

Halo AI Retrospective:

8 Years of Work on 30 Seconds of Fun



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So What Do You Care?

- The Halo AI is a mature system that has been under continuous development for 8 years.
 - Halo: The RTS
 - Halo 1: Oct. 2000 – July 2001
 - Halo2: Jan 2002 – Oct 2004
 - Halo3: Jan 2005 – Aug 2007
- Where have the cracks appeared?
- What does that say about the future?

The 30 Seconds of Fun

1. plan your approach
2. take them by surprise
3. beat them back
4. break them
5. mop them up
6. Repeat

**All of this is
very fun**

The Agenda

1. Big Ideas from Halo 1
2. Big Ideas: Evolved
3. The Future

... in no particular order.











Humble Beginnings

“Primal games”

- Hide and seek
- Chase / flee
- Tag
- King of the Hill



3 Big Ideas from Halo 1

#1: Territory



- Player needs a safe-zone
- Player expands his safe-zone

Territory as Fun

- gives player a sense of progress
- highly plannable
- encourages the encounter-as-puzzle approach

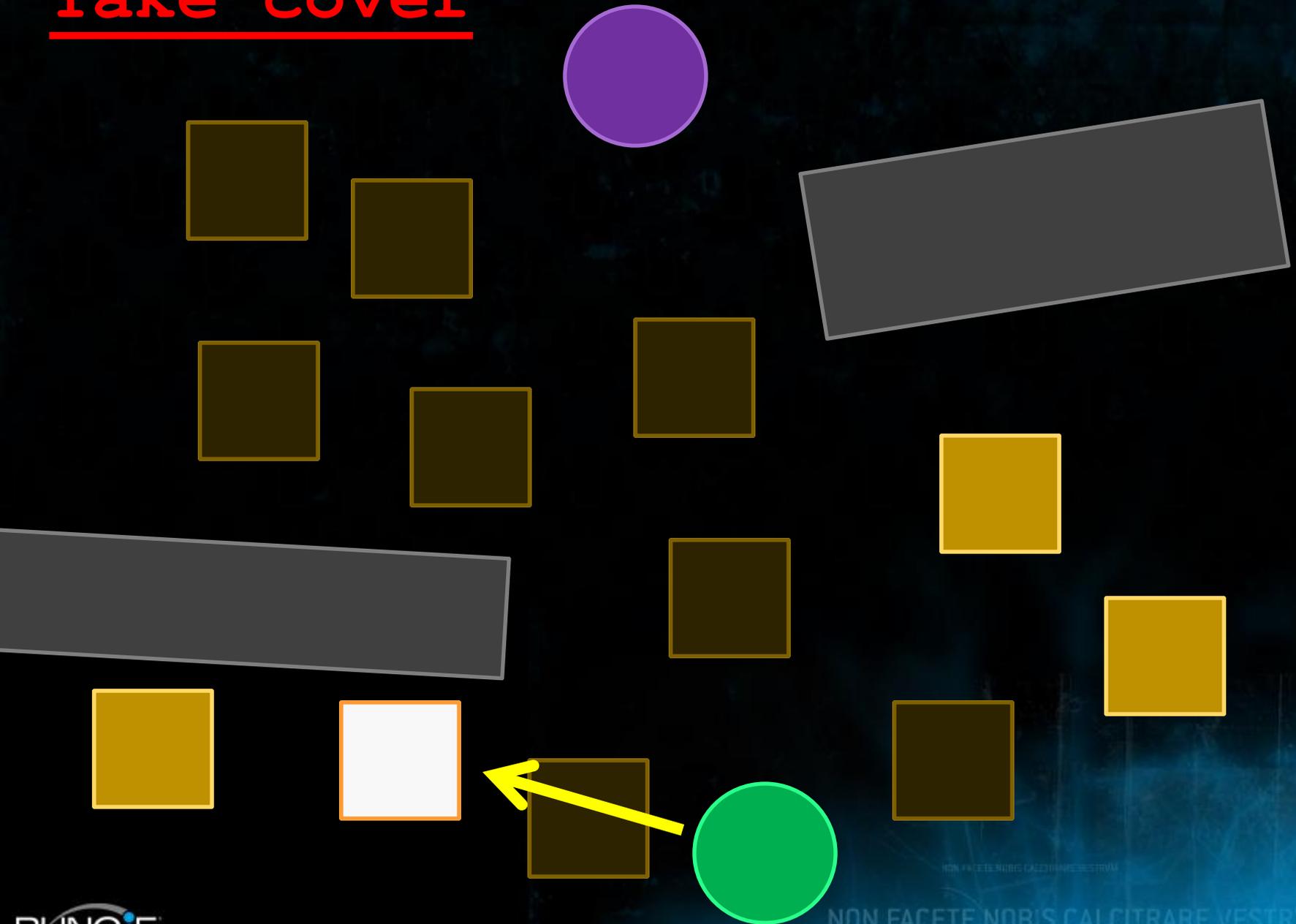
So how do we build it?







