

Law

- "Equal justice under law"
 - http://en.wikipedia.org/wiki/File:CourtEqualJustice.JPG
 - Which building is that?

Law

- Who makes the law?
- Who enforces the law?

Right to a Fair Trial Sixth Amendment: "In all criminal prosecutions, the accused shall enjoy the right to a speedy and public trial, by an impartial jury of the State and district where in the crime shall have been committed ..."

Fair Trial

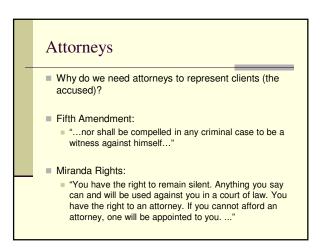
- Presumed innocence until proven guilty
- Burden of proof is on the prosecution
- Trial by jury (peers)

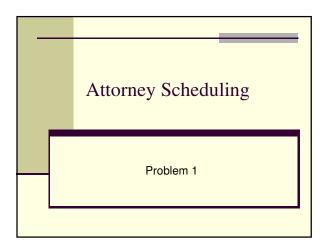
Attorneys

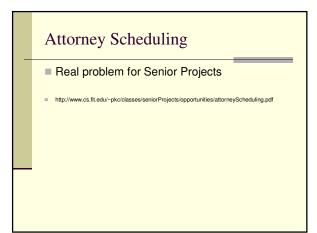
Why do we need attorneys to represent clients (the accused)?

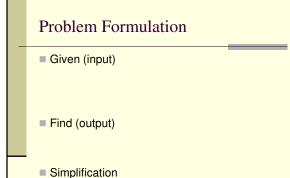
Attorneys

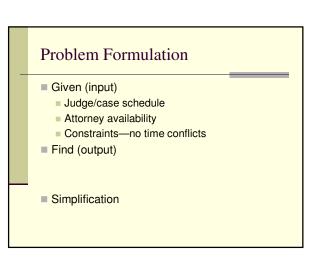
- Why do we need attorneys to represent clients (the accused)?
- Fifth Amendment:
 - "...nor shall be compelled in any criminal case to be a witness against himself..."













Simplification

Days instead of hours. Specialty, even load ... are ignored

What is your algorithm? Mon Judge Tue Wed Thu Fri John Case A Case B Jane Case C Case D Jack Case E Attorney Mon Wed Fri Tue Thu Alice available available available available available available available available <u>A</u>ndy

First Available Attorney

For each case, schedule the first available attorney

First available attorney

Judge	Mon	Tue	Wed	Thu	Fri
John	Case A			Case B	
Jane	Case C		Case D		
Jack			Case E		
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case A	available	available	available	
<u>A</u> ndy	available	available	available	available	

Fire	First available attorney								
Judge	Mon	Tue	Wed	Thu	Fri				
John	Case A			Case B					
Jane	Case C		Case D						
Jack			Case E						
Attorney	Mon	Tue	Wed	Thu	Fri				
Alice	Case A	available	available	Case B					
Andy	available	available	available	available					
		ľ							

Fire	st avail	able at	torney		
Judge	Mon	Tue	Wed	Thu	Fri
John	Case A			Case B	
Jane	Case C		Case D		
Jack			Case E		
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case A	available	available	Case B	
<u>A</u> ndy	Case C	available	available	available	

Judge	Mon	Tue	Wed	Thu	Fri
John	Case A			Case B	
Jane	Case C		Case D		
Jack			Case E		
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case A	available	Case D	Case B	
<u>A</u> ndy	Case C	available	available	available	

Judge	Mon	Tue	Wed	Thu	Fri
John	Case A			Case B	
Jane	Case C		Case D		
Jack			Case E		
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case A	available	Case D	Case B	
<u>A</u> ndy	Case C	available	Case E	available	

Cases with more than one day

- We use day as a time unit for simplicity
 - Each time unit could be:
 - an hour
 - morning/afternoon

First available attorney

	-		,	,		,
	Judge	Mon	Tue	Wed	Thu	Fri
	John			Case A		
	Jane	Case B	Case B			
	Jack			Case C	Case C	
ſ	Attornov	Mon	Tue	Wed	Thu	Fri
	Attorney		Tue	wea	Thu	ГП
	Alice	available	available	available	available	
	<u>An</u> dy	available	available	available		
					1	

