

GAME DEVELOPMENT



Building A Tower Defense Game.

DISCLAIMER

I'm an allrounder, not an expert

This presentation contains my own views

It is nowhere near a complete list

I just built a stupid game for Christ's sake

This is not an advertisement for my game either.
You get free keys in the end :)

THE GAME IDEA

THE IDEA

An art style

A game mechanic

An idea you want to convey

A story you want to tell

A feeling you want others to have

**CHOOSE
YOUR
STYLE**

STYLE

2D



2.5D (isometric)



STYLE

3D

Free Camera

Fixed Camera

Low Poly



STYLE

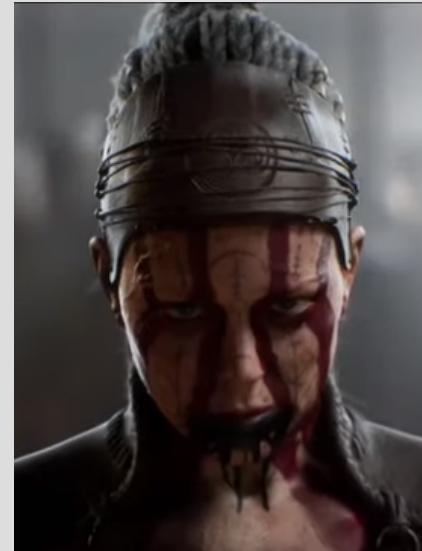
PixelArt



High End

VR

... combinations ... endless possibilities ...



THROBAX TD

We went with 2.5D isometric

Sprites generated using 3D
models in Blender

Sprites were animated in Blender

A sprite has tracks (angle) of
frames (animation)



