



CS 225

Data Structures

October 13 – AVL Applications

G Carl Evans



Why Balanced BST?



Summary of Balanced BST

Pros:

- Running Time:
 - Improvement Over:
- Great for specific applications:

Every Data Structure So Far

	Unsorted Array	Sorted Array	Unsorted List	Sorted List	Binary Tree	BST	AVL
Find							
Insert							
Remove							
Traverse							



Summary of Balanced BST

Cons:

- Running Time:

- In-memory Requirement:

Iterators

Why do we care?

```
1 DFS dfs(...);  
2 for ( ImageTraversal::Iterator it = dfs.begin(); it != dfs.end(); ++it ) {  
3     std::cout << (*it) << std::endl;  
4 }
```

Iterators

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```
1 DFS dfs(...);  
2 for ( const Point & p : dfs ) {  
3     std::cout << p << std::endl;  
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Iterators

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```
1 DFS dfs(...);  
2 for ( const Point & p : dfs ) {  
3     std::cout << p << std::endl;  
4 }
```

```
1 ImageTraversal & traversal = /* ... */;  
2 for ( const Point & p : traversal ) {  
3     std::cout << p << std::endl;  
4 }
```




CS 225 Office Hours

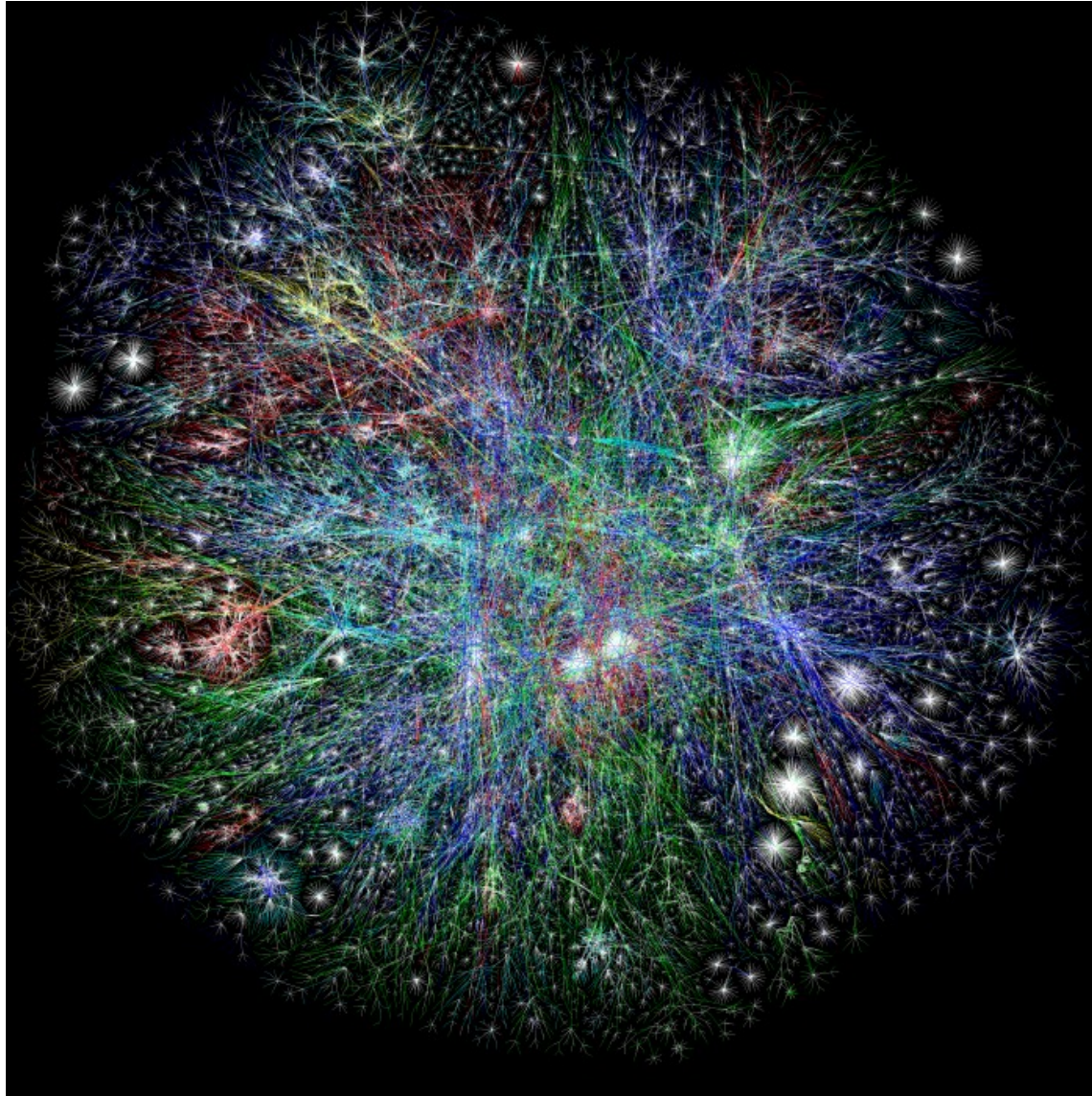
Office Hours

- Must have online contact info
- Must have a specific question
- We will remove students that don't do the above
- Purpose to get you unstuck not to fix your code



CS 225 Final Project

Working with data and using graphs



The Internet 2003

The OPTE Project (2003)

Map of the entire internet; nodes are routers; edges are connections.

HeapifyUp BasicBlock Graph

