

3 States and a Plan: The AI of F.E.A.R.



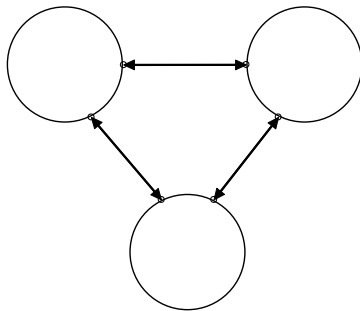
Jeff Orkin
Monolith Productions/
MIT Media Lab

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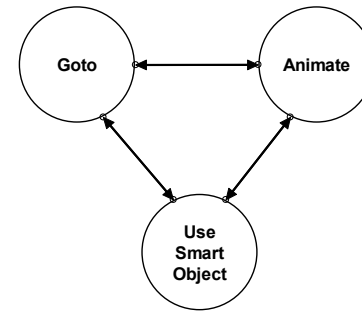
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FSM: 3 States



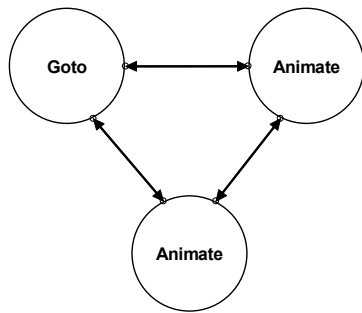
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FSM: 3 States

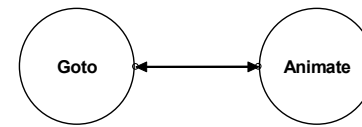


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FSM: 3 States



FSM: 2 States!



FSM: Transition Logic

```
void StateAttack::Update()  
{  
    //...  
    if( Ammo == 0 )  
    {  
        pState = Reload(bCrouch);  
        return;  
    }  
    //...  
}
```

Shogo, 1998



No One Lives Forever, 2000



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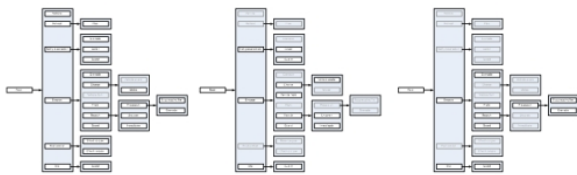
F.E.A.R., 2005



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Halo 2, 2004

Allowable behaviors for infantry, drivers, and passengers



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FSM vs Planning

FSM
- How

Planning
- What

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FSM vs Planning

FSM

- How
- Procedural

Planning

- What
- Declarative

Motivation



Here's the Plan:

- STRIPS Planning Overview
- Planning in F.E.A.R.
- ~~Differences from STRIPS~~
- ~~Squad Behaviors & Communication~~
- Beyond F.E.A.R.

What is Planning?

- Planning is a formalized process of searching for sequence of actions to satisfy a goal.
- Process is called "Plan Formulation."

STRIPS Planning



...in a nutshell

STRIPS Planning

STRIPS =
STanford **R**esearch **I**nstitute
Problem **S**olver

STRIPS Planning

- STRIPS Goal:
Desired state of the world to reach.
- STRIPS Actions:
 - Preconditions
 - Effects

States



States: FSM



Attack



Search

States: Planning

Represented as a logical sentence:

$$\text{AtLocation(Home)} \wedge \text{Wearing(Tie)}$$

Represented as a vector:

$$(\text{AtLocation}, \text{Wearing}) = (\text{Home}, \text{Tie})$$



States: Planning

Example: Lemonade Stand

$$(\text{weather}, \#\text{lemons}, \$\$) =$$

$$(\text{☀️}, \text{🍋}, \text{🌳}) \text{ or}$$

$$(\text{☁️}, \text{🍋}, \text{💰})$$

Desired (Goal, Final) State

Example: Lemonade Stand

$$(\text{weather}, \#\text{lemons}, \$\$) =$$

$$(\text{--}, \text{--}, \text{💰})$$

[slide added by C. Rich]

STRIPS Planning Example



STRIPS Planning Example



STRIPS Planning Example



STRIPS Planning Example



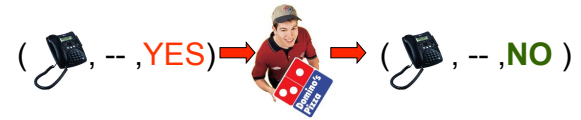
STRIPS Planning Example



STRIPS Planning Example

State: (phone#, recipe, hungry?)