Fir	First available attorney								
Judge	Mon	Tue	Wed	Thu	Fri				
John			Case A						
Jane	Case B	Case B							
Jack			Case C	Case C					
Attorney	Mon	Tue	Wed	Thu	Fri				
Alice	available	available	Case A	available					
<u>An</u> dy	available	available	available						
	1	1							

First available attorney Judge Mon Tue Wed Thu Fri John Case A Image: Case B Image: Case B Image: Case C Ima

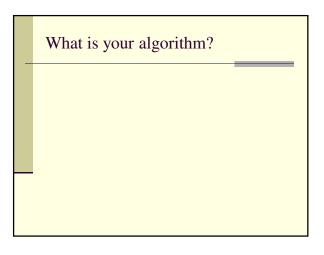
Jack			Case C	Case C	
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case B	Case B	Case A	available	
<u>An</u> dy	available	available	available		
		1			

_	First available attorney								
Ju	ıdge	Mon	Tue	Wed	Thu	Fri			
Jo	bhn			Case A					
Ja	ane	Case B	Case B						
Ja	ack			Case C	Case C				
At	torney	Mon	Tue	Wed	Thu	Fri			
Ali	се	Case B	Case B	Case A	available				
Ar	idy	available	available	available					
Cannot find an attorney for Case C									

Fi	First available attorney								
Judge	Mon	Tue	Wed	Thu	Fri				
John			Case A						
Jane	Case B	Case B							
Jack			Case C	Case C					
Attorney	Mon	Tue	Wed	Thu	Fri				
Alice	Case B	Case B	Case A	available					
<u>An</u> dy	available	available	available						
How	ever a solut	ion exists!	Can you s	ee it?					

_	First available attorney								
J	udge	Mon	Tue	Wed	Thu	Fri			
J	ohn			Case A					
J	ane	Case B	Case B						
J	ack			Case C	Case C				
At	torney	Mon	Tue	Wed	Thu	Fri			
AI	ice	Case B	Case B	Case C	Case C				
A	ndy	available	available	Case A					

Schedule Case A to Andy instead of Alice



Longest-Case First

- Sort the cases by length in descending order
- For each case, schedule the next available attorney

Longest-Case First

_					1
Judge	Mon	Tue	Wed	Thu	Fri
John			Case A		
Jane	Case B	Case B			
Jack			Case C	Case C	
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case B	Case B	available	available	
<u>An</u> dy	available	available	available		

Lo	ngest-C	Case Fi	rst		
Judge	Mon	Tue	Wed	Thu	Fri
John			Case A		
Jane	Case B	Case B			
Jack			Case C	Case C	
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case B	Case B	Case C	Case C	
<u>An</u> dy	available	available	available		
<u>An</u> dy	available	available	available		
<u>An</u> dy	available	available	available		

Judge	Mon	Tue	Wed	Thu	Fri
John			Case A		
Jane	Case B	Case B			
Jack			Case C	Case C	
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case B	Case B	Case C	Case C	
<u>An</u> dy	available	available	Case A		

Longest-Case First

Also does not guarantee finding a solution if a solution exists

Longest-Case First

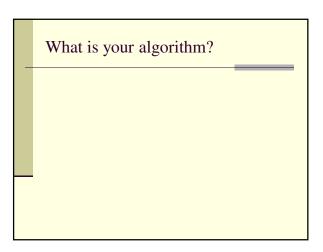
Judge	Mon	Tue	Wed	Thu	Fri
John	Case A	Case A	Case A		
Jane	Case B	Case B			
Jack			Case C	Case C	
Attorne	y Mon	Tue	Wed	Thu	Fri
Alice	available	available	available	available	
<u>An</u> dy	available	available	available		

	Loi	ngest-C	Case Fi	rst		
Ju	dge	Mon	Tue	Wed	Thu	Fri
Jo	hn	Case A	Case A	Case A		
Ja	ne	Case B	Case B			
Ja	ck			Case C	Case C	
Att	orney	Mon	Tue	Wed	Thu	Fri
Ali	се	Case A	Case A	Case A	available	
An	dy	available	available	available		
						·8

igest-C	Case Fi	rst		
Mon	Tue	Wed	Thu	Fri
Case A	Case A	Case A		
Case B	Case B			
		Case C	Case C	
Mon	Tue	Wed	Thu	Fri
Case A	Case A	Case A	available	
Case B	Case B	available		
	Mon Case A Case B Mon Case A	Mon Tue Case A Case A Case B Case B Mon Tue Case A Case A	Mon Tue Wed Case A Case A Case A Case B Case B Case C Mon Tue Wed Case A Case A Case A	Mon Tue Wed Thu Case A Case A Case A Case B Case B Case C Mon Tue Wed Thu Case A Case A Case C

Cannot find an attorney for Case C, but a solution exists!

