

A Data-Driven Game Object System

GDC 2002

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Gas Powered Games

Introduction

- Me
 - Scott Bilas
 - Background
- You
 - System architect types
 - Tired of fighting with statically typed systems for game code
- The Test Subject
 - Dungeon Siege
 - >7300 unique object types (i.e. can be placed in the editor)
 - >100000 objects placed in our two maps
 - Continuous world means anything can load at any time



Cell Phones?

Definitions

- Data-Driven
 - Meaning: “No engineer required”
 - Engineers are slow
 - Causes designers to hack around missing functionality
 - Goal: remove C/C++ from game
 - Line between engine and content is always moving

Definitions (Cont.)

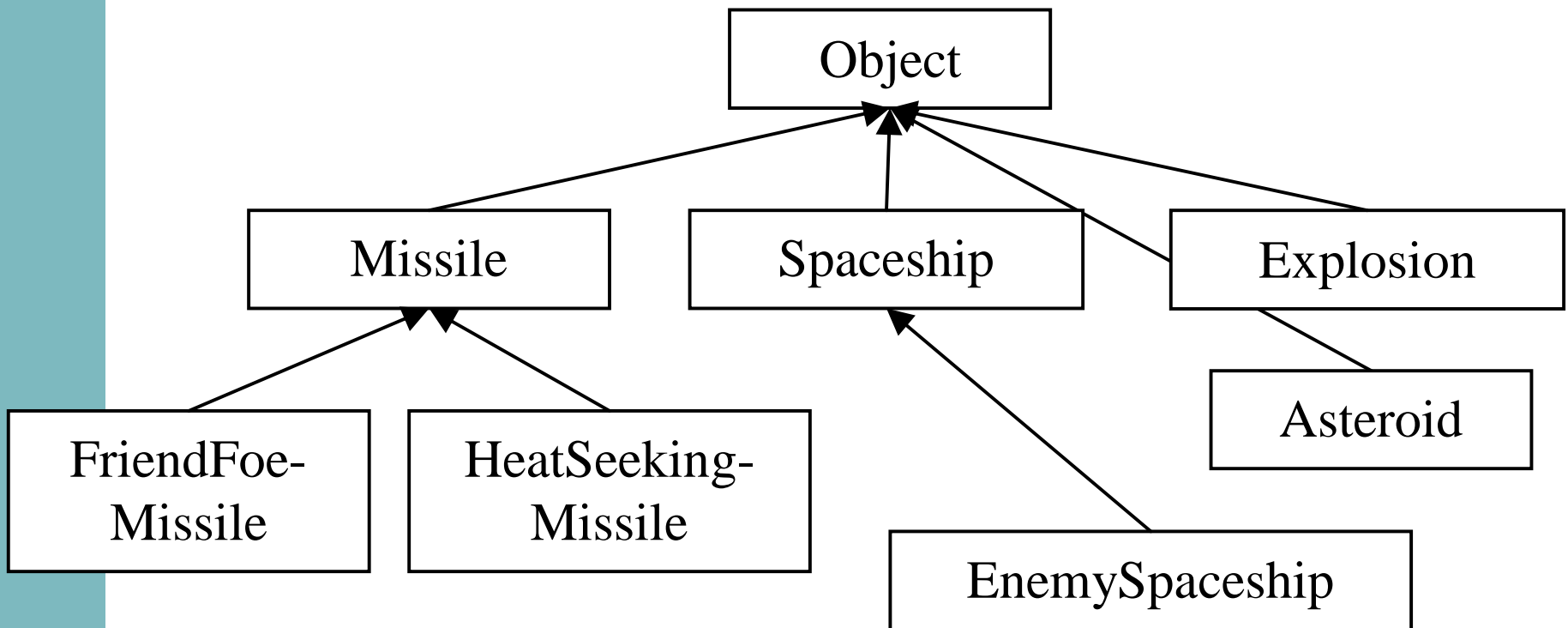
- Game Object (Go)
 - Piece of logical interactive content
 - Perform tasks like rendering, path finding, path following, speaking, animating, persisting
 - Examples are trees, bushes, monsters, levers, waypoint markers, doors, heroes, inventory items
 - Many are “pure logic”, never see them (triggers, elevator movers, camera sequences)
 - Every game has these in some form

Definitions (Cont.)

