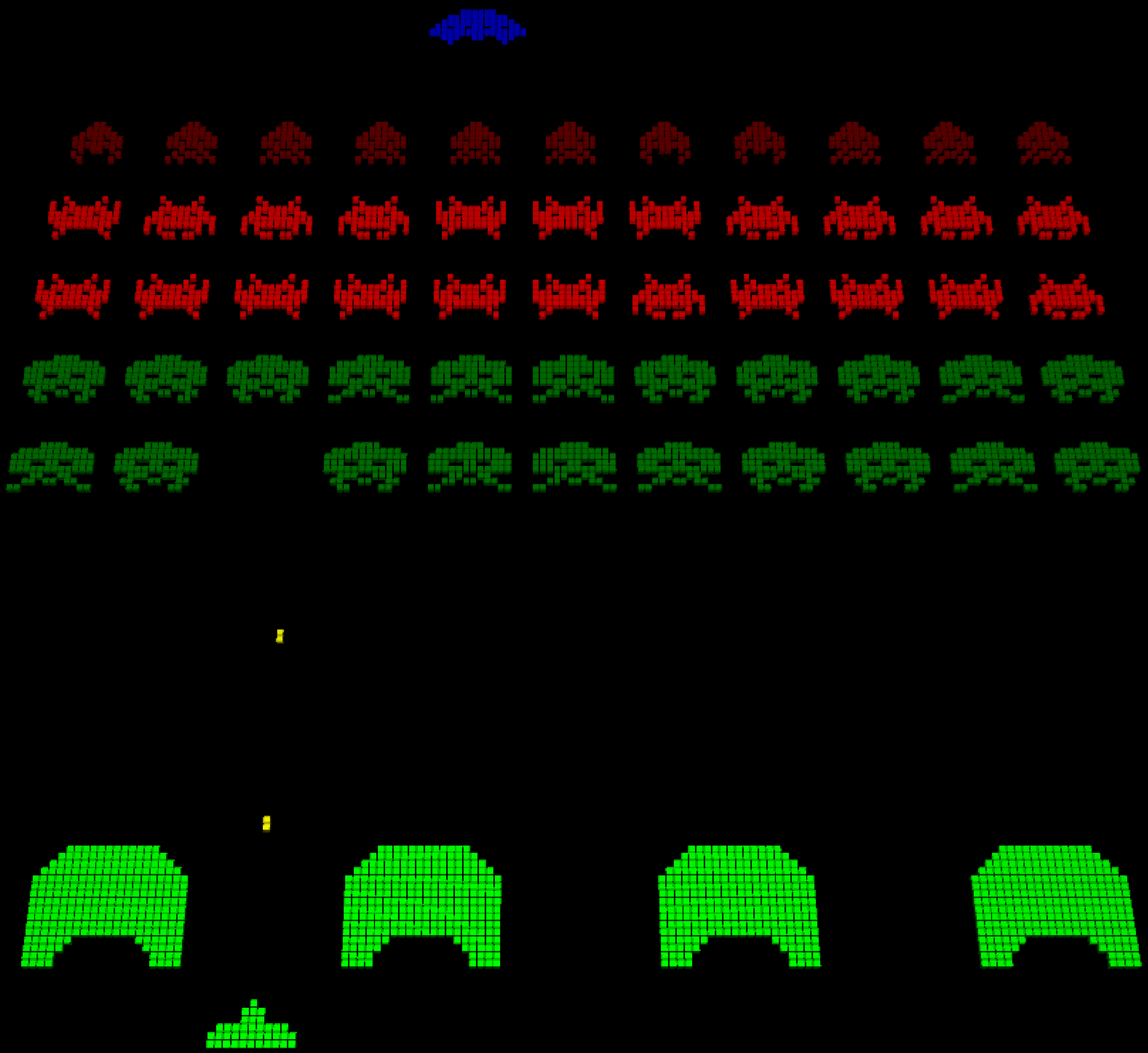


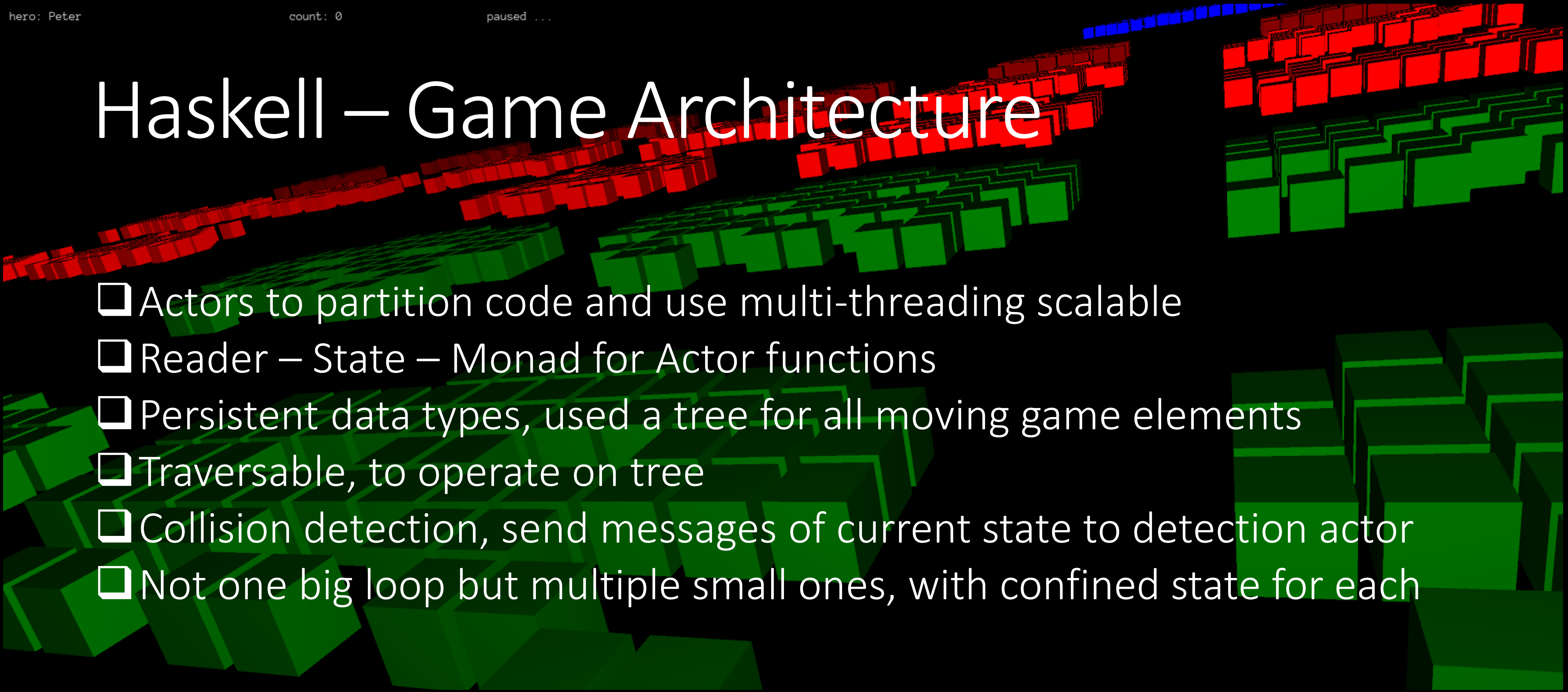
```
-- yaw, roll, pitch functions
-- functions, to rotate on axis, relative to object
rotRelativeToObjectAxis :: Orientation -> Vec3 -> Float -> Orientation
rotRelativeToObjectAxis ori axis val = let
  odir = actU ori axis
  qrot = rotU odir val
  nrot = qrot .*. ori
  in nrot
```