**CHOOSE
YOUR
LANGUAGE
AND FRAMEWORK**

FRAMEWORK

Since that somewhat dictates the language

2D

MonoGame
Godot

3D

Unity
Godot

PRO 3D

Unreal Engine
Unity

LANGUAGE

FAST

C

C++

NICE

C#

F#

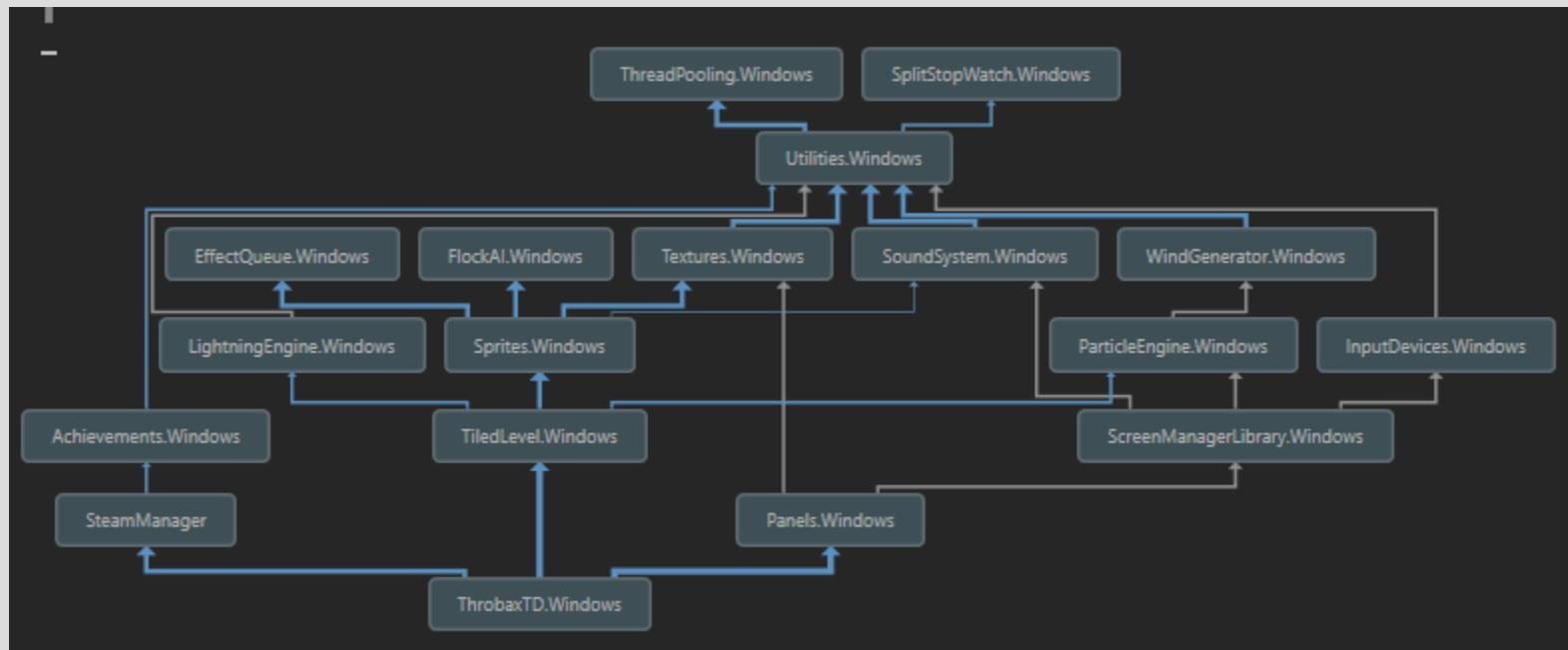
Java

Kotlin

DEV COMPONENTS OF A GAME

DEPENDENCY DIAGRAM

Of Throbax TD



CODE ANALYSIS

Of Throbax TD

Hierarchy	Maintainabil...	Cyclomatic ...	Depth of Inh...	Class Coupli...	Lines of Code ▾
▷ C# ThrobaxTD.Windows (Debug)	80	7,953	9	591	20,380
▷ C# Utilities.Windows (Debug)	80	2,549	2	263	6,636
▷ C# ScreenManagerLibrary.Windows (Debug)	82	2,025	4	150	3,980
▷ C# Sprites.Windows (Debug)	84	850	5	112	1,685
▷ C# WindGenerator.Windows (Debug)	70	421	1	42	1,185
▷ C# SoundSystem.Windows (Debug)	82	514	3	64	906
▷ C# Textures.Windows (Debug)	82	353	3	65	849
▷ C# Panels.Windows (Debug)	83	416	6	64	775
▷ C# TiledLevel.Windows (Debug)	79	312	3	80	698
▷ C# TestGame (Debug)	82	179	4	116	622
▷ C# SteamManager (Debug)	88	290	2	93	580
▷ C# EffectQueue.Windows (Debug)	85	288	3	54	563
▷ C# ParticleEngine.Windows (Debug)	75	222	4	37	524
▷ C# ThreadPooling.Windows (Debug)	89	167	1	63	504
▷ C# LightningEngine.Windows (Debug)	88	114	1	35	379
▷ C# InputDevices.Windows (Debug)	87	188	1	18	269
▷ C# SplitStopWatch.Windows (Debug)	77	51	1	4	110
▷ C# Achievements.Windows (Debug)	86	71	2	19	110
▷ C# FlockAI.Windows (Debug)	84	74	2	12	104
▷ C# LockFreeQueue.Windows (Debug)	83	25	2	4	66

I'm not proud of it :)

COMPONENTS

UI in menus

UI in levels

Level management

Music management

Sound effects

Sprites (draw, animations...)

Collisions

Pathfinding

COMPONENTS

Particle engine

Lightning engine

Networking stack

Input devices

Shaders

Post Processing

COMPONENTS

TONS OF UTILITIES

Object pooling

2D drawing extensions

Image preprocessing (boundaries)

Display-resolution independence

Collision utils

Conversions (screen->model->viewport)

Game-saves

...

DEV

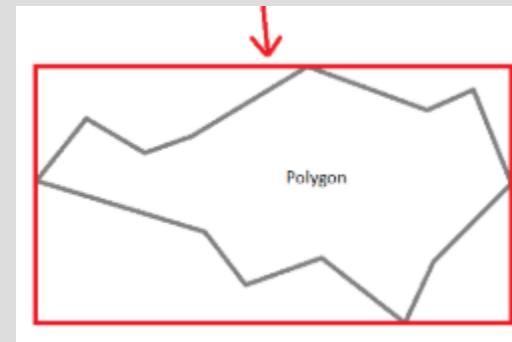
COLLISIONS

COLLISIONS

Items collide in game

Depends on the accuracy you need

Has to be fast, but is expensive

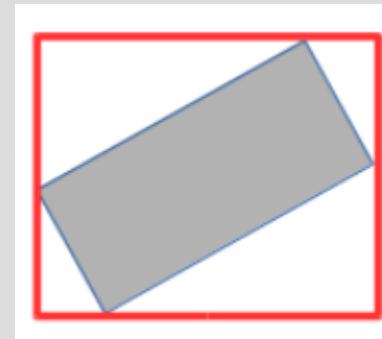


VARIOUS APPROXIMATIONS

Bounding Box

Axis Aligned Bounding Box

Bounding Sphere ... you get the idea



COLLISIONS

Items may collide between frames

You may not 'see' the collision

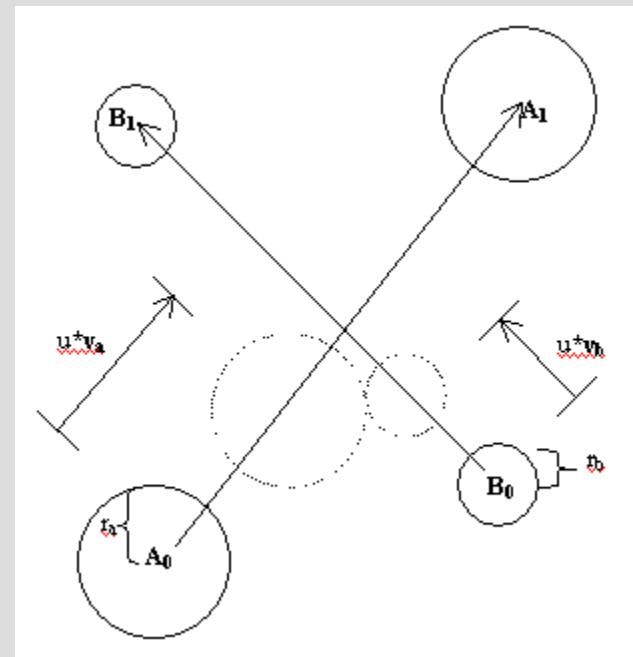
Sweep Tests to the rescue

VARIOUS PRIMITIVES

Sphere/Sphere

Sphere/Plane

AABB/AABB



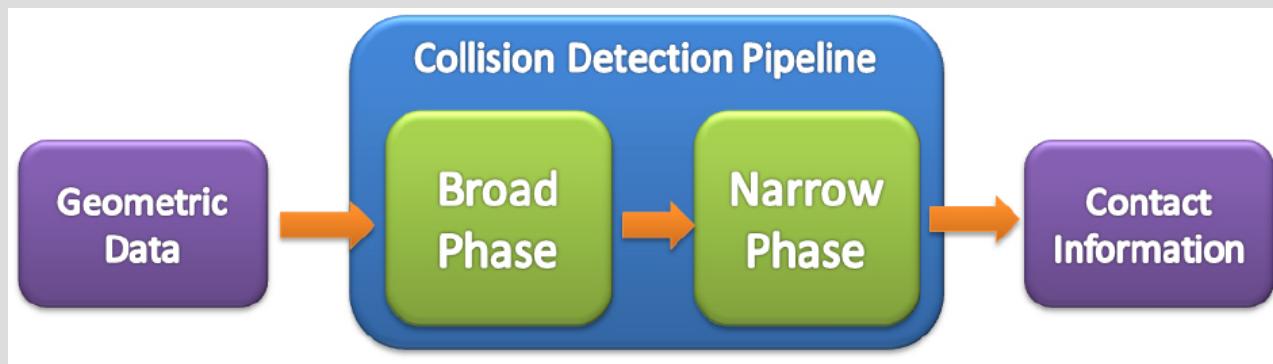
COLLISIONS

But those are really expensive

And we have N items, so N^2 tests

So we just don't do those for all N

Split Collision Detection into 2 phases



- Broad Phase Collision Detection
(for all N items)
- Narrow Phase Collision Detection
(just for candidates found in broad phase)