- Game Object System
 - Constructs and manages Go's
 - Maps ID's to object pointers
 - Routes messages
 - Build from many things, but for this talk
 - GoDb: Go database
 - ContentDb: Static content database
 - Every game has this in some form

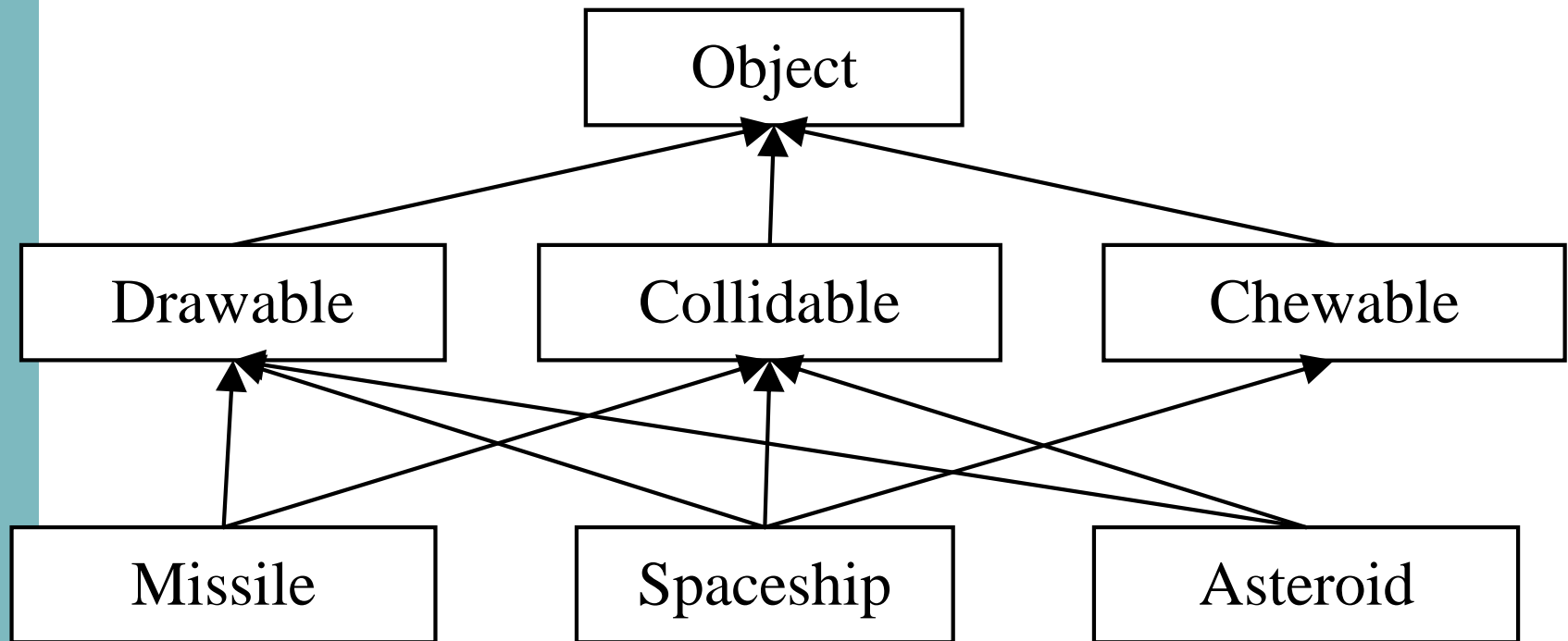
Example Class Tree

Vintage



Example Class Tree

Newfangled



It Won't Work

- There are hundreds of ways to decompose the Go system problem into classes
 - They are all wrong
 - They don't start out wrong, of course...
- Games constantly change
 - Designer makes decisions independently of engineering type structures
 - They *will* ask for things that cut right across engineering concerns

Just Give In To Change

- Requirements get fuzzier the closer your code gets to the content
- Will end up regularly refactoring
- Do not resist, will cause worse problems!
- However: C++ does not support this very well!!

C++: Not Flexible Enough

- Code has a tendency to “harden”
 - Resists change over time
 - Rearranging class tree requires lots of work
- Needing to change it causes engineering frustration, which leads to...
 - Class merging/hoisting (fights clean OOP)
 - Virtual override madness
 - Increased complexity ➔ increasing resistance
 - Doc rot, editor out of sync

