JASON GREGORY LEAD PROGRAMMER NAUGHTY DOG, INC.

Dogged Determination Technology and Process at Naughty Dog, Inc.

Tuesday, March 4, 14

"The University of Naughty Dog"

* Paul Keet, Lead Programmer, Medal of Honor Electronic Arts



Tuesday, March 4, 14



Tuesday, March 4, 14

Naughty Dog Games

- * Believable characters, compelling stories
- # Jaw-dropping visuals
- * Some of the best animation in the biz
- * Rich and immersive soundscapes
- * Touching vocal performances and memorable music
- World-class technology

So What's Our Secret?

*People

*Culture



*Process

*Technology

Tuesday, March 4, 14

People

People

* Making games (and most commercial products!) is a team effort

* What makes a great team?

* Each individual is of the highest caliber

* Team as a whole "gels" and operates effectively

* Effective hiring is the key

* Joel Spolsky, of Microsoft and Fog Creek fame, speaks of the two axes of hiring

* Is the candidate smart?

* Can the candidate get things done?

ABILITY TO GET THINGS DONE



ABILITY TO GET THINGS DONE





Tuesday, March 4, 14

ABILITY TO GET THINGS DONE

SMART, BUT <u>CAN'T</u> GET THINGS DONE



SMARTNESS

ABILITY TO GET THINGS DONE

NOT SMART, <u>CAN'T</u> GET THINGS DONE



SMARTNESS

<text>

SMARTNESS

Hiring Programmers

- * At Naughty Dog, programmer candidates are evaluated for:
 - * math and problem-solving skills,
 - * knowledge of low-level hardware and optimization techniques,
 - # general computer science (data structures, algorithms, languages)
 - * ... in that order!

Culture

Retaining Your Talent

- *** Trust** your people
- * Give them creative freedom and responsibility
- * Build a culture of mutual respect and continual learning
- * Effort translates directly to rewards
- * Don't be afraid to let a bad apple go

Flying by the Seat of Our Pants

* Richard Lemarchand, Co-Lead Designer on Uncharted series gave a great talk on this topic

"How to Fly by the Seat of Your Pants (Without Crapping Them)"

- D.I.C.E. Summit, 2010

http://www.g4tv.com/videos/44276/ dice-2010-naughty-dog-presentation/

Culture

- * Environment of mutual respect and trust
- * Open door policy; collaboration encouraged
- * Aggressively criticize ideas, but never let it get personal
- ***** No producers \Rightarrow everyone is a producer!
- * Literally every employee contributes to making the game...
 - * ... even our receptionist... and the two co-presidents!

Process

Development Process

* Each team at Naughty Dog has its own process

We'll focus on technology development process in this talk (the process used by the programmers)

* We'll also talk a bit about the overall process within the studio

Core Philosophies

- *** KISS** -- keep it simple (stupid)
- ***** Rapid iteration
- * Keep the game running at all times
- *** Everyone** always runs the latest version of the game
- * Minimal meetings (maximum communication!)
- * Manage scope of the project to maximize quality

KISS

* Not everything we do at Naughty Dog is rocket science...

* ... only some of it is!

- In fact, we usually select the simplest, most straightforward solution that gets the job done
 - # e.g., simple text files, not flashy GUIs
 - * e.g., command-line build tools
 - * Don't reinvent the wheel

Rapid Iteration

- * Focus on achieving results on-screen...
 - * ... not architectural perfection or "religious" dogma

***** Rapid iteration!

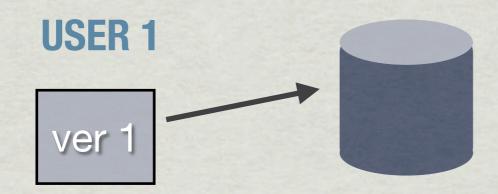
- * Get a rough prototype up and running ASAP
- * Leverage existing systems to prototype new ones
- * Refine and iterate many, many (many!) times

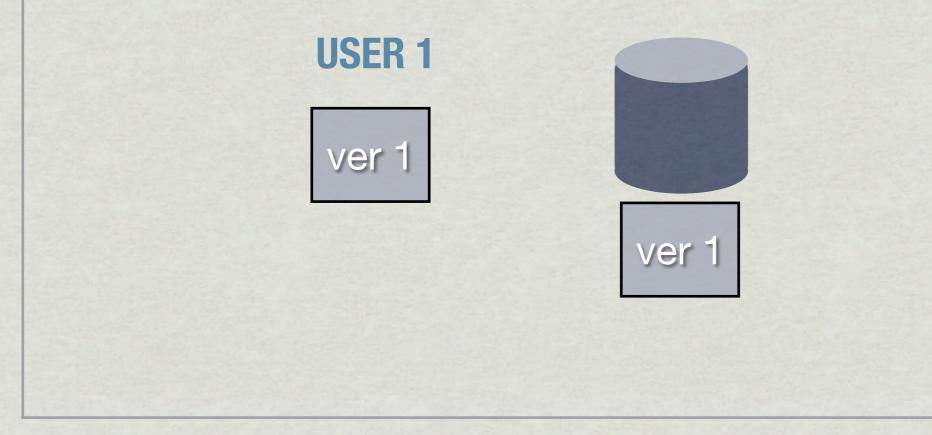
Keep It Running

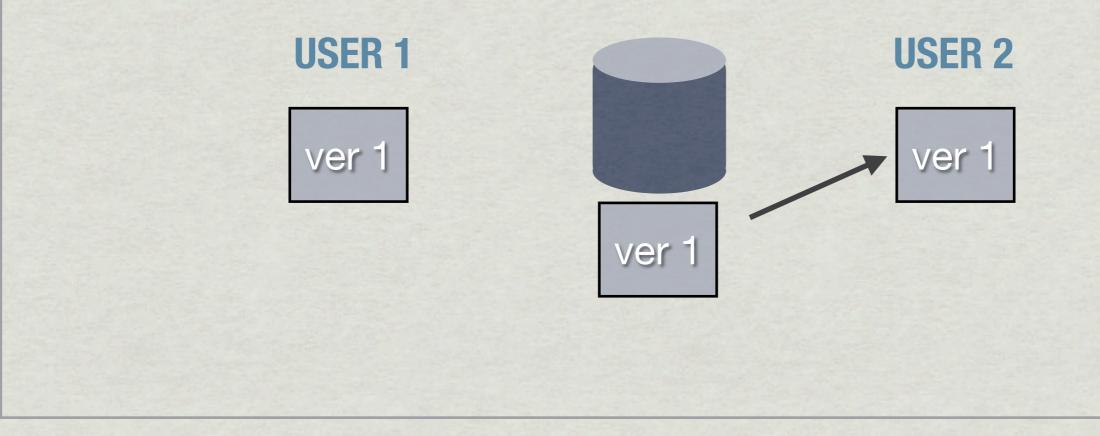
* A central pillar of our rapid iteration approach: *Keep the game running at all times** When developing a new system, we usually either:
1. gradually evolve an existing system, or
2. bring the new system up in parallel to the old

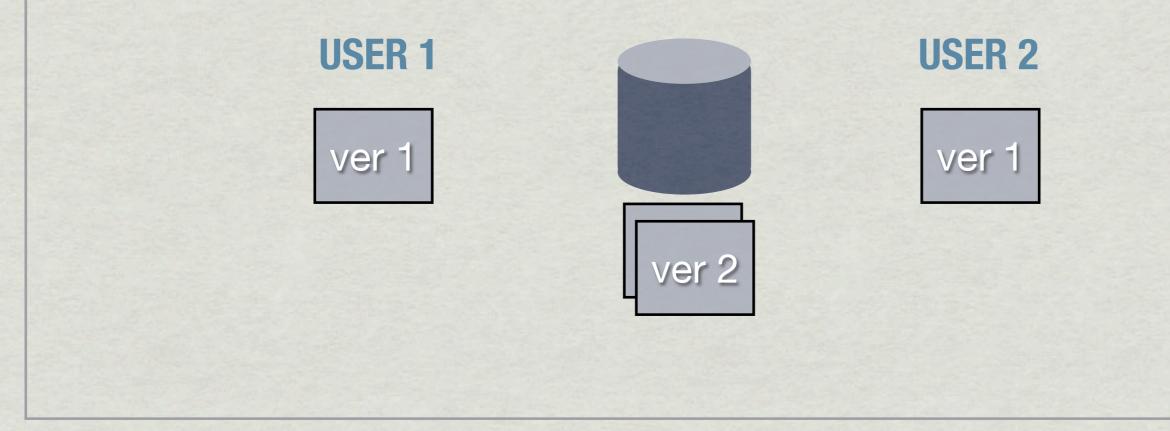


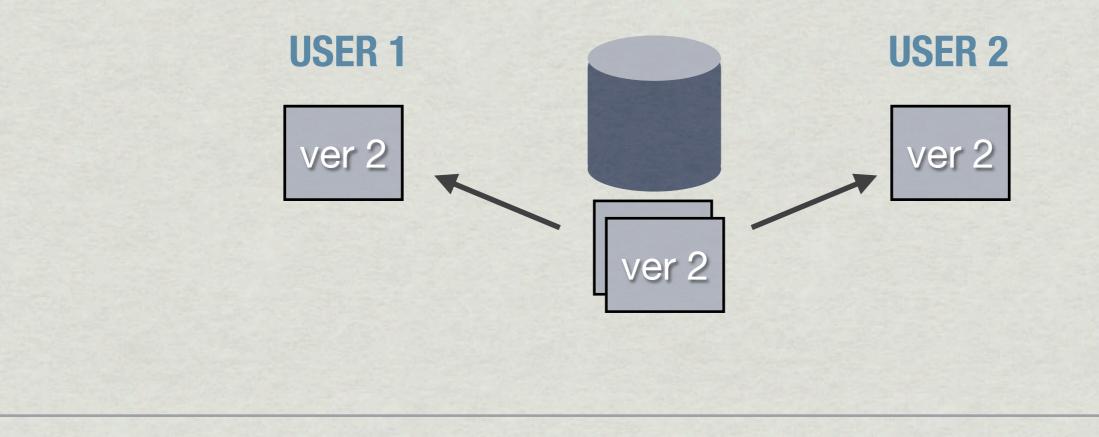


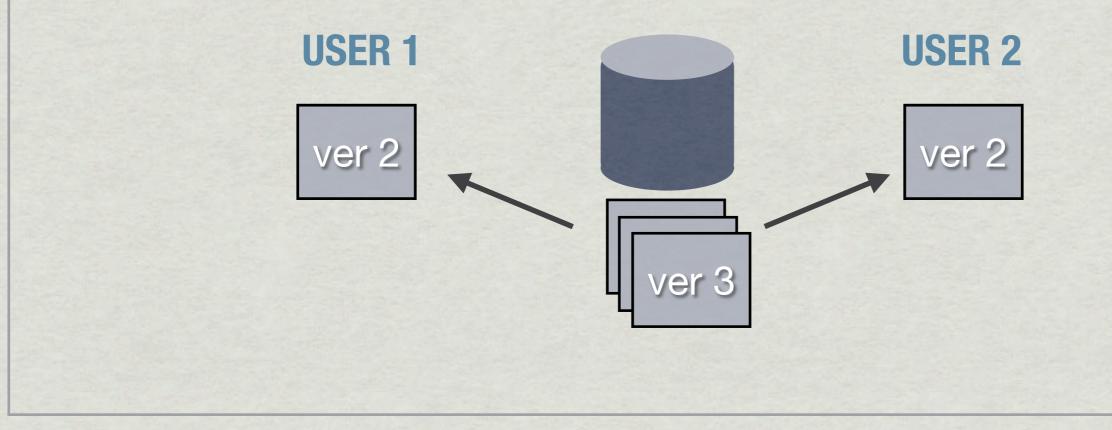


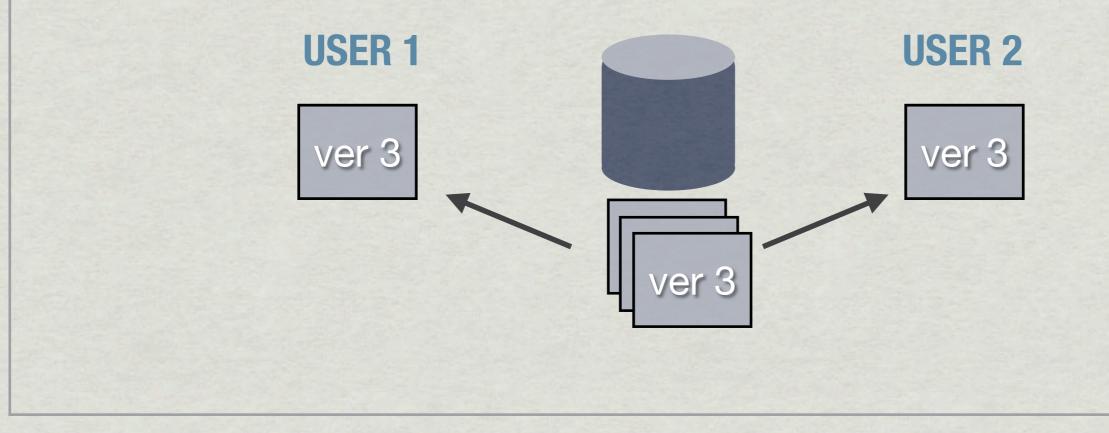










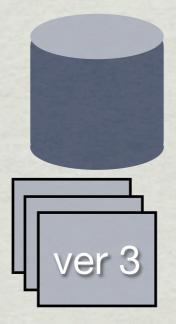


* Art assets: proprietary in-house tool ("BAM")



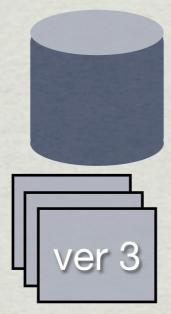


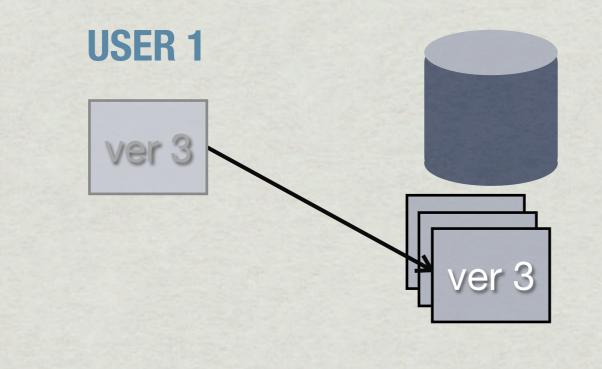




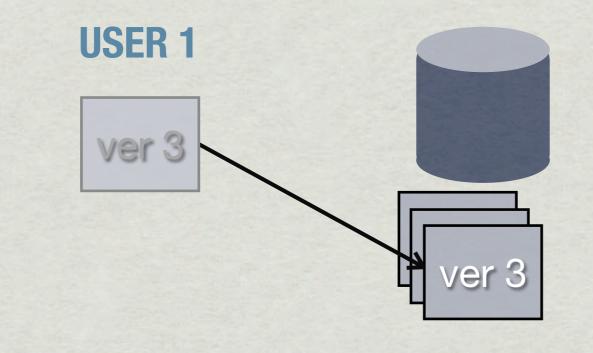
* Art assets: proprietary in-house tool ("BAM")

USER 1

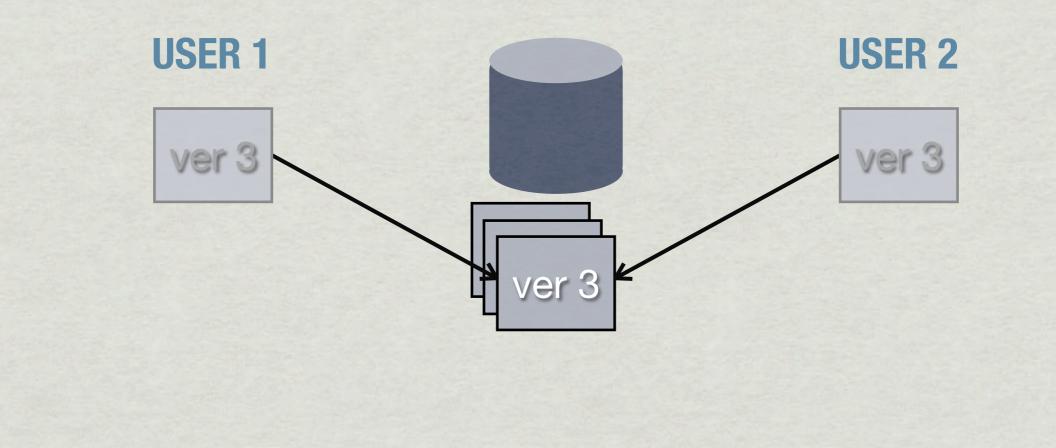


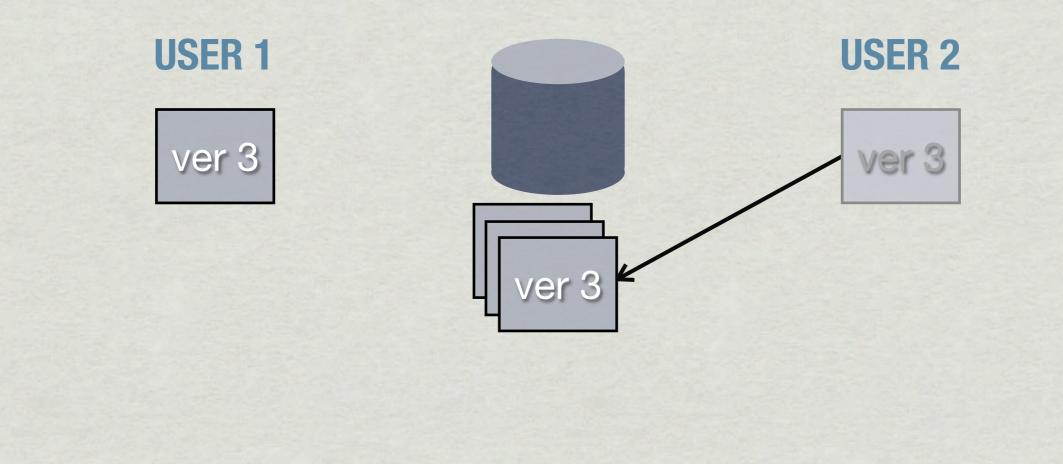


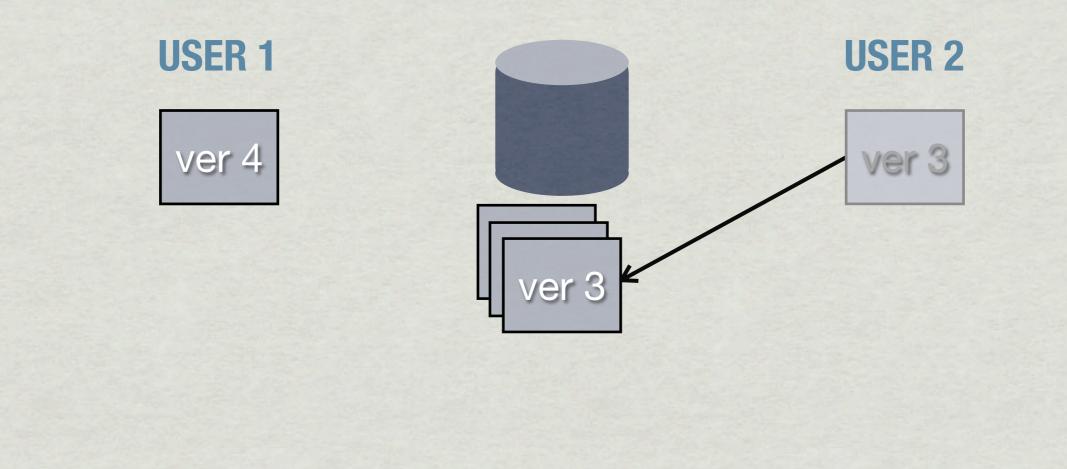
* Art assets: proprietary in-house tool ("BAM")

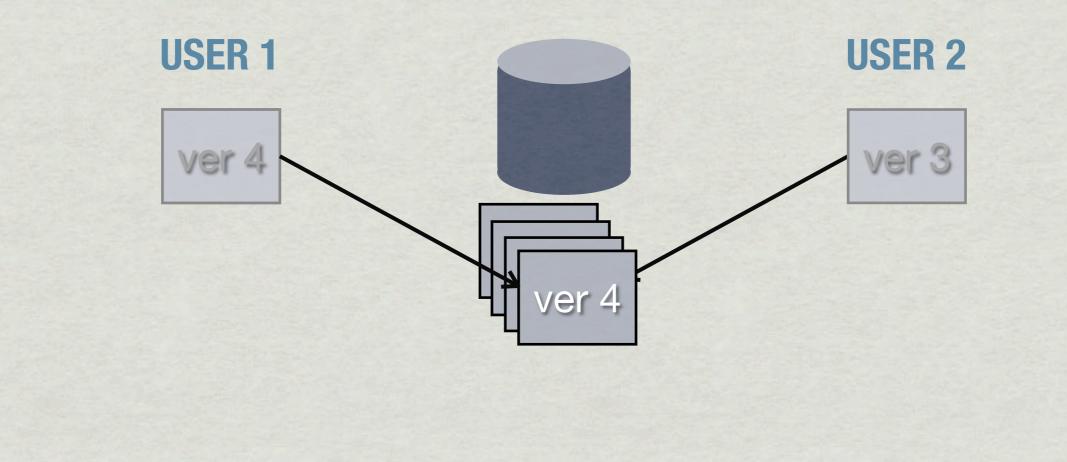


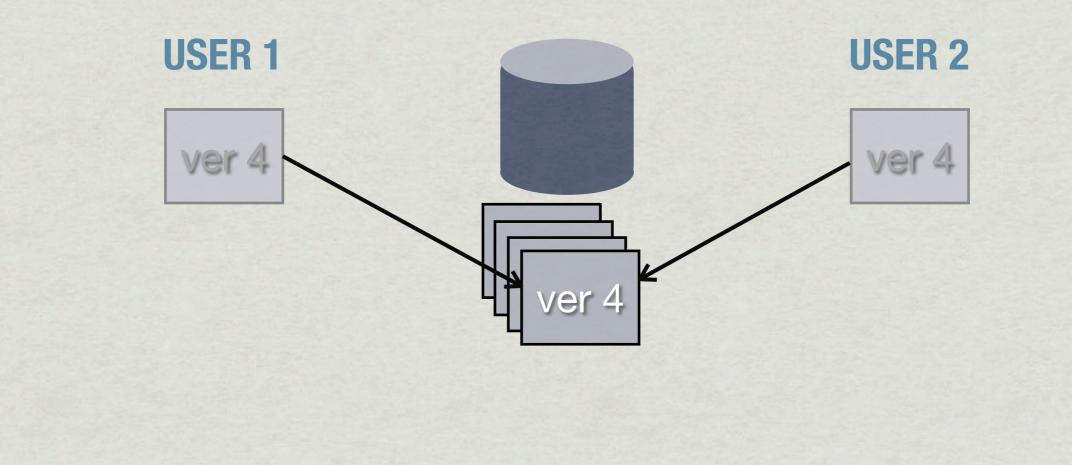
USER 2











* Everyone works on latest code/assets at all times

- * Automated build script called the buildbot builds every change checked into Perforce
 - If the build succeeds, a new version of the game is published to entire studio
 - * If the build fails, email is sent to entire studio
- * As assets are changed, artists build them globally

"But how can you work like that?"

* Sounds dangerous, right?

* But actually it's one of the best aspects of Naughty Dog's development process

- * Having latest code published immediately means that errors are discovered immediately
 - * The easiest bug to fix is the one that is freshest in your mind
- * Impossible for anyone to get months behind the team
- * There is exactly one version of the game that we all run
 - * No more "... but it works on my machine!"
- * Discourages dangerous programming practices

* Same goes for **publishing assets globally**:

* Problems are discovered quickly

- * Forces people to think carefully about their changes
- * Exactly one version of the game assets, seen by everyone
- * Rapid iteration encouraged; easy to share/collaborate
- * No more "... but it works on my machine!"

Minimal Meetings

* Very few long, formal meetings...

- * ... and a LOT of impromptu, short, informal meetings!
 - # Just pop by someone's desk and discuss
 - * Go grab other people if their input is needed
 - * Summarize results in an email or on the wiki
 - * Manage via our online task system, "Tasker"

	ps://www.taskerdog.com/tasker.php?taskid=30044	公
apps 🖬 Tasker 🔅	🕞 Buildbot ≽ Connector 🗋 TechExcel DevSuite 🔮 Cipher (The Last o	cf
Tasks Reports	Search	📄 🃎 💥 😃 🔣 Programming 🗂
<code create="" task<="" td=""><td>< Type here to create a task</td><td>Task Description Team Activity Tags Info</td></code>	< Type here to create a task	Task Description Team Activity Tags Info
Create Task	◎ ◆ 歩	Task Project: T1 V
asks (1)	My tasks Project filter: T1 Sort by: Priority	Task #30044 Created by Jacob Minkoff on 2013-08-30 11:56:07
tasks	VIGH PRIORITY	Task
eted	add a new kind of "all" state that runs with the entire script, no	ot wit add more granularity to actor load dependency debug data
	2 In fix display of state script fact dictionaries (cut off)	Subtasks Dupicate Search&Replace 🗌 Hide Con
ist 	spawn processes into the largest gap, and get rid of Large ver	Add a subtask
		Description
	Set up dynamic arrays and dictionaries of any type, for big4 an s	Currently, we can debug why an actor is loading by dumping level dependencies. Unfortunately, that only gives us data to the
	POST-MORTEM	granularity of what level is loading the actor. Further granularity would be helpful for debugging to the level of what spav or what look in the level is loading the actor as a dependency.
rogs	WEDIUM PRIORITY	For instance, if I see anim-melee-common loaded by level X, I then have to check every artgroup on every npc in the lever compare it against the looks file in dc to see which look(s) bring in that actor.
	add a new kind of "all" state that runs with the entire script, no	
clas		and breek south took and a right antaquy.
Clear elected taos	ar R fix display of state script fact dictionaries (cut off)	Team
elected tags	ar k display of state script fact dictionaries (cut off)	
elected tags ule nide-gold (1)	AN *	rsions Name/Viewed Status Hours Left Due Date Dave Smith Tue Jan 7 at 10:53 - V V NEXT
dected tags ale ilde-gold (1) (1) ature (1) ts	spawn processes into the largest gap, and get rid of Large ver	rsions nd be Name/Viewed Status Hours Left Due Date Name/Viewed Status Hours Left Due Date Image: Status Status Status Image: Status Statu
elected tags use wie wide-gold (1) (1) ature (1) ts	spawn processes into the largest gap, and get rid of Large ver	rsions Ind be Name/Viewed Status Hours Left Due Date Dave Smith Tue Jan 7 at 10:53 Dave Smith Dave Sm
elected tags use wie wide-gold (1) (1) ature (1) ts	Spawn processes into the largest gap, and get rid of Large ver Spawn processes into the largest gap, and get rid of Large ver Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays are the type of arrays are type.	rsions Ind be ot wit Name/Viewed Status Hours Left Due Date Dave Smith Tue Jan 7 at 10:53 NEXT Dave Smith Tue Jan 7 at 10:53 Tue
elected tags use wie wide-gold (1) (1) ature (1) ts	Spawn processes into the largest gap, and get rid of Large ver	rsions Name/Viewed Status Hours Left Due Date Dave Smith Ind be Market Image: Status Dave Smith The Jan 7 at 10:53 NEXT Image: Status Dave Smith The Jan 7 at 10:53 Image: Status Image: Status <td< td=""></td<>
elected tags use side-gold (1) (1) ature (1) ts	Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and dictionaries (cut off) Image: Spawn processes into the largest gap, and dictionaries (cut off)	rsions nd be ot wit rsions sions
elected tags use wie wide-gold (1) (1) ature (1) ts	 spawn processes into the largest gap, and get rid of Large ver set up dynamic arrays and dictionaries of any type, for big4 and POST-MORTEM Add a new kind of "all" state that runs with the entire script, no fix display of state script fact dictionaries (cut off) spawn processes into the largest gap, and get rid of Large version 	rsions hd be ot wit rsions rsions
elected tags use wile wide-gold (1) (1) sature (1) cts	 spawn processes into the largest gap, and get rid of Large ver set up dynamic arrays and dictionaries of any type, for big4 and POST-MORTEM add a new kind of "all" state that runs with the entire script, not fix display of state script fact dictionaries (cut off) spawn processes into the largest gap, and get rid of Large vers set up dynamic arrays and dictionaries of any type, for big4 and 	rsions Ind be of wit rsions Ind be ad be Ad be Ad team members
elected tags	 a spawn processes into the largest gap, and get rid of Large ver a set up dynamic arrays and dictionaries of any type, for big4 and POST-MORTEM add a new kind of "all" state that runs with the entire script, not fx display of state script fact dictionaries (cut off) fx display of state script fact dictionaries (cut off) s spawn processes into the largest gap, and get rid of Large version s set up dynamic arrays and dictionaries of any type, for big4 and post-MORTEM POST-MORTEM a spawn processes into the largest gap, and get rid of Large version a set up dynamic arrays and dictionaries of any type, for big4 and post-MORTEM POST-MORTEM 	rsions hd be hd be hd be but Sam Zat 10:53 base Gregory Thu Jan Zat 11:15 berome Durand Fri Sep 27 at 18:04 be hd be hd be hd be hd be ht Dure Sam Zat 14:40 fri Sep 27 at 18:04 fri Sep 27 fri Sep 27 fri Sep 27 fri Sep 27 fri Sep 27 fr

53 6					sker.php?taskid=30044	tps://www.taskerdog.c	-> C 10 ht
					chExcel DevSuite 🔮 Cipher (The Last of		
Jason Gregory Programming	>¥.₽	iii 🔊				Search	Tasks Reports
			vity Tags Info	Task Description Team Activ		< Type here to create a t	
				Task Project: T1 🔻		○ ♥ 些	Create Task
		56:07	on 2013-08-30 11:	Task #30044 Created by Jacob Minkoff	oject filter: T1 🔹 Sort by: Priority 🔹	My tasks	5
				Task		THIGH PRIORITY	asks (1) tasks
		cy debug data	load dependen	add more granularity to actor	tate that runs with the entire script, not wit	add a new kind o	leted
Search&Replace 🗌 Hide Comp	Duplicate			Subtasks	fact dictionaries (cut off)	fix display of stat	LISTS
				Add a subtask	e largest gap, and get rid of Large versions	spawn processes	s_
				Description	nd dictionaries of any type, for big4 and be	set up dynamic a	LIST
at only gives us data to the to the level of what spaw	cies. Unfortunately, elpful for debugging	nularity would be h	actor. Further gran	Currently, we can debug why an actor granularity of what level is loading the or what look in the level is loading the		POST-MORTEM	ŝ
p on every npc in the level				For instance, if I see anim-melee-co		- MEDIUM PRIORITY	progs
dency without having to gu			oks used in that lev	compare it against the looks file in dc It would be nice if I could see which lo	tate that runs with the entire script, not wit	add a new kind o	
			nt ones(s).	and check each look until I find the rig	fact dictionaries (cut off)		Cle elected taos
	Due Date	Hours Left	status	Team Name/Viewed	fact dictionaries (cut off) e largest gap, and get rid of Large versions	fix display of stat	elected tags ule
	Due Date	• 0 •		Team Name/Viewed Dave Smith Tue Jan 7 at 10:53		fix display of stat	elected tags ule nide-gold (1)
	V V	• • •		Team Name/Viewed Dave Smith Tue Jan 7 at 10:53 NEXT NEXT Jason Gregory Thu Jan 2 at 11:15	e largest gap, and get rid of Large versions	fix display of stat	elected taps ule wide-gold (1) (1) sature (1) cts
	v v	• 0 • • 0 •		Name/Viewed	e largest gap, and get rid of Large versions	fix display of stat	elected tags lule wide-gold (1) 2 (1) sature (1) cts
		• 0 • • 0 • • 0 • • 0 •		Hame/Viewed Name/Viewed	e largest gap, and get rid of Large versions nd dictionaries of any type, for big4 and be	fix display of stat pawn processes set up dynamic a POST-MORTEM add a new kind o *	elected taps ule wide-gold (1) (1) sature (1) cts
	v v	• 0 • • 0 •		Hame/Viewed Name/Viewed Name/Viewed <td>e largest gap, and get rid of Large versions nd dictionaries of any type, for big4 and be tate that runs with the entire script, not wit</td> <td>fix display of stat</td> <td>elected tags lule wide-gold (1) 2 (1) sature (1) cts</td>	e largest gap, and get rid of Large versions nd dictionaries of any type, for big4 and be tate that runs with the entire script, not wit	fix display of stat	elected tags lule wide-gold (1) 2 (1) sature (1) cts
		• 0 • • 0 • • 0 • • 0 •		Name/Viewed	e largest gap, and get rid of Large versions nd dictionaries of any type, for big4 and be tate that runs with the entire script, not wit fact dictionaries (cut off)	in the display of stat in the display of stat	elected tags Jule wide-gold (1) g (1) sature (1) cts
		• 0 • • 0 • • 0 • • 0 •		Name/Viewed	e largest gap, and get rid of Large versions nd dictionaries of any type, for big4 and be tate that runs with the entire script, not wit fact dictionaries (cut off) e largest gap, and get rid of Large versions	in the display of stat in the display of stat	Ce selected tags dule ewide-gold (1) g (1) feature (1) cts stofus (1)
		• 0 • • 0 • • 0 • • 0 •	Status	Fame/Viewed Name/Viewed Name/Viewed <td>e largest gap, and get rid of Large versions nd dictionaries of any type, for big4 and be tate that runs with the entire script, not wit fact dictionaries (cut off) e largest gap, and get rid of Large versions</td> <td>in the display of stat in the</td> <td>pelected tags fulle wilde-gold (1) g (1) eature (1) cts</td>	e largest gap, and get rid of Large versions nd dictionaries of any type, for big4 and be tate that runs with the entire script, not wit fact dictionaries (cut off) e largest gap, and get rid of Large versions	in the display of stat in the	pelected tags fulle wilde-gold (1) g (1) eature (1) cts
Show Auto Comme		• 0 • • 0 • • 0 • • 0 •	Status mit)	Team Name/Viewed Image: State of the s	e largest gap, and get rid of Large versions nd dictionaries of any type, for big4 and be tate that runs with the entire script, not wit fact dictionaries (cut off) e largest gap, and get rid of Large versions	fix display of stat pawn processes set up dynamic a post-MORTEM add a new kind o fix display of stat fix display of stat	elected tags Jule wide-gold (1) g (1) sature (1) cts