COLLISIONS

Broad Phase Collision Detection

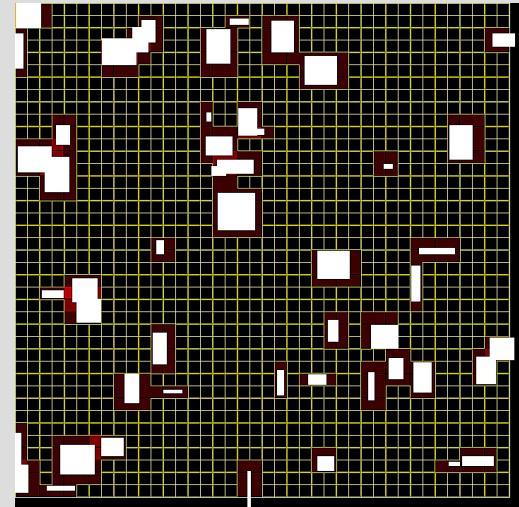
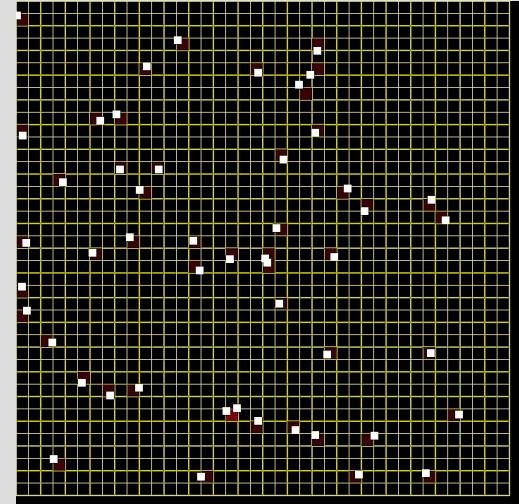
Collision Grid in 2D

(sort of static quad-tree)

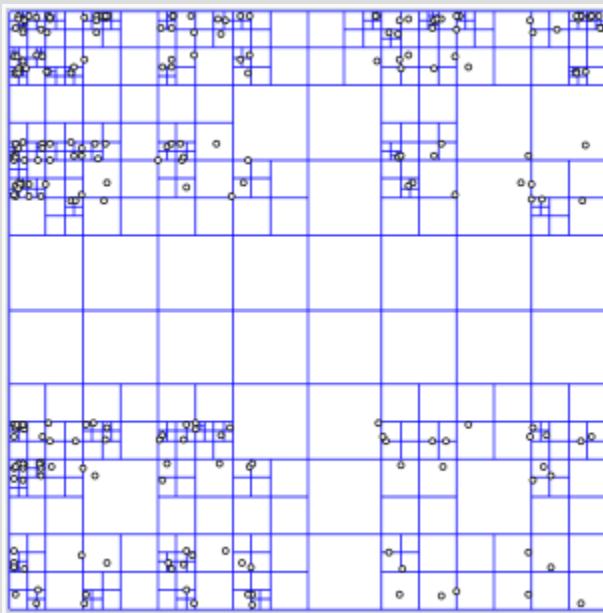
3D: static - 3D Grid / dynamic - OctTree

'is item n in cell [x,y]?'

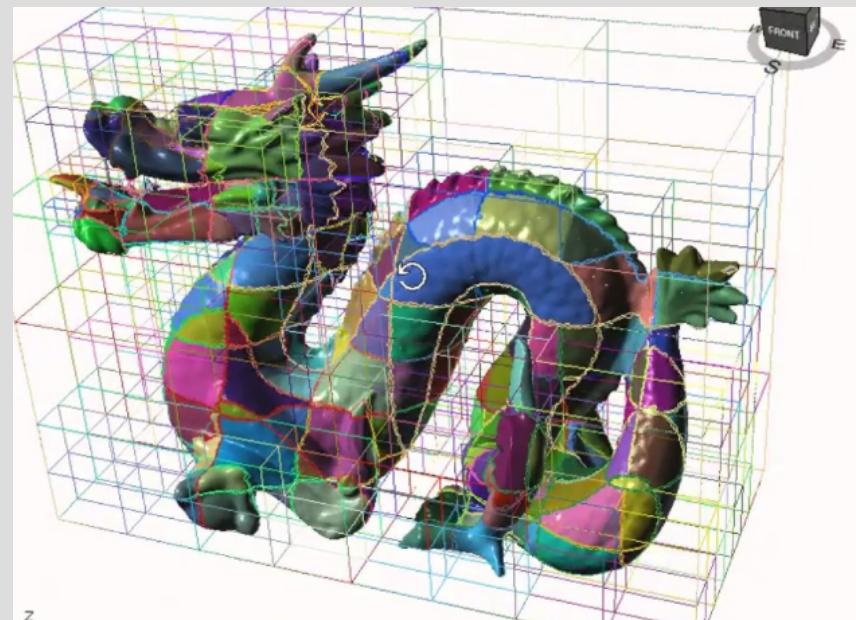
'in which cells is my AABB?'