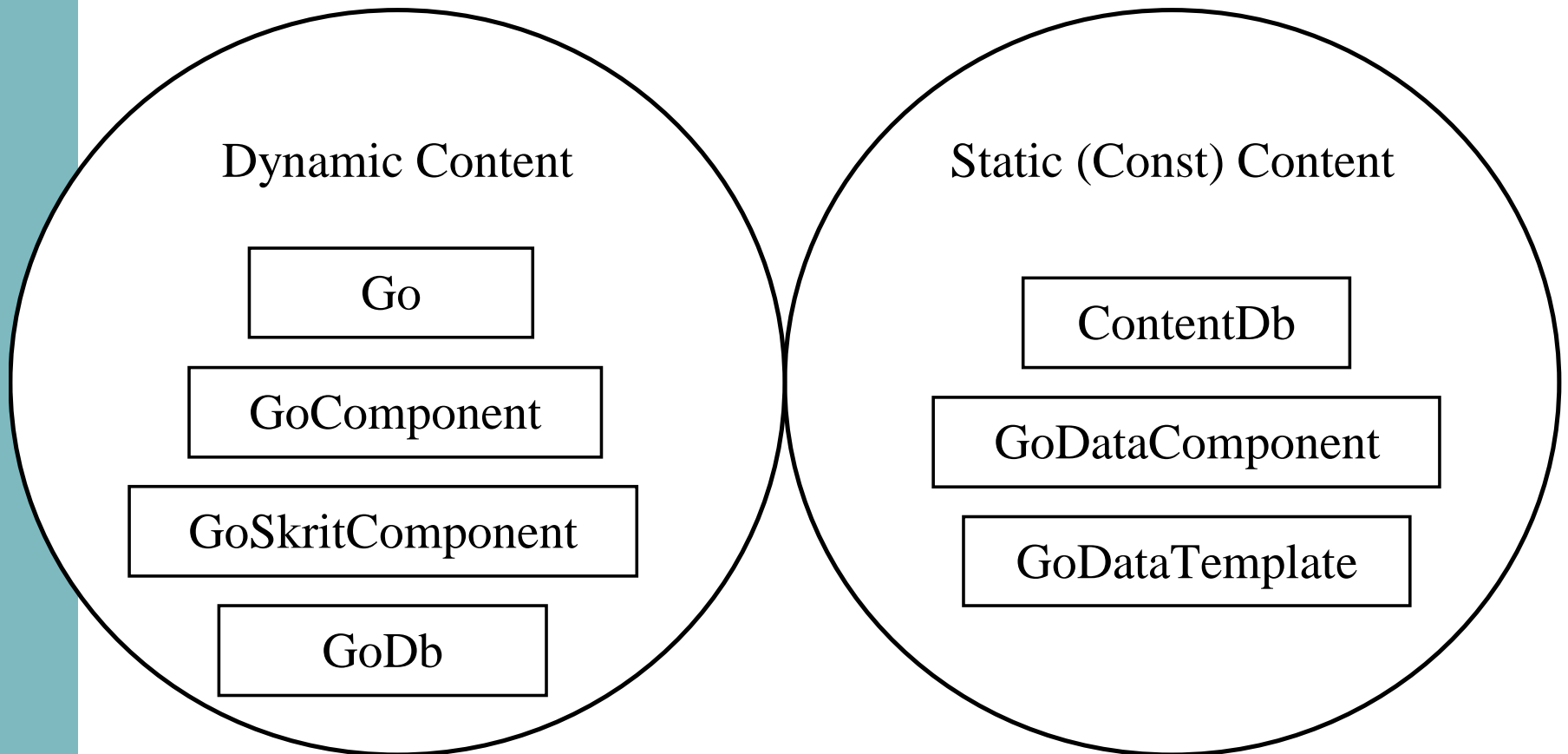
Reexamine The Problem

- This is a database
 - (a very well understood problem)
 - “The data is important, nothing else matters”
- ...and we're hard coding it every time
- To meet changing design needs, can't just data-drive the object properties, must data-drive *structure* (schema) of the objects

