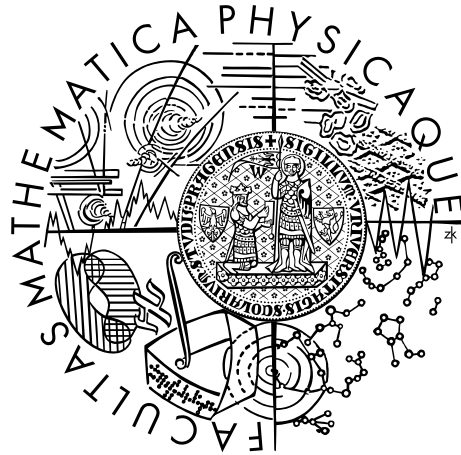


Charles University in Prague
Faculty of Mathematics and Physics

BACHELOR THESIS



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The Dungeon Throne: A 3D Dungeon Management Game

Department of Distributed and Dependable Systems

Supervisor of the bachelor thesis: Mgr. Pavel Ježek, Ph.D

Study programme: Computer Science

Study branch: TODO: IPSS?

Prague 2016

I declare that I carried out this bachelor thesis independently, and only with the cited sources, literature and other professional sources.

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Title: The Dungeon Throne: A 3D Dungeon Management Game

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Introduction

1. The Game

An example citation: Anděl [2007] TEST

1.1 Dungeon Managment Genre

1.2 Modifiability in Games

1.3 Similar Games

1.3.1 Dungeon Keeper

TODO: Design influence.

1.3.2 Garry's Mod

TODO: Modifiability influence. (Mainly game mechanics.)

1.3.3 Minecraft

TODO: Modifiability influence. (Mainly items.)

1.3.4 Dungeon Siege

TODO: ECS influence.

1.4 Thesis Goals

1.5 Thesis Structure ??

2. Problem Analysis

2.1 Game Design

-

2.2 Engine Design

- maybe mention that the goal to make an engine and that's why UE or Unity weren't used
- say that since the game is to be modifiable and extensible, run time entity creation is a must (both for modding and testing)
- might be good mention the choice before explaining why the different options were/were not chosen so that the reader knows

2.2.1 Inheritance based (wording?)

- explain what is meant by the title (classic OOP design)
- explain that since inheritance has to be done by compile time and cannot be changed during run time, this would prohibit dynamic entity creation
- for the same reason, specifying entities in config files would generally be impossible (except with something like Roslyn)
- this kind of engine would also have to be planned a lot (to avoid inheritance hierarchy hell)
- ?same reason (inheritance hierarchy) would either prohibit or discourage some attribute combinations (like a walking wall) during future modifications?

2.2.2 Component based (wording?)

- define the Component design pattern (with references to the gamedesgin-patterns.smth book)
- mention that this is very similar to the component based implementation both Unity and UE4 use
- mention its relationship with both ECS and the inheritance based design

2.2.3 Entity Component System

- define the ECS design pattern
- mention how well it supports run time entity creation and modification

- mention ease of development this model creates
- mention ease of entity access (through ID)
- talk about the difference between Component and ECS patterns
- ?mention cache friendliness? (pro: well, it exists, con: not used that much in this game)

2.3 Programming Language

- talk about the need of fast language that can be used to create 3D games with the ability to be scripted using an embedded language (or itself)
- talk about the benefit of runtime code execution (testing)
- talk about the necessity of scripting without compilation

2.3.1 C++

- industry standard
- powerful and fast
- modifiability can be added through embedded languages
- lots of materials

2.3.2 Lua

- slower than C++, faster than other scripting languages
- can be scripted by itself
- there are no 3D rendering libraries
- high portability

2.3.3 Java

- Minecraft proved that it allows highly modifiable game development
- it also shown that the performance can be a big problem
- high portability

2.3.4 C# ???

- ?should this even be included? main reason for not selecting C# was that I didn't know it well when I started
- also back then runtime code compilation was unavailable

