Killzone 2 Multiplayer Bots

Alex Champandard – AiGameDev.com
Tim Verweij – Guerrilla
Remco Straatman - Guerrilla

Game AI Conference, Paris, June 2009

KILLZONE™

Introduction

- Killzone 1 bots well received feature
- More focus on MP in Killzone 2
- Role of bots in Killzone 2

Scope

Killzone 2 / PS3
- Max 32 players
- Team-based game modes
- Multiple game modes on one map
- Players unlock / mix “badge abilities”

- Offline (1 human player & bots)
- Online (human players & bots)

Scope

Game modes
- Capture and Hold
- Body Count
- Search and Retrieve
- Search and Destroy
- Assassination

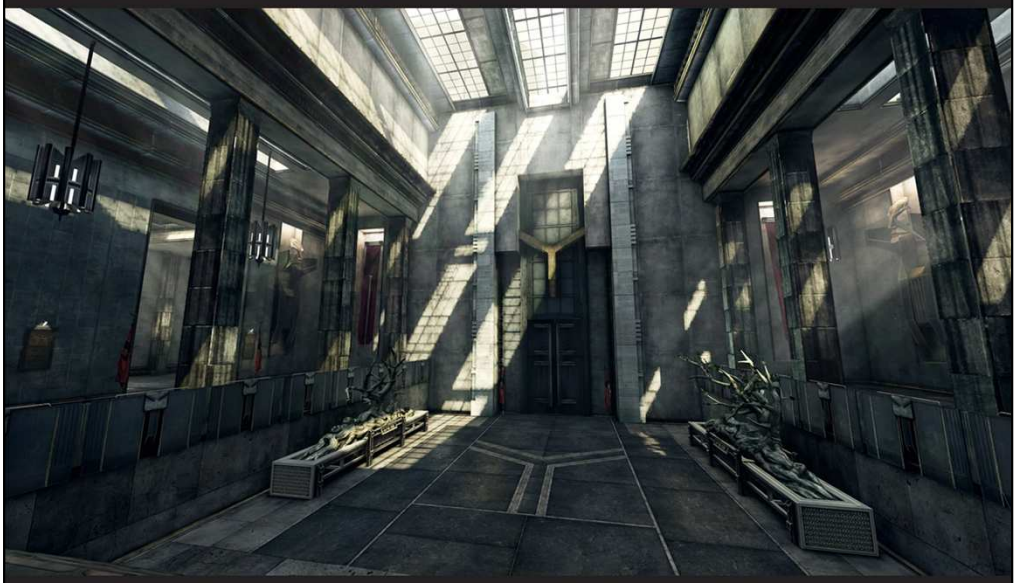
Scope

Badges

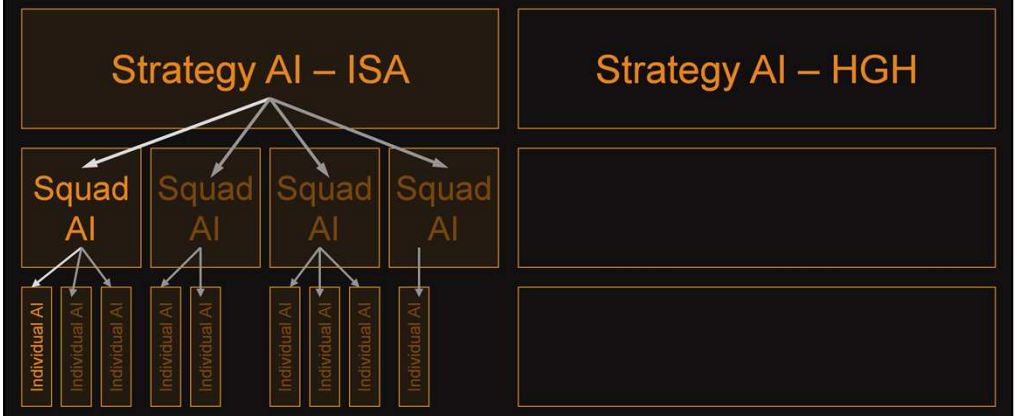
- Scout: Cloak, Spot-and-Mark
- Tactician: Spawn Area, Air Support
- Assault: Boost
- Engineer: Sentry Turret, Repair
- Medic: Heal, Med packs
- Saboteur: Disguise, C4

Scope : movie

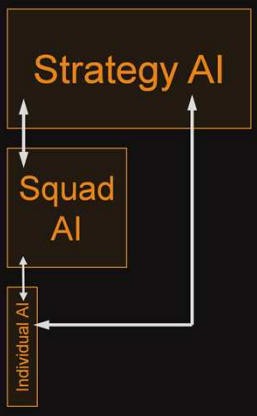
Architecture



Architecture



Architecture



- Strategy to Squad: Orders: Defend, Advance, ...
- Squad to Strategy: Feedback: Order failed

- Squad to Individual: Orders: MoveTo
- Individual to Squad: Combat information

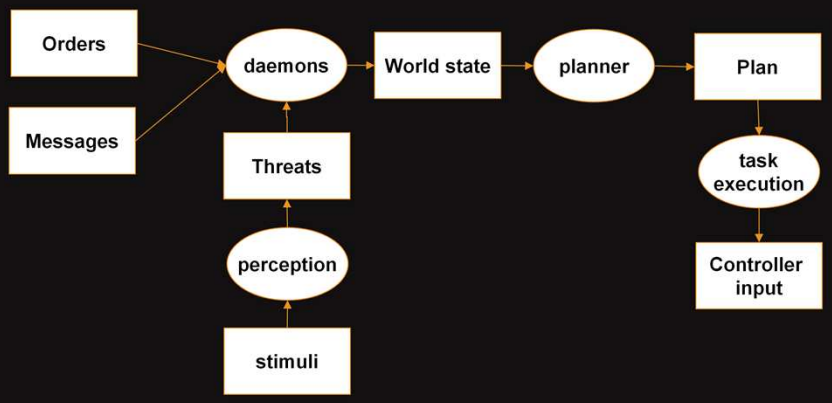
- Strategy to Individual: Orders: Assasination target
- Individual to Strategy: Request reassignment

Individual AI

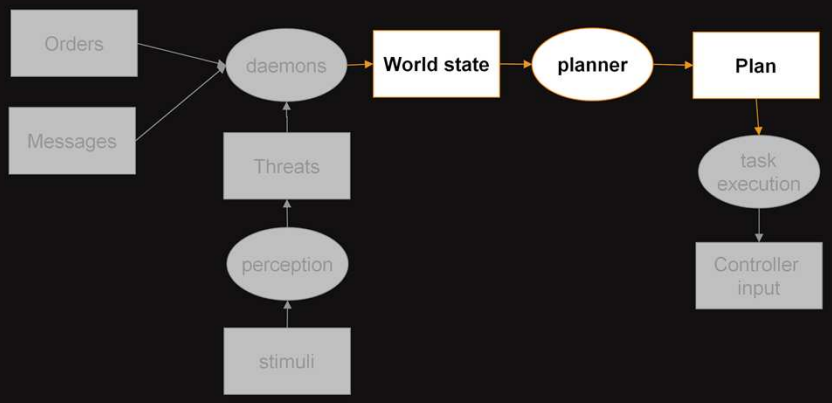
Game AI Conference, Paris, June 2009

KILLZONE™

Individual AI



Individual AI



KILLZONE™

Individual AI : HTN Planner

HTN Planning: Complexity and Expressivity.
K. Erol, J. Hendler and D. Nau.
In Proc. AAAI-94.