	tps://www.taskerdog.com/tasker.php?taskid=30044	
Apps Tasker	Buildbot >> Connector TechExcel DevSuite Cipher (The Last of	
Tasks Reports	Search	🛗 🏷 💥 😃 🔣 Programming 🔟
Create Task	Type here to create a task	Task Description Team Activity Tags Info
Create rask	回 参 址	Task Project: T1 •
S tasks (1)	My tasks Project filter: T1 • Sort by: Priority •	C Task #30044 Created by Jacob Minkoff on 2013-08-30 11:56:07
tasks (1)	WHIGH PRIORITY	Task
leted	add a new kind of "all" state that runs with the entire script, not wit	add more granularity to actor load dependency debug data
LISTS C	fix display of state script fact dictionaries (cut off)	Subtasks Dupicate Search&Replace 🗌 Hide Comp
is_	spawn processes into the largest gap, and get rid of Large versions	Add a subtask
LIST	• set up dynamic arrays and dictionaries of any type, for big4 and be	
r	POST-MORTEM	Currently, we can debug why an actor is loading by dumping level dependencies. Unfortunately, that only gives us data to the granularity of what level is loading the actor. Further granularity would be helpful for debugging to the level of what spawn or what look in the level is loading the actor as a dependency.
progs	- MEDIUM PRIORITY	For instance, if I see anim-melee-common loaded by level X, I then have to check every artgroup on every npc in the level compare it against the looks file in dc to see which look(s) bring in that actor.
		sempere is equilies are really the in ee to see triller really entry in energies
	add a new kind of "all" state that runs with the entire script, not wit	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to gu
Clea	o 🗥 *	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to gu and check each look until I find the right ones(s).
Clea selected tags dulle wilde-gold (1)	o 🗥 *	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to gu and check each look until I find the right ones(s). Team
Clea elected tags folle wide-gold (1)	Arr to a constrain the second state script fact dictionaries (cut off)	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to guard check each look until I find the right ones(s). Team Name/Viewed Status Hours Left Due Date Dave Smith Tot. Jan 7 at 10:53 0 V
Clea selected tags fulle wide-gold (1) g (1) eature (1) cts	Arrow	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to guand check each look until I find the right ones(s). Team Name/Viewed Status Hours Left Due Date Dave Smith 0 0 V Name/Viewed 0 0 V Dave Smith 0 V V NEXT 0 V V Dave Smith 0 V V Name/Viewed 0 V V
Clea selected tags dule wilde-gold (1) g (1) eature (1) cts	 A fix display of state script fact dictionaries (cut off) A fix display of state script fact dictionaries (cut off) A spawn processes into the largest gap, and get rid of Large versions A set up dynamic arrays and dictionaries of any type, for big4 and be 	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to guad check each look until I find the right ones(s). Team Name/Viewed Status Hours Left Due Date Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith Image: Dave Smith
Clea selected tags dule wilde-gold (1) g (1) eature (1) cts	 A fix display of state script fact dictionaries (cut off) A fix display of state script fact dictionaries (cut off) A spawn processes into the largest gap, and get rid of Large versions A set up dynamic arrays and dictionaries of any type, for big4 and be A POST-MORTEM 	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to guard the common as a dependency without having to guard the common as a dependency without having to guard and check each look until I find the right ones(s). Team Name/Viewed Status Hours Left Due Date Dave Smith 0 0 V Dave Smith 0 0 V NEXT 0 V V Next 0 V V Dave Smith 0 V V Next 0 V V Image: A construction of the construction
clea selected tags dule evide-gold (1) is g (1) feature (1) ects	 Image: A set of the set of the	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to gut and check each look until I find the right ones(s). Team Name/Viewed Status Hours Left Due Date Dave Smith O< V Disc Jan 7 at 10:53 O V Disc Jano Gregory O V V Disc Science Durand O V V Disc Durand O V V V Disc Durand O
clea selected tags dule twide-gold (1) g (1) feature (1) ects	 Image: A state script fact dictionaries (cut off) Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of Large versions Image: A spawn processes into the largest gap, and get rid of large versions Image: A spawn processes into the largest gap, and get rid of large versions Image: A spawn processes into the largest gap, and get rid of large versions Image: A spawn processes into the largest gap, and get rid of large versions Image: A spawn processes into the largest gap, and get rid of large versions Image: A spawn pr	R would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to gut and check each look until I find the right ones(s). Team Name/Viewed Status Hours Left Due Date Dave Smith 0 0 V
clea selected tags dule twide-gold (1) g (1) feature (1) ects	 Image: A spawn processes into the largest gap, and get rid of Large versions Spawn processes into the largest gap, and get rid of Large versions Set up dynamic arrays and dictionaries of any type, for big4 and be Set up dynamic arrays and dictionaries of any type, for big4 and be POST-MORTEM add a new kind of "all" state that runs with the entire script, not wit fix display of state script fact dictionaries (cut off) Spawn processes into the largest gap, and get rid of Large versions 	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to gut and check each look until I find the right ones(s). Team Name/Viewed Status Hours Left Due Date Dave Smith Dave Smith Due Smith V Dave Smith Dave Smith Due Date V Dave Tarris Michaesale O V V Dave Tarris Michaesale O V V Dave Tarris Michaesale O V V Distribution 2 at 13:53 O V V Distribution 2 at 13:40 O V V Distribut
clea selected tags dule evide-gold (1) is g (1) feature (1) ects	 Image: A state script fact dictionaries (cut off) Image: A spawn processes into the largest gap, and get rid of Large versions Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries (cut off) Image: A set up dynamic arrays and dictionaries (cut off) Image: A set up dynamic arrays and dictionaries (cut off) Image: A spawn processes into the largest gap, and get rid of Large versions Image: A set up dynamic arrays and dictionaries of any type, for big4 and be 	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to gut and check each look until I find the right ones(s). Team Name/Viewed Status Hours Left Due Date Dave Smith Dave Smith Dave Smith Due Date Dave Smith Dave Smith Due Date V Dave The Jan 7 at 10:53 D O V Dave The Jan 7 at 10:53 D O V Dave The Jan 7 at 10:53 D O V Dave The Jan 7 at 10:53 D O V Distribution Contraction of the Contraction of t
	 Image: A state script fact dictionaries (cut off) Image: A spawn processes into the largest gap, and get rid of Large versions Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries (cut off) Image: A set up dynamic arrays and dictionaries (cut off) Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries of any type, for big4 and be Image: A set up dynamic arrays and dictionaries dynamic arrays and be Image: A set up dynamic arrays and dynamic arr	Model de nice if I could see which looks used in that level have anim-melee-common as a dependency without having to gut and check each look until I find the right ones(s). Team Name/Viewed Status Nours Left Due Date Dave Smith 0 V V Dave Darand 0 V V

-> C A http	× Buildbot × tps://www.taskerdog.com/tasker.php?taskid=30044	
	😔 Buildbot ≽ Connector 🗋 TechExcel DevSuite 🔮 Cipher (The Last of	
Tasks Reports	Search	🛗 🃎 💥 🤽 🔀 Dason Gregory 🚹
<	< Type here to create a task	Task Description Team Activity Tags Info
Create Task	◎ ≫ 些	Task Project: T1 💌
5	My tasks Project filter: T1 Sort by: Priority	Task #30044 Created by Jacob Minkoff on 2013-08-30 11:56:07
asks (1) tasks	THIGH PRIORITY	Task
leted	add a new kind of "all" state that runs with the entire script, not	t wit add more granularity to actor load dependency debug data
LISTS C	Fix display of state script fact dictionaries (cut off)	Subtasks Duplicate Search&Replace 🛄 Hide Com
5	spawn processes into the largest gap, and get rid of Large vers	Add a subtask
IST C	Set up dynamic arrays and dictionaries of any type, for big4 and the set up dynamic arrays and dictionaries of any type.	
	POST-MORTEM	Currently, we can debug why an actor is loading by dumping level dependencies. Unfortunately, that only gives us data to the granularity of what level is loading the actor. Further granularity would be helpful for debugging to the level of what spave or what look in the level is loading the actor as a dependency.
rogs	- MEDIUM PRIORITY	For instance, if I see anim-melee-common loaded by level X, I then have to check every artgroup on every npc in the lever compare it against the looks file in dc to see which look(s) bring in that actor.
	I add a new kind of fall state that over with the entire periot, and	
	add a new kind of "all" state that runs with the entire script, not	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to g
Clea		and check each look until I find the right ones(s).
Clea lected tags		and check each look until I find the right ones(s).
Clea lected tags ile ide-gold (1)	ar K display of state script fact dictionaries (cut off)	sions d be
Clea sected tags sle ide-gold (1) (1) (1) ature (1) ts	Arr Arr fix display of state script fact dictionaries (cut off) fix display of state script fact dictionaries (cut off) fix grawn processes into the largest gap, and get rid of Large vers	the would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to g and check each look until I find the right ones(s). Team to Bave Smith Tot Jan 7 at 10:53 Tot Jan 7 at 10:53 Tot Jan 2 at 11:15 Tot Jan 2 at 11:15
Clea sected tags sle ide-gold (1) (1) (1) ature (1) ts	 Image: A set of the set of the	t wit It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to g and check each look until I find the right ones(s). Team sions d be d be t wit t wit Travis Michael Status Name/Viewed Status Mours Left Due Date Due Date Status Mours Left Due Date V V V V Due Date V V Due Date V V Due Date V V Due Date V V Due Date V V Due Date V V Due Date V V V Due Date V V V Due Date V V V Due Date V V V Due Date V V V V Due Date V V V V V V V Due Date V V V V V V V V V V V V V
Clea sected tags ale side-gold (1) (1) ature (1) ts	 A to display of state script fact dictionaries (cut off) A fix display of state script fact dictionaries (cut off) A spawn processes into the largest gap, and get rid of Large vers A set up dynamic arrays and dictionaries of any type, for big4 and A POST-MORTEM 	t would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to g and check each look until I find the right ones(s). Team to base Smith Dave Smith Dave Smith Tota lan 7 at 10:53 NEXT t wit t wit t wit
Clea slected tags sle side-gold (1) (1) (1) ature (1) ts	 Image: A set of the set of the	It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to g and check each look until I find the right ones(s). Sions Name/Viewed Status Hours Left Due Date be Name/Viewed Status Hours Left Due Date Image: Status Name/Viewed Status Hours Left Due Date Image: Status Name/Viewed Status No V Image: Status Name/Viewed Status Hours Left Due Date Image: Status Name/Viewed Status V V Image: Status Name/Viewed V V V Image: Status Image: Status V V V Image: Status V V V V Image: Status V V V V Image: Status V V V V
Clea slected tags sle side-gold (1) (1) (1) ature (1) ts	 A fix display of state script fact dictionaries (cut off) A spawn processes into the largest gap, and get rid of Large vers A set up dynamic arrays and dictionaries of any type, for big4 and A POST-MORTEM A add a new kind of "all" state that runs with the entire script, not A fix display of state script fact dictionaries (cut off) 	t wit t wit sons t wit sons t wit t wit
Clea elected tags ule nide-gold (1) (1) ature (1) ts	 Image: A spawn processes into the largest gap, and get rid of Large versions in the largest gap, and get rid of Large versions is a set up dynamic arrays and dictionaries of any type, for big4 and is post-MORTEM Image: A spawn processes into the largest gap, and get rid of Large versions is a spawn processes into the largest gap, and get rid of Large versions is a spawn processes into the largest gap, and get rid of Large versions is a spawn processes into the largest gap, and get rid of Large versions is a spawn processes into the largest gap, and get rid of Large versions is a spawn processes into the largest gap, and get rid of Large versions is a spawn processes into the largest gap, and get rid of Large versions is a spawn processes into the largest gap, and get rid of Large versions is a spawn processes into the largest gap, and get rid of Large versions is a spawn processes into the largest gap. 	It would be nicht if 1 could see witch looks used in that level nave anim-melee-common as a dependency without naving to g and check each look until I find the right ones(s). Iteam stons d be t wit sons d be d be d be t wit and check ach look until I find the right ones(s).
Clea elected tags ele elde-gold (1) (1) ature (1) ts	 fix display of state script fact dictionaries (cut off) spawn processes into the largest gap, and get rid of Large vers set up dynamic arrays and dictionaries of any type, for big4 and POST-MORTEM add a new kind of "all" state that runs with the entire script, not fix display of state script fact dictionaries (cut off) spawn processes into the largest gap, and get rid of Large vers set up dynamic arrays and dictionaries (cut off) spawn processes into the largest gap, and get rid of Large vers set up dynamic arrays and dictionaries of any type, for big4 and 	It would be mich if i could see which look used in that even have anim-menee-common as a dependency without having to g and check each look until I find the right ones(s). Iteam tions Name/Viewed Status Hours Left Due Date Dave Smith V V V Dave Smith V V V With Dave Smith V V Witt Dave Smith V V Wave Dave Status V V Dave Dave Smith
	 Image: A spawn processes into the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap. Image: POST-MORTEM Image: A dd a new kind of "all" state that runs with the entire script, not in the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap, and get rid of Large verses in the largest gap. Image: POST-MORTEM 	It would be note if it could see which folds used in that even have anim-mese-common as a dependency without having to g and check each look until I find the right ones(s). Stons Name/Viewed Status Hours Left Due Date Image: Status Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status Image: Status Id be Image: Status Image: Status Image: Status <

-> C 🙆 http	× Buildbet × second buildbet ×		숤
	Buildbot ≽ Connector 🗋 TechExcel DevSuite 🔮 Cipher (The Last of	ast of	~
Tasks Reports	Search	🛗 🃎 💥 😃 🔀 Jason Gregory	T1 .
<	Type here to create a task	Task Description Team Activity Tags Info	
Create Task	◎ ≫ 些	Task Project: T1 T	
5	My tasks Project filter: T1 Sort by: Priority	Task #30044 Created by Jacob Minkoff on 2013-08-30 11:56:07	
asks (1) tasks	- HIGH PRIORITY	Task	
leted	add a new kind of "all" state that runs with the entire script, no		
LISTS C	fix display of state script fact dictionaries (cut off)	Subtasks Dupkate Search&Replace U H	
s_	spawn processes into the largest gap, and get rid of Large vers	versions	
LIST C	set up dynamic arrays and dictionaries of any type, for big4 and	Currently, we can debug why an actor is loading by dumping level dependencies. Unfortunately, that only gives us dat	
r		granularity of what level is loading the actor. Further granularity would be helpful for debugging to the level of what or what look in the level is loading the actor as a dependency.	
xogs	- MEDIUM PRIORITY	For instance, if I see anim-melee-common loaded by level X, I then have to check every artgroup on every npc in th compare it against the looks file in dc to see which look(s) bring in that actor.	he leve
0	add a new kind of "all" state that runs with the entire script, no		ng to g
Clear elected tags		Team	
ule wide-gold (1)	spawn processes into the largest gap, and get rid of Large vers		
(I) O	set up dynamic arrays and dictionaries of any type, for big4 and	4 and be • 0 • V	
	No. 1	A Jason Gregory	
ts	POST-MORTEM	Thu Jan 2 at 11:15 • 0 • V	
ts	add a new kind of "all" state that runs with the entire script, not	t, not wit	
cts	add a new kind of "all" state that runs with the entire script, not	t, not wit V t, not wit V	
ts	add a new kind of "all" state that runs with the entire script, not	t, not wit t,	
ts	add a new kind of "all" state that runs with the entire script, not	t, not wit	
cts	Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state script fact dictionaries (cut off) Image: Add a new kind of the largest gap, and get rid of Large vers Image: Add a new kind of the largest gap, and get rid of Large vers	t, not wit t, not wit t, not wit Image: State of the sep 27 at 18:04 Pri Sep 27 at 18:04 Image: State of the sep 24 at 11:31 Image: State of the sep 24 at 11:40	to Comm
cts	add a new kind of "all" state that runs with the entire script, not fix display of state script fact dictionaries (cut off) spawn processes into the largest gap, and get rid of Large vers state of the largest gap, and get rid of	t, not wit t, not wit versions t and be	to Com
eature (1)	Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state that runs with the entire script, not Image: Add a new kind of "all" state script fact dictionaries (cut off) Image: Add a new kind of state script fact dictionaries (cut off) Image: Add a new kind of state script fact dictionaries (cut off) Image: Add a new kind of state script fact dictionaries of any type, for big4 and the state script fact dictionaries of any type, for big4 and the state script fact dictionaries of any type, for big4 and the state script fact dictionaries of any type, for big4 and the state script fact dictionaries of any type, for big4 and the state script fact dictionaries (cut off) Image: Add the state script fact dictionaries of any type, for big4 and the state script fact dictionaries (cut off) Image: Add the state script fact dictionaries (cut off) Image: Add the state script fact dictionaries (cut off) Image: Add the state script fact dictionaries (cut off) Image: Add the state script fact dictionaries (cut off) Image: Add the state script fact dictionaries (cut off) Image: Add the state script fact dictionaries (cut off) Image: Add the state script fact dictionaries (cut off) <td>t, not wit versions t and be Add team members Type comment here (Enter to submit)</td> <td>to Comm</td>	t, not wit versions t and be Add team members Type comment here (Enter to submit)	to Comm
cts	Image: Add a new kind of "all" state that runs with the entire script, not the state script fact dictionaries (cut off) Image: Fix display of state script fact dictionaries (cut off) Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes into the largest gap, and get rid of Large verses Image: Spawn processes Image: Spawn proc	t, not wit versions t and be Add team members Type comment here (Enter to submit) t and wit	to Com

(1) Tasker × 🕞 Buildbot ×	
← → C Ahttps://www.taskerdog.com/tasker.php?taskid=30044	☆ 🗶 🗄
III Apps 🖬 Tasker 😔 Buildbot ≽ Connector 🗋 TechExcel DevSuite 🔮 Cipher (The Last of	
T Tasks Reports Search	🚞 🃎 💥 🤽 🔣 Dason Gregory 📧
Type here to create a task	Task Description Team Activity Tags Info
Create Task	Task Project: T1 *
LISTS My tasks Project filter: T1 • Sort by: Priority •	
Hy tasks (1) Late tasks	Task
Completed anew kind of "all" state that runs with the entire script, not with	
TASK LISTS O The fix display of state script fact dictionaries (cut off)	Subtasks Duplicate Search&Replace 🗌 Hide Completed
_BUGS	Add a subtask
USER LIST O set up dynamic arrays and dictionaries of any type, for big4 and be.	Description Currently, we can debug why an actor is loading by dumping level dependencies. Unfortunately, that only gives us data to the
Player POST-MORTEM	granularity of what level is loading the actor. Further granularity would be helpful for debugging to the level of what spawner or what look in the level is loading the actor as a dependency.
thing-progs	For instance, if I see anim-melee-common loaded by level X, I then have to check every artgroup on every npc in the level and compare it against the looks file in dc to see which look(s) bring in that actor.
TAGS O	" It would be nice if I could see which looks used in that level have anim-melee-common as a dependency without having to guess and check each look until I find the right ones(s).
Clear I fix display of state script fact dictionaries (cut off)	Team
Schedule gamewide-gold (1) spawn processes into the largest gap, and get rid of Large versions	No. of the second se
Tools debug (1) Type set up dynamic arrays and dictionaries of any type, for big4 and be. type	
Projects POST-MORTEM	Image: Second secon
thelastofus (1) add a new kind of "all" state that runs with the entire script, not wit.	lerome Durand
fix display of state script fact dictionaries (cut off)	
spawn processes into the largest gap, and get rid of Large versions.	Tue Sep 24 at 11:31
set up dynamic arrays and dictionaries of any type, for big4 and be	Wed Jan 22 at 11(4)
POST-MORTEM	Activity Show Auto Comments
LOW PRIORITY	Type comment here (Enter to submit)
add a new kind of "all" state that runs with the entire script, not wit.	
fix display of state script fact dictionaries (cut off)	Christian Gyrling Tue Sep 24 at 11:30 Sorry, jumped the gun slightly there, but we can still hook this up through the LoadSets.
spawn processes into the largest gap, and get rid of Large versions.	

	× 😥 Buildbet ×		
	ps://www.taskerdog.com/tasker.php?taskid=30044		2
Apps 🖬 Tasker 😥	Buildbot >> Connector >> TechExcel DevSuite >> Cipher (The Later Connector >> TechExcel DevSuite >> Cipher (The Later Connector >> Cipher (The Connecto		
Tasks Reports	Search	🗮 🃎 💥 🚢 🕅 Programming	T1 •
<< Create Task	Type here to create a task	Task Description Team Activity Tags Info	
Create rask	○ 参 些	Task Project: T1 🔻	
	My tasks Project filter: T1 • Sort by: Priority	ty • O Task #30044 Created by Jacob Minkoff on 2013-08-30 11:56:07	
asks (1) asks	V HIGH PRIORITY	Task	
leted	add a new kind of "all" state that runs with the entire script,	ipt, not wit add more granularity to actor load dependency debug data	
	fix display of state script fact dictionaries (cut off)	Subtasks Dupicate Search&Replace	tide Com
ist I_	spawn processes into the largest gap, and get rid of Large	Add a subtask	
- -			
LIST O	set up dynamic arrays and dictionaries of any type, for big4	ig4 and be Description Currently, we can debug why an actor is loading by dumping level dependencies. Unfortunately, that only gives us date	ta to th
	POST-MORTEM	granularity of what level is loading the actor. Further granularity would be helpful for debugging to the level of wh or what look in the level is loading the actor as a dependency.	at spaw
rogs	- MEDIUM PRIORITY	For instance, if I see anim-melee-common loaded by level X, I then have to check every artgroup on every npc in t compare it against the looks file in dc to see which look(s) bring in that actor.	the leve
0	add a new kind of "all" state that runs with the entire script,		ng to g
Clear elected tags	fix display of state script fact dictionaries (cut off)	Team	
ule			
vide-gold (1)	spawn processes into the largest gap, and get rid of Large v	Dave Smith	
(1)	spawn processes into the largest gap, and get rid of Large v set up dynamic arrays and dictionaries of any type, for big4	ig4 and be Dave Smith Tue Jan 7 at 10:53 - 0 V	
(1)	20 x	ig4 and be ig	
(1)	Set up dynamic arrays and dictionaries of any type, for big4	ig4 and be ig4 and be ig4 and be ipt, not wit ipt, not wit ig4 and be ig5 area for a for	
(1)	Set up dynamic arrays and dictionaries of any type, for big4	ig4 and be ig4 and be ipt, not wit Dave Smith Tue Jan 7 at 10:53 NEXT Dave Smith Tue Jan 7 at 10:53 NEXT Dave Smith Tue Jan 7 at 10:53 Dave Smith Dave Smith	
(1)	Set up dynamic arrays and dictionaries of any type, for big4	ig4 and be ig4 and be ipt, not wit pe versions	
sahure (1)	Image: Set up dynamic arrays and dictionaries of any type, for big4 Image: Set up dynamic arrays and dictionaries of any type, for big4 Image: POST-MORTEM Image: Set up dynamic arrays and dictionaries of any type, for big4 Image: POST-MORTEM Image: Set up dynamic arrays and dictionaries of any type, for big4 Image: POST-MORTEM Image: Set up dynamic arrays and dictionaries of any type, for big4 Image: POST-MORTEM Image: POST-MORTEM <td>ig4 and be ig4 and be ipt, not wit pe versions</td> <td></td>	ig4 and be ig4 and be ipt, not wit pe versions	
sahure (1)	Image: Set up dynamic arrays and dictionaries of any type, for big4 Image: POST-MORTEM Image: POST-MORTEM Image: Add a new kind of "all" state that runs with the entire script, the state script fact dictionaries (cut off) Image: Post of the state script fact dictionaries (cut off) Image: Post of the state script fact dictionaries (cut off) Image: Post of the state script fact dictionaries (cut off) Image: Post of the state script fact dictionaries (cut off) Image: Post of the state script fact dictionaries (cut off) Image: Post of the state script fact dictionaries (cut off)	ig4 and be ig4 and be ipt, not wit ipt, not wit <td>uto Comm</td>	uto Comm
2 (1)	 set up dynamic arrays and dictionaries of any type, for big4 POST-MORTEM add a new kind of "all" state that runs with the entire script, fix display of state script fact dictionaries (cut off) fix spawn processes into the largest gap, and get rid of Large v set up dynamic arrays and dictionaries of any type, for big4 	ig4 and be Image: Source Smith Tax: Jan 7 at 10:53 Image: Source Smith Tax: Jan 7 at 10:53 Image: Source Smith Tax: Jan 7 at 10:53 ipt, not wit Image: Source Smith Thu: Jan 2 at 11:15 Image: Source Smith Thu: Jan 2 at 11:15 Image: Source Smith Thu: Jan 2 at 11:15 ipt, not wit Image: Source Smith Thu: Jan 2 at 11:15 Image: Source Smith Thu: Jan 2 at 11:15 Image: Source Smith Thu: Jan 2 at 11:15 ipt, not wit Image: Source Smith Thu: Jan 2 at 11:15 Image: Source Smith Thu: Jan 2 at 11:15 Image: Source Smith Thu: Jan 2 at 11:15 ipt, not wit Image: Source Smith Thu: Jan 2 at 11:15 Image: Source Smith Thu: Jan 2 at 11:15 Image: Source Smith Thu: Jan 2 at 11:15 ipt, not wit Image: Source Smith Thu: Jan 2 at 11:15 ipt, not wit Image: Source Smith Thu: Jan 2 at 11:15 igt and be Image: Source Smith Thu: Jan 2 at 11:40 Image: Source Smith Thu: Jan 2 at 11:40 <td>uto Comm</td>	uto Comm
o (1) esture (1) cts	 set up dynamic arrays and dictionaries of any type, for big4 POST-MORTEM add a new kind of "all" state that runs with the entire script, fx display of state script fact dictionaries (cut off) fx display of state script fact dictionaries (cut off) spawn processes into the largest gap, and get rid of Large v set up dynamic arrays and dictionaries of any type, for big4 POST-MORTEM POST-MORTEM COM PRIORITY add a new kind of "all" state that runs with the entire script, add a new kind of "all" state that runs with the entire script, 	ig4 and be ig4 and be ipt, not wit ge versions ig4 and be ig4 and be ig4 and be ig4 and be ig5 int ist ist ist ist ist ist ist ist ist is	uto Comm
wide-gold (1)	 set up dynamic arrays and dictionaries of any type, for big4 POST-MORTEM POST-MORTEM add a new kind of "all" state that runs with the entire script, * fx display of state script fact dictionaries (cut off) fx spawn processes into the largest gap, and get rid of Large v set up dynamic arrays and dictionaries of any type, for big4 Set up dynamic arrays and dictionaries of any type, for big4 POST-MORTEM POST-MORTEM add a new kind of "all" state that runs with the entire script, 	ig4 and be ig4 and be ipt, not wit ge versions ig4 and be ig4 and be ig4 and be ig4 and be ig5 int ist ist ist ist ist ist ist ist ist is	uto Comm

(1) Tasker	× 🕞 Buildbot ×		
	ttps://www.taskerdog.com/tasker.php?taskid=30044	\$	3 🖬
Apps Tasker	Buildbot >> Connector TechExcel DevSuite Cipher (The Last of		
T Tasks Report	Search	🚞 🃎 💥 🤽 🔣 Jason Gregory	T1 •
Create Task	Type here to create a task	Task Description Team Activity Tags Info	
	◎ ≫ 些	Task Project: T1 *	
LISTS My tasks (1)		• O Task #30044 Created by Jacob Minkoff on 2013-08-30 11:56:07	
Late tasks	WIGH PRIORITY	Task	2
Completed	add a new kind of "all" state that runs with the entire script, not w	add more granularity to actor load dependency debug data	
ASK LISTS	O In fix display of state script fact dictionaries (cut off)	Subtasks Dupikate Search&Replace 🗌 Hide C	Complete
Msh List BUGS_	spawn processes into the largest gap, and get rid of Large version	Add a subtask	
ISER LIST	set up dynamic arrays and dictionaries of any type for hind and h	Description	2
AI	set up dynamic arrays and dictionaries of any type, for big4 and b	Currently, we can debug why an actor is loading by dumping level dependencies. Unfortunately, that only gives us data to	to the
Mayer /ish	POST-MORTEM	granularity of what level is loading the actor. Further granularity would be helpful for debugging to the level of what sp or what look in the level is loading the actor as a dependency.	pawner
ning-progs cook	WEDIUM PRIORITY	For instance, if I see anim-melee-common loaded by level X, I then have to check every artgroup on every npc in the le compare it against the looks file in dc to see which look(s) bring in that actor.	evel an
	add a new kind of "all" state that runs with the entire script, not w		o gues
Cl Ind' selected tags	lear I fix display of state script fact dictionaries (cut off)	Team	2
chedule pamewide-gold (1)	spawn processes into the largest gap, and get rid of Large version	Ins Name/Viewed Status Hours Left Due Date	
ools lebug (1) /pe	set up dynamic arrays and dictionaries of any type, for big4 and b s		
ewfeature (1) ojects	POST-MORTEM	→ Jason Gregory Thu Jan 2 at 11:15 • • • 0 • V	
helastofus (1)	add a new kind of "all" state that runs with the entire script, not w		
	fix display of state script fact dictionaries (cut off)	Fri Sep 27 at 18:04	
		Christian Gyrling	
	spawn processes into the largest gap, and get rid of Large version	Jacob Plinkoff	
		ns Jacob Minkoff Wed Jan 22 at 14:40	
	spawn processes into the largest gap, and get rid of Large version	ns A Jacob Minkoff Wed Jan 22 at 14:40	omments
	spawn processes into the largest gap, and get rid of Large version state of the largest gap, and get rid of Large version set up dynamic arrays and dictionaries of any type, for big4 and big	ns No Add team members	omment
	spawn processes into the largest gap, and get rid of Large version st set up dynamic arrays and dictionaries of any type, for big4 and b POST-MORTEM	ns Ne Add team members Know Auto Co	amment
	spawn processes into the largest gap, and get rid of Large version states and dictionaries of any type, for big4 and be post-MORTEM	ns Ne Add team members Know Auto Co	omment

	ps://www.taskerdog.com/tasker.php?taskid=30044	公
apps 🖬 Tasker 🔅	🕞 Buildbot ≽ Connector 🗋 TechExcel DevSuite 🔮 Cipher (The Last o	cf
Tasks Reports	Search	📄 🃎 💥 😃 🔣 Programming 🗂
<code create="" task<="" td=""><td>< Type here to create a task</td><td>Task Description Team Activity Tags Info</td></code>	< Type here to create a task	Task Description Team Activity Tags Info
Create Task	◎ ◆ 歩	Task Project: T1 V
asks (1)	My tasks Project filter: T1 Sort by: Priority	Task #30044 Created by Jacob Minkoff on 2013-08-30 11:56:07
tasks	VIGH PRIORITY	Task
eted	add a new kind of "all" state that runs with the entire script, no	ot wit add more granularity to actor load dependency debug data
	2 In fix display of state script fact dictionaries (cut off)	Subtasks Dupicate Search&Replace 🗌 Hide Con
ist 	spawn processes into the largest gap, and get rid of Large ver	Add a subtask
		Description
	Set up dynamic arrays and dictionaries of any type, for big4 an s	Currently, we can debug why an actor is loading by dumping level dependencies. Unfortunately, that only gives us data to the
	POST-MORTEM	granularity of what level is loading the actor. Further granularity would be helpful for debugging to the level of what spav or what look in the level is loading the actor as a dependency.
rogs	WEDIUM PRIORITY	For instance, if I see anim-melee-common loaded by level X, I then have to check every artgroup on every npc in the level compare it against the looks file in dc to see which look(s) bring in that actor.
	add a new kind of "all" state that runs with the entire script, no	
clas		and breek south took and a right antaquy.
Clear elected taos	ar R fix display of state script fact dictionaries (cut off)	Team
elected tags	ar k display of state script fact dictionaries (cut off)	
elected tags ule nide-gold (1)	AN *	rsions Name/Viewed Status Hours Left Due Date Dave Smith Tue Jan 7 at 10:53 - V V NEXT
ected tags sle ide-gold (1) (1) ature (1) ts	spawn processes into the largest gap, and get rid of Large ver	rsions nd be Name/Viewed Status Hours Left Due Date Name/Viewed Status Hours Left Due Date Image: Status Status Status Image: Status Statu
elected tags use wile wide-gold (1) (1) ature (1) ts	spawn processes into the largest gap, and get rid of Large ver	rsions Ind be Name/Viewed Status Hours Left Due Date Dave Smith Tue Jan 7 at 10:53 Dave Smith Dave Sm
elected tags use wile wide-gold (1) (1) ature (1) ts	Spawn processes into the largest gap, and get rid of Large ver Spawn processes into the largest gap, and get rid of Large ver Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays and dictionaries of any type, for big4 and Spawn set up dynamic arrays are the type of arrays are type.	rsions Ind be ot wit Name/Viewed Status Hours Left Due Date Dave Smith Tue Jan 7 at 10:53 NEXT Dave Smith Tue Jan 7 at 10:53 Tue
elected tags use wile wide-gold (1) (1) ature (1) ts	Spawn processes into the largest gap, and get rid of Large ver	rsions Name/Viewed Status Hours Left Due Date Dave Smith Ind be Market Image: Status Dave Smith The Jan 7 at 10:53 NEXT Image: Status Dave Smith The Jan 7 at 10:53 Image: Status Image: Status <td< td=""></td<>
elected tags under inide-gold (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and get rid of Large ver Image: Spawn processes into the largest gap, and dictionaries (cut off) Image: Spawn processes into the largest gap, and dictionaries (cut off)	rsions nd be nd be ot wit rsions Travis Michaeline Status Name/Viewed Dave Smith Tue Jan 7 at 10:53 NEXT Dave Smith Tue Jan 7 at 10:53 Dave Smith Tue Jan 7 at 10:53 Dave Smith Dave Sm
elected tags use wile wide-gold (1) (1) ature (1) ts	 spawn processes into the largest gap, and get rid of Large ver spawn processes into the largest gap, and get rid of Large ver set up dynamic arrays and dictionaries of any type, for big4 and POST-MORTEM POST-MORTEM add a new kind of "all" state that runs with the entire script, no fix display of state script fact dictionaries (cut off) spawn processes into the largest gap, and get rid of Large vers 	rsions hd be ot wit rsions rsions
elected tags use wile wide-gold (1) (1) sature (1) cts	 spawn processes into the largest gap, and get rid of Large ver set up dynamic arrays and dictionaries of any type, for big4 and POST-MORTEM add a new kind of "all" state that runs with the entire script, not fix display of state script fact dictionaries (cut off) spawn processes into the largest gap, and get rid of Large vers set up dynamic arrays and dictionaries of any type, for big4 and 	rsions Ind be of wit rsions Ind be ad be Ad be Ad team members
elected tags	 a spawn processes into the largest gap, and get rid of Large ver a set up dynamic arrays and dictionaries of any type, for big4 and POST-MORTEM add a new kind of "all" state that runs with the entire script, not fx display of state script fact dictionaries (cut off) fx display of state script fact dictionaries (cut off) s spawn processes into the largest gap, and get rid of Large version s set up dynamic arrays and dictionaries of any type, for big4 and post-MORTEM POST-MORTEM a spawn processes into the largest gap, and get rid of Large version a set up dynamic arrays and dictionaries of any type, for big4 and post-MORTEM POST-MORTEM 	rsions hd be hd be hd be but Sam Zat 10:53 base Gregory Thu Jan Zat 11:15 berome Durand Fri Sep 27 at 18:04 be hd be hd be hd be hd be ht Dure Sam Zat 14:40 fri Sep 27 at 18:04 fri Sep 27 fri Sep 27 fri Sep 27 fri Sep 27 fri Sep 27 fr

Balance

* Careful, thoughtful balance between story and gameplay

* ... and between systemic gameplay and oneoff set pieces

* Attention to detail

* Prioritizing well / knowing what's important (and what's not)

Managing Scope

* Make the game we want to make

- * Project schedule always in service to the game (not vice versa)
- * May cut some content towards the end of the project in order to hit our ship date
- * Use various scheduling tools to plan ahead
 - * ... but not too far ahead!