```
heapifyUp(int*, unsigned int):  
  push rbp  
  mov rbp, rsp  
  sub rsp, 16  
  mov qword ptr [rbp - 8], rdi  
  mov dword ptr [rbp - 12], esi  
  cmp dword ptr [rbp - 12], 1  
  jbe .LBB0_4
```

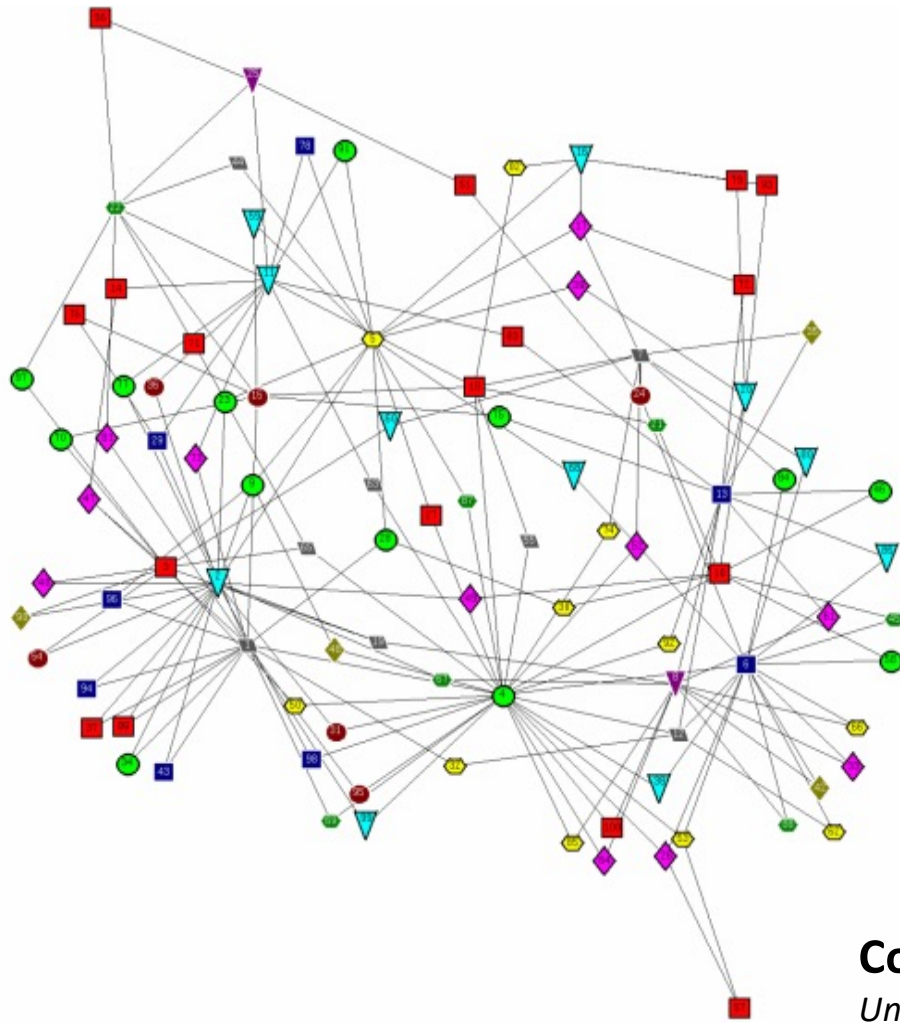
```
heapifyUp(int*, unsigned int):@@  
  mov rax, qword ptr [rbp - 8]  
  mov ecx, dword ptr [rbp - 12]  
  mov edx, ecx  
  mov ecx, dword ptr [rax + 4*rdx]  
  mov rax, qword ptr [rbp - 8]  
  mov esi, dword ptr [rbp - 12]  
  shr esi, 1  
  mov esi, esi  
  mov edx, esi  
  cmp ecx, dword ptr [rax + 4*rdx]  
  jge .LBB0_3
```

```
heapifyUp(int*, unsigned int):@19  
  mov rax, qword ptr [rbp - 8]  
  mov ecx, dword ptr [rbp - 12]  
  mov edx, ecx  
  mov ecx, dword ptr [rax + 4*rdx]  
  mov dword ptr [rbp - 16], ecx  
  mov rax, qword ptr [rbp - 8]  
  mov ecx, dword ptr [rbp - 12]  
  shr ecx, 1  
  mov ecx, ecx  
  mov edx, ecx  
  mov ecx, dword ptr [rax + 4*rdx]  
  mov rax, qword ptr [rbp - 8]  
  mov esi, dword ptr [rbp - 12]  
  mov edx, esi  
  mov dword ptr [rax + 4*rdx], ecx  
  mov ecx, dword ptr [rbp - 16]  
  mov rax, qword ptr [rbp - 8]  
  mov esi, dword ptr [rbp - 12]  
  shr esi, 1  
  mov esi, esi  
  mov edx, esi  
  mov dword ptr [rax + 4*rdx], ecx  
  mov rdi, qword ptr [rbp - 8]  
  mov ecx, dword ptr [rbp - 12]  
  shr ecx, 1  
  mov esi, ecx  
  call heapifyUp(int*, unsigned int)
```