- Domain
  - Has Methods 1 … x
    - Each with Branches 1 … y
      - Preconditions
      - Task list

- Task
  - Primitive, or
  - Compound (solve recursively)

Individual AI : HTN Planner

```
(:method (select_weapon_and_attack_as_turret ?inp_threat)
    ( branch_use_bullets   // Only use bullets against humanoids and turrets.
        (and (or (threat ?inp_threat humanoid) (threat ?inp_threat turret) )
            (distance_to_threat ?inp_threat ?threat_distance)
            (call lt ?threat_distance @weapon_bullet_max_range)  )
        ( (attack_as_turret_using_weapon_pref ?inp_threat wp_bullets))
    )
    ( branch_use_rockets // Don't use rockets against humanoids and turrets.
        (and (not (threat ?inp_threat humanoid)) (not (threat ?inp_threat turret))
            (distance_to_threat ?inp_threat ?threat_distance)
            (call lt ?threat_distance @weapon_rocket_max_range) )
        ((attack_as_turret_using_weapon_pref ?inp_threat wp_rockets))
     )
)
```

Individual AI : Plan monitoring

Plan fails when current task fails

Abort current plan preemptively when
- Better plan available
- Current plan no longer feasible

So, we keep planning @5hz, but:
- Prevent twitchy behavior
- Prevent unnecessary checks (optimizations)

- Combine planning and monitoring using **continue branches**
  - Branch with “continue” as only task in plan
  - When encountered during planning, keep current plan.

Individual AI : Plan Monitoring Example

```
(:domain attack_portable_turret
      (:method (attack_as_turret)      // Turret keeps attacking same target as long as possible.
            (   continue_attack_as_turret    // Continue branch
              (active_plan attack_as_turret)
              ( !continue)
            )
            (   branch_attack_as_turret    // Attack an enemy if possible
              ()
              (   (!forget active_plan **)
                (!remember - active_plan attack_as_turret)

                (select_threat_and_attack_as_turret 0)
                (!forget active_plan **) )
            )
      )
....
```


KILLZONE™

Individual AI : Application

- General combat behavior
- Opportunistic badge
  - Medic heal behavior
  - Engineer repair
- Ordered
  - Badge specific interpretation
- Mission specific
  - S&R Carrier
  - S&D Target

Individual AI : Application

KILLZONE™

Individual AI : Application

```
+ branch_mp_behave
  + (do_behave_on_foot_mp)
    + branch_medic_revive
      + (do_medic_revive)
        - branch_medic_revive_abort
        - branch_medic_revive_continue
        + branch_medic_revive
          (!forget active_plan **)
          (!remember - active_plan medic_revive [Soldier:TimmermanV])
          (!log_color magenta "Medic reviving nearby entity.")
          (!broadcast friendlies 30.0 10.0 medic_reviving [Soldier:TimmermanV])
          (!select_target [Soldier:TimmermanV])
          + (walk_to_attack 5416 crouching auto)
          + (wield_weapon_pref wp_online_mp_bot_revive_gun)
            - branch_auto_and_have_active
            - branch_auto_wp_pref
            - branch_dont_switch_weapon
            + branch_switch_weapon
              (#0 = wp_online_mp_bot_revive_gun)
              + (wield_weapon_pref_internal wp_online_mp_bot_revive_gun)
          (!use_item_on_entity [Soldier:TimmermanV] crouching)
          (!forget active_plan **)
```

Individual AI : Application

HTN PLAN (non-interruptible) – [BOT] Tremethick

DECOMPOSITION

TASK LIST
  (!**forget** active_plan **)
  (!**remember** – active_plan medic_revive [Soldier:TimmermanV])
  (!**log_color** magenta *"Medic reviving nearby entity."*)
  (!**broadcast** friendlies 30.0 10.0 medic_reviving [Soldier:TimmermanV])
  (!**select_target** [Soldier:TimmermanV])
  (!**walk_segment** (*2370 2369 2368 2367 2366 2365 … 5416*) standing auto () () ())
A (!**select_weapon** wp_online_mp_bot_revive_gun)
  (!**use_item_on_entity** [Soldier:TimmermanV] crouching)
  (!**forget** active_plan **)

ACTIVE TASK INFO
 AIHTNPrimitiveTaskSelectWeapon –

Individual AI : Random Numbers

Individual bot domain

- 360 methods
- 1048 branches
- 138 behaviors
- 147 continue branches

During multiplayer game (14 bots / max. 10 turrets / max. 6 drones / squads)

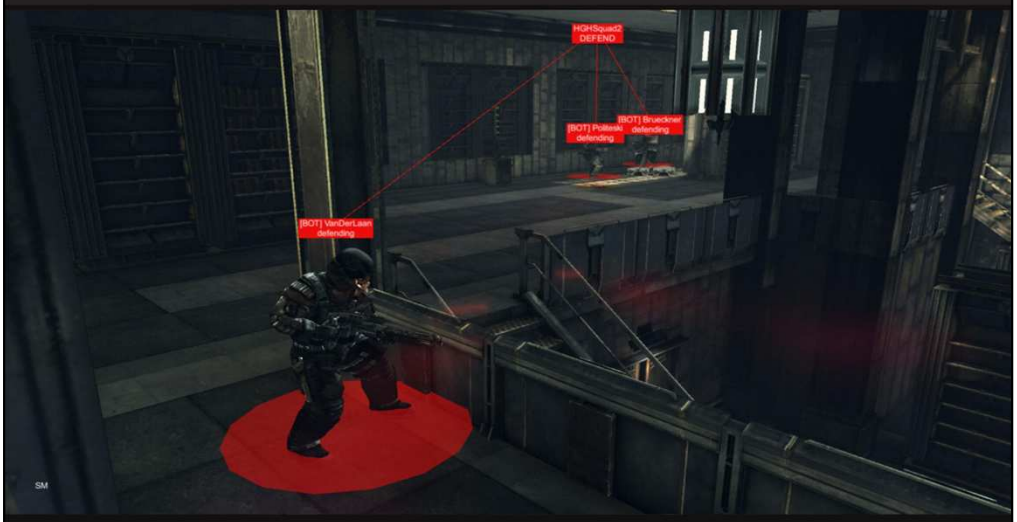
- Approx. 500 plans generated per second
- Approx. 8000 decompositions per second
- Avg. 15 decompositions per planning.
- Approx 24000 branch evaluations per second.