Lo	ngest-(Case Fi	irst		
Judge	Mon	Tue	Wed	Thu	Fri
John	Case A	Case A	Case A		
Jane	Case B	Case B			
Jack			Case C	Case C	
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case B	Case B	Case C	Case C	
<u>An</u> dy	Case A	Case A	Case A		
S	chedule C	ase A to Ar	ndy instead	of Alice	· · · ·



Longest Case, Least Available Attorney

- Consider the longest case first
- Consider the least available attorney first

	C	Case, L	east Av	vailable	e
At	torney				
Judge	Mon	Tue	Wed	Thu	Fri
John	Case A	Case A	Case A		
Jane	Case B	Case B			
Jack			Case C	Case C	
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case B	Case B	Case C	Case C	
<u>An</u> dy	Case A	Case A	Case A		

	Loi	Longest Case, Least Available					
_	Att	Attorney					
Ju	ıdge	Mon	Tue	Wed	Thu	Fri	
Jo	ohn	Case A	Case A	Case A			
Ja	ane	Case B	Case B				
Ja	ack			Case C	Case C		
At	torney	Mon	Tue	Wed	Thu	Fri	
Ali	се	Case B	Case B	Case C	Case C		
Ar	ıdy	Case A	Case A	Case A			
				I	I	I	

	ngest (corney	Case, L	east A	vailabl	e
Judge	Mon	Tue	Wed	Thu	Fri
John	Case A	Case A	Case A		
Jane	Case B	Case B			
Jack			Case C	Case C	
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case B	Case B	Case C	Case C	
Andy	Case A	Case A	Case A		

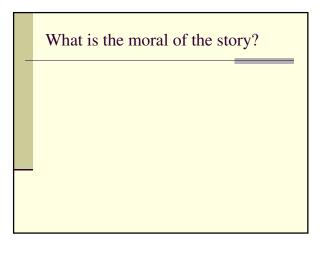
Longest case, Least available attorney

No guarantee to find a solution if one exists

	ngest Ca orney	ase, Lea	st Avai	lable	
Judge	Mon	Tue	Wed	Thu	Fri
John	Case A	Case A	Case A		
Jane	Case B	Case B			
Jack			Case C	Case C	
Attorney	Mon	Tue	Wed	Thu	Fri
Alice	Case A	Case A	Case A	available	
<u>An</u> dy	available	available	available		available
	Alice and And	y are equally a	vailable	I	

		ngest Ca orney	ise, Lea	st Avai	lable	
J	udge	Mon	Tue	Wed	Thu	Fri
J	ohn	Case A	Case A	Case A		
J	ane	Case B	Case B			
J	ack			Case C	Case C	
At	torney	Mon	Tue	Wed	Thu	Fri
AI	ice	Case A	Case A	Case A	available	
A	ndy	Case B	Case B	available		available

Cannot find an attorney for Case C, but a solution exists



What is the moral of the story?

The first solution might not work

What is the moral of the story?

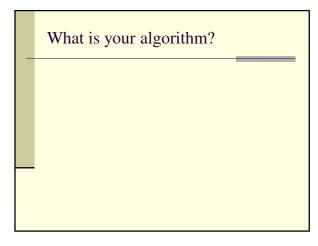
- The first solution might not work
- It's NOT about "coding"

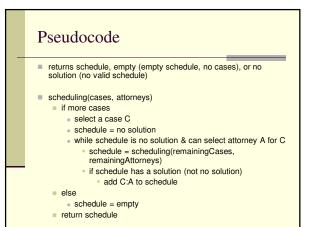
What is the moral of the story?

- The first solution might not work
- It's NOT about "coding"
- Consider a counter example that breaks your solution
 - Do you need more than one counter example?

What is the moral of the story?