```
.LBB0_3:  
  jmp .LBB0_4
```

```
.LBB0_4:  
  add rsp, 16  
  pop rbp  
  ret
```

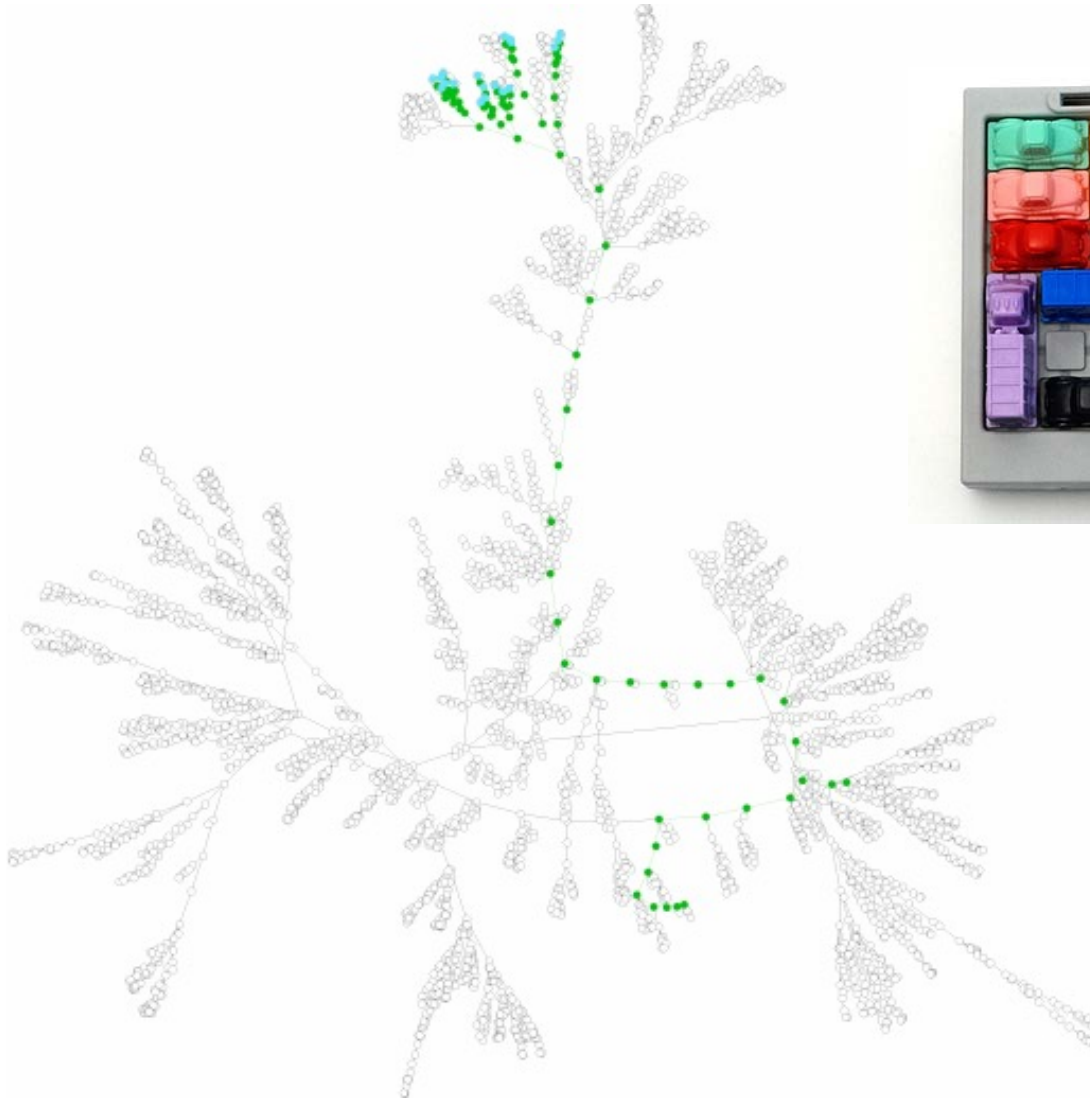
Generated using tools at <https://godbolt.org>



Conflict-Free Final Exam Scheduling Graph

Unknown Source

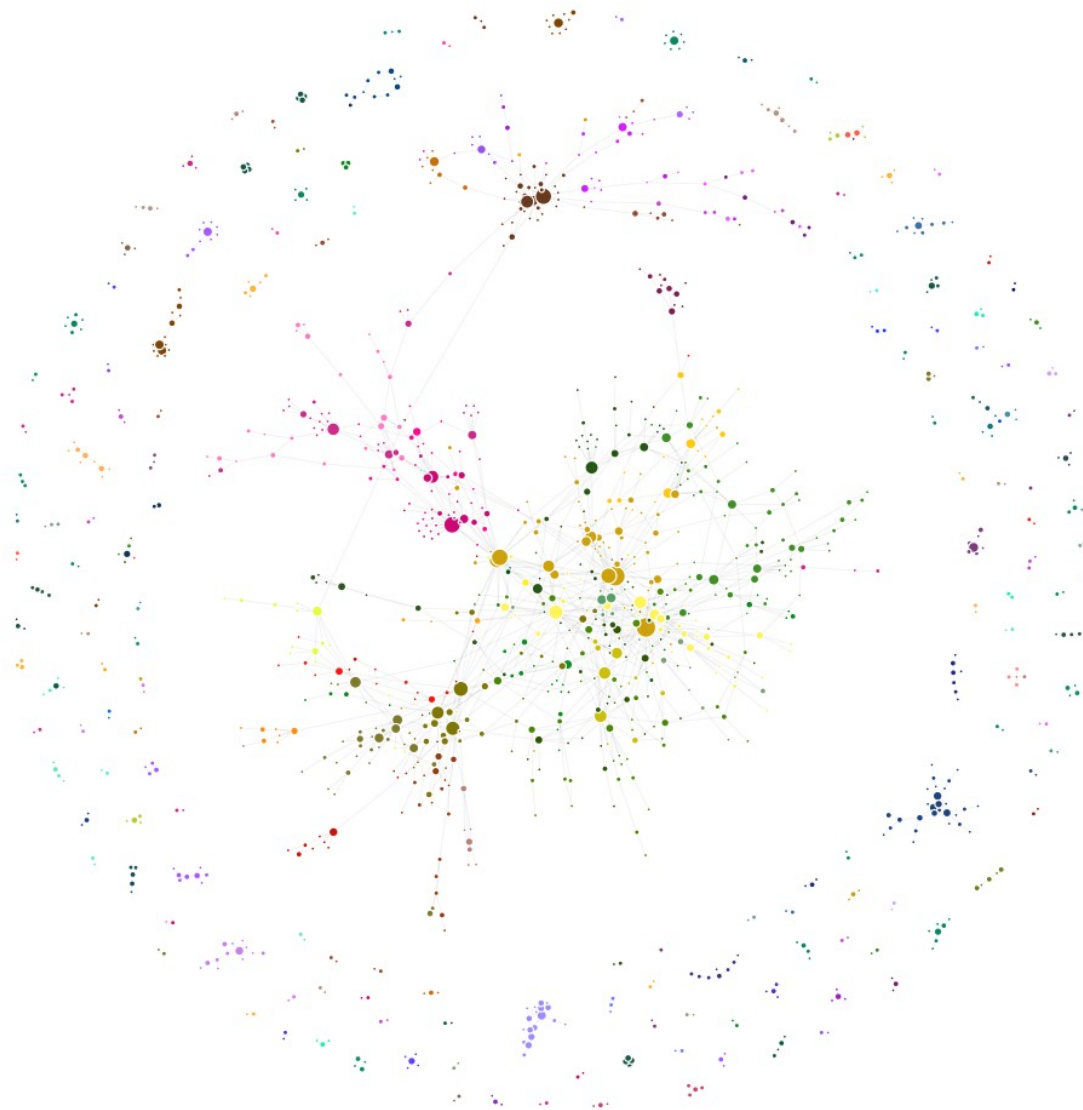
Presented by Cinda Heeren, 2016



“Rush Hour” Solution

Unknown Source

Presented by Cinda Heeren, 2016

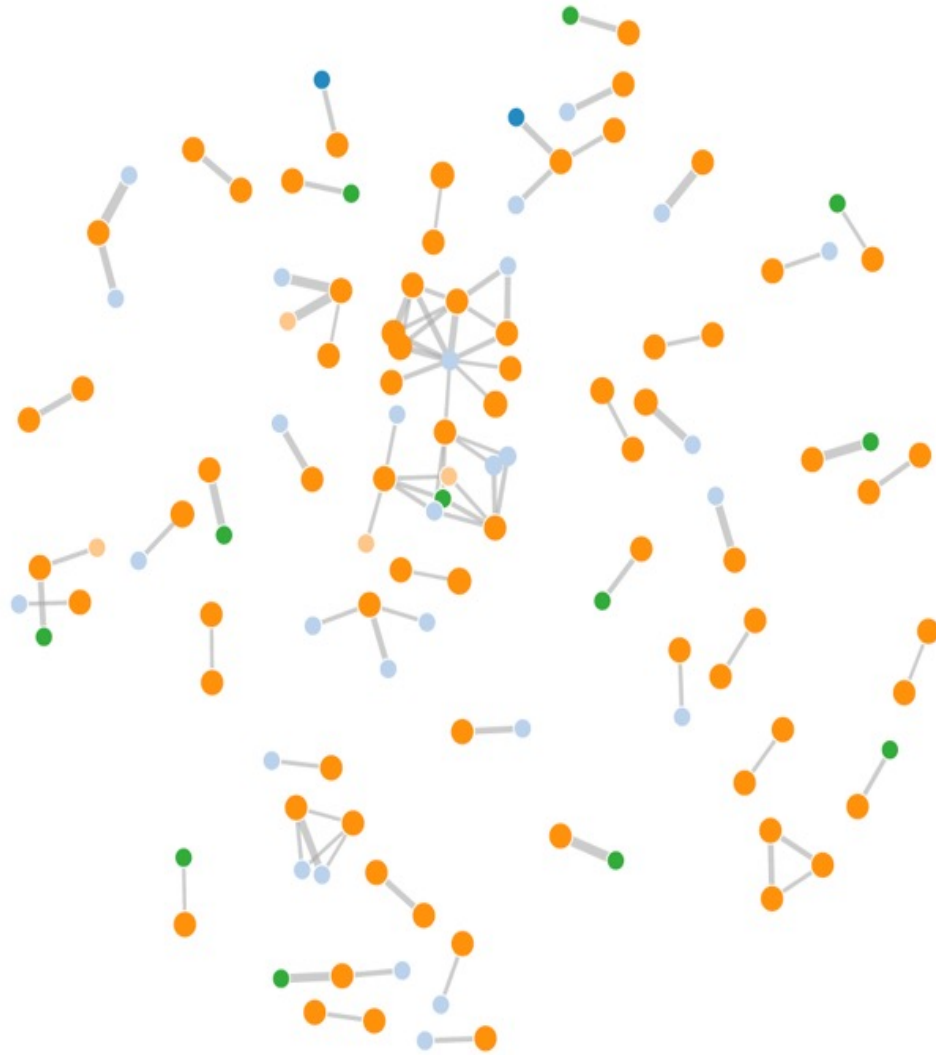