Technology

Key Foundational Technologies

- * Efficient, fragmentation-free memory allocation
- * Effective use of **multicore** computing resources
- * Careful code and data optimization based on deep understanding of the hardware
- * Powerful in-game debugging and profiling facilities
- * Empower content creators through script and datadriven systems

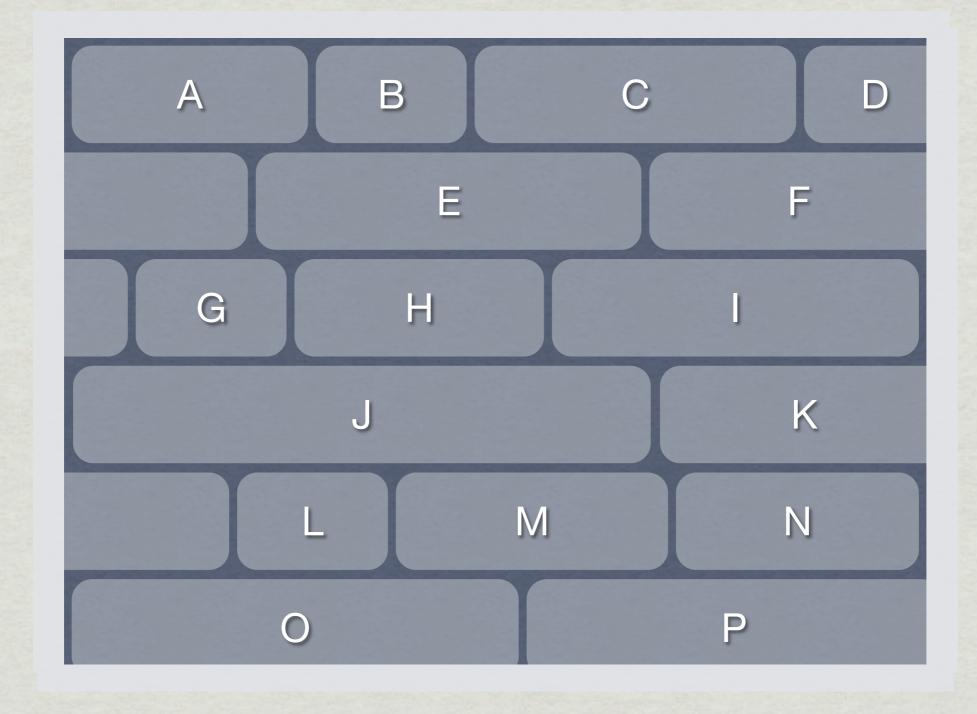
Memory Management

Memory Allocation

* Memory allocation is not free!

- * General-purpose new/malloc() needs to handle every possible request -- slow!
- * Lowest-level memory allocation routines require a context switch into the OS -- super slow!
- * Memory fragmentation is the enemy
- * Know how available memory is being used



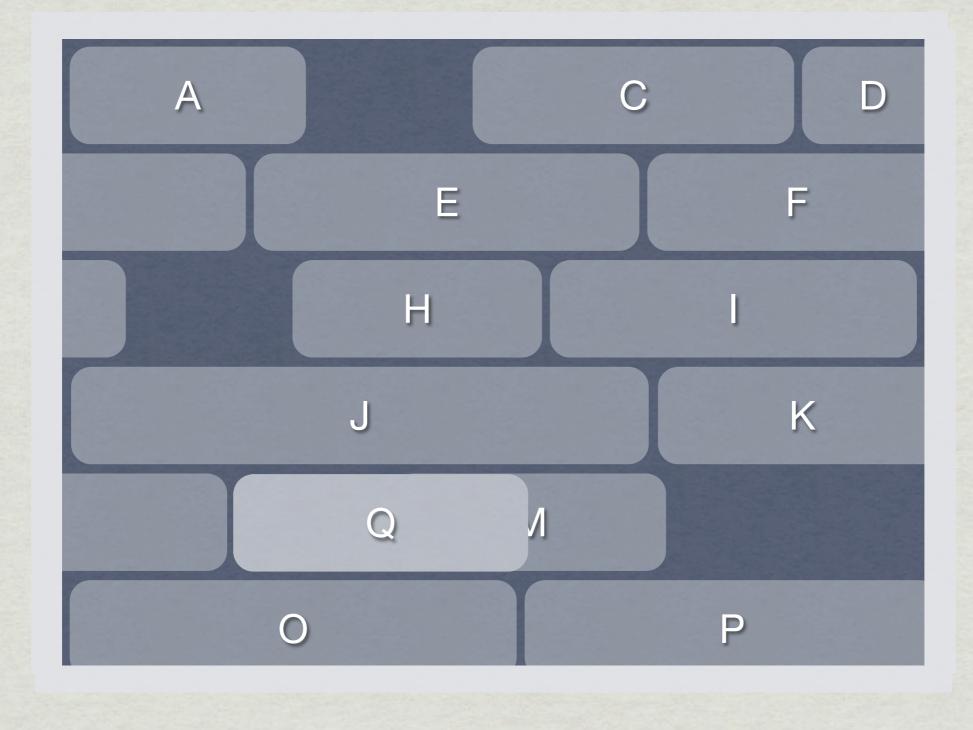
















Memory Allocation

* Always better to do allocation yourself:

* Side-step the **OS**

- * Custom-tailor allocators to match your software's allocation patterns
- *** Avoid** memory **fragmentation** entirely
- * Control your memory map explicitly