Squad AI

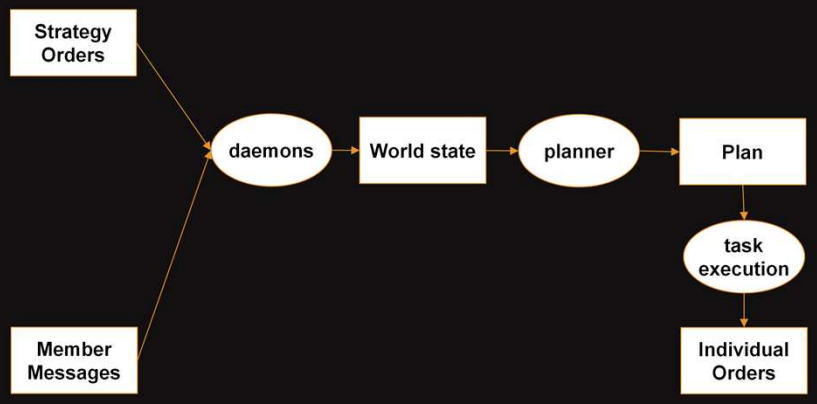
Game AI Conference, Paris, June 2009

KILLZONE™

Squad AI


HGHSquad2
DEFEND
[BOT] Bruecknerdefending
[BOT] Polliesklidefending
[BOT] VanDerLaandefending
SM

Squad AI


Strategy Orders
daemons
World state
planner
Plan
task execution
Individual Orders
Member Messages

Individual AI : Application

HTN STATE - HGHSquad2
(time 871273)
(faction hgh)
(current_level mp_level_05)
(capture_and_hold)
(capture_area_status [CaptureAndHoldArea:CnH_Area3] [AIArea:CnH_Area3] captured)
(capture_area_status [CaptureAndHoldArea:CnH_Area2] [AIArea:CnH_Area2] enemy_controlled)
(capture_area_status [CaptureAndHoldArea:CnH_Area1] [AIArea:CnH_Area1] enemy_controlled)
(have_order 2 2473)
(order 2473 2 defend [AIMarker:Assn_Hide3_Defend2] 0)
(squad_status defend ready 424.166016)
(nr_of_members 3)
(player_count 3)
(member_status [Soldier:[BOT] Brueckner] defending 2473)
(member_status [Soldier:[BOT] Politeski] defending 2473)
(member_status [Soldier:[BOT] VanDerLaan] defending 2473)
(area_of_member [Soldier:[BOT] Politeski] [AIArea:CnH_Area3])
(area_of_member [Soldier:[BOT] Brueckner] [AIArea:CnH_Area3])
(area_of_member [Soldier:[BOT] VanDerLaan] [AIArea:CnH_Area3])
(squad_member 2 [Soldier:[BOT] Politeski])
(squad_member 1 [Soldier:[BOT] Brueckner])
(squad_member 0 [Soldier:[BOT] VanDerLaan])

Squad AI

```
(:method (order_member_defend ?inp_member ?inp_id ?inp_level ?inp_marker ?inp_context_hint)
   …
   (branch_advance
      ()
      (     (!forget member_status ?inp_member **)
            (!remember - member_status ?inp_member ordered_to_defend ?inp_id)
            (!start_command_sequence ?inp_member ?inp_level 1)
             (do_announce_destination_waypoint_to_member ?inp_member)
             (!order ?inp_member clear_area_filter)
             (!order ?inp_member
                  set_area_restrictions (call find_areas_to_wp ?inp_member (call get_entity_wp ?inp_marker)))
             (!order_custom ?inp_member move_to_defend ?inp_marker ?inp_context_hint)
             (!order_custom ?inp_member send_member_message_custom completed_defend ?inp_id)
             (order_set_defend_area_restriction ?inp_member (call get_entity_area ?inp_marker))
             (!order_custom ?inp_member defend_marker ?inp_marker ?inp_context_hint)
            (!end_command_sequence ?inp_member)
      )
   )
)
```


Squad & Bot Management

Challenges

Must support 1-14 potential bots per-side.
A fixed policy just won't work...

Inspiration

Building a Better Battle: The Halo 3 AI Objectives System
Damian Isla
Game Developers Conference, 2008.

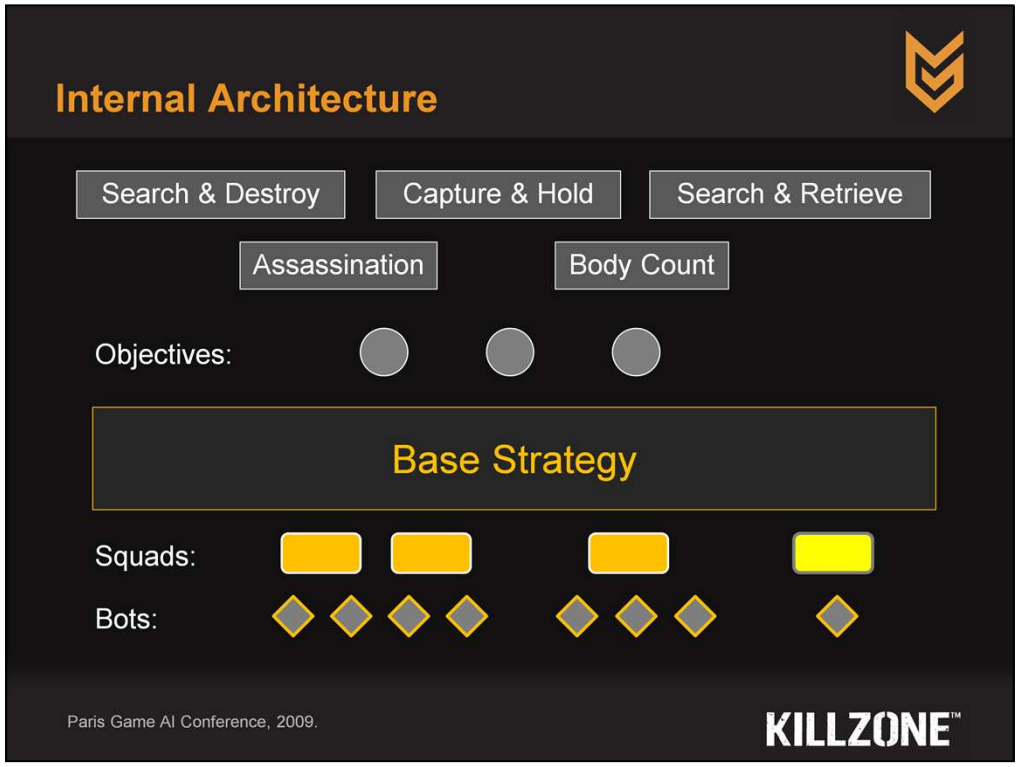
disposable enemies	persistent bots
level specific use	applied generally
for designers	for programmers
mostly declarative	mostly procedural
story-driven	strategic

Paris Game AI Conference, 2009.

KILLZONE™

Principles

The strategy is built with a goal-driven approach by separating ‘what’ to do and ‘how’ to do it.