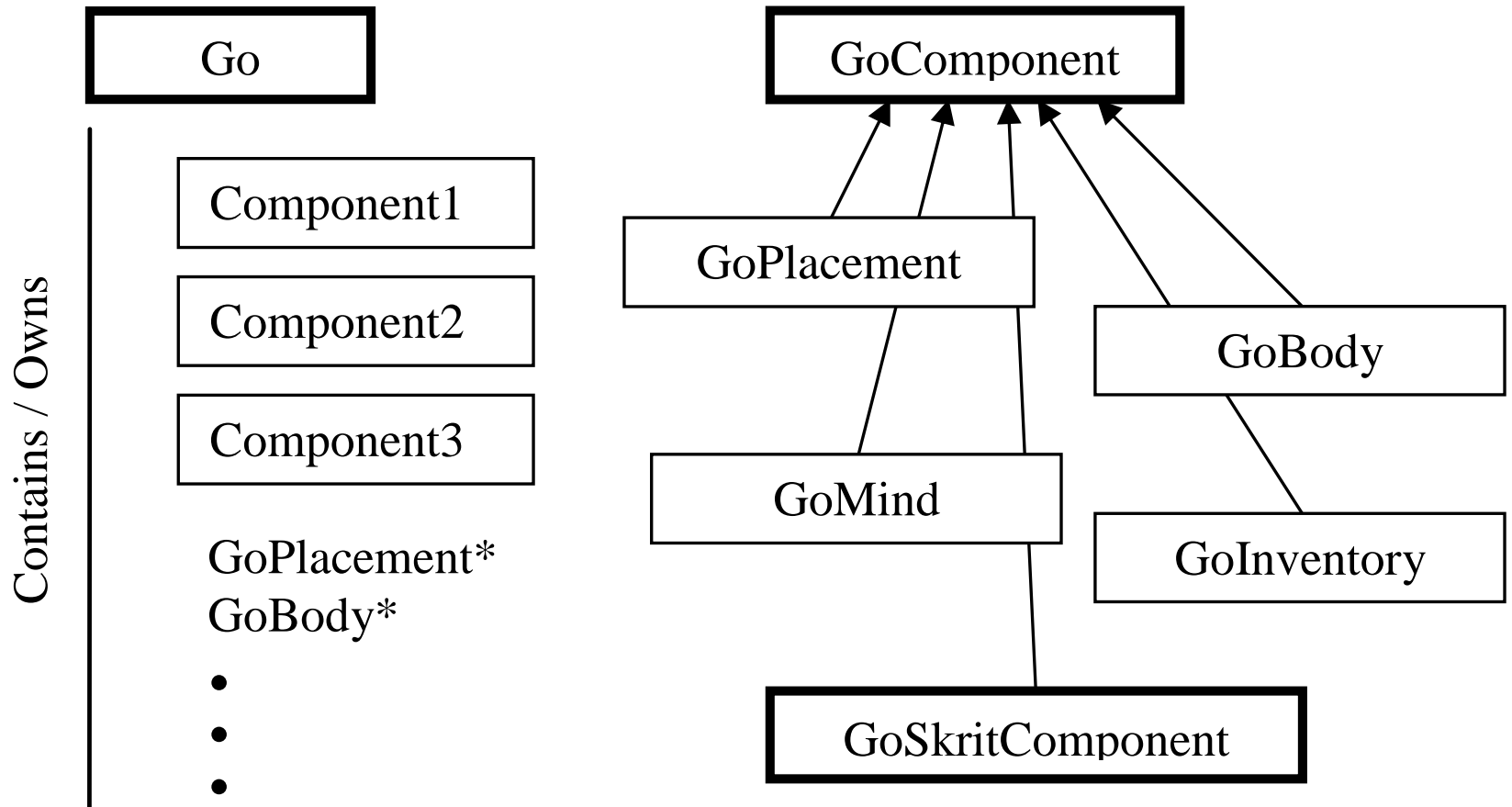
Solution: Component System

- Each component is a self-contained piece of game logic
- Assemble components into Go's to build complete objects
- Specification for assembly driven by data
- Lay out data in a C++-style specialization tree to promote reuse and reduce memory usage
- Include and enforce an external schema

Two-Part Implementation



Dynamic Content Layout



Extension: Skrit

(DS Scripting Language)

- Obvious requirement:
build components out of skrit
- Leave high performance components in C++
- Permits extremely fast prototyping
 - No rebuilds required
 - Don't even have to restart game (reload on the fly)
- Schema is internal

Extension: Skrit (Cont.)

- Simple implementation (assuming you already have event-driven scripting language ready)
 - GoSkritComponent derivative owns a skrit
 - Override all virtuals and pass as events to skrit
- Game and editor don't know/care difference between C++ and skrit components
 - (Neither do the designers)

21 C++ Components

actor, aspect, attack, body, common,
conversation, defend, edit, fader, follower, gizmo,
gold, gui, inventory, magic, mind, party, physics,
placement, potion, store

