Knowledge Servers for the Classroom

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Introduction: Current Trends

- More and more textbooks are available electronically
- Benefits of digital textbooks:
  - Can be searched quickly
  - Due to the rise of electronic book readers, students are used to consuming electronic books

Introduction: Next Steps

- Electronic textbooks do not take full advantage of current computing technology
- Our approach to advance the state of affairs:
  - A web-server that houses a variety of learning materials
  - A user interface that enables navigation and search in a variety of ways

Overview: Sources of Learning Materials

- Server houses a variety of resources:
  - Information typically found in textbooks
  - Materials typically found in companion sites
  - Resources from the web to serve a variety of learning styles
- Diverse sources address differences in prior knowledge and learning styles

Overview: Types of Learning Materials

- Textbook materials:
  - Definitions
  - Positive examples
  - Negative examples
  - Code samples
  - Programming assignments
- Instructor companion site materials:
  - Slides
- Dynamic materials:
  - Animations
- Additional materials:
  - Unit test cases for programming assignment

Organizing Learning Materials

- We developed an index in which key concepts are annotated with links to learning materials
- In addition, we developed an ontology among those key concepts
- The ontology is used in the user interface to display relationships that exist between key concepts

Representing Learning Materials

- We use semantic web techniques to:
  - Index the learning materials
  - Capture the ontology
- Our ontology contains:
  - Key course concepts
  - Subclass relationships among those concepts
  - Sibling and superclass relationships that are determined automatically

Excerpt of Ontology

```
class, Data Structure
class, Tree
class, Binary Tree
class, Binary Search Tree
class, Balanced Binary Search Tree
class, Red Black Tree

subClassOf, Tree, Data Structure
subClassOf, Binary Tree, Tree
subClassOf, Binary Search Tree, Binary Tree
subClassOf, Balanced Binary Search Tree,
            Binary Search Tree
subClassOf, Red Black Tree,
             Balanced Binary Search Tree
```

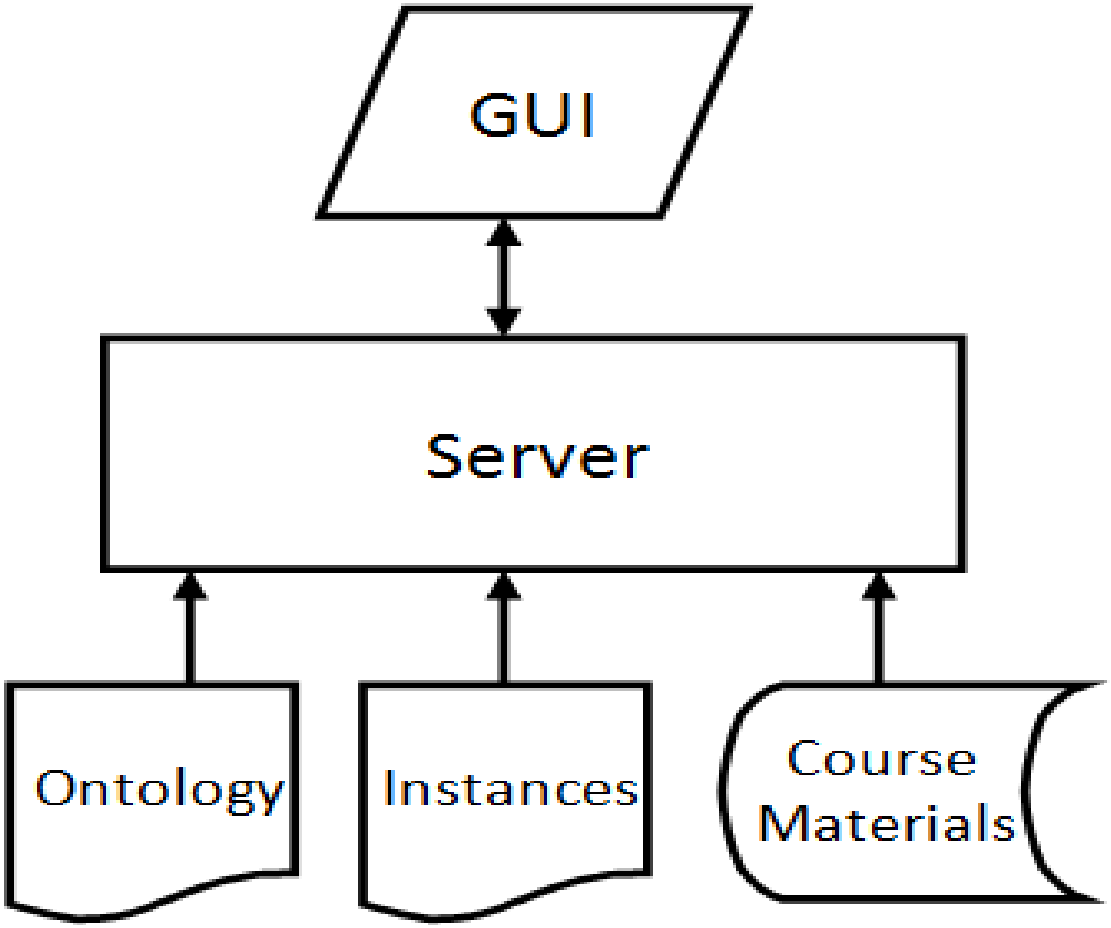
Excerpt of Learning Materials Index

```
Red Black Tree, Definition, Red-Black-Tree-def.html
Red Black Tree, Example, Red-black-tree-exa.jpg
Red Black Tree, Bottom-up Insertion Algorithm,
                Red-Black-Trees-Insertion.pdf
Red Black Tree, Top-down Insertion Algorithm,
                Red-Black-Trees-Insertion.pdf
Red Black Tree, Bottom-up Insertion Applet,
                http://people.ksp.sk/~kuko/bak/big
Red Black Tree, Top-down Insertion Applet,
                http://www.institution.edu/class/csse/
                csse230/schedule/day13/RedBlackTreeApplet.html
Red Black Tree, Alternate name, RB Tree
```