Class Hierarchy At University of Illinois Urbana-Champaign

A. Mori, W. Fagen-Ulmschneider, C. Heeren

Graph of every course at UIUC; nodes are courses, edges are prerequisites

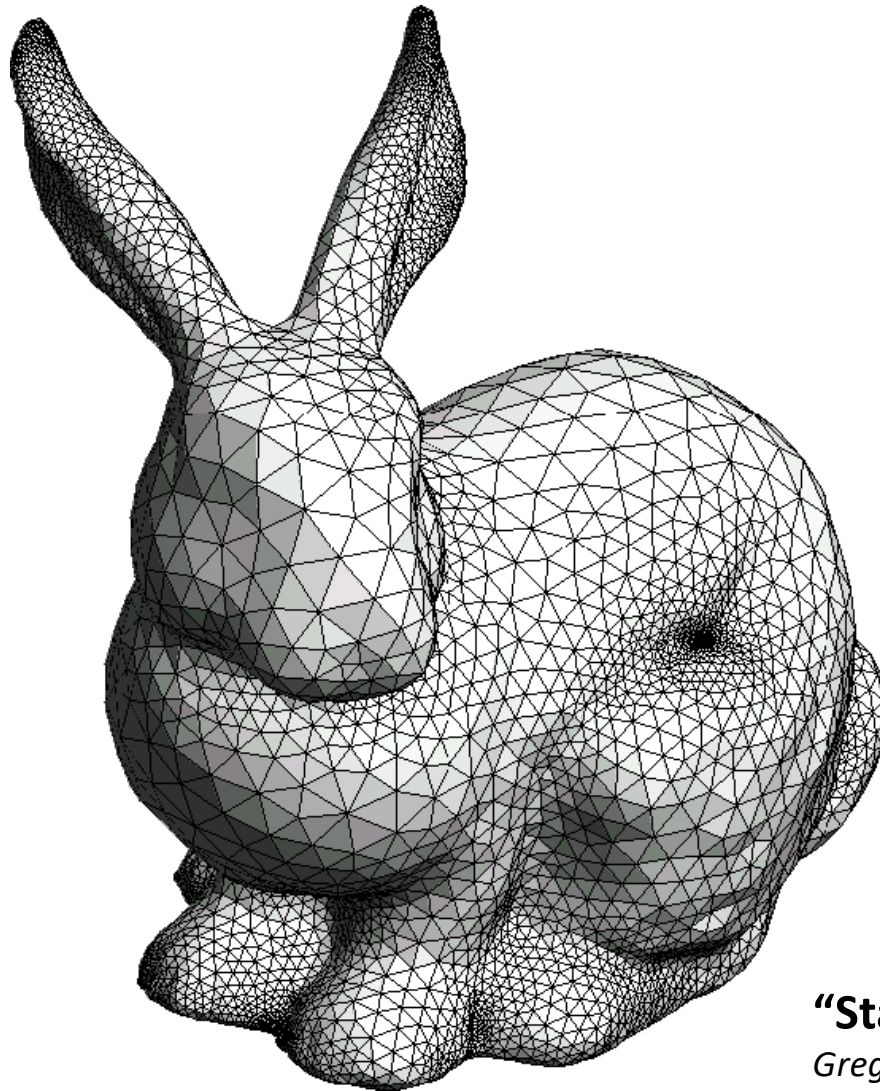
http://waf.cs.illinois.edu/discovery/class_hierarchy_at_illinois/



MP Collaborations in CS 225


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Presented by Cinda Heeren, 2016



“Stanford Bunny”
Greg Turk and Mark Levoy (1994)