Take cover



Uncover enemy



Encounters

Benefits:

- prolongs the 30 seconds
- reconfigures the problem

Recapitulated many times in
Halo 2 and Halo 3...



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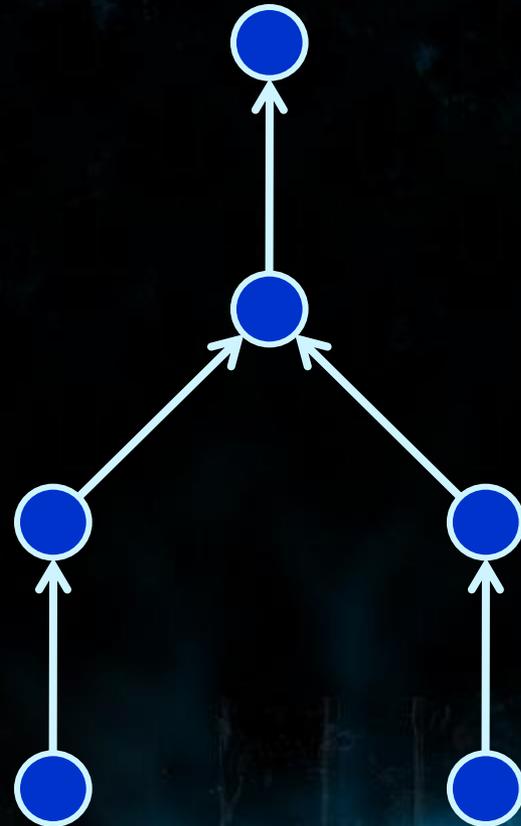
Encounters

Benefits:

- prolongs the 30 seconds
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Recapitulated many times in
Halo 2 and Halo 3...

... and formalized.



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#2: Limited Knowledge Model



Hide and Seek demands a limited knowledge model

And when you play, you play against your opponent's knowledge of the state of the world.

The outcome: AI that can make mistakes.

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Mistakes

What's so great about mistakes?

1. They make the player feel smart
2. They DON'T make the AI feel dumb

[Of course, they need to be the right KIND of mistake.]

Bad Mistakes

- Character running into a wall.
- Character standing on top of another's head.
- AI driver grinding against a rock

i.e. mistakes that break the 4th wall

mistakes that no human would ever make

Good Mistakes

- Physical mistakes
 - over-commit to a long melee (e.g. the “Hunter”)
- Bad *decisions*
 - elite berserking
- Mis-perceptions



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Mis-perceptions

Each AI has an internal model of each target.
And that model can be WRONG.

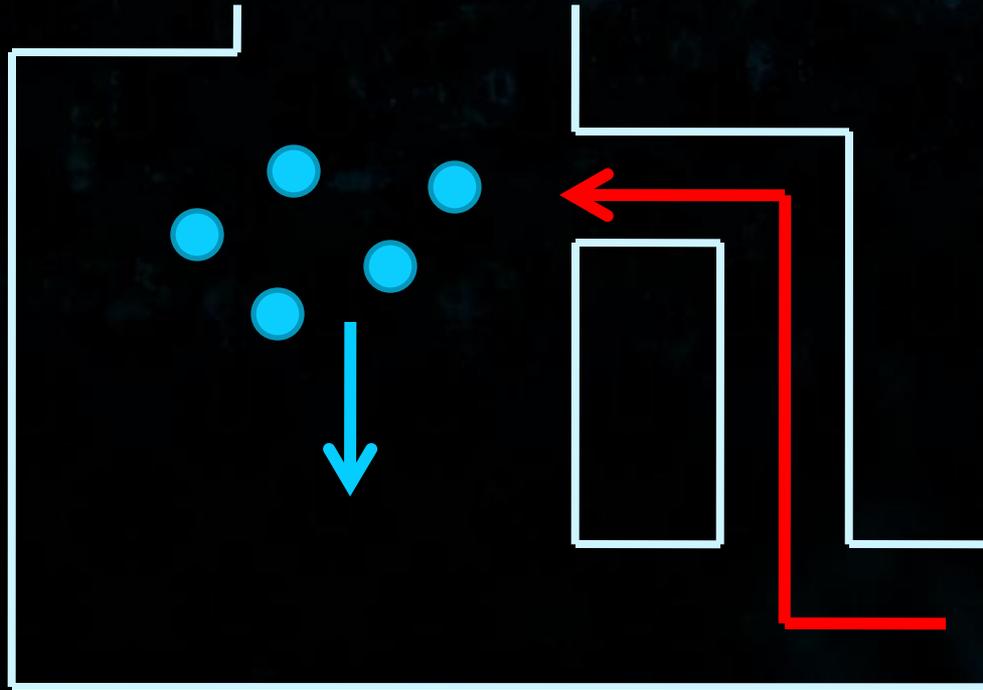
This enables:

- AI surprised by your presence
- AI surprised by your absence
- AI that be manipulated, tricked, misled, etc.

**This stuff
is fun**



Good spaces



Cover is dual purpose

- protect you from damage
- allow you to out-think your enemies (“AI blinds”)

#3: Satisfying Enemies

The Bet: It is more satisfying to kill an enemy that is perceived to be cunning, formidable and tactical.