System Overview

- Java servlet
- Served through an Apache Tomcat web server
- Ontology and index are located in separate files
- Learning materials are located in several locations, both on-site and off-site

System Overview



GUI

- When visiting the server, the user is presented with three ways of locating information:
  1) Search box
  2) Directory listing of concepts
  3) Navigable graph representing the ontology
- The search box, directory listing and graph are equivalent ways of locating information in our system

GUI: Search Result

- A search displays:
  - By default: definition of concept
  - Links to available learning materials
  - Repositioned graph
- Links are either displayed on the results page or in a new window.
  - Content from relative URLs are displayed on the results page. Typically this includes definitions and examples.
  - A "Popout" button, when clicked, displays the content in a new window
  - Content from absolute URLs is displayed outright in a new window. Typically this includes animations and slides.

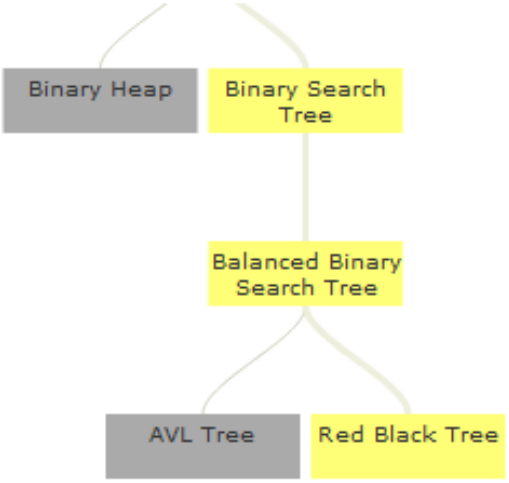
GUI: Search Result

CSSE 230 Knowledge Server

Navigate Directory

Red Black Tree

- Definition
- Example
- Bottom-up Insertion Algorithm
- Top-down Insertion Algorithm
- Bottom-up Insertion Applet
- Top-down Insertion Applet