2.4 Scripting Language

- should be fast, easily embedded into C++ and also easily used by modders

2.4.1 Custom

- challenge, experience, can be created to suit the project
- slow development, big task
- probably slow and buggy

2.4.2 Lua

- industry standard
- maybe talk about some of the different games using it
- ease of embedding into C++
- no need to create anything, just connect it to C++

Bindings

- talk about most bindings being either dead, obsolete or very archaic
- those that are up to date are mostly focused on OOP in Lua, which isn't needed in this project
- creating new binding just for this project is easy, fast and the resulting binding will only contain the features that are needed

2.5 Libraries

- just mention something about reinventing the wheel and the areas for which 3rd party libraries were used

2.5.1 3D Rendering

- almost any game will have to use some library for this as going without would take years
- ??I only thought about these in the beginning, should I add others just for comparison??
- mention that portability of the rendering library is much more important than for example the GUI library, since it's integrated deep into the engine while the GUI is not

OpenGL

- talk about what it is
- would allow later Linux port
- too low level, would slow the development process

DirectX

- talk about what it is
- similar problem to OpenGL (too low level)
- would prohibit eventual port to Linux

Ogre3D

- talk about what it is
- can wrap both OpenGL and DirectX
- higher level, lots of stuff already implemented
- describe basic usage of the library (entities, meshes, scene graph, ...)

2.5.2 Graphical User Interface

- main requirement is Ogre compatibility
- theoretically does not have to be portable as it can easily be changed (as it's not integrated into the engine)
- other requirements: graphical editor, ease of use, high level, all the widgets needed (buttons, scrollbars, editboxes, labels, ...)

Ogre Overlay

- talk about what it is
- too simple, would require for the widgets to be created during the game development process which would take a lot of time

CEGUI

- talk about what it is
- used to be bundled with Ogre
- easy to use, clean interface, good design
- ??? genrally advised by the Ogre community
- ??? used for Torchlight which proved what can be done with it

- graphical editor and existing skins
- ??I only thought about these in the beginning, should I add others just for comparison??

2.6 Algorithms

- dunno about this section, not many known or big algorithms used in the game

2.6.1 Pathfinding

- talk about the problem of pathfinding

-

Dijkstra

-

Breadth-first Search

-

A*

-

Solution ??

-

2.6.2 Level Generation ??

-

2.7 Serialization

-

2.7.1 Binary

-

2.7.2 XML

-

2.7.3 Lua

-

3. Implementation / Dev Docs?

- give some basic overview of the project
- say how to tell my functions and Ogre/CEGUI/Lua functions apart
- maybe mention why the camelCase notation of Ogre/CEGUI was not used
- mention what the compiled binary needs to run (?list dlls?)
- say how to change the paths to resources and scripts directories

3.1 Engine (?Layout)

- describe Component - System - Helper - LuaInterface - ... relationship
- possibly create a picture
- describe the "workflow" of the game? or leave it to other sections?

3.2 Game

- !ask PJ: do I have to describe functions even if they have documenting comments?
- describe how the game is initialized
- explain OIS and Ogre callbacks (+ parent classes)
- brief description of its members vs just mentioning them vs ignoring them as they will be explained later?
- level creation (new_level && generate_empty_level)
- throne monitoring? (keeping throne ID so there is only one target of the enemies)
- possibly add a subsections describing Ogre and CEGUI initialisation

3.2.1 State Design Pattern

- describe the pattern
- describe the states of the game
- explain why the pattern is NOT used

3.3 Components

- go through components one by one with UML-like pictures describing their members and purpose
- explain why strings are moved?
- explain why components need default values for every parameter of their constructor?
- go through some more complex concepts of the components (align states, maybe forward reference blueprints, etc.)

3.4 Systems

- define systems
- mention common base class and the reason for inheritance (list of systems...)
- describe the component-system relationship (none, system-component, system-components, systems-component, ...)