As much about art, animation, dialogue and character design as it is about AI.

Satisfying Enemies

- Fallible
 - mistakes are better than weaknesses
- Reactive
 - player is very important to them
 - player understands the cause and effect
- Capable
 - Roughly player-equivalent in terms of capabilities
 - e.g. vehicles, weapons



Big Ideas

1. Territory



2. Limited knowledge model



3. Satisfying Enemies









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AI Performance

Top 3 Halo 1

1. Perception raycasting
2. FP raycasting
3. Pathfinding

Top 3 Halo 3

1. Perception raycasting
2. FP raycasting
3. Pathfinding

Greater geometric complexity ensured that raycasting never became cheaper.

Scale

Territory

Limited Knowledge Model

Satisfying Enemies

Massive battles

More realistic perception

More of them

More characters

Group perception

More varieties

More complex scripting

Group dialogue

More abilities

GDC'08

Scale

Territory

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Group Dialogue

Q: Why is dialogue in the knowledge model column?

A: Because most dialogue is about knowledge-status

- “I see new enemies!”
- “There’s the demon!”
- “Look out, wraith incoming.”
- “Where’d he go?!”
- “He’s here, I found him!”

Knowledge and Dialogue

Look out,
we got a sniper!

Ka-blam!

Nice shot,
sir!

Sniper
down!

Combat Dialogue

Halo 1

166 vocalization categories

5,147 recorded lines

Encounter sizes 10-15

Halo 3

320 vocalization categories

32,353 recorded lines

Encounter sizes 20-30

Aural Coherence

Problem: As the number of characters in an encounter go up, the coherence of the auditory experience goes down.

Where are you?!

There he is!!!

Where'd he go?

I see you!

Take this!

He's in cover!

Is he over there?

He's not here!

Nice shot!

Dropship!

Ow that hurt!

Man down!

Aural Coherence

Solution: Find ways to filter the dialogue

Where are
you?!

He's not
here!

Is he over
there?

I don't see
him!

There
he is!!!

Take this!

Nice shot!

Eat lead!

You're mine!