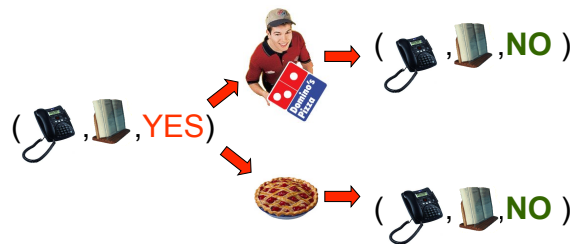
Goal: (-- , -- , **NO**)



STRIPS Planning Example

State: (phone#, recipe, hungry?)

Goal: (-- , -- , **NO**)



STRIPS Planning Example




STRIPS Planning Example

State: (phone#, recipe, hungry?)



Action

Preconditions: ( , -- , --)

Effects:

Delete List: Hungry(**YES**)

Add List: Hungry(**NO**)

STRIPS Planning Example



STRIPS Planning Example



STRIPS Planning Example



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STRIPS Planning Example

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Design Philosophy

Designer's job is:
Create environments that allow AI to showcase their behaviors.

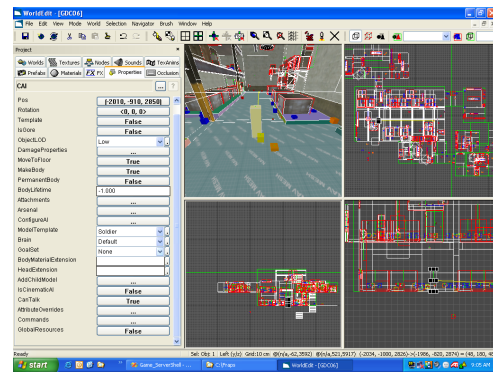
Designer's job is NOT:
Script behavior of individual AI.

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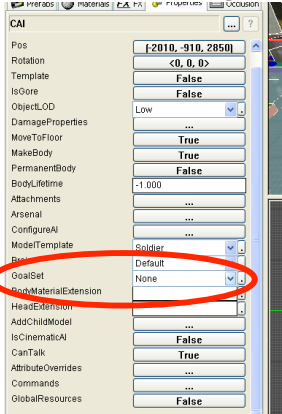
Planning Video #1



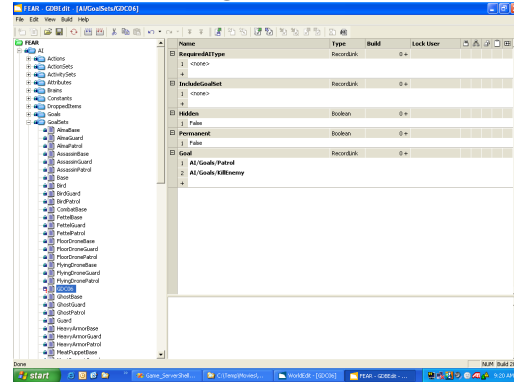
Planning Video #1



Planning Video #1



Planning Video #1



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Planning Video #1

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Planning Video #1

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Planning Video #2

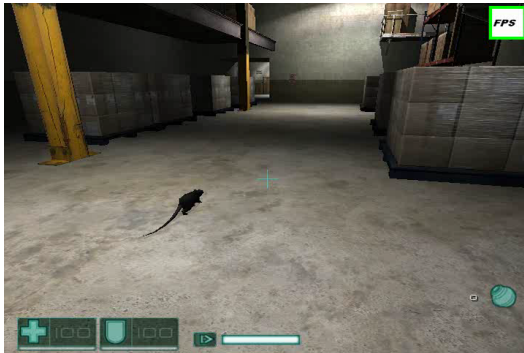
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Planning Video #3