Showcase Game

Features

- □ *Sound, GUI, Key-Input*
- □ *Different game modes*
    - □ Intro Screen
    - □ Flying / Playing
- □ *Animated Invaders*
- □ *Fast Key-Input & Shooting*
- □ *Collision Detection by Haskell*

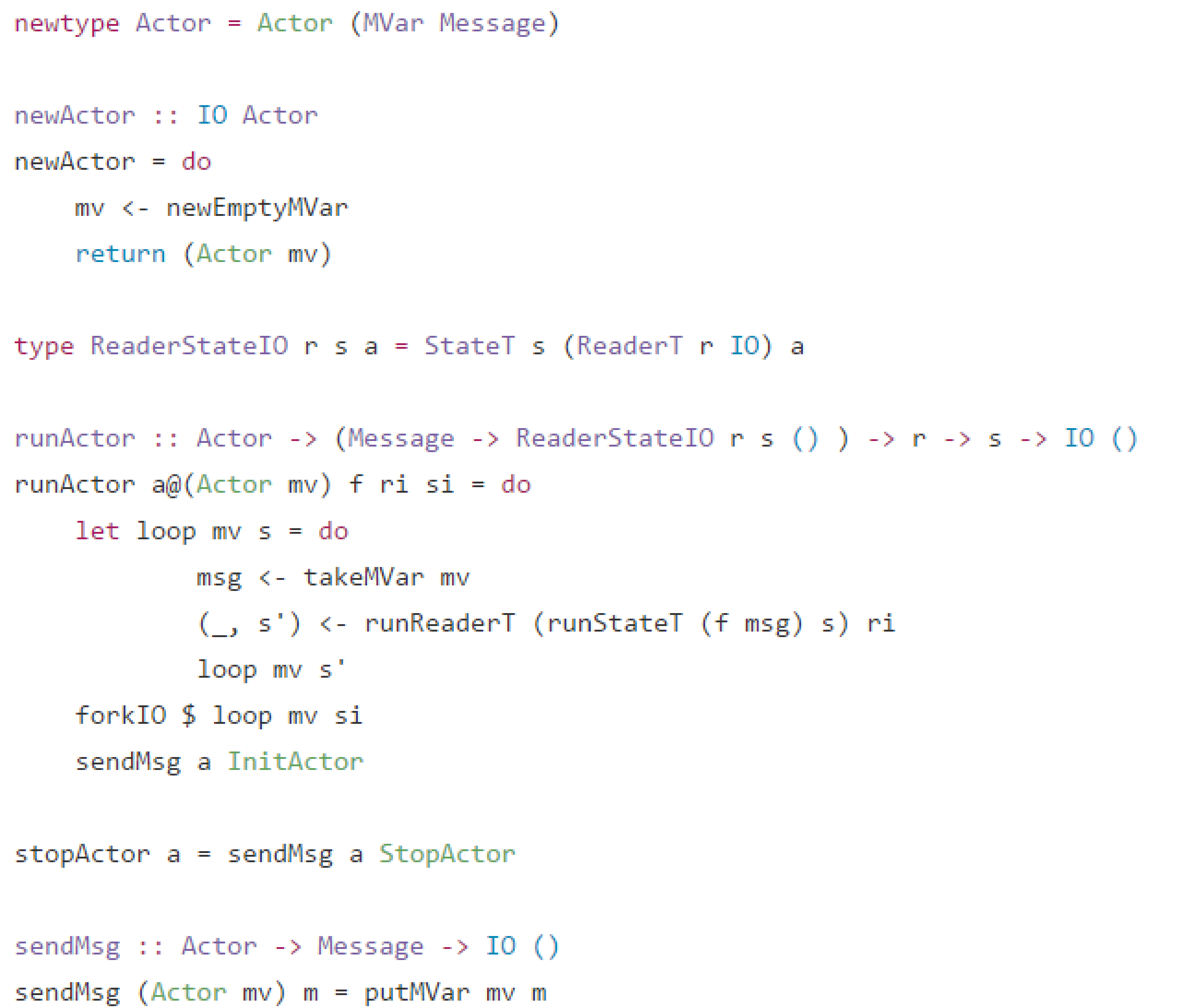




Haskell – Game Architecture

- □ Actors to partition code and use multi-threading scalable
- □ Reader – State – Monad for Actor functions
- □ Persistent data types, used a tree for all moving game elements
- □ Traversable, to operate on tree
- □ Collision detection, send messages of current state to detection actor
- □ Not one big loop but multiple small ones, with confined state for each