- The first solution might not work
- It's NOT about "coding"
- Consider a counter example that breaks your solution
 - Do you need more than one counter example?
- Note that we started with more simplified problems first





Not all cases/attorneys are equal Consider certain cases/attorneys before others • *could* (not will) find the schedule faster Case ordering • Node ordering • Attorney ordering • Branch ordering

Case/Node Ordering Which case should we consider first?

Case/Node Ordering

Most difficult case first, why?

Case/Node Ordering

- Most difficult case first, why?
- if later, fewer attorneys left, more likely to get stuck

Case/Node Ordering

- Most difficult case first
 - if later, fewer attorneys left, more likely to get stuck
- Longest case

Case/Node Ordering

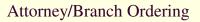
- Most difficult case first
 - if later, fewer attorneys left, more likely to get stuck
- Longest case
- What about a short case that only one attorney can be scheduled?

Case/Node Ordering

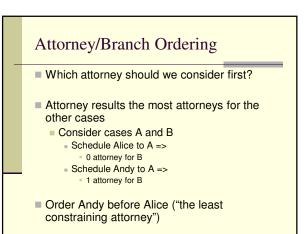
- More difficult case first
 - if later, fewer attorneys left, more likely to get stuck
- Longer cases
- What about a short case that only one attorney can be scheduled?
- Case/node with fewest attorneys/branches first ("the most constraining case")

Attorney/Branch Ordering

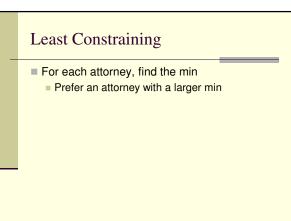
Which attorney should we consider first?



- Which attorney should we consider first?
- Attorney results the most attorneys for the other cases
 - Consider Cases A and B
 Schedule Alice to A =>
 - O attorney left for B
 - Schedule Andy to A =>
 - 1 attorney left for B

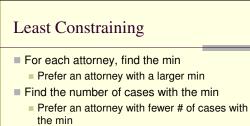


	Attor	ney/Bra	anch O	ordering	5	
	Case A	Case B	Case C	Case D	Case E]
	1	Alice?	1	3	3	
	4	Andy?	4	4	0	
	2	Amy?	2	2	3	
• The			_	attorney is ass		ase



Least Constraining

- For each attorney, find the min
 - Prefer an attorney with a larger min
- Find the number of cases with the min
 - Prefer an attorney with fewer # of cases with the min



- Find the sum
 - Prefer an attorney with a larger sum

Obvious Scenarios with No Solutions

Check before trying to schedule:

Obvious Scenarios with No Solutions

- Check before trying to schedule:
 - For each day, number of attorneys is fewer than number of cases

Obvious Scenarios with No Solutions

- Check before trying to schedule:
 - For each day, number of attorneys is fewer than number of cases
 - A case that no attorney can be scheduled
 - e.g. The case is Monday thru Friday, but none of the attorneys are available five days in a row

Actions for no Solutions

- No solutions:
 - "Obvious": found before scheduling
 - "Not Obvious": found during scheduling
- Actions:

Actions for no Solutions

No solutions:

- "Obvious": found before scheduling
- "Not Obvious": found during scheduling
- Actions:
 - Report to user and exit
 - Suggest the user to reduce cases and/or increase attorneys
 - Output partial schedule

Partial Schedule

What properties are preferred?

Partial Schedule

Maximize the number of scheduled cases

Partial Schedule

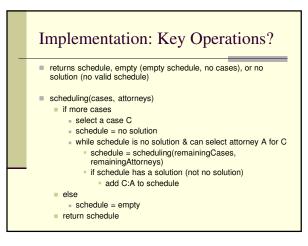
Maximize the number of scheduled cases
 "longest path", weight = 1

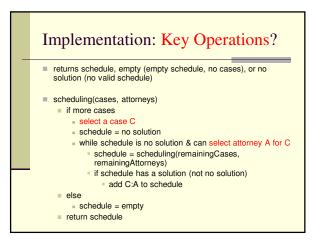
Partial Schedule

- Maximize the number of scheduled cases
 "longest path", weight = 1
- Maximize the total length of scheduled cases

Partial Schedule

- Maximize the number of scheduled cases"longest path", weight = 1
- Maximize the total length of scheduled cases"longest path", weight = case length





Selecting a case or attorney

- Selecting a case
 Most-constraining case
- Selecting an attorney
 - Least-constraining attorney
- Both involve one key operation, what is it?