COLLISIONS



Quad-Tree



Oct-Tree

DEV

SPRITES

SPRITES

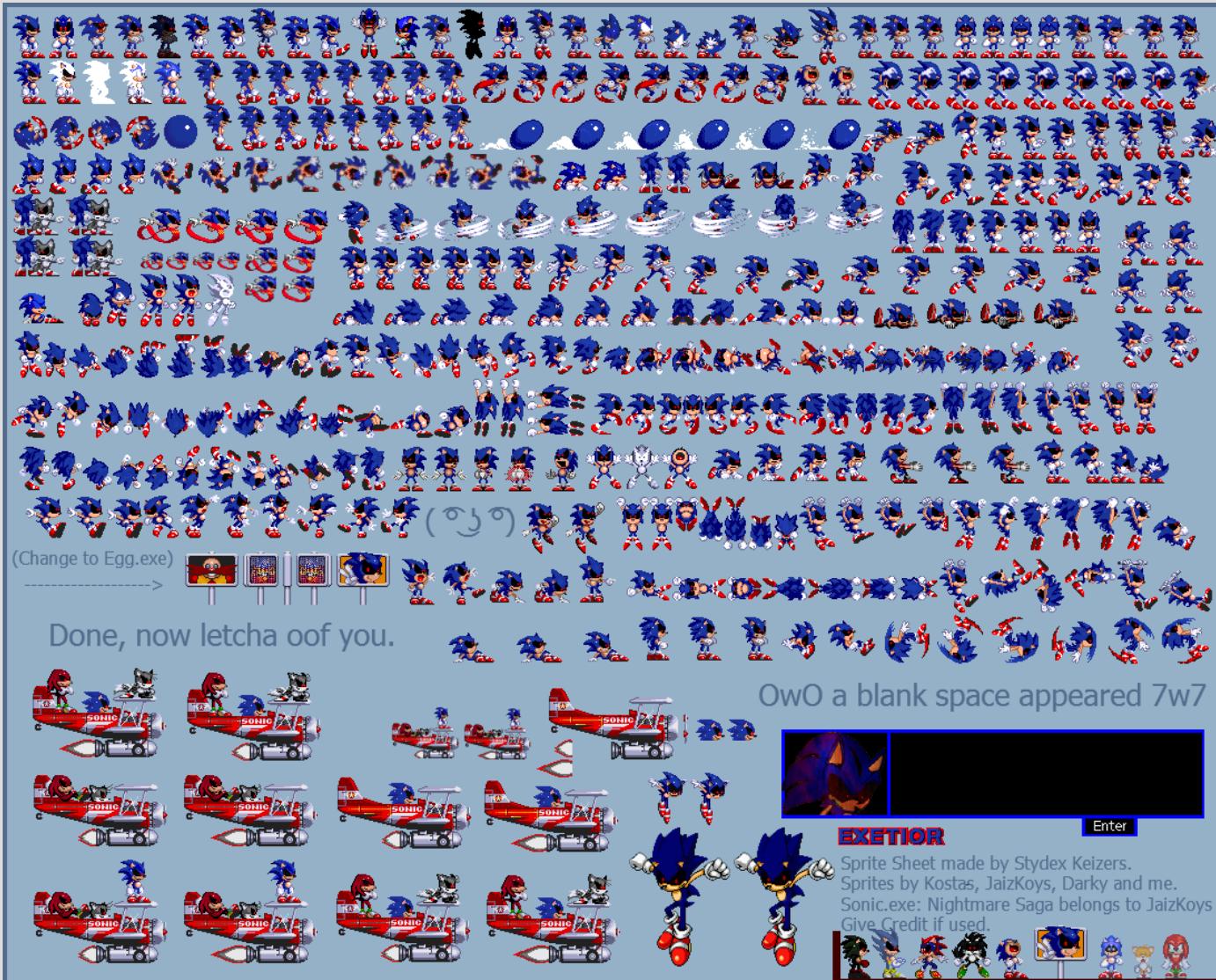
Animations consist of single images

Make a class that provides the right image for
the right orientation or movement phase

Your hero-class will extend the sprite-class
and add things like Shoot() or Hit()...

Use sprite-sheets

SPRITESHEETS



DEV

PATH FINDING

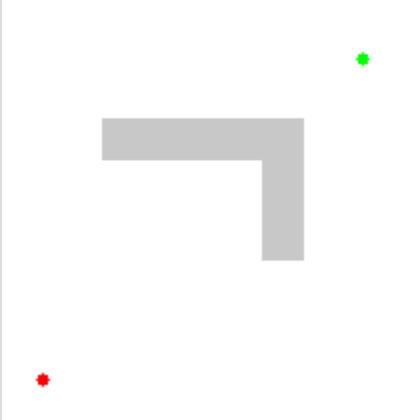
PATH FINDING

Entities have to move from A to B

How do they manage that?