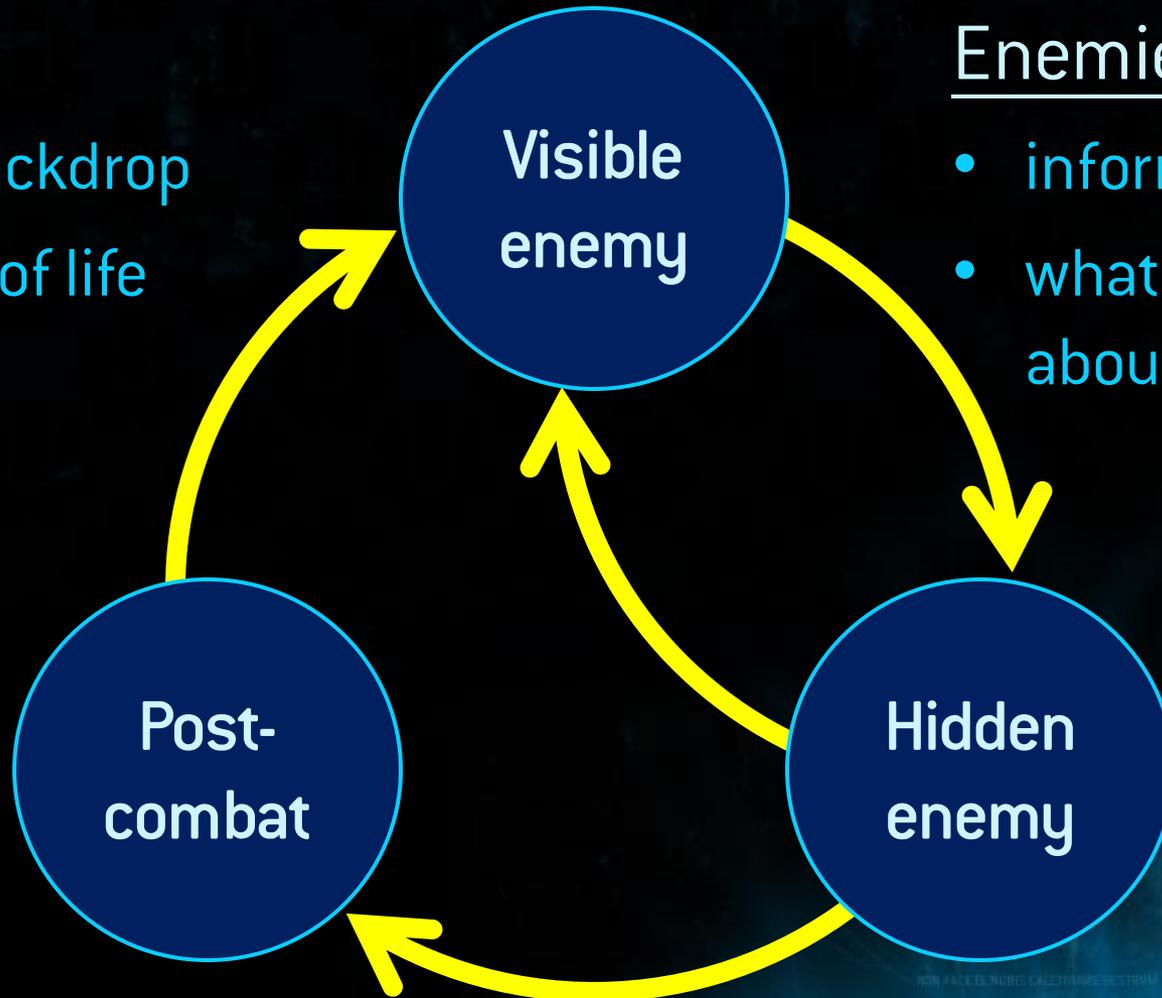
Group Knowledge

Allies

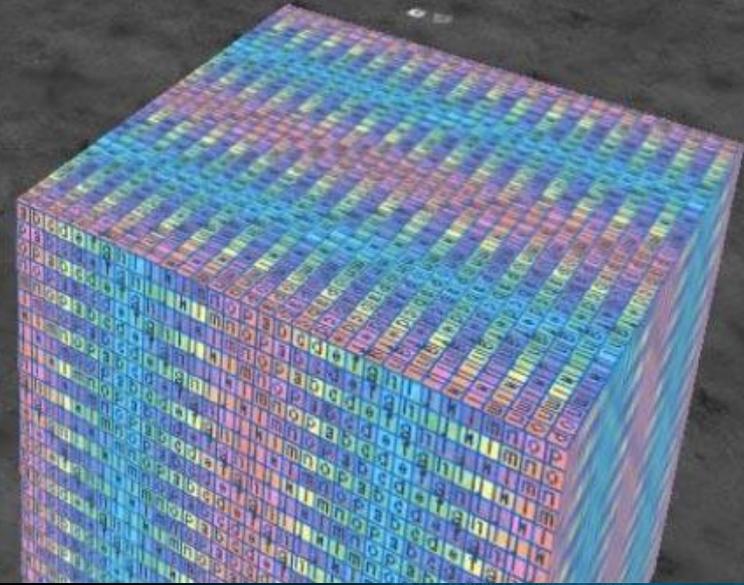
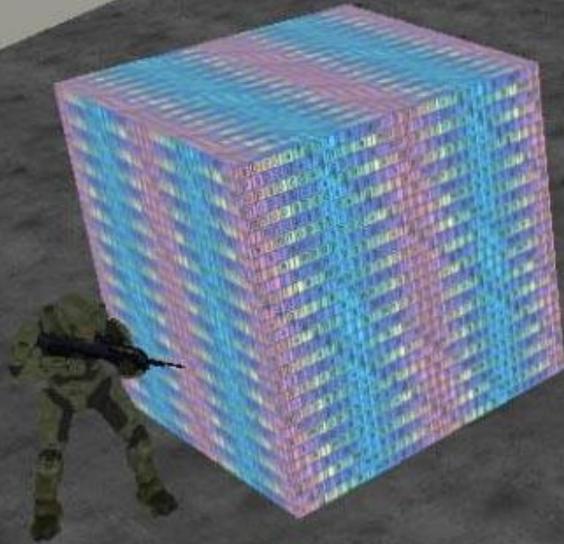
- aural backdrop
- illusion of life

Enemies

- information
- what they know about the player



2445 2445: lost_contact? (1st_cntct -1)



2445 2445: lost_contact! (1st_cntct -1)

lost_contact!

Lost contact!



He's pinned down!

2598 2598: he's pinned down? (srch_pinned -1)

he's pinned down!

2813 2813: come back coward? (tnt_invsgt_stayback -1)

3017 3017: don't make 'em mad? (Ent_r2 -1)

Come back,
coward!



3017 3017: don't_make_'em_mad? (tnt_re -1)