Actors: looping function within Reader-State-Monad

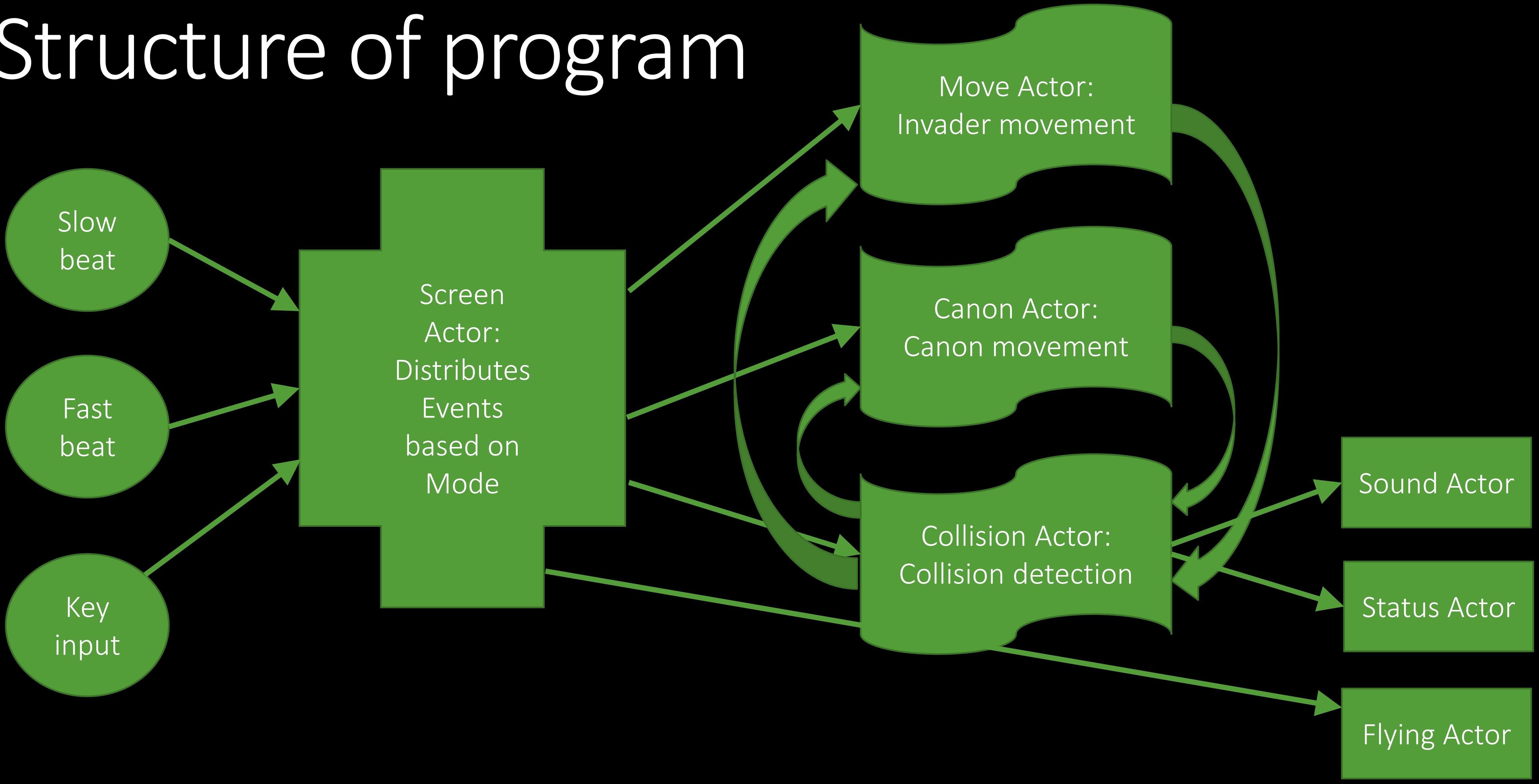


```haskell
newtype Actor = Actor (MVar Message)

newActor :: IO Actor
newActor = do
    mv <- newEmptyMVar
    return (Actor mv)

type ReaderStateIO r s a = StateT s (ReaderT r IO) a

runActor :: Actor -> (Message -> ReaderStateIO r s () ) -> r -> s -> IO ()
runActor a@(Actor mv) f ri si = do
    let loop mv s = do
            msg <- takeMVar mv
            (_, s') <- runReaderT (runStateT (f msg) s) ri
            loop mv s'
    forkIO $ loop mv si
    sendMsg a InitActor

stopActor a = sendMsg a StopActor

sendMsg :: Actor -> Message -> IO ()
sendMsg (Actor mv) m = putMVar mv m
```

Actors

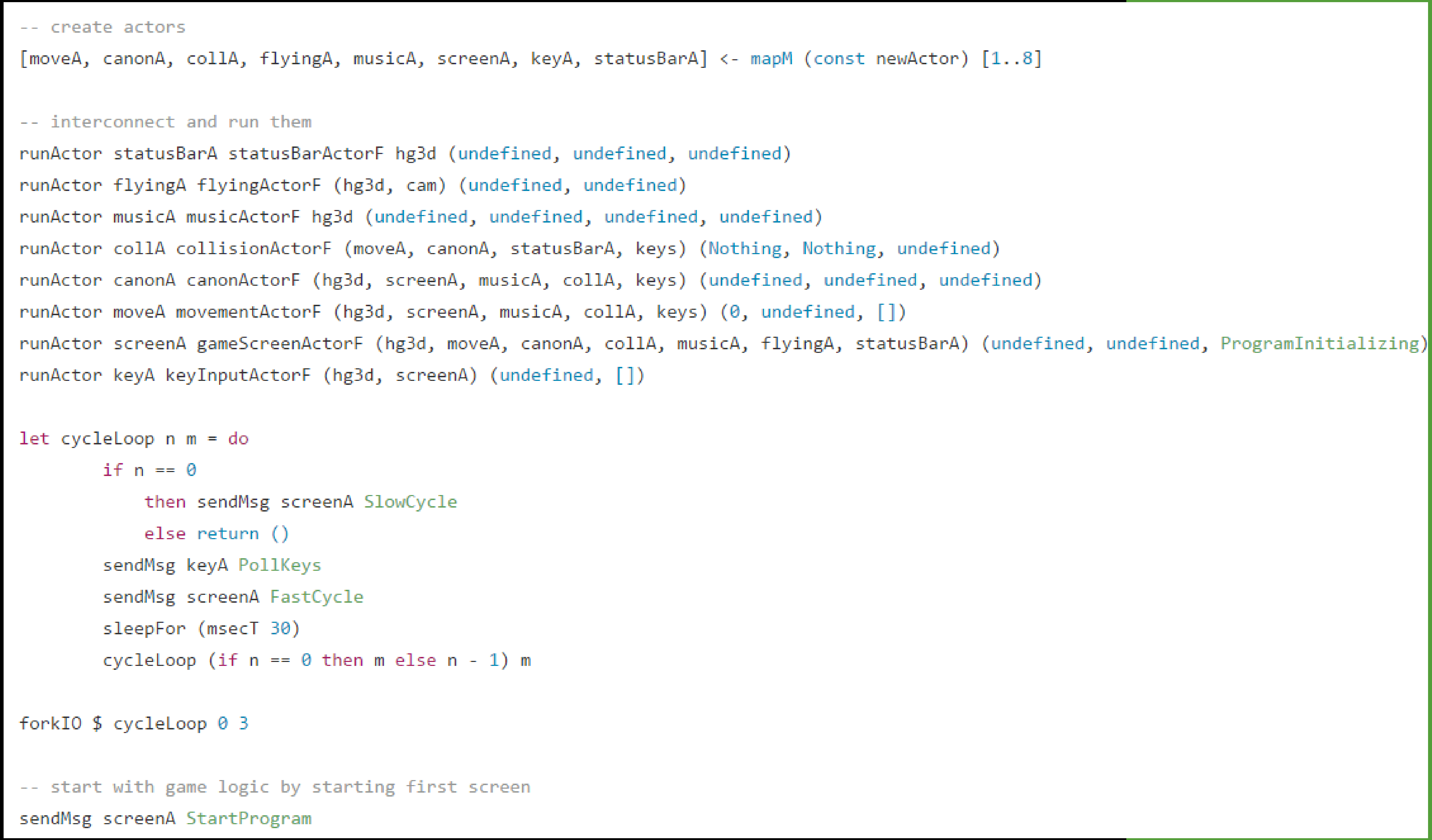
https://www.youtube.com/watch?v=VczbbiRmDik