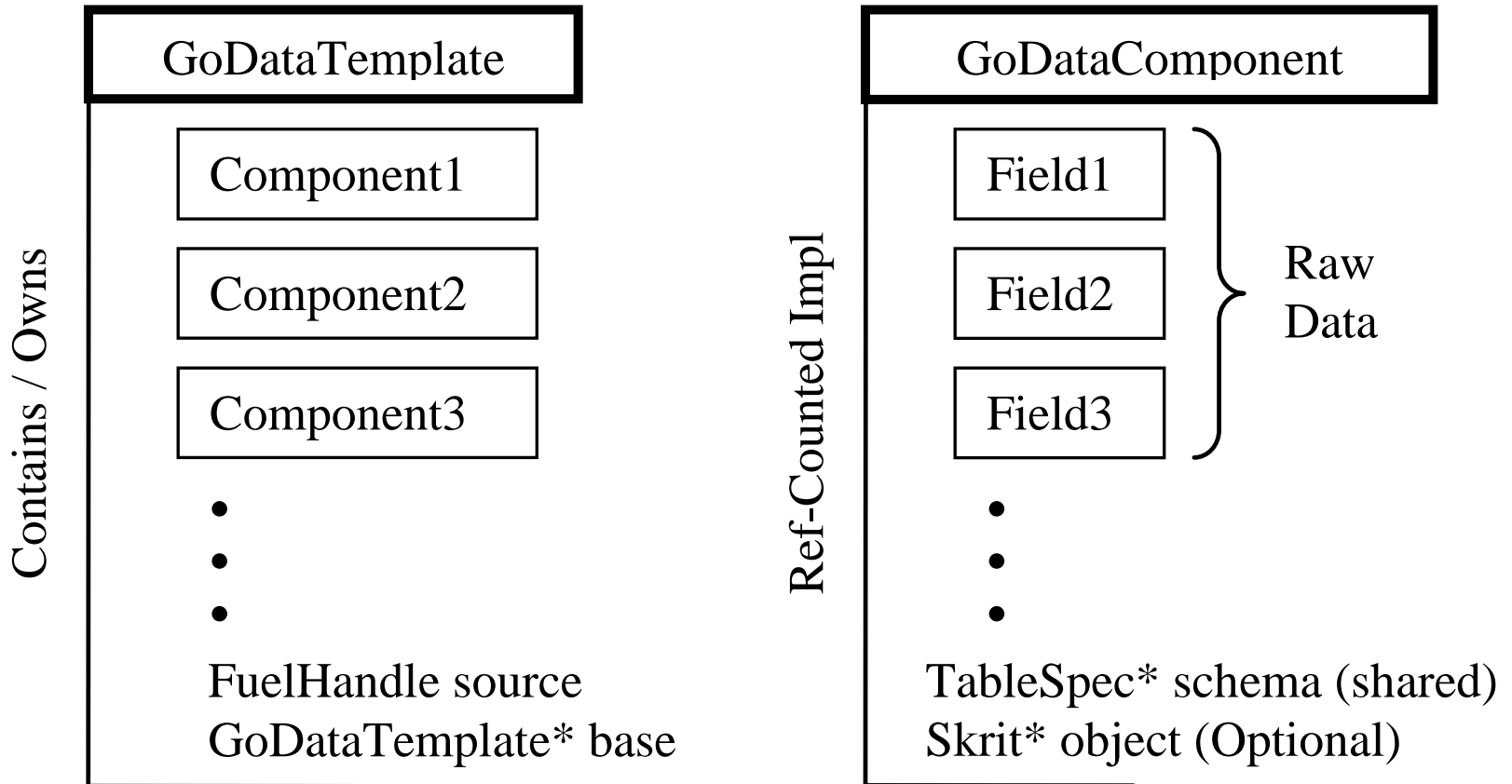
148 Skrit components

base_chest, cmd_actor_stats, cmd_ai_dojob, cmd_animation_command, cmd_auto_save, cmd_camera_command, cmd_camera_move, cmd_camera_waypoint, cmd_delete_object, cmd_dumb_guy, cmd_enter_nis, cmd_inv_changer, cmd_leave_nis, cmd_party, cmd_party_wrangler, cmd_report_gameplay_screen_player, cmd_selection_toggle, cmd_send_world_message, cmd_steam_puzzle, cmd_texture, dev_console, dev_path_point, door_basic, elevator_2s_1c_1n, elevator_2s_1c_1n_act_deact, elevator_2s_1c_2n, elevator_2s_2c_1n, elevator_2s_2c_2n, elevator_2s_3c_1n, elevator_2s_4c_2n, elevator_3s_1c_1n, elevator_3s_2c_1n, elevator_hidden_stairwell, elevator_hidden_stairwell_act_deact, elevator_instant_1c, elevator_instant_4s_1c, fireball_emitter, fire_emitter, fire_emitter_act, generic_emitter, generic_emitter_act, glow_emitter, glow_emitter_act, go_emitter, particle_emitter, particle_emitter_act, sound_emitter, sound_emitter_act, spark_emitter, animate_object, camera_quake, camera_stomp, decal_fade, effect_manager, effect_manager_server, gom_effects, guts_manager, light_colorwave, light_enable, light_flicker, light_flicker_lightweight, nodal_tex_anim, nodal_tex_swap, tsd_manager, water_effects, generator_advanced_a2, generator_auto_object_exploding, generator_basic, generator_breakable, generator_cage, generator_dumb_guy, generator_in_object, generator_object_exploding, generator_object_pcontent, generator_random, activate_chapter, alignment_switcher, attach_robo, breaking_object, check_bool, check_level, check_quest, chipper, clone_preloader, enchantment_manager, experience_award, fountain, freeze_manager, generic_accumtrigger, generic_objblock, hidden_reveal, interface_fade, msg_switch, object_selection_toggle, on_client, play_chapter_sound, point_snapper, position_sync, respawn_shrine, screen_report, self_destruct, set_bool, tip, vis_toggle, locked, on_off_lever, gremal_reward, spell, spell_area_effect, spell_balance, spell_body_bomb, spell_chain_attack, spell_charm, spell_damage_volume, spell_deathrain, spell_death_explosion, spell_default, spell_fire, spell_freak, spell_freeze, spell_instant_hit, spell_launch, spell_lightning, spell_mass_control, spell_mass_enchant, spell_multiple_hit, spell_penalty, spell_polymorph, spell_reactive_armor, spell_resurrect, spell_return_summoned, spell_status_effect, spell_summon, spell_summon_multiple, spell_summon_random, spell_switch_alignment, spell_transmute, spell_turret, test_marker, test_timer, trapped, trp_explosion, trp_firetrap, trp_launch, trp_lightning, trp_particle, trp_trackball, minigun_magic