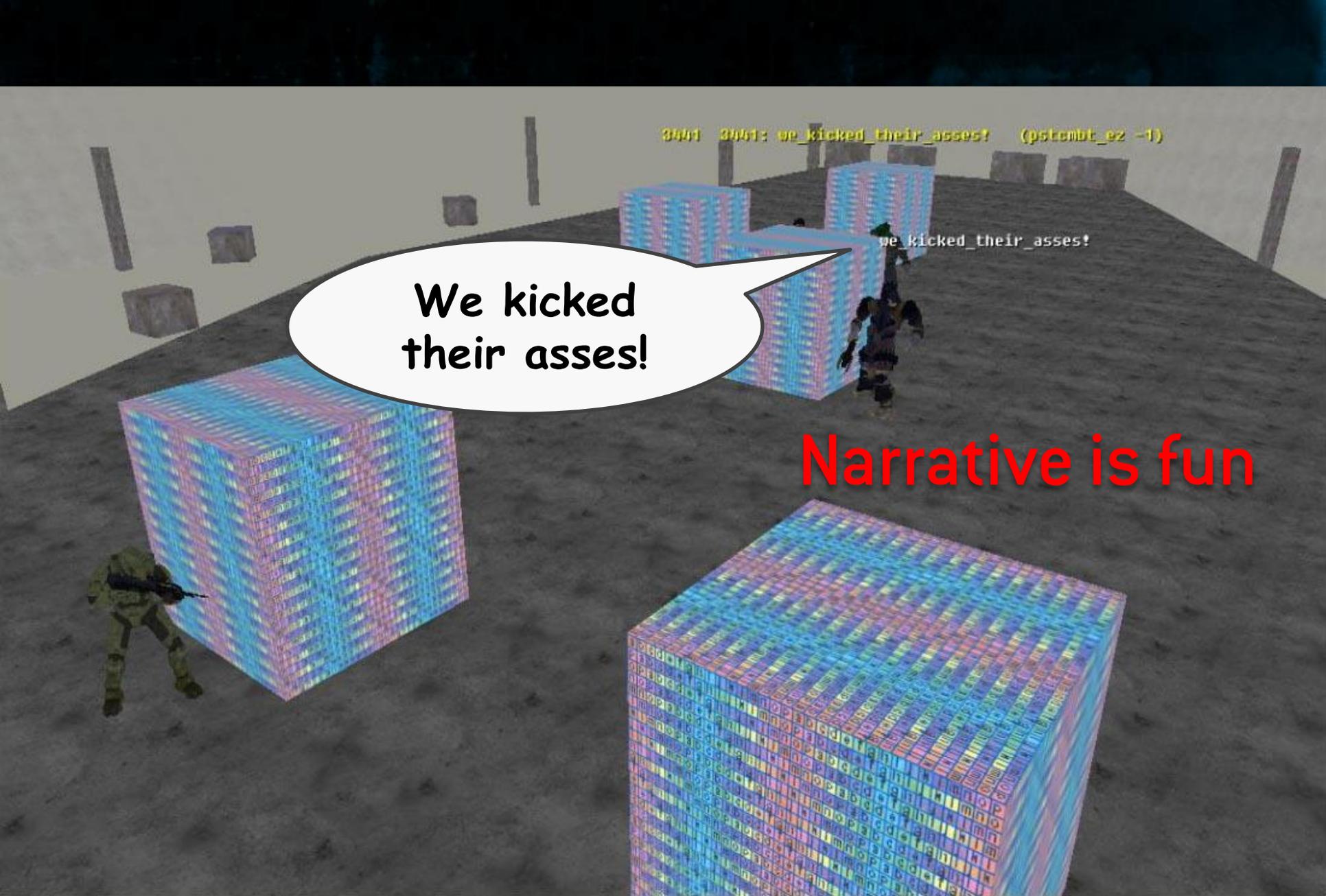
don't_make_'em_mad?

Don't make him mad...

3282 3282: is_that_it? (endcmpt -1)

is_that_it?

Is that it?



We kicked their asses!

3441 3441: we_kicked_their asses? (pstcnbt_ez -1)

we_kicked_their asses!