Final Project - Form a Team

- Team formation will be happening next week.
- If you don't find a team we will match you up.
- You must fill out the form next week



Range-based Searches

Q: Consider points in 1D: $\mathbf{p} = \{p_1, p_2, \dots, p_n\}$.
...what points fall in $[11, 42]$?

Tree construction:

Range-based Searches

Balanced BSTs are useful structures for range-based and nearest-neighbor searches.

Q: Consider points in 1D: $\mathbf{p} = \{p_1, p_2, \dots, p_n\}$.
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Range-based Searches

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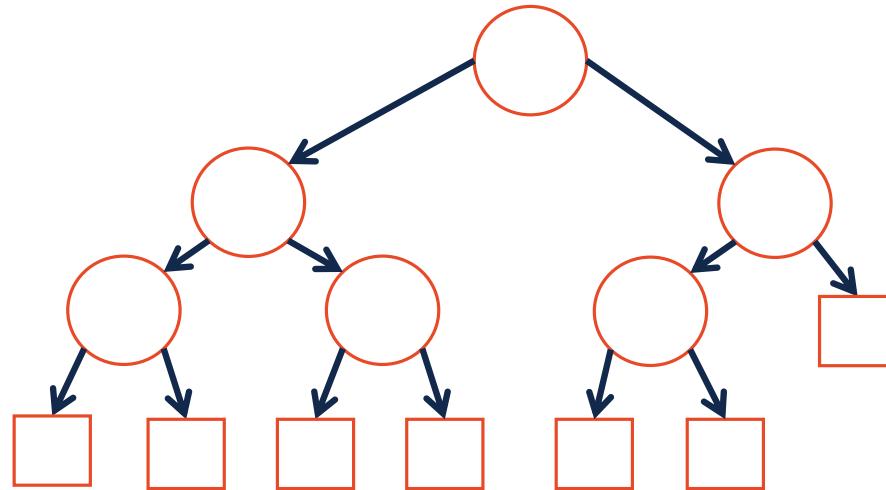


Range-based Searches

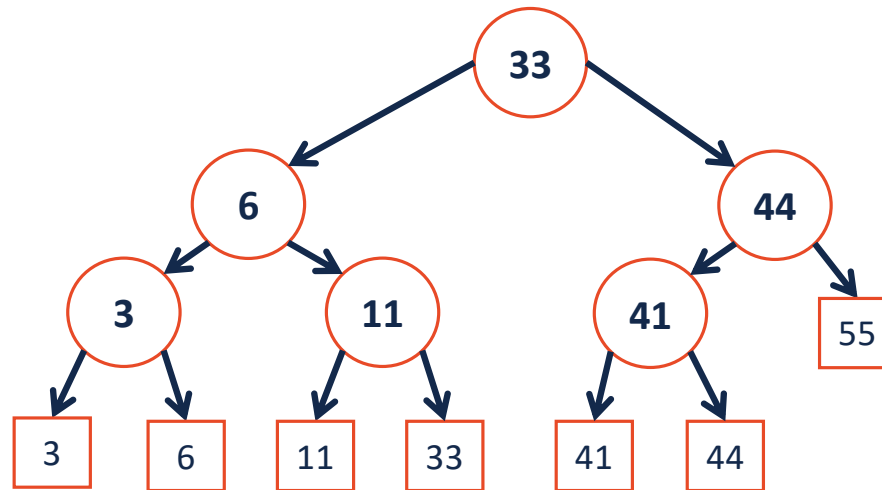
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Tree construction:

Range-based Searches

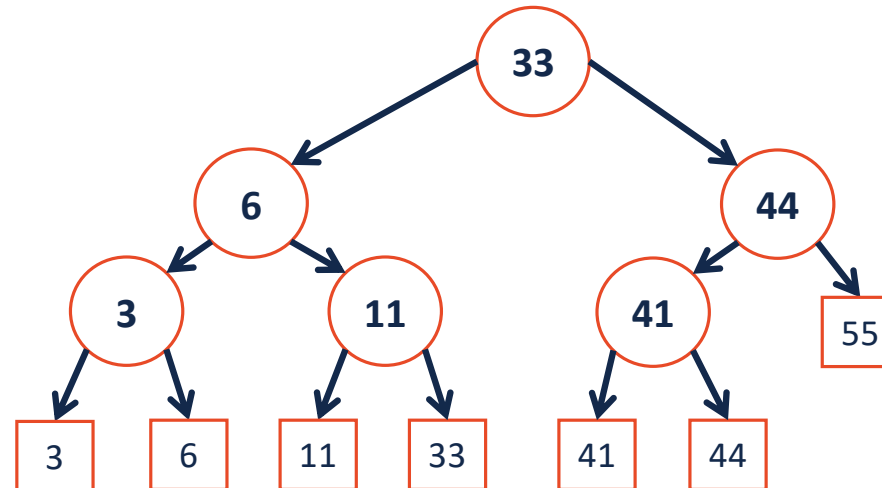