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Planning Video #4



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Planning Video #4

Soldier	Assassin	Rat
1 AI/Actions/Attack	1 AI/Actions/Attack	1 AI/Actions/Animate
2 AI/Actions/AttackCrouch	2 AI/Actions/InspectDisturbance	2 AI/Actions/Idle
3 AI/Actions/SuppressionFire	3 AI/Actions/LookAtDisturbance	3 AI/Actions/GoToNode
4 AI/Actions/SuppressionFireFromCover	4 AI/Actions/SurveyArea	4 AI/Actions/UseSmartObjectNode
5 AI/Actions/FlushOutWithGrenade	5 AI/Actions/AttackMeleeUnlocked	
6 AI/Actions/AttackFromCover	6 AI/Actions/TraverseBlockedDoor	
7 AI/Actions/BlindFireFromCover	7 AI/Actions/UseSmartObjectNodeBounced	
8 AI/Actions/AttackGrenadeFromCover	8 AI/Actions/MountNodeUnlocked	
9 AI/Actions/AttackFromView	9 AI/Actions/DismountNodeUnlocked	
10 AI/Actions/DrawWeapon	10 AI/Actions/TraverseLinkUnlocked	
11 AI/Actions/HolsterWeapon	11 AI/Actions/AttackFromAmbush	
12 AI/Actions/ReloadCrouch	12 AI/Actions/DodgeRollParanoid	
13 AI/Actions/ReloadCovered	13 AI/Actions/AttackLungeUnlocked	
14 AI/Actions/InspectDisturbance	14 AI/Actions/LopeToTargetUnlocked	
15 AI/Actions/LookAtDisturbance		
16 AI/Actions/SurveyArea		
17 AI/Actions/DodgeRoll		
18 AI/Actions/DodgeShuffle		
19 AI/Actions/DodgeCovered		
20 AI/Actions/Uncover		
21 AI/Actions/AttackMelee		

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Benefits of Planning

1. Decoupling Goals & Actions
2. Layering Behaviors
3. Dynamic Problem Solving

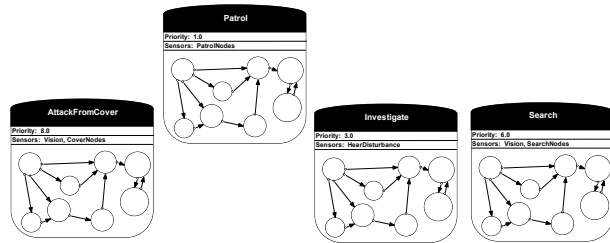
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Decoupling Goals & Actions



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Decoupling Goals & Actions



Decoupling Goals & Actions



Decoupling Goals & Actions



Benefits of Planning

1. Decoupling Goals & Actions
2. Layering Behaviors
3. Dynamic Problem Solving

Layering Behaviors



Layering Behaviors

Goal	
1	AI/Goals/Guard
2	AI/Goals/KillEnemy
+	

Action	
1	AI/Actions/Idle
2	AI/Actions/Attack
+	



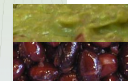
Layering Behaviors



Layering Behaviors

Goal	
1	AI/Goals/Guard
2	AI/Goals/KillEnemy
3	AI/Goals/Dodge
+	

Action	
1	AI/Actions/Idle
2	AI/Actions/Attack
3	AI/Actions/DodgeShuffle
4	AI/Actions/DodgeRoll
+	

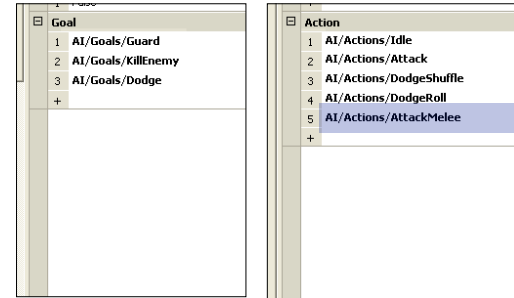


Layering Behaviors



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Layering Behaviors



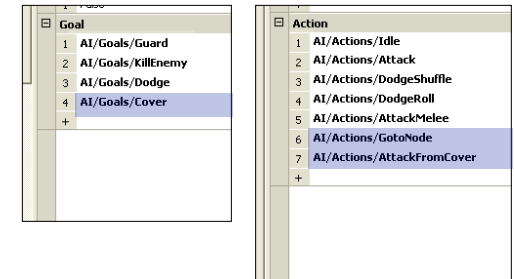
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Layering Behaviors



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Layering Behaviors



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Layering Behaviors



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Layering Behaviors

Goal	Action
1 AI/Goals/Guard	1 AI/Actions/Idle
2 AI/Goals/KillEnemy	2 AI/Actions/Attack
3 AI/Goals/Dodge	3 AI/Actions/DodgeShuffle
4 AI/Goals/Cover	4 AI/Actions/DodgeRoll
	5 AI/Actions/AttackMelee
	6 AI/Actions/GotoNode
	7 AI/Actions/AttackFromCover
	8 AI/Actions/DodgeCovered