Narrative is fun

Scale

Territory

Limited Knowledge Model

Satisfying Enemies

Massive battles

More realistic perception

More of them

More characters

Group perception

More varieties

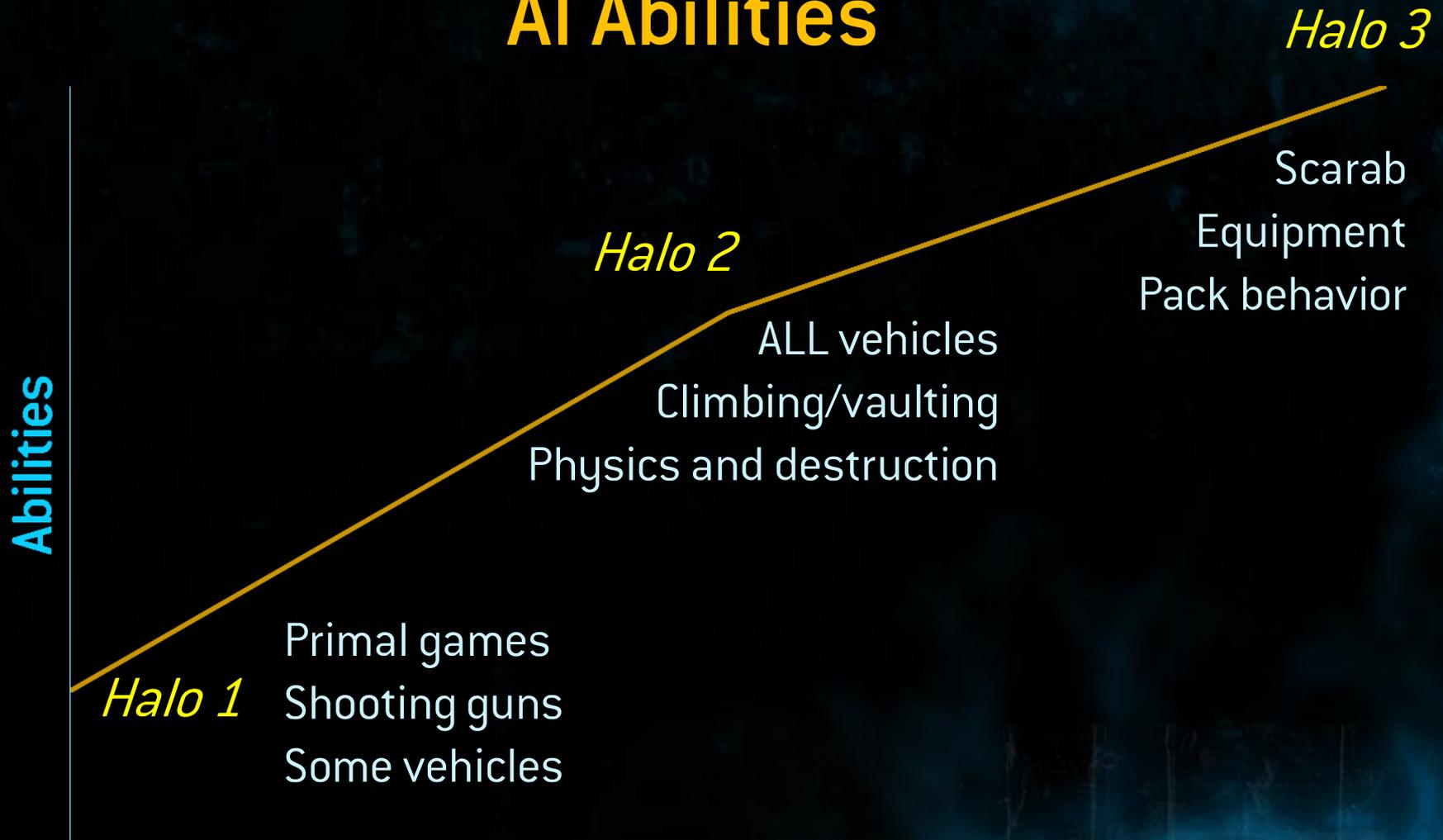
More complex scripting

Group dialogue

More abilities



AI Abilities



More is Better

Brute Force Approach to AI:

More reactions to more specific triggers = more common sensical AI

- More things to do adds variety and replayability.
- Leverages players' tendency to impose a narrative on the chaos of battle.

Abilities are fun

More abilities are more funner

Bubble Shield

The Easy part:

- Decide when to deploy

The Hard Part:

- Doesn't block line of sight
- DOES block line of fire
- Potentially every behavior is affected

i.e. AI needs to understand the concept of “unbreakable glass”



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Bubble Shield

The Easy part:

- Decide when to deploy

The Hard Part:

- Doesn't block line of sight
- DOES block line of fire
- Potentially every behavior is affected

```
cover_control
{
    if (path_finished() &&
        target_visible())
    {
        change_position()
    }
}
```

i.e. AI needs to understand the
concept of “unbreakable glass”

The World



Perception

What do you know?



Behavior

What do you do?



Control

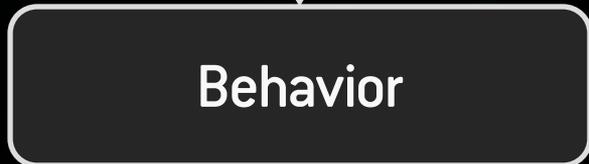
Do it!