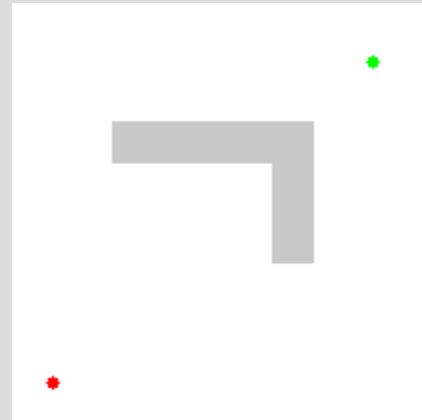
Standard A* implementation

Here without heuristic



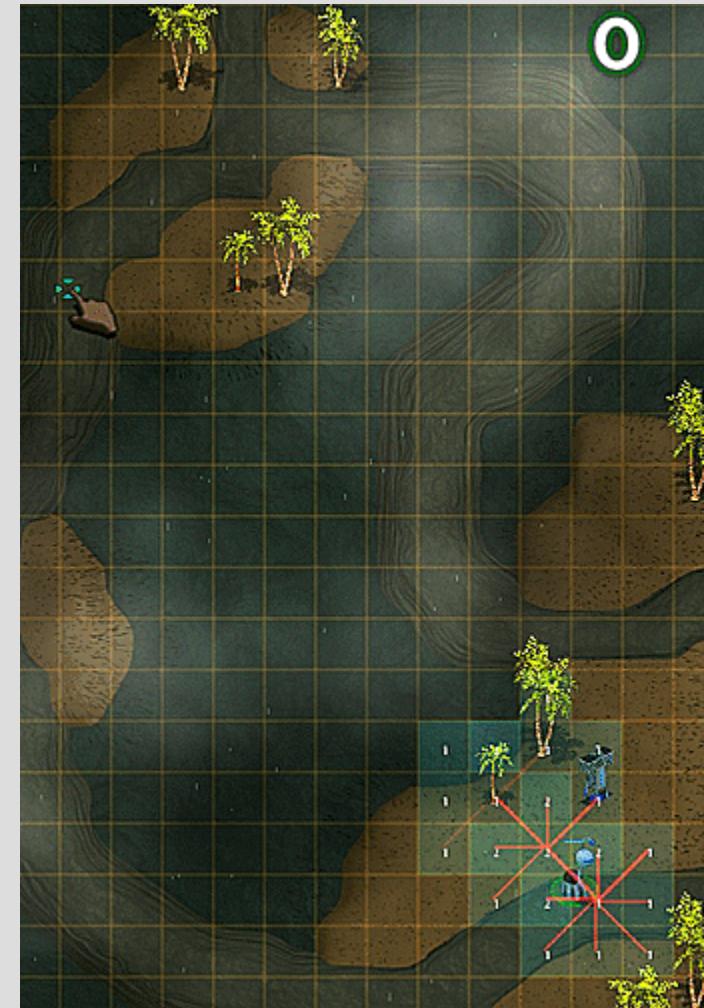
PATH FINDING

And with heuristic



PATH FINDING

Debug output from Throbax



DEV

SHADERS

SHADERS

Vertex Shader

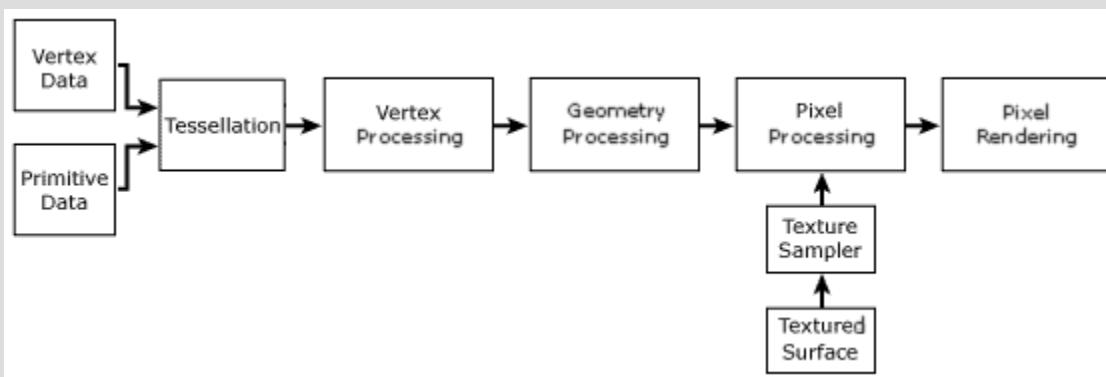
Geometry Shader

Pixel (Fragment) Shader

Compute Shader

Varies widely

(directX, openGL, versions, etc)



SHADERS

We used pixel shaders

The language used is HLSL

Is compiled and transferred directly to the graphics card

All textures reside on the graphics card

Transferring textures is VERY expensive

```
1 sampler ColorMapSampler : register(s0);
2
3 float4 PixelShaderGrayScale(
4             float4 pos : SV_POSITION,
5             float4 color1 : COLOR0,
6             float2 Tex : TEXCOORD0) : SV_TARGET0
7 {
8     float4 color = tex2D(ColorMapSampler, Tex)
9
10    float value = (color.r + color.g + color.b) /
11        color.r = value;
12        color.g = value;
13        color.b = value;
14
15    return color;
16 }
```



DEV

POST PROCESSING

POST PROCESSING

Also done with shaders

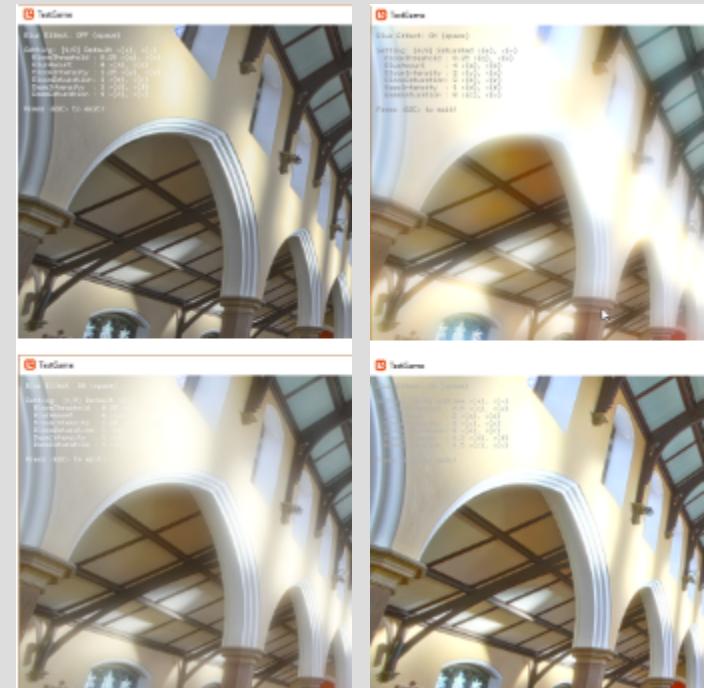
First draw portions of the game
to render-targets

Then compose the final scene
drawing those render-targets to the
back-buffer

Just looks more professional

Different effects for different layers

We chose a bloom effect



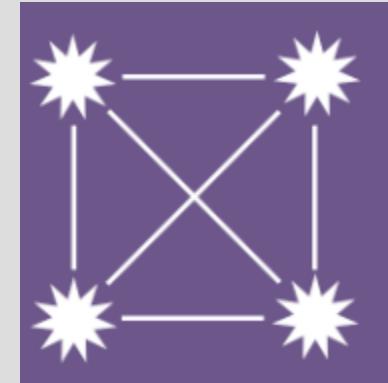
DEV

MULTIPLAYER

CONNECTION TYPES

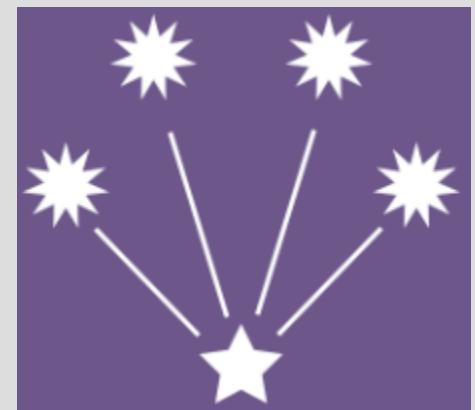
Peer to Peer

All clients are interconnected



Client-Server

All clients connect to a single server



HANDLING INPUT

Some instance has to manage a state (server)

Client ask the server for [action]

Server responds

Client commences

The server-engine is always right

Server sends global-state-updates periodically
to counter de-syncing (float...)