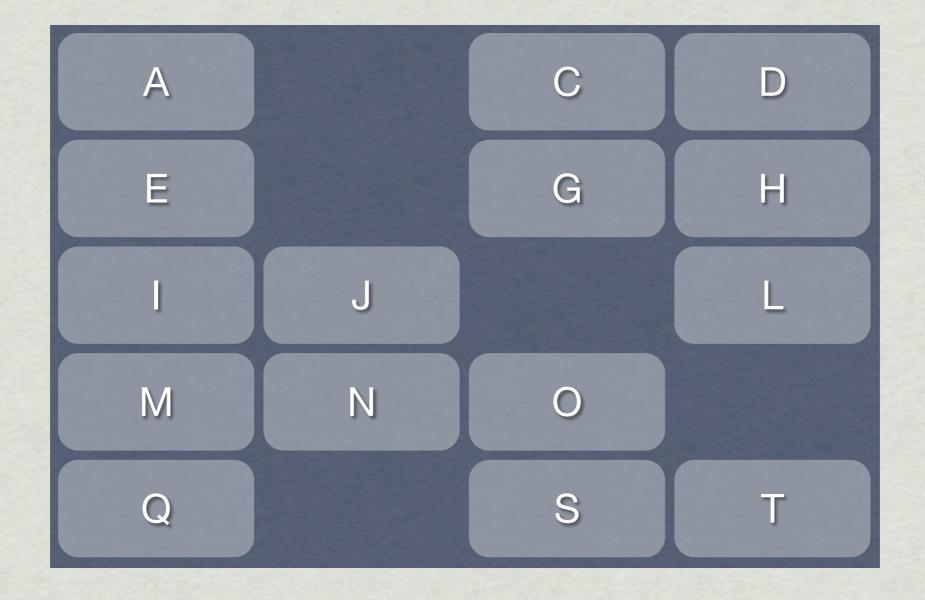




Tuesday, March 4, 14



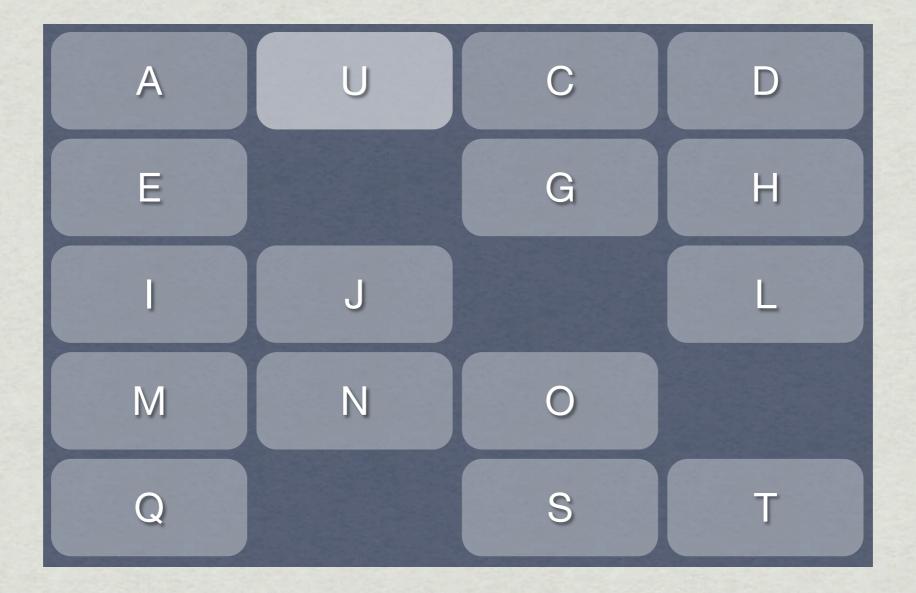




Tuesday, March 4, 14

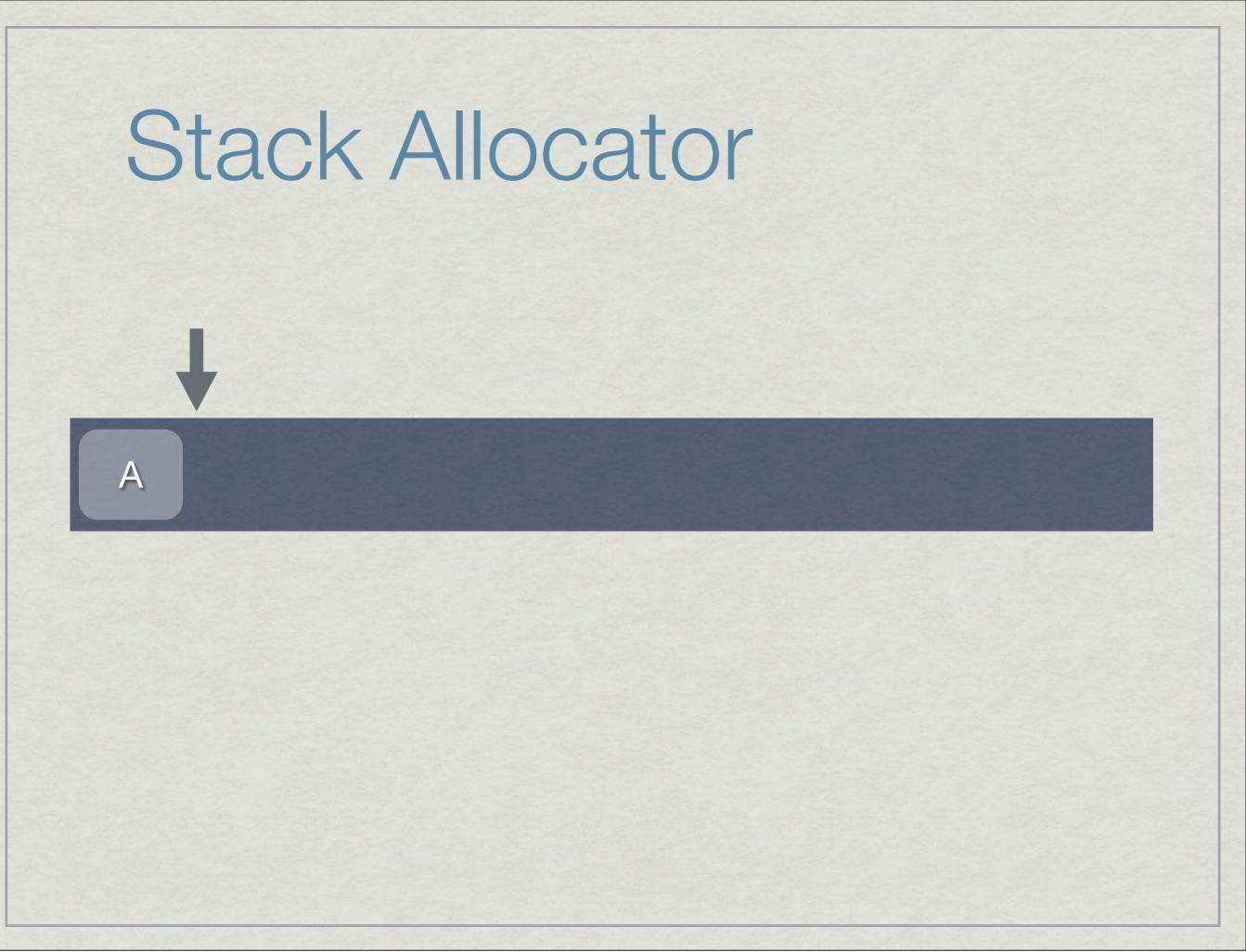


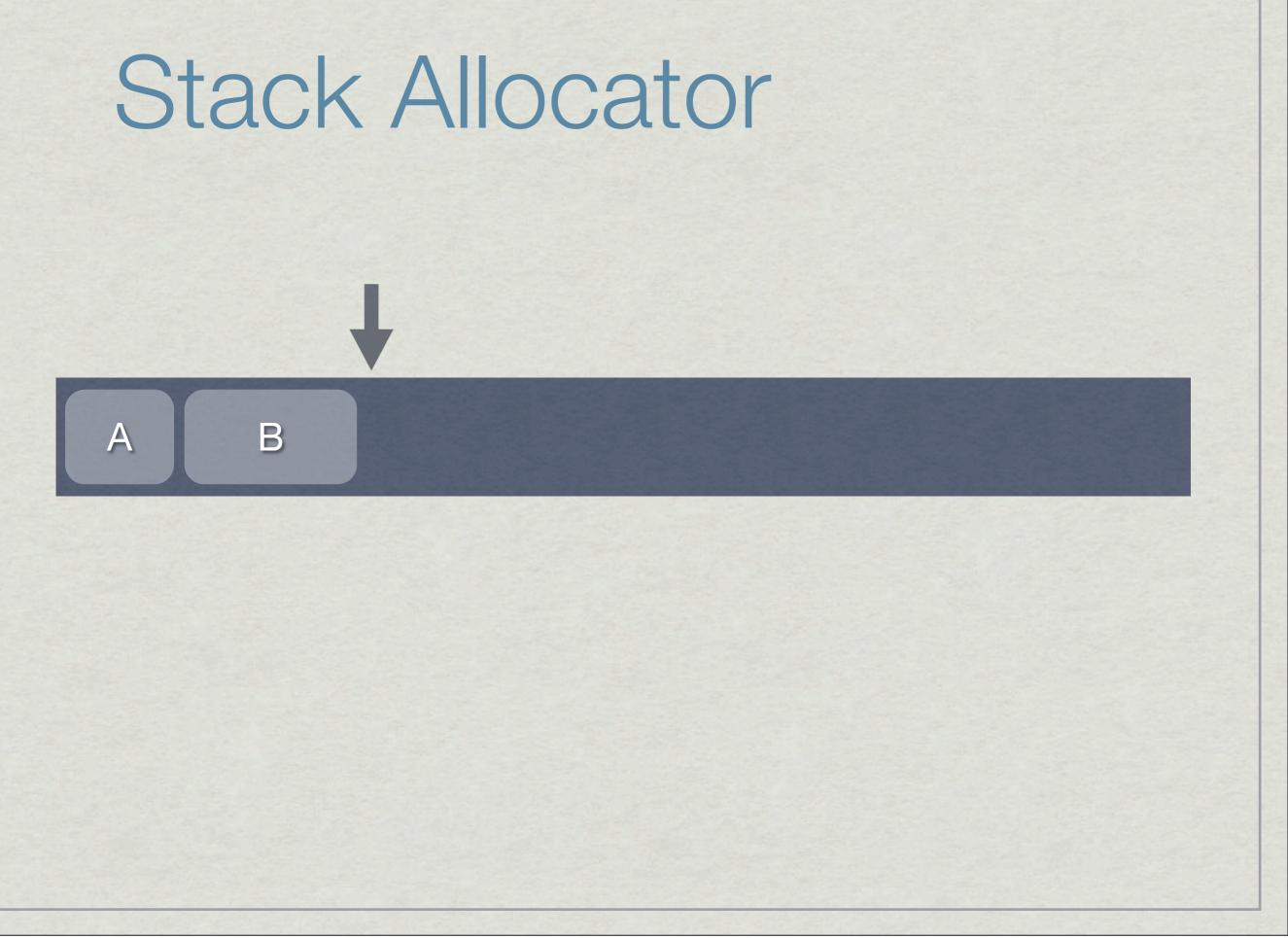


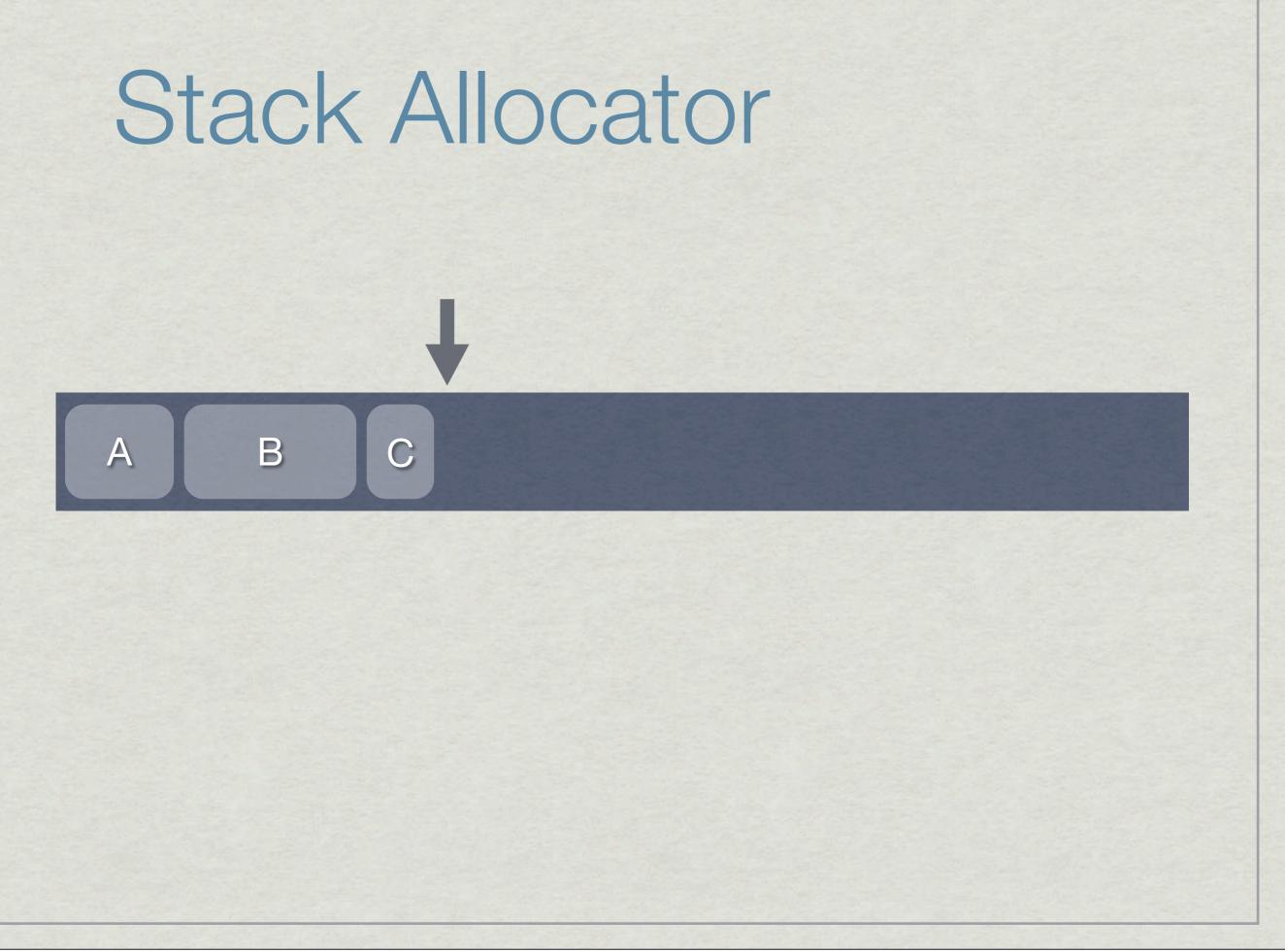


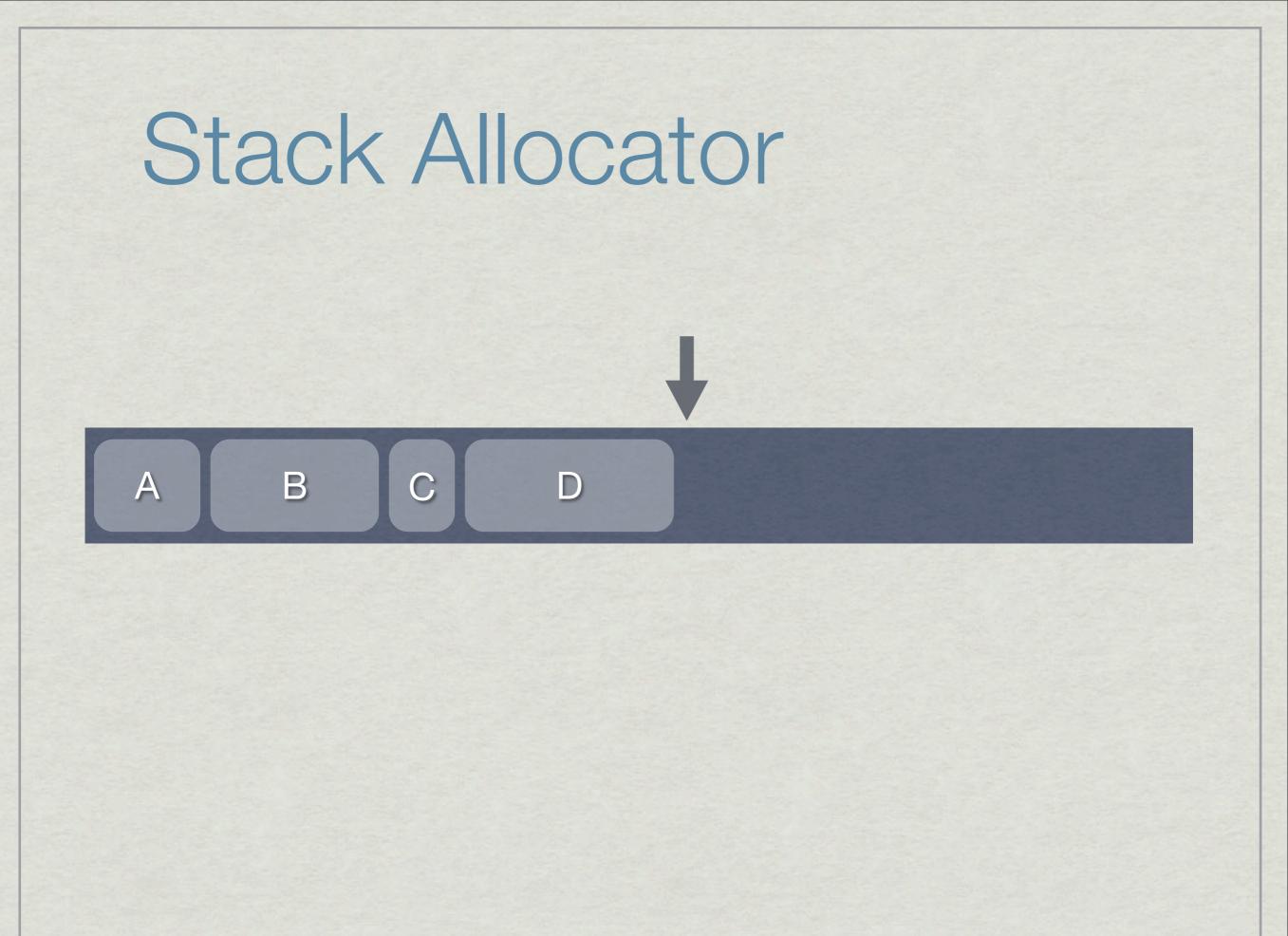
FRAGMENTATION HAPPENS, BUT NOT A PROBLEM

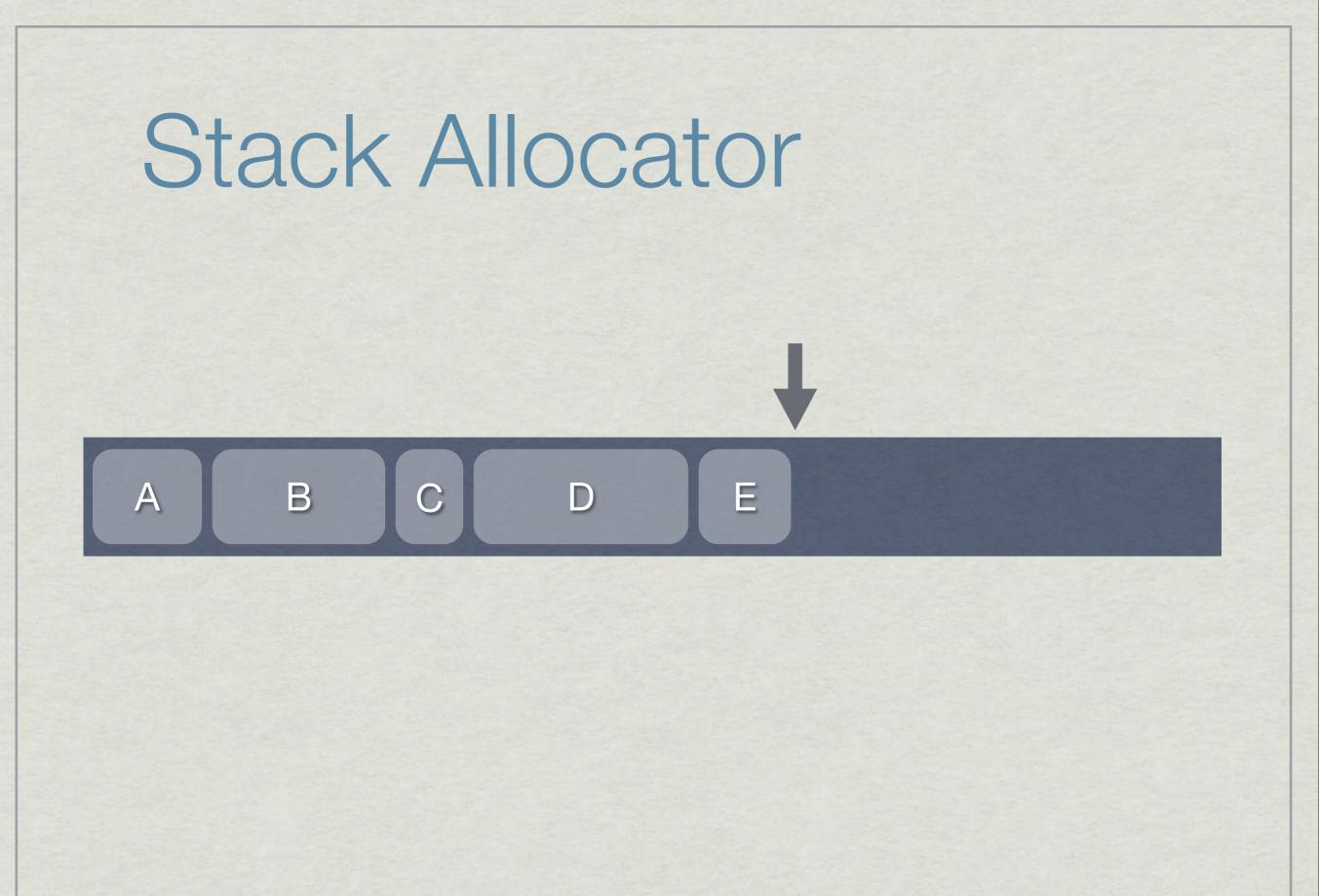
Stack Allocator

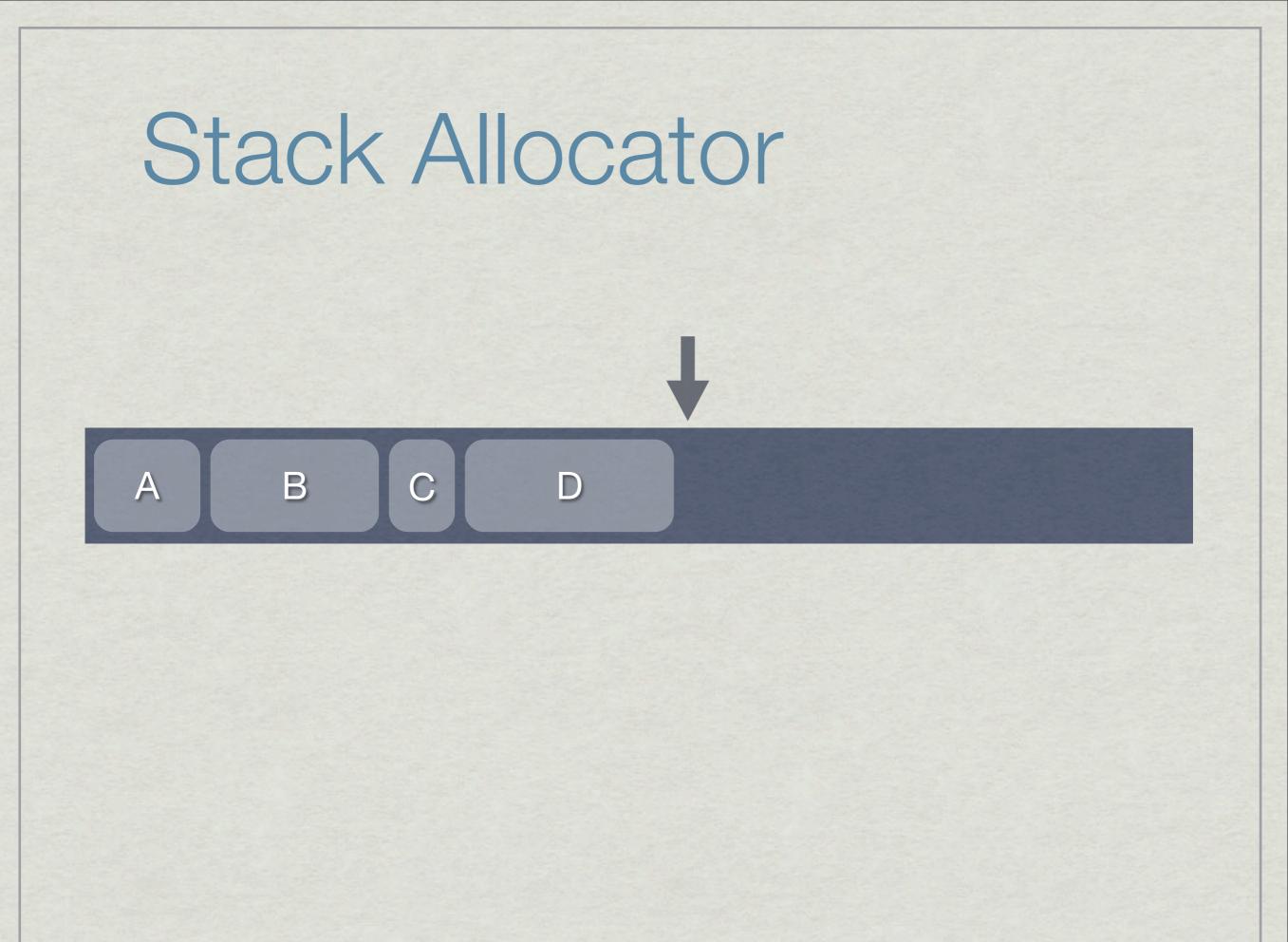


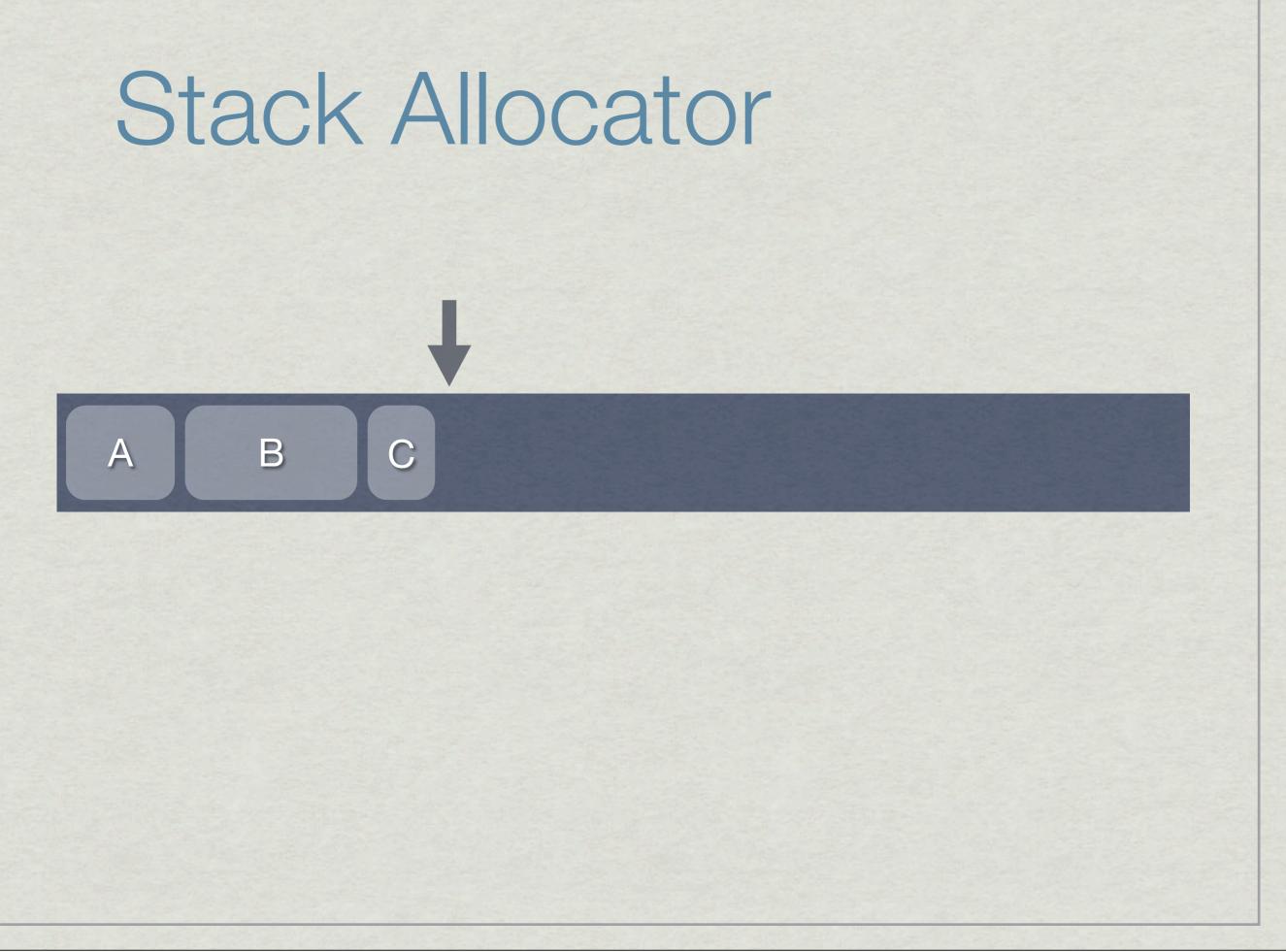




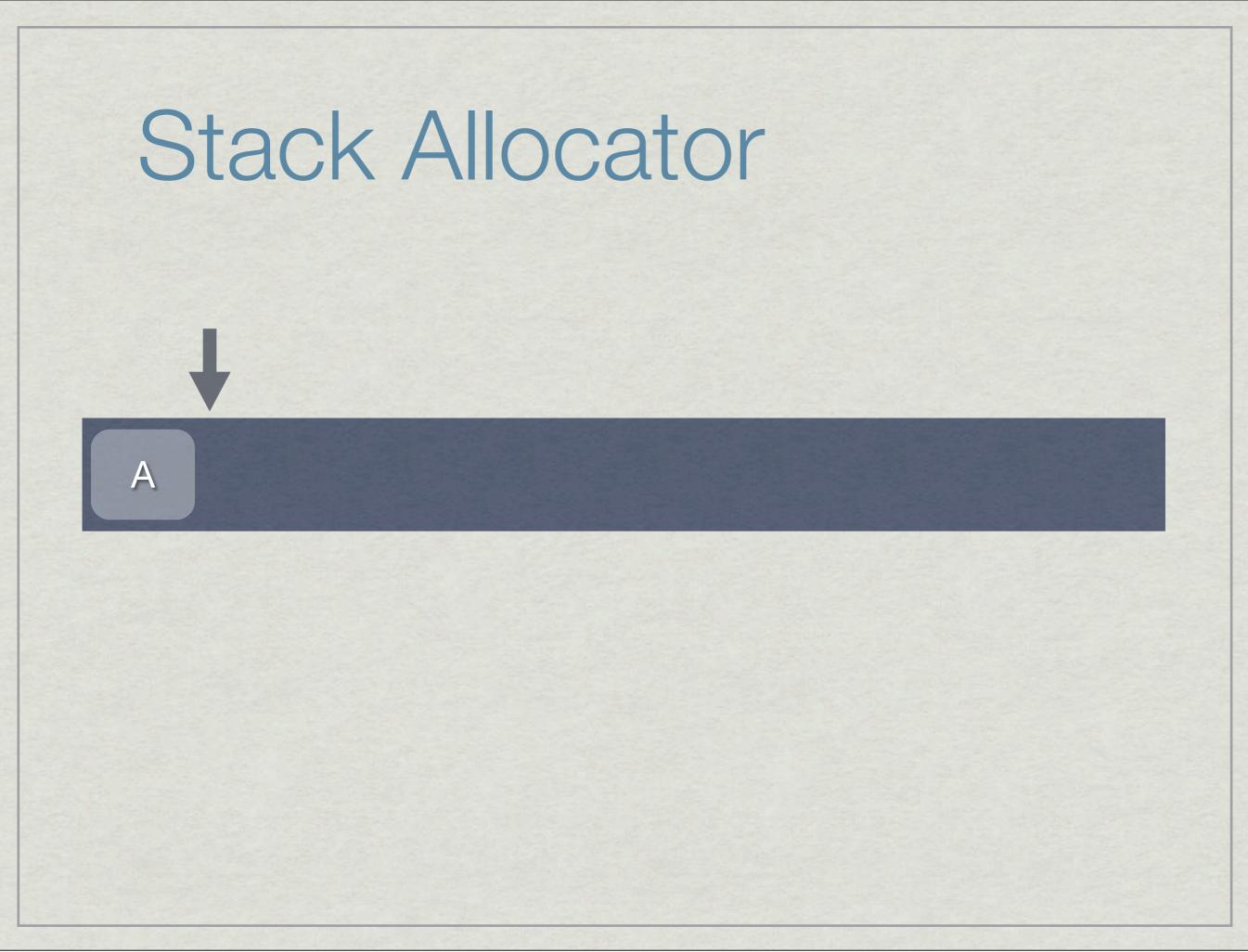


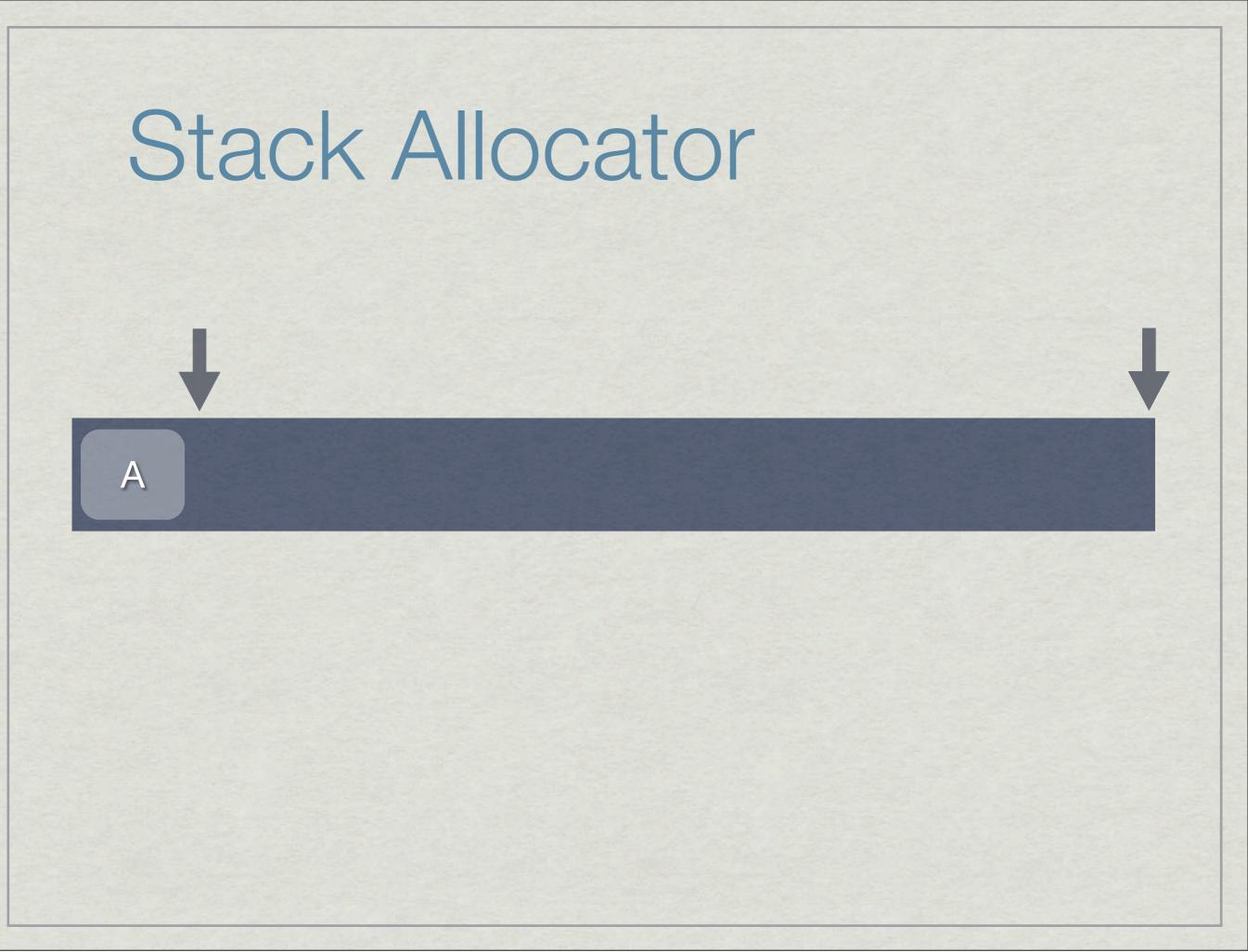


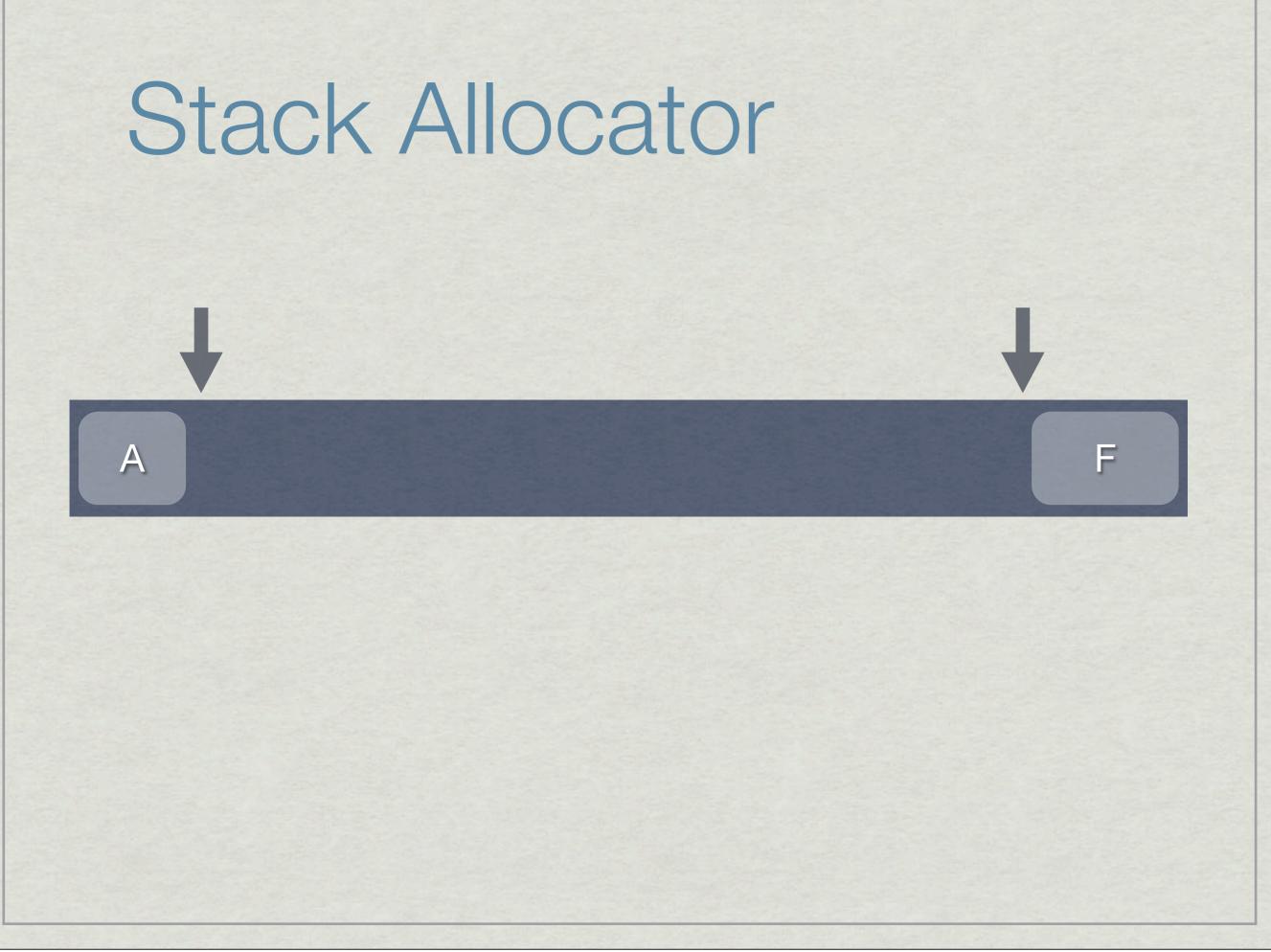


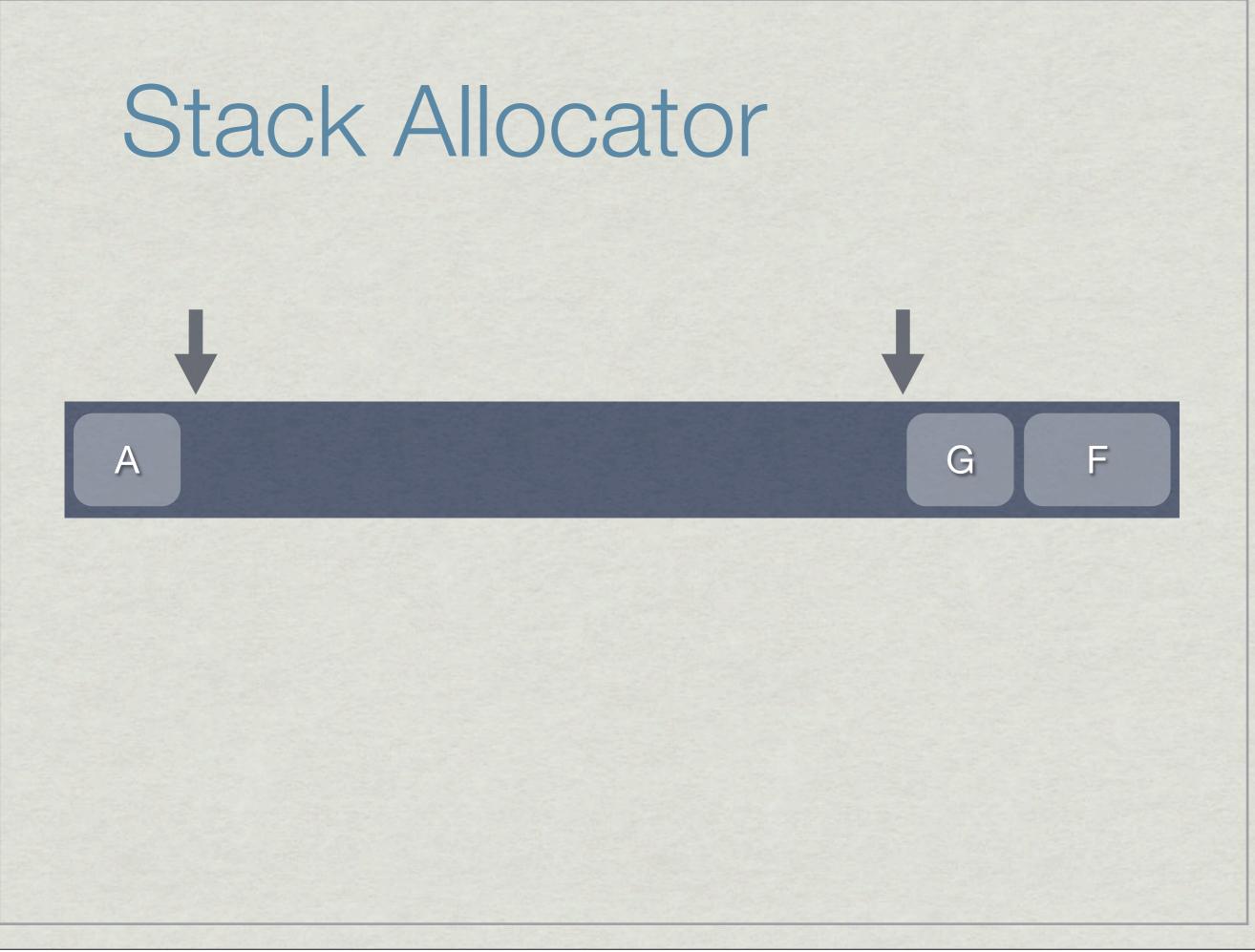








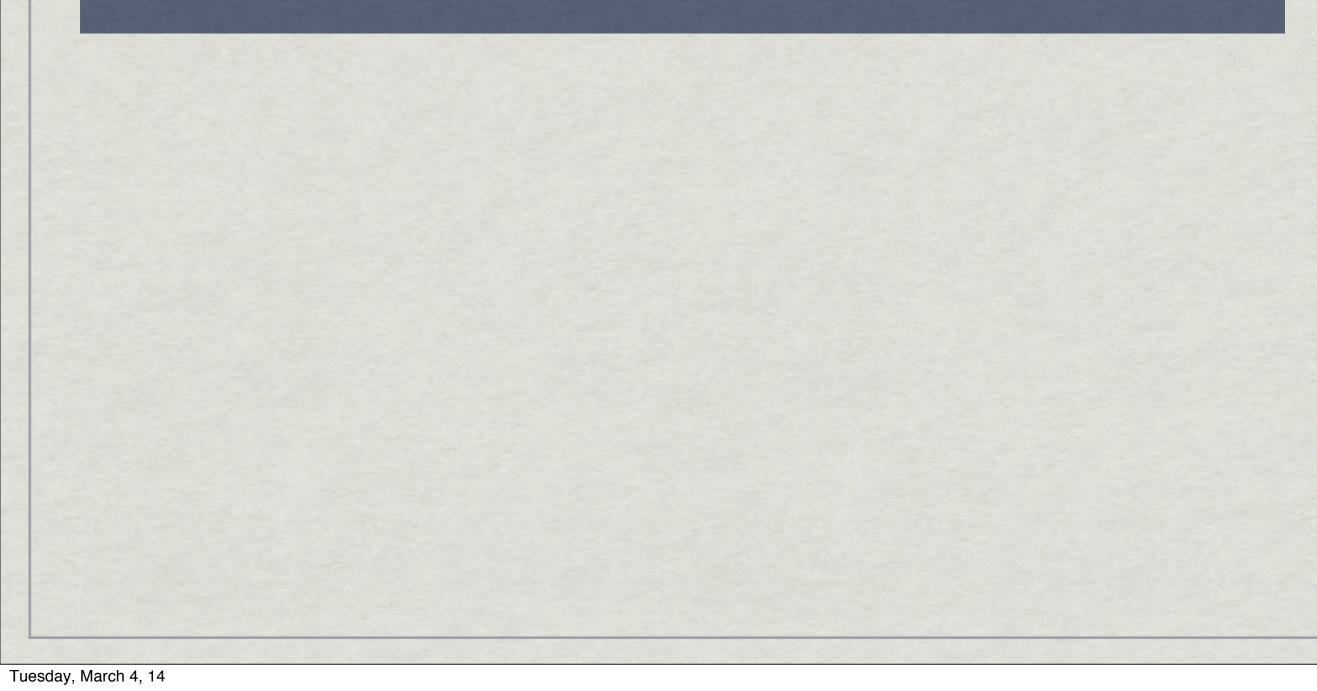


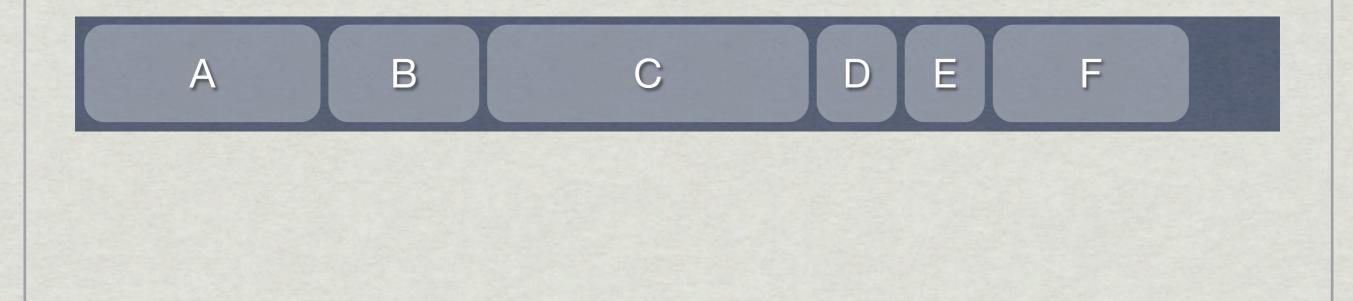


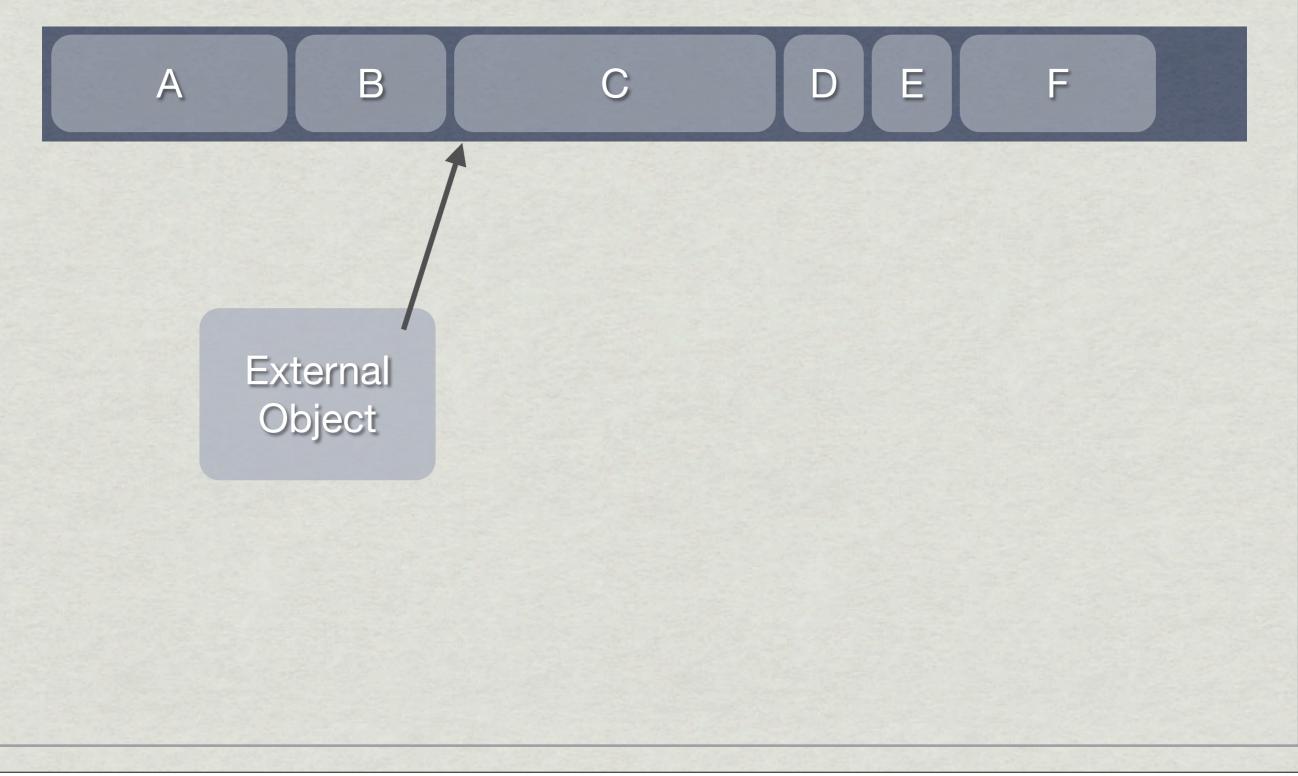


NO FRAGMENTATION (AS LONG AS WE ALWAYS FREE IN <u>REVERSE</u> ORDER)

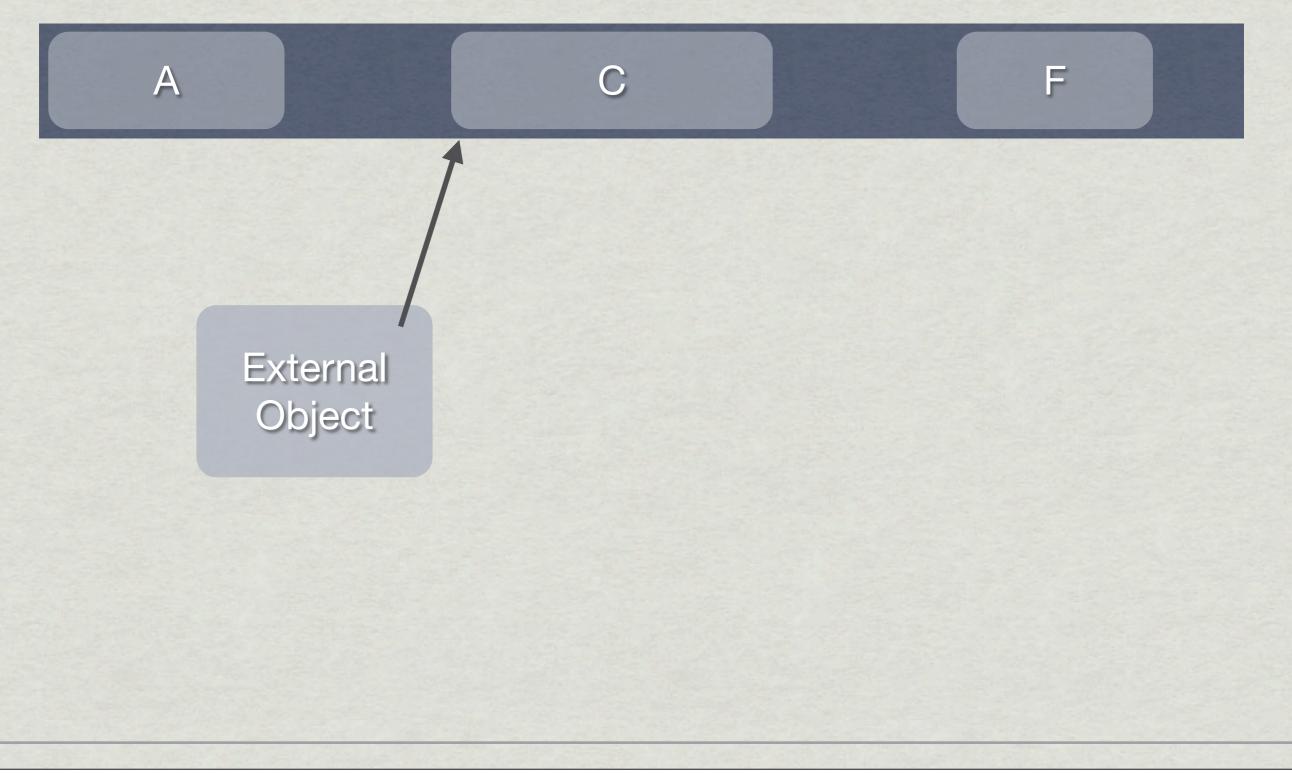
Tuesday, March 4, 14

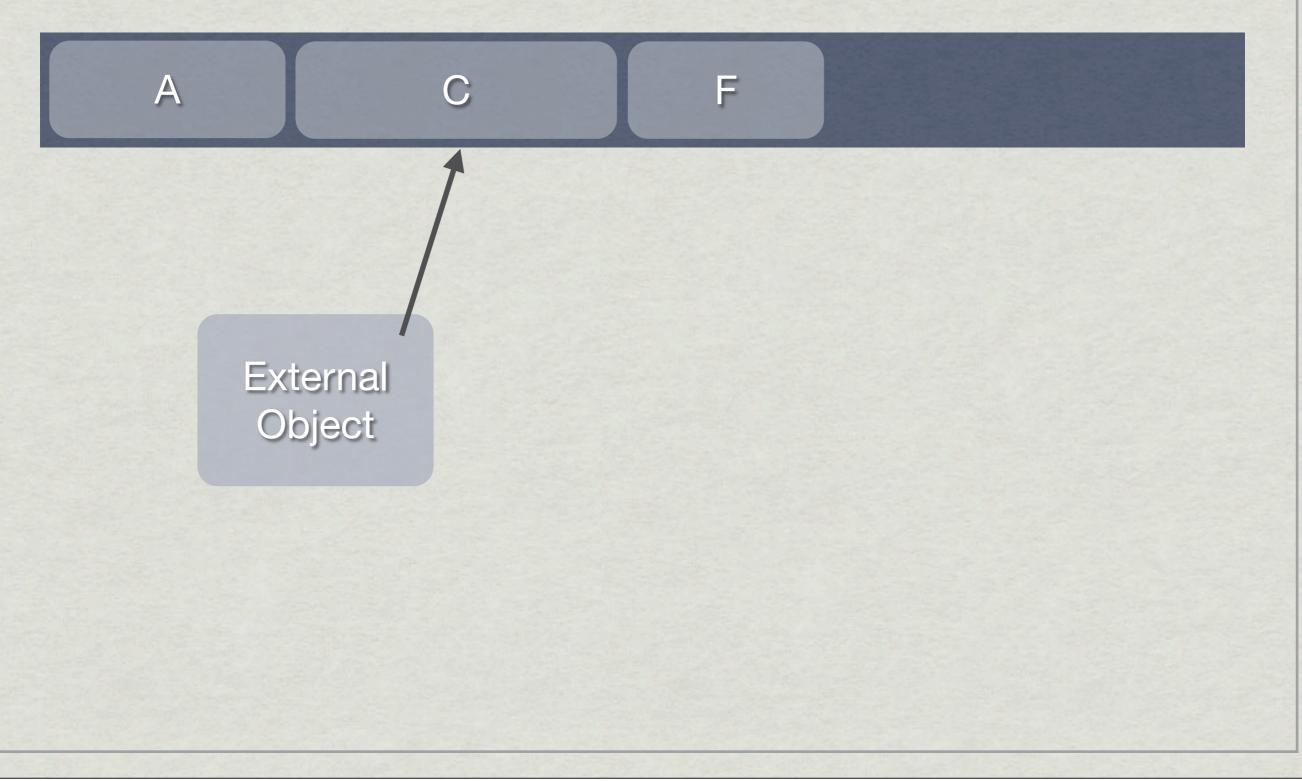


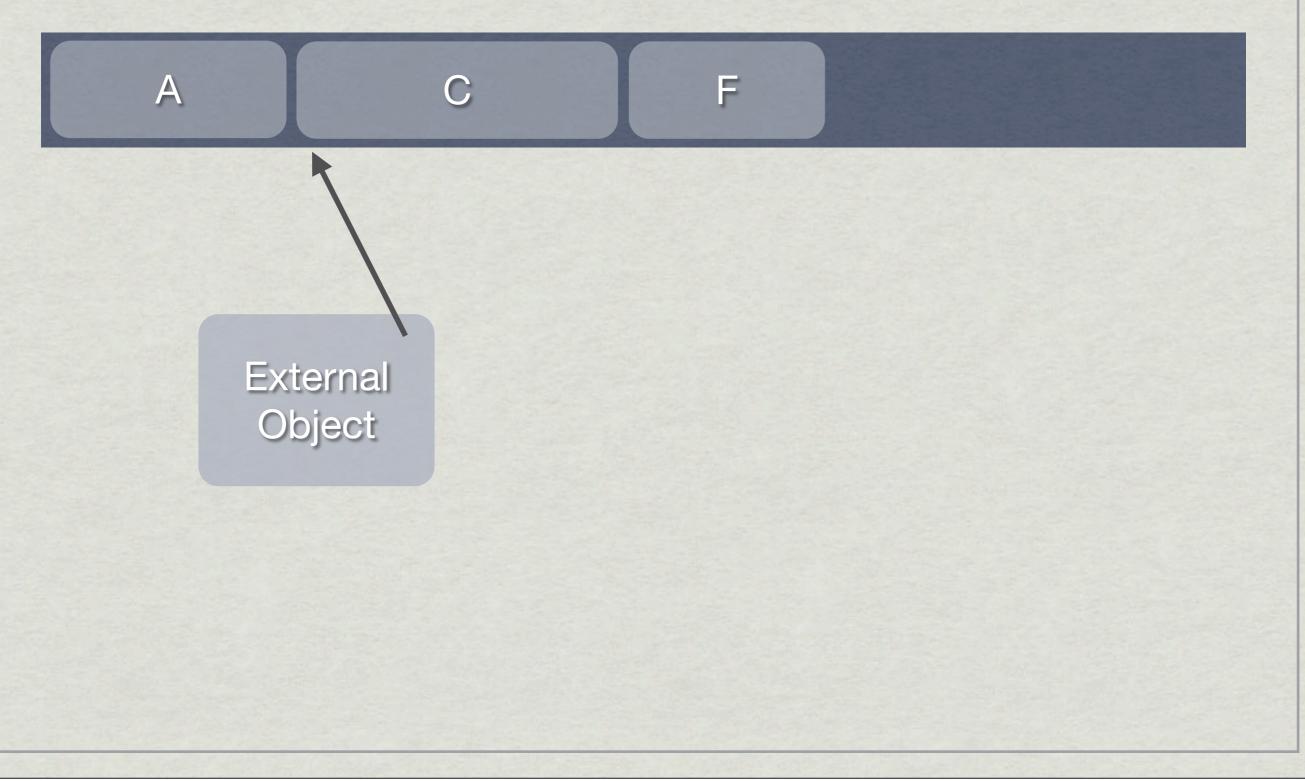




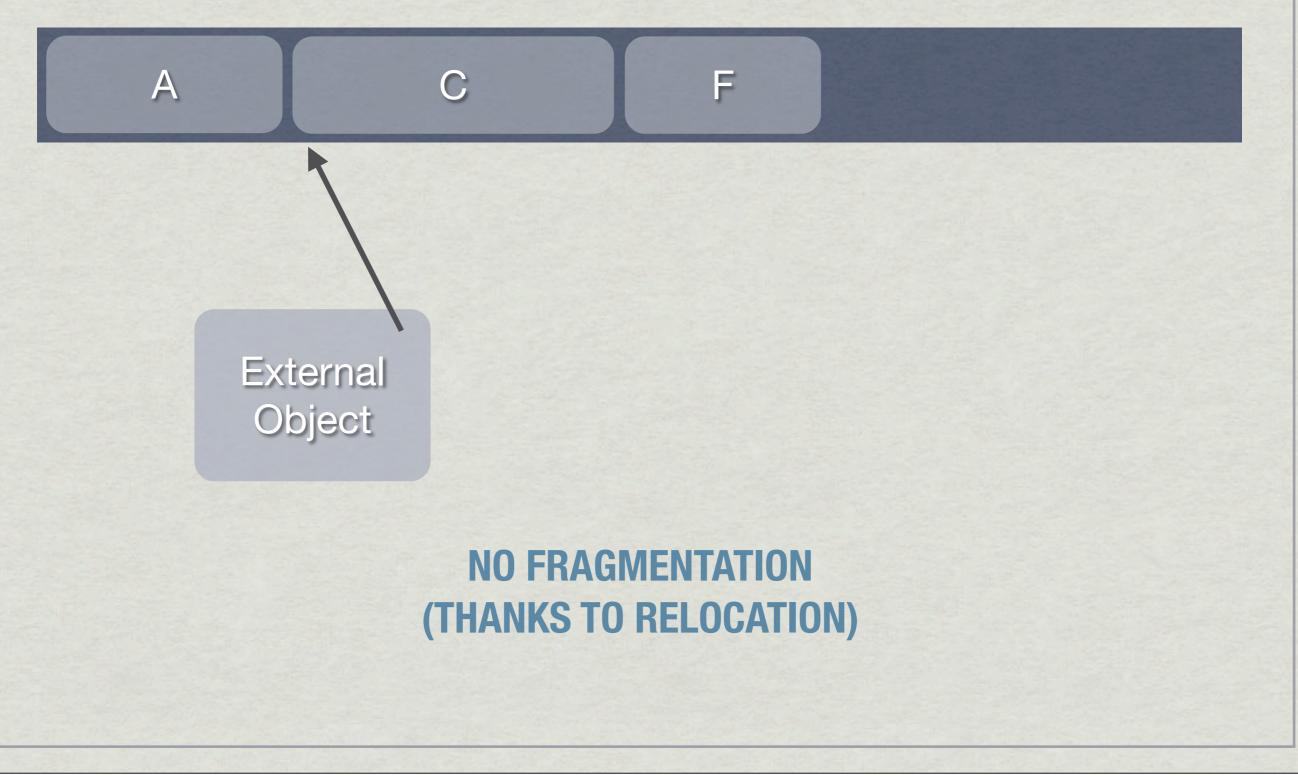
Tuesday, March 4, 14







Relocatable Heap



Mapping Your Memory

We employ an explicit memory map to manage and track our allocations

```
MemoryMapEntry g_memoryMap[] = {
    {       GLOBAL, SYSTEM, SIZE_MB(256) },
      {      VRAM, SYSTEM, SIZE_MB(256) },
      {      DEBUG_GLOBAL, SYSTEM, SIZE_MB(128} },
      {      DEBUG_VRAM, SYSTEM, SIZE_MB(128} },
      // GLOBAL allocators
      {      PHYSICS, GLOBAL, SIZE_MB(5) },
      {      OBJECTS, GLOBAL, SIZE_MB(32) },
      // ...
};
```