Range-based Searches

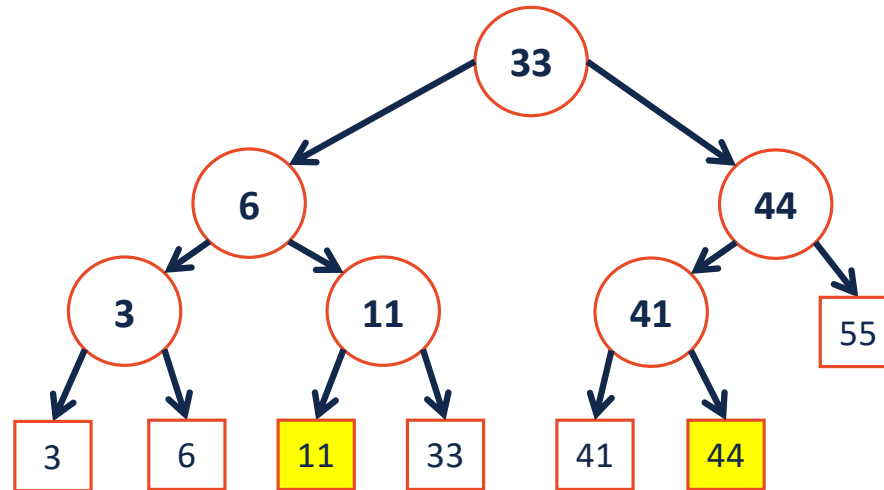


Range-based Searches

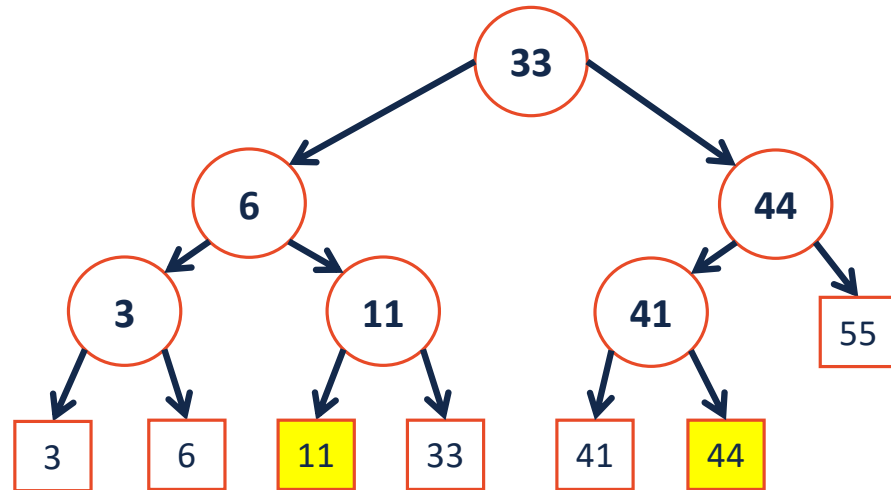
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Range-based Searches



Running Time



Range-based Searches

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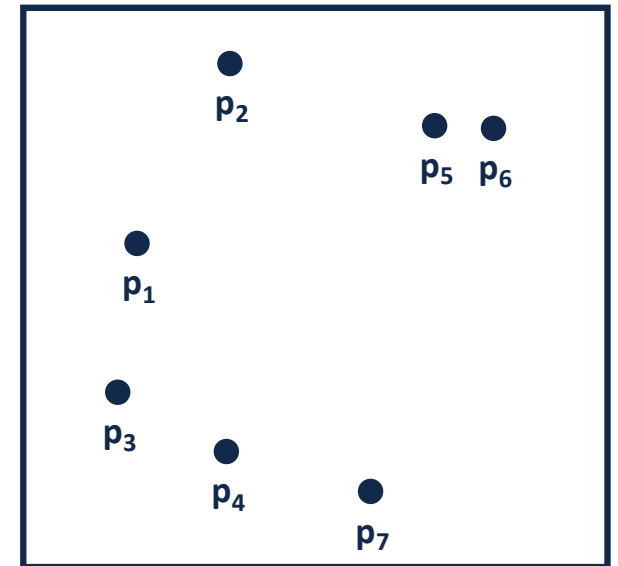


Range-based Searches

Consider points in 2D: $\mathbf{p} = \{p_1, p_2, \dots, p_n\}$.

Q: What points are in the rectangle:
[$(x_1, y_1), (x_2, y_2)$]?

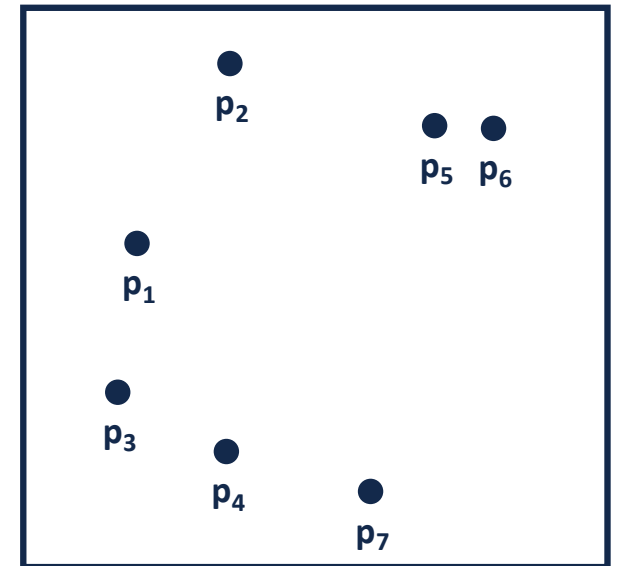
Q: What is the nearest point to (x_1, y_1) ?



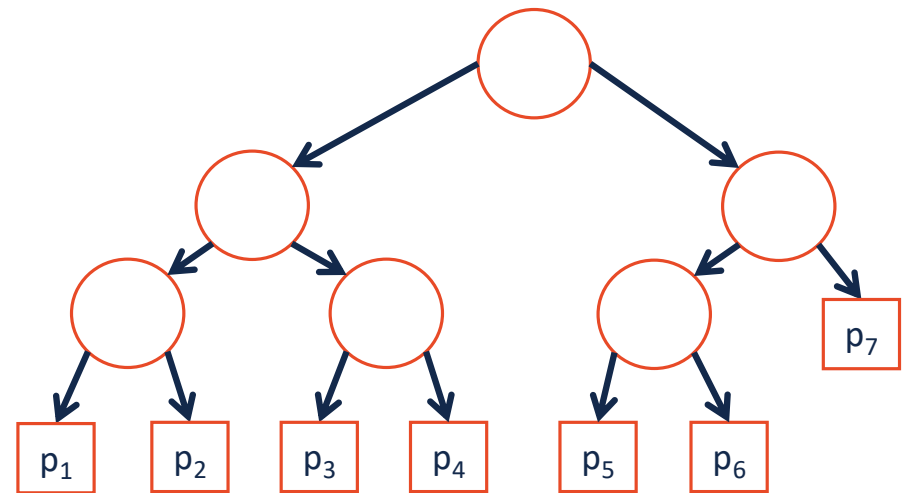
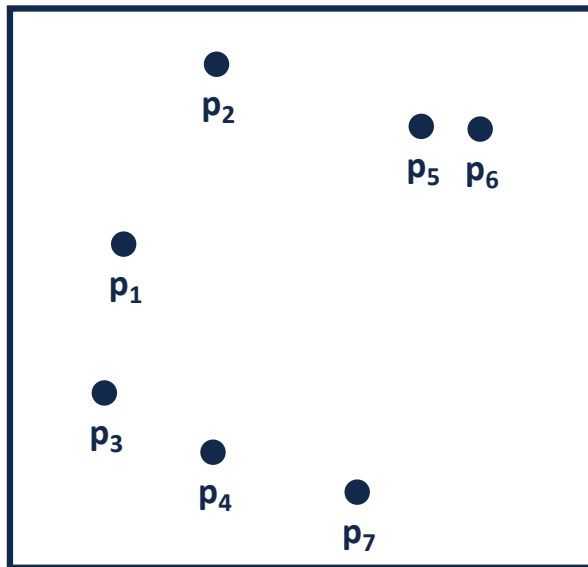
Range-based Searches

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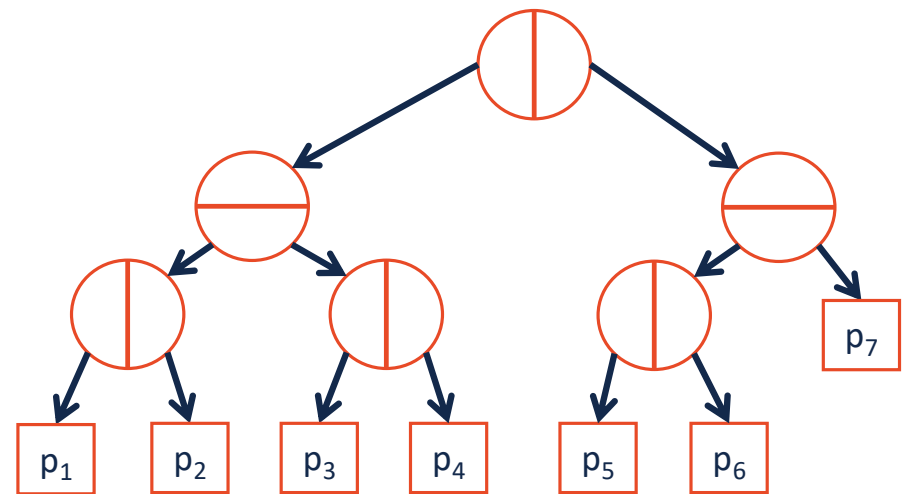
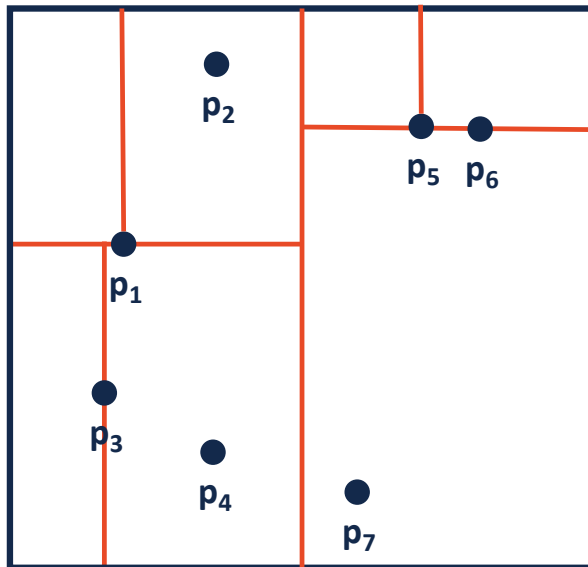
Tree construction:



Range-based Searches



kD-Trees



kD-Trees