Selecting a case Selecting a case Most-constraining case Selecting an attorney Least-constraining attorney Both involve one key operation Finding available attorneys for each case Comparison of time segments of attorneys for each case

Comparing Time Segments

- Case X: Mon, Tue
 - Alice: Mon, Tue, Wed, Thu
 - Andy: Mon, Wed, Fri
 - Amy: Mon, Tue, Thu, Fri

Which is More Important?

- Efficient data structure for
 - Case schedule or
 - Attorney availability?

Data Structure for Attorney Availability

Data Structure for Attorney Availability

2D-array (table similar to previous slides)
 Column=day, row=attorney, cell=available

Data Structure for Attorney Availability

- 2D-array (table similar to previous slides)
 Column=day, row=attorney, cell=available
 Interval
 - Start day, end day

Data Structure for Attorney Availability

- 2D-array (table similar to previous slides)
 Column=day, row=attorney, cell=available
- Interval
 - Start day, end day
 - Indexed by start day: (attorney, end day)

Data Structure for Attorney Availability

- 2D-array (table similar to previous slides)Column=day, row=attorney, cell=available
- Interval
 - Start day, end day
 - Indexed by start day: (attorney, end day)
- Duration
 - Start day, duration

Data Structure for Attorney Availability 2D-array (table similar to previous slides)

- Column=day, row=attorney, cell=available
- Interval
 - Start day, end day
 - Indexed by start day: (attorney, end day)
- Duration
 - Start day, duration
 - Indexed by start day: (attorney, duration)

Data Structure for Attorney Availability

- 2D-array (table similar to previous slides)
- Column=day, row=attorney, cell=available
 Interval
 - Start day, end day
 - = Start day, end day
 - Indexed by start day: (attorney, end day)
- Duration
 - Start day, duration
 - Indexed by start day: (attorney, duration)
 - Indexed by (start day, duration): attorney

Designing Tables in Databases

Consider storing attorney availability in a DB
 Does the data structure discussion affect how you would design the DB tables?

Designing Tables in Databases

- Consider storing attorney availability in a DB
 Does the data structure discussion affect how you would design the DB tables?
- What is the moral of the story?

Designing Tables in Databases

- Consider storing attorney availability in a DB
 Does the data structure discussion affect how
 - you would design the DB tables?
- What is the moral of the story?
 Considering the key operations is important

Multiple Segments in Attorney Availability

- Assume days in cases are consecutive
- Days in attorney availability might not be consecutive

Multiple Segments in Attorney Availability

- Assume days in cases are consecutive
- Days in attorney availability might not be consecutive
 - Initial Andy's availability: Mon-Fri
 - Case: Wed-Thu
 - Updated Andy's availability: Mon-Tue, Fri
- Can the data structure accommodate it?

Multiple Segments in Attorney Availability

- Assume days in cases are consecutive
- Days in attorney availability might not be consecutive
 - Initial Andy's availability: Mon-Fri
 - Case: Wed-Thu
 - Updated Andy's availability: Mon-Tue, Fri
- Can the data structure accommodate it?
 - Mon: (Andy, 2)
 - Fri: (Andy, 1)

Checking Attorney Availability

Case starts on Mon

Do you want to check availability starting:
 Tue, ..., Fri?

Checking Attorney Availability

- Case starts on Mon
 Do you want to check availability starting:
 Tue, ..., Fri? No
- Case starts on Wed
 Do you want to check availability starting:
 Before Wed: Mon &Tue?
 - After Wed: Thu & Fri?

Checking Attorney Availability

Case starts on Mon

Do you want to check availability starting:
 Tue, ..., Fri? No

Case starts on Wed

- Do you want to check availability starting:
 - Before Wed: Mon &Tue? Yes
 After Wed: Thu & Fri? No

Checking Attorney Availability

- Case: starts on Wed, length 1 (ie Wed only)
 - Mon: (Andy, 3)
 - Tue: (Alice, 3)
 - Wed: (Amy, 3)
 - Who do you prefer and why--attorney/branch ordering?