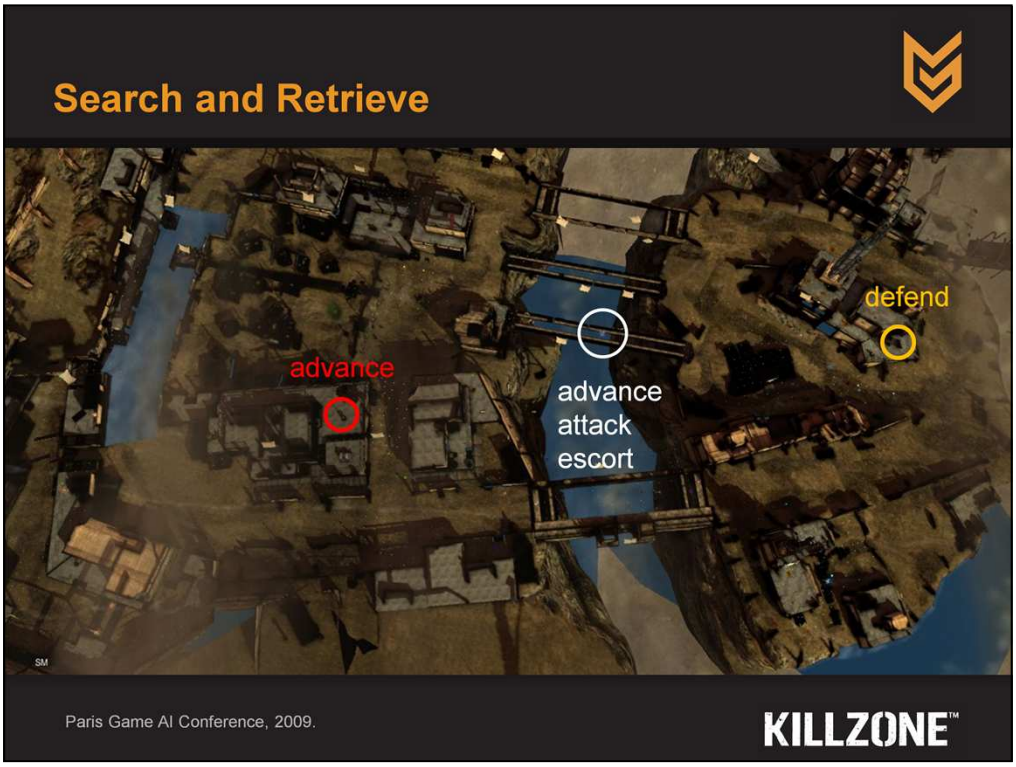

Internal Architecture
Search & Destroy
Capture & Hold
Search & Retrieve
Assassination
Body Count
Objectives:
Base Strategy
Squads:
Bots:
Paris Game AI Conference, 2009.
KILLZONE™

AI Objectives

	Static	Dynamic
Offensive	AdvanceWaypoint	AttackEntity
Defensive	DefendMarker	EscortEntity

Paris Game AI Conference, 2009.

KILLZONE™



Defend Marker near home base (weight 1.0)

Advance Waypoint to enemy base (weight 1.0)

Attack Entity or Escort Entity on carrier (weight 2.0)

Sub-Objectives

Objectives must also scale up and down with the number of bots.
Need rich and detailed information for each objective.
Provides more diverse behaviors when there are few bots!

For example:

- Multiple specific defend locations, e.g. entry points.
- Different approach routes, e.g. for flanking.

Search & Destroy: Defending (1)

Search & Destroy: Defending (2)

Paris Game AI Conference, 2009.

KILLZONE™

Search & Destroy: Defending (3)

Paris Game AI Conference, 2009.

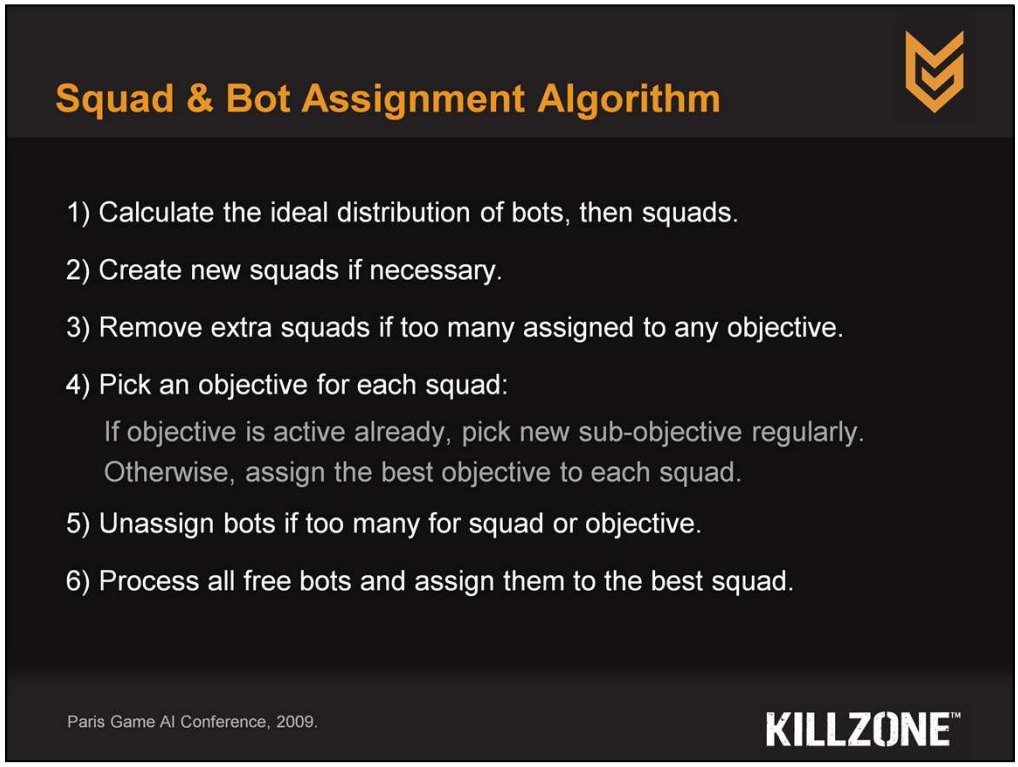
KILLZONE™

Assignments

Achieving Objectives

Paris Game AI Conference, 2009.

KILLZONE™



Squads created to fulfill objectives / sub-objectives.

- There are always objectives, even just regroup.

Squads created based on bots available, with desired bot count:

- Try to respect Desired/Min/Max squad size.
- Keep the squads balanced.

Squads are assigned based on proximity to the target objective.

After objective, squads persist and bots revert to autonomous behavior.

Squad & Bot Assignment Heuristics

a. Assign bots to squads
   - Based on distance to squad center, or objective.
   - Preference to other bots.

b. Assign squads to objectives
   - First come, first served!

c. Bot badge selection
   - Global policy, chosen by design.

KILLZONE™

For every area we control; generate an DefendMarker objective

For as many areas as we still want to capture (based on current score, heuristic):

Choose the best targets based on current assignments, nearby friendlies, own spawnpoints.

If troops left, assign attack objectives to less desired areas. (lone scout approach)

Combine manual annotations with

Add many annotations and filter them out at runtime.

Manual Level Annotations

"Create the information by hand first, then automate it later if necessary."

Fixed number of levels,
Not overly big by design,
Low overhead for annotations.

Paris Game AI Conference, 2009.

KILLZONE™

Regroup Locations

Paris Game AI Conference, 2009.