3.4.1 CombatSystem

- describe the update logic
- describe entity querying
- describe effect application
- talk about the fabulousness of the query & effect design!
- talk about the run away mechanism?
- talk about runtime projectile creation?
- talk about line of sight and LoS wrt BB?

3.4.2 EntitySystem

- describe the update logic
- describe cleanup (and its delay and why it's necessary)
- id system (back then vs now)
- entity creation process
- component containers
- describe component manipulation (add, load, set, delete, delete now, ...)
- mention entity registration for the entity creator window

- describe function array (reason, jmp table bonus, etc.)
- explain the macros!
- describe why constructors are delayed (so that the lua function where it's create continues before constructor call)
- maybe talk more about component loading from lua? or leave that to the scripting part? or never mention it?

3.4.3 EventSystem

- describe the update logic
- describe event persistence/destruction
- describe how to make event one (successful) pass only
- targeted/area events and area event expansion
- delete component vs delete entity discussion
- describe handling (fixed C++ vs Lua)
- this should be first time we encounter update periods and time multipliers, explain!

3.4.4 GridSystem

- describe the update logic (+freed/unfreed and Grid relation)
- talk about grid graphics used for debugging?
- explain structure placement
- describe alignment checks

3.4.5 TaskSystem

- describe the update logic
- talk about busy state, processing tasks and checking if task is complete
- probably only forward reference the Lua part? or talk about it right here?
!ask PJ!

3.4.6 WaveSystem

- describe states and maybe mention why the State design patter wasn't used (too simple)
- describe the update logic of the different states (-i countdown, spawning, chilling)
- talk about the spawning mechanism, blueprint vector, spawn nodes
- talk about wave entity monitoring and wave ending
- talk about the wave table
- talk about the wstart and wend callbacks
- talk about endless mode
- possibly explain how to write a wave? or add that to the scripting part?

3.4.7 Other

- here explain in alphabetical order the remaining systems
- say why these are not as important (that is, not important to be described) as the others

AISystem

- describe the update logic
- mention update forcing (in relation to the update period mentioned earlier)

GraphicsSystem

- say how it's supposed to maintain all manual graphics logic but atm only does explosions (since it's the only manual graphics object)
- describe the update logic

HealthSystem

- describe the update logic
- mention configurable regeneration period

InputSystem

- describe the update logic
- explain initial purpose and why it's not used atm

ManaSpellSystem

- describe the update logic (both mana regen and entity spell casting)
- possibly talk about the relationship between player spells and entity spells

MovementSystem

- describe the update logic
- talk about move and checked_move (and can_move_to) and why checked is not used but can be from lua (and was intended for 1st person mode)

ProductionSystem

- describe the update logic
- explain how products are spawned and placed

TimeSystem

- describe the update logic (mention the multiple comps updated)
- explain time event handling (and use)
- explain time event advancements

TriggerSystem

- describe the update logic
- explain how triggering works and why it works that way (factions)
- explain the general trap concept?

3.5 Helpers

- describe what helpers are and how are they used
- forward reference the not-singleton status of EntitySystem?
- explain why they were created (use in Lua and optionally in C++ for better code readability)
- explain why they are slower than direct component manipulation
- explain component-helper relationship
- mention the general structure of a helper
- maybe talk about why they are namespaces and not classes? (+ namespace -i allows static class without any change basically)

3.6 Script

- talk about how it works (it's basically a wrapper facade)
- mention `lpp::Exception`
- explain the Lua C API (only informative? add a new section with a tutorial? tell the reader to read the Lua Programming Language 3rd edition book?)
- maybe go through some of the more complex functions?

3.7 LuaInterface

- talk about why it's needed (Lua needs static)
- talk about why it's centralised in one class?