Multiple Time Segments

- Do we prefer
 - Fewer segments
 - More segments

Multiple Time Segments

Do we prefer

- Fewer segments
- More segments
- Prefer fewer longer segments

Data Structure for Case Schedule

Data Structure for Case Schedule

2D array (like previous slides)
 row=judge, column=day, cell=caseID

Data Structure for Case Schedule

- 2D array (like previous slides)
 - row=judge, column=day, cell=caseID
- Interval
 - start day, end day

Data Structure for Case Schedule

- 2D array (like previous slides)
 row=judge, column=day, cell=caseID
- Interval
 - start day, end day
 - array of (start day, end day, caseID, judge)

Data Structure for Case Schedule

- 2D array (like previous slides)
 - row=judge, column=day, cell=caseID
- Interval
 - start day, end day
 - array of (start day, end day, caseID, judge)
- Duration
 - start day, duration

Data Structure for Case Schedule

- 2D array (like previous slides)
 - row=judge, column=day, cell=caseID
- Interval
 - start day, end day
 - array of (start day, end day, caseID, judge)
- Duration
 - start day, duration
 - array of (start day, duration, caseID, judge)

Additional Constraints/Preferences

Additional Constraints/Preferences

Time unit in hours instead of days

Additional Constraints/Preferences

Time unit in hours instead of days
 More "columns" in our tables for input

Additional Constraints/Preferences

- Time unit in hours instead of days
 More "columns" in our tables for input
- Specialty in certain cases

Additional Constraints/Preferences

- Time unit in hours instead of days
 - More "columns" in our tables for input
- Specialty in certain cases
 Only consider those attorneys (fewer branches)

Additional Constraints/Preferences

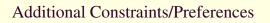
Time unit in hours instead of days

- More "columns" in our tables for input
 Specialty in certain cases
- Only consider those attorneys (fewer branches)
- Prefer certain judges

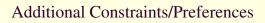
Additional Constraints/Preferences

Time unit in hours instead of days

- More "columns" in our tables for input
- Specialty in certain cases
 - Only consider those attorneys (fewer branches)
- Prefer certain judges
 - Consider those attorneys first (branch ordering)



- Time unit in hours instead of days
 More "columns" in our tables for input
- Specialty in certain cases
 Only consider those attorneys (four brack)
 - Only consider those attorneys (fewer branches)
- Prefer certain judges
 Consider those attorneys first (branch ordering)
- More even workload for each attorney



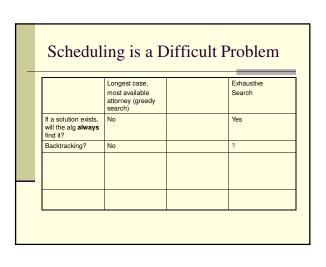
- Time unit in hours instead of days
 - More "columns" in our tables for input
- Specialty in certain cases
 - Only consider those attorneys (fewer branches)
- Prefer certain judges
 - Consider those attorneys first (branch ordering)
- More even workload for each attorney
 - Consider attorneys with lighter load first (branch ordering)

	Longest case,	Exhaustive
	most available attorney (greedy search)	Search
If a solution exists, will the alg always find it?		

Scheduling is a Difficult Problem

	Longest case, most available attorney (greedy search)	Exhaustive Search
If a solution exists, will the alg always find it?	No	?

 Schedul	ing is a D	Difficult P	Problem
	Longest case, most available attorney (greedy search)		Exhaustive Search
If a solution exists, will the alg always find it?	No		Yes
Backtracking?	?		



	Longest case,	Exhaustive
	most available attorney (greedy search)	Search
If a solution exists, will the alg always find it?	No	Yes
Backtracking?	No	Yes
Worst-case time complexity: # of tree nodes (n cases, m attorneys)	?	

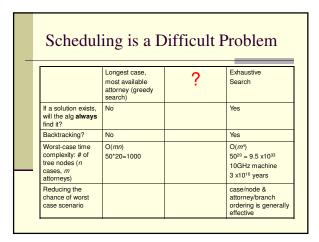
Scheduling is a Difficult Problem Image: search Exhaustive Search attorney (greedy search) Search If a solution exists, will the alg **always** find it? No Yes Backtracking? No Yes Worst-case time complexity: # of tree nodes (n case, m attorney (source) O(mn) ? omplexity: # of tree nodes (n case, m attorneys) So'20=1000 Image: source)

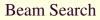
	Longest case, most available attorney (greedy	Exhaustive Search
If a solution exists, will the alg always find it?	search) No	Yes
Backtracking?	No	Yes
Worst-case time complexity: # of tree nodes (n cases, m attorneys)	O(<i>mn</i>) 50*20=1000	O(<i>m</i> ⁿ) 50 ²⁰ = ?