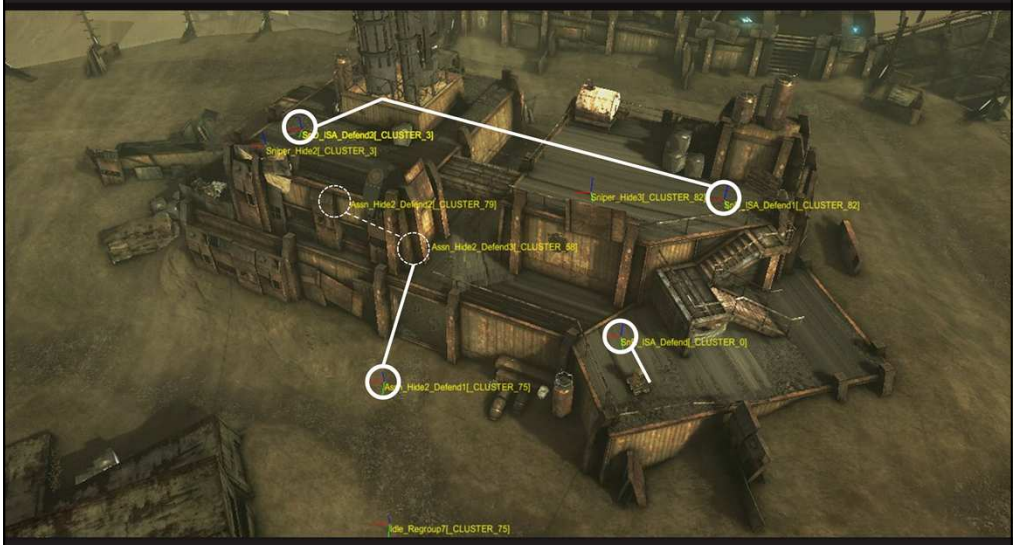
KILLZONE™

Sniping Locations

Paris Game AI Conference, 2009.

KILLZONE™

Mission Specific Defense



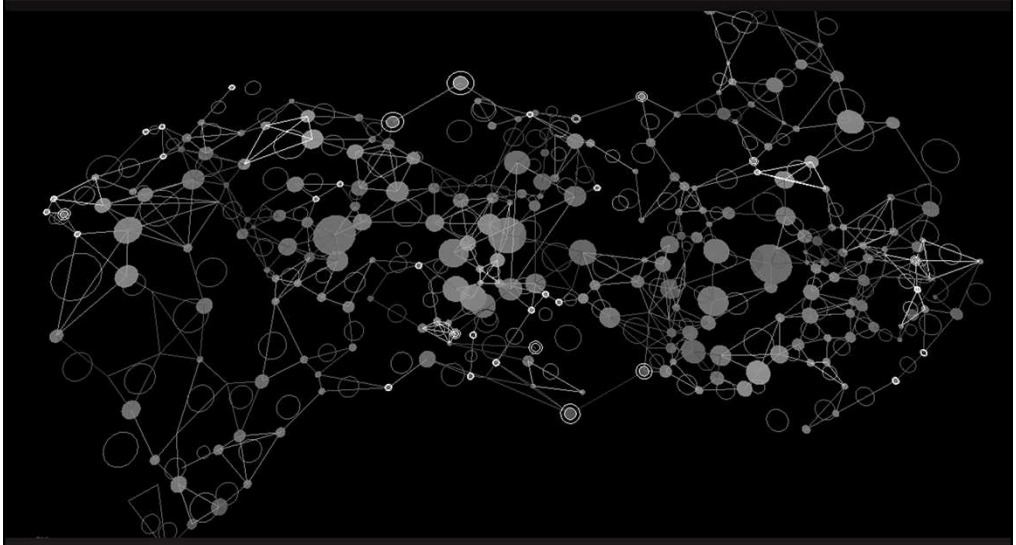
Paris Game AI Conference, 2009.

