Killzone 2 Multiplayer Bots

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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)
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

Support
• Assault: Boost
• Engineer: Sentry Turret, Repair
• Medic: Heal, Med packs
• Saboteur: Disguise, C4
Scope: movie
Architecture

Strategy AI – ISA

- Squad AI
  - Individual AI
  - Individual AI
  - Individual AI

Strategy AI – HGH

- Squad AI
  - Individual AI
  - Individual AI
  - Individual AI
  - Individual AI
  - Individual AI
  - Individual AI
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
Individual AI

- Orders
- Messages
- daemons
- World state
- planner
- Plan
- Threats
- perception
- stimuli
- task execution
- Controller input
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)
(: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)))
)
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.
(: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 **) )
     )
   )
   ....
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
+ 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
Squad AI

- Strategy Orders
- Member Messages
- daemons
- World state
- planner
- Plan
  - task execution
  - Individual Orders
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])
...
(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.

<table>
<thead>
<tr>
<th>disposable enemies</th>
<th>persistent bots</th>
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</thead>
<tbody>
<tr>
<td>level specific use</td>
<td>applied generally</td>
</tr>
<tr>
<td>for designers</td>
<td>for programmers</td>
</tr>
<tr>
<td>mostly declarative</td>
<td>mostly procedural</td>
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<tr>
<td>story-driven</td>
<td>strategic</td>
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</tbody>
</table>
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:
AI Objectives

Static

Offensive

Defensive

Dynamic

AdvanceWaypoint

DefendMarker

AttackEntity

EscortEntity
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)
Search & Destroy: Defending (3)

Assignments

Achieving Objectives
1) Calculate the ideal distribution of bots, then squads.

2) Create new squads if necessary.

3) Remove extra squads if too many assigned to any objective.

4) Pick an objective for each squad:
   - If objective is active already, pick new sub-objective regularly.
   - Otherwise, assign the best objective to each squad.

5) Unassign bots if too many for squad or objective.

6) Process all free bots and assign them to the best squad.
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.
Capture and Hold

defend

advance

advance
Strategic Reasoning
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.
Regroup Locations
Sniping Locations
Mission Specific Defense
Automatic Level Processing

Because it’s awesome.™
Strategic Graph

Strategic Graph

WHY?
Support runtime strategic decision making algorithms.
Help interpret the manual annotations dynamically.

WHAT?
Set of areas created as groups of waypoints.
High-level graph based on the low-level waypoint network.

HOW?
Automatic area generation algorithm done at export time.
Waypoint Network
Waypoint Areas
Strategic Graph
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.
Strategic Graph

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

Example: Regroup Location Selection

Identify candidates:
- Don’t use the same location as other squads.
- Also avoid the previous selected regroup locations.
- Filter based on the squad type (e.g. snipers).

Select location:
- Pick the candidate with the most positive influence.
Assassination: Attack Wave 1
Assassination: Attack Wave 2
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.
Strategic Pathfinding Costs
Strategic Pathfinder

Strategic Pathfinder
Incremental Single-Source Algorithm

Improve the distance estimates over multiple updates. Can scale up and down in accuracy (to a point).

Algorithm combines Dijkstra & Bellman-Ford-Moore. Uses tricks to deal with changes more effectively.

Realistic Autonomous Navigation in Dynamic Environments
Alex J. Champanand
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 2
Squad Corridors: Squad 1
Squad Corridors: Sniper Squad
Squad Corridors: Sniper Squad
Take Away

Strategy is more than the sum of its parts.
Future work

- Data mining
- Use in early test phases of MP
- Teaching role of bots
- React to friendly squads, human players
Guerrilla is hiring!

We’re looking for:

- **Senior AI Programmer**
- **Game Programmer**
- **Tools programmer**
- more...

Talk to Remco or Tim, or
gamesjobs@guerrilla-games.com