Structure of program


Slow beat
Fast beat
Key input
Screen Actor: Distributes Events based on Mode
Move Actor: Invader movement
Canon Actor: Canon movement
Collision Actor: Collision detection
Sound Actor
Status Actor
Flying Actor

Actors are clearly separated pieces

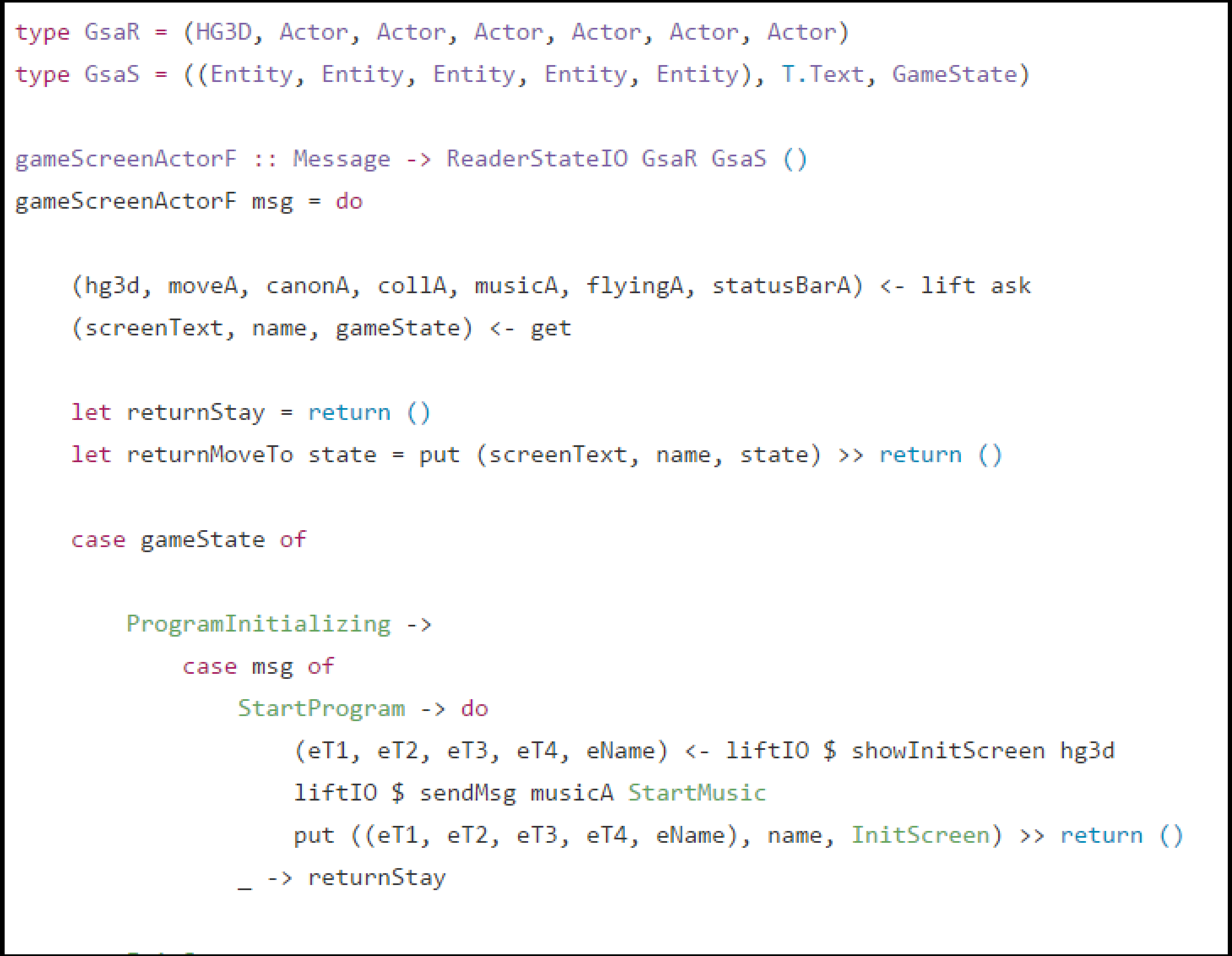
MAIN



```haskell
-- create actors
[moveA, canonA, collA, flyingA, musicA, screenA, keyA, statusBarA] <- mapM (const newActor) [1..8]

-- interconnect and run them
runActor statusBarA statusBarActorF hg3d (undefined, undefined, undefined)
runActor flyingA flyingActorF (hg3d, cam) (undefined, undefined)
runActor musicA musicActorF hg3d (undefined, undefined, undefined, undefined)
runActor collA collisionActorF (moveA, canonA, statusBarA, keys) (Nothing, Nothing, undefined)
runActor canonA canonActorF (hg3d, screenA, musicA, collA, keys) (undefined, undefined, undefined)
runActor moveA movementActorF (hg3d, screenA, musicA, collA, keys) (0, undefined, [])
runActor screenA gameScreenActorF (hg3d, moveA, canonA, collA, musicA, flyingA, statusBarA) (undefined, undefined, ProgramInitializing)
runActor keyA keyInputActorF (hg3d, screenA) (undefined, [])

let cycleLoop n m = do
        if n == 0
            then sendMsg screenA SlowCycle
            else return ()
        sendMsg keyA PollKeys
        sendMsg screenA FastCycle
        sleepFor (msecT 30)
        cycleLoop (if n == 0 then m else n - 1) m

forkIO $ cycleLoop 0 3

-- start with game logic by starting first screen
sendMsg screenA StartProgram
```