3.7.1 Initialising the API

- explain the C++ function binding process
- explain the Lua module hierarchy
- explain other aspects besides function binding

3.7.2 Extending the API

- explain the general body of the interface functions (stack, return etc.)
- (super) small tutorial on how to add new interface functions

3.8 GUI

- talk about the GUI hierarchy
- explain initialization
- explain CEGUI button binding? maybe in general CEGUI manipulation?
- explain save/load file listing
- mention the `GUIWindow` class, base class of the following GUI windows
- explain why it has `escape_pressed` handler and does not use CEGUI handlers for that (would be needed for all subwindows, too much a hassle - also would probably disregard the conditional closing)

3.8.1 Console

- talk about how awesome it is during debugging
- explain how execution and printing works (+ the history concept?)
- explain why it does not execute lines but multi lines after the execute button is pressed

3.8.2 EntityCreator

- mention that currently it is used for entity placement and the creation part is supposed to be a graphical way to make entities that is not currently in the game
- explain how it works
- explain how it's used for testing
- maybe mention that this is where the `registered_entity` from `EntitySystem` is used

3.8.3 EntityTracker

- explain how tracking works
- talk about why it's useful
- mention the upgrade, exp convert and delete functionality?

3.8.4 ResearchWindow

- explain initialisation, how it works
- explain `dummy_unlock` and its relationship with serialization

3.8.5 Other

- say that these are generally not that complex and quite straight forward

BuilderWindow

- talk about building registration (how it relates to unlocking)
- talk about the assembly line (also used in spell casting window) and why it's good (lack of images -> buttons need to be big and readable)
- don't forget to mention that this is just a graphical front end to `EntityPlacer` (with price management etc.) as is `EntityCreator` (though that one ignores price, and has all unlocked even enemies)

GameLog

- just mention that it is basically the ingame chat posting info for the player
- also maybe again mention history (same as console)?

MessageToPlayerWindow

- talk about button renaming and action assignment
- then mention how to use this as a whole

OptionsWindow

- talk about actions, key bindings and video settings (+ how they are done?)

SpellCastingWindow

- talk about spell registration (how it relates to unlocking)
- just mention the assembly line (already explained in BuilderWindow)
- talk about the relationship with the SpellCaster and how spell casting works on this side (simple invoking of the spell caster and marking the spell as active if needed)
- don't forget to mention that this is just a graphical front end to SpellCaster basically

TopBar

- just say something about its purpose (monitoring of resources)

3.9 SpellCaster

- discuss the spell casting concept in the game
- mention the spell types
- explain why it's so damn cool (ease of spell creation, run time spell creation)
- forward reference the Lua spell structure, which is explained later in Scripting

3.10 Utilities

- just say that these are classes that are not directly part of the game world but are used as background tools that support the game

3.10.1 Camera

- talk about how it allows free/nonfree mode, resetting and backups
- maybe talk more about the free nonfree mode and how to toggle them (both keybind and command)

3.10.2 Effects

- talk about how awesome they are and allowed the creation of extensible effect application framework in CombatSystem
- explain how to write one
- mention that they are used as template arguments and as such should conform the given interface (also explain that)
- maybe illustrate their structure on one of them

3.10.3 EntityPlacer

- explain its purpose and how it works
- explain why only the graphics component data is used (so it's ignored by the game world and serializer, etc.)

3.10.4 LevelGenerator

- explain their purpose and how to write one
- mention the cycle count constructor parameter
- mention the default tables in config (and that it's easy to add new ones)

RandomLevelGenerator

- say that this is just naive algorithm for a pseudo random level generation using number of neighbours that are gold deposits to determine if a gold deposit should be spawned

3.10.5 RayCaster

- explain that I'm a noob that stole other programmer's idea for this from the Ogre wiki
- explain why it's needed (polygon precision ray casting -¿ half cubes, without it only bounding boxes are checked and free space is impenetrable)

3.10.6 SelectionBox

- explain its purpose and how it works
- talk about single/area selection and multi selection using shift

3.10.7 Conditions

- explain their purpose, how they are used in querying and effect application
- mention that it's a good way for extensibility as new can be easily implemented
- mention that they are often used as template parameters and thus need to conform an interface (but not by inheritance)
- talk about the interface
- maybe demonstrate on an example