Scheduling is a Difficult Problem

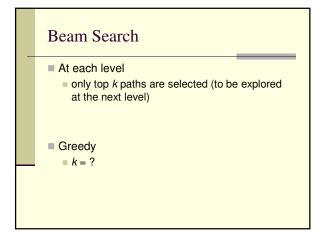
	Longest case, most available attorney (greedy search)	Exhaustive Search
If a solution exists, will the alg always find it?	No	Yes
Backtracking?	No	Yes
Worst-case time complexity: # of tree nodes (<i>n</i> cases, <i>m</i> attorneys)	O(<i>mn</i>) 50*20=1000	O(<i>m</i> ⁹) 50 ²⁰ = 9.5 x10 ³³ 10GHz machine ? years

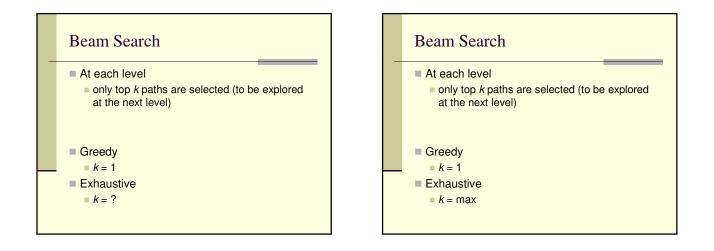
	Longest case, most available attorney (greedy search)	Exhaustive Search
If a solution exists, will the alg always find it?	No	Yes
Backtracking?	No	Yes
Worst-case time complexity: # of tree nodes (n cases, m attorneys)	O(<i>mn</i>) 50*20=1000	O(<i>mⁱ</i>) 50 ²⁰ = 9.5 x10 ³³ 10GHz machine 3 x10 ¹⁶ years
Reducing the chance of worst case scenario		?



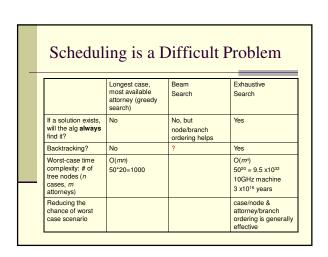


- At each level
 - only top k paths are selected (to be explored at the next level)





	U		t Problem
	Longest case, most available attorney (greedy search)	Beam Search	Exhaustive Search
If a solution exists, will the alg always find it?	No	?	Yes
Backtracking?	No		Yes
Worst-case time complexity: # of tree nodes (<i>n</i> cases, <i>m</i> attorneys)	O(<i>mn</i>) 50*20=1000		O(<i>m</i> ¹) 50 ²⁰ = 9.5 x10 ³³ 10GHz machine 3 x10 ¹⁶ years
Reducing the chance of worst case scenario			case/node & attorney/branch ordering is generally effective



Schedul	ing is a I	Difficult	Problem
	Longest case, most available attorney (greedy search)	Beam Search	Exhaustive Search
If a solution exists, will the alg always find it?	No	No, but node/branch ordering helps	Yes
Backtracking?	No	No	Yes
Worst-case time complexity: # of tree nodes (<i>n</i> cases, <i>m</i> attorneys)	O(<i>mn</i>) 50*20=1000	?	$O(m^{2})$ $50^{20} = 9.5 \times 10^{33}$ 10GHz machine 3×10^{16} years
Reducing the chance of worst case scenario			case/node & attorney/branch ordering is generally effective

Scheduling is a Difficult Problem

	Longest case,	Beam	Exhaustive
	most available attorney (greedy search)	Search	Search
If a solution exists, will the alg always find it?	No	No, but node/branch ordering helps	Yes
Backtracking?	No	No	Yes
Worst-case time complexity: # of tree nodes (<i>n</i> cases, <i>m</i> attorneys)	O(<i>mn</i>) 50*20=1000	O(<i>kmn</i>) 100*50*20=100K	$O(m^{\prime\prime})$ $50^{20} = 9.5 \times 10^{33}$ 10GHz machine 3×10^{16} years
Reducing the chance of worst case scenario			case/node & attorney/branch ordering is generally effective

Constraint (CSP)	Satisfaction F	roblems
Attorney Scheduling	Search Tree	CSP
Cases	Nodes	Variables
Attorneys	Branches	Values
	de ordering constraining variable	
,	/Branch ordering constraining value	