Multicore Hardware

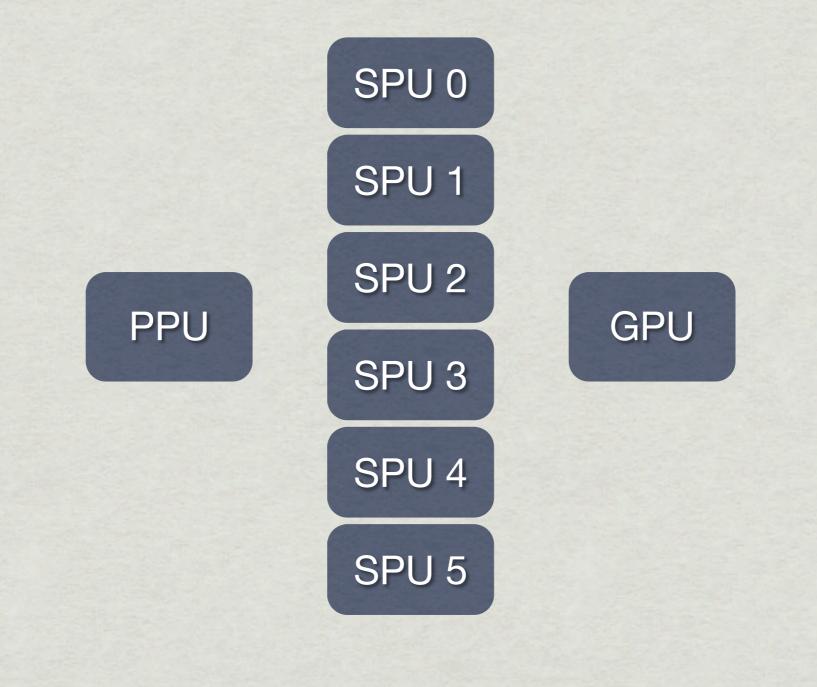
Multicore Hardware

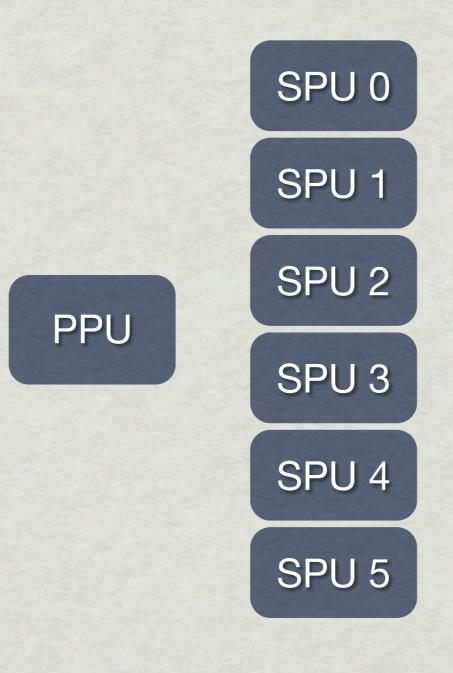
* PS2, PS3 and PS4 are multicore architectures

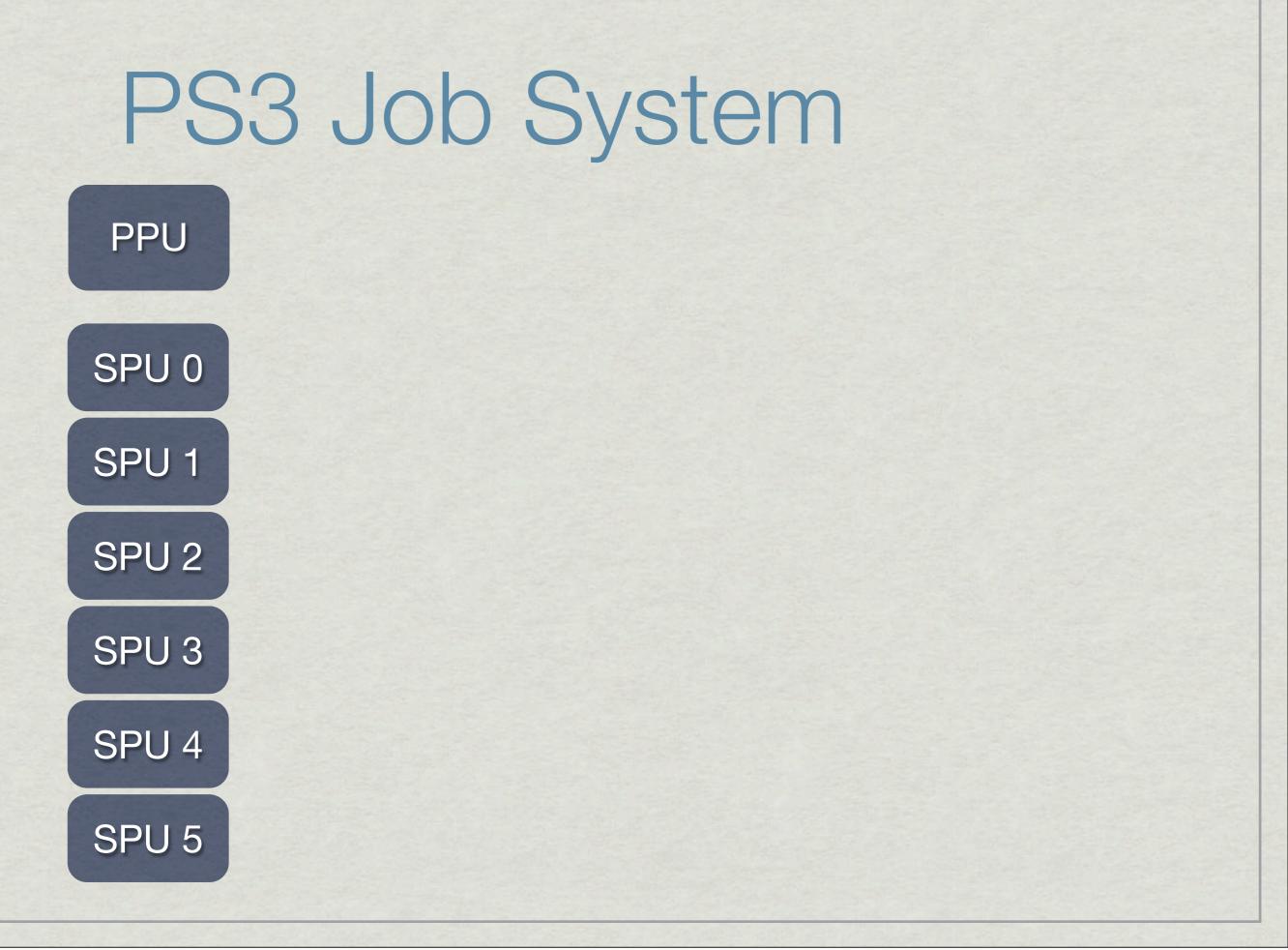
- *** PS3:** one central CPU (PPU) + 6 synergistic processing units (SPUs) + GPU
- *** PS4:** 8 CPU cores organized into two clusters + GPU with powerful general-purpose compute engine
- * Crucial to take full advantage of all processing resources!

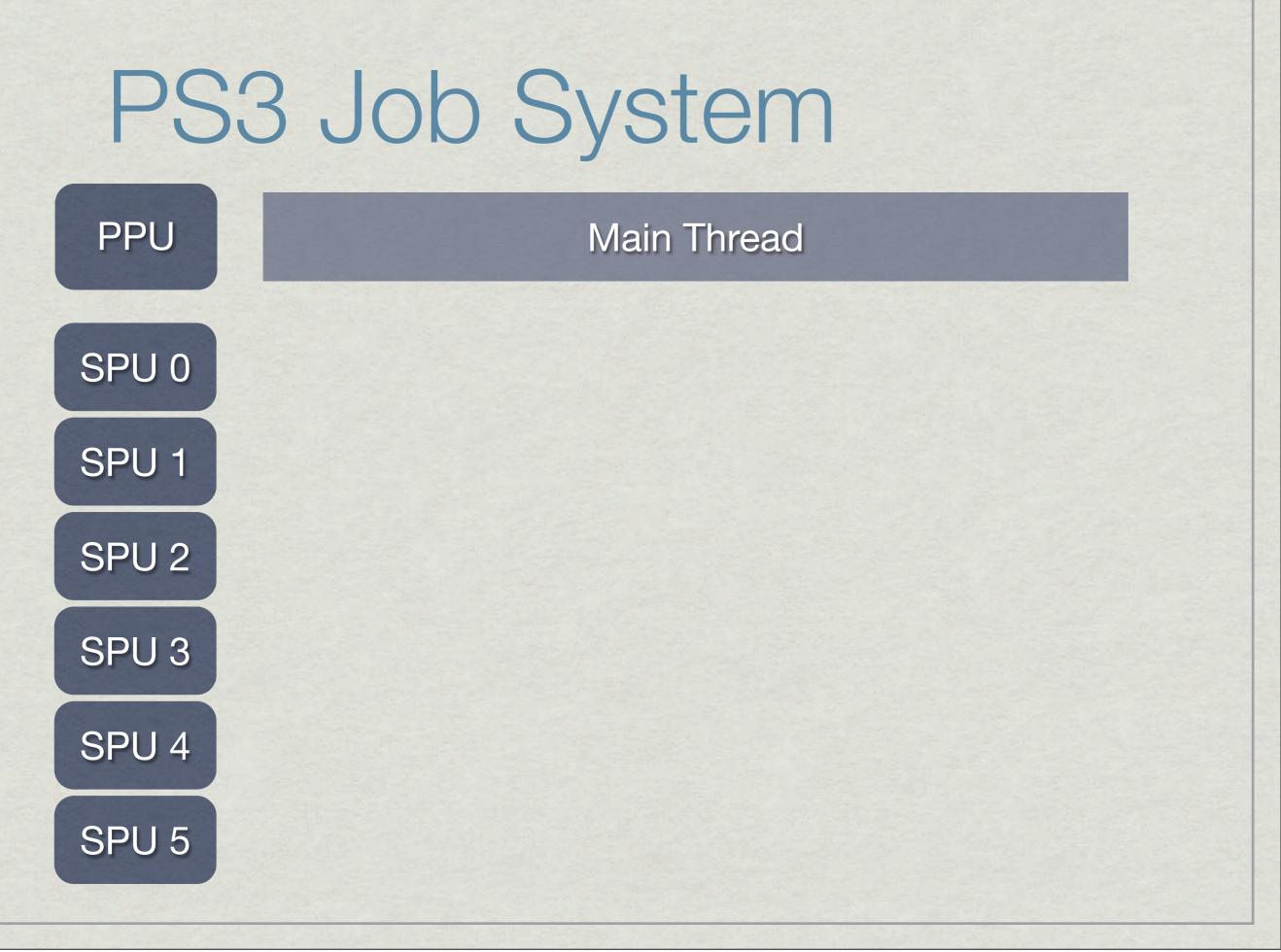
Multicore: Job System

- * On PS3, we developed a highly efficient job system in conjunction with the ICE team
 - *** Job** = input, scratch, and output **buffer**(s) + code
 - * Jobs are kicked by the PPU (or by other jobs) and scheduled to run on the SPUs
 - *** Gather** results of job(s) later in this frame, or during the next frame
 - * Fairly granular -- thousands of jobs / frame



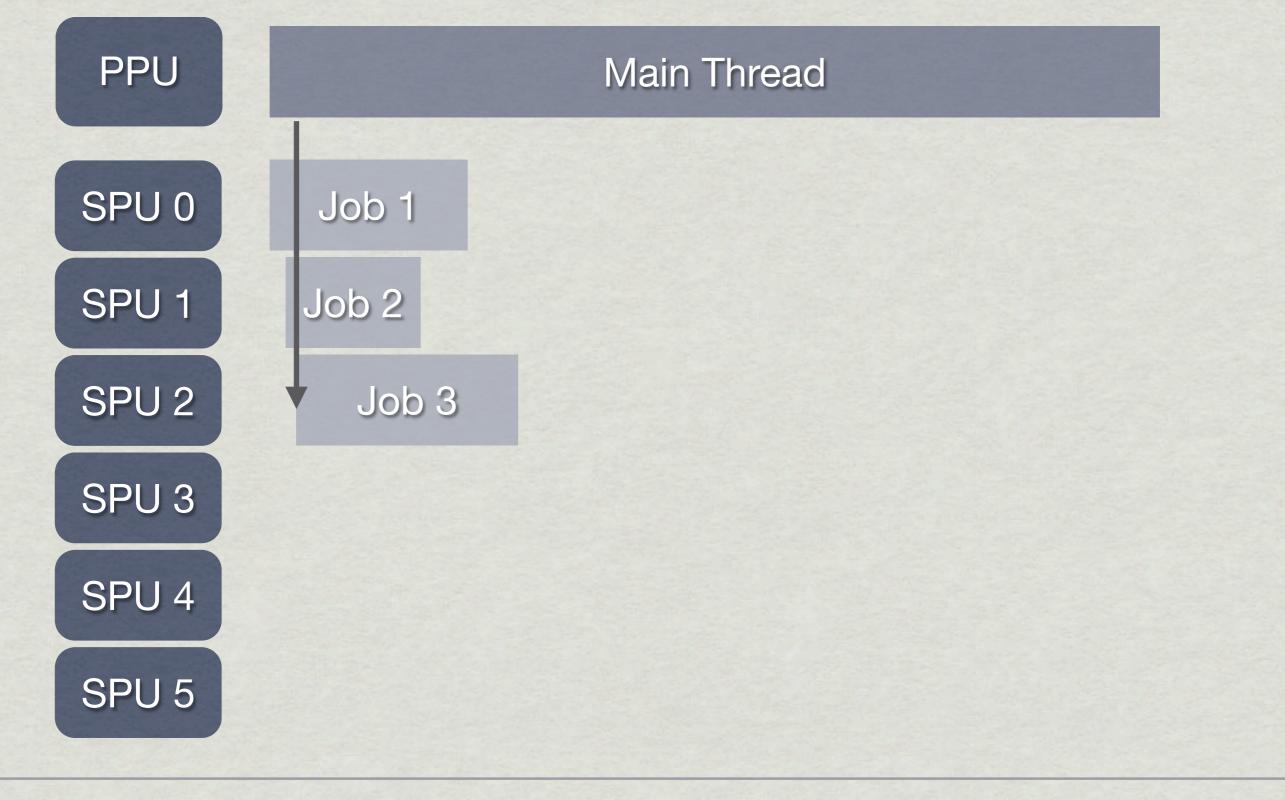




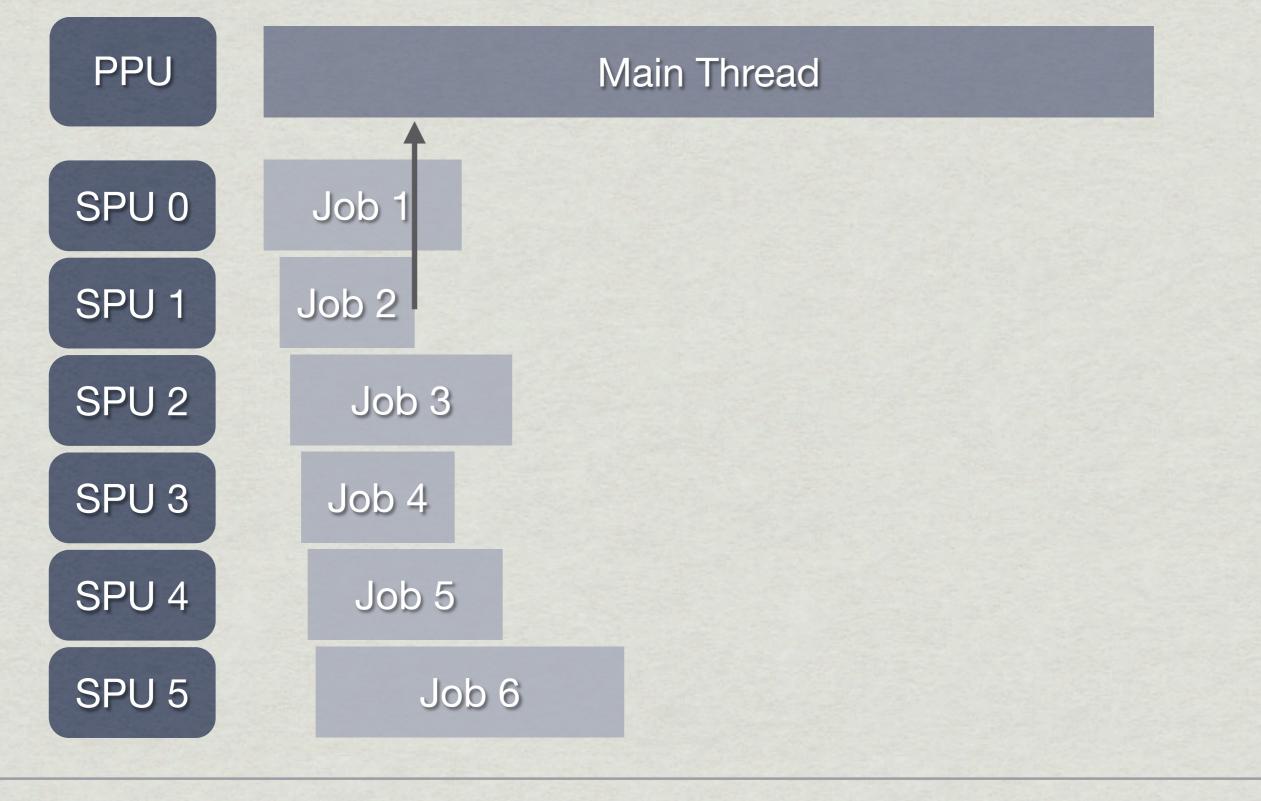








PPU	Main Thread					
SPU 0	Job 1					
SPU 1	Job 2					
SPU 2	Job 3					
SPU 3	Job 4					
SPU 4	Job 5					
SPU 5	Job 6					

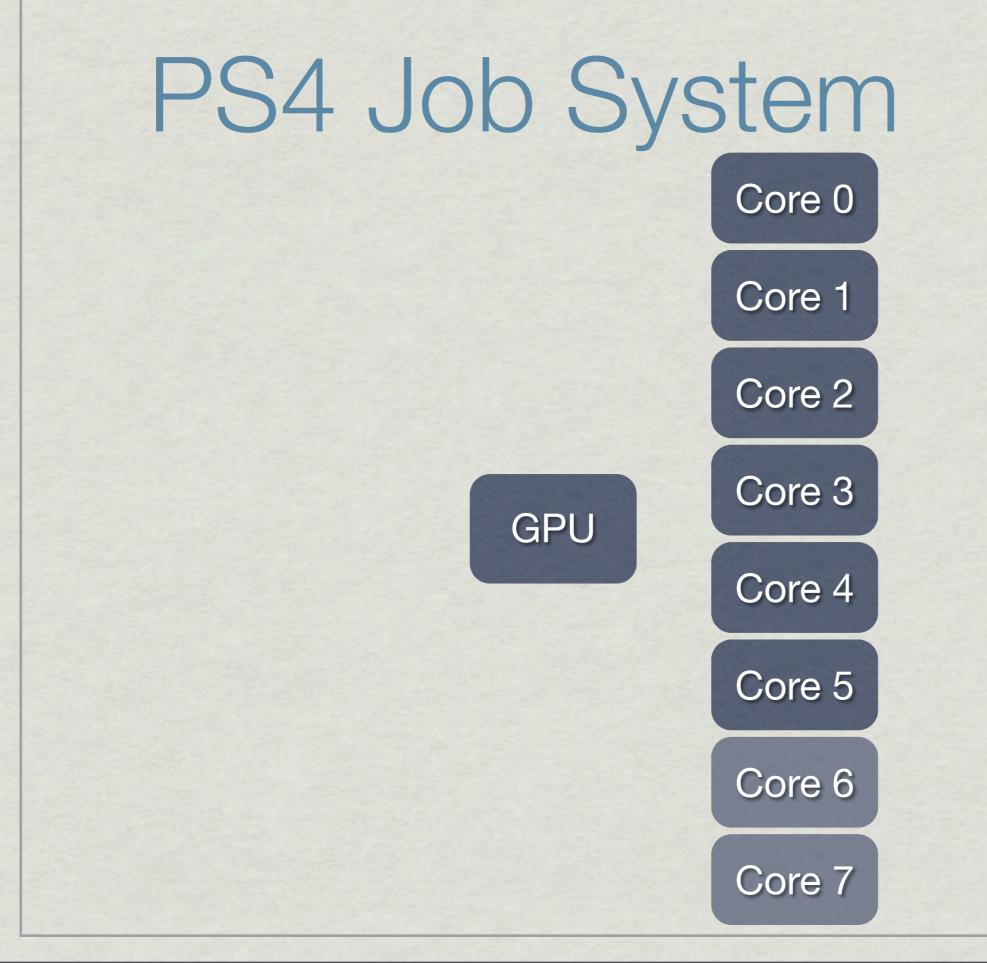


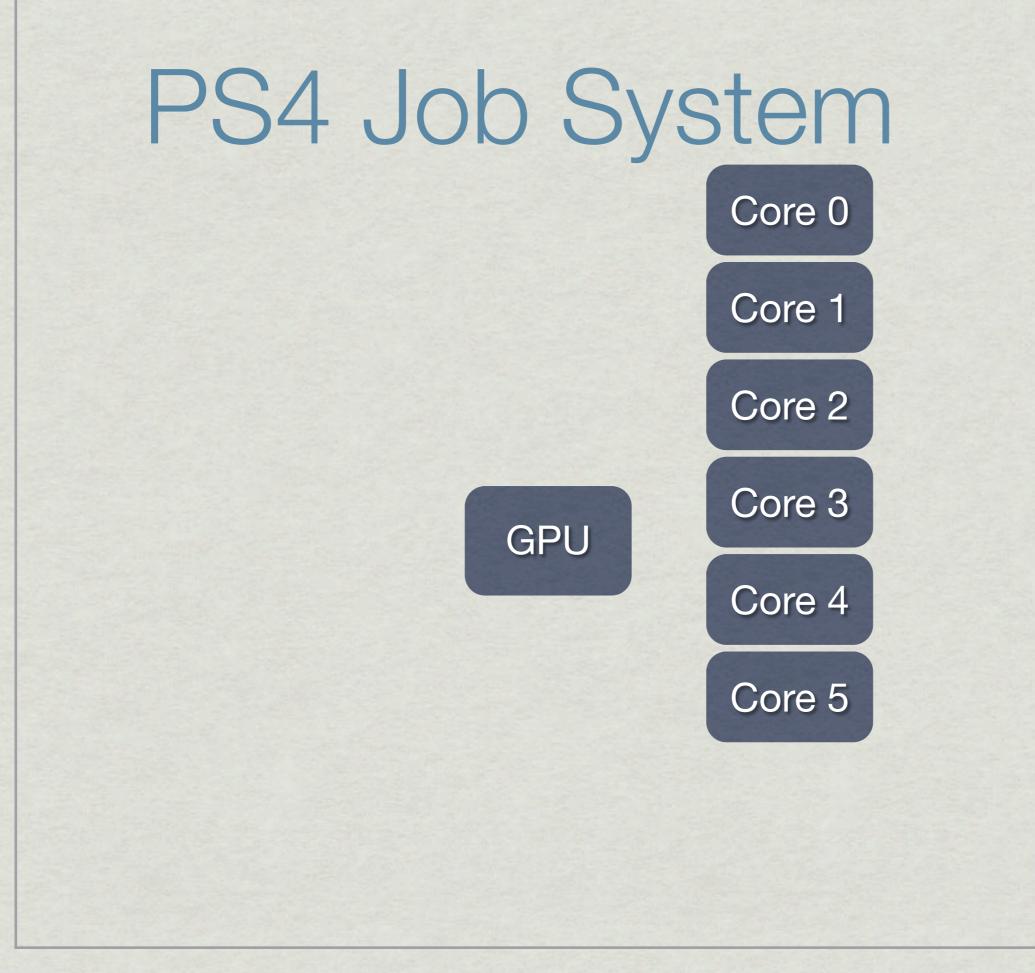
SPU 0 Job 1 SPU 1 Job 2 Job 7 SPU 2 Job 3 SPU 3 Job 4 SPU 4 Job 5 SPU 5 Job 6	PPU	Main Thread					
SPU 2Job 3SPU 3Job 4SPU 4Job 5	SPU 0	Job 1					
SPU 3Job 4SPU 4Job 5	SPU 1	Job 2 Job 7					
SPU 4 Job 5	SPU 2	Job 3					
	SPU 3	Job 4					
SPU 5 Job 6	SPU 4	Job 5					
	SPU 5	Job 6					

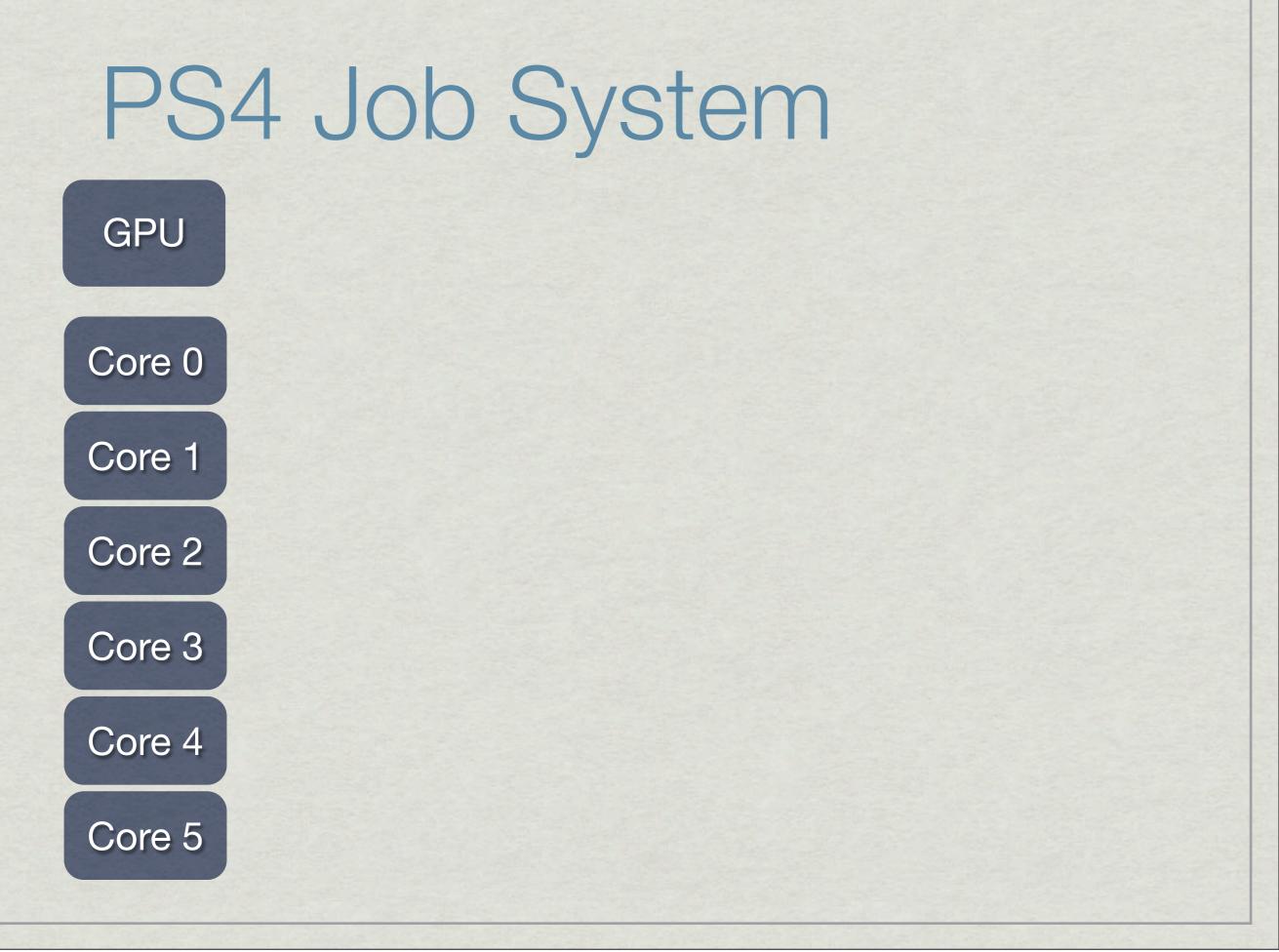
PPU	Main Thread							
SPU 0	Job 1	Job 1 Job 1			0 Job 13			
SPU 1	Job 2	Job 7	Job 7 Job 14		Job 15			
SPU 2	Job 3	Job 3				Job 21		
SPU 3	Job 4	Job 8	Job 8 Job 12		Job		16	
SPU 4	Job 5	Job 5 Jo			Job 17			
SPU 5	J	Job 6			Job 1	9 J	ob 20	

Multicore: Job System

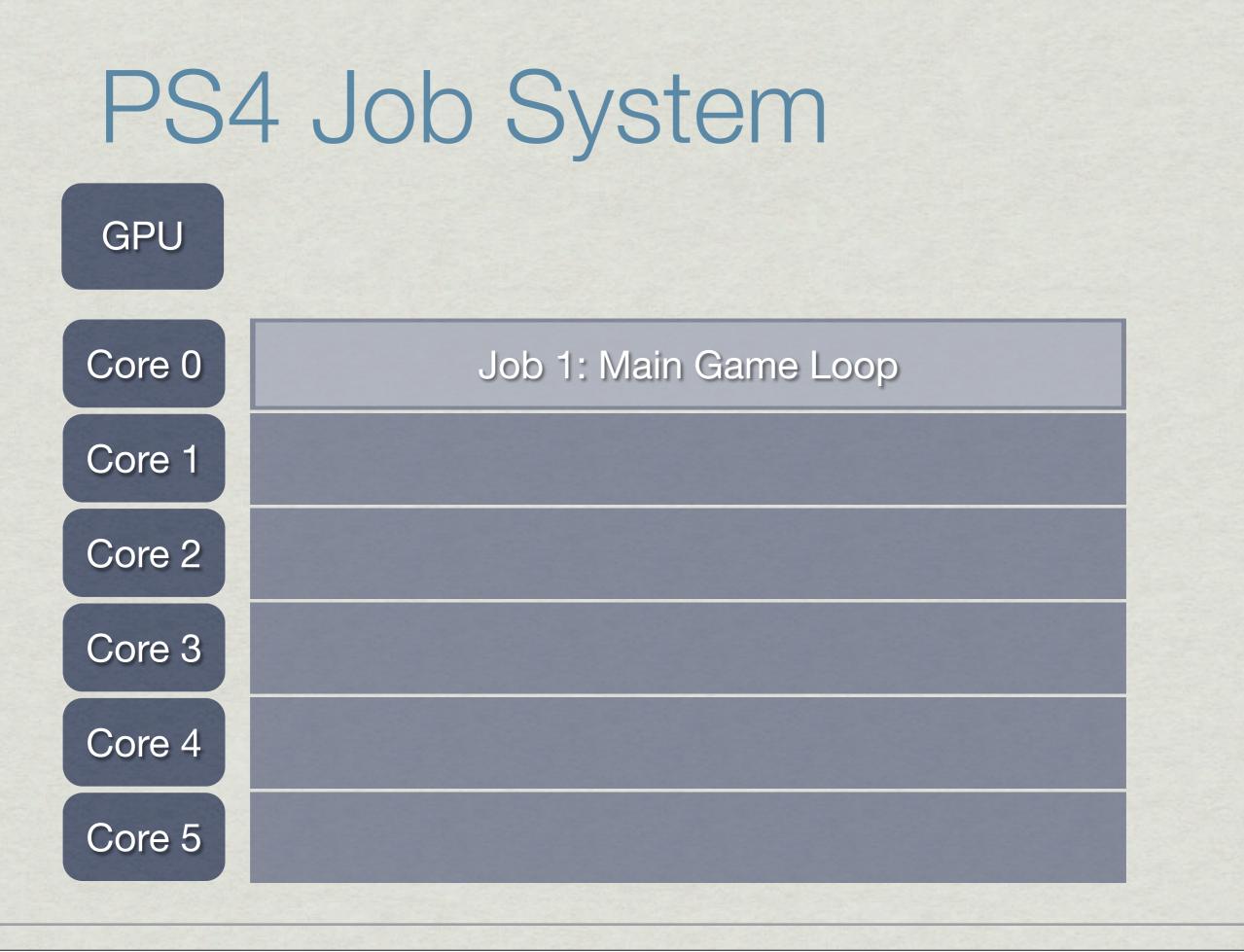
- * On PS4 we implemented a new job system
 * Similar concept to SPU job system on PS3
 * 6 CPUs, 6 worker threads
 - * Jobs are kicked, picked up by available worker
 - * Each job acts like a lightweight fiber
 - *** Shared memory**, but can retain input, scratch and output buffer(s) for legacy code migration

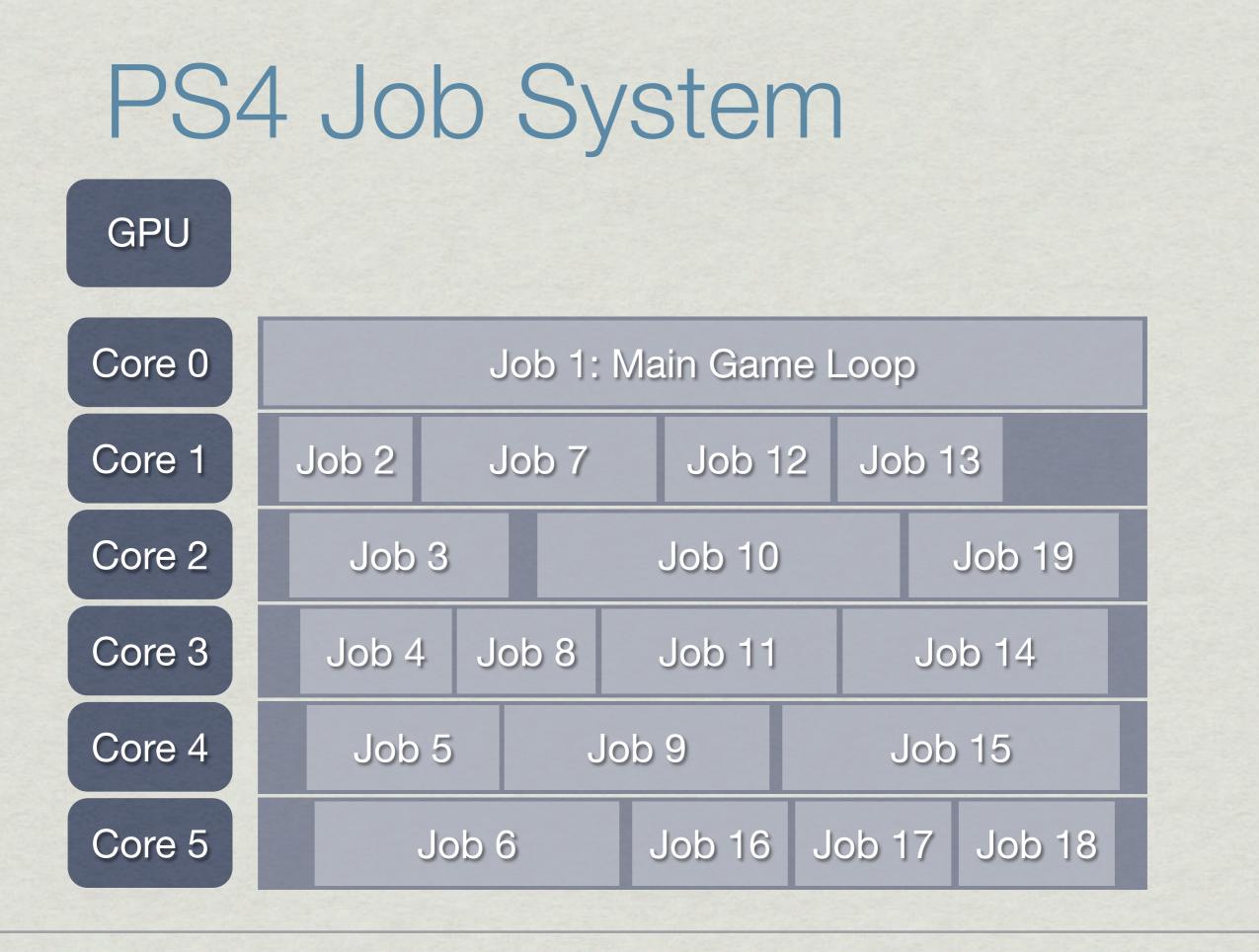






PS4 Job System					
GPU					
Core 0	Worker Thread 0				
Core 1	Worker Thread 1				
Core 2	Worker Thread 2				
Core 3	Worker Thread 3				
Core 4	Worker Thread 4				
Core 5	Worker Thread 5				