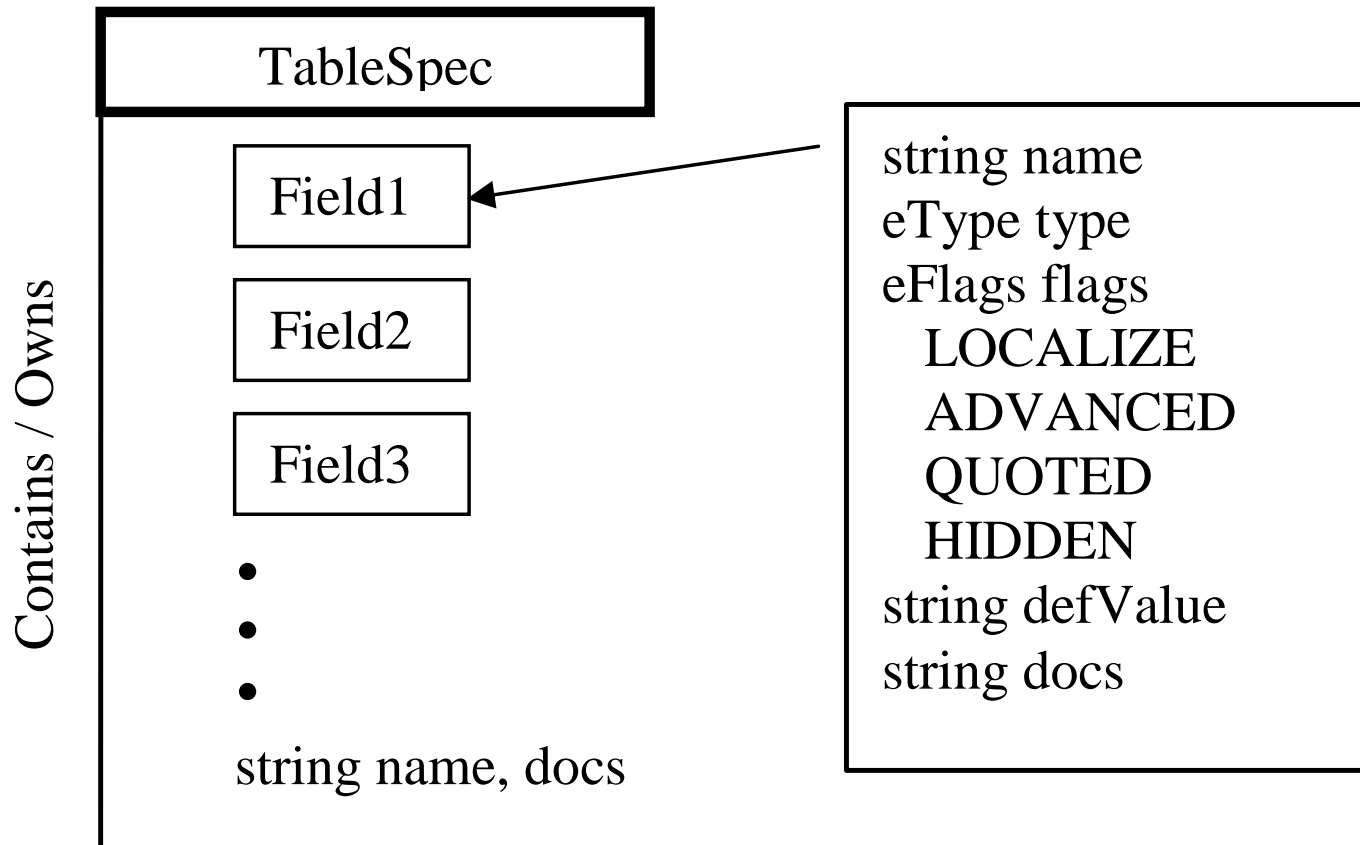
Alert! Before Moving On

- Generic datastore required to continue
 - INI file, config file, XML store, RIFF, all the same
 - Permits generic data retrieval/storage
 - DS has “gas”, think “INI with nesting + goodies²”
- Not difficult to roll your own
 - Many books/articles on this
 - Probably need one for other parts of the game anyway (i.e. you’ll find uses for it no problem)

Static Content Layout (Code)



Schema Layout (Code)



Compile ContentDb

Part 1: Build Schema

1. Process components.gas (C++ table specs)
 - a. Build table specs directly from .gas spec
2. Recursively scan components base directory for all skrit components
 - a. Compile each skrit
 - b. Build table specs from metadata in

...now we've got the schema constructed.

C++ Component Schema (Data)

```
[t:component,n:gui]
{
    doc = "Objects with GUI may be placed in inventory";
    required_component* = aspect;

    [inventory_icon]
    {
        type = string;    default = b_gui_ig_i_it_def;
        doc = "Bitmap displayed when dragging or in inventory";
    }
    [active_icon]
    {
        type = string;    default = b_gui_ig_i_ic_def;
        doc = "Bitmap displayed in quick-select window";
    }
    ...
}
```


Skrit Component Schema (Data)

(Concept adapted from UnrealScript)

```