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Layering Behaviors



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Layering Behaviors

Goal	Action
1 AI/Goals/Guard	1 AI/Actions/Idle
2 AI/Goals/KillEnemy	2 AI/Actions/Attack
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	5 AI/Actions/AttackMelee
	6 AI/Actions/GotoNode
	7 AI/Actions/AttackFromCover
	8 AI/Actions/DodgeCovered
	9 AI/Actions/BlindFireFromCover

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Layering Behaviors



Layering Behaviors

Goal	Action
1 AI/Goals/Guard	1 AI/Actions/Idle
2 AI/Goals/KillEnemy	2 AI/Actions/Attack
3 AI/Goals/Dodge	3 AI/Actions/DodgeShuffle
4 AI/Goals/Cover	4 AI/Actions/DodgeRoll
5 AI/Goals/Ambush	5 AI/Actions/AttackMelee
	6 AI/Actions/GotoNode
	7 AI/Actions/AttackFromCover
	8 AI/Actions/DodgeCovered
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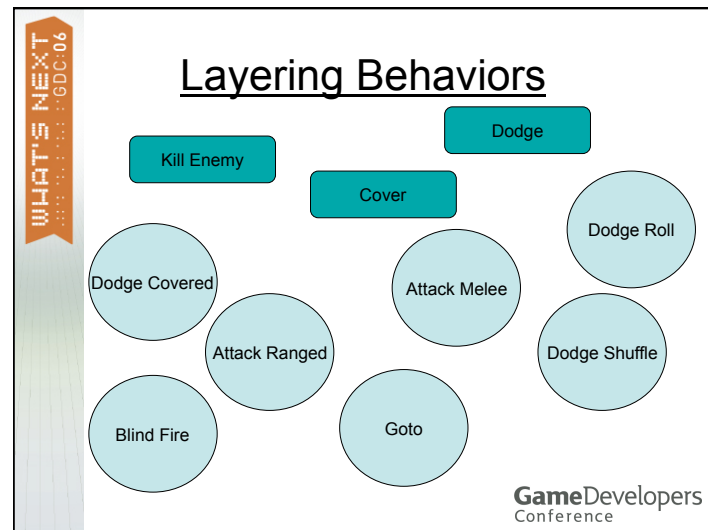
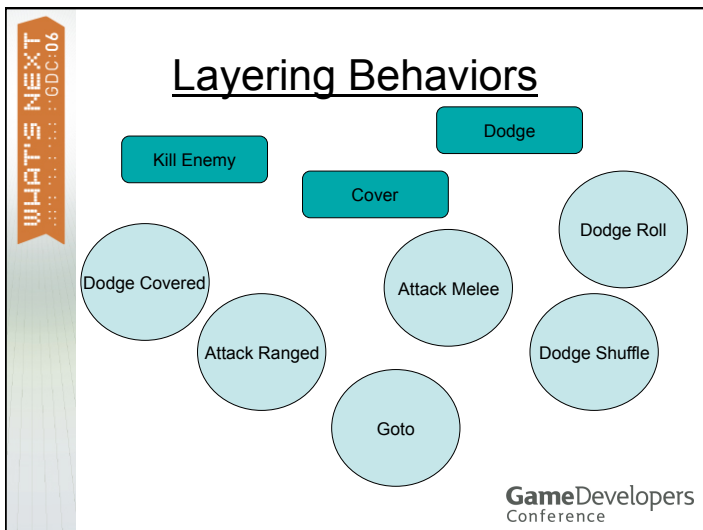
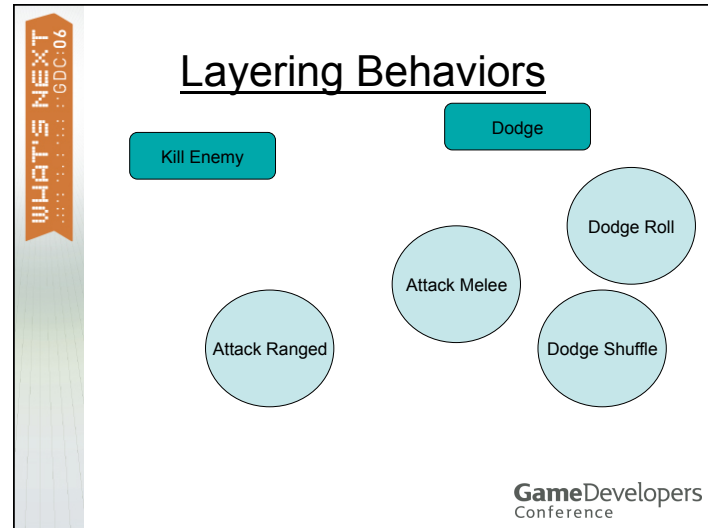
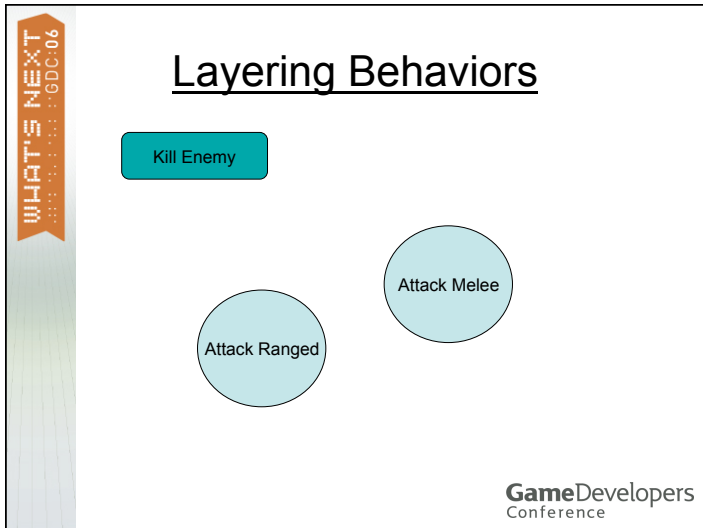
Layering Behaviors