PROBLEMS TO SOLVE

NAT PUNCHTHROUGH

Get to other clients over their firewall

DE-SYNCHING

Different CPUs handle floats differently

The game-engine may stall

RANDOM NUMBERS

Use some noise function and distribute seeds

We use a Simplex Noise []

APPROACHES

DETERMINISTIC LOCKSTEP

All clients run the same engine

One of them is the server

On input ask server & await
response (lock)

Server waits for all clients to send
an [action] (fixed step-time)

CLIENT-SERVER MODEL

Dedicated server

Server runs server code

On input ask server & await
response

Server answers immediately

THROBAX TD

We use a mix of both

Clients are connected P2P

One of them is the server (game-starter)

Clients ask server for [action]

Clients wait for response

Server checks for validity (for example two
players cannot build on the same tile)

Server immediately sends response

Server sends global-state-updates every 5
seconds round robin to all users within those 5
seconds

DEV

GAME ASSETS

GAME CONTENT

GAME ASSETS

Graphics

Sprites

Special effect graphics

Fonts

Music (songs, loops)

Sound FX

Story

Cut-scenes

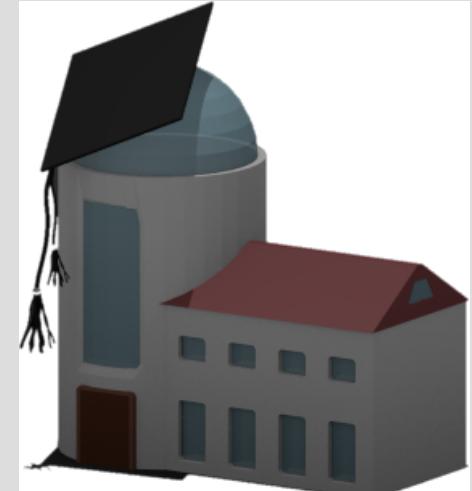
GRAPHICS

It's hard work

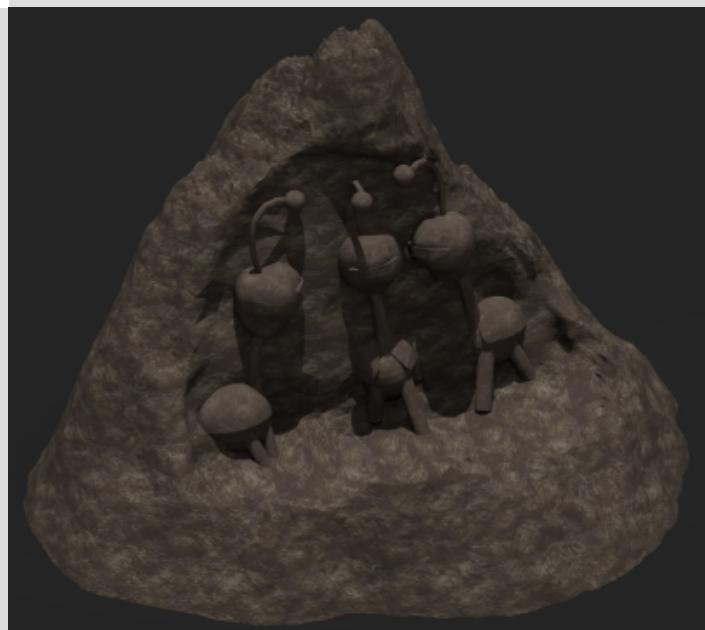
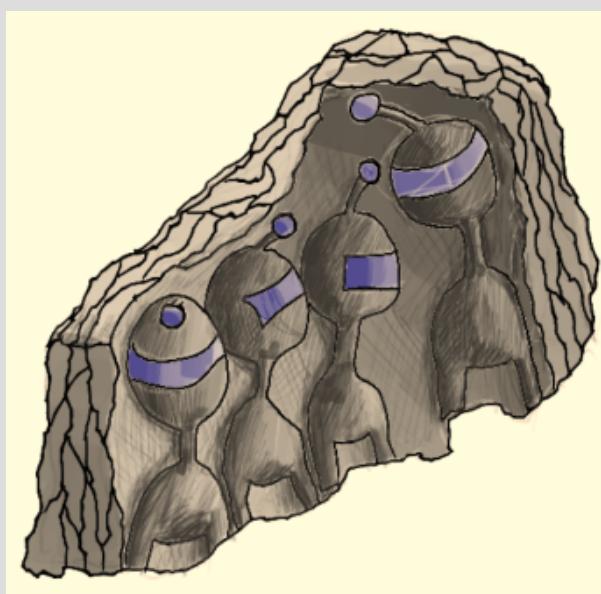
Many iterations

Take your time

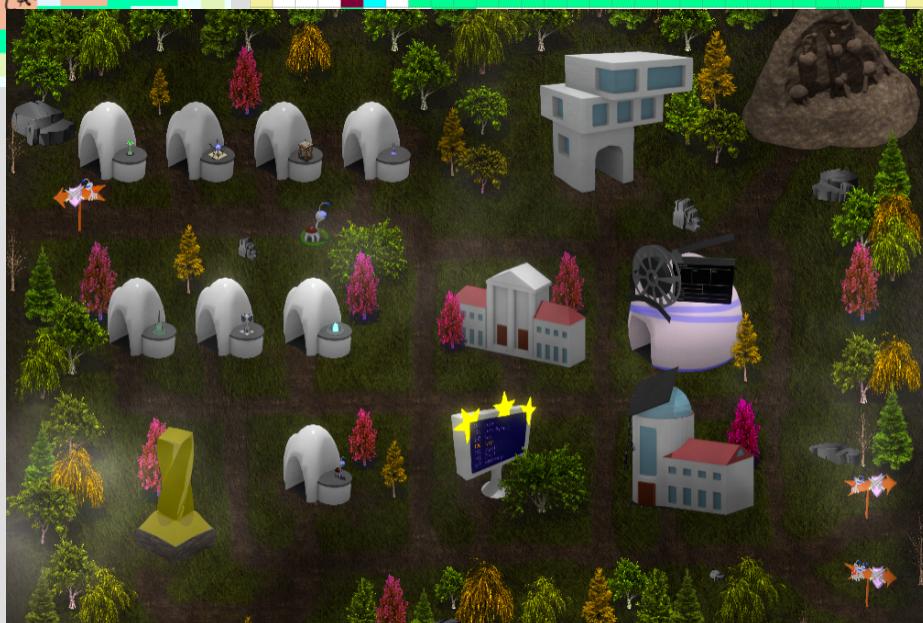
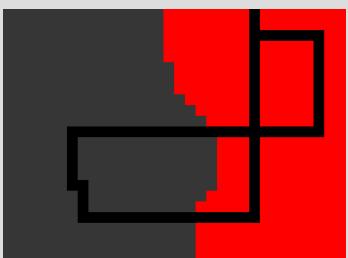
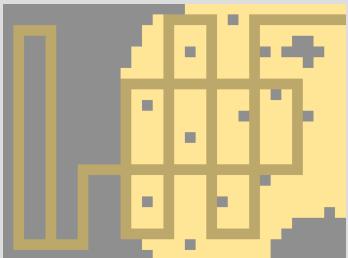
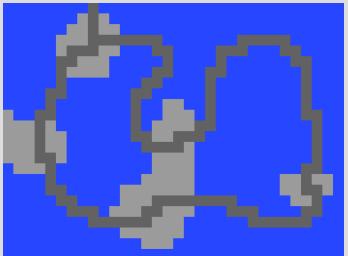
Or get someone to do that for you :)