property string effect_script$           = ""
doc = "Name of the SiegeFx script that will be providing the visual.";
property string end_script$             = ""
doc = "Name of the SiegeFx script that will be providing the visual "
      "when un_summoning.";
property string script_params$          = ""
doc = "Parameters to send to SiegeFx script";
property string template_name$         = ""
doc = "Template name of actor to summon";
property string state_name$            = "summoned"
doc = "Name of effect to use as a generic state and as a screen name.";
property string description$           = ""
doc = "Description of enchantment being applied";
property string caster_description$     = ""
doc = "Description of enchantment being applied to the caster";
property bool   guard_caster$          = true
doc = "Make the summoned creature follow the caster.";
property bool   change_align$         = true
doc = "set summon alignment to be that of the caster.";
property bool   delete_inv$           = true
doc = "delete summons inventory when removed.";
```

Compile ContentDb

Part 2: Build Templates

(This is just prep work)

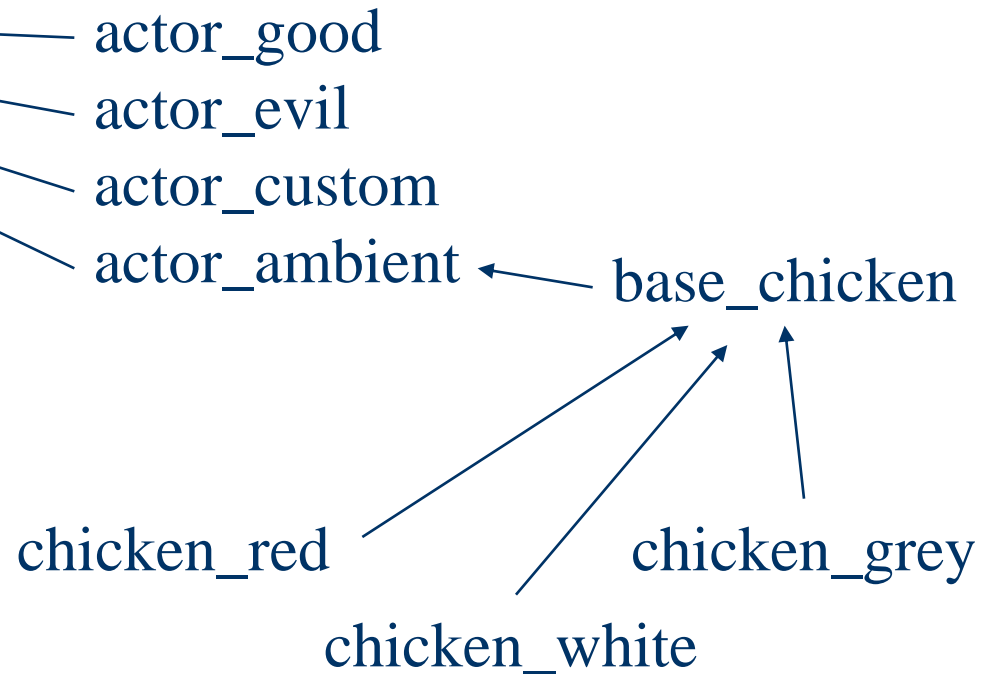
1. Recursively scan .gas template tree
 - a. Note: doesn't need to be a physical tree
2. Open data handles to each template
3. Keep track of root nodes, build specialization tree