The World

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The World



The World

Throw grenade



Get in turret



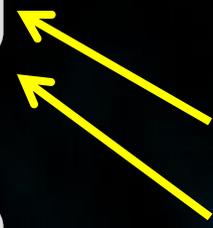
Charge target



Deploy shield



Take cover



Search for target



The World



Perception



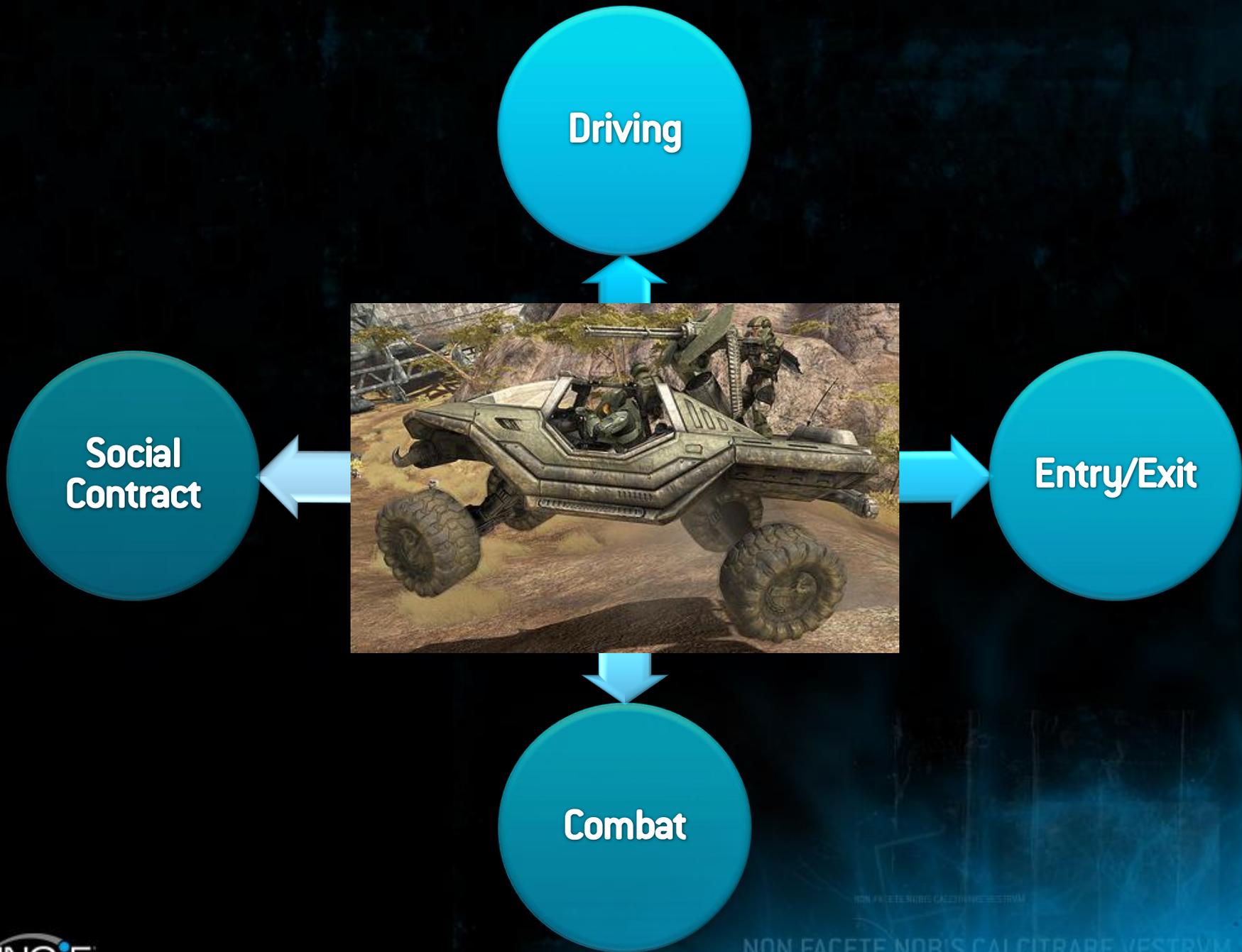
Behavior



Control



The World



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Vehicles

Player drives up to me

What seat do I get in?

- depends on the weapons my buddies and I are holding

When we tip over, do I

- take off?
- stick around?



Halo 2: Attack all of this through behavior. Not pretty.

Vehicles

Halo 3: The Vehicle “Concept”

- Implements the social contract
- Handles arbitration
- The vehicle IS a territory

In Halo2, when an AI tips over his vehicle, he get distracted and wanders off towards the nearest fight.

Vehicles

Halo 3: The Vehicle “Concept”

- Implements the social contract
- Handles arbitration
- The vehicle IS a territory

In Halo3, when an AI tips over his vehicle, he hangs out in the vicinity waiting for a chance to right it again.