KILLZONE™

Automatic Level Processing

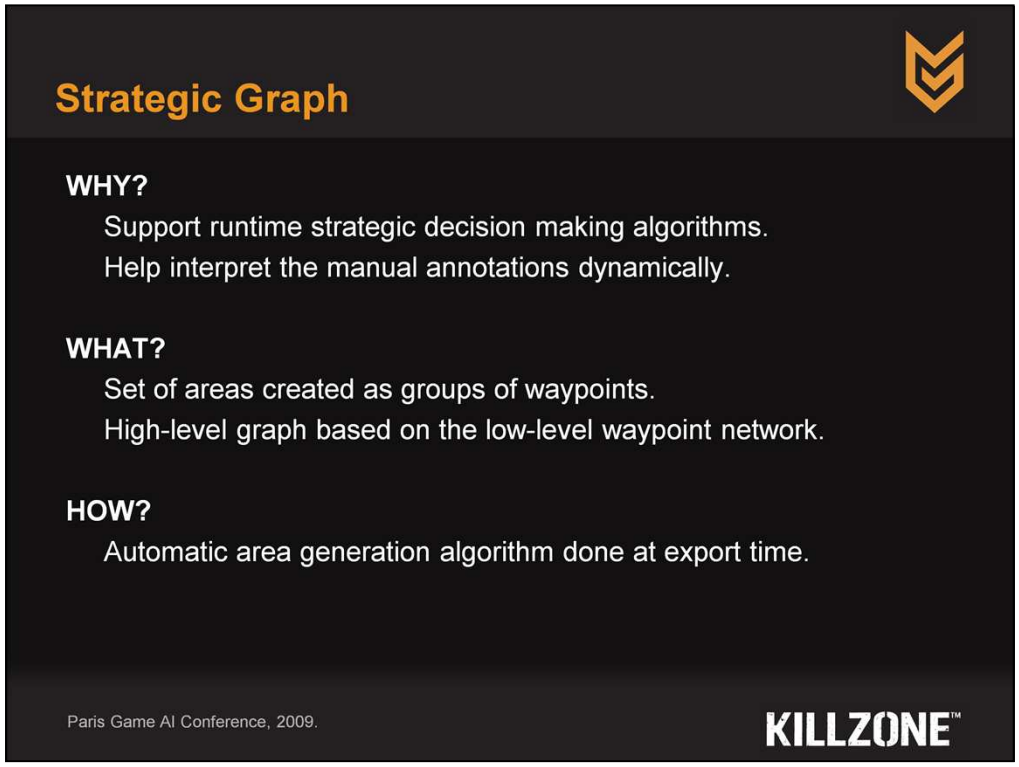
Because it's awesome.™

Strategic Graph

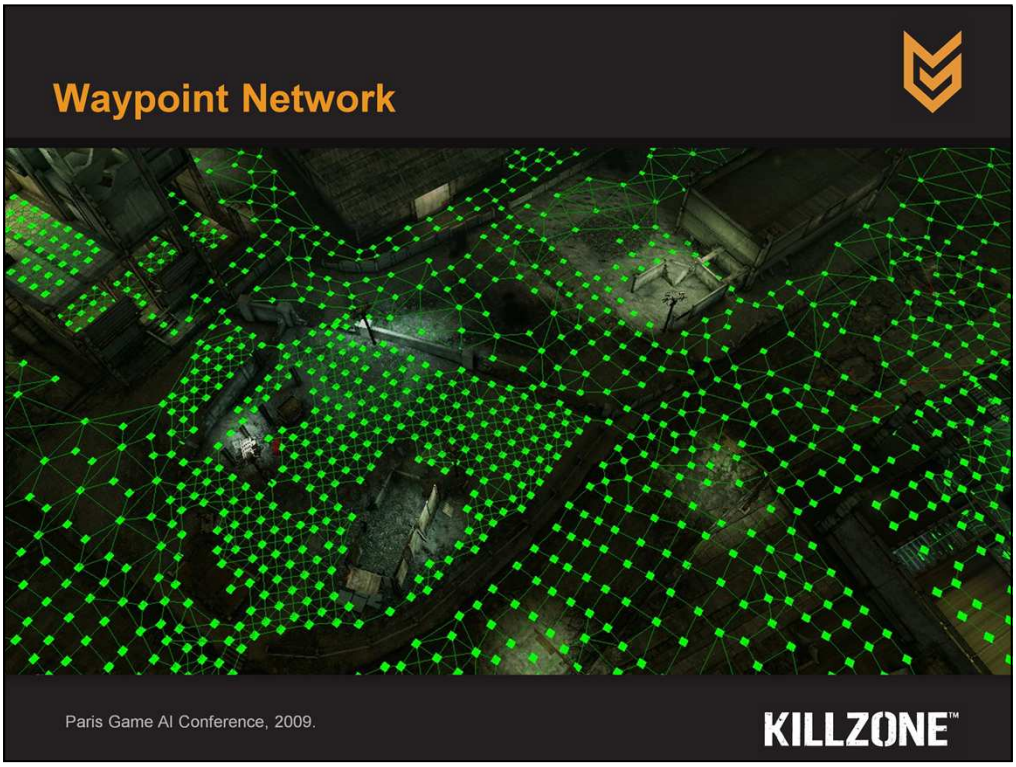


Paris Game AI Conference, 2009.

KILLZONE™



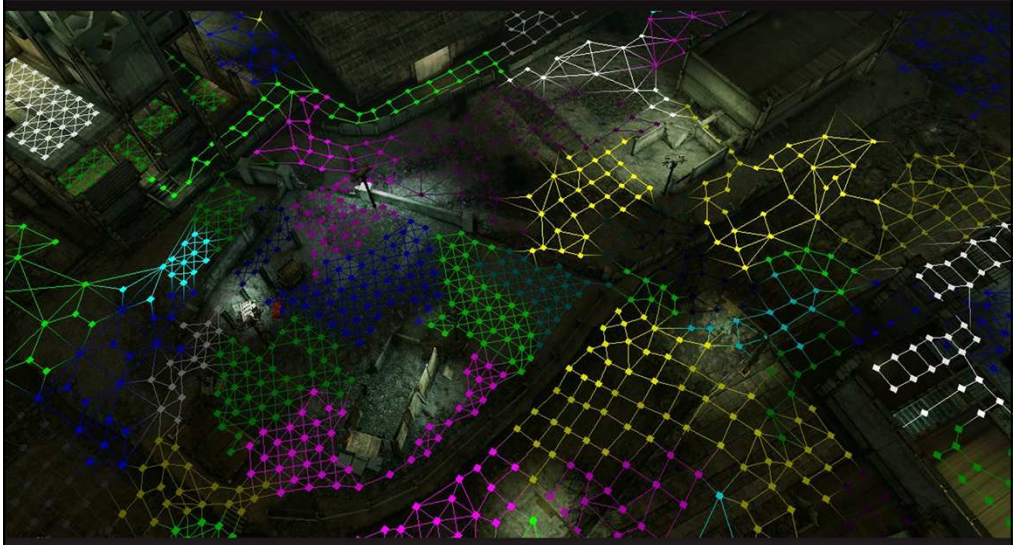
Not done dynamically however, assumes dynamic obstacles don't impact connectivity.



Goal is to create areas useful for tactical reasoning during the game.

Calculated based on what's feasible at runtime.

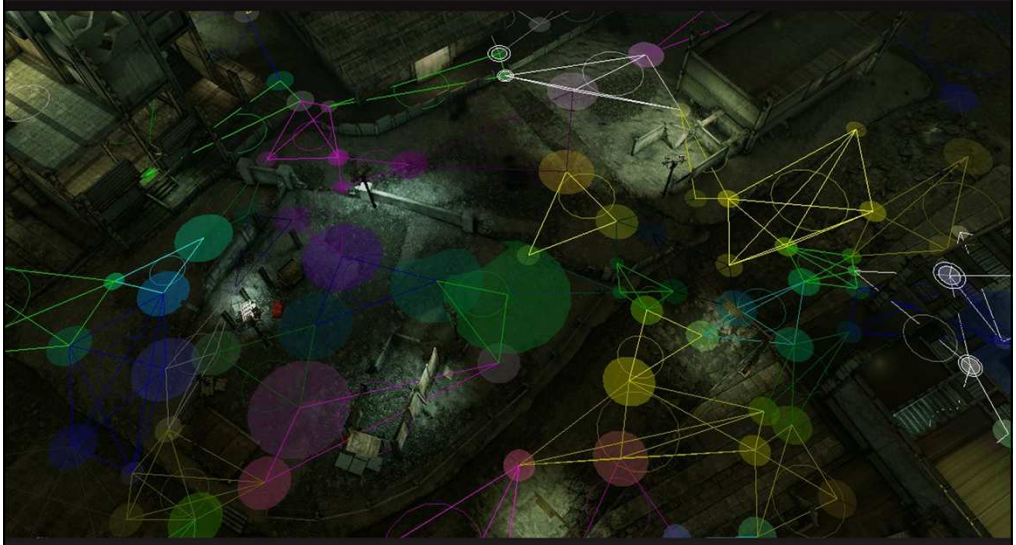
Waypoint Areas



Paris Game AI Conference, 2009.

KILLZONE™

Strategic Graph



Paris Game AI Conference, 2009.