Template Forest (Data)

Root Templates

actor
interactive
non_interactive
trap
emitter
command
elevator
generator
ui

Specialization Tree



Template Specification (Data)

```
[t:template,n:chicken_white]
{
  category_name = "1w_ambients";
  doc = "chicken_white";
  specializes = base_chicken;
  [aspect]
  {
    [textures] { 0=b_c_na_ckn_white; }
  }
  [common]
  {
    [template_triggers]
    {
      [*]
      {
        action* = call_sfx_script("feathers_flap_white");
        condition* = receive_world_message("we_anim_sfx",1);
      }
    }
  }
  [physics]
  {
    break_effect = feathers_white;
    explode_when_killed = true;
  }
}
```

Compile ContentDb

Part 3: Compile Templates

1. Recursively compile templates root-down
2. Add data components on demand
3. Read in values, override base template fields

This is all similar to C++ base-first member initialization in ctors.

Compile ContentDb

Special notes

- We want a flat tree for performance reasons
 - Depends on how frequently you construct objects and how fast your data override system is
 - Also permits special const-read optimization that can eliminate memory usage and CPU for variables that are never changed
- Copy data components on write to avoid unnecessary memory usage
- If have many templates, will need to JIT compile leaf templates to save memory

Editor Integration

- This is *almost* trivial
- Editor should have a property sheet type thing
 - This is a one-entry view into the db
 - Map types and names onto fields using schema
 - Can un-override easily by querying template
 - Be sure to add a column or tooltip for docs!

Editor Integration (Cont.)

- For DS all editing support done through a special “GoEdit” component
 - Transforms data between game object and editor
 - Supports cheap rollback (undo) by double buffering
 - Does not exist in game, only needed in editor
 - Automates saving all game object instances – just compare vs. the const data and write out if different
- Not recommended: permitting forced overrides of duplicate data

Instance Specification (Data)

```
[t:chicken_red,n:0x837FD928]
{
  [placement]
  {
    p position = 1.3,0,1.8,0x1738FFDB;
    q orientation = 0.3828,0.2384,-0.7772,0.98;
  }
  [common]
  {
    screen_name = "Super Chicken";
  }
  [body]
  {
    avg_move_velocity = 18.000000;
  }
}
```

Loading Objects

- In DS, objects are referenced by content ID
- Look up instance block to get template to use
- Instantiate Go by that template
 - For each block in instance, create a new data component
 - Specialize that data component from base in template
 - Finally iterate through GoComponents and xfer in data to set initial values

New C++ Components

- Can be done with little regard for other components (just add it)
- Derive from GoComponent *only*
 - Specializing an existing class just asking for trouble
- Add new block to C++ components schema (DOC IT)
- Use a factory method
 - Simple LUT mapping name ➔ ‘new GoJooky’
- Wait a second, wouldn't it be better to write using the scripting language? (Probably...)

New Skrit Components

- Same as C++, just stick it in there
- Everything should be autodetect here
- Extend the scripting language with metadata
 - Pass it straight through to schema query
 - Can implement flags, docs, and custom game features like “server only” components etc.

Managing the Template Tree

- Can be maintained by nearly anyone once it's set up
- Should have multiple roots for broad types
- Try to avoid data duplication
- Reserve one branch for test templates
 - Mark it dev-only (so is excluded for retail build)
 - Prefix with test_ or dev_ to avoid namespace pollution
 - DS ended up with 150 or so

Advantages I Forgot To Mention

- Direct and automatic editor support
- Designers can construct their own types to place in the editor (careful, monitor this!)
- By only saving out modified data in instances, can make global changes easily by modifying templates
- Reorganizing the template tree is easy
- If embed a sub-tree for designers to build custom views into the database

Some Pitfalls

- C++ components prone to becoming intertwined
 - Operations can end up being order-dependent, though this is more easily controlled
 - Nothing here is unique to components
- It's a little *too* easy to add templates, perhaps
 - DS has >7300 of them, many auto-generated
 - System was designed for <100
 - Need to keep close eye on template complexity to avoid memory/CPU hog (i.e. unnecessary components or wacky specialization)
- “With power comes responsibility”

Future

- Schema extensible
- Add flags and constraints that editor can use
 - Auto-detect when can use color chooser or slider or listbox or whatever
- Add defaults computed from script

Contact Info

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