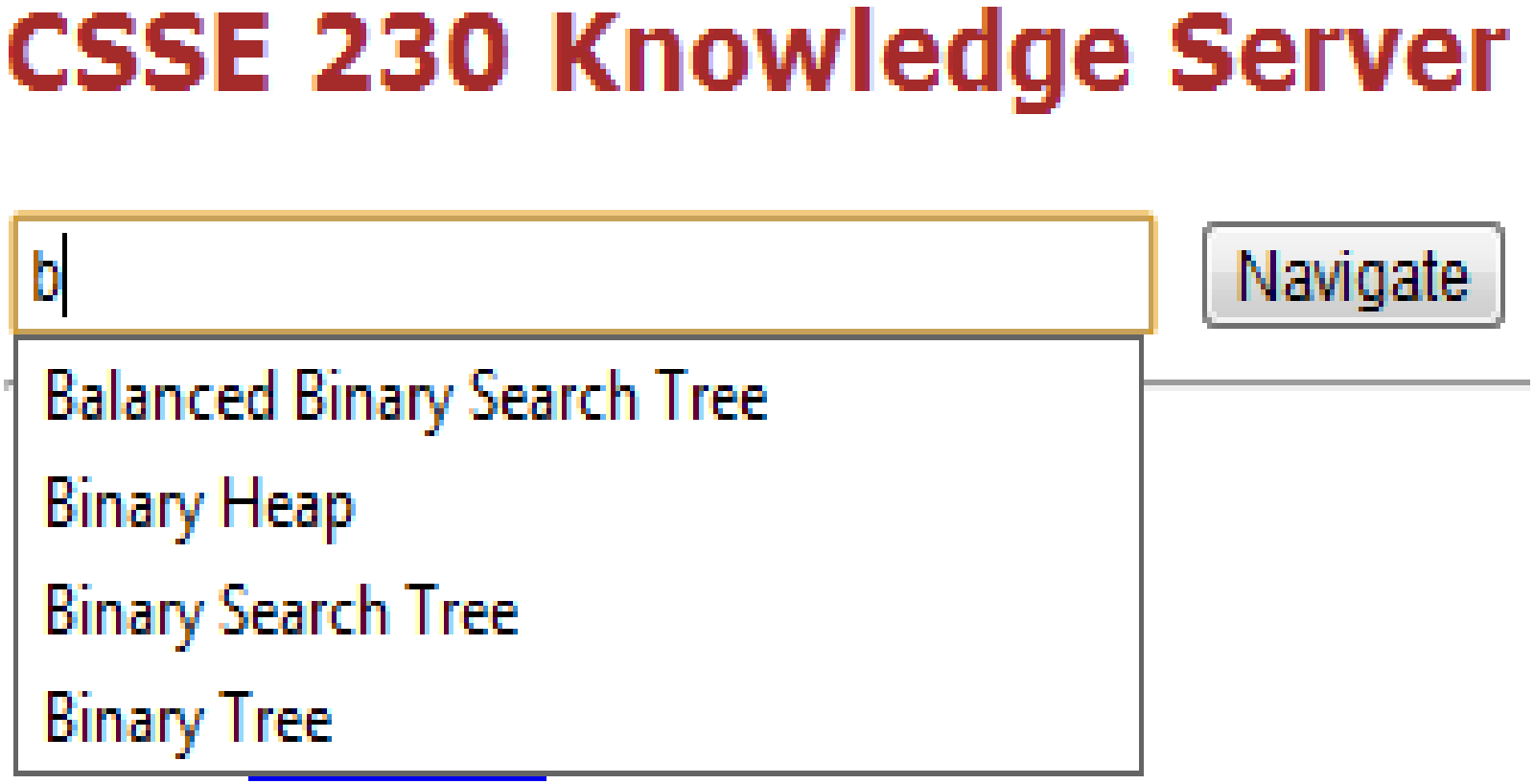


Example

Popout

GUI: Search with Autocomplete

- Autocomplete is pre-loaded with key concepts



GUI: Directory Listing

CSSE 230 Knowledge Server

Navigate Directory

Directory

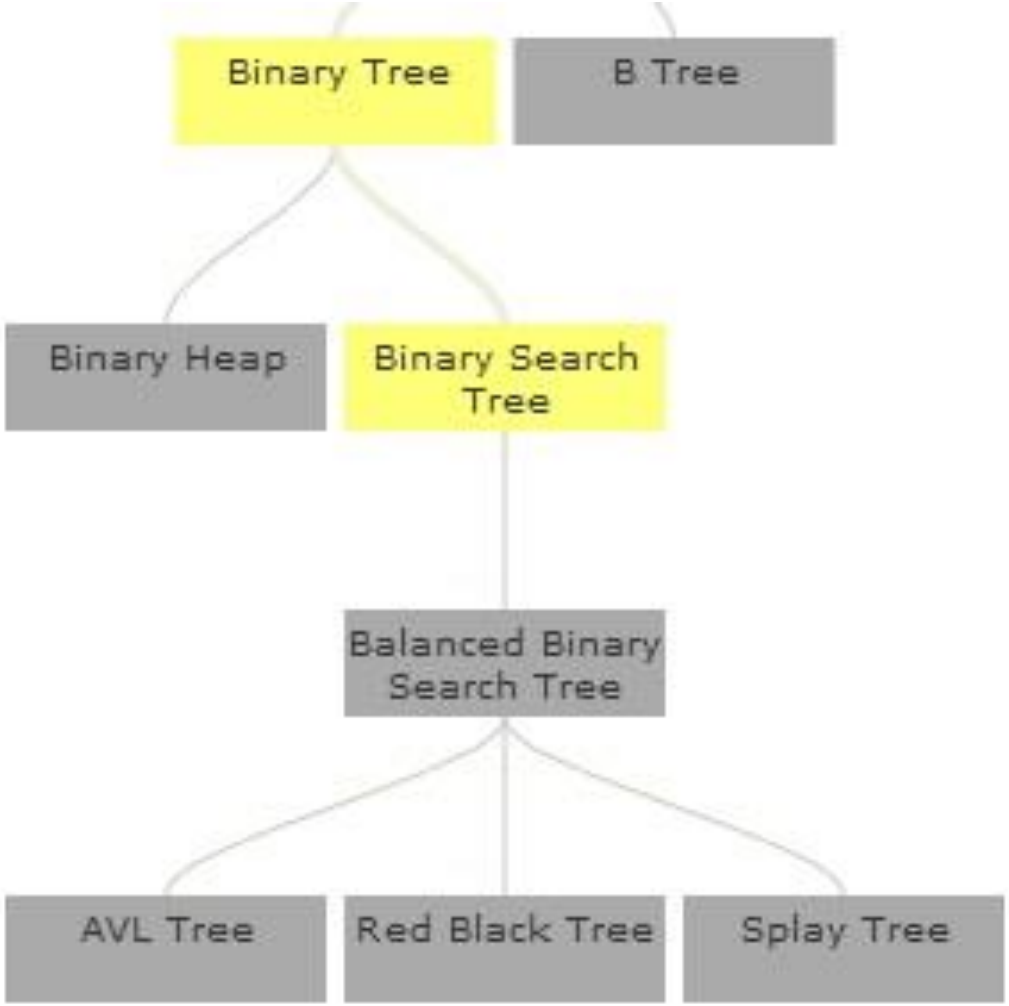
- AVL Tree
- Balanced Binary Search Tree
- Binary Heap
- Binary Search Tree
- Binary Tree
- Data Structure
- Hash Table
- Priority Queue
- Red Black Tree
- Tree

GUI: Navigable Graph

- On start-up, the upper portion of the ontology is displayed as a graph
- The user may click on any of the concepts resulting in several events:
  - The same learning materials are displayed as when searching
  - The graph is re-centered around the selected concept

GUI: Navigable Graph

- Excerpt of graph:



Evaluation: Procedure

- Knowledge server deployed half way through the term
- Assigned a homework consisting of a comparative evaluation of several data structures:
  - Provide an example application that serves to highlight the strength of each data structure
  - Justify choice by appealing to the complexity of major operations, i.e., insertion, removal and lookup
- Students were asked to use the knowledge server first, before venturing onto other sources of their choice

Evaluation: Procedure

- Anonymous survey to assess the usefulness of the contents and the GUI
  - Two Lickert scale questions
  - Six open ended questions
- Eighteen students participated

Evaluation: Results

- Mean responses for questions 1 and 2 using a scale of 1-5; strongly agree to strongly disagree

Survey Item	Mean
To develop the Data Structures Field Guide, the contents of the Knowledge Server was useful.	2.5
The user interface of the Knowledge server is useful.	1.9

Evaluation: GUI

- Two open-ended questions invited our students to comment on the usefulness of the GUI
  - Students very much liked the diagrammatic representation of the ontology
  - It helped them understand the relationship between the data structures