KILLZONE™

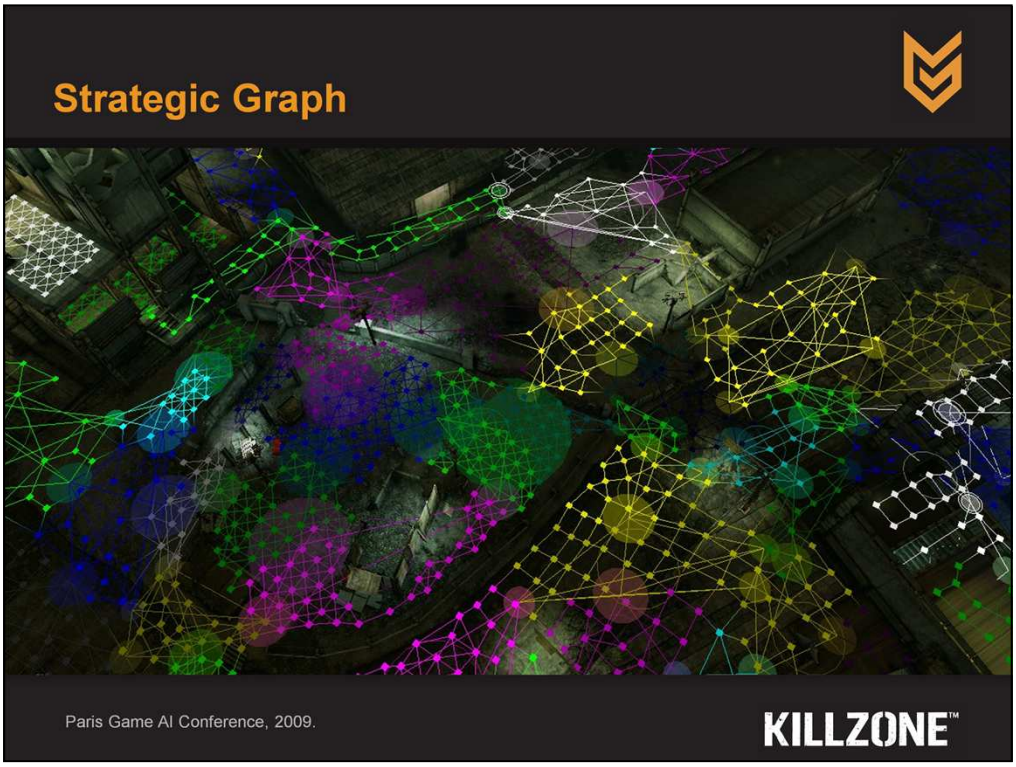
Area Clustering

Algorithm:

1) Start with one waypoint per area.
2) Find the best possible areas to merge.
3) Repeat until target area count reached.

Heuristic:

Area size and waypoint count (squared).
Inter-area links between waypoints.
High-level graph quality, minimize connections.



Good quality areas without line of sight checks or pathfinding.

Try this at home!

Strategic Graph

Runtime Information

Influence Mapping

WHY?

Dynamic information overlaid onto the graph.

Used for many decisions: where to hide / regroup / defend.

WHAT?

Areas store positive / negative influence based on faction “controls”.

Compromise of stable strategic information and up-to-date.

HOW?

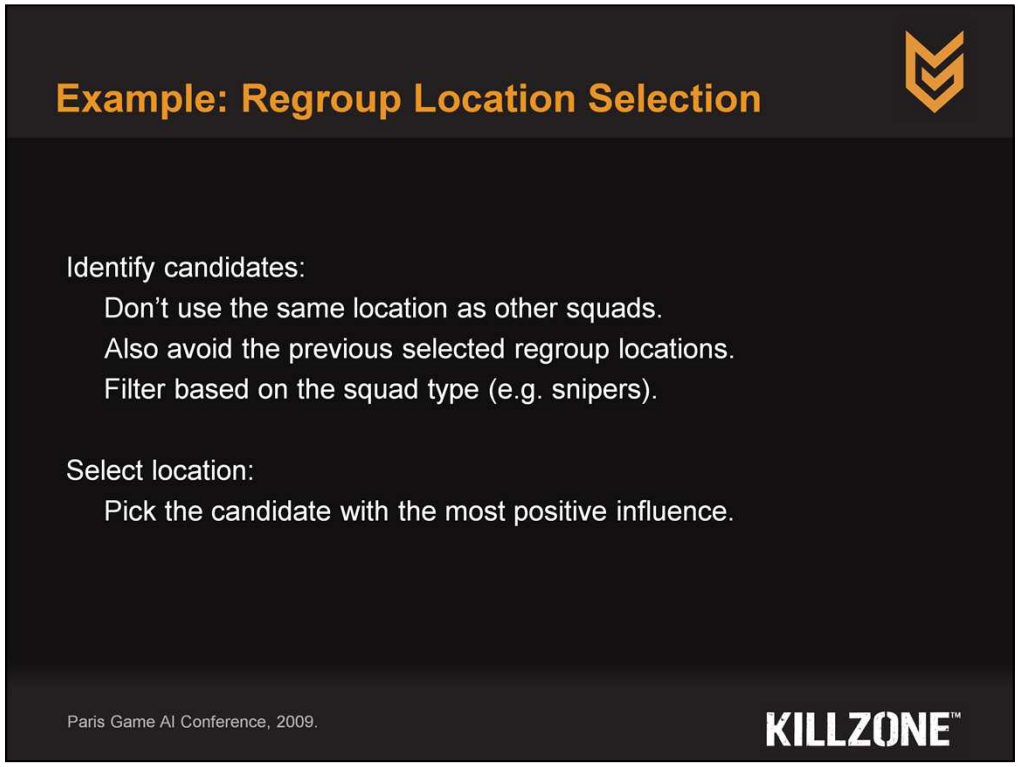
Calculated based on all bots, turrets, and deaths.

Values are smoothed in the graph, new values weighted in.

Influence Map

Paris Game AI Conference, 2009.

KILLZONE™



Taboo search with weighted selection.

Assassination: Defenders

Paris Game AI Conference, 2009.

KILLZONE™

Assassination: Attack Wave 1

Paris Game AI Conference, 2009.

KILLZONE™

Assassination: Attack Wave 2

Paris Game AI Conference, 2009.

KILLZONE™

Strategic Pathfinding

WHY?

Help make medium-term strategic decisions in space.

Take into account the strategic graph and influence map.

WHAT?

A single-source pathfinder that calculates distances to a point.

A cache of the distance and spanning tree, used for path lookup.

HOW?

Each squad has its own pathfinder, based around its assignment.

Individual pathfinder finds waypoint path within selected areas.

Area cost calculated from influence map:

- Safe areas given almost free cost.
- Risky areas exponentially worse.

Pathfinder updated as costs change: take the worst case scenario into account.

Strategic Pathfinder

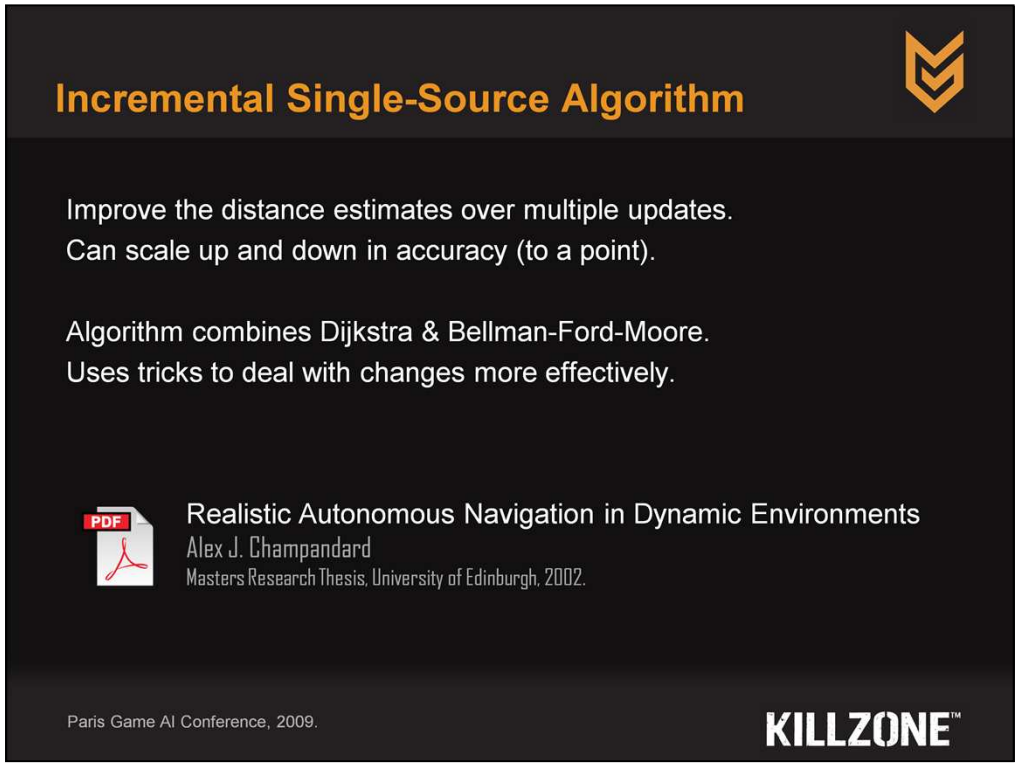
Paris Game AI Conference, 2009.