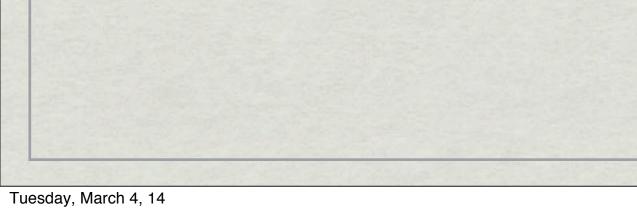


GPU	Rendering + GPGPU Wavefronts									
Core 0	Job 1: Main Game Loop									
Core 1	Job 2	J	ob 7		Job 1	2	Job 13			
Core 2	Job) 3			Job 10			Job 19		
Core 3	Job 4	, Jo	8 do		Job 11 Job 14		14			
Core 4	Job	5	J	ob 9			Job 15			
Core 5	Job 6				lob 16	J	ob 1	7 J	ob 18	

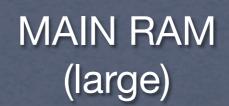
Optimization

Understand Your Hardware

- * The secret to writing highly efficient code is mastery of your hardware (PlayStation1 through PlayStation4)
 - * Memory caching and its implications
 - * Superscalar CPU architecture and pipelining
 - * Branch prediction, data dependencies, load-hit-store, ...
 - * Assembly language downcoding
 - * Optimization of data layouts as well as code

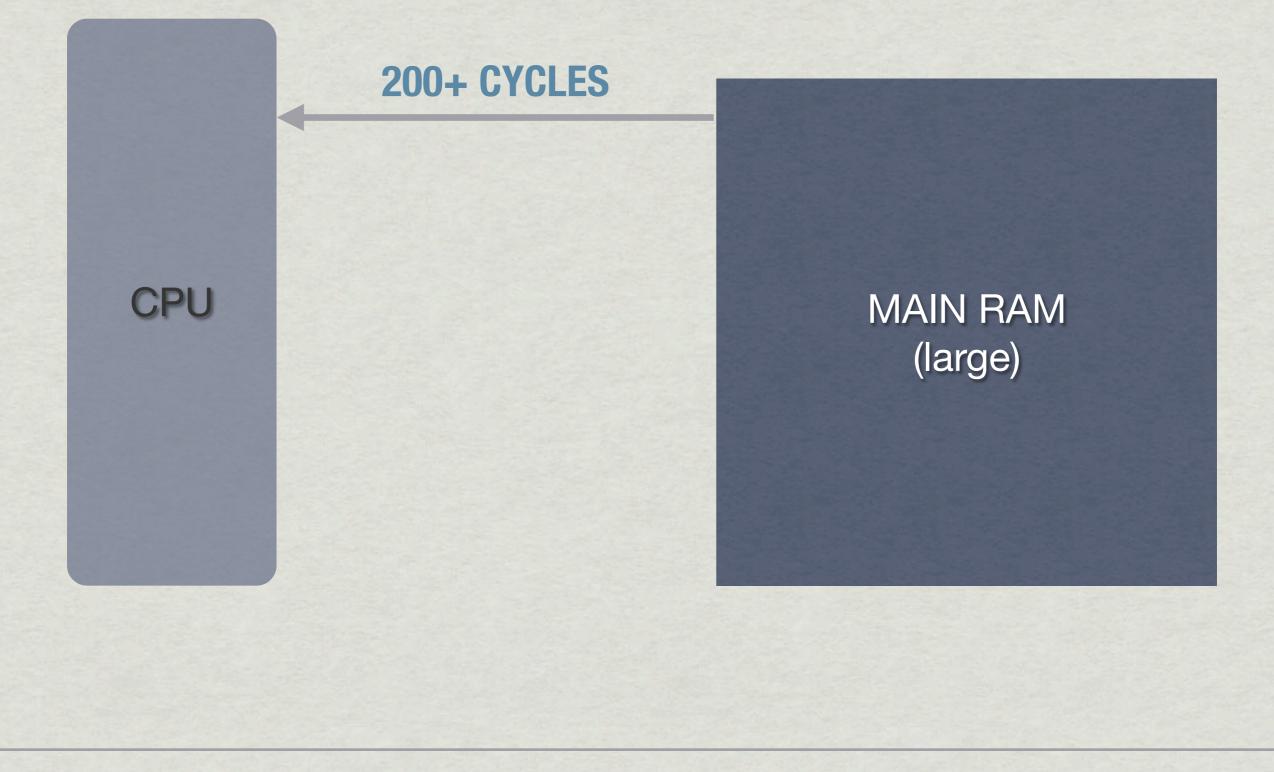


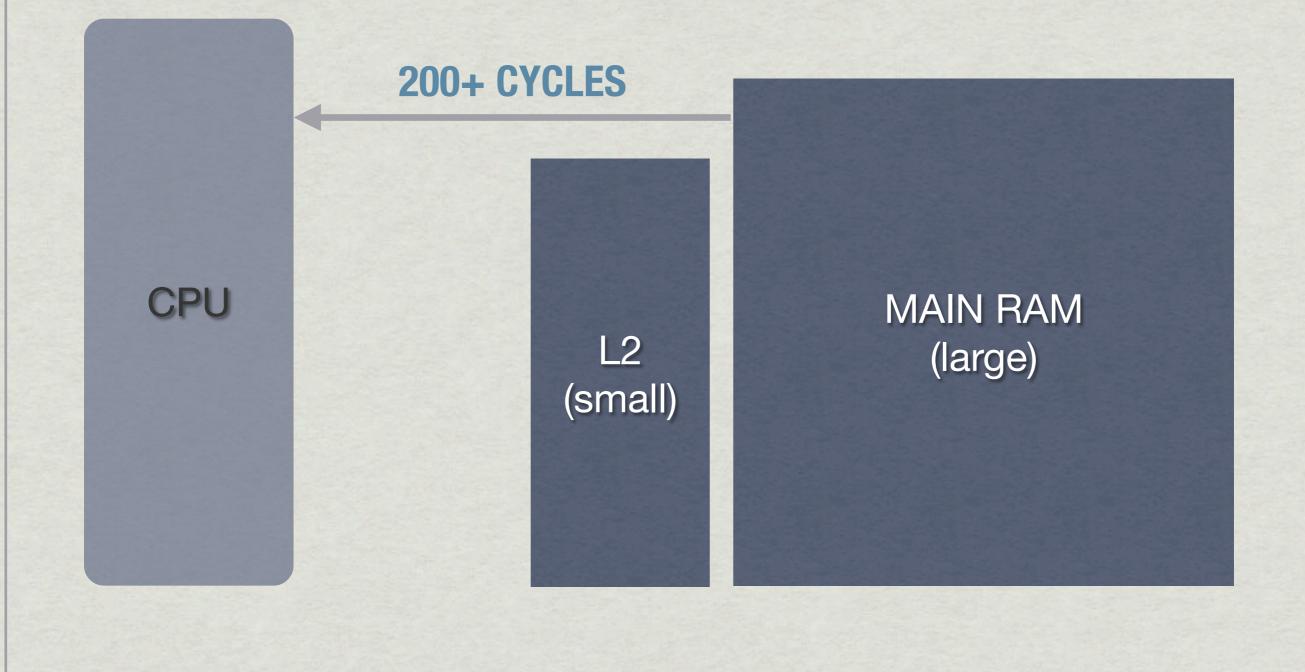
CPU

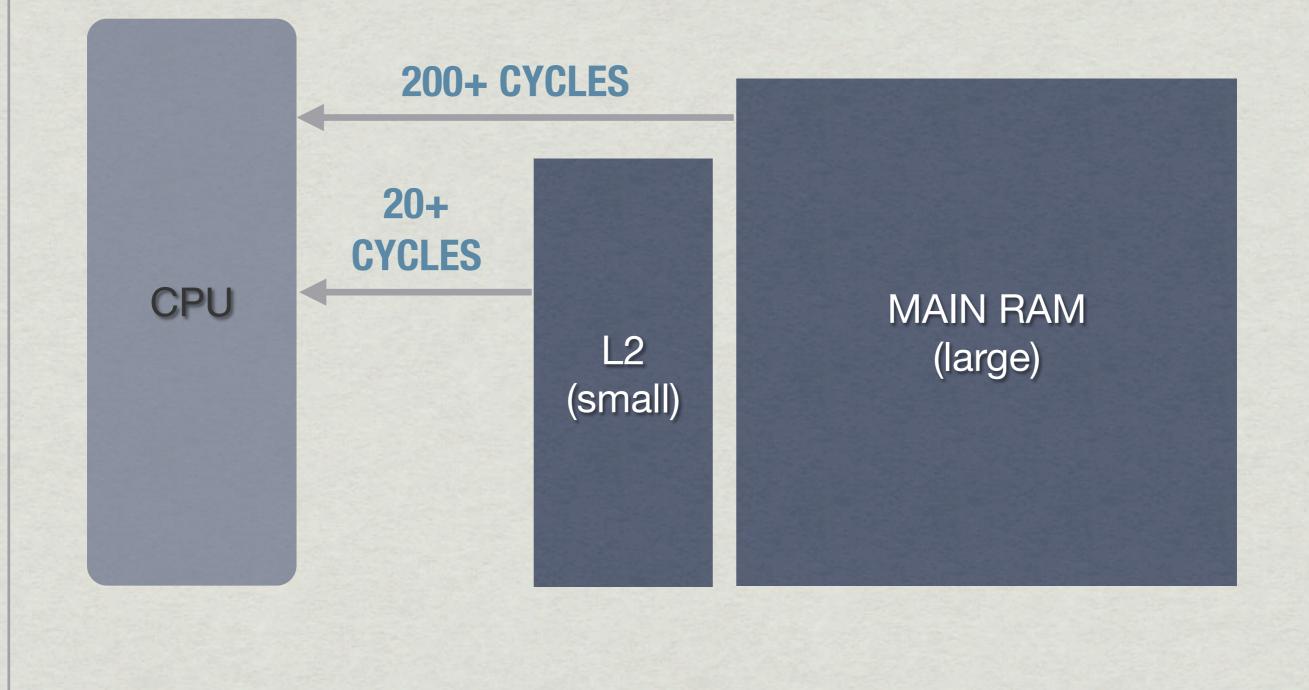


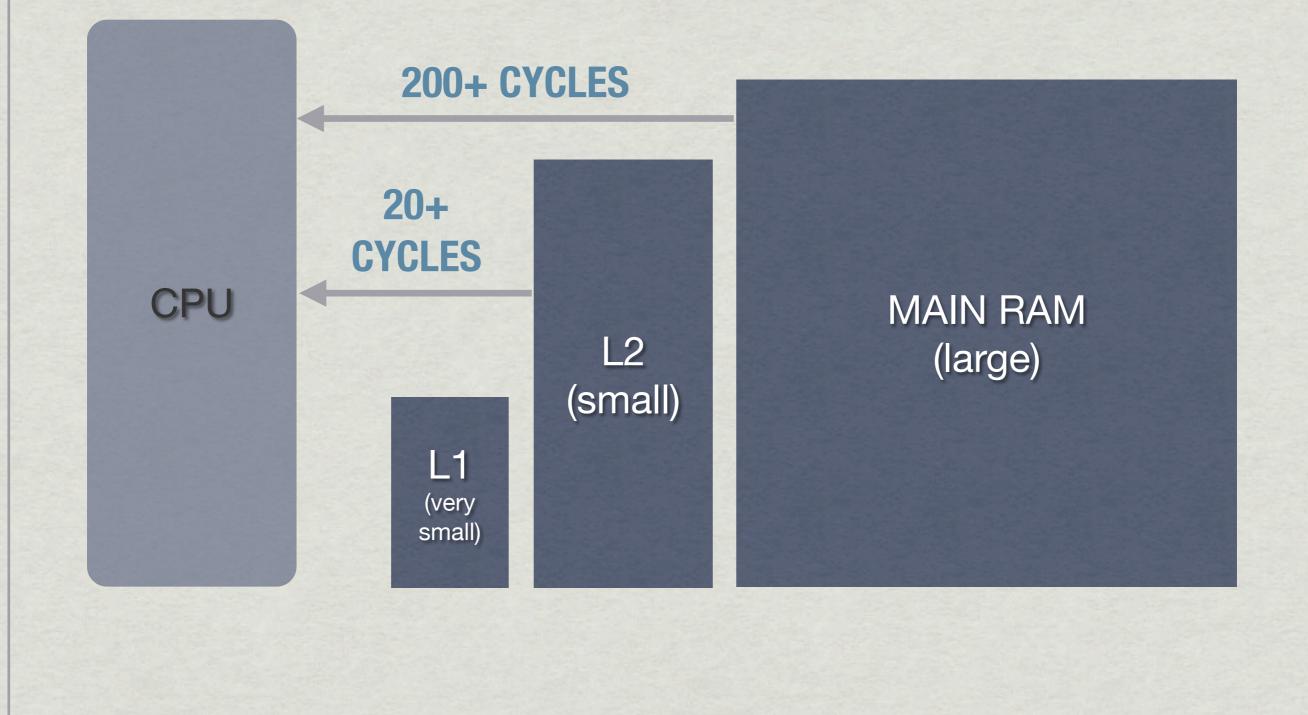
Tuesday, March 4, 14

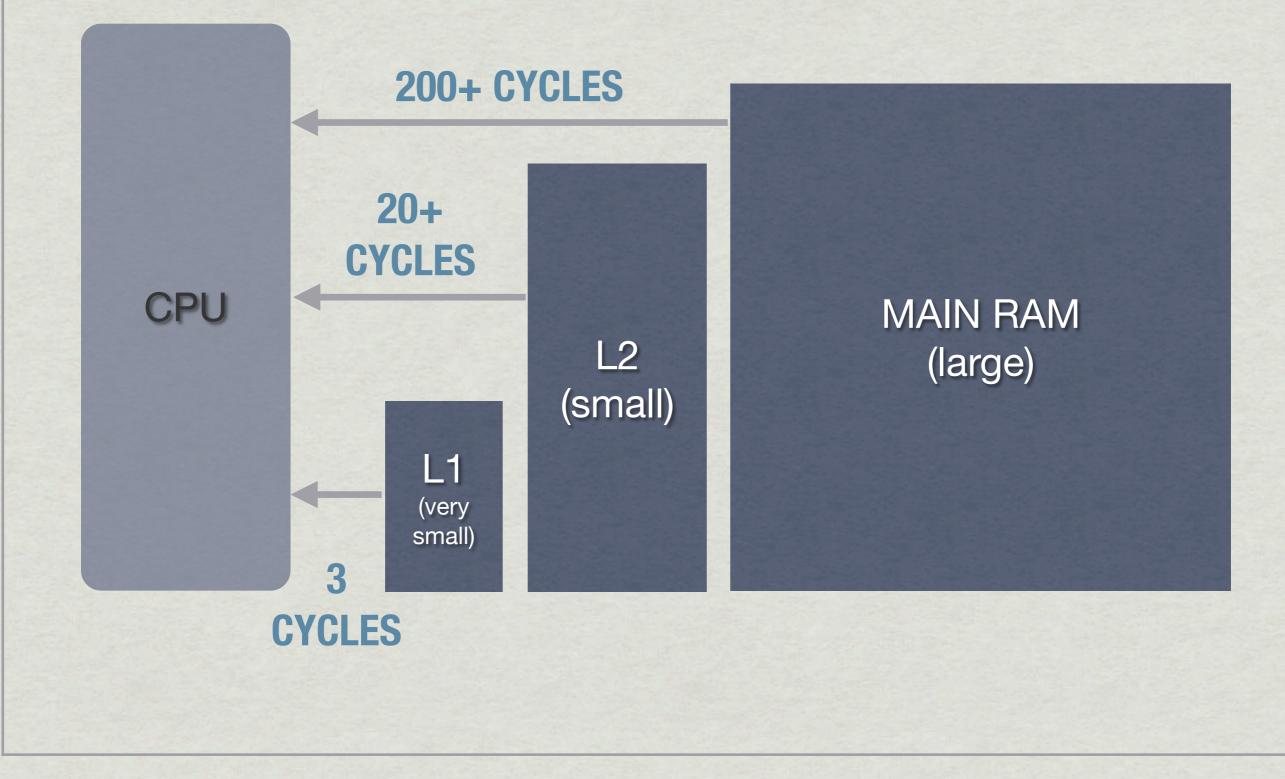
CPU

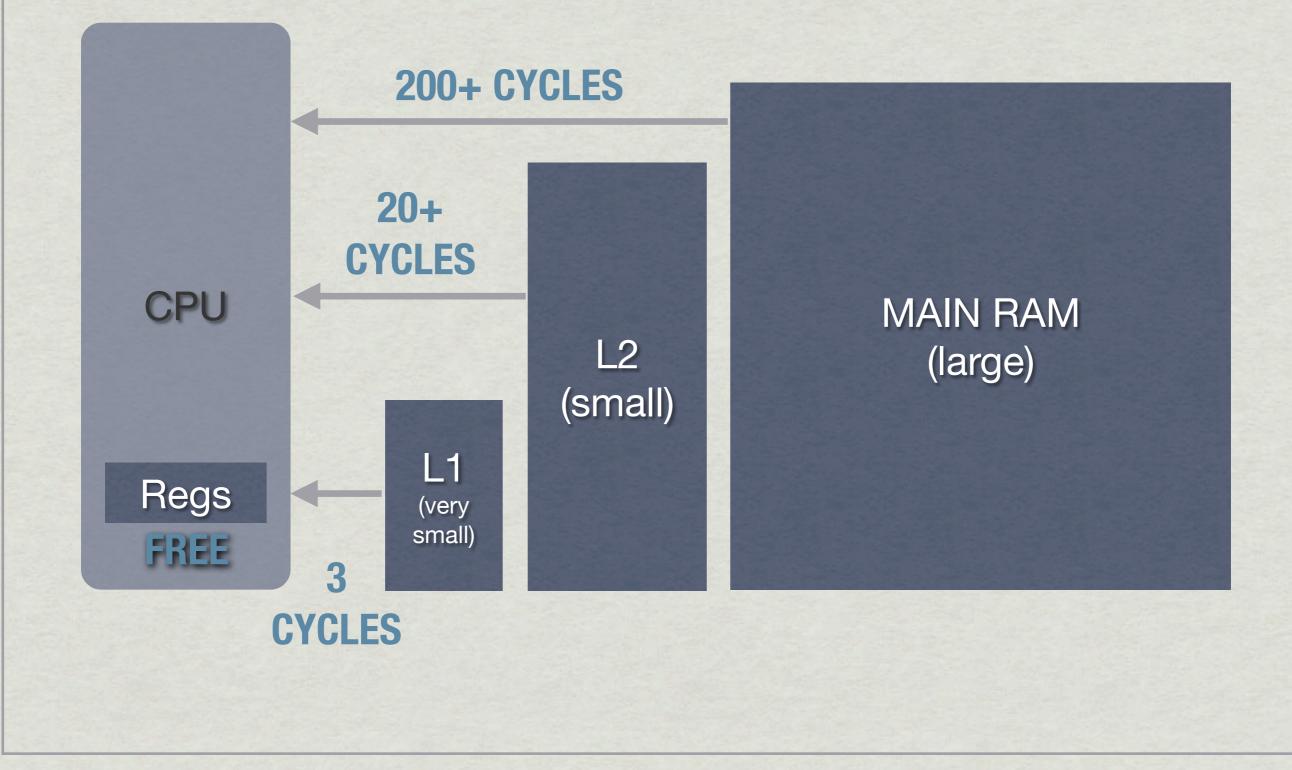


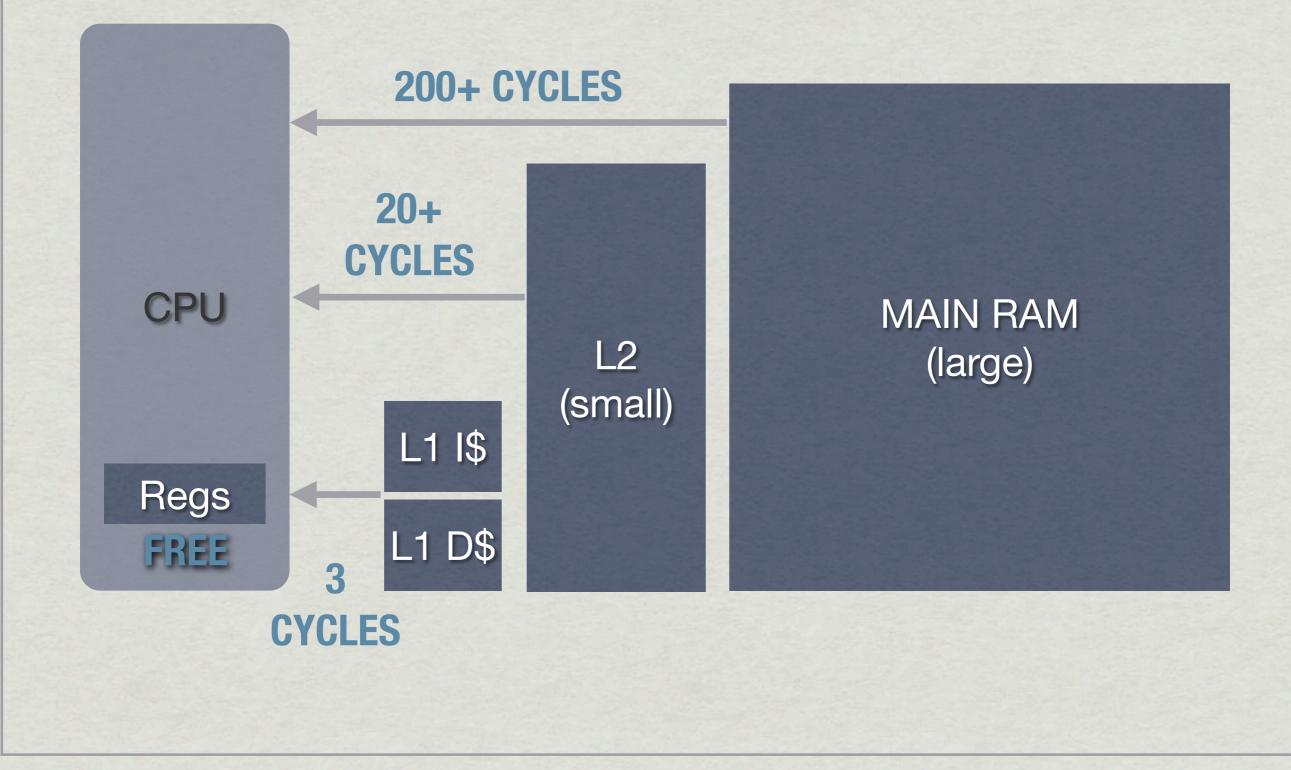








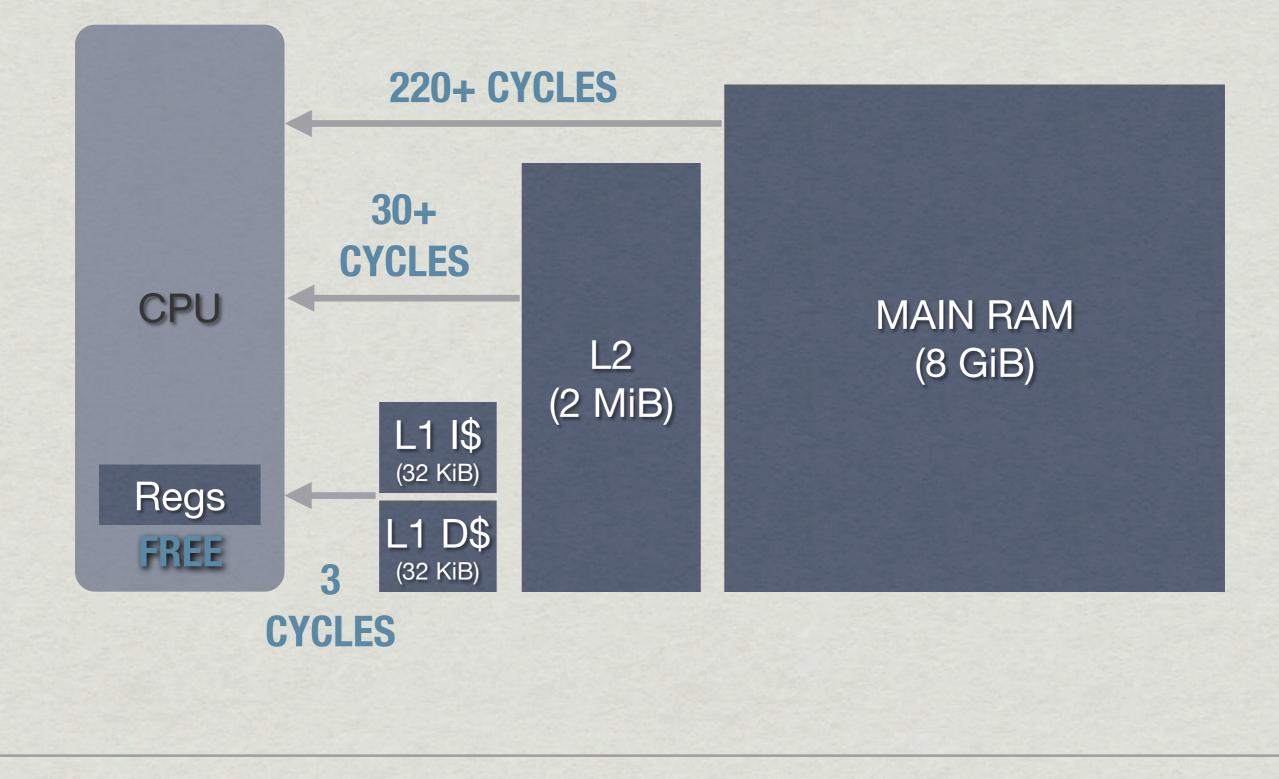


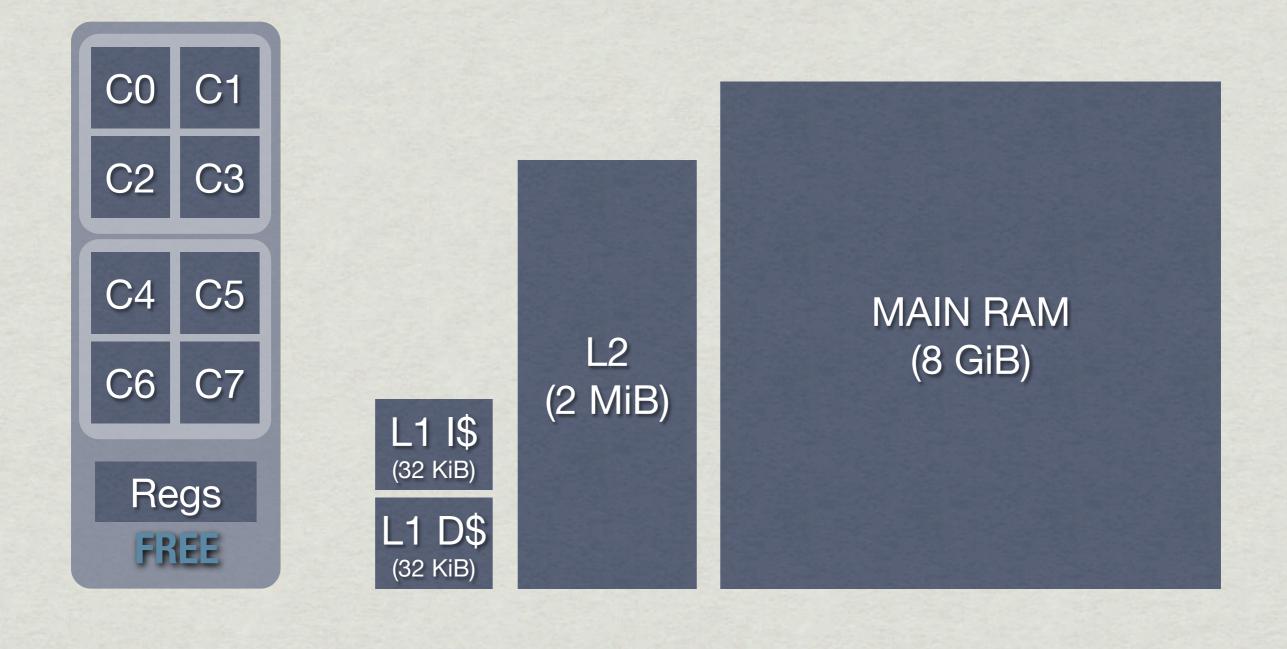


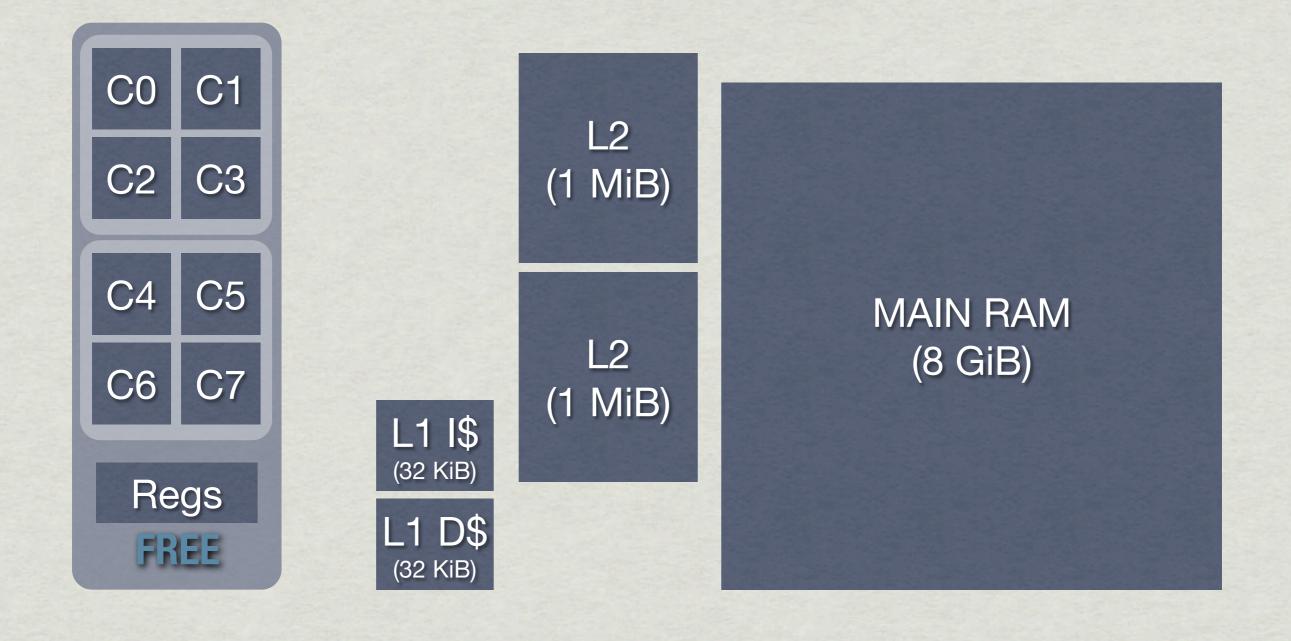
* Understanding the cache allows you to optimize
* Don't forget the 80/20 rule
* General rules of thumb:

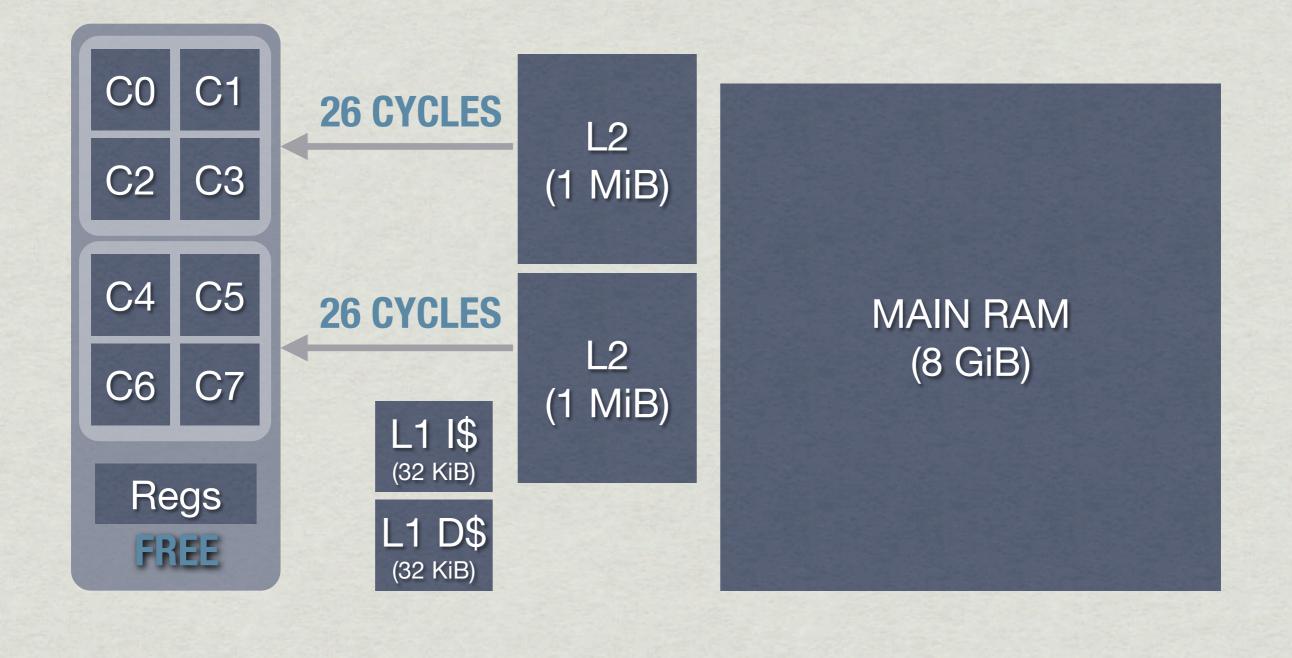
* Keep high-performance code small (fit in I\$)