GRAPHICS



LEVEL DESIGN



LEVEL DESIGN

Monsterliste

	Monster	Besonders anfällig auf	Besonders resistent gegen	Reward	Type	Portal-Version Besonders anfällig auf	Portal-Version Besonders resistent gegen	Portal-Base
	Bouncer	ALLES		1	low	ALLES		30
	BubbleBlobSwarm	Normal		1	low	Normal		100
	HeliBubble	Lightning		2	norm	Lightning	Normal Poison	200
	Mini-Spider	Lightning	Normal Poison	1	low	Lightning	Normal Poison	70
	Spider	Lightning Ice	Poison	20 (p=10)	BOSS	Lightning Ice	Poison	10000
	BubblePillar	Poison Radiation		4	high	Poison Radiation	Normal	100
	PodRacer	Ice	Normal Lightning Poison Radiation	7	LOW-BOSS	Ice	Normal Lightning Poison Radiation	1000
	ScrewDriver	Radiation Poison Ice		3	norm	Radiation Poison Ice		1000

Normale Progressionen

Tactics

Normal progression

Rushing spiders

Rushing pod-racers

Shield

Warning shot

Spawner

Mix

Power-Regeneration

CUT-SCENES

Storyboard - Cutscene 1 - "Die Myliad"

Besteht aus:

- Die Myliad
- Das Artefakt

BOLD words indicate very fast pace.

#	SATZ German	SATZ German (in Echt jetzt)	SATZ English (for real)	BILDBESCHREIBUNG
1	Auf einem weit entfernten Planeten lebten einst die Myliad.	Puh... Wah-ouw. Also. Nochmal. Auf einem weit entfernten Planeten lebten einst die Myliad.	Phew. <u>Wah-ouw</u> . Okay. Where do we start. On this planet, far, far away, once lived the Myliad.	Kleiner Planet.
2	Ein Volk von zweibeinigen Humanoiden, deren Kultur weit entwickelt war.	Das war'n Volk von zweibeinigen Humanoiden und von denen die Kultur war ziemlich weit entwickelt.	The Myliad were a people of two-legged humanoids whose culture was .. <u>aehm</u> .. fairly advanced.	(Raumfahrt sichtbar)
3	Sie waren sehr angesehen in der interstellaren Allianz, die zentral vom großen Rat regiert wurde.	Die waren ziemlich angesehen in der interstellaren Allianz, die zentral vom großen Rat regiert wurde.	The interstellar alliance, which was governed by the central council, held them in the highest respect.	Bild von Arzt mit Patienten verschiedenster Arten von Lebewesen.
4	Eines Tages wurde auf ihrem Heimatplaneten ein seltsames Artefakt gefunden.	Irgendwann mal, eines Tages, is' auf ihrem Planeten ein seltsames Artefakt gefunden worden.	However, one day someone found a curious artifact on the <u>Myliad's</u> home planet.	Krater mit einer Metallkapsel in der Mitte.
5	Es war ein ramponiertes Metallbehältnis und niemand wusste woher es kam.	Es war so'n ramponiertes altes Metallbehältnis und 's wusste eigentlich keiner woher das jetzt genau herkam.	It was a strangely battered old metal container and nobody had the slightest clue where it might have come from.	Nahaufnahme der Metallkapsel.
6	Es befand sich ein solider, grüner Würfel darin, der äußerst widerstandsfähig war.	In diesem Metallbehältnis war'n grüner Würfel. Und der war ziemlich widerstandsfähig.	Inside it they found a solid and pretty durable green cube.	Offene Metallkapsel auf Labortisch mit grünem Würfel darin. Forscher daneben.
7	Er wies aber auch Merkmale von lebendem Gewebe auf und änderte	Der hatte aber auch Merkmale von lebendem Gewebe und eines Tages	The cube showed some characteristics of a living organism.	Würfel auf Labortisch. Angehängt an Elektroden. Forscher rund