- □ Create actors
- □ Wire them
- □ Start beat
- □ Send init msg

State Machine for mode handling



```
type GsaR = (HG3D, Actor, Actor, Actor, Actor, Actor, Actor)
type GsaS = ((Entity, Entity, Entity, Entity, Entity), T.Text, GameState)

gameScreenActorF :: Message -> ReaderStateIO GsaR GsaS ()
gameScreenActorF msg = do

    (hg3d, moveA, canonA, collA, musicA, flyingA, statusBarA) <- lift ask
    (screenText, name, gameState) <- get

    let returnStay = return ()
    let returnMoveTo state = put (screenText, name, state) >> return ()

    case gameState of

        ProgramInitializing ->
            case msg of
                StartProgram -> do
                    (eT1, eT2, eT3, eT4, eName) <- liftIO $ showInitScreen hg3d
                    liftIO $ sendMsg musicA StartMusic
                    put ((eT1, eT2, eT3, eT4, eName), name, InitScreen) >> return ()
                _ -> returnStay
```

Screen ActorI

gameState is stored in state monad

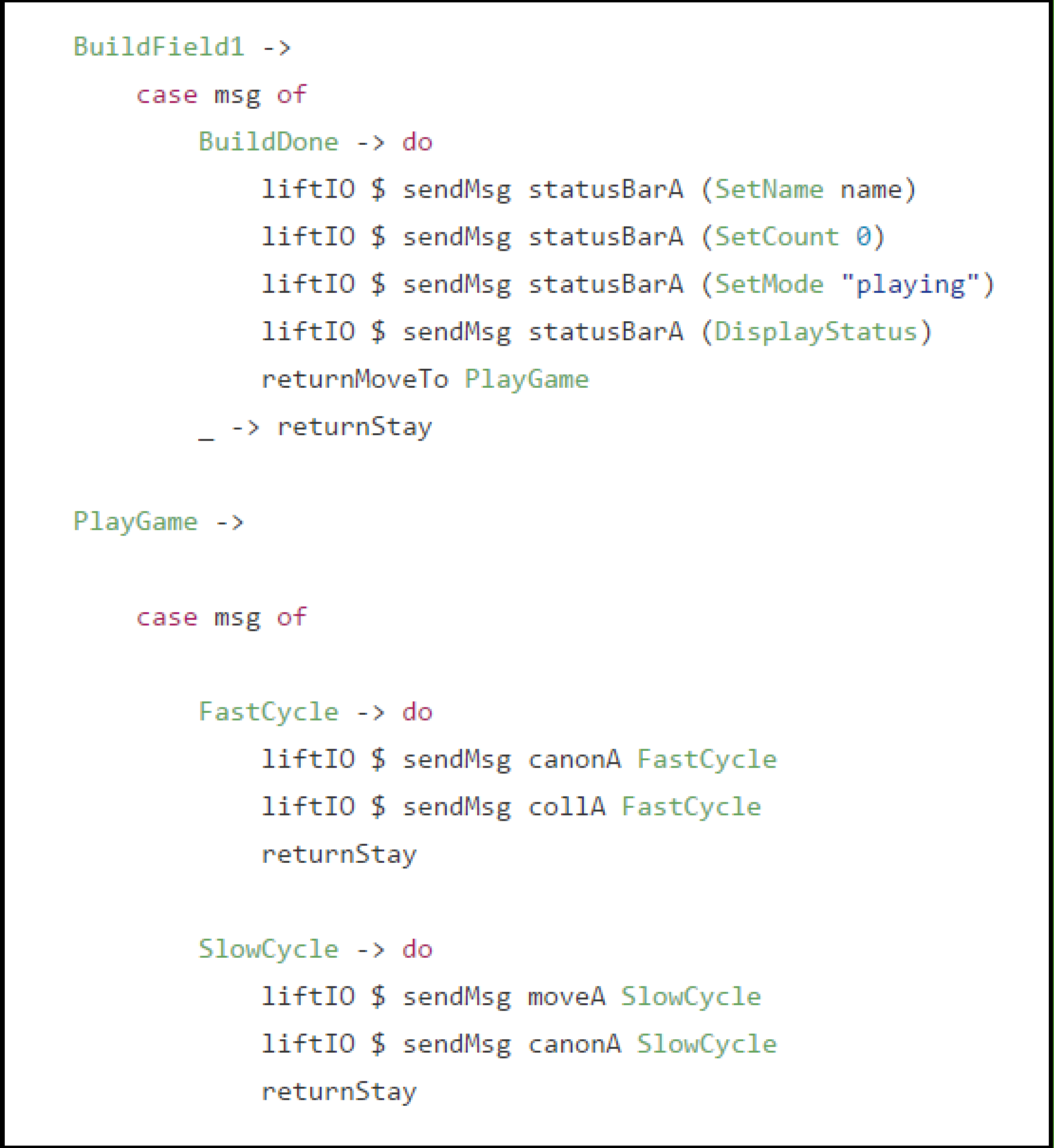
Big switch on gameState

Incoming messages are handled depending on current gameState