The World



Perception



Behavior

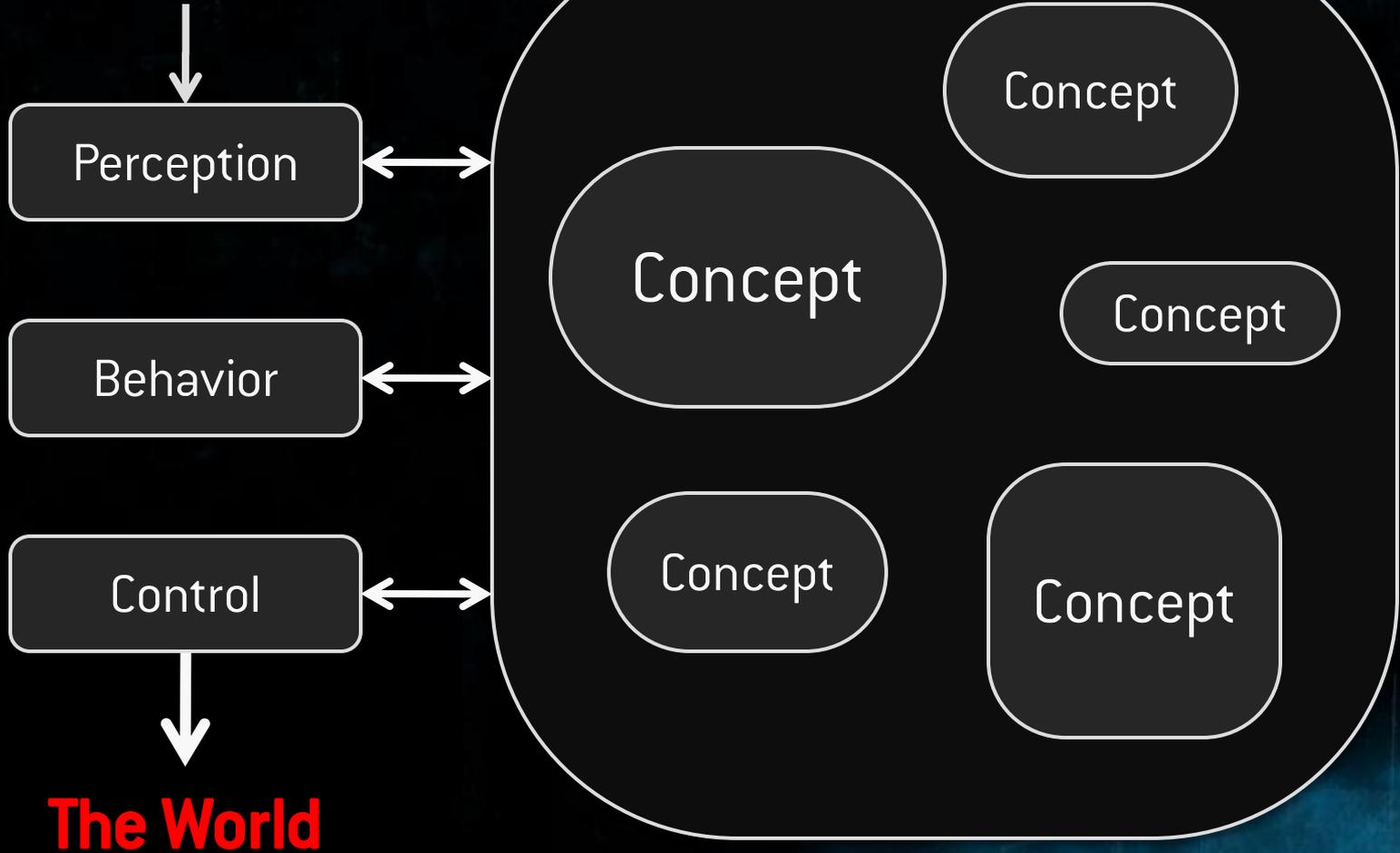


Control



The World

The World



The World



THE FUTURE

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Big Challenges

The obvious:

- Animation technology still sucks
- Design interfaces still suck
- Pathfinding will suck forever

Big Problems

The player is getting out of the vehicle. Is he ...

- Leaving it behind?
- Switching to a better one?
- Stopping to pick up a weapon?



Only one solution:

Telepathy

When should the AI get out?

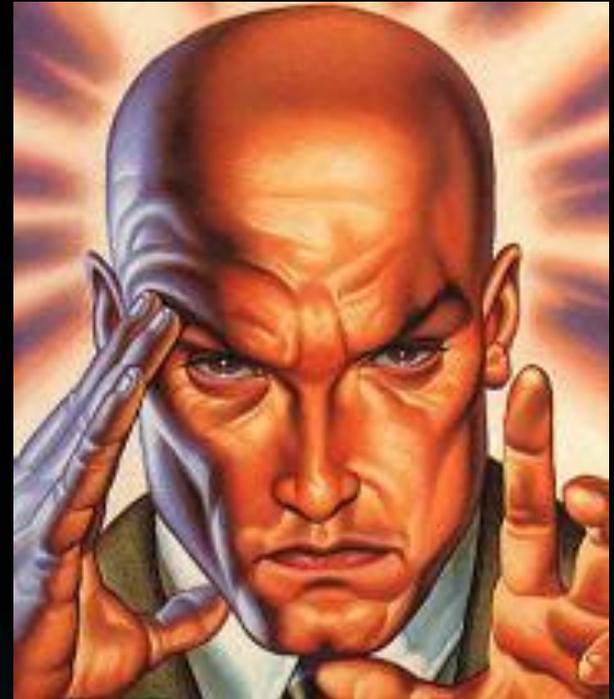
Telepathy

A lot of the responsiveness that we want from our characters requires a determination of intent of the player

Wrong choices are very costly

- “that AI just stole my warthog!”
- “why isn’t my marine following me?”
- “no, I want you get in the PASSENGER seat!”

Two directions we could go with this



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1) Player Modeling

- We have miles to go here
- We will never be 100%
- Not even humans are 100%
- And sometimes 99% is just not good enough

Why?

“It’s no good if 1 in 100 times, the computer books you the wrong flight.”

2) Player–AI Communication

The problem is not really that a mistake is made.
The problem is that I can't do anything about it.
I don't have a way of saying, "no".



2) Player–AI Communication

- I don't want to give them orders: I want to have a conversation!
- Essential to growing AI abilities
- As abilities extend further into the social domain...
 - where even bubble shields and warthogs have social aspects
- ... some form of rudimentary language will be necessary in order to navigate the domain, share knowledge and derive intent.

2) Player–AI Communication

This should be easy!

BUT ... it is a design problem, not an AI one

Thank you...

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be up on
www.bungie.net/publications
next week





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