**TESTING
YOUR
GAME**

TESTING

Playtesting

No matter how cool your game is, you'll get sick
of it

So get some people to do that for you

Feedback channel

Community management

Give due credit

Maybe do early access

BALANCING

It's the most important thing

It's the most time consuming thing

Try to calculate it

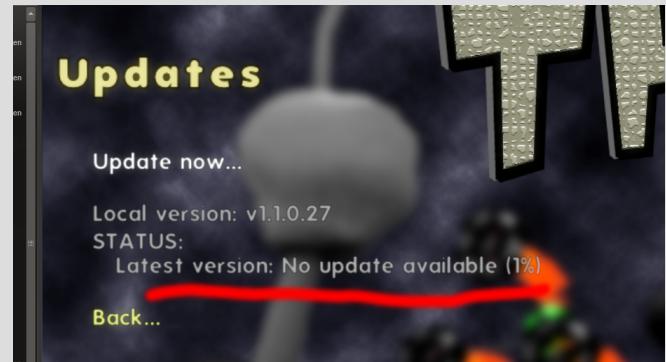
Then balance it manually

Build load/save functions,
even if you won't use them later on in-game

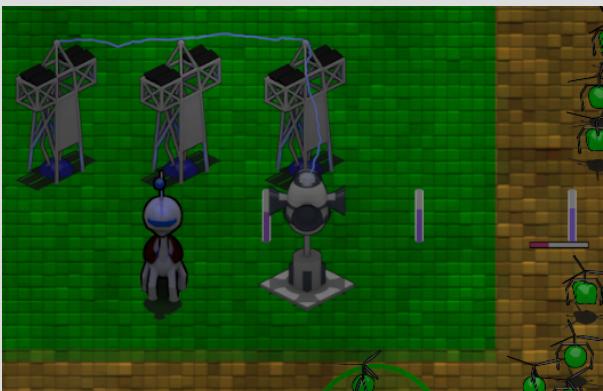


Z-Fighting

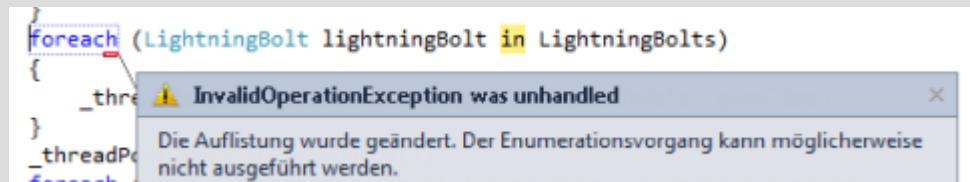
BUG FIXING



Updater



Placement



Concurrency

AND TONS
OF CRASHES

COMMON BUGS

Multi-threading issues

Mem leaks

GC-runs

The GC is your enemy!

**PICK A
DISTRIBUTION
PLATFORM**

DISTRIBUTION PLATFORM

Steam

Gog

Epic Store

Google Play Store

Apple Store

Self published

...

CONSIDER

Getting an accountant

Cost of micro payments

Cost upload volume

Publishing tools on each platform

Achievements, trading cards, ...?

NETWORKING

User-Management

Global leaderboards

Lobbies

In-game chat

Game-Starter (invites)



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All Games > Strategy Games > Throbax TD

Throbax TD

Community Hub



Throbax TD is the "Tower Defense" game you are looking for: Help Ughlar fight his way through 50 levels, buy over 100 upgrades and get all of the 50+ achievements.

ALL REVIEWS:

Mostly Positive (21)

RELEASE DATE:

5 Nov, 2015

DEVELOPER:

Unterrainer Informatik OG

PUBLISHER:

Unterrainer Informatik OG

Popular user-defined tags for this product:

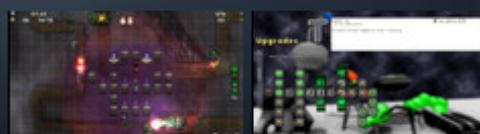
Early Access

Tower Defense

Action

Indie

+



MARKETING

MARKETING

Discussion boards
(reddit, dev boards...)

Youtube, Twitter, Facebook, Instagram...

Community in general

Beware of dev-dev pitfall
(you are a developer, you attract developers, not
potential customers)

MARKETING

Crowdfunding
(Indiegogo, Kickstarter...)

Platform specific marketing
(Steam store page...)

Publisher
(there are small ones, but beware)

INDIEGOGO CAMPAIGN



Idea was to get us funded

25.000 \$ Target

9 Pledge tiers

Nice page

(sadly, it's offline now and we don't have any screenshots)

INDIEGOGO CAMPAIGN

Along with stretch goals
and everything

We were on page 1 in category 'games' on
Indiegogo for 2 months



INDIEGOGO - SUMMARY

Visitors	577
Unique visitors to the campaign page. Updated once per day.	
Views	769
Total views to the campaign page - includes views by the same visitor. Updated once per day.	
Funders	9
Contributions	\$350
Followers	9
Referrals	229
Number of visits resulting from someone sharing your campaign using widgets, Facebook, Twitter, and more.	

CROWDFUNDING LESSONS LEARNED

It's the people YOU bring to the page

Get it viral or lose

Only things getting funded are:

- my lovely dog needs a kidney
- stuff that's already financed anyway

Vast majority of those projects get a huge campaign-saving pledge in the last second

It's mostly used as a marketing tool, not to get
money

GENERAL TIPS & TRICKS

CODING

Use sprite-sheets

Assets > Code

Write tests

Keep your code clean

There is no 'quickly' or 'temporary'

There are no 'workarounds'
(it will come back and bite you)

WRITE TESTS DAMN IT !!!11

COMMUNITY

Community is your best marketing-tool

Get a friend as a community manager

Make pre-releases

Make demos

Get beta-testers

Get people for translations

Gift keys

MARKETING

Pick a name that says all

Pick a name that's easy to remember, and easy
to pronounce :)

You need a marketing-hook
(something that stands out at first glance)

You have to be 'different' (so many games)

No one's gonna give you exposure for free!

**THAT'S
ALL
FOLKS.**

RESOURCES

3D Modelling / Animation

- Blender - <https://www.blender.org/>
- 3DS Max - <https://www.autodesk.com/products/3ds-max/overview>
- Maya - <https://www.autodesk.com/products/maya/overview>

Help

- Free Code - <https://github.com/UnterrainerInformatik>
- Link List - <https://github.com/UnterrainerInformatik/GameDevelopmentLinks>
- Collision Grid - <https://github.com/UnterrainerInformatik/collisiongrid>
- Bloom Effect - <https://github.com/UnterrainerInformatik/BloomEffectRenderer>
- Per-Pixel-Coll - <https://github.com/UnterrainerInformatik/perPixelCollision>

Networking

- Deterministic LockStep - <https://medium.com/@treeform/dont-use-lockstep-in-rts-games-b40f3dd6fddb>

Sprites

- TexturePacker - <https://www.codeandweb.com/texturepacker>

Throbax TD

- Steam page - https://store.steampowered.com/app/341570/Throbax_TD/
- Free Key - just email to: **psilo@unterrainer.info**

Stuff I Got Images From

- <https://docs.microsoft.com/en-us/windows/win32/direct3d9/direct3d-architecture>

Stuff I Got Images From

- <https://www.youtube.com/watch?v=Qb93QSvxXrs>
- <https://en.wikipedia.org/wiki/Quadtree>
- https://en.wikipedia.org/wiki/A*_search_algorithm