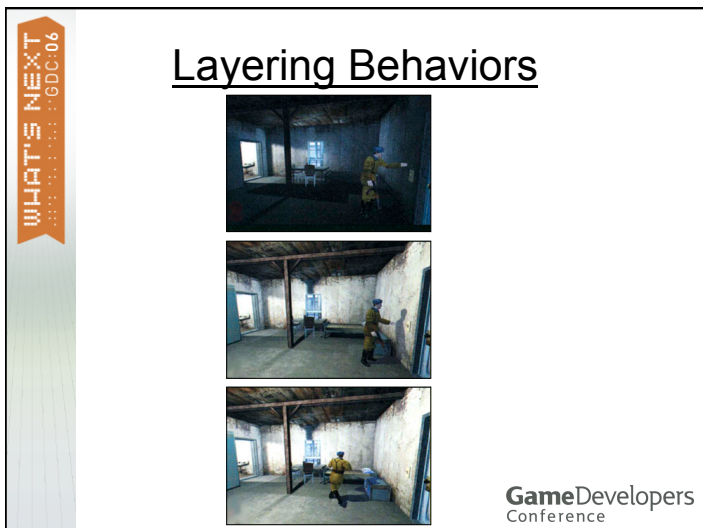
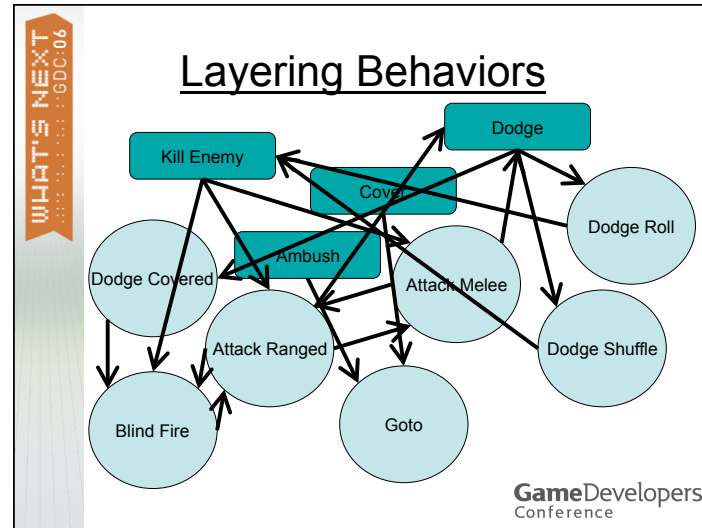
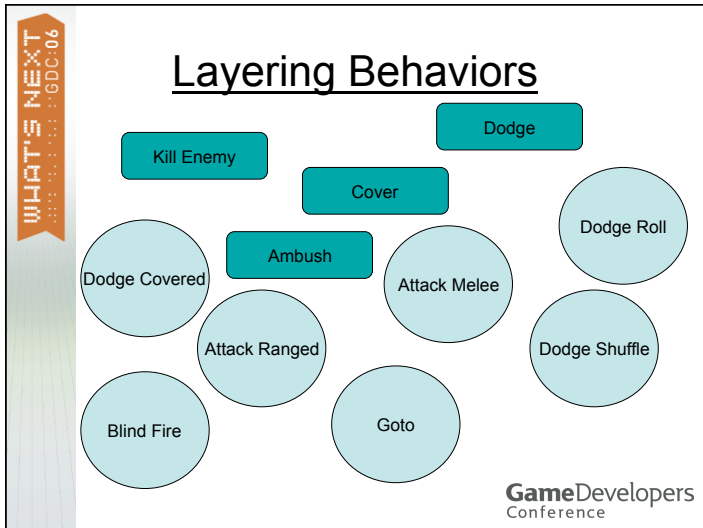