In this actor they are just re-distributed to next actors

Example: In pause mode keys are not forwarded, other keys are valid

Depending on mode, messages are distributed to next actor



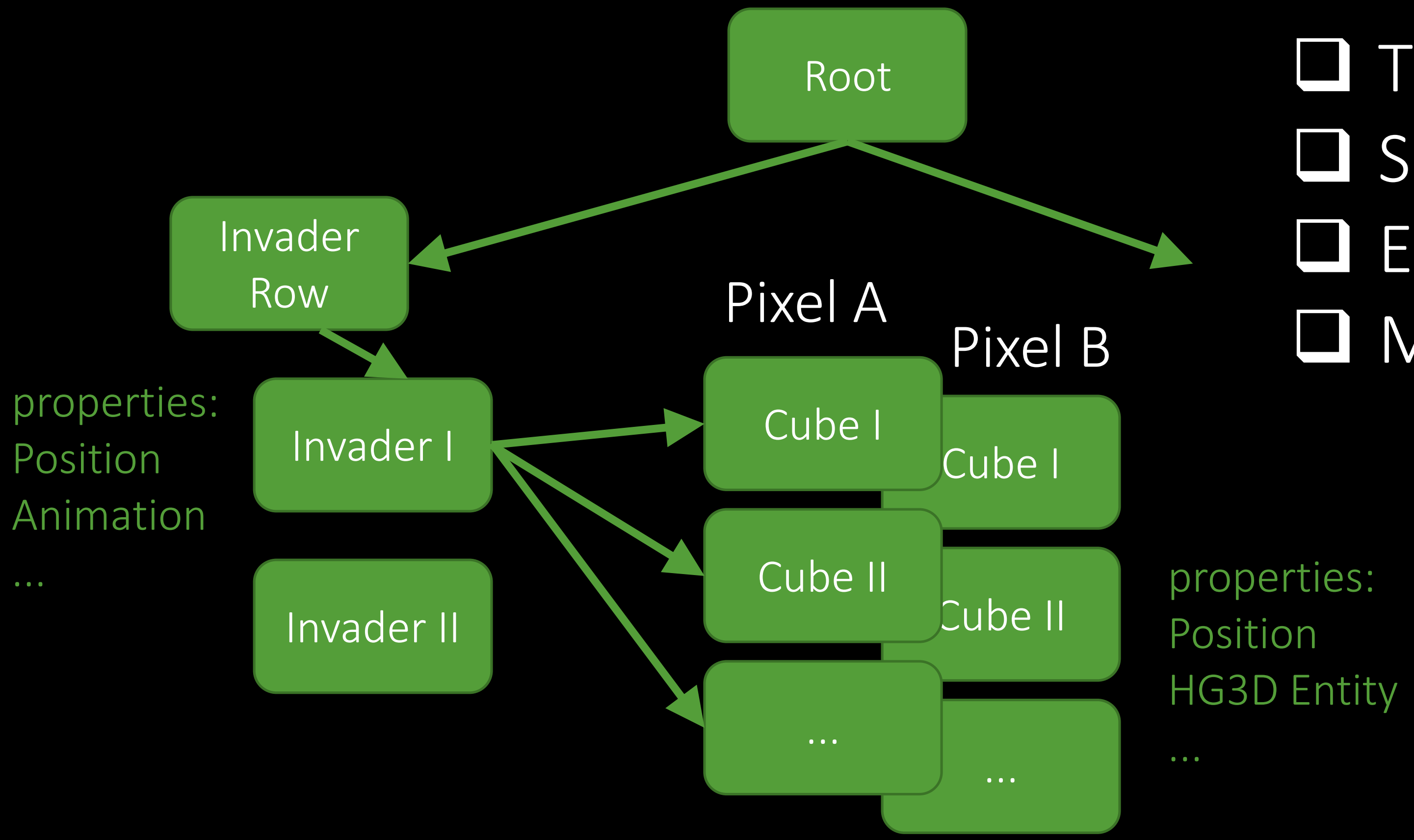
```
BuildField1 ->
    case msg of
        BuildDone -> do
            liftIO $ sendMsg statusBarA (SetName name)
            liftIO $ sendMsg statusBarA (SetCount 0)
            liftIO $ sendMsg statusBarA (SetMode "playing")
            liftIO $ sendMsg statusBarA (DisplayStatus)
            returnMoveTo PlayGame
        _ -> returnStay

PlayGame ->

    case msg of

        FastCycle -> do
            liftIO $ sendMsg canonA FastCycle
            liftIO $ sendMsg collA FastCycle
            returnStay

        SlowCycle -> do
            liftIO $ sendMsg moveA SlowCycle
            liftIO $ sendMsg canonA SlowCycle
            returnStay
```

Screen Actor II

There are two beats, a fast and a slow cycle beat

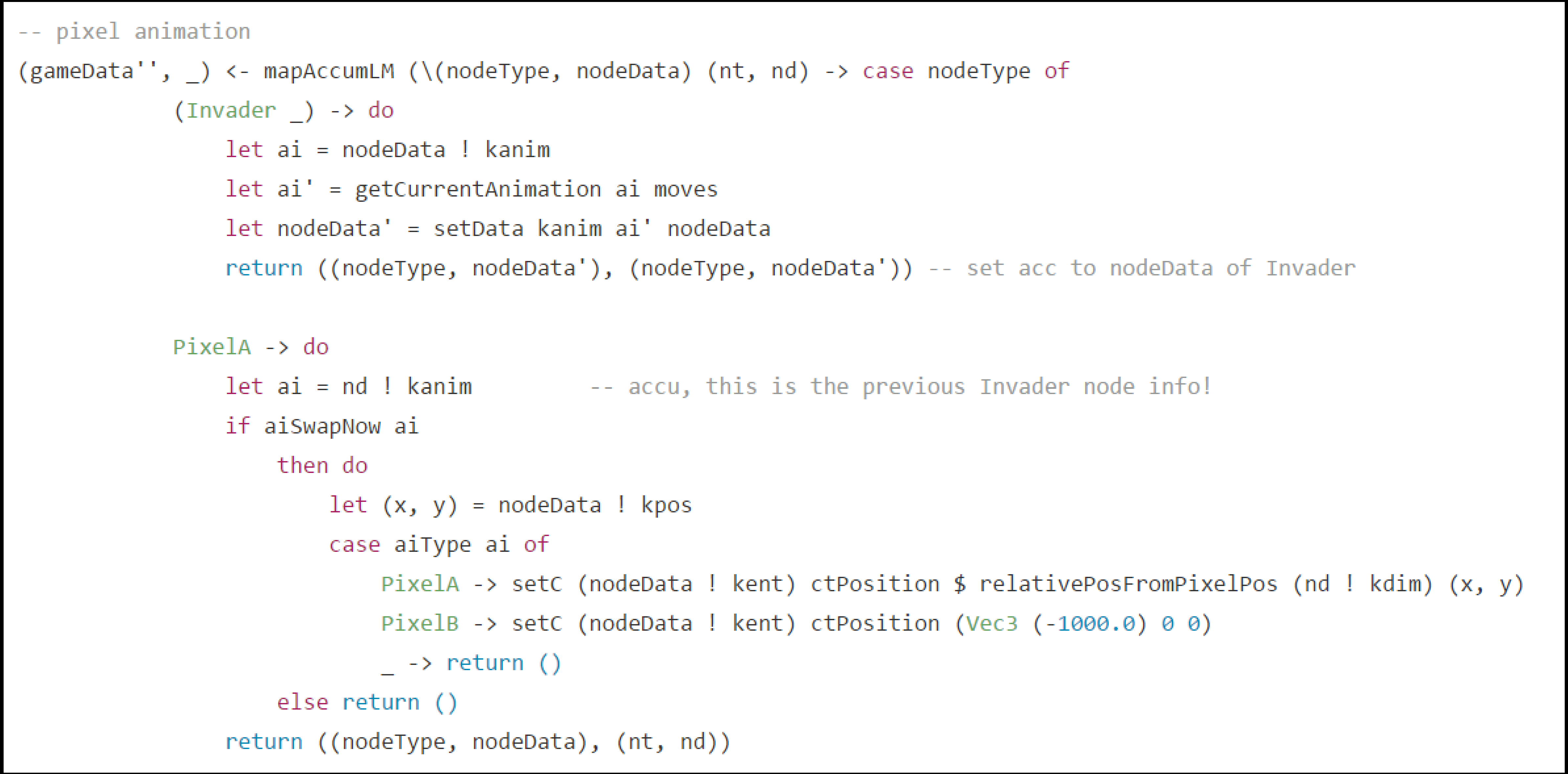
During gameplay canon movement and collision detection are done more often then movement of invaders