3.11 Pathfinding

- recapitulate from analysis that a modifiable function was used that allows different algorithms, heuristics and path types
- mentions its parameters (destruction, add path are primary!)
- mention how destruction works
- mentions why path addition is optional (for checks)

3.11.1 Grid

- explain its purpose and implementation
- mention that it only provides a set of grid related operations on a set of IDs it's provided (and assumes those are grid)
- mention random node placement and entity distribution
- mention free node list for ease (and speed) of access
- explain graph creation and linking
- explain general usage

3.11.2 Algorithms

- explain how they should be implemented (what functions, as they are used as template parameters)
- mention that A* is the only currently implemented
- mention portal implementation
- mention difference in complexity (component lookups)
- mention any other differences from a general A*

3.11.3 Heuristics

- explain how they are used and why they are inheriting a base class while other functors are not (state needed for some -i run away heuristic)
- maybe demonstrate on an example as the code is small?

3.11.4 Path Types

- explain what these things are and when they are used to check if the algorithm should stop
- explain their effect on the A* algorithm

3.12 Serialization

- talk about how easy component serialization is and how to create template specializations for new components
- show an example?
- explain the whole saving process, ents to be destroyed, unlocks, player, grid etc.
- explain the loading process

3.13 Player

- just say that it is used as a resource bank, keeping track of gold, mana, units etc
- mention that it also holds the starting unlocks used for new games (saved there during the game initialisation)

3.14 Singleton Design Pattern

- explain what this stuff is, its pros & cons
- mention that the main reason for its use in this game is having one instance, not that much global access

3.14.1 Script

- mention how two Lua virtual machines cannot communicate and data are bound to C++ (via EntitySystem) so it's completely unnecessary to have more than one Scripting engine

3.14.2 GUI

- why would we want to have two GUIs?
- mention that here is the global access very good for testing?

3.14.3 Player

- why would we want two sets of player resources?
- serialization preserves them and shown is only the main set (also used is only the main one)

3.14.4 Grid

- explains how it only operates on a set of given IDs that are made during graph creation (+ mentions it would be easy to implement their switch) so there does not need to be more than one pathfinding grid
- also mention that due to the nature of the game levels, it would be nonsense to have two grids

3.14.5 EntitySystem

- explain how even though it's getting passed around a lot (mainly Helpers), there could be a reason to use more than one EntitySystem instance (like a backup for example) and thus the Singleton pattern might not be the best choice
- maybe compare it to the 4 previous classes

3.15 Scripting

- talk about the API, possibly mention some API reference text file that I should make as an attachment

3.15.1 Initialisation

- talk about the config.lua & init.lua duo
- explain different options in config
- explain how scripts packs are added to init
- talk about the core.lua file of each script pack and what it should do (probably with an example)
- explain how to add a new script directory
- explain how to override some behaviour
- explain the new level callback and for what it can be used (+ the return value meaning)

3.15.2 Entity Representation

- explain the structure of a script representing an entity (with a small example)

3.15.3 Blueprints

- explain what is a blueprint, how to make one and how to use it
- explain why it's a table and not just a function and why the functions in different blueprint should have different names

3.15.4 Research

- explain how to add new unblocks and modify existing ones

3.15.5 Spells

- explain the structure of a spell table and how to make new spell
- mention again the spell types and the difference they make in the spell table function implementations
- mention that spells can be made during run time for testing purposes

3.15.6 Creating a Mod (? Modification)

- provide a simple tutorial on how to make a new mod
- possibly the tower defense one?

3.16 Extending the Game

- small sequence of tasks that are needed for a new feature addition (that is component, system etc.)
- idea: show how a TargetedComponent would be implemented, allowing handlers for targeting/untargeting and how this could be used to create a chess mod

4. User's Documentation

4.1 wubwubwub

Conclusion

Bibliography

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