Layering Behaviors

Kill Enemy

Attack Ranged





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- ## Benefits of Planning
1. Decoupling Goals & Actions
 2. Layering Behaviors
 3. Dynamic Problem Solving
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Dynamic Problem Solving



Dynamic Problem Solving

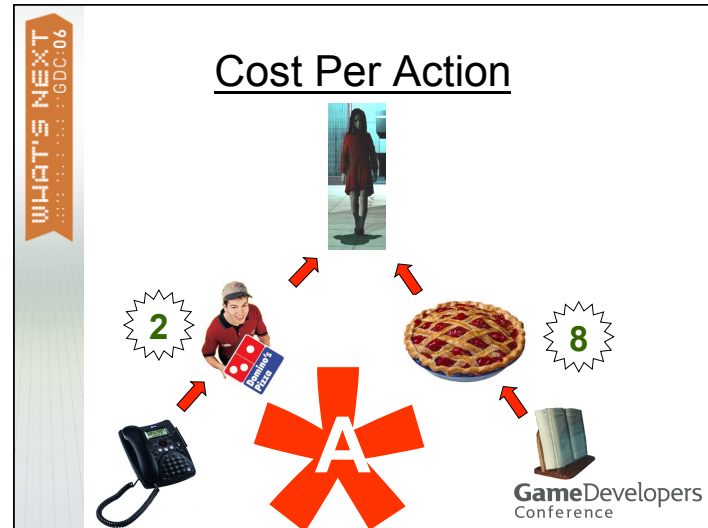
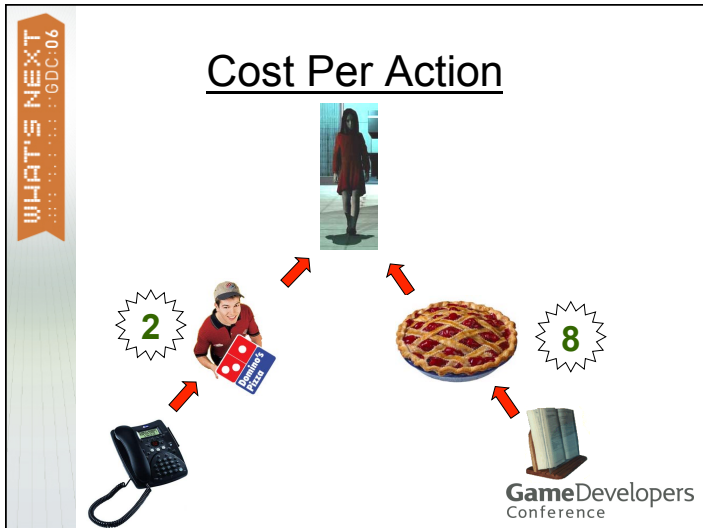


Planning Algorithm

[Slide added by C. Rich]

Cost Per Action





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Cost Per Action

A*	Navigation	Planning
Nodes:	NavMesh Polys	World States
Edges:	NavMesh Poly Edges	Actions
Goal:	NavMesh Poly	World State

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Summary

- Goals and actions as *data* (vs. code)
 - easier development
 - additivity
 - actions specified as [add/delete lists](#)
- AI planner *automatically* strings together actions (vs. manually coded FSM's or BT's)
 - flexibility, "problem solving"
 - search using [backward chaining](#)

[Slide added by C. Rich]