KILLZONE™

Strategic Pathfinder

Paris Game AI Conference, 2009.

KILLZONE™



Updates estimates iteratively and greedily.

Deals with rebasing the origin and changing the source.

Most accurate near the source, ideal in this case.

Once converged, can update estimates incrementally.

Can adjust the amount of work done each update, trading off quality for speed.

Example: Squad Corridors

Each squad has cost based on previous squads shortest path.

Other squad corridors are not as cheap (neutral cost).

Squads actively pick paths to avoid other squads.

Squad Corridors: Squad 1

Paris Game AI Conference, 2009.

KILLZONE™

Squad Corridors: Squad 2

Paris Game AI Conference, 2009.

KILLZONE™

Squad Corridors: Squad 2

Paris Game AI Conference, 2009.

KILLZONE™

Squad Corridors: Squad 1

Paris Game AI Conference, 2009.

KILLZONE™

Squad Corridors: Sniper Squad

Paris Game AI Conference, 2009.

KILLZONE™

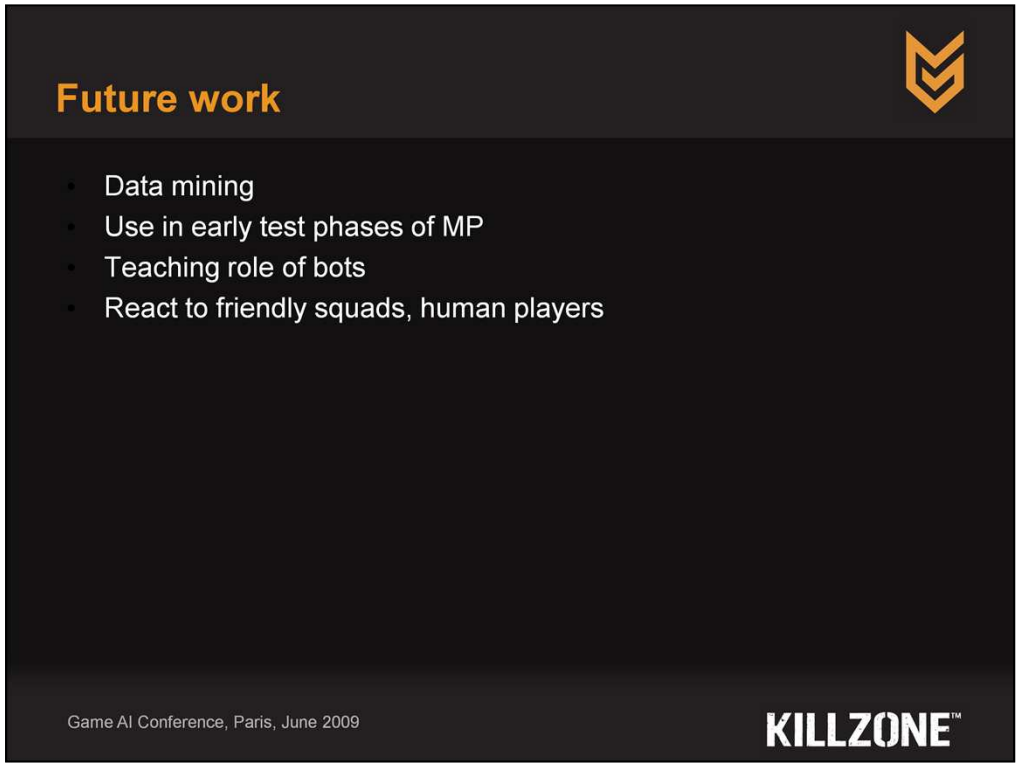
Squad Corridors: Sniper Squad

Paris Game AI Conference, 2009.

KILLZONE™

Take Away

Strategy is more than the sum of its parts.



Future work / discussion

Squad now almost makes no decision.

Specific context commands. Communication through hierarchy proper.

Remove cheat (ammo).

Adaptive badge selection and badge combos

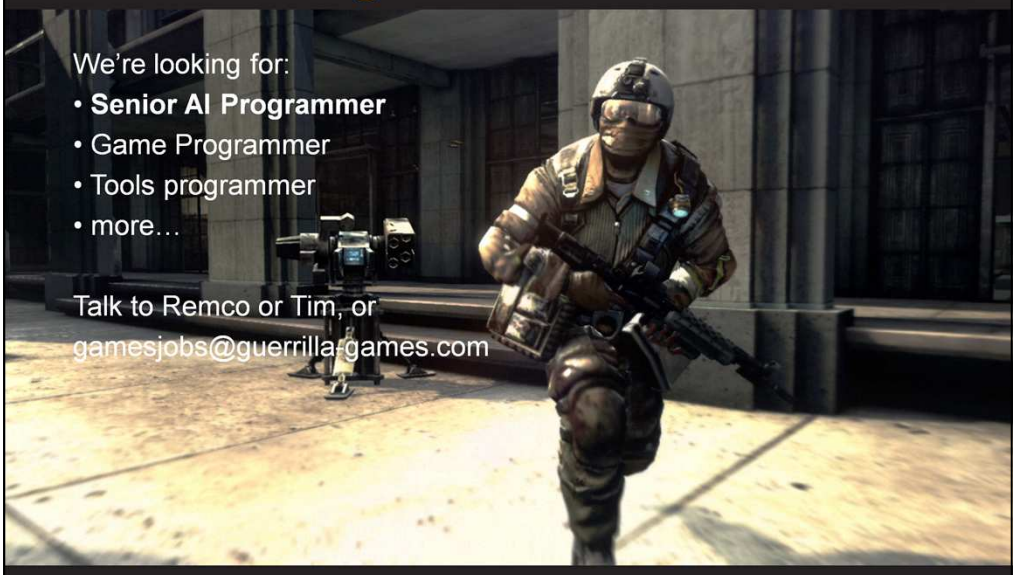
Use online game states to discover sniper positions and other data mining opportunities during development and after deployment.

Integrate game squads / AI squads

Chatter

RTS AI and FPS AI getting closer from different sides. Future use of techniques.

Guerrilla is hiring!



Game AI Conference, Paris, June 2009

KILLZONE™