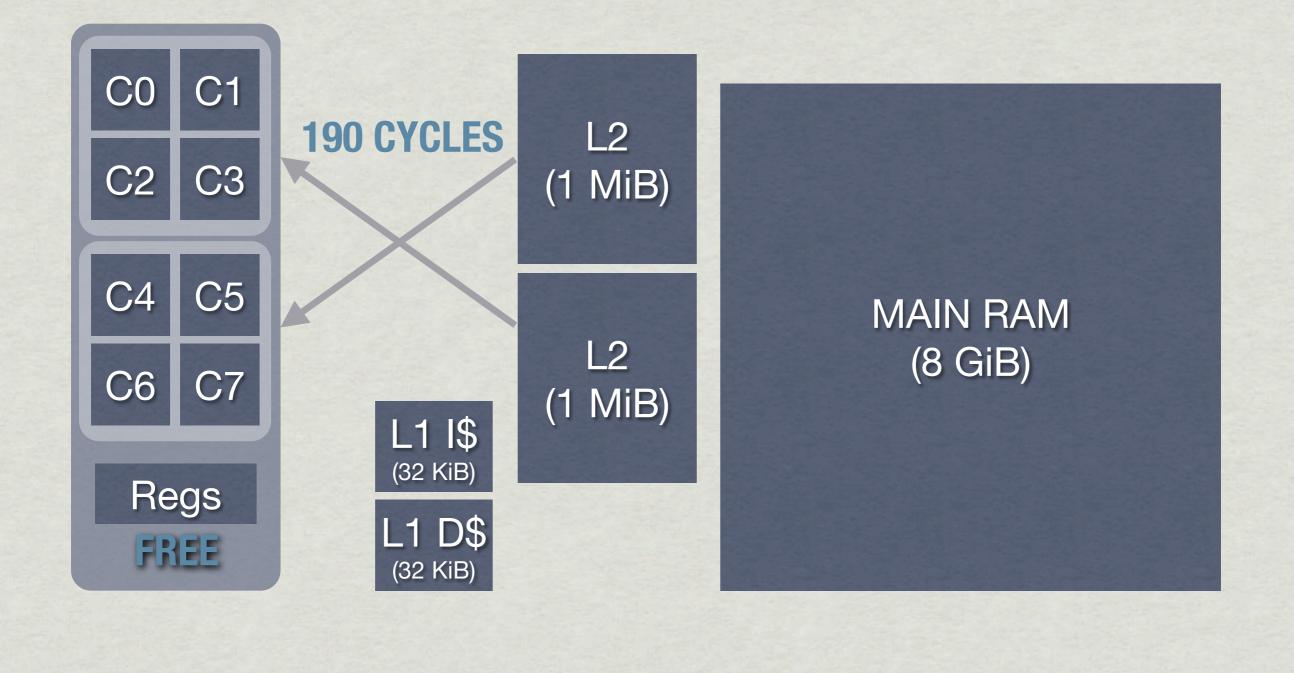
* Keep high-performance data small and contiguous (fit in D\$)





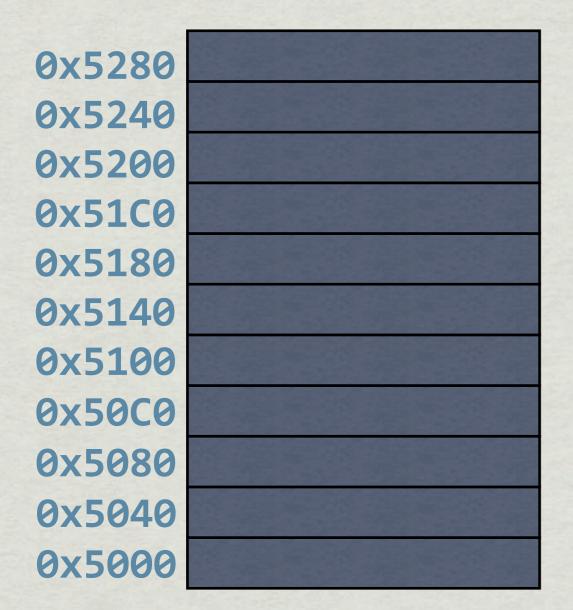






MAIN RAM

CACHE



x0280	
x0240	
x0200	
x01C0	
x0180	
x0140	
x0100	
x00C0	
x0080	
x0040	
x0000	

MAIN RAM

CACHE



x0280	
x0240	
x0200	
x01C0	
x0180	
x0140	
x0100	
x00C0	
x0080	
x0040	
x0000	

MAIN RAM

CACHE

0x5280	0x0280
0x5240	0x0240
0x5200	0x0200
0x51C0	0x01C0
0x5180	0x0180
0x5140	0x0140
0x5100	0x0100
0x50C0	0x00C0
0x5080	<u>0x0080</u>
0x5040	0x0040
0x5000	0000x0

PS4 Optimization

*** PS4-specific:** avoid cross-cluster L2 cache line sharing (190 cycles versus 26 cycles)!

U32 g_jobCount[6]; // one per core

PS4 Optimization

*** PS4-specific:** avoid cross-cluster L2 cache line sharing (190 cycles versus 26 cycles)!

```
struct JobCount
{
    U32 m_count;
    U8 m_padding[60];
};
JobCount g_jobCount[6]; // one per core
```