- Overall, students were very happy with the GUI

Evaluation: Contents

- Four open-ended questions invited our students to comment on the usefulness of the contents
  - Students liked the definitions which are part of each data structure
  - Several students would have liked to see information on sorting and searching
  - Some students would have liked to see direct information on the runtimes of operations
  - Several students would have liked to see less external information such as provided by the links to Wikipedia pages
  - Several students would have liked to see more information produced by us

Evaluation: Analysis

- Due to time constraints, a portion of the information in our server were links to Wikipedia pages
- Students would like to see more of our own material

Future Work: Extend Learning Materials

- For the next offering of the course, we plan to:
  - Add more of our own materials
  - Perform a more rigorous evaluation starting at the beginning of the term

Future Work: Expand Learning Materials

- Expand to other courses at our own institution and beyond
  - Extend the scope of learning materials to cover topics from our CS-1 and CS-2 courses.
  - Share our server with colleagues who use the same or a similar textbook
  - Expand the learning materials to be more comprehensive through cross-institution collaboration

Future Work: Social Networking

- Empower students to submit additional learning materials
- Fellow students review and rate submitted materials
- Benefits:
  - Results in more comprehensive learning materials
  - Draws in students by giving them ownership in the learning materials

Conclusion

- We believe the future of textbooks lies in dynamically served contents
- The contents are provided through a collaborative editing approach
  - Similar to the approach used by Wikipedia®
- Authors provide different kinds of learning materials appealing to a variety of learning styles and backgrounds

Questions?

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