Data Structure (Persistent)



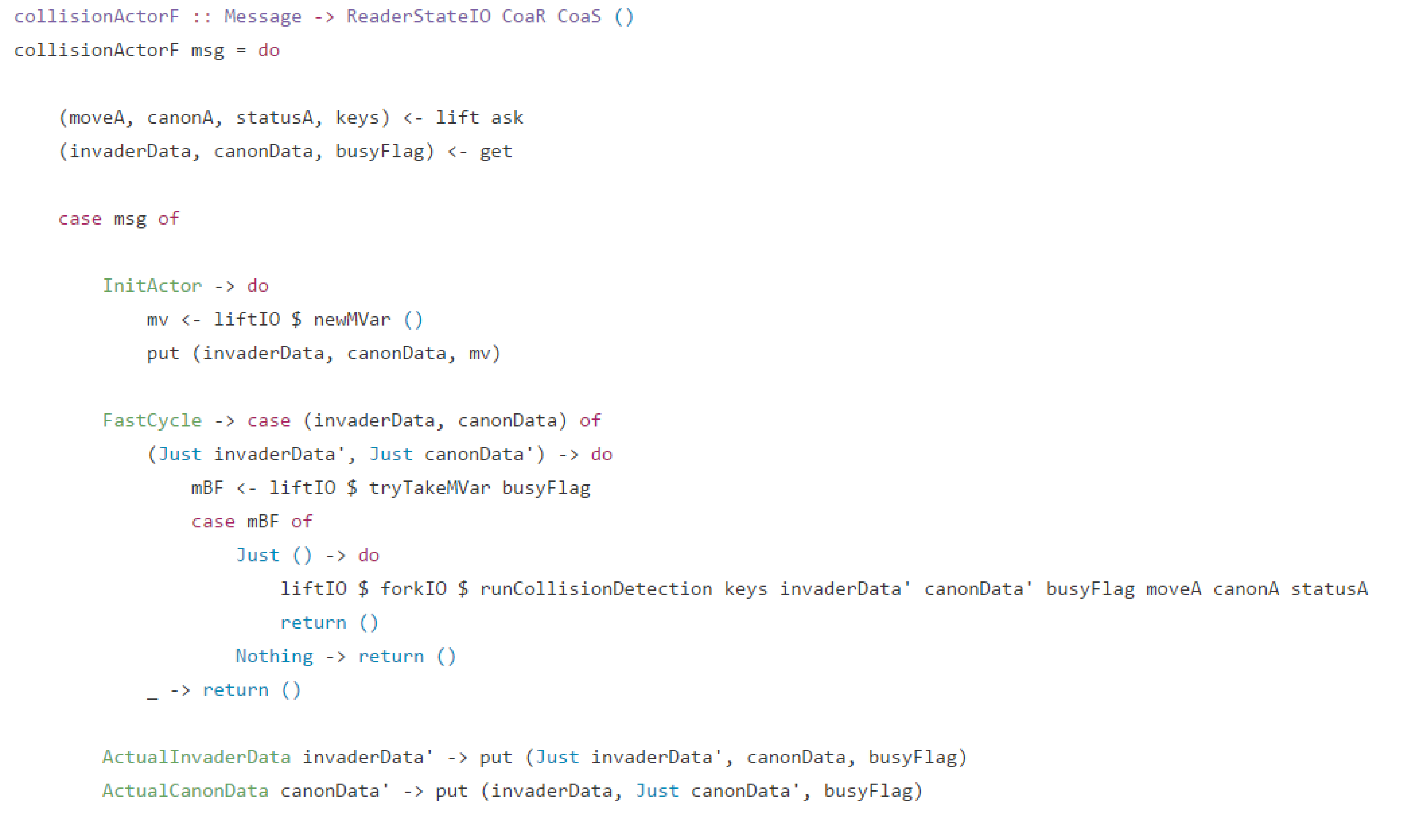
- ❑ Tree structure to be flexible
- ❑ Sub-elements move with parent
- ❑ Each element is an Hmap
- ❑ More: canon, shot, ...