INSTRUCTION FETCH

INSTRUCTION DECODE/ REGISTER FETCH



EXECUTION



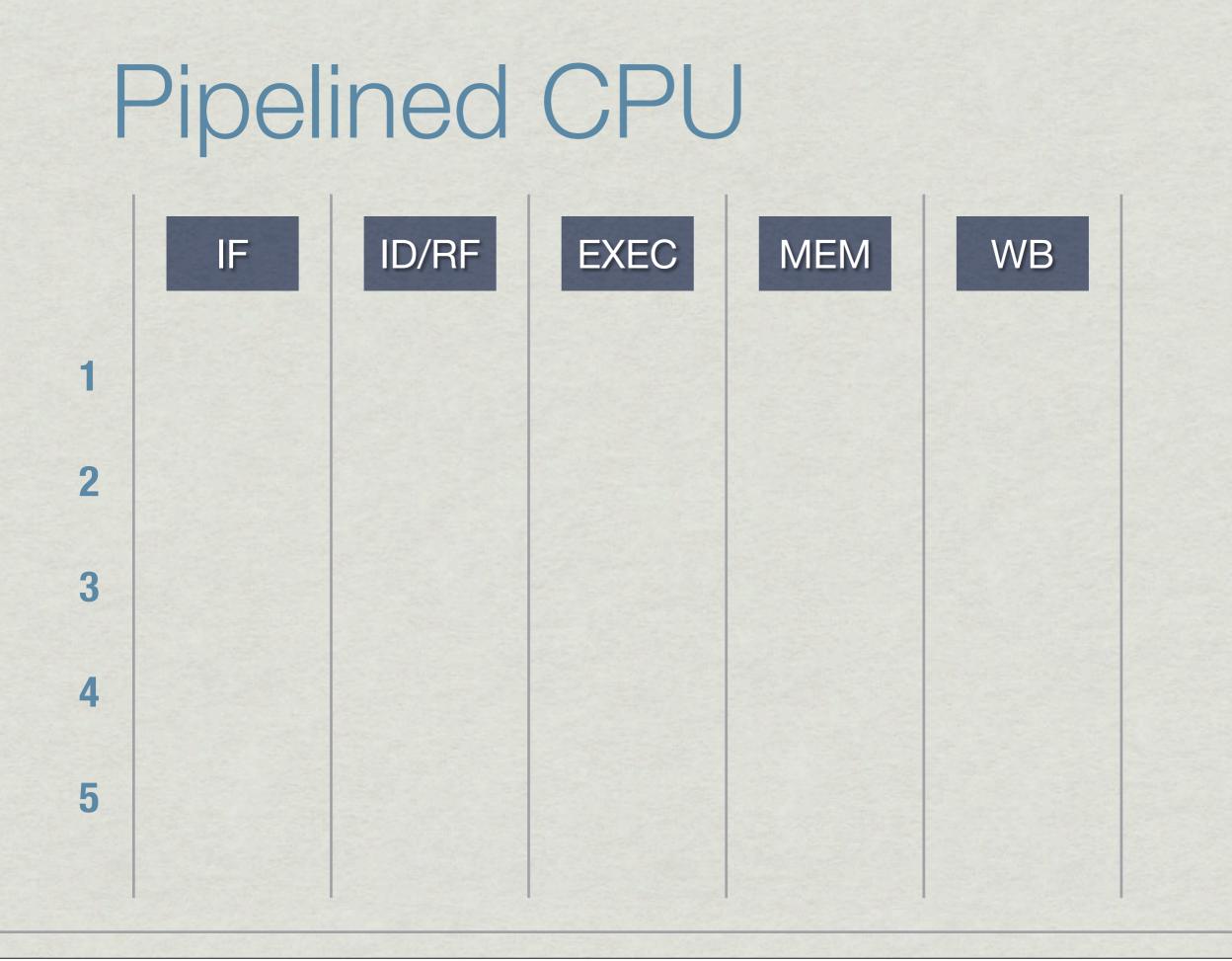
MEMORY ACCESS

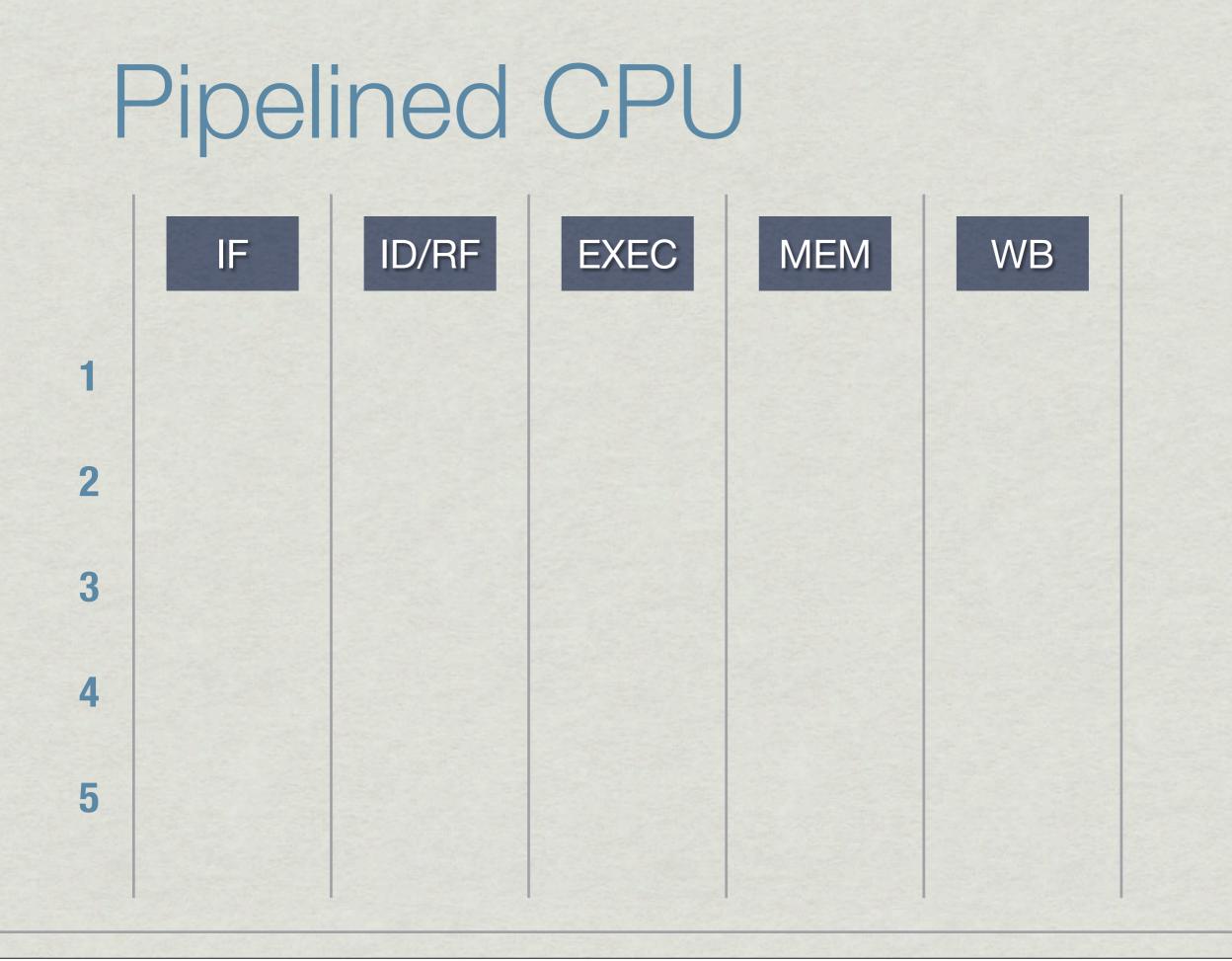


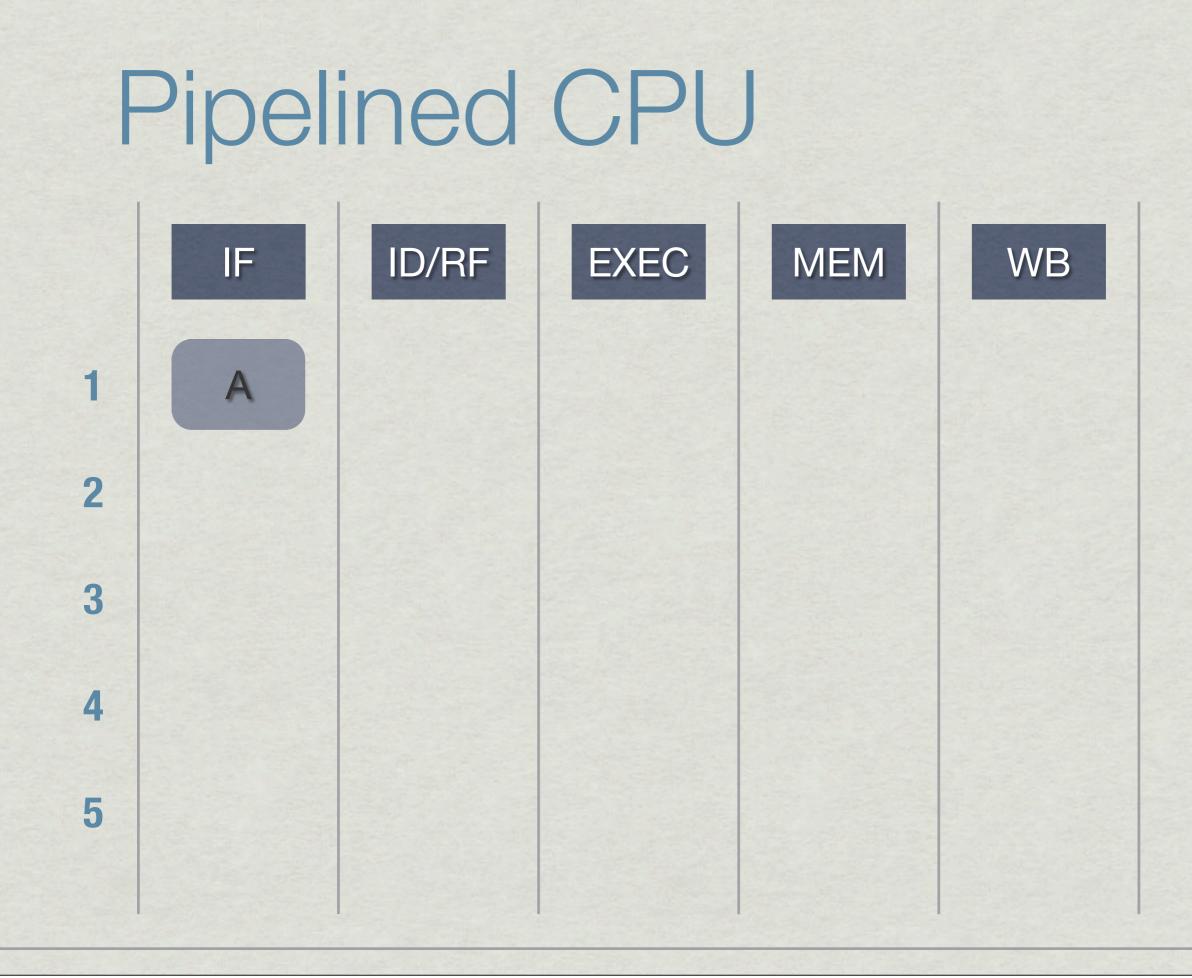
WRITE-BACK

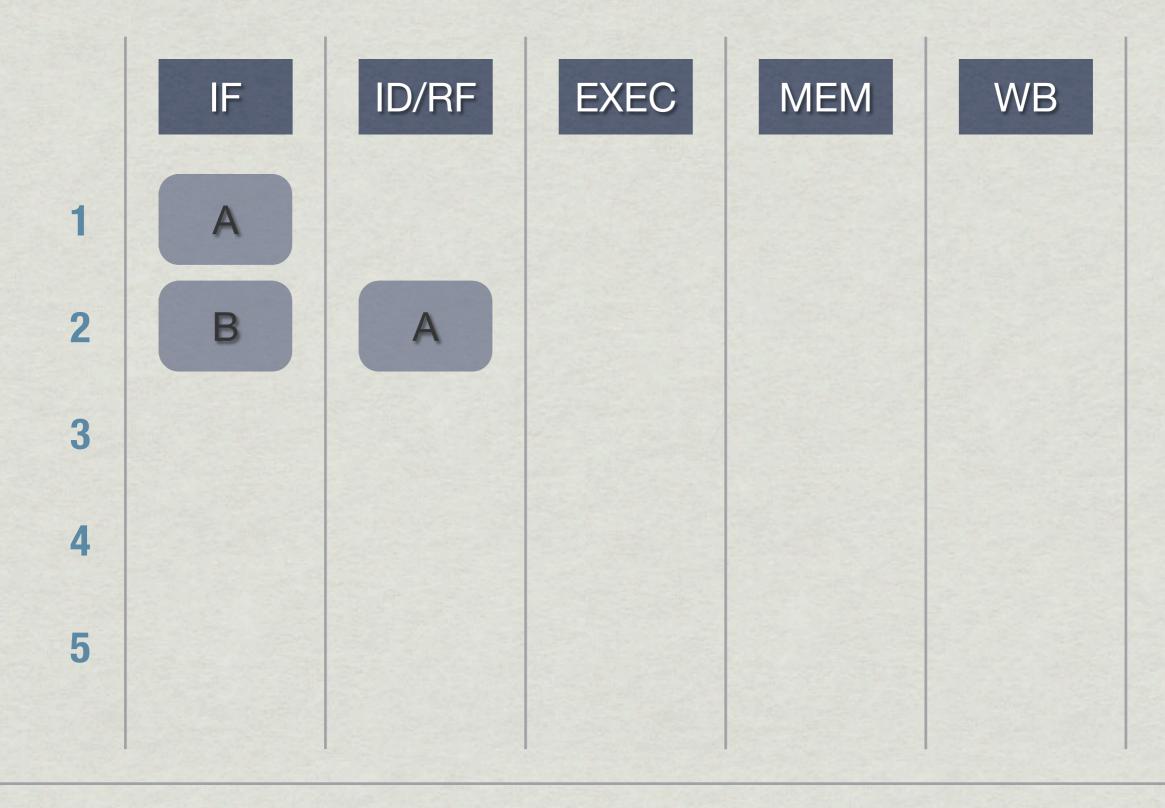




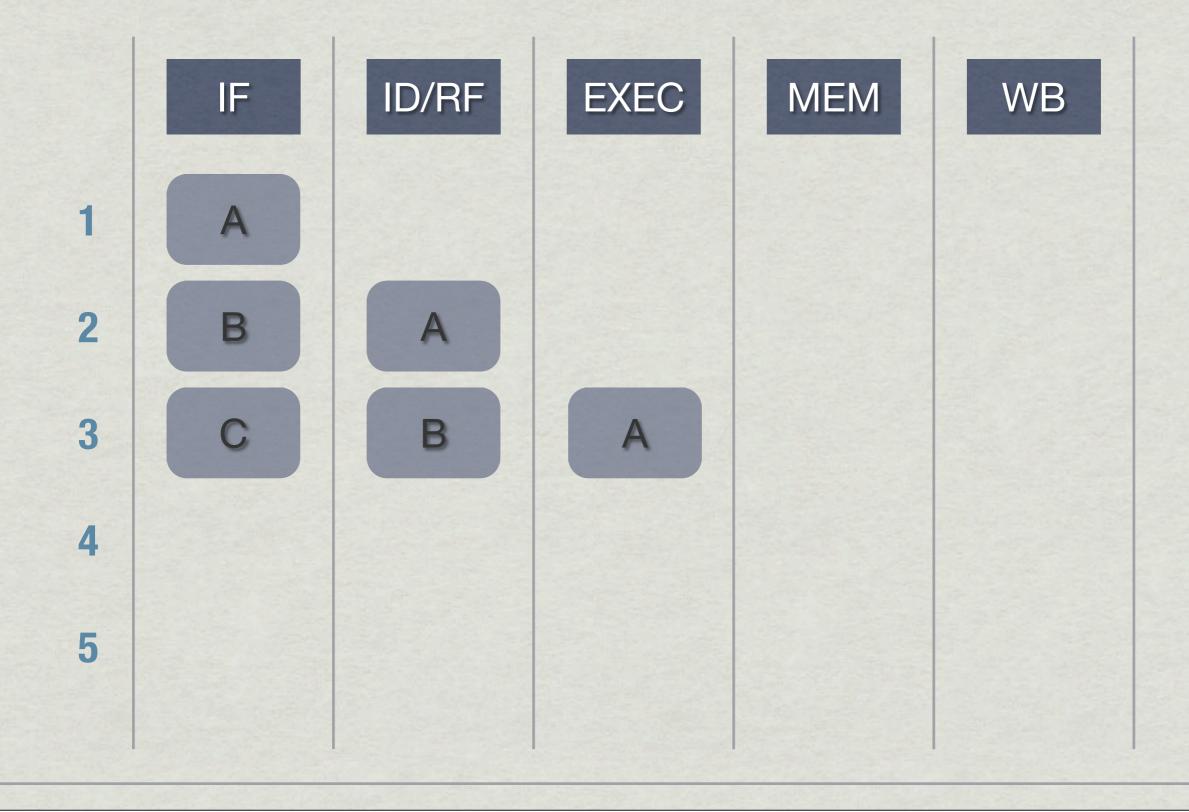


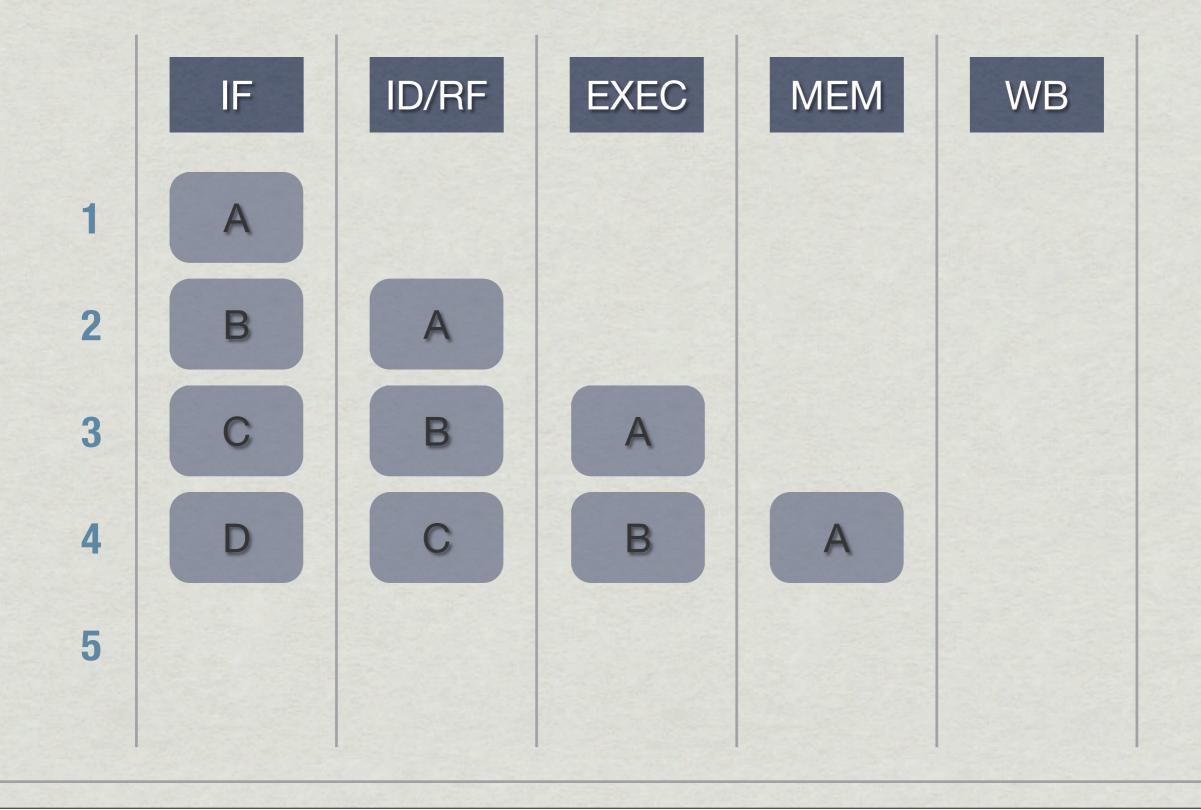


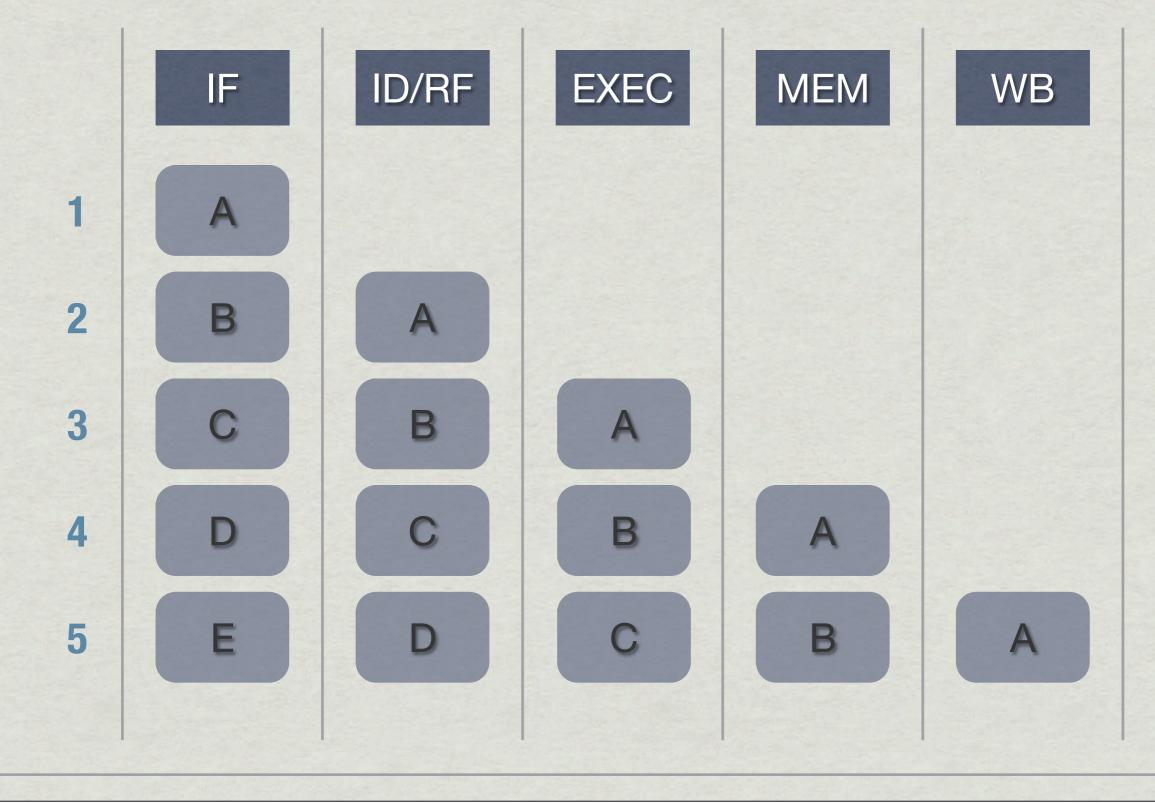




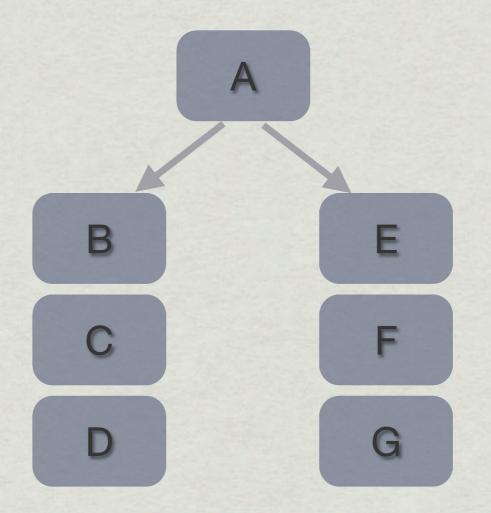
Tuesday, March 4, 14

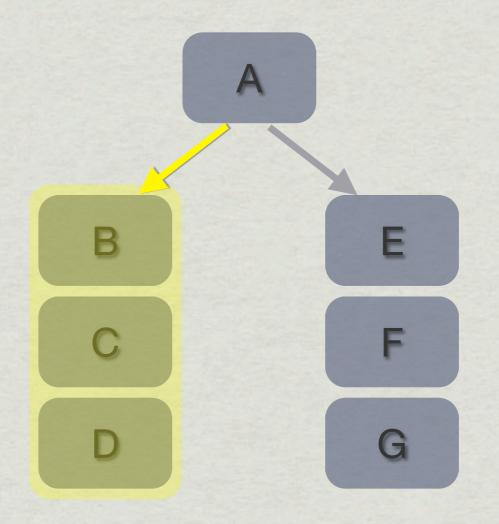


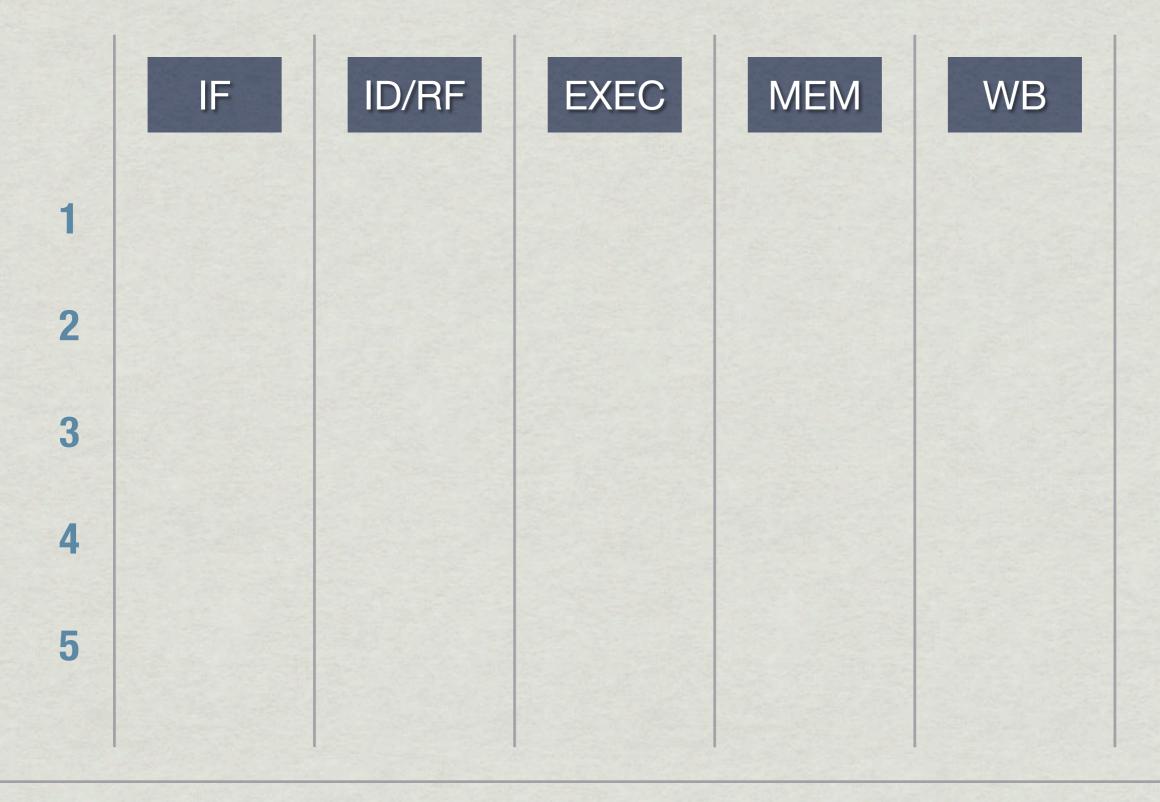


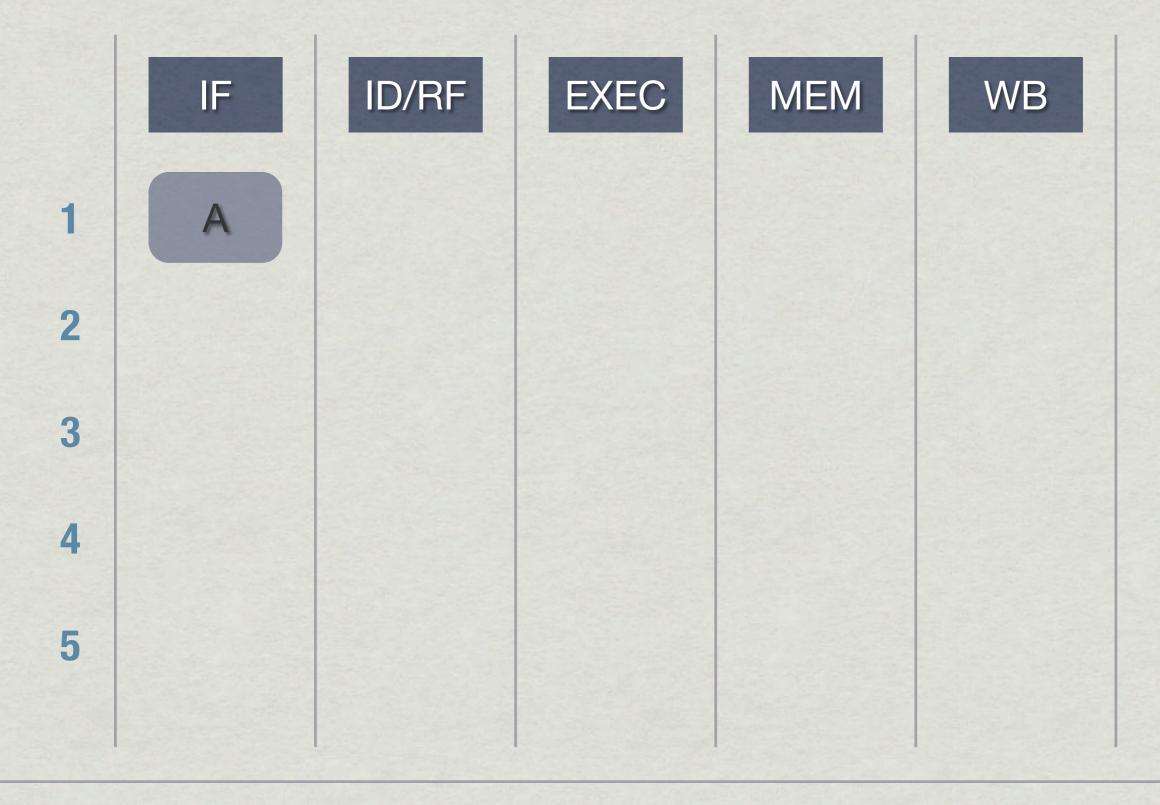


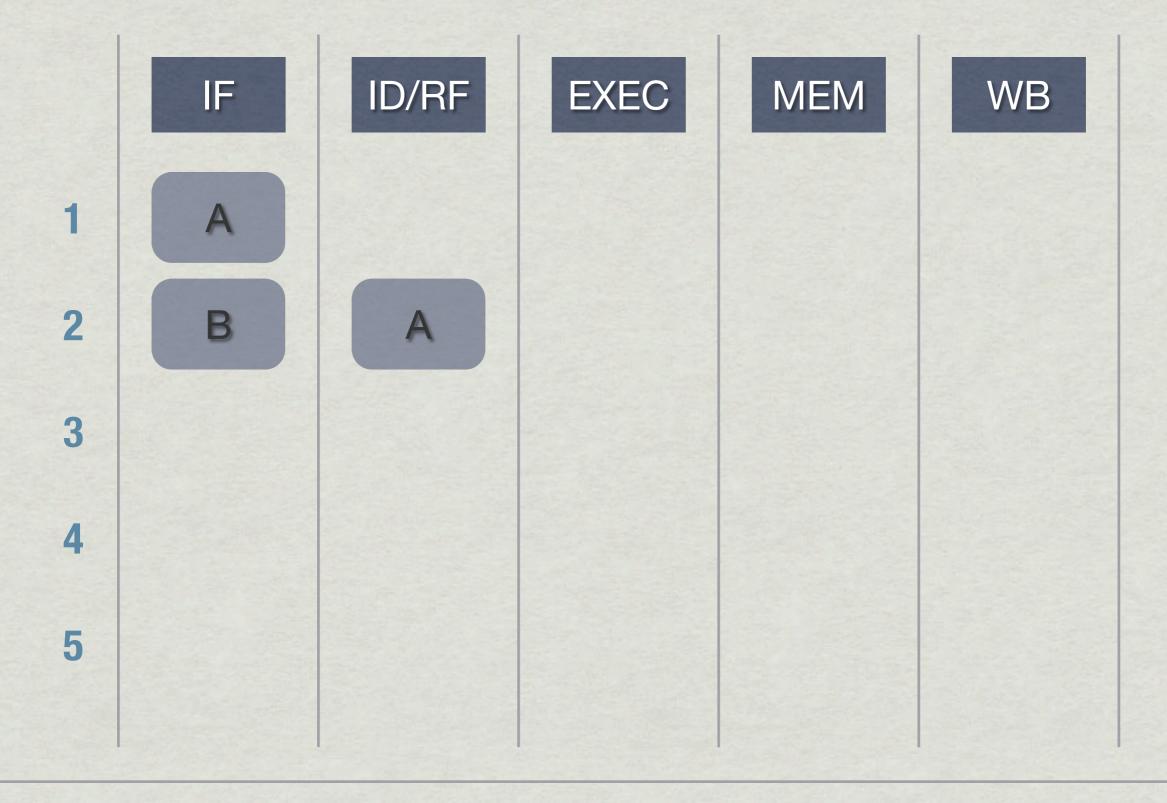
Tuesday, March 4, 14

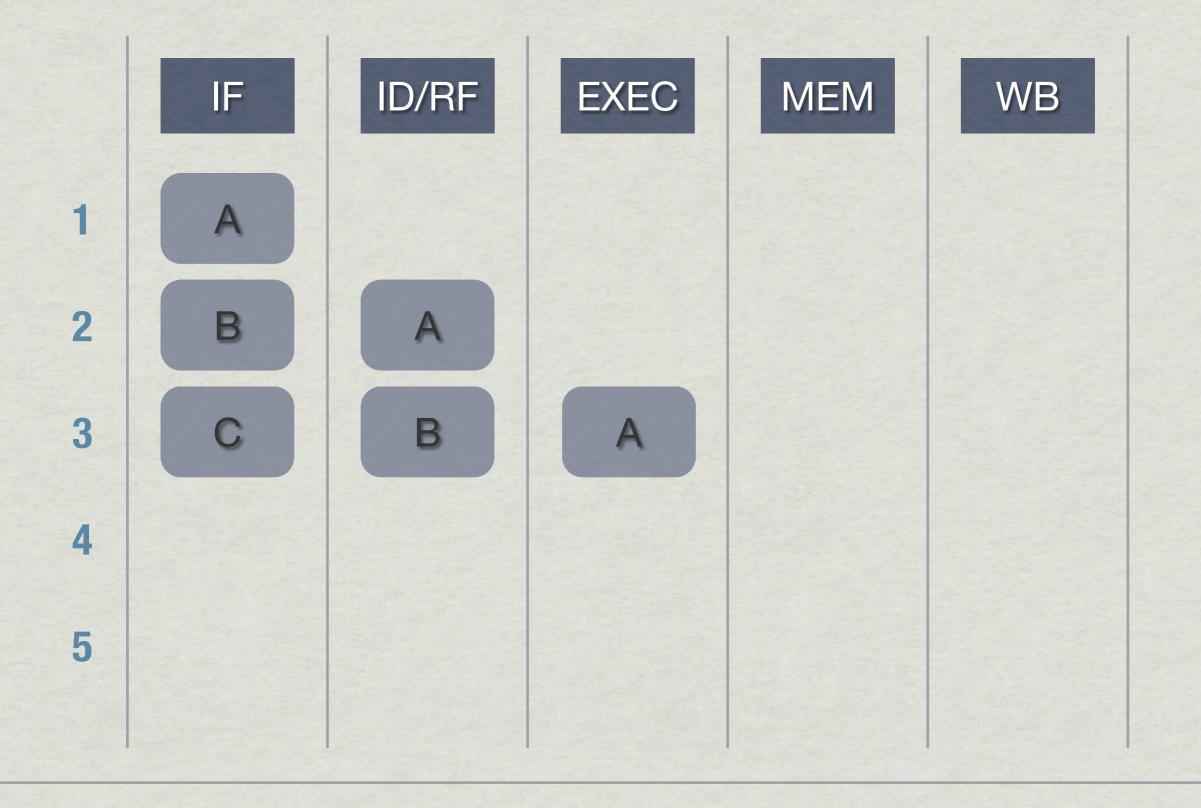


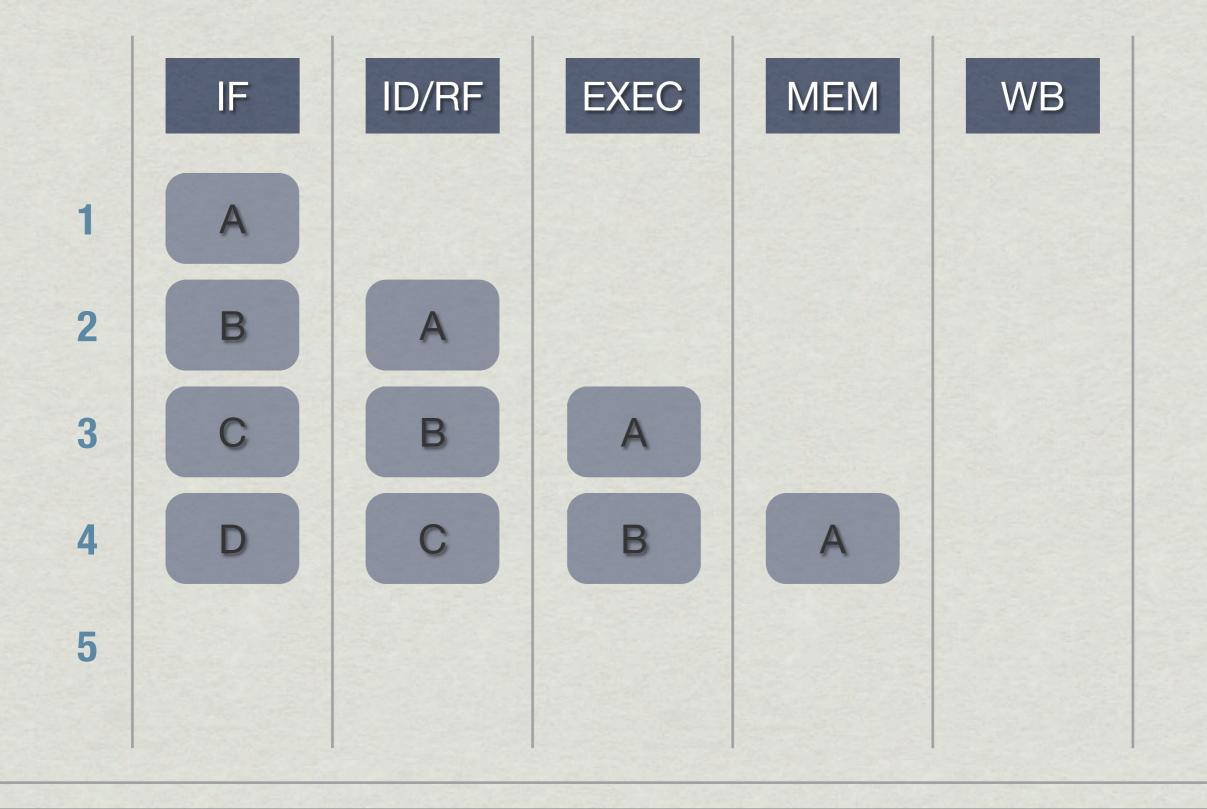


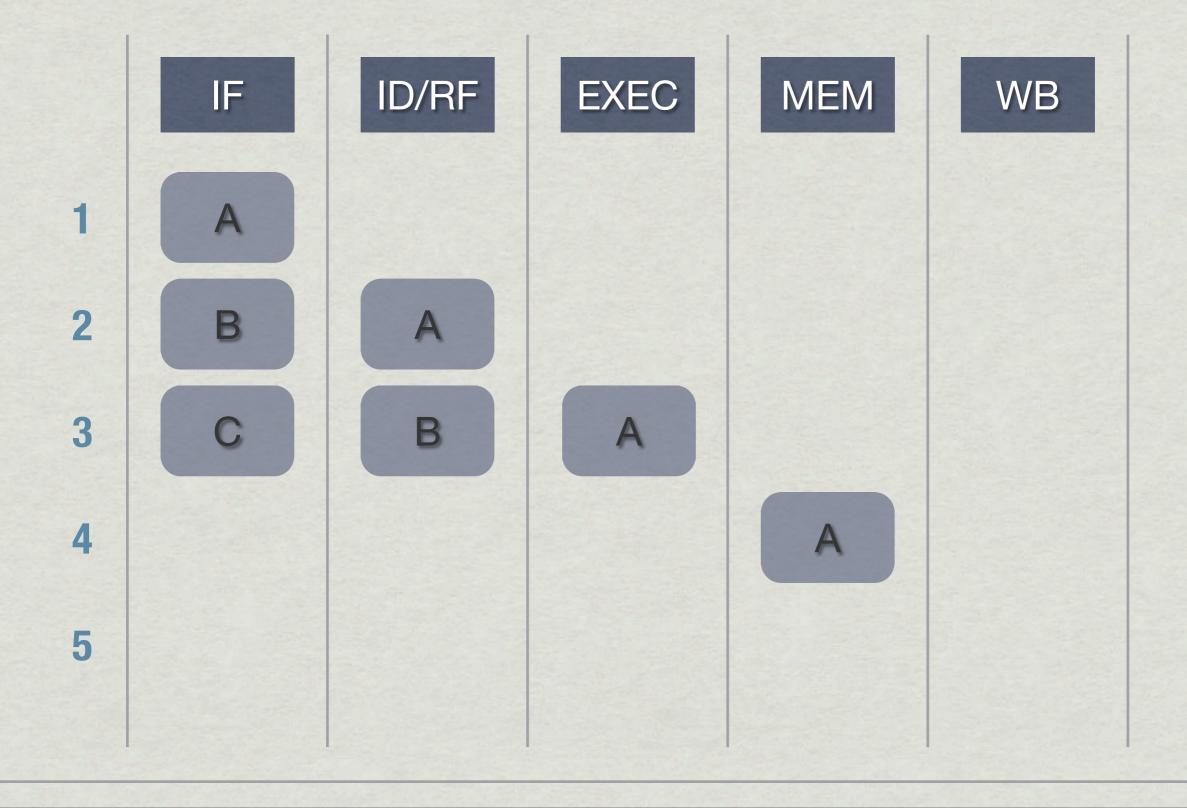


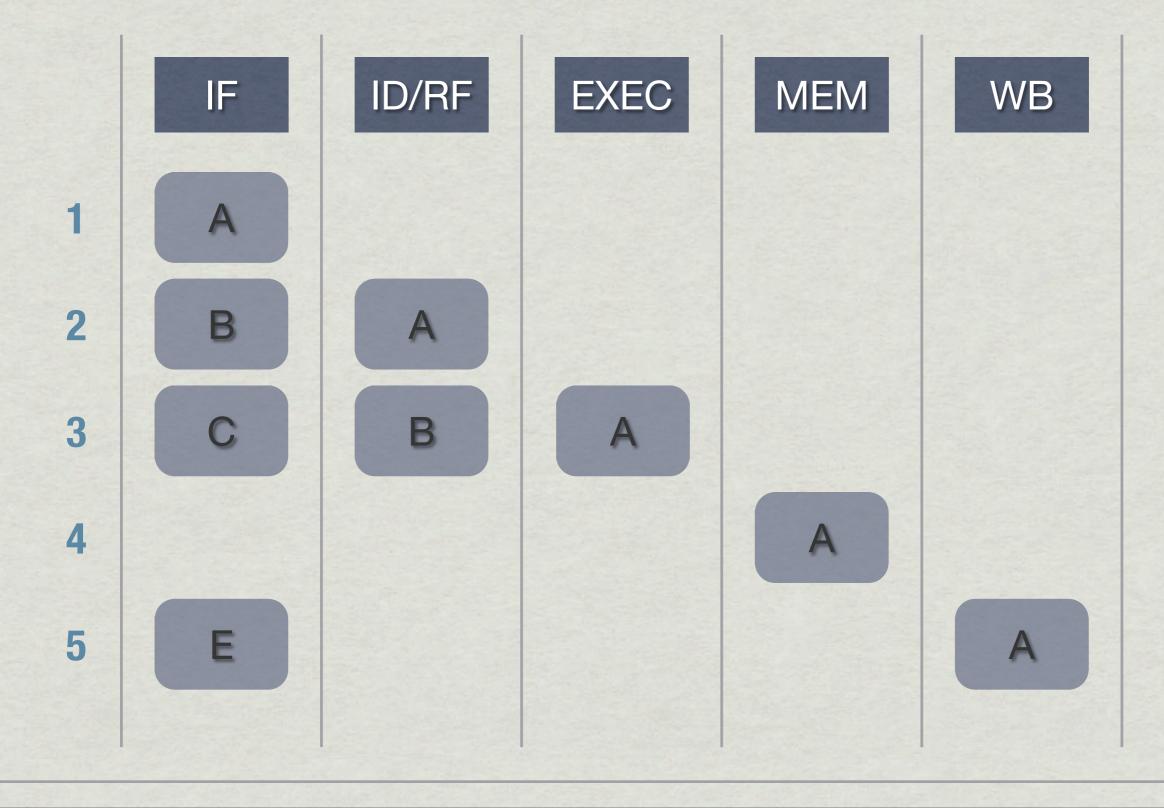












- * How can we take advantage of this knowledge?
 - 1. How good is your CPU's branch prediction HW?
 - 2. If **not good** (e.g. PS3 PPU!), avoid branches in highperformance code:
 - * Calculate both results and use fsel
 - * Split branchy loops into separate cases
 - Select simpler, less branchy algorithms (e.g. insertion sort over quicksort) where applicable

Tools

In-Engine Debugging and Profiling Tools

- Crucial to build in-engine tools to aid in development
 - * In-game development menus and shortcut keys
 - *** Debug drawing** facilities
 - In-engine profiling tools
- # Useful to all disciplines
 - * Programmers, designers, artists, sound team, ...

In-Game Menus



Debug Drawing

8.000333 "playtest-layout-dimensions" is fetivel 00:05:02

FPS: 30.0

Tuesday, March 4, 14

Debug Drawing

FPS:

18.97 -0.00 -20.68

30.0

Demeanor: Collie-fist-normal-ambient* [ambient] Gun State: Holstered

Selected Controls: Normal

- Square

- Ĉirele - Triangle

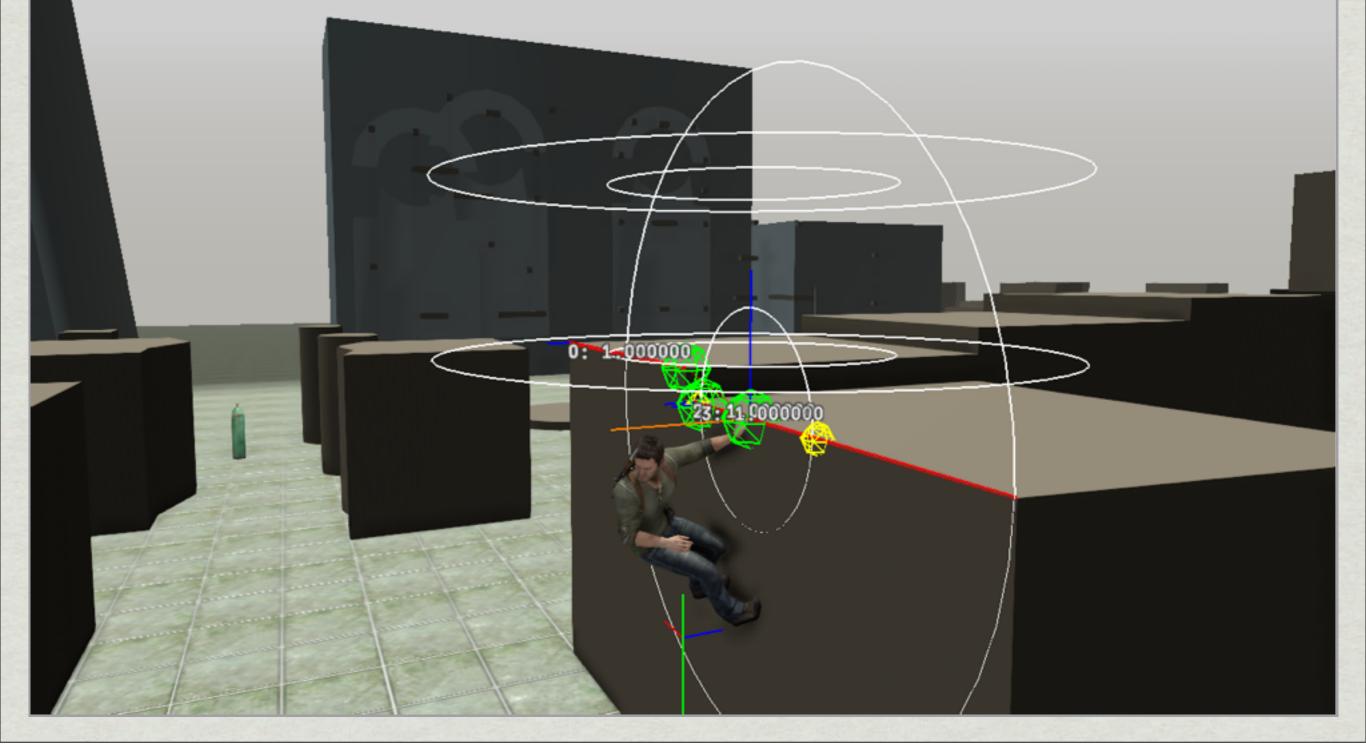
Tuesday, March 4, 14

Stop

Halk To Run To

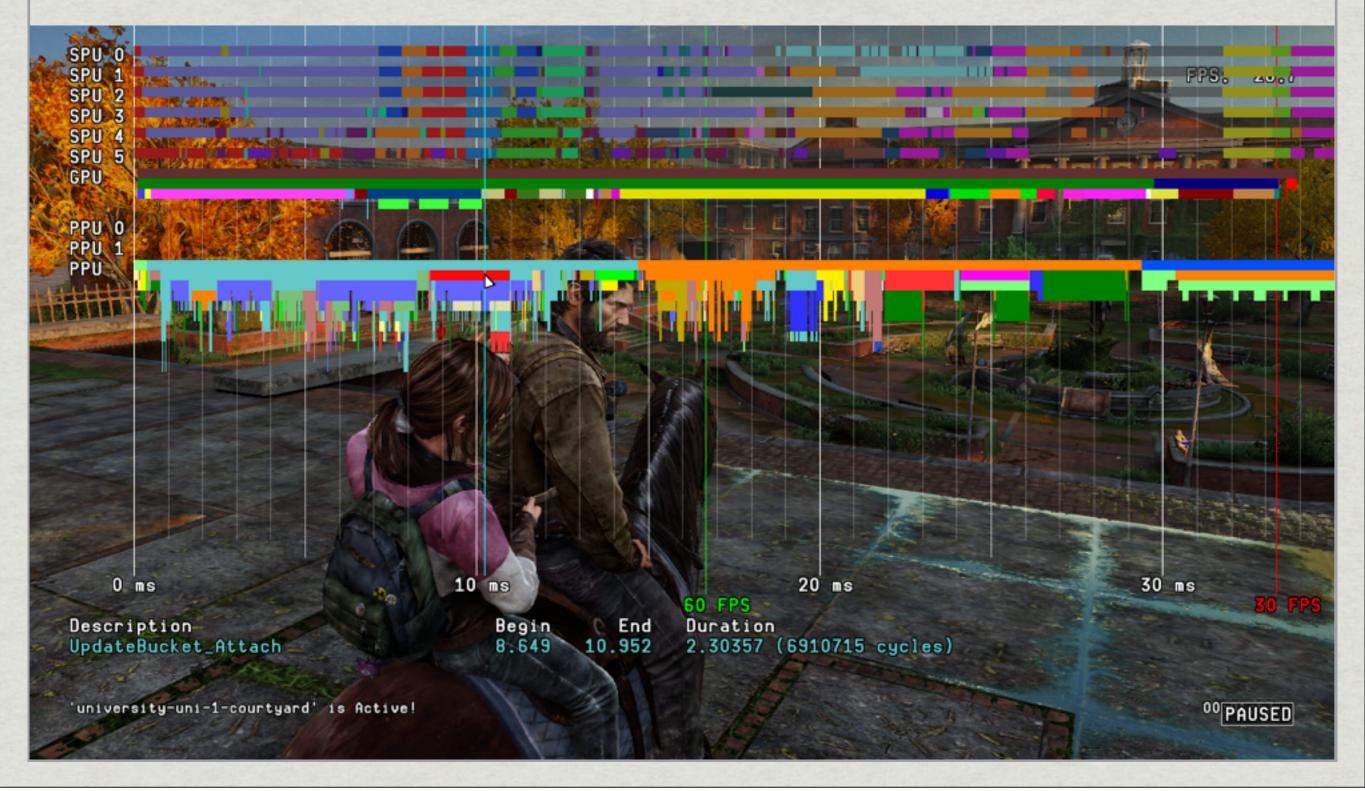
Sprint To

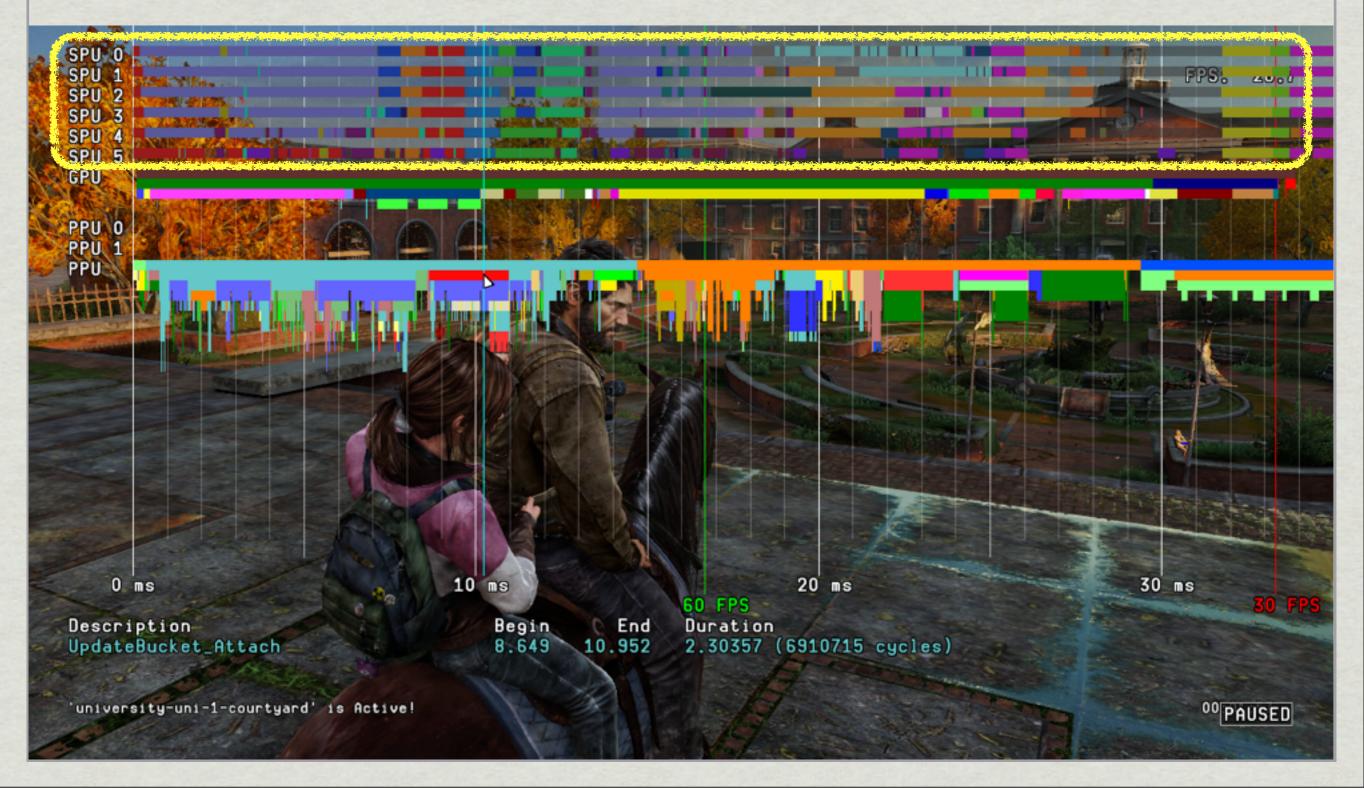
Debug Drawing



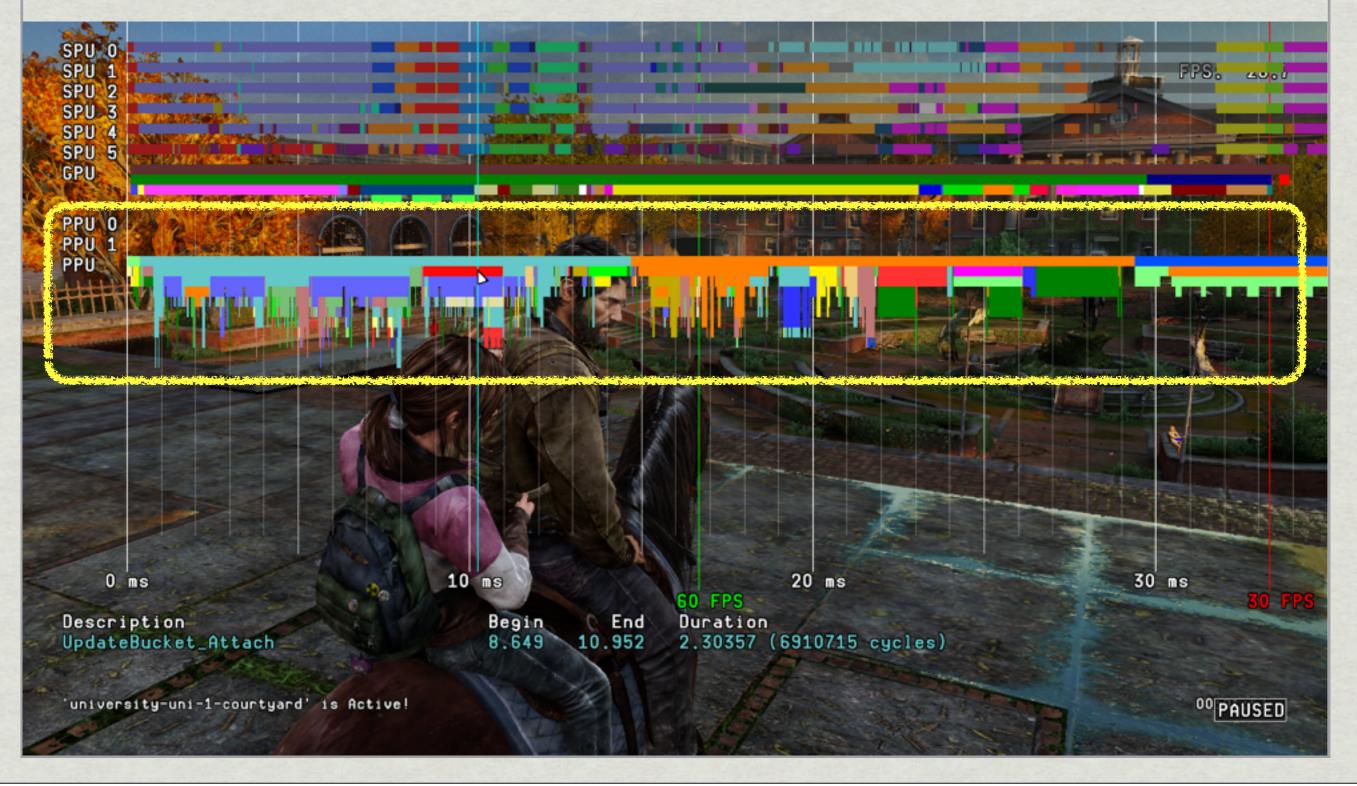
Tuesday, March 4, 14

-[Retail Memory] OS Memory Code And Static Data : 23.13 / 23.13 MB PRXs Debug PRXs : 2.19 / 2.38 MB Debug PRXs : 0.00 / 3.00 MB Global Memory : 0.01 / 66.00 MB IO Memory : 119.91 / 120.00 MB Threads Contexts : 1.07 / 1.50 MB (Max 1.11 MB) Available Sys Memory : 26.49 MB (Min 26.46 MB) Total: 256.00 MB	FPS: 30.0
-[Debug Memory]	
-[Stack Memory] Max Stack Usage : 117.47 / 256.00 KB	
tommys-dam-tom=path=sluice-gate-start' is Active!	00:02:15

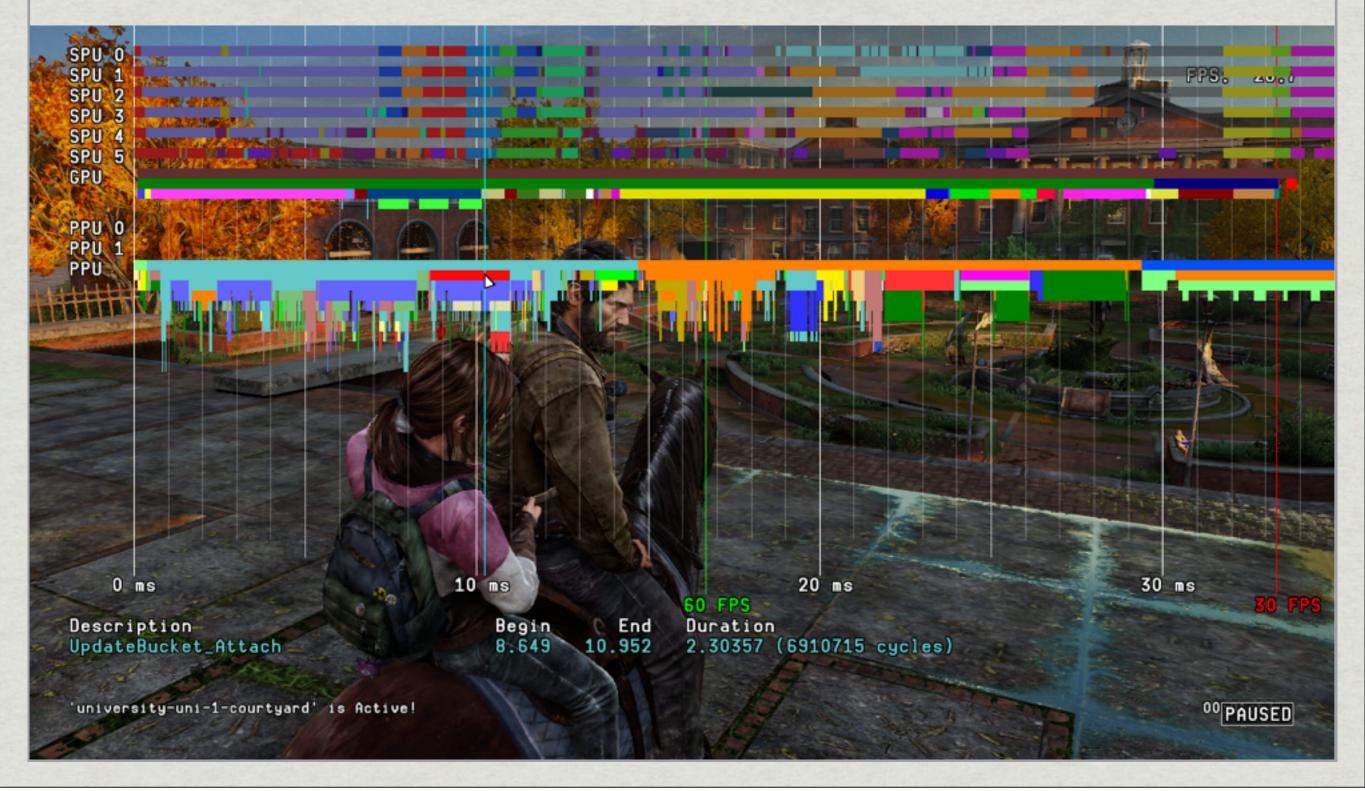












- * Put the power to create into the hands of the content creators!
- * Reduce dependencies on programming team
- * At Naughty Dog, we do this via:
 - * Data-driven systems with easy-to-edit data files
 - Runtime scripting language for use by designers and artists

- * Both data scripts and runtime scripts written in Scheme (a Lisp variant)
 - * Rich Lisp history at Naughty Dog!
 - * Scheme offers powerful language customization tools via hygienic macros
 - * Allows you to easily customize the language to suit your needs

* Example of simple data definition script:

```
(define-physics-sound
```

```
:models
:joint
:roll
:slide
:light-force 2.0
:hard-force 10.0
```

```
('tin-cans 'rusty-cans)
             'root
:light-hit 'sfx-cans-hit-light
:hard-hit 'sfx-cans-hard-hit
             'sfx-cans-roll
            'sfx-cans-slide
```

- * Users can edit data-definition scripts in any text editor
- Re-build the data and hot-swap into the running game via a command-line Scheme interpreter





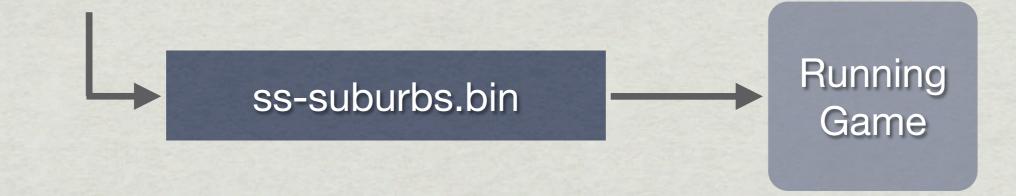
* Example of runtime script:

```
;; . . .
(state ('open)
  (on (start)
    (animate 'self 'gate-idle-open)
  (on (event 'close)
    (wait-animate 'self 'gate-close)
    (go 'idle)
```

* Users can edit runtimes scripts in any text editor

Re-build the script and hot-swap into the running game via a command-line Scheme interpreter

> (mr "ss-suburbs.dc")



* Users can edit runtimes scripts in any text editor

Re-build the script and hot-swap into the running game via a command-line Scheme interpreter

> (mr "ss-suburbs.dc")



Conclusion

Conclusion



*Culture



*Process

*Technology

Lighting and Shading



Visual Effects



Audio



Animation



Thanks for Listening!

*****Questions?

jason_gregory@naughtydog.com

www.gameenginebook.com