Animation - Traverse over tree



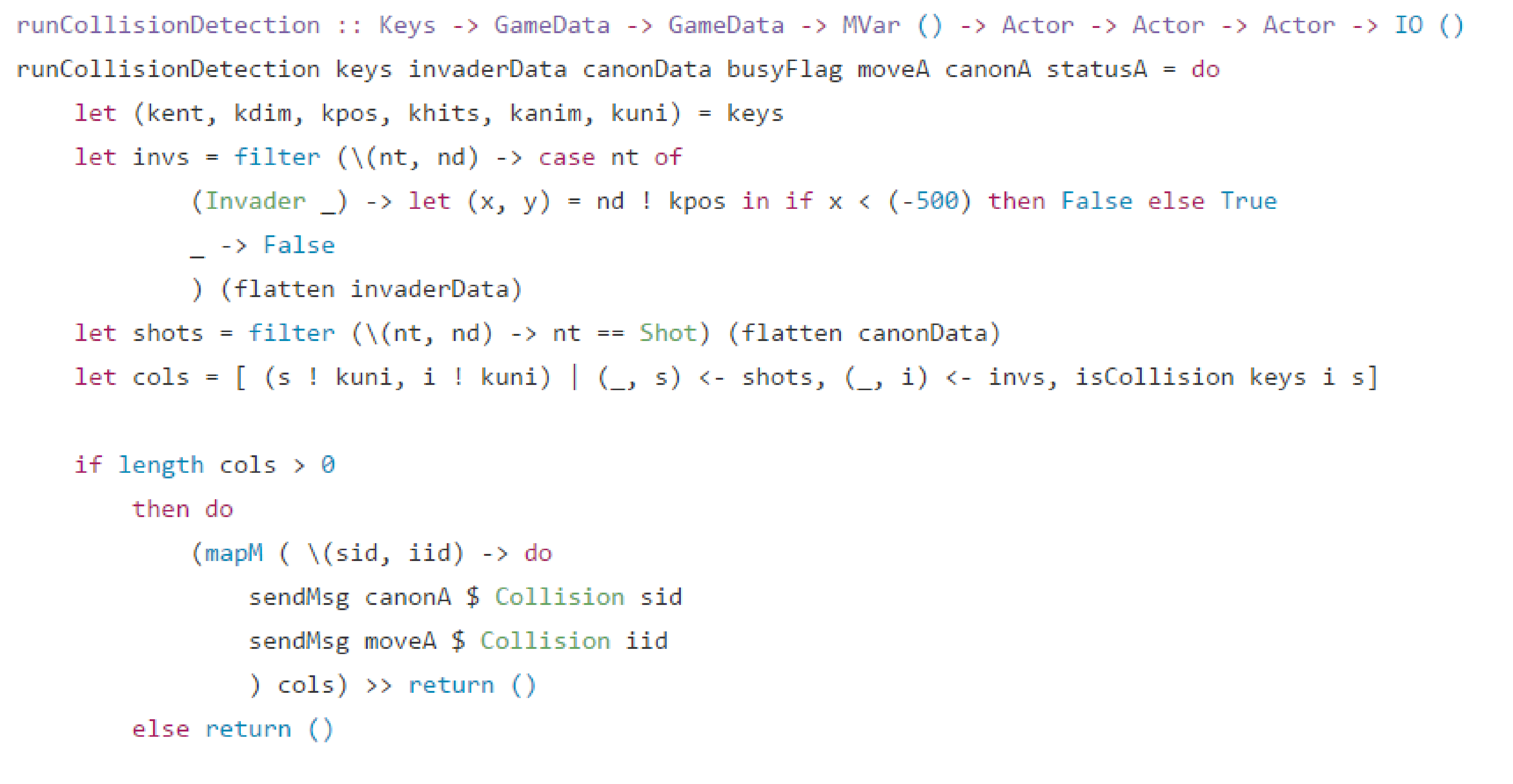
```
-- pixel animation
(gameData'', _) <- mapAccumLM (\(nodeType, nodeData) (nt, nd) -> case nodeType of
            (Invader _) -> do
                let ai = nodeData ! kanim
                let ai' = getCurrentAnimation ai moves
                let nodeData' = setData kanim ai' nodeData
                return ((nodeType, nodeData'), (nodeType, nodeData')) -- set acc to nodeData of Invader

            PixelA -> do
                let ai = nd ! kanim         -- accu, this is the previous Invader node info!
                if aiSwapNow ai
                    then do
                        let (x, y) = nodeData ! kpos
                        case aiType ai of
                            PixelA -> setC (nodeData ! kent) ctPosition $ relativePosFromPixelPos (nd ! kdim) (x, y)
                            PixelB -> setC (nodeData ! kent) ctPosition (Vec3 (-1000.0) 0 0)
                            _ -> return ()
                    else return ()
                return ((nodeType, nodeData), (nt, nd))
```

Collision Detection I



```
collisionActorF :: Message -> ReaderStateIO CoaR CoaS ()
collisionActorF msg = do

    (moveA, canonA, statusA, keys) <- lift ask
    (invaderData, canonData, busyFlag) <- get

    case msg of

        InitActor -> do
            mv <- liftIO $ newMVar ()
            put (invaderData, canonData, mv)

        FastCycle -> case (invaderData, canonData) of
            (Just invaderData', Just canonData') -> do
                mBF <- liftIO $ tryTakeMVar busyFlag
                case mBF of
                    Just () -> do
                        liftIO $ forkIO $ runCollisionDetection keys invaderData' canonData' busyFlag moveA canonA statusA
                        return ()
                    Nothing -> return ()
            _ -> return ()

        ActualInvaderData invaderData' -> put (Just invaderData', canonData, busyFlag)
        ActualCanonData canonData' -> put (invaderData, Just canonData', busyFlag)
```

Collision Detection II



```haskell
runCollisionDetection :: Keys -> GameData -> GameData -> MVar () -> Actor -> Actor -> Actor -> IO ()
runCollisionDetection keys invaderData canonData busyFlag moveA canonA statusA = do
    let (kent, kdim, kpos, khits, kanim, kuni) = keys
    let invs = filter (\(nt, nd) -> case nt of
            (Invader _) -> let (x, y) = nd ! kpos in if x < (-500) then False else True
            _ -> False
            ) (flatten invaderData)
    let shots = filter (\(nt, nd) -> nt == Shot) (flatten canonData)
    let cols = [ (s ! kuni, i ! kuni) | (_, s) <- shots, (_, i) <- invs, isCollision keys i s]

    if length cols > 0
        then do
            (mapM ( \(sid, iid) -> do
                sendMsg canonA $ Collision sid
                sendMsg moveA $ Collision iid
                ) cols) >> return ()
        else return ()
```

Program Structure

fully benefits from Haskell, still beginner friendly style

- ❑ modular by actors
- ❑ fully multi-threaded
- ❑ simple tree data structure
- ❑ HMap for properties
- ❑ beginner/intermediate Haskell
- ❑ API enables this kind of structure

Combines persistent data structure with threading, still being modular

No complex Haskell magic needed, uses the basics of FP

Feature Coverage of HGamer3D

very basic feature coverage:

- 3d geometry, GUI, sound, device input, light, material
- wish-list: particles, effects, animation, network, physics, ...
- targeting today: education, fun programming, ...

included:

- easy to use
- beginner friendly API
- fully multi-threading capable

Outlook

```
let future = fmap (createNewVersions .
                   addFeatures .
                   evolveGame)  (Maybe neededTime)
```

www.hgamer3d.org

Thank You For Your Time!